

## PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM (PRRIP or PROGRAM) Final Statement – PRRIP Tern and Plover Habitat Synthesis Chapters

On March 17, 2015 the PRRIP Governance Committee (GC) approved the following motion:

The Governance Committee approves the Technical Advisory Committee recommendation to accept the Tern and Plover Habitat Synthesis Chapters, revised by the Executive Director's Office in response to peer review comments, as FINAL. These chapters are approved by the Governance Committee as final with the understanding they will be used for decision making purposes, and with the understanding the revised chapters and all associated peer review documents will be made available to the public and posted on the Program web site.

The final revised Tern and Plover Habitat Synthesis Chapters are attached as a unified document as **Exhibit A**. A summary peer review report is attached as **Exhibit B**. Program responses to summarized peer review comments on general questions is attached as **Exhibit C**. Program responses to each individual peer review comment are attached as **Exhibit D**.

All further questions regarding the Tern and Plover Habitat Synthesis Chapters, their use, and the peer review should be directed to the Executive Director's Office (EDO).



2/25/2015

## PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Data Synthesis Compilation

Interior Least Tern (*Sterna antillarum athalassos*) and Piping Plover (*Charadrius melodus*) Habitat Synthesis Chapters



Prepared by staff of the Executive Director's Office for the Governance Committee of the Platte River Recovery Implementation Program

February 25, 2015



## PREFACE

This document was prepared by the Executive Director's Office (EDO) of the Platte River Recovery Implementation Program ("Program" or "PRRIP"). The information and analyses presented herein are focused solely on informing the use of Program land, water, and fiscal resources to achieve one of the Program's management objectives: increasing production of interior least tern and piping plover from the Associated Habitat Reach (AHR) along the central Platte River in Nebraska. The Program has invested six years in implementation of an adaptive management program to reduce uncertainties about proposed management strategies and learn about river and species responses to management actions. During that time, the Program has implemented management actions, collected a large body of physical and species response data, and developed modeling and analysis tools to aid in data interpretation and synthesis.

Implementation of the Program's AMP has proceeded with the understanding that management uncertainties expressed as hypotheses encompass complex physical and ecological responses to limited treatments that occur within a larger ecosystem that cannot be controlled by the Program. The lack of experimental control and complexity of response precludes the sort of controlled experimental setting necessary to cleanly follow the strong inference path of testing alternative hypotheses by devising crucial experiments (Platt 1964). Instead, adaptive management in the Platte River ecosystem must rely on a combination of monitoring of physical and biological response to management treatments, predictive modeling, and retrospective analyses (Walters 1997). The Program has pursued all three of these approaches, producing multiple lines of evidence across a range of spatial and temporal scales.

Several lines of evidence now indicate that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the stated management objective for least terns and piping plovers. Presenting these lines of evidence for broader examination is the primary objective of this publication. As this evidence has emerged, the Program's Independent Science Advisory Committee

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(ISAC) and various stakeholders also requested the EDO examine the hydrology and physical characteristics of other regional river segments used by these species to glean additional management insights for the central Platte River. Fulfilling those requests is the second objective of this publication.

This document is compilation of six topical chapters with unique objectives and analyses that generally build on one another. Each chapter, which is intended to be useful as an independent document, includes background information on the Program and thus may contain redundant content. Chapter 1 was developed to provide background and context to the discussions in the subsequent chapters. It provides a brief history of least tern and piping plover occurrence in the central Platte River, changes in river morphology that sparked regulatory intervention through the Endangered Species Act, and the collaborative process that resulted in the Program. Chapter 2 provides an overview of the Program's Adaptive Management Plan, which is being implemented to evaluate competing species management strategies. Hypothesized beneficial effects of management actions are discussed and compared to implementation and effectiveness monitoring results.

Chapters 3 and 4 focus very specifically on least tern and piping plover habitat suitability in relation to the hypothesized benefits of implementation of the FSM management strategy. Chapter 3 focuses on priority hypotheses assumptions related to the beneficial effects of the FSM strategy on sandbar height. Chapter 4 shifts to an exploration of the relationships between channel width metrics and nest incidence to address stakeholder concerns that not enough emphasis is being placed on the importance of channel width in species habitat selection.

Following Chapter 4, the focus shifts from adaptive management and hypothesis evaluation to comparative analyses of the central Platte River with other river segments and systems used by the species. Chapter 5 provides an examination of historical and contemporary central and lower Platte River hydrology and physical process relationships in relation to species nesting ecology. Chapter 6 compares and contrasts



hydrology and physical characteristics of contemporary regional river segments used by the species to identify physical differences that may be important for species use and productivity.

The chapters in this data synthesis compilation were reviewed twice by Program's Technical and Independent Science Advisory Committees. Those reviews were extremely helpful and resulted in significant improvements to both the form and content of the chapters. The final draft chapters were also subjected to an additional external peer review facilitated by a third party neutral. Reviewers were selected based on their expertise in the areas of tern and plover ecology, ecological statistics, geomorphology, hydrology, riparian ecology, and adaptive management. The summary report from the external peer review process is included as Appendix A of this document. Program responses to external peer review comments and recommendations are included as Appendix B of this document. As with prior reviews, the independent external peer review process resulted in significant improvements to the chapters. The Executive Director's Office gratefully acknowledges the contributions all internal and external reviewers.

#### References

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#### **EXECUTIVE SUMMARY**

The Program invested six years implementing an Adaptive Management Plan (AMP) to evaluate, in part, the Program's ability to improve the productivity of least terns and piping plovers in the Associated Habitat Reach (AHR). During this time, enough progress has been made to allow us to address critical uncertainties and assess the performance of the Flow-Sediment-Mechanical (FSM) management strategy. In short the Executive Director's Office of the Program concludes that implementation of the FSM strategy will not produce or maintain suitable in-channel nesting habitat for these species. A narrative of key findings follows.

Implementation of Short-Duration High Flow (SDHF) releases, the physical process driver of the 10 FSM management strategy, is hypothesized to produce suitably-high sandbar habitat for least tern and 11 piping plover nesting in areas of sediment balance. Natural high flow events in 2008, 2010, 2011, and 2013 12 all exceeded SDHF magnitude and duration; these high flow events failed to build suitable habitat as 13 observed sandbar heights following these events did not exceed the Program's minimum height suitability 14 criterion in areas of sediment balance. Instead, the amount of suitable habitat declined from a high of 24 15 acres in 2008 as constructed in-channel sandbar habitats that met the criterion were eroded. As a 16 consequence of the loss of constructed habitat, species use of in-channel habitats declined from a high of 17 25 nests (20 least tern and 5 piping plover) in 2008 to 0 nests in 2013. 18

The disparity between observed and hypothesized beneficial effects of SDHF-magnitude flows on sandbar suitability can primarily be attributed to the prior assumption that sandbars build to the peak water surface during high flow events. Observational studies since 2007 indicate a height of 1.5 ft below peak water surface is a more reasonable estimate of sandbar height potential. When the prior height assumption is replaced with the estimated sandbar heights of 1.5 ft below peak flow, SDHF is no longer predicted to 5

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produce sandbars exceeding the minimum height criterion for suitable nesting habitat. Flow magnitudes of roughly twice SDHF may be necessary to create suitably-high sandbars in channel widths suitable for nesting.

27 As the negative indicators for FSM performance discussed above began to emerge, the Program's Independent Scientific Advisory Committee (ISAC) and stakeholders requested the EDO begin to compare 28 and contrast the physical characteristics of the AHR and other regional river segments in an effort to glean 29 additional management insights. The lower Platte River segment was an obvious choice for comparison 30 given that the presence of viable species subpopulations in the historical AHR was inferred, in part, from 31 contemporary species use of that segment of the river. Both species arrive and begin initiating nests prior 32 to the late-spring runoff which typically occurs in mid-June in the Platte basin. Given sandbar heights in 33 relation to stage-discharge relationships in both the central and lower Platte, nests initiated prior to the late 34 35 spring rise are likely to be inundated.

The timing of the late spring rise is especially problematic for piping plovers and it does not appear 36 37 that either segment can support sufficient in-channel productivity to maintain a subpopulation of that species over the long term. The ability to maintain a stable least tern subpopulation is likely tied to the 38 success of renesting following the late spring rise. Given the challenges to maintaining adequate 39 productivity, these findings suggest that use and success on novel habitats like in-channel sand spoil piles 40 and off-channel sand mines may be necessary to allow these species to persist in a river basin with 41 42 hydrology that is not ideally suited to the species' nesting ecology. Development of species population models in 2015 will help us better understand population dynamics in relation to on and off-channel 43 habitats. 44

A final comparative investigation was conducted to identify regional river segments that do support
 species population densities similar to proposed recovery objectives for the AHR. Although these species
 nest sympatrically on several river systems in Nebraska, the only river segments in this region that support

48 population densities approximating proposed AHR recovery objectives occur on the Niobrara River. Peak flow volumes and magnitudes on the Niobrara are quite similar to the contemporary AHR. However, the 49 timing of the annual peak flow is typically earlier and base flows remain higher during the summer months. 50 The earlier timing of the annual peak may be especially important in relation to piping plover productivity. 51 There are also intractable differences in physical conditions between the two segments that are likely related 52 to species occurrence. The width of the Niobrara River is highly variable due to the influence of bedrock 53 outcroppings and the median bed material grain size is much finer than the AHR (0.24 mm vs. 0.96 mm). 54 These differences likely contribute to the formation of large sand flats (~ 30 ac) that are used by the species 55 on the Niobrara. Channel widths within the AHR can be mechanically manipulated and widened, but it is 56 not feasible to attempt to shift the bed material grain size of the AHR into the range of the Niobrara from 57 either a technical or cost perspective. 58

In summary, these investigations lead us to conclude implementation of the FSM management strategy will almost certainly not create suitable least tern and piping plover nesting habitat on an annual or near-annual basis. Moreover, intractable differences between physical conditions in the AHR and other regional river systems that are used by these species raise serious doubt that the Program can successfully manage flow and sediment to create and maintain suitable in-channel nesting habitat. The mechanical creation and maintenance of in-channel and off-channel nesting habitat in the AHR, however, is ongoing and evaluations of use and productivity on these habitats are forthcoming.

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## CHAPTER 1 – History and Context: The Path to Adaptive Management of Least Tern and Piping Plover Habitat in the Central Platte River

#### 4 Abstract

5 Observations of least tern and piping plover use of the central Platte River are reviewed in relation to changes in hydrology and channel morphology over historical timeframes. The first species observations 6 7 in Nebraska date to the period of exploration in the early 1800s. Observations in the Associated Habitat Reach (AHR) of the central Platte River date to the 1940s. By that time, basin hydrology had been altered 8 by irrigation infrastructure and the channel was actively narrowing in response to changing flow, sediment 9 and disturbance regimes. Given the lack of species observations in the central Platte prior to hydrologic 10 11 alteration, a decline in habitat suitability and use has been inferred from: 1) reduction in unvegetated channel width, 2) lack of contemporary in-channel nesting, and 3) ongoing species use of the lower segment 12 of the Platte River and other regional river segments. A collaborative adaptive management approach is 13 being used to test two management strategies to improve productivity of least tern and piping plover from 14 15 the AHR.

#### 16 Introduction

The Platte River Recovery Implementation Program (Program) is responsible for implementing certain aspects of the endangered interior least tern (*Sternula antillarum athalassos*; hereafter, least tern) and threatened piping plover (*Charadrius melodus*) recovery plans. More specifically, the Program's Adaptive Management Plan (AMP) management objective is to increase productivity of the least tern and piping plover from the Associated Habitat Reach (AHR) of the Platte River in central Nebraska. This ninety-mile reach extends from Lexington, NE downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and one half miles of the river (Figure 1).

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Figure 1. Associated Habitat Reach of the central Platte River in Nebraska extending from Lexington
 downstream to Chapman.

The Program is entering its seventh year implementing an adaptive management program to test 28 strategies for improving least tern and piping plover productivity in the AHR. Subsequent chapters of this 29 document present analysis and interpretation of modeling, research, and monitoring efforts to date. The 30 objective of this introductory chapter is to provide a brief overview of the large body of relevant Platte 31 River literature and outline regulatory actions that led to the formulation of the Program. The chapter begins 32 with a review of least tern and piping plover monitoring and research in the AHR. Changes in hydrology 33 34 and channel characteristics over historical timeframes are then explored. Finally, the rationale for regulatory intervention on behalf of the species is discussed and related to two management paradigms 35 being evaluated by the Program. 36

## 37 Interior Least Tern and Piping Plover Life History

Interior least terns are long-distance migrants that breed in North America and winter in Central and South America. Least terns forage on small fish they capture by diving into shallow riverine habitats and freshwater ponds. The breeding range for least terns spans from Montana to Texas and from Eastern New Mexico and Colorado to Indiana and Louisiana (USFWS 1990). Least terns are a colonial nesting



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bird that mobs predators or other intruders by dive-bombing and defecating on them. The species breeds and nests on barren to sparsely vegetated riverine sandbars, sand and gravel pits, lake and reservoir shorelines, rooftops, ash pits, and salt flats from late April to early August. Least terns usually lay two to three eggs in a shallow scrape and may renest if their nest is destroyed (USFWS 1990).

The incubation and brood rearing period for nests and chicks generally lasts from 38 to 50 days. Least terns are a precocial species; however, chicks are not capable of foraging on their own so only a single brood is raised each year as adults must continue to feed offspring for several weeks after fledging. The least tern was listed as endangered on June 27, 1985 (USFWS 1990); however, a recently completed fiveyear review recommends delisting least terns due to recovery (USFWS 2013). The US Fish and Wildlife Service (USFWS) is now in the process of putting in place the necessary monitoring plans, conservation agreements, and population models in hopes of moving forward with a proposed delisting in the near future.

The northern Great Plains population of piping plovers was listed as threatened on January 10, 1986 53 (USFWS 2009). Piping plovers breed in North America and Canada and winter along the Atlantic and Gulf 54 coast and in the Bahamas and West Indies. Three breeding populations of piping plovers are recognized; 55 56 however, this discussion focuses solely on the northern Great Plains population. This population breeds in alkaline wetlands and along lake shorelines of the northern Great Plains and on the Missouri River and its 57 tributaries in North and South Dakota and Nebraska. Piping plovers on the breeding grounds generally 58 forage on insects and spiders. This species nests from early April to early August and draws predators away 59 from nests and young using an injury feigning broken-wing display (USFWS 2009). 60

Nests are generally located on barren to sparsely vegetated sand and gravel found on riverine sandbars, sand and gravel pits, lake and reservoir shorelines, and sand, gravel or pebbly mud found at alkali wetlands. Piping plovers generally lay four eggs in a shallow scrape lined with small pebbles and may renest if their nest is destroyed. The incubation and brood rearing period for nests and chicks generally

lasts from 52 to 65 days. Piping plovers are a precocial species with chicks that forage with an adult from
shortly after hatch until fledging. Piping plovers generally only produce a single brood of fledglings;
however, renesting after fledgling a brood has been observed (USFWS 2009).

68 Least tern and piping plover observations in the Associated Habitat Reach of the central Platte River

69 prior to systematic monitoring

Historical records of least tern occurrence in Nebraska were compiled by Ducey (1985, 2000) and 70 Pitts (1988). The first recorded observation of least terns in what is now Nebraska was made near the mouth 71 of the Platte River in 1804 by the Lewis and Clark expedition as they traveled up the Missouri River. The 72 next recorded observations were made by Duke Paul Wilhelm at the mouth of the Platte River in 1823. 73 74 Subsequent observations in the 19<sup>th</sup> century include the Loup River in 1857, the North Platte River in Keith County in 1859, and on the banks of a wetland basin near York, Nebraska in 1896 and 1897 (Ducey 2000, 75 Pitts 1985). Least terns were next observed nesting on the South Platte River near the city of North Platte 76 in 1926-1929 with 57 nests recorded as well as documentation of foraging movements to the North Platte 77 River and sand pit lakes when the South Platte River went dry (Tout 1947). 78

The next recorded least tern observation on the Platte River occurred near Columbus in 1941, the 79 same year that Lake McConaughy, the largest reservoir in the basin, was completed. Ten nests were 80 81 observed on river sandbars (Shoemaker 1941). The first recorded least tern observations in the Program's AHR occurred in 1942 when a colony was discovered nesting on the river near Lexington, Nebraska by Dr. 82 Ray S. Wycoff. Dr. Wycoff studied the colony for 17 years and observed nesting on a low sandbar in the 83 channel, high in-channel island created by sand mining, and at adjacent sandpits (Wycoff 1960). In 1943, 84 85 a single nest was observed on a swimming lake beach near Plattsmouth (Heineman 1944). In 1948 and 1949 least tern were again observed nesting on the South Platte River (Benckeser 1948, Audubon Field Notes 86 3:244). 87



Pitts (1988) compiled records from the Proceedings of the Nebraska Ornithologists Union, Wilson Bulletin, and Nebraska Bird Review and other sources to identify annual adult and nest sightings by county for the period of 1804-1984. Records of adult and nest sightings in the AHR began with Dr. Wycoff's observations which account for the majority of AHR records. Other observations prior to the first systematic survey results for the AHR in 1979 include one mid-reach adult observation in 1960 and observations of adult birds in the downstream portion of the reach in 1953, 1954, 1957, 1959, and 1973.

Early records of piping plover observations in Nebraska are much more limited and are typically 94 95 very general in nature (Pitts 1988). The earliest mention of the species (Hunter 1900) referred to the piping plover as being "common" in the Nebraska sandhills but "rare" near Lincoln, Nebraska. Subsequent 96 references list the species as a common migrant that breeds in scattered spots along lakes and rivers in the 97 state (Wolcott 1909, Moser 1942, Tout 1951, Nebraska Bird Review 1955, Rosche 1979). The first 98 quantitative observations of adults occurred near Omaha and at Capitol Beach in Lincoln in the early 1940s 99 (Moser 1942). Pitts' (1988) review of adult and nest observations by county (1804-1984) identified six 100 years prior to the beginning of systematic survey efforts when adults were observed near the upper end of 101 the AHR (1950-1952, 1954-1956), one year in the middle portion of the reach (1957), and two years in the 102 downstream portion of the reach (1954, 1959). 103

#### 104 Systematic monitoring of least tern and piping plover in the Associated Habitat Reach

Intermittent systematic monitoring of least tern piping plover occurrence and productivity has been conducted in the AHR since 1979 with variable degrees of monitoring effort expended every year after 1982 (Pitts 1988, Lingle 2004, Baasch 2010, 2012, 2014). A total of approximately 1,789 least tern and 776 piping plover nests have been documented in the AHR (Table 1; Figure 2). Of all nests documented in the AHR, 88.2% of least tern nests and 75.4% of piping plover nests occurred on off-channel sandpit habitat. Approximately 3.3% of least tern nests and 7.1% of piping plover nests occurred on natural sandbars; the

- remaining in-channel nests were observed on islands that were mechanically created and maintained as
- 112 nesting habitat.
- 113 Table 1. Central Platte River nest incidence by habitat type for the period of 1979-2013.

	Interior Least Tern		Piping Plover	
Habitat Type	Count	Percent	Count	Percent
Sandpit	1,578	88.2%	585	75.4%
Natural Sandbar	59	3.3%	55	7.1%
Constructed or Managed Sandbars	152	8.5%	136	17.5%
Total	1,789	100.0%	776	100.0%





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- Figure 2. Central Plate River least tern and piping plover nest incidence 1978-2013 by year and habitat type. Asterisks indicate periods when monitoring effort changed significantly.
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- 119

120 In-channel habitat selection and productivity investigations



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Ziewitz et al. 1992). The investigations identified low quantities of suitable nesting habitat and observed high levels of nest loss and chick mortality due to inundation of sandbars. Faanes noted a total loss of nests and young, while Ziewitz noted 8 of 13 nests were lost to inundation. A reduction of peak flows and vegetation encroachment into the channel from the pre-development period were cited as the reasons for low nest incidence and poor productivity (Atkins 1979, Faanes 1983, Ziewitz et al. 1992).

#### 128 Changes in Associated Habitat Reach hydrology over historical timeframes

Water development in the Platte River basin began in the mid-1800s as settlers migrated to the 129 region in search of gold and to homestead after the Federal Government opened the basin for settlement. 130 The Platte River is now heavily developed with over seven thousand diversion rights and seven million 131 acre-feet of storage (Figure 3; Simons & Associates Inc. 2000). Platte River discharge records begin in 132 1895, fifteen years before the completion of Pathfinder Dam, the first major agricultural storage project in 133 the basin. Mean annual discharge and the magnitude of the mean annual peak discharge in the contemporary 134 river are less than 40% of what was observed during the brief period of record prior to reservoir construction 135 (Table 2; Stroup et al. 2006). 136



Figure 3. Cumulative usable storage in reservoirs in the Platte River basin (Simons and Associates Inc.2000).

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140	able 2. Mean annual discharge and mean annual peak discharge at Overton gage adapted from Stroup	et
141	l. (2006).	

	1895- 1909	1910- 1927	1928- 1941	1942- 1958	1959- 1974	1975- 1998	1999- 2013
Mean Annual Discharge (cfs)	4,584	4,323	1,845	1,223	1,636	1,938	1,232
Mean Annual Peak Discharge (cfs)	20,725	18,218	11,548	6,685	7,301	7,176	5,056

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#### 143 Changes in Associated Habitat Reach sediment transport over historical timeframes

There is little bed material or sediment transport data available for the historical AHR. Simons and 144 Associates Inc. (2000) generated a crude predevelopment sediment transport estimate of approximately 7.8 145 million tons per year based on a flow/sediment regression analysis and an estimate of sediment trapping in 146 North Platte River reservoirs. Murphy et al. (2004) estimated much lower predevelopment sediment loads 147 on the order of 1-2 million tons per year using a range of sediment discharge equations and discharge 148 records from the period of 1895-1909. As indicated by the differences in these estimates, there is a high 149 degree of uncertainty related to sediment loads in the historical AHR. Contemporary sediment load 150 estimates are less variable and generally range from 400,000 - 1 million tons per year (Simons and 151 Associates Inc. 2000, Murphy et al. 2004). 152

One of the most significant changes in sediment dynamics from predevelopment conditions is a 153 sediment deficit in the upper half of the AHR due to clear water hydropower returns at the J-2 Return 154 structure on the south channel downstream of Lexington, NE (Figure 4). An average of approximately 73% 155 of Platte River flow is diverted at the Tri-County Diversion Dam downstream of North Platte and returns 156 to the river at the J-2 Return where it constitutes approximately 47% of river flows (Murphy et al. 2004). 157 Once diverted at North Platte, flow travels through several off-line reservoirs, where almost all of the 158 sediment is trapped. Accordingly, return flows at the J-2 Return structure are sediment-starved resulting in 159 a sediment deficit (hungry water) below the return. 160



Figure 4. Map of Lake McConaughy, Tri-County Supply Canal and J-2 Return Canal. Figure reproduced
from Department of the Interior (2006).

## 165 Changes in Associated Habitat Reach channel morphology over historical timeframes

The reduction in AHR active channel width (unvegetated width between permanently vegetated 166 left and right banks) over historical timeframes through expansion of woody vegetation was first quantified 167 by Williams (1978) and has been expanded upon in several subsequent analyses (Eschner et al. 1983, 168 Currier et al. 1985, Peake et al. 1985, O'Brien and Currier 1987, Lyons and Randle 1988, Sidle et al. 1989, 169 Johnson 1994, Simons and Associates 2000, Parsons 2003, Murphy et al. 2004, Schumm 2005, Horn et al. 170 2012). With the exception of Parsons (2003), which asserted no width change, investigators have generally 171 concluded that the AHR experienced a significant width reduction as a result of the expansion of 172 cottonwood forest into the channel. The change is evident in comparisons of aerial photography (Figure 5). 173



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Figure 5. Comparison of 1938 and 1998 aerial photographs of the Associated Habitat Reach at River Mile 218 in the Odessa to Kearney bridge segment. Much of the 1938 channel area is occupied by riparian 176 cottonwood forest. 177 178

The surveyed bank-to-bank or total width of the channel in the 1860s excluding large permanent 179 islands was highly variable and averaged 3,800 ft (Figure 6). The proportion of the total width of the 180 181 historical channel that was unvegetated is not known but has been estimated to be on the order of 90% (Johnson 1994). At the earliest aerial photography collection in 1938, unvegetated channel width averaged 182 2,600 ft. By 1998, average unvegetated width was 900 ft. Johnson (1994) evaluated the rate of change in 183 active channel width in the AHR from 1938 to 1988 and found the majority of narrowing occurred during 184 the 1940s and 1950s with channel area stabilizing by the 1980s (Figure 7). 185



Figure 6. Total channel width in the Associated Habitat Reach from the 1860s General Land Office (GLO)
survey, total unvegetated width in 1938 aerial photographs and total unvegetated width in 1998 aerial
photographs.

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Figure 7. Change in active channel area in the upper half of the Associated Habitat Reach 1938-1988 from
 aerial photography (Johnson 1994).

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196	The drivers of woody vegetation expansion were explored in many of the channel width analyses
197	with investigators generally concluding the change was due to alterations in hydrology caused by water
198	development in the basin. Alternative hypotheses of the specific mechanisms of narrowing include:
199	1) a reduction of peak flow magnitude and associated ability to scour vegetation (Williams 1978, O'Brien
200	and Currier 1987, Murphy et al. 2004),
201	2) a reduction in flow during the cottonwood germination period leading to increased recruitment
202	(Johnson 1994, Simons and Associates 2000), and
203	3) a decrease in desiccation mortality of seedlings in summer as the river transitioned from ephemeral to
204	perennial due to irrigation return flows (Schumm 2005).
205	Although changes in AHR channel width have been widely studied and debated sandbar
200	Antibugh changes in Arrice channel which have been which studied and debuted, sandbar
206	characteristics in the historical river are not well documented. Several investigations include brief
207	descriptions of sandbars and islands recorded by travelers in the 19th Century (Eschner et al. 1983, Simons
208	and Associates 2000, Murphy et al. 2004). The most descriptive observation of bedforms was contained in
209	Mattes (1969) who reproduced a quote from a Mr. Evens in 1848 describing the Platte River near Kearney
210	as "running over a vast level bed of sand and mica *** continually changing into short offsets like the
211	shingled roof of a house***." Other travelers generally characterized the bed of the river as being comprised
212	of innumerable sandbars continually shifting and moving downstream (James 1823, Mattes 1969).
213	The first detailed characterization of AHR sandbar morphology was provided by Ore (1964) who
214	classified Platte River bedforms as transverse bars. Further attempts to characterize sandbar morphology
215	identified dominant bedforms as transverse/linguoid bars (Smith 1971, Blodgett and Stanley 1980),
216	macroforms (Crowley 1981 and 1983), or a combination of both types (Horn et al. 2012). The historical
217	accounts of Platte River bedforms appear to agree well with contemporary descriptions of
218	transverse/linguoid bars.

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#### 219 Regulatory intervention in the Platte River Basin through the Endangered Species Act

The interior population of the least tern was listed as endangered under the Endangered Species 220 Act in 1985 and the piping plover was listed as threatened in 1986. Soon after listing, the USFWS made 221 the determination that these species were threatened by upstream impoundments and diversions that 222 reduced the magnitude of the annual spring runoff credited with historically creating and maintaining 223 suitable sandbar nesting habitat on a near-annual basis (Freeman 2010, Department of the Interior 2006). 224 The following excerpt from the Biological Opinion for the Platte River Recovery Implementation Program 225 226 (USFWS 2006) provides the rationale for USFWS conclusions about the effects of upstream water development on least tern and piping plover habitat in the AHR. 227

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#### Decline in Availability of Riverine Nesting Habitat

As discussed above water resource development in the Platte River basin has been 229 extensive resulting in reduced peak and annual flows, reduced sediment load and 230 transport, and resulting changes in river plan form that allow the vegetation of formally 231 active river channel (Murphy et al. 2004, FEIS 2006). Within the action area, open sandbar 232 habitat along the Platte River between North Platte and Grand Island has largely 233 disappeared as a result of these changes (Eschner et al. 1981, Sidle and Kirsch 1993, Sidle 234 et al. 1989 and 1992, Williams 1978, Currier et al. 1985, Lyons and Randle 1988, Murphy 235 et al. 2004, NRC 2005, FEIS 2006). 236

The current lack of riverine nesting in the central Platte River adversely affects the least tern and piping plover. The NRC (2005) concluded that current conditions in the central Platte River, including the lack of hydrological conditions necessary for development and maintenance of nesting habitat "... appear to be compromising the continued existence – that is, the survival – of the NGP population of the piping plover."" (p100). The NRC

242	(2005) further stated that loss of habitat along the river appears to be forcing birds to use
243	alternative sites that are less secure from predators and other sources of disturbance.
244	Periodically, flooding of sufficient magnitude to scour perennial vegetation off sandbars
245	and form new barren sandbars does occur. However, sandbars that develop under current
246	hydrologic conditions in the central Platte River are typically small and low in elevation.

These sandbars are frequently overtopped even by minimal flow changes that occur 247 throughout the nesting season, and are unsuitable for nesting under current conditions 248 (Sidle et al. 1992). An aerial videography study conducted by Ziewitz et al. (1992) 249 documented moderately vegetated sandbars and sandbars that were slightly exposed in the 250 central Platte River. The differences between the central and lower reaches of the Platte 251 River were readily apparent. In the central Platte River, mean nest elevations were lower 252 than the mean sandbar elevation, which was the opposite of the relative elevations 253 observed on the lower reach (Ziewitz et al. 1992). Little suitable nesting habitat was 254 observed in videos taken of the central reach of the Platte River (Ziewitz et al. 1992). 255

256 To some degree, flooding of nests is a natural phenomenon to which least terns and piping plovers have adapted through re-nesting and other reproductive strategies (Sidle et al. 257 1992, Kirsch and Sidle 1999). However, habitat changes along the Platte described by 258 Eschner et al. (1981), Sidle et al. (1989), USFWS (1981), and Williams (1978), have 259 occurred faster than flora or fauna have been able to adapt. Water resource development 260 has taken place at a substantial rate, as has the narrowing and forestation of the Platte 261 River. The effects of groundwater withdrawal have also contributed to degradation of in-262 channel and floodplain habitat. Releases from the J-2 Return near Lexington exacerbate 263 264 flooding when coupled with local thunderstorms (Lingle 1993b). Under current channel

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265	conditions, many releases from upstream water control structures can result in flooding,
266	and further exacerbate natural flooding events.

Although riverine nesting habitat in the central Platte River is limited, the lower Platte 267 River still functions somewhat naturally. The character of the Platte River changes notably 268 at Columbus, where the Loup River enters the Platte River. The river channel is wider, and 269 larger, higher sandbars are present. The Loup and Elkhorn rivers still provide enough flow 270 to the lower Platte River to support sediment transport, sandbar dynamics, and vegetation 271 272 scouring (Rodekohr and Engelbrecht 1988, Sidle et al. 1992). As a result, the lower Platte River still offers habitat forming spring flows which scour vegetation and maintain 273 sandbars, and lower but continuous summer flows to isolate sandbars from mammalian 274 predators and human disturbance and ensure the availability of forage. Sidle et al. (1992 275 and 1993) documented before and after conditions of such a flood using aerial 276 videography. During the 1990 nesting season, flows in June jumped from 6,215 cfs (176 277 cms) to 32,182 cfs (911.3 cms) at the North Bend gauging station. At the Louisville gauge 278 (below the mouths of the Loup and Elkhorn rivers), flows increased from 5,368 cfs (152 279 cms) to 60,505 cfs (1,713.3 cms) between June 13 and June 17. Flows returned to pre-280 flood levels within a few days, and Sidle et al. (1992 and 1993) reported extensive egg and 281 chick mortality. They also reported woody vegetation being scoured from islands and 282 banks, and an 83 percent increase in barren sandbar area once flows dropped. Periodic 283 scouring flows can result in mortality, but are necessary to maintain sandbar habitat. In 284 addition, the lower Platte River floodplain supports sand and gravel mining as does the 285 central reach, and terns and plovers also nest on these artificial sites. 286

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- As indicated in the excerpt, a decline in AHR least tern and piping plover habitat suitability has been inferred from:
- the body of evidence documenting a significant change in Platte River hydrology and reduction in
   unvegetated AHR channel width over historical timeframes,
- 2) presence of nesting on sandpits but lack of suitable sandbar nesting habitat and in-channel productivityin the contemporary AHR, and
- 3) species use of riverine habitat in the contemporary lower Platte River which experiences higher peak
   flow magnitudes.

Within this context, the USFWS began issuing jeopardy opinions for water projects that could 296 further affect the hydrology of the AHR. These jeopardy opinions prompted the states of Wyoming, 297 Colorado, and Nebraska and the Department of the Interior to enter into a Cooperative Agreement in 1997 298 for the purpose of negotiating a program to conserve threatened and endangered species habitat in the AHR 299 while accommodating certain ongoing water development activities in the basin. Through the negotiation 300 process, it became apparent that uncertainty and disagreements about species habitat requirements and 301 302 appropriate management strategies were making it difficult to reach agreement on a program. Resolution was achieved through development of an Adaptive Management Plan (Program 2006) that treats these 303 disagreements as uncertainties related to two competing management strategies. 304

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## Competing Management Paradigms

The Program's two competing management strategies reflect different paths to achieving the objective of improving production of least tern and piping plover from the AHR. The first strategy is the Mechanical Creation and Maintenance (MCM) approach. This approach focuses on mechanical creation and maintenance of both in- and off-channel habitats for the species including the construction of in-channel nesting islands, acquisition and restoration of off-channel sandpit habitat, and the construction of new off-



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channel sandpit habitat. Various entities created, maintained, and monitored mechanical in- and off-channel
least tern and piping plover nesting habitat in the AHR since the 1980s. Accordingly, there is little
uncertainty about the ability to construct and manage mechanical habitats that will be used by the species.
Uncertainties include differences in selection and productivity on in-channel habitats versus off-channel
habitats (Program 2006).

The second strategy is the Flow-Sediment-Mechanical (FSM) approach. This approach is rivercentric with a focus on restoring channel width, improving sediment supply, and increasing annual peak flow magnitudes to increase sandbar height and maintain width. Chapter 2 provides an overview of Program implementation of FSM management actions and species response. Chapter 3 provides a more in-depth discussion of sandbar height and evaluation of hypotheses related to the ability of the FSM strategy to produce sandbar heights suitably high for nesting.

The FSM strategy is rooted in the view that the historical AHR provided suitable habitat conditions 322 and supported viable sub-populations of both the least tern and piping plover prior to the onset of water 323 324 development and channel narrowing. As discussed previously, there is a large body of evidence documenting AHR channel narrowing over historical timeframes with the most significant changes 325 occurring during the period of 1940-1970 (Johnson 1994). However, least tern and piping plover 326 observations in the AHR began after the bulk of water development had already occurred and the channel 327 was narrowing. Consequently, a decline in habitat suitability could not be inferred from a corresponding 328 decline in species use or productivity. 329

Instead, the decline in habitat suitability and species use was inferred from 1) the change in channel width, 2) lack of on-channel nesting in the contemporary AHR, and 3) contemporary species use of the lower Platte River and other river systems. This inference involves two assumptions that can be addressed through retrospective and comparative analyses. First, it assumes that other river segments being used by

- the species support viable species sub-populations. Second, it assumes these segments are functional analogs to the historical AHR. Chapters 5 and 6 explore the validity of these assumptions and potential
- implications for the Program's ability to create and maintain on-channel habitat using flow.

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## CHAPTER 2 – Implementing the Flow-Sediment-Mechanical Management Strategy and Interior Least Tern and Piping Plover Response

#### 4 Abstract

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Adaptive management is being implemented at a large scale on the Platte River to reduce 5 uncertainty regarding the response of the central Platte River to management actions. Monitoring suggests 6 7 the scale of Program management actions and natural analog events since 2007 is sufficient to test the concept that the Flow-Sediment-Mechanical (FSM) management strategy will increase sandbar height and 8 produce suitably high sandbars for interior least tern and piping plover nesting. Effectiveness monitoring 9 of channel morphology following flow releases and natural high flow events indicates a decline in the 10 amount of suitable habitat over time as constructed islands eroded. Validation monitoring of in-channel 11 species use indicates a corresponding decline in in-channel nest incidence. The decline in suitable habitat 12 and nest incidence despite Program management and natural events hypothesized to produce suitable 13 habitat is an indication that the FSM strategy, as currently conceived, will not improve production of least 14 tern and piping plover from the central Platte River. 15

#### 16 Introduction

The Platte River Recovery Implementation Program (Program) is responsible for implementing certain aspects of the endangered interior least tern (*Sterna antillarum athalassos*; hereafter, least tern) and threatened piping plover (*Charadrius melodus*) recovery plans in the Associated Habitat Reach (AHR) of the Platte River in central Nebraska. This ninety-mile reach extends from Lexington, NE downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and one half miles of the river (Figure 1).





Figure 1. Associated Habitat Reach of the central Platte River in Nebraska extending from Lexington
 downstream to Chapman including bridge segments.

27	During the First Increment of the Program (2007-2019), stakeholders committed to working toward
28	this management objective by acquiring and managing land (10,000 acres) and water (130,000-150,000
29	acre-feet/year) resources to benefit the species. However, there is significant disagreement about species
30	habitat requirements and the appropriate strategy for managing the Program's land and water resources
31	(Freeman 2010). In order to reach consensus for Program implementation, stakeholders agreed to treat
32	disagreements as uncertainties to be evaluated within an adaptive management framework. The result is an
33	Adaptive Management Plan (AMP) designed to test two competing management strategies to achieve, in
34	part, the objective of improving production of least tern and piping plover from the central Platte River
35	(Program 2006).



The Program is attempting address key scientific and technical uncertainties through application of adaptive management and linking the results of monitoring, research, analysis, and synthesis to decisionmaking by the Governance Committee (GC). This series of chapters represents the first effort by the Program to fully synthesize multiple lines of evidence, provide the GC with information useful in the decision-making process, and complete one full loop of the adaptive management cycle.

#### 41 Adaptive Management Implementation Approach

## 42 Adaptive Management Definition

According to the Adaptive Management Plan (AMP), the Program defines adaptive management as "a series of scientifically driven management actions (within policy and resource constraints) that use the monitoring and research results provided by the Integrated Monitoring and Research Plan (IMRP) to test priority hypotheses related to management decisions and actions, and apply the resulting information to improve management" (Program 2006). The AMP goes on to identify the common six steps of adaptive management as noted in Figure 2.



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51 **Figure 2:** Adaptive management cycle.


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53 While many definitions of adaptive management exist, this is the understanding of how adaptive 54 management will be applied within the Program. It also represents how the scientific and technical aspects 55 of the Program have been implemented since 2007. A discussion of Program progress in relation to each 56 step of the adaptive management cycle follows.

57 Assess

Program participants developed conceptual ecological models (CEMs) as a first step in assembling the 58 AMP (Program 2006). Those CEMs provide a basic visual framework for the hypothesized understanding 59 60 of central Platte River processes relative to the target species, including the least tern and piping plover. A hierarchy of broad and priority hypotheses, management strategies and actions, implementation activities, 61 and data evaluation detailed in the AMP are an extension of the relationships identified in the CEMs. The 62 63 AMP contains specific management actions grouped collectively into two management strategies (Program 2006). The first management strategy is the river-centric Flow-Sediment-Mechanical (FSM) approach, 64 often referred to as "Clear-Level-Pulse". Management actions include: 65

66 • Mechanical

67	a.	Consolidate the flow and river channels to maximize stream power and help induce braided
68		channel characteristics;
69	b.	Mechanically cut banks and lower islands to a level that will be inundated by anticipated
70		annual peak flows; and
71	c.	Mechanically clear vegetation from islands and banks in the single channel as needed to
72		aid in the widening process and make sediment available for recruitment to the river.

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Minimum channel width target is 750 feet.

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76	• Sediment
77	a. Mechanically place sediment into the river from banks, islands and out-of-bank areas at a
78	rate that will eliminate the sediment deficiency and restore a balanced sediment budget.
79	• Flow
80	a. Use Environmental Account water from Lake McConaughy to generate short-duration
81	near-bankfull flows (Short-Duration High Flows or SDHF) of 5,000 to 8,000 cfs in the
82	habitat reach for three days in the springtime or other times outside of the main irrigation
83	season. The intent is to achieve these flows on an annual or near-annual basis.
84	The FSM management strategy is river-centric as indicated by the management actions and
85	hypothesized beneficial effects. The alternative Mechanical Creation and Maintenance (MCM) or "Clear-
86	Level-Plow" approach focuses on mechanical creation and maintenance of both in- and off-channel nesting
87	habitats. MCM management actions include construction of in-channel nesting islands, restoration of
88	degraded off-channel sandpit nesting habitat, and the construction of new off-channel sandpit nesting
89	habitat.
90	The focus of this chapter is on our evaluation of the ability of the FSM strategy to improve
91	production of least tern and piping plover on the central Platte River. The hypothesized beneficial effects
92	of the FSM strategy include:
93	• Hypothesis PP-1: Flows of 5.000 to 8.000 cfs magnitude for a duration of three days (defined in
94	the AMP as a "short-duration high flow" or "SDHF") are needed with both mechanical actions of
05	consolidating flow and river widening to raise sandbars to an elevation suitable for least tern and
95	vising allow and fiver widening to faise sandbars to an elevation suitable for least term and
96	piping plover nesting habitat.
97	• Hypothesis PP-2: Sediment augmentation is required in conjunction with increases in flows and
98	contributes to wider sustainable channels, contributes to increases in occurrence of sandbars,

99	restores stream bed elevation, and over time will promote the occurrence of a braided plan form in
100	currently anastomosed reaches of the river.

- Hypothesis PP-3: The mechanical action of consolidating flows will help shift the river to a braided
   condition, which widens the river and creates more sandbars. Cutting banks and leveling islands
   in conjunction with SDHF will widen the river.
- 104

Specific priority hypotheses with detailed X-Y graphs were added to the AMP to provide the data evaluation context for exploring the relationships addressed in the broader hypotheses (Program 2006). Priority hypothesis Flow #1 (see Figure 3) suggests that under a balanced sediment budget, an SDHF discharge of 5,000-8,000 cfs for three days (roughly 50,000 to 75,000 acre-feet of water in volume, and the only flow management action prescribed in the AMP) will build sandbars to an elevation that is suitable for least tern and piping plover nesting.







# 113 Design and Implementation

114	The priority least tern and piping plover management uncertainties to be evaluated through
115	implementation of the AMP include: 1) the ability of the FSM strategy to produce and maintain riverine
116	sandbars that are suitably high for nesting; 2) whether or not the species will select in-channel habitats over
117	off-channel habitat; and 3) differences in productivity between the two habitat types. To date, the Program's
118	focus has largely been on evaluating the ability of the FSM strategy to produce suitable nesting habitat. The
119	Program's AMP provides the following approach to implementing and evaluating the management actions:
120	1. Begin with efforts at a sufficient scale to test concepts, to generate anticipated effects
121	large enough to measure, but at a scale unlikely to cause undesirable impacts to third
122	parties.
123	2. Monitor the effects of actions on key indicators of resource management objectives,
124	and on indicators of undesirable consequences.
125	3. Determine if the same management action should be scaled up, or if the management
126	action should be modified or abandoned.
127	4. Assuming management actions are resulting in desired outcomes, and as safety and
128	efficacy of actions are established, increase scale to accomplish key management
129	objectives by the end of the Program First Increment.
130	The AMP includes an Integrated Monitoring and Research Plan (IMRP) that presents the Program's
131	approach to evaluating species and physical process response to Program management actions and natural
132	events on system, reach, and project scales (Program 2006). The approach consists of monitoring (e.g.,
133	baseline data and long-term trend detection), experimental research (e.g., to determine cause-and-effect
134	relationships), simulation modeling (e.g., to provide a tool to design experiments and test scientific
135	understanding), and independent peer review. A discussion of the overall experimental design and all

activities being conducted under the IMRP is beyond the scope of this chapter. However, as an example,
system-scale monitoring and modeling resources relevant to testing hypothesis PP-1 (above) are presented
in Table 1. Two additional system-scale projects (geomorphology and vegetation monitoring and twodimensional hydrodynamic and sediment transport modeling efforts) are ongoing, but are not discussed
here. They will conclude in 2014 and 2016, respectively (Tetra Tech Inc. 2014, EA Science, Engineering
and Technology Inc. 2014).

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Table 1. Biological and physical process monitoring, mechanistic models, and research relevant to
 evaluating the ability of the Flow-Sediment-Mechanical strategy to create and maintain sandbars suitably
 high for least tern and piping plover nesting (Hypothesis PP-1).

Effort	Frequency	Description
Least Tern and Piping Plover Use and Productivity Monitoring	Annual	Document species use, habitat variables and productivity in the AHR. (Program 2010a)
Least Tern and Piping Plover Habitat Availability Analysis	Annual	Document occurrence and amount of habitat in AHR meeting minimum species habitat suitability criteria (Rainwater Basin Joint Venture 2013)
Discharge Measurements	Real-time	Real-time Platte River discharge monitoring at six locations in the AHR. Stream gaging conducted in cooperation with the USGS and Nebraska Department of Natural Resources
June Color-Infrared Imagery	Annual	Document in-channel and off-channel habitat conditions during least tern and piping plover nest initiation period (Program 2011)
November Color-Infrared Imagery and Light Detection and Ranging	Annual	Document channel morphology and topography under leaf-off and low discharge conditions. (Program 2011)
System-Scale Geomorphology and Vegetation Monitoring	Annual	Monitor sediment transport, channel morphology and in-channel vegetation throughout the AHR. Data include bed and suspended sediment load measurements, repeat channel transect surveys, bed and bank material sampling, and vegetation monitoring (Program 2010b)
HEC-GeoRAS Hydraulic Model of AHR	As Necessary	Segment-scale hydraulic model for evaluation of channel hydraulics and development of water surface profiles across a range of discharges (HDR Inc. 2011)
HEC 6-T Sediment Transport Model of AHR	As Necessary	Segment-scale sediment transport model for evaluation of sediment deficit and augmentation activities (HDR Inc. 2011)

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147 Program monitoring and data synthesis efforts fit broadly into the categories of implementation, effectiveness, and validation monitoring. Implementation monitoring is conducted to determine if the 148 management actions are being implemented according to design requirements and standards. Effectiveness 149 monitoring of physical habitat performance indicators is conducted to determine if management actions are 150 achieving or moving towards management experiment performance criteria. Validation monitoring of 151 species use and selection determines if species are responding to management actions and/or if the Program 152 is making progress towards achieving species management objectives. A review of monitoring that is 153 specific to testing the ability of FSM to create suitably high nesting habitat (Hypothesis PP-1) follows. 154

# 155 <u>Mechanical</u>

The first management action contemplated under the Mechanical portion of the FSM strategy is the consolidation of flow in reaches where discharge is distributed between multiple channels. The Program began investigating the feasibility of large-scale flow consolidation in 2009 and has determined that while technically feasible, regulatory constraints and property law would likely prevent implementation. Accordingly, the Program has abandoned flow consolidation as a management action. The practical implication is the loss of the ability to consolidate flow as a mechanism for supporting increased main channel width and stage variability in 50% of the AHR that is currently unconsolidated.

The other aspects of the mechanical component of FSM have been implemented in the AHR by various conservation organizations since the 1980s in an effort to remove and prevent woody vegetation from reestablishing in the channel. Overall, conservation organizations own over 30,000 acres in the AHR and have at least partial management control of the channel in approximately 47% of the reach. Since Program inception in 2007, in-channel vegetation control efforts have included spraying of invasive species, disking, island clearing, and channel widening. These actions have been implemented by the Platte Valley Weed Management Area, USFWS Partners for Fish and Wildlife, The Crane Trust, The Nature



Conservancy, The Audubon Society, the Nebraska Public Power District (NPPD), the Central Nebraska Public Power and Irrigation District (CNPPID), and the Program. Mechanical channel maintenance activities are ongoing in nine out of 13 bridge segments in the AHR (Table 2). In addition, the Platte Valley Weed Management Area has conducted a reach-wide common reed (*phragmites australis*) spraying program since 2008 involving aerial and ground application of herbicide to all common reed infestations detected in the channel (Craig, 2011).

	Length	
Bridge Segment	Managed (mi)	Mechanical Management Actions
Lexington to Overton	9.0	Vegetation removal from banks and islands, channel disking
Overton to Elm Creek	4.0	Vegetation removal from banks and islands, island leveling, channel widening, channel disking
Elm Creek to Odessa	4.0	Vegetation removal from banks and islands, island leveling, channel disking
Odessa to Kearney	0.0	
Kearney to Minden	4.7	Vegetation removal from banks and islands, channel disking
Minden to Gibbon	5.5	Vegetation removal from banks and islands, island leveling, channel disking
Gibbon to Shelton	1.7	Vegetation removal from banks and islands, channel disking
Shelton to Wood River	2.5	Vegetation removal from banks and islands, channel disking
Wood River to Alda	4.0	Vegetation removal from islands, island leveling, channel disking
Alda to Hwy 281	6.5	Vegetation removal from banks and islands, channel disking
Hwy 281 to Hwy 34	0.0	
Hwy 34 to Chapman	0.0	
TOTAL	41.9	

176 Table 2. Mechanical management actions undertaken by various entities since Program inception in 2007.

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178 <u>Sediment</u>

The sediment component of the FSM strategy involves mechanical sand augmentation at the upstream end of the AHR to offset a sediment deficit from clear water hydropower returns at the J-2 return



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181 facility near Lexington, NE (see Figure 1). The average annual sediment deficit is greatest in the south channel of the river immediately downstream of the J-2 Return. The deficit decreases in the downstream 182 direction with approximately the lower half of the reach (downstream of Minden) in dynamic equilibrium.<sup>1</sup> 183 There are no major tributary inputs of sediment in the AHR. Accordingly, the deficit is made up by erosion 184 of channel bed and bank materials (Holburn et al. 2006, Murphy et al. 2006, HDR Engineering Inc. 2011). 185 The long-term average annual sediment deficit in the AHR is on the order of  $150,000 \text{ tons}^2$  with 186 the majority of the deficit occurring during high-discharge years (The Flatwater Group Inc. 2010, HDR 187 188 Engineering Inc. 2011). Sediment augmentation efforts began in 2006 as part of channel widening activities by NPPD at the Cottonwood Ranch property in the Overton to Elm Creek bridge segment. The Program 189

has since expanded those efforts including the addition of a second augmentation site upstream of the

191 Overton Bridge (Table 3).

192

<sup>&</sup>lt;sup>1</sup> Holburn et al. (2006) concluded that the AHR channel transitioned from degrading to stable near RM 202 near Gibbon based on repeat transect surveys. Murphy et al. (2006) concluded that the AHR channel transitioned from degrading to stable downstram of RM 202.2 near Gibbon based on sediment transport modeling. HDR Engineering Inc. (2011) HEC-6T modeling indicated that predicted changes in bed elevation stabilized (IE no more degradational trend) near RM 2010 at Minden.

<sup>&</sup>lt;sup>2</sup> The mean annual sediment deficit was originally estimated to be on the order of 185,000 tons by the Bureau of Reclamation using the SedVeg model (Murphy et al. 2006). The Program subsequently funded the development of a HEC-6T sediment transport model to update sediment deficit predictions and facilitate the evaluation of sediment augmentation alternatives (HDR Inc. 2011). That modeling effort produced a slightly lower mean deficit estimate on the order of 150,000 tons (The Flatwater Group Inc. 2010). As discussed in HDR Inc. (2011), the deficit appears to be highly viable from year to year with the highest deficits occurring during high flow years.

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Table 3. Total annual discharge, sediment load, and sediment augmentation by water year. Sediment loads
 from Program system-scale geomorphology monitoring.

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Water	Total Annual Discharge at Overton	Sediment Augmented	Total Sediment Load at Overton	Total Sediment Load at Kearney	Total Sediment Load at Shelton	Total Sediment Load at Grand Island
Year	(Acre-ft)	(tons)	(tons)	(tons)	(tons)	(tons)
2006	272,032	15,570				
2007	569,912	21,875				
2008	525,025	42,500				
2009	585,994	50,000	200,000	207,300	214,900	281,500
2010	1,377,665	50,000	613,000	730,000	719,000	877,000
2011	2,691,194	50,000	1,424,000	1,728,000	1,467,000	2,011,000
2012	1,247,736	0	567,000	641,000	495,000	713,000
2013	638,733	182,000	255,200	268,700	165,700	209,700

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The Program began conducting annual system-scale geomorphology and vegetation monitoring in 2009. Analysis of transect survey and sediment transport measurement data (Tetra Tech Inc. 2014) for the period of 2009-2013 strongly indicates that the portion of the reach upstream from Kearney was degradational during that period, with an average annual sand deficit in the range of 100,000 tons. Tetra Tech Inc. (2014) considered both survey and model results and concluded that the portion of the reach downstream from Kearney was most likely aggradational. However, given potentially contradictory lines of evidence, Tetra Tech Inc. (2014) indicated that this conclusion was only weakly supported by the data.

204 <u>*Flow*</u>

The FSM strategy was developed in the midst of historic drought conditions in the Platte River basin (Freeman 2010). During the period of 2000 – 2006, mean annual discharge at Grand Island was 45% of the long-term (1942-2011) mean of 1,150,000 acre-ft. High flows were also largely absent during most of the Program negotiations. The median annual peak discharge during the 2000 – 2006 period was 2,080 cfs, which was less than 30% of the long term median of 7,100 cfs. Within the context of drought, the AMP

- envisioned the need for controlled high flow releases of at least 5,000 cfs on a near-annual basis beginning
  in the first year of Program implementation to test flow-related hypotheses (Program 2006).
- To date, the Program has implemented two high flow releases. The first, in 2009, was intended to be a test of flow routing capabilities and achieved a peak discharge of 3,600 cfs (Program and USFWS 2009). The second flow release in the spring of 2013 achieved a peak discharge of 3,800 cfs. Persistent channel conveyance limitations upstream of the AHR continue to limit the Program's ability to generate flow release magnitudes in the 5,000 to 8,000 cfs range.

However, the easing of basin drought and subsequent river discharge recovery coincident with 217 Program inception in 2007 has provided natural high flows of similar magnitude and greater duration than 218 219 contemplated in the AMP. During the first seven years of Program implementation (2007-2013) mean annual discharge more than doubled (521,000 ac-ft to 1,240,000 ac-ft) and the three-day mean annual peak 220 discharge at Grand Island exceeded 5,000 cfs in five out of seven years and 8,000 cfs in four out of seven 221 years (Figure 4; Table 4). Overall, the shift in basin hydrology has resulted in a seven-year period (2007-222 223 2013) with peak flow frequency, magnitude, and duration that significantly exceed what could have been 224 achieved during the 2000-2006 period under full FSM implementation.



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Figure 4. Comparison of mean daily discharge for periods of 2000 – 2006 and 2007-2013 at Grand Island (USGS Gage 06770500) including identification of Program flow releases in 2009 and 2013.

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Table 4. 2007-2013 annual peak flow event magnitudes, durations and volumes at Grand Island (USGS Gage 06770500) in relation to the Short-Duration High Flow management action performance criteria.

0	,		6	1
	Three-Day Mean			
	Peak Discharge			Total Event Volume*
Year	(cfs)	Days > 5,000 cfs	Days > 8,000 cfs	(acre-ft)
SDHF	5,000 - 8,000	3	0	50,000 - 75,000
2007	5,543	3	0	84,813
2008	10,900	13	5	253,012
2009	3,180	0	0	-
2010	8,540	17	6	535,319
2011	9,883	81	16	3,287,603
2012	3,183	0	0	-
2013	9,167	9	6	245,871
. ~	<u> </u>			

\*Cumulative flow volume for consecutive days of discharge greater than 2,000 cfs.

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235	The overall status of FSM management action implementation during the first seven years of Program
236	is as follows:

Flow – peak discharges exceeding minimum SDHF magnitude and duration occurred in five out of
 seven years (2007, 2008, 2010, 2011 and 2013) at Grand Island.

- Sediment Augmentation occurred in six out of seven years. Water year augmentation volumes in years when sediment was augmented, ranged from 21,875 tons to 182,000 tons. The upper half of the reach was in sediment deficit and the lower half was likely aggradational, although that conclusion appears to only be weakly supported by the data.
- Mechanical Flow consolidation was abandoned as an un-implementable management action.
   Various combinations of mechanical vegetation removal from banks and islands, island lowering,
   channel widening, and in-channel disking were ongoing in 47% of the AHR during the first seven
   years of Program implementation.
- 247

# 248 Evaluate – Effectiveness Monitoring

The Program's fundamental sandbar performance criterion is mid-channel bars greater than 0.25 249 250 acres in size and greater than 1.5 ft above river stage at 1,200 cfs. The bars must also be less than 25% vegetated, occur in channels greater than 400 ft wide, and be greater than 200 ft from predator perches 251 (Program 2012). These criteria represent the minimums thought necessary for initiation of in-channel 252 nesting in the AHR. Sandbar height is hypothesized to respond to a single flow event (Program 2006). 253 Therefore, physical channel response data collected by the Program in areas of sediment balance (at a 254 minimum) should be useful in testing the ability of FSM management strategy to provide the hypothesized 255 beneficial effects. 256



257 The Program conducts an annual habitat availability analysis to calculate the total acreage of inchannel habitat that conforms to the minimum habitat suitability criteria (Rainwater Basin Joint Venture 258 2013). The analysis is Geographic Information System (GIS) based and utilizes annual aerial imagery and 259 topographic (LiDAR) data in conjunction with stage-discharge relationships from the system-scale HEC 260 Geo-RAS model. During the 2007-2013 nesting seasons, total sandbar area in the AHR conforming to the 261 minimum criteria ranged from 0 to approximately 55 acres (Table 5). Conforming acres prior to 2013 were 262 mechanically created and maintained by other conservation organizations that own property in the AHR. 263 Total acreage was highest in 2007. Subsequent high flows in 2008, 2010 and 2011 eroded most of the 264 mechanically created bars and did not produce natural sandbars that met the minimum criteria. In the fall 265 of 2012, the Program constructed 55 acres of sandbar habitat that was available during the 2013 nesting 266 season. The 2013 habitat availability assessment is pending so the number acres conformed to the 267 Program's minimum habitat suitability criteria are currently unknown. 268

Table 5. Available sandbar nesting area conforming to Program minimum suitability criteria by year and type.

Year	Natural Sandbars(Ac)	Constructed Sandbars (Ac)
2007	0	24.4*
2008	0	20.5
2009	0	15.3
2010	0	5.2
2011	0	4.7
2012	0	0.0
2013	0	55.0**

\*No topographic data available for 2007 so all constructed sandbar acres included as suitable
 \*\*2013 assessment not complete. All constructed sandbar acres included as suitable.

273 *Evaluate – Validation Monitoring* 

The Program implements annual habitat selection and productivity monitoring in the AHR (Program 2010a). From 2007-2013, least tern in-channel nest counts ranged from 0 to 20 nests and piping plover inchannel nest counts ranged from 0 to 13 nests (Table 6). In 2007, two least tern nests and one piping plover brood was observed on a low sandbar that had been cleared of vegetation the previous fall and overtopped



in the spring but not mobilized. In 2012, one piping plover nest was observed on a sandbar that had been cleared of vegetation in 2010 and overtopped by flow in 2011 but not mobilized. These habitats could reasonably be characterized as either natural or managed. All other in-channel nests occurred on bars specifically constructed and maintained as nesting habitat.

		Least Tern		Piping Plover			
Year	Total Nests	Successful Nests	Fledglings	Total Nests	Successful Nests	Fledglings	
2007	13	2	2	4	2	7	
2008	20	7	9	5	1	3	
2009	8	5	4	2	1	1	
2010	0	0	0	11	4	10	
2011	0	0	0	0	0	0	
2012	0	0	0	1	1	4	
2013	0	0	0	0	0	0	
Total	41	14	15	23	9	25	

Table 6. Least tern and piping plover in-channel nesting incidence and productivity by year, 2007-2013.

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With the exception of piping plover in 2010, in-channel nest counts during the period of 2007-2013 284 generally trended downward in parallel with the reduction in availability of suitable habitat (Table 5). In 285 2013, a significant amount of newly-created mechanical habitat was available but there was no species 286 response which was likely due to extremely low discharges during the species nest initiation periods which 287 288 reduced the suitability of in-channel habitat (Baasch 2014). During the same period (2007-2013), offchannel nest counts in the AHR were stable to increasing (Table 7). This is an indication that reduction of 289 in-channel nesting incidence is more likely associated with a decrease in habitat availability than other 290 factors that may influence the overall species sub-populations utilizing the AHR. 291

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-						
	Least Tern			Piping Plover		
Year	Total Nests	Successful Nests	Fledglings	Total Nests	Successful Nests	Fledglings
2007	40	20	38	23	13	18
2008	44	20	35	16	7	7
2009	52	31	42	13	8	11
2010	80	44	64	22	18	36
2011	90	53	89	34	27	45
2012	88	63	84	45	31	55
2013	95	51	64	31	23	28
Total	489	282	416	184	127	200

203	Table 7	Least tern and	nining nlove	r off-channe	l nesting ind	cidence hv ve	ar 2007-2013
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# 295 Evaluate – Synthesis

The scale of flow, sediment, and mechanical management actions and natural analogs during 2007-296 2013 appear to have met or exceeded implementation objectives for the First Increment in at least a portion 297 of the AHR. Specifically, fully consolidated portions of the AHR downstream of Kearney. During this same 298 299 period, the Program monitored physical and biological response to these actions through IMRP activities. Accordingly, data generated from implementation of the IMRP should be useful in evaluating the 300 hypothesis that the FSM strategy will create suitable in-channel nesting habitat and increase the productivity 301 of least terns and piping plovers. During this period, nesting incidence and production declined on in-302 channel habitat as constructed nesting islands were eroded away by high flow events. With the exception 303 of one sandbar that was disked to remove vegetation, was subsequently overtopped by flow and a piping 304 plover nested on it, sandbars created by flow events in 2008, 2010 and 2011 were not used by the species 305 and no sandbars created by the flow events met the Program's minimum suitability criteria. 306

To date, the FSM implementation objective with the highest level of associated uncertainty has been the concept of sediment balance and the potential effects of deficit conditions on sandbar habitat. Sandbars are present in the AHR following peak flow events (n=1,263 in the downstream half of the reach in 2010; Chapter 3). Accordingly, the limiting factor in relation to tern and plover habitat suitability has not been the absence of sandbars, it has been sandbar height. Specifically, stage increase during peak

flow events (in relation to maximum sandbar heights) does not appear to have been sufficient to produce bars high enough to be suitable for nesting and/or are safe from inundation (see Chapters 3 and 5).

There appears to be little literature that addresses the relationship between sediment supply (degradation vs. aggradation) and sandbar height other than Germanoski and Schumms' (1993) investigation of changes in braided river morphology under aggrading and degrading conditions. That investigation indicated a temporary increase in sandbar heights as channel incision around bar forms decreased water surface elevations relative to those forms. In short, no evidence was found to support reduced sandbar heights under conditions of sediment deficit.

We also reviewed the Chen et al. (1999) analysis of channel gradation trends in Nebraska as 320 another avenue for evaluation of the potential effects of sediment balance on the presence/absence of 321 suitable sandbar nesting habitat. That investigation found the Platte River at Odessa stream gage 322 (upstream portion of the AHR) to be degrading at a rate of approximately 0.1 m per decade. The lower 323 Platte River at the Louisville gage was degrading at a rate of 0.1 m per decade and the Niobrara River at 324 Spencer was degrading at a rate of 0.4 m per decade prior to gage discontinuation in the late 1960s. Large 325 areas of sandbar habitat are present and the target species nest at much higher levels in both of these 326 reaches than in the AHR. Accordingly, we have little confidence that completely offsetting the sediment 327 deficit in the AHR during the period of 2009-2013 would have substantially changed observed sandbar 328 329 characteristics resulting in the formation of suitable sandbar habitat.

Overall, the decline of in-channel habitat meeting minimum suitability criteria and associated decline in-channel nest incidence appear to be strong indicators that the FSM management strategy, as currently conceived, will not produce the suitable nesting habitat necessary to improve in-channel productivity of least tern and piping plover from the AHR. Given the disparity between hypothesized

beneficial effects and habitat observations, a detailed evaluation of hypothesis assumptions is warranted
 and has been included as Chapter 3.

336 Adjust

The ultimate utility of the data analyses contained in this series of chapters is two-fold: 1) 337 synthesize multiple lines of evidence into a "weight of evidence" approach for addressing priority 338 hypotheses contained in the Program's AMP and 2) provide scientific information useful to the GC for 339 Program decision-making. The following chapters delve into the relationships between channel 340 341 characteristics, flow, and the results of Program management actions and natural analogs related to these relationships. Once subjected to the Program's rigorous internal peer review process, these syntheses will 342 be used as reference material to write the annual State of the Platte Report and assess what is noted as Big 343 Question #1 – will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an 344 annual or near-annual basis (Program 2012, 2014)? After peer review, if this question is answered 345 conclusively in the negative, the GC will be apprised of alternative management actions that could be taken 346 and will have to decide how to allocate Program land, water and financial resources accordingly. At that 347 point, the Platte River Recovery Implementation Program may likely be the first large-scale adaptive 348 management program in the country to successfully complete one full loop of the adaptive management 349 process. 350

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# CHAPTER 3 – Evaluation of Assumptions Used to Infer the Ability of Short-Duration High Flow Releases to Create Suitably-High Least Tern and Piping Plover Nesting Habitat

4 Abstract

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Analyses of the ability of Short-Duration High Flow (SDHF) releases to create suitably-high 5 nesting habitat for least terns and piping plovers assumed that sandbars build to the peak flow stage during 6 7 high flow events. The Platte River Recovery Implementation Program measured sandbar heights following natural high flow events in 2010, 2011, and 2013. Sandbar height-area relationships following the 2010 8 event appear to provide the most conservative (high) estimate of sandbar height potential. Observed mean 9 sandbar heights following that event were on the order of 1.5 feet below the peak flow stage. At that height, 10 sandbars produced by an SDHF release would typically not meet the Program's minimum sandbar height 11 suitability criterion for interior least tern and piping plover nest initiation and would likely be inundated 12 during the nesting season in most years. 13

# 14 Introduction

The Platte River Recovery Implementation Program (Program) is responsible for implementing certain aspects of the endangered interior least tern (*Sterna antillarum athalassos*; hereafter, least tern) and threatened piping plover (*Charadrius melodus*) recovery plans. More specifically, the Program's management objective is to increase productivity (nesting pairs and fledge ratios) of the least tern and piping plover from the Associated Habitat Reach (AHR) of the Platte River in central Nebraska. This ninety-mile reach extends from Lexington, Nebraska (NE) downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and one half miles of the river (Figure 1).

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Figure 1. Associated Habitat Reach of the central Platte River extending from Lexington downstream to
 Chapman, NE.

During the First Increment of the Program (2007-2019), stakeholders have committed to working 26 toward this management objective by acquiring and managing 10,000 acres of land and 130,000-150,000 27 acre-ft of water to benefit the species. However, there has been significant disagreement about species' 28 habitat requirements and the appropriate strategy for managing the Program's land and water resources 29 (Freeman 2010). In order to reach consensus for Program implementation, stakeholders agreed to treat 30 disagreements as uncertainties to be evaluated within a science-based adaptive management framework. 31 32 The result is an Adaptive Management Plan (AMP) designed to test competing management strategies 33 (Program 2006).

- One management strategy is the Flow-Sediment-Mechanical (FSM) approach. This approach focuses on the creation and maintenance of in-channel habitat for the species though flow and sediment management. Proposed actions include:
- 1) vegetation clearing and channel widening (Mechanical),
- 38 2) offsetting the average annual sediment deficit of approximately 150,000 tons in the west half
  39 of the AHR through augmentation of sand (Sediment), and



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implementation of short-duration high flows of 5,000 to 8,000 cfs for three days (Flow) to scour vegetation and build sandbars to a height suitable for nesting.

The primary physical process driver of the FSM management strategy is the implementation of short-duration high flows (SDHF) of 5,000 to 8,000 cfs for three days on a near annual basis. Implementation of SDHF is intended to increase the magnitude of peak flows (indexed by the  $Q_{1.5}$  flow; the peak flow exceeded in two out of three years) from approximately 4,000 cfs to 5,000 – 8,000 cfs. Total release volumes on the order of 50,000 to 75,000 acre-ft are necessary to achieve full SDHF magnitude and duration due to reservoir release ramping constraints and flow attenuation.

The programmatic Environmental Impact Statement (EIS) analyses of the potential benefits of the 48 FSM strategy assumed that sandbars build to the water surface during peak flow events in areas of sediment 49 balance (DOI 2006, USFWS 2006). Consequently, the modeled increase in Q<sub>1.5</sub> stage of 30% to 50% from 50 existing conditions was used as an indicator that SDHF releases would increase maximum sandbar heights 51 by 30% to 50% in reaches with a balanced sediment budget. This assumption is reflected in the X-Y graph 52 for detailed hypothesis Flow #1 in the Program's AMP (Figure 2). The detailed hypothesis is linked to 53 54 Broad Hypothesis PP-1, which introduces the concept of SDHF producing suitably-high nesting habitat for least terns and piping plovers (Figure 2). The EIS stressed the fact that the Q<sub>1.5</sub> stage was used solely as an 55 index of sandbar height and was not linked directly to actual sandbars or nest sites. A monitoring program 56 was determined to be necessary to evaluate the ability of flows to build sandbars of suitable height for 57 nesting (USFWS 2006; pg. 5-113). 58



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# **Broad Hypothesis PP-1 (Part 1):**

Flows of 5,000 to 8,000 cfs magnitude in the habitat reach for a duration of three days at Overton on an annual or near-annual basis will build sand bars to an elevation suitable for least tern and piping plover habitat.

Alternative Hypothesis PP-1 (Part 1):

Flow magnitudes and channel compilations are insufficient to generate bars high enough to provide habitat for LT and PP.

# **Detailed Hypothesis Flow #1**

Increasing the variation between river stage at peak (indexed by Q1.5 flow at Overton) and average flows (1,200 cfs index flow), by increasing the stage of the peak (1.5-yr) flow through Program flows, will increase the height of sand bars between Overton and Chapman by 30% to 50% from existing conditions.





Figure 2. Broad hypothesis PP-1 and priority hypothesis Flow #1 (and associated X-Y graph) from the
 Platte River Recovery Implementation Program Adaptive Management Plan (Program 2006).

62	Although the concept of suitability was included in hypothesis PP-1, no performance criteria were
63	defined beyond the general objective of creating and maintaining ten (10) acres of habitat per river mile
64	(Program 2006). The Program attempted to address the lack of a descriptive definition of suitable habitat
65	by convening a workshop of stakeholders and species experts in 2009 to establish minimum suitability
66	criteria for in- and off-channel habitat (Program 2009). The criteria were developed based on professional
67	judgment and a limited body of published nest site selection data for the AHR (Table 1). The Program's
68	minimum suitability criteria represent minimum conditions deemed necessary for nest initiation. The
69	frequency of habitat availability for nesting and/or risk of inundation at the minimums were determined to
70	be important for achieving the species' management objectives, but were not incorporated into the criteria.

Table 1. Minimum in-channel habitat suitability criteria for least tern and piping plover in the Associated
 Habitat Reach of the central Platte River. Criteria represent minimum conditions thought necessary for nest
 initiation on in-channel habitats.

Criterion	Value(s)	Rationale		
Sandbar Area	$\geq$ 0.25-acre sandbars of suitable height & $\geq$ 1.5 acres of bare sand per <sup>1</sup> / <sub>4</sub> mile of river	Smallest natural and/or constructed sandbar area in the AHR with observed nesting (Unpublished data).		
Sandbar Height	≥ 1.5 feet above river stage at 1,200 cfs	The discharge (and associated river stage) baseline of 1,200 cfs was selected because it is the USFWS target discharge during summer months under normal hydrologic conditions (Bowman 1994). The height above flow stage criterion of 1.5 feet was selected based on observed Platte River nest heights above river stage in Ziewitz et al. (1992).		
Total Channel Width	$\geq$ 400 feet	Professional opinion of the minimum width necessary to support suitable nesting areas that conformed to the water barrier and predator perch criteria.		
Water Barrier	$\geq$ 50 feet	Professional opinion of minimum width of water necessary to buffer nest sites from shoreline.		
Distance to Predator Perch $\geq 200$ feet		Typical distance observed at on- and off-channel nest locations in the AHR (Unpublished data)		



75 The minimum criteria were based on minimal data with the intent of making refinements over time based on habitat variables collected at in-channel least tern and piping plover nest locations in the AHR. 76 However, since the criteria were developed there has been a decline in availability of in-channel habitat 77 meeting the minimum suitability criteria and a corresponding decrease in species nesting on in-channel 78 habitats despite the occurrence of several natural high flow events that exceeded the SDHF in magnitude 79 and duration (see Chapter 2). The corresponding declines in availability of suitable habitat and species' use 80 support the inferences that the decline in in-channel species use is a result of loss of in-channel habitat, the 81 minimum criteria are generally representative of conditions necessary for selection of in-channel habitat, 82 and flows exceeding SDHF in magnitude and duration did not produce suitable species nesting habitat. 83

This chapter presents an investigation of the assumptions that culminated in the hypotheses that SDHF releases would create suitably-high species nesting habitat. Data from Program hydraulic modeling and observations of sandbar heights relative to peak flow stage are compared to assumed relationships in priority hypothesis Flow #1 (Figure 2). Hypothesis assumptions are then replaced with observed relationships and compared to the minimum suitability criteria to evaluate the hypothesis that SDHF releases will produce suitably-high sandbar habitat for nesting and improve species productivity (Broad Hypothesis PP-1).

# 91 Methods

#### 92 Study Area

This investigation utilizes data collected in the 90 mile AHR of the Platte River in central Nebraska. The AHR is the focus area for the Program and is located at the terminus of major irrigation infrastructure on the Platte River. Flows through the AHR are heavily influenced by irrigation diversions. Up to 75% total annual discharge can consist of clear water hydropower returns that enter the channel at the J-2 hydropower return near Lexington, NE (Figure 1).



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Within the AHR, real-time flow records are collected by the United States Geological Survey (USGS) at gage stations near Lexington, Kearney, and Grand Island, NE (Figure 1). Annual aerial imagery and Light Detection and Ranging (LiDAR) data coverages include all main and side channel areas within the 90 mile reach. Likewise, the Program's system-scale hydraulic model includes the main channel and all side channels or anabranches. Least tern and piping plover use, productivity, and habitat selection monitoring covers all potential in- and off-channel nesting habitat in the AHR.

# 104 Stage-Discharge Relationships

In 2009, the Program retained a contractor to develop a reach-scale 1-dimensional steady flow 105 hydrodynamic model of the Platte River within the AHR (HDR Inc. 2011). The United States Army Corps 106 of Engineers HEC-GeoRAS software was used to develop the model, in part to facilitate the use of model 107 output for GIS analyses. Model geometry was developed using high-resolution (+/- 0.28 ft vertical 108 accuracy) LiDAR data collected in 2009 with cross section spacing at approximately 1,500 ft intervals. 109 Ground surveys conducted during implementation of the Program's system-scale geomorphology and 110 vegetation monitoring protocol (Program 2010) were used to supplement topographic data in the inundated 111 portion of the channel. The split flow optimization feature in HEC-RAS was used to balance flow 112 distribution in split flow reaches. The model was calibrated to stream gage rating curves and water surface 113 elevations at the time of LiDAR data collection and ground surveys. At SDHF-magnitude discharges of 114 5,000 to 8,000 cfs, predicted stage at gage locations calibrated to within approximately 0.25 ft of rating 115 curves (Figure 3). 116



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Figure 3. Comparison of water surface elevations predicted by HEC-RAS and published rating curve for USGS Gage No. 06770200 near Kearney, NE (HDR Inc. 2011).

The steady flow model was run for a series of discharges from 1,200 to 15,000 cfs and stage-121 discharge relationships were exported for each main channel cross section. Cross sections were ranked by 122 total (bank-to-bank) channel width and sections that did not meet the 400 ft minimum width suitability 123 criterion were excluded from the analysis. All remaining stage-discharge relationships (n=278) were then 124 normalized to a stage of 0 ft at 1,200 cfs total river flow and ranked by stage increase from 1,200 to 8,000 125 cfs total river flow. The cross sections with 25<sup>th</sup>, median and 75<sup>th</sup> percentile increases in stage were 126 identified and plotted to demonstrate variability in stage-discharge relationships in the AHR. Stage increase 127 was also plotted for United States Fish and Wildlife Service (USFWS) minimum and target channel widths 128 129 of 750 and 1,200 ft.



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#### 130 Sandbar Height

The Program collected concurrent 6-inch resolution color infrared (CIR) aerial photography and 131 0.7-meter Ground Sample Distance (GSD) LiDAR topography in the fall of 2010 following a natural high 132 flow event that occurred in June. Mean absolute accuracy of the LiDAR laser point surface at ground 133 surveyed control points was 0.0001 ft with a standard deviation of 0.16 ft and a maximum error of 0.32 ft 134 (Aero-Graphics 2010). After acquisition, LiDAR data was processed into a 3-foot bare-earth digital 135 elevation model (DEM). Aerially exposed unvegetated sandbars were visually identified and delineated by 136 137 hand from the aerial photography using ESRI ArcMAP, version 10.1 geographic information system (GIS) program (Figure 4). 138



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Figure 4. Example of mid-channel unvegetated emergent sandbar area delineations from fall 2010 aerial 140 imagery. Discharge at imagery collection was approximately 850 cfs. 141 142

Detailed hypothesis Flow #1 includes the assumption of a balanced sediment budget (Figure 2). As 143 a consequence, the sandbar height analysis area was confined to the lower 58 miles of the AHR (Kearney

- 144
- Chapman) that is considered to be in long-term sediment balance (Holburn et al. 2006, HDR Inc. 2011; 145



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- Chapter 2). Side channels in split flow reaches, which generally do not meet the Program's minimum
  species' habitat width criterion of 400 ft, were also omitted from the analysis.
- The HEC-GeoRAS steady flow model was run at three-day mean peak discharge at Grand Island 148 for the 2010 event (8,200 cfs) and a DEM of the modeled peak water surface elevation was exported to 149 ArcMAP. The three-day mean peak discharge was used to standardize height data to the targeted Program 150 peak-flow release duration. The ArcMAP Raster Calculator was used to calculate the difference between 151 bare earth and water surface elevation DEMs. The resultant 3 foot by 3 foot raster layer was converted to 152 a polygon layer (Raster to Polygon function) and raster cells were dissolved into individual sandbars. The 153 new polygon layer was spatially joined to the height values stored in the original raster layer (the result of 154 the raster calculator) and the area of each sandbar was calculated. 155
- The maximum and mean area-height distributions were then developed for all sandbars (n=1,262) and for sandbars exceeding the Program's minimum individual sandbar size suitability criterion of 0.25 acres (n=120). All references to sandbar height herein refer to height below peak stage, not bar height above the channel bed. It was necessary to calculate sandbar heights relative to peak stage in order to provide a standard datum across the range of stage-discharge variability in the AHR. For example, a mean sandbar height of 3.0 feet above channel bottom could be inundated in narrow reaches and exceed maximum flood stage in wide reaches.
- The results of the 2010 analysis were also qualitatively compared to two other flow events. The first was an extended high flow event that occurred during the summer of 2011 that was produced by historic snowfall in the North Platte basin. The second event occurred in the fall of 2013 and was produced by a historic rainfall event in the South Platte basin. In both cases, the Program collected the data necessary to implement the sandbar height analysis described above. However, the analyses were not completed for reasons discussed later in this document.



#### 169 *Potential for SDHF Release to Produce Suitably-High Sandbars*

The 2010 sandbar area-height distributions were used in conjunction with 750 and 1,200 ft channel stage-discharge relationships to predict mean sandbar stage for sandbars that would be expected to be created through implementation of a full SDHF release (8,000 cfs). Predicted mean sandbar stages were then compared to the Program's minimum habitat suitability criterion to determine if mean sandbar heights exceeded the minimum height criterion of 1.5 ft above 1,200 cfs stage.

Suitability in relation to hydrology was evaluated using stage-discharge relationships, sandbar area-175 height distributions and daily discharge records at Grand Island (USGS Gage No. 06770200) for the post-176 Lake McConaughy period of record (1942 - 2013). Maximum stage was identified in the months of May, 177 June and July and for the entire May-July period for each year. Those stages were compared to the predicted 178 mean SDHF sandbar stage for 750 and 1,200 ft channels to identify the number of years when river stage 179 exceeded sandbar stage during each month as well as during the period as a whole. Hydrology during the 180 remainder of the First Increment and into the future will likely not match what was experienced during the 181 period of 1942-2013; however, that period includes both wet and dry cycles and should provide a general 182 183 indication of suitability over the long-term.

184 **Results** 

# 185 Stage-Discharge Relationships

The X-Y graph for Flow #1 (Figure 2) hypothesizes that an increase in  $Q_{1.5}$  peak flow magnitude from 5,000 cfs to 8,000 cfs through SDHF releases will increase stage variation by 0.4 ft. This stage increase was generated from hydraulic computations in the 1-dimensional SedVeg hydraulic and sediment transport model used in the EIS analysis of Program benefits (Murphy et al. 2006). Stage-discharge relationships in that model do not appear to have been calibrated to measured water surface elevations. Stage-discharge relationships in the Program's calibrated HEC-RAS hydraulic model indicate that the absolute stage

increase is roughly twice what was hypothesized, but the overall percent increase is similar (Table 2; Figure

- 193 5). Accordingly, the absolute increase in sandbar height from 5,000 to 8,000 cfs would be greater than
- 194 hypothesized **if** sandbars build to the peak stage of the formative event.

195 Table 2. Comparison of hypothesized and modeled stage increases from 5,000 to 8,000 cfs.

A		<u> </u>			
				Increase	Increase
	1,200 cfs	5,000 cfs	8,000 cfs	from	from
	Stage	Stage	Stage	5,000 cfs	5,000 cfs
Channel Width	(ft)	(ft)	(ft)	(ft)	(%)
Hypothesis Flow #1	0	0.8	1.2	0.4	50%
HEC-RAS Median	0	1.6	2.4	0.8	50%
HEC-RAS 750 Ft	0	1.6	2.5	0.9	56%
HEC-RAS 1,200 Ft	0	1.2	1.9	0.7	58%

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Figure 5. 25<sup>th</sup> percentile, median and 75<sup>th</sup> percentile HEC-RAS stage-discharge relationships for AHR channels exceeding 400 ft in width. HEC-RAS stage-discharge relationship for 750 ft and 1,200 ft wide channels. Hypothesis Flow 1 stage-discharge relationship. All relationships are normalized to a datum of 0 ft stage at 1,200 cfs.

206 Sandbar Height

# 207 Analysis of 2010 Natural High Flow Event

The sandbar height analysis utilized data collected following a natural high flow event that occurred in June of 2010. The event was similar to SDHF in magnitude with a three-day mean peak discharge of 8,200 cfs at Grand Island (Figure 6). Hydrograph rise and fall rates were also similar, but duration exceeded the SDHF by approximately two weeks. Field observations and aerial imagery acquired during the event indicate the flow magnitude and duration were sufficient to mobilize the bed and build sandbars (Figure 7).



Figure 6. June 2010 natural high flow event hydrograph and example hydrograph for a Short-Duration High Flow release.



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Figure 7. June 2010 aerial imagery at River Mile 206. Submerged mobile sandbars and constructed island habitat are visible in the image. 218

October 2010 imagery was used to identify and delinate unvegetated emergent sanbars created 220 during the 2010 high flow event. The delineation identified 1,263 sandbars in the 58-mile reach from 221 Kearney to Chapman totalling 126.7 acres (ac) or 2.2 ac per river mile (Table 3). Most of the emergent bars 222 were very small; only nine percent (n=120) exceeded the Program's minimum suitability criterion of 0.25 223 ac. The largest sandbar observed was 1.0 ac in size and the total area of bars exceeding the Program's 224 minimum size criterion was 48.1 ac. 225

226 Table 3. 2010 sandbar analysis summary.

Date of LiDAR Acquisition	10/28/2010		
Discharge at LiDAR Acquisition	500 – 1,200 cfs		
Analysis Segment	Kearney - Chapman		
Analysis Segment Length	58 mi		
Number of Sandbars	1,263		
Total Sandbar Area	126.7 ac		
Maximum Sandbar Area	1.0 ac		
Mean Sandbar Area	0.1 ac		
Number of Sandbars $> 0.25$ ac	120		
Total Area Bars $> 0.25$ ac	48.1 ac		
Area of Bars $> 0.25$ ac per River Mile	0.8 ac		
Mean Sandbar Height Below Peak Stage	1.5 ft		
Standard Deviation of Mean	0.5 ft		
Mean Height Difference Mean to Max	0.3 ft		

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The mean height of all sandbars ranged from 0.0 ft to 4.0 ft below peak stage. Mean height of sandbars greater than 0.25 ac in size ranged from 0.2 ft to 2.7 ft below peak stage. Average of mean height for all bars was 1.5 ft below peak (n=1,263; SD=0.5). Average of mean height for bars greater than 0.25 ac was also 1.5 ft below peak (n=120; SD=0.5). The average difference in height from mean bar height to maximum bar height was 0.3 ft. The cumulative distribution of sandbar area and height indicates approximately 70 total acres, including 28 acres of sandbars greater than 0.25 ac in size, had average heights greater than 1.5 ft below the peak stage (Figure 8).



Figure 8. Cumulative distributions of sandbar area below peak stage following the 2010 natural high flow
event.

Detailed hypothesis Flow #1 assumes that sandbars build to the peak flow stage during high flow events producing a 1:1 relationship between stage increase and increase in sandbar height. Bar heights following the 2010 event did not approximate peak flow stage. The mean of average sandbar height observed was 1.5 ft below peak stage which appears to represent a more reasonable estimate of sandbar height potential for habitat analyses. Bar area at the mean height was also well below the stated objective



of 10 ac per river mile. A total of approximately 28 ac or 0.5 ac/mi (meeting the minimum area requirement
of 0.25 ac) exceeded a height of 1.5 ft below peak stage in the 58 mi analysis reach.

# 245 <u>Comparison of Analysis Results with 2011 and 2013 Natural High Flow Event Hydrology and Sandbar</u> 246 <u>Response</u>

In the spring of 2011, the AHR experienced an extended high flow event caused by historic snowfalls in the North Platte basin the previous winter. The three-day mean peak at Grand Island was 9,883 cfs and discharge remained above the minimum SDHF magnitude of 5,000 cfs for more than two months. The peak occurred in late June and discharge declined slowly through the summer months (Figure 9).



Figure 9. 2011 natural high flow event hydrograph and example hydrograph for a Short-Duration High Flow release.

At the time of fall 2011 imagery and LiDAR acquisition, discharge remained elevated at approximately 2,700 cfs. A sandbar delineation identified 20.2 total acres of aerially-exposed unvegetated sandbars in the analysis reach from Kearney to Chapman. This is about 20% of the exposed sandbar area that would have been expected given the median stage-discharge relationship for the reach (Figure 5) and



the sandbar area-height relationship following the 2010 event (Figure 8). The lower than expected sandbar
heights may have been the result of significant reworking of bar surfaces during the slowly descending
recession limb of the hydrograph.

In the fall of 2013, the AHR experienced a much shorter natural high flow event produced by a historic rainfall event in the South Platte basin. The three-day mean peak discharge at Grand Island was 9,166 cfs and event duration at peak was approximately one week (Figure 10). Overall, this event was the most similar to a SDHF release since Program inception in 2007, but was preceded by four months of very low discharge due to drought conditions in the basin. Prior to the flood water reaching the AHR, discharge was less than 50 cfs and most of the channel was covered by annual vegetation and cottonwood seedlings.



Figure 10. 2013 natural high flow event hydrograph and example hydrograph for Short-Duration High Flow release.

Because of the similarity to SDHF, a sandbar area-height analysis was planned using the methodology presented herein. However, visual comparisons of pre- and post-event aerial imagery

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indicated that flow magnitude and duration were not sufficient to mobilize the entire bed and rework the
vegetated sandbars. Instead, the unvegetated thalweg was incised and sediment was deposited on the
vegetated barforms (Figure 11). Consequently, the fall event was not included in the analysis.



Figure 11. Comparison of bedforms at River Mile 204 before and immediately following the fall 2013 natural high flow event. The high-flow even degraded the unvegetated thalweg and deposited sediment on existing vegetated sandbars.



- 281 Potential for SDHF to Produce Suitably-High Sandbars
- Sandbar Height in Relation to the Program's Minimum Height Suitability Criterion 282

283 Broad Hypothesis PP-1 hypothesizes that SDHF releases will produce suitably high sandbar nesting habitat. The Program's minimum suitability criterion for sandbar height is 1.5 ft above the 1,200 cfs stage. 284 Based on previously discussed stage discharge relationships and average sandbar height of 1.5 ft below 285 peak stage, a full SDHF magnitude release of 8,000 cfs would be expected to produce mean sandbar heights 286 of approximately 1.0 ft above 1,200 cfs stage in 750 ft channels and 0.4 ft above 1,200 cfs stage in 1,200 ft 287 channels (Figure 12). Predicted mean bar heights at both the minimum (750 ft) and maximum (1,200 ft) 288 channel width targets are somewhat below the minimum suitability criterion. 289



<sup>290</sup> 291

Figure 12. Stage-discharge and mean sandbar height relationships in comparison to the Program's minimum height suitability criterion of 1.5 ft above 1,200 cfs stage. The extrapolated sandbar height 1.5 ft 292 below peak stage is based on observations following the 2010 high flow event. 293

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#### 294 Inundation Risk

The Program's minimum sandbar height criterion was intended to characterize the conditions necessary for selection of in-channel habitat. As such, the criterion does not address the potential for nest and chick inundation during the nesting season. In the AHR, the least tern and piping plover nesting period typically includes the months of May, June and July. Inundation of sandbar nesting habitat during that period would likely result in nest and chick mortality. Consequently, frequency of inundation is a good indicator of habitat suitability.

At a full SDHF magnitude of 8,000 cfs and mean sandbar heights of 1.5 ft below peak stage, discharges of approximately 2,900 cfs and 2,300 cfs would be predicted to inundate the mean sandbar stage in 750 and 1,200 ft channels, respectively. During the period of 1942-2013, these discharges were exceeded during the nesting season in approximately 67% of years in 750 ft channels and 76% of years in 1,200 ft channels (Table 4).

	Mean SDHF	Discharge at Mean SDHF	Percent of Years Discharge Exc (1942-2013)			ge Exceeded
	Sandbar	Sandbar				
Channel	Stage	Stage				
Width	(ft)	(cfs)	May	June	July	May - July
750 Ft	0.9	2,960	46%	50%	36%	67%
1,200 Ft	0.4	2,320	58%	57%	46%	76%

306	Table 4. Discharge	exceedance at mean	SDHF sandbar	stage for the	period of	f 1942-2013
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## 308 Discussion

Hypothesis Flow#1 was based on stage-discharge relationships from a numerical model (SedVeg) and assumed that sandbars build to the peak water surface during high flow events. The increase in peak flow stage (5,000 cfs to 8,000 cfs) based on the calibrated Program hydraulic model was found to be greater than hypothesized but the percent increase similar to hypothesized (Table 2). However, sandbar height 5

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observations do not support the assumption that sandbars build to the peak water surface during high flow events. Mean observed sandbar heights following a 2010 flow event were on the order of 1.5 ft below peak stage. Sandbar heights following a 2011 high flow event were lower than 2010 and a high flow event in 2013 did not mobilize the bed sufficiently to create new sandbars. Based on observations following these events, 1.5 ft below peak stage appears to be a more reasonable (and potentially conservatively-high) approximation of sandbar height potential for the purpose of Program modeling and predictive analyses.

Given mean sandbar heights of 1.5 ft below peak stage, implementation of SDHF releases would 319 320 be expected to produce very little sandbar area exceeding the Program's minimum height suitability criterion, which represents the minimum conditions thought necessary for nest initiation. If nests were 321 initiated on sandbars created as a result of SDHF releases, they would likely be inundated during the nesting 322 season in many years. Flow releases of greater magnitude than SDHF would likely increase the potential 323 to produce sandbars meeting the minimum height criterion. Based on the stage-discharge and mean sandbar 324 325 height relationships in Figure 12, discharges of 11,000 to 15,000 cfs are predicted to be necessary to increase mean bar height to the minimum criterion in 750 - 1,200 ft channels. To date, the Program has not 326 contemplated peak flow releases of this magnitude. 327

As previously discussed, the sandbar height-area distribution used in this analysis was derived from 328 a single natural high flow event that was similar in magnitude to a SDHF release, but was two weeks longer 329 in duration. The reliance on a single flow event is an obvious limitation of the analysis given that event 330 magnitude, duration and hydrograph shape may all influence sandbar area-height distributions in the AHR. 331 However, we believe that use of observed heights from even one event facilitates the development of more 332 realistic and defensible predictions of the potential for species productivity than the assumption that bars 333 334 build to the peak flow stage. Sandbar monitoring efforts will continue and analyses of bar heights following future flow releases and natural flow events will be used to refine the Program's understanding of sandbar 335 height potential in the AHR over the remainder of the First Increment of the Program. 336



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## CHAPTER 4 – A Meta-Analysis of the Relationship between Least Tern and Piping Plover Nest Incidence and Channel Width in Nebraska

4 Abstract

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A meta-analysis was performed to examine the relationship between least tern and piping plover 5 nesting colony incidence and channel width in several Nebraska river segments used by the species. Results 6 7 indicate that species width selection may be similar across analysis segments located in the lower Platte, Niobrara, and Loup Rivers. The probability of nesting colony incidence increased with increasing channel 8 width so long as channels were not broken by vegetated islands. In channels broken by vegetated islands, 9 probability of nesting colony incidence was low and did not increase with increasing channel width. 10 Approximately ninety percent of channel widths at lower Platte and Niobrara tern and plover nesting colony 11 locations exceeded 1,200 ft, which is much wider than the Program's minimum habitat suitability criterion 12 of 400 ft. An increase in the Program's minimum width criterion and focusing sandbar height suitability 13 analyses toward unvegetated channels on the order of 1,200 ft wide may be warranted. 14

## 15 Introduction

The Platte River Recovery Implementation Program (Program) is responsible for implementing certain aspects of the endangered interior least tern (*Sterna antillarum athalassos*; hereafter, least tern) and threatened piping plover (*Charadrius melodus*) recovery plans. More specifically, the Program's management objective is to increase productivity of the least tern and piping plover from the Associated Habitat Reach (AHR) of the Platte River in central Nebraska. This ninety-mile reach extends from Lexington, NE downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and one half miles of the river (Figure 1).

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Figure 1. Associated Habitat Reach of the central Platte River extending from Lexington downstream to Chapman, NE.

During the First Increment of the Program (2007-2019), stakeholders have committed to working toward this management objective by acquiring and managing 10,000 acres of land and 130,000-150,000 acre-ft of water to benefit the species. However, there has been significant disagreement about species' habitat requirements and the appropriate strategy for managing the Program's land and water resources (Freeman 2010). In order to reach consensus for Program implementation, stakeholders agreed to treat disagreements as uncertainties to be evaluated within an adaptive management framework. The result is an Adaptive Management Plan (AMP) designed to test competing management strategies (Program 2006).

One management strategy is the Flow-Sediment-Mechanical (FSM) approach. This approach focuses on the creation and maintenance of in-channel habitat for the species though flow and sediment management actions. Proposed actions include:

- 1) vegetation clearing and channel widening (Mechanical),
- offsetting the average annual sediment deficit of approximately 150,000 tons in the west half
   of the AHR through augmentation of sand (Sediment), and



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implementation of short-duration high flows of 5,000 to 8,000 cfs for three days (Flow) to scour vegetation and build sandbars to a height suitable for nesting.

The primary physical process driver of the FSM management strategy is the implementation of short-duration high flows (SDHF) of 5,000 to 8,000 cfs for three days on a near annual basis. Implementation of SDHF is intended to increase the magnitude of peak flows (indexed by the  $Q_{1.5}$  flow; the peak flow exceeded in two out of three years) from approximately 4,000 cfs to 5,000 – 8,000 cfs. Total release volumes on the order of 50,000 to 75,000 acre-ft are necessary to achieve full SDHF magnitude and duration due to reservoir release ramping constraints and flow attenuation.

The programmatic Environmental Impact Statement (EIS) analyses of the potential benefits of the FSM strategy was focused on the ability of SDHF release to produce suitably-high sandbars for nesting (DOI 2006, USFWS 2006). However, United States Fish and Wildlife Service (USFWS) comments on recent observational studies of sandbar height relationships (EG Chapter 3) indicate a concern that too heavy of an emphasis was placed on sandbar height. The USFWS expressed the view that habitat selection is primarily a function of channel width with the species selecting for wide channels.

The USFWS noted several investigators have identified channel width as a potentially important variable for least tern and piping plover nest initiation in the Platte River system. Ziewitz et al. (1992) performed a habitat selection analysis for 40 nest sites that defined average channel width as the area of a ¼-mile channel segment free of permanent vegetation divided by the length of the segment. Their analysis indicated that mean width, as defined above, at central Platte River (CPR; n=6) and lower Platte River (LPR; n=34) nest sites was significantly greater than mean width at systematic sample of locations (CPR: 968 ft vs. 659 ft, LPR: 1,702 ft vs. 1,410 ft).

Elliott (2011) performed a geomorphic classification of the lower segment of the Platte River below
 the Loup River confluence and evaluated species nest occurrence in relation to geomorphic groupings. The
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classification defined total channel width as the distance between left and right channel banks including
permanently vegetated islands. Elliott found that tern and plover nest sites in 2006–2008 (n=265) occurred
disproportionally in narrower reaches without permanently vegetated islands leading to the conclusion that,
"narrow channels have sufficient transport capacity to maintain sandbars under recent (2006) flow regimes
and likely are the most amenable to maintaining tern and plover habitat in the Lower Platte River."

Jorgensen et al. (2012) investigated the relationship between channel width and nest site incidence 68 in the LPR using a transect-based logistic regression approach. Jorgensen et al. defined width as the distance 69 between left and right channel banks, but treated channel segments split by vegetated islands as separate 70 channels. For example, a 1,200 ft channel split in the middle by a 200 ft wide vegetated mid-channel island 71 would be treated as two 500 ft channels. The analysis found a strong relationship between nesting site 72 incidence (n=64) and channel width. The modeled probability of presence of nesting sites was low (<0.03) 73 when channel widths were  $\leq 1,072$  ft and increased sharply as channel width increased. Model results 74 indicated that 2,000 ft wide channels had a probability of nesting site presence exceeding 0.80. 75

Each of the three cited investigations had unique objectives and employed a different definition of 76 channel width (Figure 1) which influenced the authors' methods and interpretations of analysis results. In 77 Ziewitz et al. (1992), mean channel widths were area-based and excluded permanently vegetated islands 78 from the calculation and the authors concluded the species used wide channels with large areas of dry, bare 79 sand. Elliott (2011) included vegetated islands in channel width calculations and concluded narrower 80 channels, with less potential for occurrence of vegetated islands, were more suitable for tern and plover 81 82 nesting. Jorgensen et al. (2012) separated river segments with vegetated islands into multiple channel measurements and found that the probability of nesting increased sharply with increasing channel width 83 and the species did not use anabranch (side) channels. These differences made it difficult for the EDO to 84 conclude with confidence these three analyses collectively point to species selection for wide channels. In 85



- 86 addition these three analyses did not explicitly incorporate the presence or absence of islands suitable of
- nesting at nonuse and use locations (although presence of an island is implied by use), which limits the 87
- inference that can be drawn from such studies (see Discussion). 88



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In order to collectively evaluate the findings of these investigations, a transect-based retrospective 94 width analysis similar to Elliott (2011) and Jorgensen et al. (2012) was performed that included multiple 95 width metrics similar to those employed in previous analyses. This provided the opportunity to examine 96 interactions between multiple width metrics. Our analysis was also expanded beyond the Platte River to 97 include segments of the Niobrara and Loup Rivers. This was done to: 1) facilitate channel width 98 comparisons across river systems; 2) to determine if species selection of nest sites in relation to channel 99 width was similar across river systems; and 3) when possible, provide stronger inference from larger and 100 more spatially diverse sources of data. 101

**Methods** 102

Study Location 103

The study included analysis segments from three regional river systems utilized by the species 104 (Figure 2). See Chapter 6 for a more detailed discussion of segment selection. The 40-mile Niobrara River 105

Figure 1. Example of influence of different width definitions on channel width measurements. The 'channel width' in the example ranged from 380 ft to 1,930 ft depending on whether the Jorgensen et al. (2012) or Elliot (2011) definition was used. 92

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segment extended from State Highway 137 downstream to the Spencer Hydropower plant. The 72-mile Loup River segment extended from the confluence of the Middle and North Loup Rivers downstream to the confluence with the Platte River at Columbus. The 103-mile lower Platte River segment extended from the confluence of the Loup River downstream to the Missouri River confluence. The central Platte River segment is the 90-mile Associated Habitat Reach (AHR) extending from Lexington downstream to Chapman.



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Figure 2. Study location map showing analysis segments on the Niobrara, Loup, Associate Habitat Reachof the central Platte River and lower Platte River.

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116 Nest Data

Least tern and piping plover nest data was obtained from several sources. Niobrara River nest locations were provided for the period of 2005-2013 by Jim Jenniges, biologist with the Nebraska Public Power District (personal communication, 2014). Loup River nest locations for the period of 2010-2012 were obtained from USFWS reports (Lackey and Runge 2010, Lackey 2011, 2012). Lower Platte River



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nest locations for the period of 2008-2013 were obtained from joint annual reports produced by the Tern
and Plover Conservation Partnership and Nongame Bird Program of the Nebraska Game and Parks
Commission (Brown and Jorgensen 2008, 2009, and 2010, Brown et al. 2011, 2012, and 2013). Nest and/or
colony locations were generally reported to the nearest 0.1 miles.

Analyses were performed at a colony-scale, that is, locations with  $\geq 1$  nest were treated as a single observation assumed to be located at a single point. This was necessary because nesting data from all segments were reported at this scale. A total of 78 colony locations (all years) were identified in the Niobrara River segment, 16 in the Loup River segment, and 73 in the lower Platte River segment.

## 129 Aerial Imagery

130 Channel widths were estimated from Farm Service Agency (FSA) National Aerial Imagery 131 Program (NAIP) aerial imagery collected during the months of June and July which provided data coverage 132 for all analysis segments. NAIP imagery was not collected annually resulting in the need to occasionally 133 use one imagery dataset for two analysis years (Table 1). This was deemed to be acceptable given Jorgensen 134 et al. (2012) found little change in the area or distribution of permanently-vegetated islands between years. 135 AHR width comparisons were made using 2012 NAIP imagery.

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Table 1. NAIP imagery years used for analysis of channel width metrics and nest incidence. Note AHRwidth comparisons were made using 2012 NAIP imagery.

Nest	NAIP Imagery Year Used for Analysis						
Data Year	Loup River Segment	Lower Platte River Segment	Niobrara River Segment				
2005			2005				
2006			2006				
2007			2007				
2008		2009	2007				
2009		2009	2009				
2010	2010	2010	2010				
2011	2010	2010	2010				
2012	2012	2012	2012				
2013		2012	2012				

138

## 139 *Channel Width Measurements*

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140 Channel width measurements were taken perpendicular to the flow direction at approximately 1,000 ft intervals for each year nesting locations were available (hereafter referred to as "available" 141 locations). Another set of width measurements were taken at each nesting colony location (hereafter 142 referred to as "use" locations). Two width measurements were recorded at each of the use and available 143 locations including 1) total channel width and 2) maximum unvegetated width (Figure 3). Total channel 144 width was calculated as the total distance from left bank to apparent right bank and included permanently 145 vegetated islands. This definition was consistent with the total channel width definition used by Elliott 146 (2011). Maximum unvegetated width was calculated as the longest contiguous unvegetated width from 147 apparent left bank to apparent right bank. This was similar to the Jorgensen et al. (2012) definition of active 148 channel width except that the remaining, shorter unvegetated channel width along individual transects were 149 not included as additional transects. The width measurements were obtained using ESRI ArcMAP 150 geographic information system (GIS) software. Polylines were drawn at each use and available location 151 152 and the XTools utility was used to calculate polyline lengths.

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Figure 3. Examples of total and maximum unvegetated channel width metrics used in our investigation.

# 156 Data assimilation and processing

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A single data set was created by combining the width measurements at use and available locations. 157 A value of zero was assigned to each location a measurement was taken if it was an available location and 158 a one if it was a nesting colony location. The river system was also included to identify each location to the 159 river where the measurements were taken. A covariate called "channel break" was created and was assigned 160 a value of one (1) if the maximum unvegetated width was  $<0.95 \times$  total channel width and zero (0) if the 161 maximum unvegetated width was  $\geq 0.95 \times$  total channel width. Due to slight variability in both 162 measurements, maximum unvegetated width may occasionally be greater than or less than total channel 163 width in places where the channel was free of permanently vegetated mid-channel islands. Using  $0.95 \times$ 164 total channel width as the cutoff for the channel break covariate was done to reduce the sensitivity of the 165 classification to measurement error. The maximum unvegetated width and total channel measurements were 166 obtained from two independent data sets. The channel break covariate was used as an indicator of whether 167 or not the channel was free of permanently vegetated mid-channel islands. Data from the AHR was not 168 included in our analyses described below because of the substantial amount of ongoing mechanical channel 169 maintenance and the effects these actions have on total channel width and the relationships between channel 170 width metrics. IE, the very few sites repeatedly used by the species were those where nesting islands were 171

created. Finally, the assimilated data was split into training and test datasets; approximately 50% of the data
was randomly assigned to the training dataset and 50% to the test dataset.

174 Relationship between total channel width and maximum unvegetated width

The relationship between maximum unvegetated width and total channel width was tested at 175 available locations. Analyses were performed using generalized additive models (gam) assuming a 176 Gaussian (normal) response and a smoothing spline (Hastie and Tibshirani 1990). Generalized additive 177 models are a type of regression models that allows for nonlinear relationships between the response variable 178 (maximum unvegetated width) and a covariate (total channel width). Generalized additive models use a 179 series of polynomials to approximate unknown functional relationships, which made them particularly 180 useful in this case given the theoretical relationship between the variables was unknown. Although gams 181 can be used to model nonlinear relationships when the functional form of the relationship is unknown, 182 particular care needs to be taken so the model does not over fit the data. To ensure over fitting did not occur, 183 the target equivalent degrees of freedom for the smoothing spline were varied in integer values from 1 to 184 5. Additive and interaction effect of river system (Niobrara, Loup, and lower Platte Rivers) were also 185 included to test for an interaction, additive or no effect of river system. This resulted in 15 models to fit 186 using training data. To select the best model, mean square error was calculated for test data and the model 187 that minimized this value was chosen (Hastie et al. 2009). The analysis was conducted using data collected 188 at available locations on the Niobrara, Lower Platte, and Loup Rivers and not within the AHR because of 189 the extensive amount of in-channel management in the AHR segment that substantially influences channel 190 width relationships. 191

## 192 Relationship between nest incidence and total channel width

Logistic regression was used to relate channel metrics to the probability that a location had a nesting
 colony present. Logistic regression is a type of regression model that is appropriate for a dichotomous



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response variable. The purpose of logistic regression is to relate covariates to the probability that the 195 response is one of the two outcomes. For our analysis the response variable was nesting colony locations 196 and available locations. Logistic regression was used to determine the influence of the channel metrics on 197 probability that a location would be a nesting colony location. Eight logistic regression models were 198 developed. Model formulae outlined below include symbols "+" to indicate inclusion of main effects and 199 "\*" to indicate inclusion of main effects and an interaction between main effects. Our eight models 200 included most subsets of the main and interactions effects of river system (Niobrara, Lower Platte, and 201 Loup Rivers), channel break, and total channel width. The eight models were: "channel break \* total 202 channel width \* river system", "channel break \* total channel width + river system", "channel break + total 203 channel width + river system", "channel break \* total channel width", "channel break + total channel 204 width", "channel break", "total channel width" and an intercept only model. We choose to limit the model 205 set in our analysis to the 8 models above, rather than preform an exhaustive search among all combinations 206 and interactions of the covariates (which would have resulted in 27 models) because some models in this 207 expanded set were not meaningful to management (e.g., a model with the single effect of "river system") 208 or were not thought to be biologically relevant (e.g., "channel break \* river system"). The logistic regression 209 models were fit to the training data set. The probability of nesting incidence for each observation in the test 210 data was then predicted using the eight logistic regression models. The predicted probability of nesting and 211 the test data set was then used to calculate the predictive deviance (i.e., -2 times the predictive log-212 likelihood). The model with the lowest predictive deviance was selected. 213

214 Application of analysis results to the Associated Habitat Reach

Analysis results were applied to the AHR in two ways. First, logistic regression analysis results were applied to the range of available channel widths in the AHR to predict probability of nest incidence. Second, channel width relationships at use sites in other segments were visually compared to relationships at available locations in the AHR.



#### 219 Results

220 *Relationship between total channel and maximum unvegetated widths* 

The modeled relationship between total channel and maximum unvegetated width (Figure 4) for 221 the lower Platte River segment indicated the majority of channels are consolidated and free of vegetated 222 223 islands (total = max unvegetated) until total channel width exceeded approximately 1,800 ft. At 1,800 ft, the expected maximum unvegetated width began decreasing with increasing total channel width although 224 there was a high degree of variability present in the segment width data. In the lower Platte River segment, 225 channels as narrow as 1,100 ft were broken (i.e., contained vegetated islands) and channels as wide as 2,300 226 ft were fully consolidated (i.e., no vegetated islands; Figure 4). The majority of consolidated channels, 227 228 however, occurred when total channel width was <2,000 ft. The Niobrara River segment was very similar to the lower Platte River (Figure 4). The general relationship in the Loup River segment was similar, but 229 overall total channel widths were much narrower. Most fully-consolidated channels in the Loup River 230 segment occurred when total channel width was <1,200 ft. 231





233

- Figure 4. Relationship between total channel width and maximum unvegetated width for the lower Platte, 234 Niobrara, and Loup River segments. 235
- 236

#### Relationship between nest incidence and channel width 237

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The comparison of channel width and nesting colony incidence in the lower Platte River, Loup River, and Niobrara River segments indicated 69% of nest sites occurred in fully-consolidated channels and 239 70% occurred in channels with a maximum unvegetated width >1,200 ft. The majority (57%) of nest sites 240



- occurred in fully-consolidated channels that were >1,200 ft wide (Figure 5). The widest fully-consolidated
- channels seem to be selected by the species, but channels with the widest total channel widths were not.
- Nests were also rarely (13%) initiated in channels <1,200 ft in width regardless of whether or not they were
- fully consolidated.
- Table 2. Total channel width and maximum unvegetated width statistics at systematic available locations and species nesting colony locations. Bolded values were greater.

TOTAL CHANNEL WIDTH							
	10th Percentile		Median		90th Percentile		
	Available	Use	Available	Use	Available	Use	
Lower Platte	1,138	1,362	1,684	1,760	2,588	2,178	
Niobrara	810	1,281	1,363	1,579	1,974	2,303	
Loup	446	521	746	865	1,276	1,405	
AHR	321		734		1,371		
MAXIMUM UNVEGETATED WIDTH							
	10th F	Percentile	Median		90th Percentile		

	Available	Use	Available	Use	Available	Use
Lower Platte	881	1,107	1,322	1,627	1,798	1,995
Niobrara	520	1,043	1,060	1,415	1,551	1,800
Loup	394	445	661	595	1,044	1,079
AHR	263		541		972	



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Figure 5. Total channel width and maximum unvegetated width at available and species nesting colony locations in the lower Platte River, Niobrara River, and Loup River segments. Note, nesting colony locations are shown for all years. Available locations from only 2012 are shown to simplify visual comparisons.

The logistic regression model with the lowest predictive deviance (highest predictive ability) 254 contained the main effects of total channel width, channel break and the interaction of total channel width 255 and channel break. The probability of nesting increased rapidly as total channel width increased for 256 channels that were unbroken (no vegetated islands). The probability of nesting, however, remained nearly 257 constant as total channel width increased for channels that were broken (Figure 6). Similarly, the highest 258 probabilities of nesting occurred in channels where the total channel width and maximum unvegetated 259 width was ~2000 ft since these were the widest unbroken channels observed (Figure 5). The river segment 260 covariate did not increase the predictive value of the model. 261





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Figure 6. Predicted probability of nesting for channel segments that occur as one continuous unbroken width (red) and broken width (black) for the lower Platte (upper left), Loup (upper right), and Niobrara (lower left) from best-fit model. Note the predicted probability of nesting is only plotted over the range of total channel widths that occurred within each river system. The plus signs show the total channel widths for which nesting sites and available points occurred. Predicted probability of nesting was also plotted for the Associated Habitat Reach (AHR) of the central Platte River segment (lower right) for comparison. Data from central Platte River (AHR) were not used to estimate model parameters.

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## 283 Discussion

The analyses presented herein generally support the assertion that the probability of nest incidence increases with increasing channel width. However, our study did not explicitly incorporate the presence or



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286 absence of sandbars suitable for nesting at nesting and so-called "available" locations. That is, although we know a suitable sandbar was present at each colony nesting location, we do not know if any such bar was 287 present at the available or nonuse locations. The implication is that we cannot determine from our data if 288 colony nest site selection depends on channel width or if terns and plovers choose these sites because 289 suitable sandbars for nesting only occur in wide channels. It is also possible that the presence of nesting 290 colonies is due to some combination of both sandbar forming and habitat selection process that are 291 responsible for the relationship between colony incidence and channel width. This caution of inference, 292 however, is not unique to our study and is also a potential confounding factor in Ziewitz et al. (1992), Elliot 293 (2011) and Jorgensen et al. (2012). 294

The presence of permanently-vegetated islands in channels of any width influenced selection much more strongly than was anticipated. Probability of nesting increased rapidly with increasing total channel width in channels that were fully consolidated, but actually decreased as total channel width increased in channels that were broken by vegetated islands. Major findings included:

Tern and plover channel width selection may be similar in the lower Platte, Niobrara, and Loup River
 segments. More data would be valuable for confirming this finding.

Probability of nest incidence increased with increasing channel width as long as channels were not
 broken by vegetated islands.

303 3. In channels broken by vegetated islands, probability of nest incidence was low and did not increase
 304 with increasing channel width.

4. Approximately ninety percent of total and maximum unvegetated channel widths at lower Platte and
 Niobrara tern and plover nesting colony locations exceeded 1,200 ft. The median total and maximum
 unvegetated channel widths at tern and plover colonies located on the lower Platte and Niobrara Rivers
 exceeded 1,400 ft.

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5. Channel width at nesting colony locations in the lower Platte and Niobrara River segments generally
 exceed available widths in the AHR and Loup segment. As such, the predicted probability of in-channel
 nesting in the AHR and Loup segments was low.

312 Application to Program Management

These findings can be applied to Program analyses and management in three ways. First, as discussed in Chapter 3, the Program's minimum species habitat criterion for channel width is 400 ft. This appears to be low based on the results of this analysis. A minimum criterion of an unbroken (no vegetated islands) width closer to 1,200 ft may be more appropriate based on widths at colony locations in other segments. Very little of the AHR segment currently supports unbroken channel widths exceeding 1,200 ft.

Second, these findings indicate that evaluation of the potential for Program flow releases to create suitably-high sandbar habitat should focus on examination of physical process relationships in channels with widths on the order of 1,200 ft. This will allow the Program to focus sandbar height suitability and inundation risk analyses toward channels with a higher probability of selection given the results of this analysis. Accordingly, Chapter 3 sandbar height and inundation frequency estimates for 1,200 ft channels are likely more representative of conditions at potential colony locations than the 750 ft channel estimates.

Finally, the findings of this analysis may help explain the limited species response to in-channel nesting habitat created and maintained by the Program in the AHR. To date, the Program has constructed in-channel nesting habitat at the Shoemaker Island, Elm Creek, and Cottonwood Ranch habitat complexes. During the 2012–2014 nesting seasons, a total of two piping plover nests were initiated on these constructed islands. The channels were free of permanently vegetated islands; however, the mean of maximum unvegetated width is below 1,000 ft at all complexes.



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380	APPENDIX A – DATA ANALYSIS DOCUMENTATION
381	
382 383	Electronic copies of data, analysis code, and a data analysis tutorial are available to Program participants at:
384 385	https://www.platteriverprogram.org/sites/Intranet/NonPublicProgramLibrary/Chapter%204%20Width%2 0Analysis%20Data%20and%20R%20code.zip
386 387	Others may obtain this data from the Executive Director's Office by emailing Jason Farnsworth at <u>farnsworthj@headwaterscorp.com</u> or by calling (308) 237-5728.



## CHAPTER 5 – An Examination of Platte River Hydrology in Relation to Interior Least Tern and Piping Plover Reproductive Ecology

### 4 Abstract

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John William Hardy's (1957) concept of the physiological adaptation of interior least tern (Sternula 5 antillarum athalassos) to begin nesting concurrent with recession of the spring rise has been embraced in 6 7 Platte River literature and expanded to include the piping plover (*Charadrius melodus*). The distributions of central Platte River species nest initiation dates were examined in relation to the annual hydrograph of 8 the historical central Platte River and contemporary central and lower Platte River. An emergent sandbar 9 habitat model was also developed to evaluate the potential for reproductive success given observed 10 hydrology, stage-discharge relationships, and sandbar height distributions. No evidence was found to 11 suggest that these species are physiologically adapted to begin nesting concurrent with the recession of the 12 late-spring rise on the Platte River. Model results indicate limited potential for piping plover reproductive 13 success due to the timing and length of the nesting and brood rearing period in relation to the timing of the 14 late-spring rise. Least tern success potential is higher due to the shorter nesting and brood rearing duration 15 which increases the likelihood of successful renesting following nest loss during the late-spring rise. A 16 sensitivity analysis of model results indicated that potential for reproductive success was most sensitive to 17 the sandbar height variable. Sandbar heights used in the model were conservatively-high based on 18 observations in the central Platte River since 2010. Additional efforts to define sandbar height relationships 19 would improve the predictive capability of the model. 20

## 21 Introduction

In 1953, John William Hardy conducted a field study of a colony of interior least tern (*Sterna antillarum athalassos*; hereafter, least tern) on the Ohio River in Gallatin County, Illinois. In 1953, the spring rise on the Ohio River began in early May and sandbars did not appear until the second week in June. On 20 June, when he began observing the colony, several active nests were already present. Based on that



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observation and correspondence with other ornithologists, he noted that it was possible that least terns have
gradually undergone a physiological adaption to nest coincident with the cessation of spring floods.
However, he also stated that species knowledge in 1953 was not sufficient to justify such a conclusion
(Hardy 1957).

30	The first investigation of breeding ecology of least tern and piping plover (Charadrius melodus)
31	along the central Platte River in Nebraska was conducted in 1979 (Faanes 1983). Faanes located 17 least
32	tern and 40 piping plover nests on river sandbars. All nests were inundated by rising water on the 21 June
33	at a discharge of 3,000 cfs. Faanes cited Hardy's suggestion of a relationship between nesting and cessation
34	of spring floods and concluded that in 1979 late spring discharge was highly altered because of late Rocky
35	Mountain snowmelt and heavy rainfall. Subsequent Platte River literature embraced Hardy's observation
36	as well, simply stating that least terns begin nesting in the spring after water levels recede and sandbars are
37	exposed (Sidle et al. 1988, Kirsch 1996).

- In 2006, this concept was codified in the United States Fish and Wildlife Service (USFWS) Environmental Impact Statement (EIS) for the Platte River Recovery Implementation Program (Program) and was expanded to include the piping plover (DOI 2006; Pg. 2-9). The text is reproduced below:
- 41

## INTERIOR LEAST TERN AND PIPING PLOVER NESTING FLOWS

Historically, nesting habitat for terns and plovers was created by high spring and early
summer flows that built sandbars and scoured new vegetation from existing sandbars. As
these high spring flows receded, birds began nesting at higher elevations of the sandbars
as they were exposed and began to dry. Nests at these higher elevations were frequently
spared inundation during all but major summer storm events.

- 47 Therefore, the flow requirements for nesting are threefold:
- 48 (1) Flows must be high enough in the spring to shift sediments and create sandbars with49 high elevations.
- 50 (2) Flows must recede early in the nesting season to allow birds to initiate nests at these 51 elevations.



- (3) Flows for the remainder of the nesting season need to recede to avoid inundation of
   nests, while still providing sufficient protection from terrestrial predators, providing habitat
   for fish that are eaten by terns, and supporting insect populations eaten by plovers.
- 55

The relationship between the annual hydrograph and species ecology has been explored and debated in other river systems (Dugger et al. 2002, Jorgensen 2009, Catlin et al. 2010). The objective of this investigation was twofold. The first objective was to examine the timing of the late-spring rise in relation to least tern and piping plover nesting ecology on the historical and contemporary central Platte River and the contemporary lower Platte River. The second objective was to compare and contrast the potential for species productivity in the central and lower Platte River segments given our current understanding of channel hydraulics and sandbar height relationships.

### 63 *Methods*

## 64 Study Area

Two reaches of the Platte River in Nebraska were included in this investigation (Figure 1). The first was a 90 mile Associated Habitat Reach (AHR) in central Nebraska extending from Lexington, Nebraska downstream to Chapman, Nebraska. The second reach was a 33 mile segment extending downstream from the Elkhorn River confluence to the Missouri River near Plattsmouth Nebraska (LPR Reach).



#### 69 70

Figure 1. Map of study area identifying analysis reaches and stream gages.

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The AHR is the focus area for the Program and is located at the terminus of major irrigation infrastructure on the Platte River. Flows through the AHR are heavily influenced by irrigation diversions and returns. The LPR Reach includes the lower segment of the Platte River below the Elkhorn River, another major tributary. The hydrology of the LPR segment differs from the AHR due to the influence of several major tributaries including the Loup and Elkhorn Rivers. Least terns and piping plovers routinely initiate nests on naturally formed sandbars in the LPR reach (Brown and Jorgensen 2008, 2009, and 2010, Brown et al. 2011, 2012, and 2013).

Nesting of least terns and piping plovers on the river in the AHR has largely been confined to mechanically constructed and maintained sandbar habitat. However, limited nesting on natural sandbars within the AHR has been observed following high flow periods in the late-1970s and mid-1980s (Faanes



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1983, Ziewitz et al. 1992; Chapter 1). The species have also infrequently used sandbars that have been
mechanically cleared and subsequently overtopped by high flows (Baasch 2014; Chapter 1).

84 Least Tern and Piping Plover Nest and Brood Exposure Data

Least tern and piping plover nest initiation dates were compiled from central Platte River 85 monitoring data for the period of 2001-2013 (Baasch 2014). Standardized Program nest exposure periods 86 (nest initiation to chick fledging) were used to establish the range in the nesting and brood rearing period 87 for each species. The 5<sup>th</sup> and 95<sup>th</sup> percentile nest initiation dates were used to define the nesting and brood 88 rearing season. Using the 5<sup>th</sup> and 95<sup>th</sup> percentile dates eliminated the disproportionate effect of early and 89 late nests on season length. The nesting and brood rearing season length for piping plovers was 1 May 90 91 through 26 August and was 28 May through 30 August for least terns (Table 1). Approximately 90% of the in-channel least tern and piping plover nest initiation dates reported lower Platte River during the period of 92 2008-2013 fell within the windows described above (Brown and Jorgensen 2008, 2009, and 2010, Brown 93 et al. 2011, 2012, and 2013). 94



Table 1. Associated Habitat Reach (AHR) 90<sup>th</sup> percentile least tern and piping plover nesting and brood rearing dates, 2001-2013.

Nest Exposure Metric	Piping Plover	Interior Least Tern
Analysis Nest Count (Number of Nests)	287	770
Nest Initiation and Egg Laying Period (Days)	8	7
Incubation Period (Days)	28	21
Brooding Period (Days)	28	21
Period for Successful Nesting (Days)*	64	49
First Nest Initiation Date (Day-Month)	1-May	28-May
First Hatch Date (Day-Month)	6-Jun	25-Jun
First Fledge Date (Day-Month)	4-Jul	16-Jul
Median Nest Initiation Date (Day-Month)	15-May	10-Jun
Median Hatch Date (Day-Month)	20-Jun	8-Jul
Median Fledge Date (Day-Month)	18-Jul	29-Jul
Last Nest Initiation Date (Day-Month)	23-Jun	12-Jul
Last Hatch Date (Day-Month)	29-Jul	9-Aug
Last Fledge Date (Day-Month)	26-Aug	30-Aug
Nesting Window / Analysis Period (Days)	118	95

\* Nest initiation and egg-laying period + incubation period + brooding period

\*\* Nest initiation date was determined by the date a nest (scrape with  $\geq 1$  egg) was first observed or by egg floating techniques.

101 \*\*\*Hatch date was determined by observations of  $\geq 1$  chick or was estimated based on chick age.

<sup>102</sup> \*\*\*\*Fledge date was determined by earlier date between first observing sustained flight and a predefined

103 fledging age for each species.

- In- and off-channel least tern and piping plover nest initiation data and discharge records were plotted together to produce visual comparisons of the species nesting seasons in relation to the annual hydrograph of the central and lower Platte River. A direct annual analysis of in-channel nest initiation dates in relation to peak discharge dates was not possible given the lack of nesting in the central Platte River and lack of season-long, systematic species monitoring data for the lower Platte River.
- 110 Historical Central Platte River Flow Record Extension
- 111 Mean daily flow observations in the historical AHR (1895-1938) were of specific interest in this
- study. However, with the exception of a five-year period from 1902 to 1906, these observations were
- unavailable prior to 1915 (Stroup et al., 2006). Mean daily flow observations, however, were available on
- the North Platte River near North Platte, Nebraska and on the North Platte River above Lake McConaughy



115 dating back to 1895. The historical observations at both North Platte River locations were only available for warm season months (April - October) and included all years between 1895 and 1915 with the exception 116 of 1910 near North Platte and 1913 to 1914 above Lake McConaughy (Stroup et al., 2006). As such, a flow 117 record extension technique (Maintenance of Variance Extension Type 1; Hirsch 1982) was used to estimate 118 warm season mean daily flows on the Platte River near Overton, Nebraska from 1895 to 1914 using mean 119 daily flows from the North Platte River near North Platte and above Lake McConaughy. Estimating flows 120 within the AHR from North Platte River flow data was justified because the large majority of historical 121 flows through the Platte River have been provided by the North Platte River (Stroup et al., 2006). A high 122 correlation existed between the logarithm of mean daily flow on the Platte River at Overton and on the 123 North Platte River near North Platte (r = 0.72) and above Lake McConaughy (r = 0.72) during the 1902 to 124 1906 period of concurrent flow observations. 125

A preliminary analysis showed the Maintenance of Variance Extension Type 1 (MOVE.1; Hirsch, 1982) flow record extension technique predicted observed flows as well as or slightly better than alternative techniques including MOVE.2 and MOVE.3, which required greater levels of computation. The MOVE.1 method is described briefly below using notation consistent with that of Wiche et al. (1989), while a more detailed derivation can be found in Hirsch (1982). Consistent with other applications of the MOVE.1 method (Hirsch, 1982; Wiche et al., 1989; Vogel and Stedinger, 1985), all analyses were performed using the logarithms of the observed mean daily flow data.

To extend flows it is necessary to estimate the relationship between estimated flows and observed flows. For the purpose of the analysis, two time periods were defined.  $N_I$  was when concurrent observations of flow were available at the location of interest (historical AHR) and the alternative location (one of the North Platte River locations) and the second time period ( $N_2$ ) was when observations of flow were only available at the alternative location. The following equation was used to estimate flows at the location of interest:
[1]

139 
$$\widetilde{y}_i = a + bx_i$$

Where  $\tilde{y}_i$  is the estimated flow at the location of interest at time *i*, while  $x_i$  is the observed flow at the alternative location at time *i*. When parameters *a* and *b* in equation 1 are solved to ensure the mean and variance of the estimated flows at the location of interest during  $N_2$  are equal to the mean and variance of the observed flows at the location of interest during  $N_1$ , equation 1 becomes:

144 
$$\widetilde{y}_{i} = m(y_{1}) + \left[\frac{s(y_{1})}{s(x_{1})}\right] [x_{i} - m(x_{1})]$$
 [2]

where  $m(y_1)$  is the sample mean of the observed daily flows at the location of interest during  $N_I$ ,  $s(y_1)$  is the sample standard deviation of the observed daily flows at the location of interest during  $N_I$ ,  $s(x_1)$  is the sample standard deviation of the observed daily flows at the alternative location during  $N_I$ , and  $m(x_1)$  is the sample mean of the observed daily flows at the alternative location during  $N_I$ . Equation 2 was the model used to estimate flows using the MOVE.1 method.

The MOVE.1 method was applied twice to obtain a warm season daily flow record from 1895 to 150 1914 for the Platte River near Overton, Nebraska. The first application was to use the North Platte River 151 near North Platte, Nebraska as the alternative location, which allowed for estimates to be made for all years 152 of interest at Overton with the exception of 1910. The second application was to fill in the 1910 void at 153 Overton using the North Platte River above Lake McConaughy as the alternative location. The calculated 154 parameter values used in Equation 2 when applying the MOVE.1 method have been shown in Table 2 for 155 156 both applications and were calculated using concurrent  $N_l$  observed data at each of the locations. The slight differences in parameter values at the location of interest calculated from observed  $N_l$  flows were attributed 157 to different dates of concurrent flows between the location of interest and both alternative locations. More 158 than 5 years of overlap in flow observations at each location were available during later time periods, and 159 thus available for inclusion in the  $N_I$  period of flows used to calculate model parameters. It was assumed 160 on and off-channel development (e.g., storage, accretions, and depletions) were at a minimum during the 161 earliest flows, making them the most useful. 162



Applic	ation 1:	Application 2:				
North Platte R	iver near North	North Platte	River above			
Platte, N	Vebraska	Lake McConau	ughy, Nebraska			
$N_1$	1902 - 1906	$N_1$	1902 - 1906			
	1895 - 1901					
$N_2$	1907 - 1909	$N_2$	1910			
	1911 - 1914					
$m(y_1)$	3.40	$m(y_1)$	3.40			
$s(y_1)$	0.54	$s(y_1)$	0.55			
$m(x_1)$	3.38	$m(x_1)$	3.27			
$s(x_1)$	0.53	$s(x_1)$	0.63			

Table 2: Parameter values for two applications of the MOVE.1 method used to extend the historical Platte
 River flow record near Overton, Nebraska.

165

The performance of the MOVE.1 method was evaluated for both applications by using the method 166 to estimate the observed Platte River flows near Overton, Nebraska during the 1902 to 1906 period. For 167 each application, the commonly applied Nash Sutcliffe Coefficient of Efficiency (NSCE) was used to 168 evaluate model performance (Nash and Sutcliffe, 1970). The NSCE was chosen to provide some context in 169 the model evaluation as an NSCE value of less than 0 indicates inadequate model performance, a value of 170 0 indicates the model performs as well as simply using the sample mean as the estimate, and a value of 1 171 indicates the model perfectly reproduces the observed data. NSCE values greater than or equal to 0.50 are 172 deemed satisfactory when modeling flows (Moriasi et al., 2007). The NSCE values for the first and second 173 application of the MOVE.1 methods were 0.75 and 0.70, respectively, when the MOVE.1 methods were 174 used to estimate the 1902 to 1906 observed mean daily flows at Overton. These values were deemed 175 satisfactory and, as summarized by Moriasi et al. (2007), are in the general range of reported NSCE values 176 when modeling flow. 177

#### 179 Modeling the Availability of Emergent Sandbars

181 Daily discharge records for the contemporary reaches of the Platte River were retrieved from the USGS National Water Information System (www.waterdata.usgs.gov) for 1954-2012, which was the 182 longest concurrent period of record for both the central and lower Platte reaches. Gage 06770500 at Grand 183 Island was used for AHR hydrology and gage 06805500 at Louisville was used for LPR Reach hydrology. 184 The historical central Platte River daily discharge records from the flow record extension exercise (1895-185 1914) were combined with records from USGS Gage 06768000 at Overton (1915-1938) to produce a 44-186 year historic time period data series. The period includes hydrologic impacts of the Pathfinder Dam project 187 which was completed in 1909 but ends prior to completion of Seminoe Dam in 1938. Overall, this period 188 reflects 1% to 29% of the cumulative usable storage developed in the basin since settlement (Simons and 189 Associates Inc. 2000). 190

## 191 <u>Stage-Discharge Relationships</u>

The use of hydraulic relationships at gage locations for least tern and piping plover nesting habitat 192 analyses has been criticized as potentially being not representative of the geomorphic variability of the river 193 system, specifically in reaches with nesting least terns and piping plovers (Jorgensen 2009, Catlin et al. 194 2010). Comparisons of stage-discharge relationships at gage locations and nest sites were developed to 195 address this issue. During the period of 2007-2013, in-channel nesting occurred in the AHR at River Mile 196 199 and 230 on sandbars that had been disked and subsequently overtopped by peak flow events. Modeled 197 HEC-RAS stage-discharge relationships at these locations (See Chapter 3 for a description of the model) 198 were compared to USGS stage-discharge relationships at the Kearney and Grand Island gages (Figure 2). 199 Based on a visual comparison, the stage-discharge relationship at the Grand Island gage (06770500) appears 200 to be representative of the relationships at the two observed nesting locations. 201





Brown et al. 2011, 2012, and 2013). The stage-discharge relationship of the Ashland gage (06801000) was

most representative, generally being within 0.5 ft of stage at the nesting colony locations at all but the

215 highest discharges (Figure 3).



The relationship for the historical AHR was generated from a HEC-RAS hydraulic model of the 222 historical channel near Odessa, Nebraska (Simons and Associates Inc. 2012). No stream gage stage-223 discharge relationships exist for the historical AHR so the representativeness of the relationship could not 224 be assessed. 225

The stage-discharge relationships for the contemporary AHR and LPR Reaches are similar (Figure 226 4). However, the stage increase with discharge in the historical AHR was somewhat lower than the 227 contemporary LPR Reach. The reason for this disparity is apparent from a channel cross section 228 comparison. The historical AHR was much wider than the contemporary LPR Reach despite having 229 somewhat lower mean annual and median annual peak discharges (Figure 5). 230

<sup>216</sup> 217 218 219 for comparison. 220





## 232

Figure 4. Stage-discharge relationships used for model reaches. All relationships normalized to a stage of

1.0 ft at 100 cfs for comparison.





Figure 5. Channel width and median annual peak discharge comparison for model reaches. Note, the historical AHR was substantially wider than the contemporary LPR Reach and median annual peak flow was much lower.

## 240 Sandbar Heights

The Program used a combination of remote-sensing data and hydraulic modeling to develop a 241 distribution of sandbar heights relative to peak stage following a natural high-flow event that occurred in 242 2010 (See Chapter 3). The median height of sandbars formed during the 2010 event in the contemporary 243 AHR was 1.5 ft below the peak stage (See Chapter 3). The USGS conducted field surveys of sandbar 244 topography in the LPR Reach following the same 2010 event and generated a similar sandbar height 245 distribution (Alexander et al. 2013). The LPR Reach distribution height index was adjusted from the 246 instantaneous peak of 138,000 cfs to the three-day mean peak of 108,667 cfs resulting in a median sandbar 247 height of 2.0 ft below peak stage. The LPR and AHR sandbar height distributions are presented in Figure 248 6. 249





Figure 6. Cumulative distribution of heights of sandbars formed during the 2010 natural high-flow event for model reaches.

Sandbar data was not available for the historical AHR so sandbar heights were estimated using 255 grain size and sandbar height data from the contemporary AHR and LPR reaches. Median bed material 256 grain size in the AHR is 0.96 mm and the LPR is 0.22 mm. The median sandbar height in the AHR is 1.5 257 ft below peak stage and the median height in the LPR is 2.0 ft below peak stage. The slightly lower sandbar 258 heights observed in the lower Platte River are consistent with published bedform height relationships (Ikeda 259 1984, van Rijn 1984, and Julien and Klaassen 1995) in which bedform height potential decreases as bed 260 material grain size decreases. The median bed material grain size of the historical AHR of approximately 261 0.4 mm (USACE 1931) was finer than the contemporary AHR (0.96 mm) and coarser than the LPR Reach 262 (0.22 mm). Consequently, median sandbar heights should have been between 1.5 ft and 2.0 ft below peak 263 stage. In an effort to provide conservatively-high sandbar height estimates, the contemporary AHR median 264 height of 1.5 ft below peak stage was used for the historical AHR. 265

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## 267 Emergent Sandbar Availability Model

268	A simple spreadsheet model was developed to estimate the annual availability of emergent sandbar
269	habitat during the nesting season using discharge records, stage-discharge relationships, and observed
270	sandbar heights in the central and lower Platte River segments. The modeling approach was similar to the
271	habitat analysis performed for the Program EIS (DOI 2006) with the exception that assumption of sandbars
272	building to annual peak stage was replaced with sandbar heights following the 2010 natural high-flow event
273	(See Chapter 3). Results were evaluated against the USFWS flow requirements for nesting to infer how
274	often the flow requirements would have been met. Model input and output variables are listed in Table 3.

Table 3. Emergent sandbar habitat model input and output variables.

	Model Input Variables									
	Maximum of mean daily flow (cfs) from 1 January of the previous year									
DISCH <sub>HAB</sub>	through 1 July of analysis year. Considered to be the discharge that									
	controlled sandbar height in analysis year									
STAGE <sub>HAB</sub>	River stage (ft) associated with DISCH <sub>HAB</sub>									
BAR HEIGHT	Sandbar height (ft) below peak stage.									
STAGEBAR	Stage (ft) of sandbars									
DISCHDAILY	Daily river discharge (cfs)									
STAGEDAILY	Daily river stage (ft)									
	Model Output Variables									
SUCCESS	Number of days when piping plover nests could be initiated, incubated,									
WINDOW <sub>PLOVER</sub>	and hatch and the chicks successfully fledged without being inundated.									
SUCCESS	Number of days when least tern nests could be initiated, incubated, and									
WINDOW <sub>TERN</sub>	hatch and the chicks successfully fledged without inundation.									

- 277 The model included the following calculations for each analysis year:
- 2781. The maximum daily discharge for the period beginning 1 January in the year prior to each279analysis year and ending on 1 July of the analysis year was identified. This was considered to280be the habitat-forming discharge (DISCH<sub>HAB</sub>) that controlled the height of sandbars in the281analysis year. The 1.5 year period for identification of DISCH<sub>HAB</sub> allowed for sandbar282persistence through two growing seasons.

283	2.	Stage-discharge relationships (Figure 6) were used to determine the stage (STAGE <sub>HAB</sub> ) of the
284		habitat-forming discharge.
285	3.	Sandbar height (BAR HEIGHT) relative to peak stage for each reach was subtracted from
286		$STAGE_{HAB}$ to determine the stage of sandbar height ( $STAGE_{BAR}$ ).
287	4.	Stage-discharge relationships were used to convert daily discharge ( $DISCH_{DAILY}$ ) to daily stage
288		$(STAGE_{DAILY})$ during the least tern and piping plover nesting and brood rearing seasons of each
289		year.
290	5.	Daily river stage (STAGE <sub>DAILY</sub> ) was compared to sandbar stage (STAGE <sub>BAR</sub> ) to determine if
291		bar height exceeded river stage (i.e., were emergent).
292	6.	The maximum number of contiguous days during the nesting and brood rearing seasons when
293		bar height exceeded stage was identified.
294	7.	The period for successful nesting and brood rearing (64 days for piping plovers and 49 for least
295		terns; Table 1) was subtracted from this total to determine the number of days during each
296		nesting season when a nest could have been initiated and successfully fledge chicks without
297		being inundated (SUCCESS WINDOW).

Median observed sandbar heights were used in the model. Analyses of least tern and piping plover nest locations in the LPR Reach indicate nests are typically distributed across the higher portions of sandbars but not always at the highest elevation (Alexander et al. 2013). Accordingly, the SUCCESS WINDOW model output should be viewed as an approximation of potential for successful nesting given observed hydrology.

303



305	Analysis of Model Sensitivity to Stage-discharge Relationships and Sandbar Height
306	Model stage-discharge relationships (stage per unit discharge) and BAR HEIGHT values were increased
307	and decreased by increments of 25% and 50% to evaluate the sensitivity of model output (SUCCESS
308	WINDOW) to each of these model inputs separately and in combination. The percent of analysis years
309	when successful nesting was possible (SUCCESS WINDOW $> 0$ ) was calculated along with percent change
310	from baseline model results. Sensitivity analysis matrices are located in Appendix A.
311	Analysis of Model Results in Relation to Flow Requirements for Nesting
312	Requirement 1 – Flows high enough to shift sediments and create high sandbars
313	The flow requirement for creation of "high" sandbars (DOI 2006) is ambiguous.
314	Accordingly, the analysis of this requirement was limited to a simple comparison of sandbar height
315	relative to mean annual river stage. Mean annual discharge was calculated for each analysis year
316	and the stage associated with that discharge was compared to sandbar stage (STAGE $_{BAR}$ ). Box plots
317	were developed to facilitate a comparison of reaches.
318	Requirement 2 – Flow recede early in the nesting season to allow birds to initiate nests
319	The number of consecutive days at the end of each annual nest initiation period with
320	sandbar stage (STAGE <sub>BAR</sub> ) exceeding river stage was identified. Annual values were binned to
321	identify the number of years when sandbars were emergent for various periods of time.
322	Requirement 3 – Flows need to remain low enough to avoid inundation after nest initiation
323	Much of the observed species brood rearing occurs during the months of July and August.
324	(Table 1). Accordingly, the analysis for requirement 3 focused on identifying the frequency of
325	sandbar inundation during those months. Daily river stage was compared to sandbar stage
326	(STAGE <sub>BAR</sub> ) during the periods of 1-15 July, 16-31 July, 1-15 August, 16-31 August, and 1 July –

- 31 August. The number of years when daily stage exceeded sandbar stage was identified for eachanalysis period.
- 329 Overall Potential for Successful Nesting free from Inundation

The annual species SUCCESS WINDOWs combine the availability of sandbars for nest initiation and potential for inundation into a single estimate of the number of days during each year that nests could be initiated and successfully fledge chicks without being inundated. Median values were calculated as well as the number of years with the potential for season-long success and the number of years with no potential for success.

#### 335 Results

## 336 Species Nest Initiation in Relation to Platte River Hydrology

Two spring rises are evident in the long-term mean daily discharge series (Figure 7). The first 337 occurs in the February – March period and is typically attributed to the melting of low-elevation snow cover 338 in the basin. The second peak occurs in mid-June due to runoff from Rocky Mountain snowmelt and 339 precipitation events in the basin. The peaks are less defined in the contemporary AHR reach due to the 340 influence of on-line storage reservoirs (Simons and Associates Inc. 2000). Following the late-spring runoff 341 in June, mean discharge decreases quickly to summer base flow levels. It should be noted that in years of 342 severe drought, the late spring rise is often completely absent due to the lack of appreciable runoff in the 343 basin. Because of this, the long-term median date of the annual peak discharge falls between the early and 344 345 late-spring rise periods in all cases (See Chapter 6).



Figure 7. Distribution of AHR piping plover nest initiation dates (2001-2013) in relation to the annual 347 hydrographs of the LPR Reach (1954-2012), contemporary AHR (1954-2012) and historical AHR (1895-348 1938). 349 350

The least tern and piping plover nest initiation periods overlap, but piping plover nest initiation 351 activity typically peaks in mid-May and least tern activity peaks a month later in June (Figures 7 and 8). In 352 the case of piping plover, the beginning of nest initiation coincides with the end of the early-spring rise but 353 peaks in May, prior to the late-spring rise in June (Figure 7). The timing of piping plover nest initiation 354 appears to be problematic in relation to the annual hydrograph of both the lower and contemporary central 355 Platte River. Nests initiated prior to the late-spring rise are susceptible to inundation and potential for 356 renesting is limited once discharges recede to summer base flow levels. 357



358

Figure 8. Distribution of AHR least tern nest initiation dates (2001-2013) in relation to the annual hydrographs of the LPR Reach (1954-2012), contemporary AHR (1954-2012) and historical AHR (1895-1938).

The least tern nest initiation period coincides more closely with the late-spring rise although the peak of initiation still slightly precedes the mid-June peak (Figure 8). This is an indication that nesting regularly occurs prior to the late-spring rise and those nests are susceptible to inundation. However, the least tern nest initiation period extends through July when discharge recedes to summer base flow levels. Given the nest initiation window extends later into the summer and least tern require less time for incubation and brood rearing, there is greater potential for successful renesting following nest loss during the latespring rise.

## 370 Emergent Sandbar Habitat Model

The visual comparison of species nest initiation dates in relation to the annual hydrograph is useful for evaluating general relationships over the long term; however, the magnitude and timing of peak flows can vary substantially between years and the late-spring rise may be absent altogether during severe drought

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periods. The emergent sandbar availability model was developed to facilitate more detailed evaluations within and between individual years. Individual analyses were performed for each of the three stated flow requirements for nesting:

## 377 <u>Requirement 1 – Flows high enough to shift sediments and create high sandbars</u>

The first flow requirement for nesting was for flows to be high enough to mobilize sediments and create high sandbars. Model-predicted annual sandbar heights were calculated relative to mean annual stage (Figure 9). Median sandbar heights in the LPR reach were 1.6 ft higher than mean annual river stage. Median heights in the contemporary AHR were 0.4 ft higher than mean annual river stage. Median heights in the historical AHR were predicted to be below mean annual river stage. The substantially lower sandbar height prediction for the historical AHR was driven by limited stage increase due to the extremely wide channel in relation to discharge (Figure 5).





388

## Requirement 2 – Flows recede early in the nesting season to allow birds to initiate nests

The second flow requirement is for the spring rise to recede early enough in the nesting 389 season for the species to initiate nests. The percent of time (consecutive) that sandbars were 390 emergent during species nest initiation windows was calculated for each reach. Modeled emergent 391 sandbar availability was greater in the LPR Reach than the contemporary or historical AHR. 392 Availability was also greater during the least tern nest initiation window than during the piping 393 plover nest initiation window. Overall, the model indicates that years of limited habitat availability 394 395 may have been somewhat frequent (Figure 10). The model predicted that emergent sandbars were available for less than 14 days (25% of nest initiation period) during the piping plover nest initiation 396 period in approximately 55% of years in the contemporary reaches and 89% of years in the 397 historical AHR. Sandbars were available for less than 14 days during the least tern nest initiation 398 period in approximately 22% of years in the LPR Reach, 39% of years in the contemporary AHR, 399 and 68% of years in the historical AHR. 400



Figure 10. Percent of analysis years when model predicted sandbars were emergent for less than 14 days during the nest initiation period.

Requirement 3 – Flows need to remain low enough to avoid inundation after nest initiation
 The third requirement is for flows to remain low enough after nest initiation to avoid
 inundation during the incubation and brood rearing periods. The percent of model analysis years
 when sandbars were inundated during two week periods in July and August were calculated (Figure
 11). The LPR Reach had the lowest potential for inundation with sandbars being inundated during
 the July – August period in slightly less than 40% of years. The historical AHR exhibited the highest
 potential at almost 80% of years.



Figure 11. Percent of years when emergent sandbars were predicted to inundated during the months of July and August.

414

411

## 415 Overall Potential for Successful Nesting free from Inundation

Emergent sandbar model output consisted of the window (SUCCESS WINDOW) in days during each year when the species could have initiated a nest and successfully fledged chicks without inundation. Table 4 provides a comparison of SUCCESS WINDOWs by species and analysis reach. The median SUCCESS WINDOW was highest for both species in the LPR Reach. The historical AHR had the highest percentage of years with no potential for success and lowest

percentage of years with season-long success. Overall, the model predicted limited potential for
 successful nesting for both species in the historical AHR.

In the contemporary AHR and LPR Reach, the model predicted limited potential for successful fledging of piping plover chicks. The potential for successful fledging of least tern chicks was somewhat higher although the median window was only three weeks in the LPR Reach and two weeks in the contemporary AHR. The modeling exercise also suggests that the greatest potential for successful nesting free of inundation occurs in drought years that immediately follow high flow years because of the presence of suitably-high sandbars and the low magnitude or complete lack of a late-spring runoff during the nesting season.

430	Table 4. E	mergent sar	ndbar habitat	model ou	tput by reach	1.

0							
	Medi SUCCESS V (day	an VINDOW s)	No SUCCESS V (% of y	) WINDOW ears)	Season-Long SUCCESS WINDOW (% of years)		
Reach	Piping Plover	Least Tern	Piping Plover	Least Tern	Piping Plover	Least Tern	
LPR Reach	4	21	42%	17%	22%	25%	
Contemporary AHR	0	14	53%	29%	25%	29%	
Historical AHR	0	0	84%	68%	5%	7%	

431

## 432 Discussion

As discussed, Hardy's (1957) proposition that least tern have become physiologically adapted to arrive within a river system and begin nesting coincident with the receding spring high flows has been applied to the contemporary and historical Platte River. In the AHR, this concept has been expanded to include the piping plover. Least tern and piping plover nest initiation dates were compared to the timing of the spring rise on the contemporary and historic central Platte River as well as the contemporary lower Platte River. The late-spring rise on the Platte River typically occurs during mid- to late-June and recedes in late June through the end of July. Observed least tern and piping plover nest initiation dates within the



AHR, however, peak 2-4 weeks prior to the timing of the late spring rise. Consequently, our analyses do not support the proposition that least tern and piping plover are physiologically adapted to arrive and begin nesting in the Platte River coincident with the recession of the spring rise. The nesting ecology of the piping plover appears to be especially problematic because the late-spring rise often occurs after most nests have been initiated and there is little potential for renesting. The peak of least tern nest initiation also often occurs prior to the late-spring rise, but the later overall nest initiation period and shorter nesting and brood rearing periods provide more potential for renesting following that event.

447 The analyses of model results in relation to the three USFWS flow requirements for nesting indicated low potential for successful nesting (i.e., fledging chicks) in many years. The combination of 448 limited availability of emergent sandbars during nest initiation and high potential for inundation during the 449 summer months equated to a high proportion of analysis years when there was little to no potential for 450 successful nesting. This was especially true for piping plover and is supported by the low incidence of 451 successful in-channel nesting in the lower Platte River reach (Brown and Jorgensen 2008, 2009, and 2010, 452 Brown et al. 2011, 2012, and 2013). The modeling exercise did suggest that drought years following high 453 flow years provide the greatest potential for successful nesting without inundation. This because suitably-454 high nesting habitat is present and the lack of an appreciable late-spring rise limits inundation potential. 455 The 2012 nesting season in the LPR reach is an excellent example of this scenario. See Brown et al. (2012) 456 for a discussion of species use and productivity under those conditions. 457

The model sensitivity analysis indicated that predictions are more sensitive to the sandbar height variable (BAR HEIGHT) than to stage-discharge relationships (Appendix A). For example, increasing the LPR Reach BAR HEIGHT from 2.0 ft below peak stage by 50% to 1.0 ft below peak stage increases the percent of years when SUCCESS WINDOW >0 by 15% for terns and 24% for plovers. In contrast, increasing the stage increase per unit of discharge by 50% increases the percent of years when SUCCESS WINDOW >0 by 10% for both species. The sandbar heights used in the model were based on field



observations following a single high flow event in 2010. As such, their applicability across years and for 464 the historical AHR is a major uncertainty in the analysis. Ideally, model predictions of inundation mortality 465 and potential for fledging success would have been evaluated using species monitoring data. This was not 466 possible because: 1) systematic monitoring data was not available for the historical AHR, 2) the monitoring 467 data for the contemporary AHR was of limited utility given the limited amount of in-channel nesting, and 468 3) the LPR Reach monitoring data was also of limited utility because annual monitoring often began after 469 the beginning of the nest initiation period and ended prior to chicks reaching fledging age. Although 470 validation was not possible, specific instances of observed inundation were evaluated. 471

#### 472 Historical AHR

Wycoff (1960) provided the earliest least tern nest records in the historical AHR. His observations in the 1940s occurred slightly after the historical analysis period in this investigation, but before significant changes in AHR channel width. In 1947, the mean daily annual peak discharge of 13,900 cfs occurred on 23 June. In-channel nests were observed in 1948 and were inundated twice. The highest recorded mean daily peak discharge during the nesting season was 4,480 cfs on 23 June. This was significantly below the habitat-forming discharge of 13,900 cfs.

## 479 *Contemporary AHR*

Faanes (1983) reported that all in-channel least tern and piping plover nests in 1979 were inundated on 21 June by rising flows. In 1978, the mean daily annual peak discharge was 10,500 cfs. The mean daily discharge on 21 June 1979 was 3,000 cfs. The contemporary AHR model predicts that bars created by a discharge of 10,500 cfs would be inundated at a discharge of 4,350 cfs. More recently, two least tern nests were initiated on the channel in 2014 (unpublished data, collected as part of 2014 PRRIP monitoring activities in the AHR following a fall 2013 high flow event with a peak mean daily discharge of 10,100 cfs.

Those nests were inundated on 10 June when mean daily discharge was 2,910 cfs. The AHR model predicts that bars created by a discharge of 10,100 cfs would be inundated at a discharge of 4,110 cfs.

488 LPR Reach

A 2008 mean daily peak discharge of 84,000 cfs at Louisville produced sandbar habitat inundated 489 by a mean daily peak discharge 21,000 cfs in mid-June of 2009 which inundated 50 least tern and 14 piping 490 plover nests (Brown and Jorgensen 2009). The LPR Reach model predicts that sandbars created by a 491 discharge of 84,000 cfs would be inundated at a discharge of 34,200 cfs. In 2010, a mean daily peak 492 discharge of 120,000 cfs at Louisville produced sandbar habitat inundated by a mean daily peak discharge 493 of 33,200 cfs in late June of 2011 inundating all 56 least tern and 7 piping plover nests observed on the 494 river (Brown et al. 2011). The model predicts sandbars created by a discharge of 120,000 cfs would be 495 inundated at 52,600 cfs. 496

Observed instances of nest inundation in the contemporary AHR and LPR reaches indicate that 497 sandbar overtopping and nest loss occurred at discharges lower than were predicted by the model. This is 498 consistent with the effort to use conservatively-high sandbar height values in this analysis. The specific 499 dates and discharges associated with inundation in the historical AHR were not recorded but the highest 500 discharge recorded during the nesting season was significantly below the habitat-forming peak discharge 501 502 of the previous year. Overall, sandbar height values applied in the model appear to be generally appropriate to slightly conservatively-high. Sensitivity analysis results in Appendix A indicate that the use lower 503 sandbar height values would have a substantial negative effect on potential for productivity. 504

The potential for success of late-season least tern nests is another model uncertainty. A substantial level of late renesting was reported in the LPR Reaches in 2009 and 2011 following large losses to inundation, but the chicks were not monitored to fledging age so it is unknown if any of these chicks fledged (Brown and Jorgensen 2009, Brown et al. 2011). Additional systematic information on the fledging success

of nests that were initiated late in the season in the LPR Reach would be useful for evaluating productivity
of least tern nests following the late-spring rise.

511 Central Platte River Management Implications

As discussed in Chapter 1, the decline in in-channel species habitat suitability in the AHR has been 512 inferred from the reduction in AHR channel width from the historical/pre-development period, lack of in-513 channel nesting in the contemporary AHR, and species use of the LPR Reach. This inference assumes the 514 channel in the LPR Reach currently supports reproductive levels sufficient to maintain species populations 515 and that the LPR Reach is a functional analog for the historical AHR. These analyses call into question the 516 assertion that in-channel sandbars on the LPR Reach support a viable sub-population of piping plover. This 517 518 is generally supported by the low level of in-channel piping plover nesting in the LPR reach. The mean inchannel piping plover nest count for the period of 1986-2013 is 5.6 nests or 0.2 nests per river mile (see 519 Chapter 6). The viability of the in-channel least tern population is likely linked to the fledging success of 520 renesting events following the late-spring rise. Monitoring of late nests through fledging age would allow 521 for a better understanding of least tern population dynamics in the LPR Reach. 522

The inference that the LPR Reach is a functional analog for the historical AHR is also not supported by this analysis. The historical AHR was likely much less suitable for nesting than the contemporary LPR reach. The late-spring rise consistently occurred during mid-June, well into the nesting season. Channel width in the historical AHR was much wider than the contemporary LPR Reach and flows approximately 50% lower. Consequently, stage increase and associated ability to build suitably-high sandbars was likely very limited and the annual peak flow consistently occurred during the nesting season.

529 Why then, do these species occur along the Platte River? An alternative view is suggested by 530 historical and contemporary species use of both in- and off-channel habitats. The earliest species 531 observations in the AHR (Wycoff 1960) include documentation of nesting on natural sandbars, artificially-



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created in-channel islands comprised of sand mine spoil, and at off-channel sand mines. In the lower portion of the basin, records in the late 1800s include off-channel nesting at rainwater basins and along lake shorelines (Pitts 1988, Ducey 2000). In the contemporary LPR and AHR segments, these species routinely make use of off-channel sand mine habitats regardless of whether or not in-channel habitat is available (Baasch 2014, Brown and Jorgensen 2008, 2009, and 2010, Brown et al. 2011, 2012, and 2013).

Historically, off-channel habitat has been viewed as an inferior alternative to in-channel nesting habitat that became necessary as in-channel habitat suitability declined over historical timeframes (Sidle and Kirsch 1993, National Research Council 2005). However, given what appears to be limited potential for successful in-channel nesting in all reaches and consistent use of off-channel habitats like sand mines, these habitats may have allowed the species to expand into and persist in a basin with hydrology not ideally suited to their reproductive ecology.

543 Development of AHR species population models would allow the Program to further explore use 544 and productivity in- and off-channel habitats. Development of those models is a priority work item in 2015. 545 An expanded analysis of AHR hydrology and physical characteristics in relation to other rivers used by the 546 species also provides further opportunity to identify characteristics that may be important for species use 547 and productivity. Those comparisons have been included in Chapter 6.

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## APPENDIX A – MODEL SENSITIVITY ANALYSIS RESULTS

This appendix presents the results of a sensitivity analysis for each of the model segments. Figures A-1 647 and A-2 present the sensitivity analysis stage-discharge relationships along with the relationships at LPR 648 and contemporary AHR stream gages and nest colony locations presented in the text. Figure A-3 provides 649 the sensitivity analysis stage-discharge relationships along with the hydraulic model stage-discharge 650 651 relationship used in the historical AHR analysis. Table A-1 presents the SANDBAR HEIGHT values used in the sensitivity analysis for each segment. 652



653 654

Figure A-1. LPR Reach sensitivity analysis stage-discharge relationships in comparison to the Ashland

gage relationship used in the model, Louisville gage relationship, and relationship at nesting colonies.



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Figure A-2. Contemporary AHR sensitivity analysis stage-discharge relationships in comparison to the Kearney gage relationship used in the model, Grand Island gage relationship, and relationship at nesting colony locations.



Figure A-3. Historical AHR sensitivity analysis stage-discharge relationships in comparison to the modeled relationship used in the analysis.

664	Table A-1.	Sensitivity a	nalvsis SAI	NDBAR	HEIGHT	values for the	LPR Reach
001	140101111	bononi i ci	iai joio oi ii	(DDI III)	IIDIOIII	raideb for the	DI ICICCUCII

Songitivity Dun	SANDBAR HEIGHT Value							
Sensitivity Kun	LPR Reach	Contemporary AHR	Historical AHR					
-50%	3.0	2.3	2.3					
-25%	2.5	1.9	1.9					
0% (Model Value)	2.0	1.5	1.5					
25%	1.5	1.1	1.1					
50%	1.0	0.8	0.8					

665

Tables A-2 through A-4 present sensitivity analysis results. In each case, two matrices are presented for each species. The first presents the percent of years under each stage-discharge and SANDBAR HEIGHT sensitivity run when SUCCESS WINDOW >0 (IE. when there is some potential for success). The second set of matrices present the change in percent of years when SUCCESS WINDOW >0 from the baseline model run.

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# Table A-2. Sensitivity analysis results for LPR Reach.

	TERN	- Percent o	of Years w	/ SUCCES	S WINDO	W >0		TERN - Change in % of Years w/ SUCCESS WINDOW >0					OOW >0	
			Sta	ige Dischai	ge					Stage Discharge				
		-50%	-25%	0	25%	50%				-50%	-25%	0	25%	50%
t	50%	83%	93%	98%	98%	100%		t	50%	0%	10%	15%	15%	17%
igh	25%	53%	83%	88%	95%	98%		igh	25%	-31%	0%	5%	12%	15%
He	0%	32%	64%	83%	88%	93%		He	0%	-51%	-19%	0%	5%	10%
3ar	-25%	7%	46%	66%	83%	88%		Bar	-25%	-76%	-37%	-17%	0%	5%
I	-50%	3%	32%	53%	69%	83%			-50%	-80%	-51%	-31%	-14%	0%
Р	LOVE	R - Percent	of Years	w/ SUCCE	SS WINDO	OW >0		PLOVER - Change in % of Years w/ SUCCESS WINDOW >(					<b>DOW &gt;0</b>	
			5	Stage Disch	1						5	Stage Discl	1	
		-50%	-25%	0	25%	50%				-50%	-25%	0	25%	50%
ıt	50%	58%	68%	81%	81%	83%		ıt	50%	0%	10%	24%	24%	25%
igh	25%	29%	58%	68%	73%	81%		igh	25%	-29%	0%	10%	15%	24%
He	0%	12%	39%	58%	68%	68%		He	0%	-46%	-19%	0%	10%	10%
3ar	-25%	3%	24%	44%	58%	64%		3ar	-25%	-54%	-34%	-14%	0%	7%
	-50%	0%	12%	29%	47%	58%			-50%	-58%	-46%	-29%	-10%	0%

673

674

## Table A-3. Sensitivity analysis results for the contemporary AHR.

	TERN	Percent o	f Years w/	SUCCESS	WINDOV	V >0	Т	TERN - Change in % of Years w/ SUCCESS WINDOW >0					
			S	tage Disch	ı				Stage Disch				
		-50%	-25%	0	25%	50%			-50%	-25%	0	25%	50%
t	50%	71%	93%	98%	100%	100%	t	50%	0%	22%	27%	29%	29%
igh	25%	47%	71%	88%	93%	98%	igh	25%	-24%	0%	17%	22%	27%
He	0%	31%	56%	71%	86%	93%	He	0%	-41%	-15%	0%	15%	22%
3ar	-25%	14%	37%	58%	71%	85%	Sar	-25%	-58%	-34%	-14%	0%	14%
I	-50%	8%	31%	47%	61%	71%		-50%	-63%	-41%	-24%	-10%	0%
Р	LOVE	R - Percent	of Years v	v/ SUCCES	SS WINDO	W >0	PL	OVER -	ER - Change in % of Years w/ SUCCESS WINDOW >0				
			S	tage Disch	L					5	Stage Discl	h	
		-50%	-25%	0	25%	50%			-50%	-25%	0	25%	50%
t	50%	47%	66%	76%	80%	81%	t	50%	0%	19%	29%	32%	34%
igh	25%	22%	47%	58%	71%	76%	igh	25%	-25%	0%	10%	24%	29%
He	0%	8%	25%	47%	58%	66%	He	0%	-39%	-22%	0%	10%	19%
3ar	-25%	2%	15%	29%	47%	56%	3ar	-25%	-46%	-32%	-19%	0%	8%
_	-50%	0%	8%	22%	32%	47%		-50%	-47%	-39%	-25%	-15%	0%

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# Table A-4. Sensitivity analysis results for the historical AHR.

TERN - Percent of Years w/ SUCCESS WINDOW >0								TERN - Change in % of Years w/ SUCCESS WINDOW >0							
		Stage Disch								Stage Disch					
		-50%	-25%	0	25%	50%				-50%	-25%	0	25%	50%	
Height	50%	30%	63%	79%	86%	88%		t	50%	0%	33%	49%	56%	58%	
	25%	16%	30%	56%	70%	79%		igh	25%	-14%	0%	26%	40%	49%	
	0%	12%	19%	30%	49%	63%		Bar He	0%	-19%	-12%	0%	19%	33%	
3ar	-25%	9%	14%	21%	30%	47%			-25%	-21%	-16%	-9%	0%	16%	
H	-50%	2%	12%	16%	21%	30%			-50%	-28%	-19%	-14%	-9%	0%	
P	PLOVER - Percent of Years w/ SUCCESS WINDOW >0							PLO	LOVER - Change in % of Years w/ SUCCESS WINDOW >0						
		Stage Disch								Stage Disch					
		-50%	-25%	0	25%	50%				-50%	-25%	0	25%	50%	
t	50%	14%	35%	47%	60%	65%		ight	50%	0%	21%	33%	47%	51%	
Bar Heigh	25%	9%	14%	19%	37%	47%			25%	-5%	0%	5%	23%	33%	
	0%	9%	9%	14%	16%	35%		He	0%	-5%	-5%	0%	2%	21%	
	-25%	9%	9%	12%	14%	16%		Bar	-25%	-5%	-5%	-2%	0%	2%	
	-50%	2%	9%	9%	14%	14%		_	-50%	-12%	-5%	-5%	0%	0%	

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# CHAPTER 6 – Hydrology and Physical Characteristics of River Segments Used by the Least Tern and Piping Plover: A Regional Case Study to Inform Central Platte River Habitat Management

4 Abstract

1

The hydrology and physical characteristics of the contemporary Associated Habitat Reach (AHR) 5 of the central Platte River were compared to other regional river segments used by least terns and piping 6 7 plovers. The Niobrara River was the only unmanaged river that supported species densities and fledge ratios approximating United States Fish and Wildlife Service proposed recovery objectives for the AHR. 8 Important differences between the AHR all other segments include much coarser bed material and the likely 9 related absence of large sand flats used by the species. The Platte River Recovery Implementation 10 Program's ability to manage the AHR to shift the bed material grain size distribution into the range of the 11 other segments is limited. Other differences, such as comparatively lower minimum discharges during the 12 nesting season, may be more easily addressed. 13

## 14 Introduction

The interior least tern (Sterna antillarum athalassos; least tern) and piping plover (Charadrius 15 melodus; piping plover) nest sympatrically on several major river systems in the northern Great Plains 16 17 including the Missouri, Platte, Niobrara and Loup rivers (Ziewitz et al. 1992). The interior least tern was listed as endangered under the Endangered Species Act in 1985 and the piping plover was listed as 18 threatened in 1986. Soon after listing, the United States Fish and Wildlife Service (USFWS) concluded that 19 alteration of the flow regime of the Big Bend reach of the Platte River caused a decline in the availability 20 of suitable nesting habitat and threatened the continued existence of these species (Department of the 21 Interior 2006). 22

At its inception in 2007, the Platte River Recovery Implementation Program (Program) was tasked with implementing certain aspects of the species recovery plans on the Platte River upstream of the Loup



25 River confluence. At that time, Program stakeholders began implementation of an Adaptive Management Plan that includes testing of a river process-based strategy (Flow-Sediment-Mechanical or FSM) to create 26 and maintain least tern and piping plover nesting habitat (Program 2006). The first six years of Adaptive 27 Management Plan implementation have provided indications that full implementation of the FSM 28 management strategy will likely not create or maintain least tern and piping plover nesting habitat on an 29 annual or near annual basis as was initially hypothesized (See Chapters 2 & 3). In 2013, the Program's 30 Independent Science Advisory Committee recommended that the Program compare physical conditions in 31 the Associated Habitat Reach (AHR) to other systems in the region with least tern and piping plover nesting 32 in an effort to glean potential management insights (Program 2013a). This sentiment was echoed by the 33 USFWS (Hines 2014). 34

The objectives of the investigations presented here were three-fold. The first was to provide an overview of proposed AHR species recovery objectives in relation to range-wide and regional population densities as a reference point for expectations about species populations in the recovered AHR. The second was to compare the physical characteristics of the AHR to those of other river segments used by the species in this region. The third objective was to identify and discuss the Program's ability to address physical differences between the AHR and other segments with population densities similar to recovery objectives for the AHR.

#### 42 Methods

## 43 Study Area

The piping plover range-wide population comparison included records for the Northern Great Plains/Prairie region, which extended from Saskatchewan, Canada south to Kansas (Elliott-Smith et al. 2009). The least tern range-wide population comparison spanned the breeding range of the interior population of the least tern, which extended from the upper Missouri River downstream of Lake Fort Peck to the lower Mississippi River at the Gulf of Mexico. The physical conditions comparison included seven

49 braided sand bed segments of three river systems including the Niobrara River, Loup River, and Platte Rivers (Table 1; Figure 1). These segments were chosen because of their proximity to the central Platte 50 River, history of species use, and similar channel morphologies. The Missouri River segment downstream 51 of Gavin's Point Dam was omitted from the comparison because the significant proportion of species use 52 on created and managed habitat (US Army Corps of Engineers 2006, 2007) provided limited opportunity 53 to evaluate use in relation to naturally-occurring channel characteristics. The Niobrara River reach below 54 the Spencer Hydropower dam was omitted because of the delta effect caused by backwater from Lewis and 55 Clark Lake (Alexander et al. 2010). 56

57 Table 1. Physical comparison river segments

Segment Name	Length (mi)	Description				
Contemporary Associated Habitat Reach	00	Lexington, NE to Chapman, NE				
(Contemporary AHR)	90					
Historical Associated Habitat Reach (Historical	90	Lexington, NE to Chapman, NE				
AHR)	90	circa 1900				
I ower Platte Piver Peach 1 (I PP Peach 1)	33	Elkhorn River confluence to the				
Lower Flatte River Reach I (LFR Reach I)	55	Missouri River				
Lower Platta Diver Deach 2 (LDD Deach 2)	70	Loup River confluence to the				
Lower Flatte River Reach 2 (LFR Reach 2)	70	Elkhorn River Confluence				
Loup River Upstream of Diversion (Loup River	20	Confluence of North Loup River to				
US)	30	Loup Power Diversion				
Loup River Downstream of Diversion (Loup	24	Loup Power Diversion to Platte				
River DS)	54	River				
Niobrara River Upstream of Spencer (Niobrara	40	Highway 137 to Spencer				
River)	40	Hydropower Plant				



61

Figure 1. Map of study area identifying physical comparison river segments.

The AHR is the focus area for the Program and is located at the terminus of major irrigation 62 infrastructure on the Platte River. Flows through the contemporary AHR are heavily influenced by 63 irrigation diversions and returns. LPR Reach 2 includes the segment of Platte River below the Loup River 64 near Columbus, Nebraska, which is the first major tributary to the Platte River downstream of the 65 confluence of the North and South Platte Rivers. LPR Reach 1 includes the lower segment of the Platte 66 River between the Elkhorn River, another major tributary, and the confluence with the Missouri River. The 67 hydrology of both LPR segments differs from the AHR due to the influence of these tributaries. 68

The Loup River segment upstream of the Loup Power diversion (Loup River US) extends from the 69 North Loup River confluence downstream to the Loup Power Diversion. Flows in this segment are 70 somewhat unregulated. The Loup River segment downstream of the diversion (Loup River DS) is heavily 71 influenced by the diversion of base flows for hydropower generation. The Niobrara River segment upstream 72 of the Spencer hydropower dam is similar to the Loup River US reach in that it is somewhat unregulated. 73


As mentioned previously, the Niobrara River segment downstream of the Spencer hydropower dam was
not included in this analysis because it is heavily influenced by backwater from Lewis and Clark Lake
(Alexander et al. 2010).

77 Range-Wide Population Densities

Range-wide piping plover occurrence was derived from the 2006 international piping plover census 78 (Elliott-Smith et al. 2009) and was standardized by dividing total reported population within each survey 79 80 reach by the length of the respective survey reach. Least tern estimates and densities were derived from a 2005 report on least tern distribution and abundance prepared by The American Bird Conservancy for the 81 U.S. Army Corps of Engineers (Lott 2006) using the same method. AHR density objectives were prorated 82 from the Lutey (2002) objective for the central Platte River reach extending from Lexington, NE to 83 Columbus, NE. The AHR comprises 63% of the total reach length from Lexington to Columbus. The total 84 piping plover population objective of 126 adults was prorated to 79 adults and the least tern objective of 85 300 adults was prorated to 189 adults. It should be noted that the population densities, as calculated, were 86 intended to facilitate comparisons of total populations in relation to total segment length. Actual populations 87 were almost certainly not equally distributed within any of the segments. 88

#### 89 Regional Nest Densities

Nest density estimates for regional river segments were derived using the same methodology as the range-wide estimates. However, they were based on segment-specific monitoring protocols representing a range of effort and methods. Nest counts for the lower Platte River segments were obtained from joint annual reports produced by the Tern and Plover Conservation Partnership and Nongame Bird Program of the Nebraska Game and Parks Commission (Brown and Jorgensen 2008, 2009, and 2010, Brown et al. 2011, 2012, and 2013). In some cases, actual adult and nest counts were not reported and had to be estimated from summary figures. Nest counts for Loup River segments were obtained from Appendix E-2 of the 2012



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Power District final Federal Energy Regulatory Commission (FERC) Final License Application for relicensing of the Loup River Hydroelectric Project (Loup Power District 2012a). Niobrara River nest counts were provided by Jim Jenniges, biologist with the Nebraska Public Power District (personal communication, 2014). The central Platte River nest density objectives were derived from the prorated adult population objectives in Lutey (2002) by dividing prorated objectives by two to determine number of breeding pairs and assuming a minimum of one nest per breeding pair.

#### 103 *Hydrologic Comparisons*

The comparison of hydrology in contemporary regional river segments was based on a database of 104 United States Geological Survey (USGS) daily flow records for the 32 year period of 1980-2011 that was 105 assembled in support of a range-wide least tern population model (Casey Lott, personal communication, 106 December 10, 2013). During database development, all flow records were queried and visually inspected 107 to identify and correct recording errors and interpolate missing values. The 1980-2011 flow records were 108 used in order to maintain consistency with the larger ongoing population modeling effort. Program analyses 109 of contemporary AHR hydrology typically include the entire period of record following completion of Lake 110 111 McConaughy in 1941. The entire post-Lake McConaughy period of record (1942-2011) was slightly dryer than the 1980-2011 period (mean annual discharge of 1,590 cfs versus 1,895 cfs) and peak discharge was 112 slightly lower (median peak of 5,925 cfs versus 6,095 cfs) than the 1980-2011 period. Table 2 identifies the 113 stream gages used in the river segment hydrologic comparison. 114



115	Table 2. United States Geological Survey stream gages used in hydrologic comparison of river segme					
	Segment Name	USGS Stream Gage (Gage Number)				
	Associated Habitat Reach	Platte River near Grand Island (06770500)				
	Lower Platte River Reach 1 (LPR Reach 1)	Platte River at Louisville (06805500)				
	Lower Platte River Reach 2 (LPR Reach 2)	Platte River at North Bend (06796000)				
	Loup River Upstream of Diversion (Loup	North Loup River near St. Paul (06790500) +				
	River US)	Middle Loup River at St. Paul (06785000)				
	Loup River Downstream of Diversion (Loup	Loup Piver peer Genera (06703000)				
	River DS)	Loup River hear Genoa (00795000)				
	Niobrara River Upstream of Spencer (Niobrara	Nichrara Piver near Verdel (06/65500)				
	River)	Niobiaia Kivei neal Veldel (00403300)				

116

Tern and piping plover nest initiation windows and total nesting periods used in the hydrology comparisons were based on AHR monitoring data for the period of 2001-2013 (Baasch 2014). The 2012-2013 data were outside of the hydrology analysis period but were included because the data was used to develop characterizing metrics, not in a correlation analysis. The 5<sup>th</sup> and 95<sup>th</sup> percentile nest initiation dates for all nests were used in conjunction with standardized Program nest exposure periods (nest initiation to chick fledging) to define the analysis period for each species.

#### 123 *Physical Characteristics Comparison*

River segment channel slope, bed material grain size, and area of sandbars used by the species were 124 125 obtained from agency documents, reports and scientific literature (Table 4). It should be noted that these data were collected by various entities using a range of methods, which introduces a degree of uncertainty 126 in the comparisons. In the case of sandbar areas in the Loup River segments, sandbars with nests 127 observations were identified from approximate locations reported by the USFWS in 2010-2012 (Lackey 128 and Runge 2010, Lackey 2011, 2012). Once identified, the bars were delineated and measured in ArcMAP 129 from Farm Service Agency (FSA) National Aerial Imagery Program (NAIP) aerial photography, which 130 were collected during June and July. 131



132	Table 4. Sources of channel segment slope, bed material grain size and sandbar area data used in the
133	physical characteristics comparison.

		Median Bed Material	Mean Area of Sandbars
Segment Name	Channel Slope	Grain Size	with Nest Records
Contemporary CPR	Simons & Associates Inc. (2000)	Tetra Tech Inc. (2013)	Ziewitz et al. (1992)
I DD Deach 1	Loup Power District	Loup Power District	Brown and Jorgensen
LFK Kedell I	(2012b)	(2012b)	(2009)
I DD Deach 2	Loup Power District	Loup Power District	Brown and Jorgensen
LFK Keach 2	(2012b)	(2012b)	(2009)
Loup Divor US	Loup Power District	Loup Power District	Estimated from USFWS
Loup River US	(2012b)	(2012b)	Nest Locations
Loup Divor DC	Loup Power District	Loup Power District	Estimated from USFWS
Loup River DS	(2012b)	(2012b)	Nest Locations
Niobrara River	Alexander et al. (2010)	Hajek et al. (2010)	Adolf (1998)

#### 134

The mode (bed, mixed or suspended) of river segment sediment transport during peak flow events 135 was characterized based on the ratio of shear velocity  $(u_*)$  to sediment fall velocity  $(\omega)$  at the median annual 136 peak discharge. Shear velocity was characterized as  $u_* = \sqrt{ghS}$  where g = gravitational acceleration (9.8)137 m s<sup>-2</sup>), h was flow depth in meters at median annual peak discharge, and S was channel slope. Sediment fall 138 velocity was characterized as  $\omega = \frac{RgD^2}{C_1\nu + (0.75C_2RgD^3)^{0.5}}$  where D was median segment bed material grain size 139 in meters, R = submerged specific gravity (1.65), g = gravitational acceleration (9.8 m s<sup>-2</sup>), v = kinematic 140 viscosity (1.0 x 10<sup>-6</sup> for water at 20°C) and  $C_1$  and  $C_2$  were constants. The constants for natural sand grains 141  $(C_1=18 \text{ and } C_2=1)$  recommended by Ferguson and Church (2004) were used. Modes of sediment transport 142 for  $u_*/\omega$  of 0.2-0.5 were characterized as bedload, 0.5-2.0 mixed bed and suspended load, and 2.0-5.0 as 143 suspended load (Julien 2010). 144

Total channel widths for each river segment were estimated from 2010 NAIP aerial imagery in ArcMAP. Total width was defined as the total distance from apparent left bank to right bank including vegetated islands but excluding large (multiple square miles) upland areas between channels at major flow splits. This definition was used in an effort to be consistent with the methods used by Elliott et al. (2009)

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149	in a geomorphic classification of the lower Platte River. Widths for the LPR Reaches were recalculated
150	because Elliott e al. (2009) did not report values for the individual segments contained in this comparison.
151	Total channel width was measured at 1,000 foot intervals from aerial images for river segment in ArcMAP.
152	Mean widths and coefficient of variation were calculated for each channel segment.
153	Results
154 155 156	Range-Wide Population Estimates
157	Piping Plover
158	Within the Great Plains/Prairie region, piping plovers nested on five river systems in 2006 with
160	approximately 16% of the total population nesting on riverine habitat (Elliott-Smith et al. 2009). River
161	survey segments from Elliott-Smith et al. (2009) and were generally similar to the physical comparison
162	reaches in this investigation. The highest density of approximately five piping plovers per river mile
163	occurred on the Missouri River below Gavin's Point Dam (Table 5). However, 83% of piping plover adults
164	in that reach (in 2006) nested on created and/or managed riverine habitat (US Army Corps of Engineers
165	2007). The decoupling of species habitat from hydrology and physical process relationships in that segment
166	reduced its utility in this investigation.

Table 5. Lutey (2002) central Platte River piping plover recovery objective and 2006 piping plover census
 river segment adult densities from Elliott-Smith et al. (2009).

River Segment	Adults	<b>River Miles</b>	Adults per Mile*
Lutey (2002) Objective for AHR	<i>79</i>	90	0.9
Missouri River below Gavin's Point Dam	292	58	5.03
Niobrara River - Spencer Dam to Missouri River	98	40	2.45
Missouri River Below Garrison Dam	170	138	1.23
Niobrara River - Spencer Dam to Norden Dam	106	105	1.01
Missouri River Below Ft. Randall Dam	37	48	0.77
Lower Platte River – Elkhorn to Missouri	6	33	0.18
Loup River – North Loup to Diversion	6	38	0.16
Lower Platte River – Loup to Elkhorn	8	70	0.11
Elkhorn River	3	91	0.03
Missouri River Below Fort Peck	5	280	0.02
Central Platte River - AHR	2	90	0.02

<sup>169</sup> \*This is a general description of adult density. Adults were likely not evenly distributed throughout the

170 survey segments.



171 The only unmanaged river segments in 2006 with piping plover densities that approximated the prorated Lutey (2002) objective of 0.9 adults/mile for the AHR occurred on the Niobrara River. The 172 reported piping plover populations on both the lower Platte and Loup Rivers were on the order of 22% (0.2 173 adults/mile) of the proposed AHR recovery objective. However, it should be noted that the number of piping 174 plover observed on the lower Platte has been highly variable over time. During the period of 1988 to 2009, 175 the number of adult piping plovers observed on the lower Platte below Columbus ranged from 0 to 176 approximately 160 (0 to 1.6 adults/mile) with an average of approximately 50 adults (0.5 adults/mile; 177 Brown and Jorgensen 2009). This was approximately 55% of the proposed AHR recovery objective density. 178

#### 179 Least Terns

In 2005, least terns were observed on 14 interior river systems (Lott 2006). Survey segments from 180 Lott (2006) and were similar to the physical comparison reaches in this investigation with the exception 181 that the lower Platte and Loup River segments were not divided into multiple segments. The highest 182 densities of least terns occurred on the Mississippi, Missouri, Arkansas and Niobrara Rivers (Table 6). 183 Overall, the results were similar to piping plovers. A limited proportion of least tern nesting on the Missouri 184 185 River below Gavin's Point Dam (24%) occurred on natural islands (US Army Corps of Engineers 2006) and the only unmanaged river segments with least tern densities that approximated the prorated Lutey 186 (2002) objective of 2.1 adults/mile for the AHR occurred on the Niobrara River. 187

As with piping plovers, the number of least terns observed on the lower Platte was highly variable over time. During the period of 1987 to 2009, the number of adult least terns observed on the lower Platte River ranged from 0 to approximately 400 (0 to 4 adults/mile) with an average of approximately 230 adults (2.5 adults/mile) below the Loup River confluence (Brown and Jorgensen 2009). Using the long-term average, the lower Platte River supported a population density similar to the AHR recovery objective.



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Table 6. Lutey (2002) central Platte River least tern recovery objective and 2005 interior least tern river
 segment adult densities from Lott (2006).

		River	Adults per		
River Segment	Adults	Miles	Mile*		
Lutey (2002) Objective for AHR	189	90	2.1		
Mississippi River (Helena, AR- Greenville, MS)	3,784	140	27.0		
Mississippi River (Cairo, IL-Osceola, AR)	2,450	154	15.9		
Mississippi River (Osceola, AR- Helena, AR)	1,721	120	14.3		
Mississippi River (Greenville, MS- Vicksburg, MS)	1,291	100	12.9		
Missouri River- Gavin's Point Reach, SD-NE*	476	58	8.2		
Mississippi River (Vicksburg, MS- Baton Rouge, LA)	1,622	200	8.1		
Arkansas River, OK (Tulsa to Muskogee)	417	64	6.5		
Niobrara River, NE (HWY 137 - Spencer Dam)	190	40	4.8		
"Lower" Canadian River, OK (below Eufaula Lake)	118	27	4.4		
"Lower" Red River, OK, TX, AR (Denison Dam- Index, Arkansas)	812	240	3.4		
Arkansas River, OK (Keystone Dam to Zink Lake)	54	17	3.2		
Missouri River- Garrison River Reach, ND	199	84	2.4		
Niobrara River, NE (Spencer Dam- confluence with Missouri)	84	39	2.2		
Missouri River- Ft. Randall River Reach, SD	76	36	2.1		
Mississippi River (Cape Girardeau, MO- Cairo, IL)	92	50	1.8		
"Upper" Canadian River, OK-TX (Canadian, TX to Eufaula Lake)	342	300	1.1		
Arkansas River, OK (Kaw to Keystone)	104	92	1.1		
Arkansas River, AR (McKlellen-Kerr Navigation System)	319	289	1.1		
"Upper" Red River (PDT Fork, OK-TX (west of Lake Texoma)	394	410	1.0		
Cimarron River, OK (confluence with Crooked Creek-Keystone)	186	220	0.8		
"Lower" Ohio River Sandbars	132	255	0.5		
"Lower" Platte River (Columbus to confluence with Missouri)	53	105	0.5		
Niobrara River, NE (National Scenic River, Norden to HWY 137)	15	40	0.4		
Loup River	19	68	0.3		
Central Platte River - AHR	3	90	0.03		
This is a general description of adult density. Adults were likely not evenly distributed throughout the					

195 196

197

#### 198 Regional Scale Nest Densities and Fledge Ratios

survey segments.

Nest counts from regional river segments provided another line of evidence for comparison of river segments. Available nest densities from each segment have been included in Table 7. Due to variability in monitoring methodologies, survey effort, and number of years with nest records, Table 7 should only be viewed as a general indicator of comparative nest densities. The prorated Lutey (2002) population objectives for the AHR were divided by two to identify breeding pairs and an annual nest count of one nest per breeding pair was used to identify a minimum AHR nest density objective. Mean nest counts in the



- LPR Reaches (piping plover: 9.2; least tern: 62.1) were somewhat lower than the minimum number of nests
- expected (piping plover: 25; least tern: 115) given the mean adult counts (piping plover: 50; least tern: 230).
- Table 7. Lutey (2002) central Platte River Associated Habitat Reach (AHR) piping plover recovery objective and observed regional piping plover and least tern river segment nesting densities.

Jeenve and observed regional piping prover and reast term river segment nesting densities.						
	Period of	Reach	Mean	Nests per	Mean	Nests per
	Nest	Length	Plover	Mile	Tern	Mile
River Segment	Records	(mi)	Nests		Nests	
Lutey (2002) Objective for AHR		90	39.5	0.4	94.5	1.1
LPR Reach 1	1986-2013	33	5.6	0.2	36.6	1.1
LPR Reach 2	1986-2013	70	3.6	0.1	25.5	0.4
Loup River US	1985-2012	38	3.4	0.1	10.5	0.3
Loup River DS	1985-2011	34	0.9	0.0	6.0	0.2
Niobrara River	2005-2013	40	17.6	0.4	30.4	0.8

209

Fledge ratio data from comparison segments has been included in Table 8. Reported piping plover fledge ratios on the lower Platte River were significantly lower than the proposed AHR objective and fledge ratios on the Niobrara River were slightly lower. Reported least tern fledge ratios on both the lower Platte and Niobrara Rivers were near the proposed AHR objective.

Table 8. Lutey (2002) central Platte River Associated Habitat Reach (AHR) piping plover recovery objective and observed regional piping plover and least tern fledge ratios.

		Plover	Tern
		Fledge	Fledge
River Segment	Monitoring Years	Ratio	Ratio
Lutey (2002) Objective for AHR		1.13	0.7
LPR Reaches	1986-1991, 1994 & 2001	0.65	0.68
Loup Reaches	No Data	-	-
Niobrara River	1996-1997	0.94	0.69

216

#### 217 Physical Conditions Comparison

218

The results of the segment hydrology comparisons are included in Tables 9 and 10.

#### Table 9. Peak discharge metrics from segments of the Associated Habitat Reach (AHR) of the central 219 Platte River, lower Platte River, Loup River and Niobrara River.

220	

					Percent of	Percent of
					Annual	Annual
					Peaks	Peaks
					Occurring	Occurring
		Median	Maximum	Median	outside of	outside of
		Annual	Annual	Date of	Plover	Tern
		Peak	Peak	Annual	Nesting	Nesting
	Analysis	Discharge	Discharge	Peak	Window	Window
<b>River Segment</b>	Period	(cfs)	(cfs)	Discharge	(5/1-8/26)	(5/28-8/30)
AHR	1980-2011	6,095	23,500	5-May	47%	66%
LPR Reach 1	1980-2011	39,450	138,000	1-Jun	34%	50%
LPR Reach 2	1980-2011	20,950	82,300	31-May	41%	50%
Loup River US	1980-2011	8,285	24,050	29-May	41%	53%
Loup River DS	1980-2011	9,565	40,200	29-May	47%	56%
Niobrara River	1980-2011	5,655	22,200	15-Apr	59%	66%

221

Table 10. Annual and low discharge metrics from segments of the Associated Habitat Reach (AHR) of 222 the central Platte River, lower Platte River, Loup River and Niobrara River. 223

				Median of
				Minimum
				Disch. (cfs)
			Number	During
		Mean	of Years	Entire
		Annual	with Zero	Species Nest
	Analysis	Discharge	Discharge	Season
River Segment	Period	(cfs)	Days	(5/1 - 8/30)
AHR	1980-2011	1,895	5	265
LPR Reach 1	1980-2011	8,505	0	2,025
LPR Reach 2	1980-2011	5,122	0	1,085
Loup River US	1980-2011	2,289	0	740
Loup River DS	1980-2011	964	2	22
Niobrara River	1980-2011	1,887	0	815

\*See footnote Table 9. 224

Hydrologic conditions in the contemporary AHR are most similar to those of the Niobrara. 225 Differences between the two reaches were the earlier median date of the annual peak discharge on the 226

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- 227 Niobrara and lower median of minimum discharges during the nesting season in the AHR. The differences
- in low flow characteristics are also apparent in the absence of days with no flow in the Niobrara segment.
- Relevant channel morphology metrics are summarized in Table 11.
- Table 11. Comparison of channel morphology in segments of the Associated Habitat Reach (AHR) of the central Platte River, lower Platte River, Loup River and Niobrara River.

								Mean
				Median	Flow			Area of
		Mean	Coeff. of	Bed	Depth at			Sandbars
		Total	Variation	Material	Median			with
		Channel	Total	Grain	Peak		Sediment	Nesting
	Channel	Width	Channel	Size	Disch.		Transport	Records
River Segment	Slope	(ft)	Width	(mm)	(ft)	$u_*/\omega$	Mode	(ac)
AHR	0.0012	900	0.62	0.96	3.3	0.9	Mixed	1.2
LPR Reach 1	0.0008	1,500	0.28	0.22	7.1	4.9	Suspended	16.9
LPR Reach 2	0.0009	1,800	0.41	0.23	4.7	4.0	Suspended	10.8
Loup River US	0.0015	1,000	0.29	0.24	2.7	3.7	Suspended	11.8
Loup River DS	0.0015	600	0.43	0.20	3.9	5.7	Suspended	22.3
Niobrara River	0.0010 - 0.0015	1,100	0.43	0.24	3.9	4.0	Suspended	27.9

232

The most obvious differences between channel morphology metrics between segments are median bed material grain size and sandbar area (Table 11). The median bed material grain size in the AHR is significantly coarser than the lower Platte, Loup and Niobrara River segments. The other obvious difference between segments is mean sandbar area used by the species. The lower Platte, Loup and Niobrara River segments produce emergent sandbars exceeding 10 acres in size. Sandbars of that size are not present in the AHR.

Channel segment differences that are difficult to quantify but are potentially important include bedrock influences in the Niobrara River segment and the presence of large flow splits in the AHR. The Niobrara River segment differs from all other reaches in the influence of bedrock on channel characteristics which can be seen in the wide range of channel slopes and widths in the segment (Alexander et al. 2010). This variation likely influences segment sediment transport capacity and patterns of erosion and deposition.



The AHR contains four significant flow splits around large islands up to 15 miles long. These islands, which were present in the original 1866 General Land Office Survey, result in split flow conditions in 50% of the AHR. In these reaches, as an example, a total channel width of 1,000 ft may be distributed between a 600 ft-wide main channel and several secondary channels separated by permanent upland areas. Flow splits of this frequency and length are absent from the other river segments in the comparison.

#### 249 Discussion

#### 250 Species Population Objectives in Relation to other River Segments

In 2006, 84% of the Great Plains/Prairie region population of piping plover occurred on nonriverine habitats (Elliott-Smith et al. 2009). Of the five river systems with on-channel piping plover observations, the only unmanaged river segments with adult population densities approaching the Lutey (2002) central Platte River (AHR) objectives were located on the Niobrara River (Table 5). Based on regional nest observations (Table 7), the combined average piping plover nest count from all lower Platte and Loup River segments was 13.5 nests, well below the proposed recovery objective for the AHR.

In 2005, least terns were observed on 14 interior river systems. The highest densities of least terns 257 occurred on the Mississippi, Missouri, Arkansas and Niobrara Rivers (Table 6). Similar to the piping plover, 258 the only regional unmanaged river segments with least tern densities that approximated proposed AHR 259 objective occurred on the Niobrara River (Table 3). However, the average number of least terns observed 260 on the lower Platte River during the period of 1987-2009 was on the order of 230 birds, which was much 261 higher than the 2005 count and similar to the proposed AHR recovery objective. Although the mean lower 262 Platte River segment had adult count was similar to the proposed AHR recovery objective, nest counts of 263 0.5 nests per pair (adult count divided by two) were lower than expected. This can likely be attributed to 264 observations of least terns that nested on off-channel habitat foraging on the river (and imperfect nest 265 detection). This behavior is common in the AHR (Sherfy et al. 2012). 266

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In general, the Niobrara River provided the best adult count approximation to the Lutey (2002) objectives for the AHR. The limited fledge ratio data for the Niobrara was also comparable to the prorated Lutey (2002) objectives (Table 8). The total number of nests observed on the Niobrara River in relation to adult counts was lower than expected at around 0.5 nests per pair (adult count divided by two) but may be the result of low monitoring effort in relation to the amount of available nesting habitat.

#### 272 River Segment Physical Conditions Comparison

A summarization of physical conditions in the AHR in relation to the Niobrara and LPR Reach 1, 273 the two comparison segments with the highest least tern and piping plover densities, has been included as 274 Table 13. From a hydrologic perspective, the AHR is most similar to the Niobrara River with similar mean 275 276 annual and median and maximum annual peak discharges during the period of 1980-2011. Difference include the lower low flows in the AHR during the nesting season and the timing of the annual peak 277 discharge and low flows during the nesting season. The median date of the annual peak discharge in the 278 AHR is 5-May, which is almost three weeks later than the median date of 15-April on the Niobrara River. 279 Consequently, a higher proportion of annual peaks occur during the least tern and piping plover nesting 280 seasons in the AHR (see Chapter 5). 281

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283	Table 13. Summarization of physical conditions in the central Platte River Associated Habitat Reach
284	(AHR), Niobrara and LPR Reach 1 segments.

Metric	AHR	Niobrara	LPR Reach 1	
Segment Length (mi)	90	40	33	
Hydrologic Analysis Period	1980-2011	1980-2011	1980-2011	
Median Annual Peak Discharge	6 095	5 655	39.450	
(cfs)	0,075	5,055	37,430	
Maximum Annual Peak Discharge	23 500	22 200	138 000	
(cfs)	23,300	22,200	150,000	
Median Date of Annual Peak	5-May	15-Apr	1-Jun	
Discharge	5 May			
Annual Peaks Outside of Piping	e of Piping 47%		34%	
Plover Nest Window	1770	5770	5170	
Annual Peaks Outside of Least Tern	66%	66%	50%	
Nest Window	0070	0070		
Mean Annual Discharge (cfs)	1,895	1,887	8,505	
Number of Years with Zero	5	0	0	
Discharge Days				
Median of Minimum Discharge	265	815	2 025	
During Nesting Season (cfs)	205	015	2,025	
Mean Total Channel Width (ft)	900	1,100	1,500	
CV of Total Channel Width	0.62	0.43	0.28	
Channel Slope	0.0012	0.0010-0.0015	0.0008	
Median Bed Material Grain Size	0.06	0.24	0.22	
(mm)	0.90	0.24	0.22	
Flow Depth at Median Peak (ft)	3.3	3.9	7.1	
$u_* / \omega$ at Median Peak	0.9	4.0	4.9	
Sediment Transport Mode	Mixed	Suspended	Suspended	
Mean Area of Sandbars with Nest Records (ac)	1.2	27.9	16.9	

285

From a channel morphology perspective, all of the segments included in the comparison are braided sand bed channels although bedrock influences the channel characteristics of the Niobrara River segment. The channel slope of the AHR is steeper than LPR Reach 1 and flatter than the Niobrara River segment (Table 13). Minimum and mean channel widths in the AHR are similar to those of the Niobrara segment. In approximately 50% of the AHR, total width is distributed between multiple channels. Large flow splits are uncommon in other segments. The maximum channel widths in all of the other segments exceed that of the AHR.



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293 The most obvious physical differences between the AHR and all other segments are the median grain size of bed material and area of sandbars used by the species. The median grain size of the AHR is 294 0.96 mm, which is much coarser than the median grain sizes of 0.2 - 0.3 mm in the other reaches. The 295 difference in bed material grain size translates to differences in sediment transport mode under peak flow 296 conditions. In the AHR, sediment transport at the median peak discharge is mixed bed and suspended load. 297 The other segments are dominated by suspended load at peak discharges. This difference in sediment 298 transport likely contributes to the disparity in sandbar area between segments. Median sandbar area used 299 by least terns and piping plovers in all other segments exceeded 10 acres. Sandbars of that size are not 300 present in the AHR. A visual comparison of emergent sandbar area in each reach during the summer of 301 2010 has been provided (Figure 2) as a recent example of physical conditions following sandbar-forming 302 peak discharges in all comparison reaches. 303



304

Figure 2. NAIP aerial imagery showing sandbars in physical comparison reaches during the summer of

2010. Sandbars significantly exceeding five acres in area were present in all segments except for thecentral Platte River.

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308 In the summer of 2010, all of the segments except for the central Platte River exhibited a channel pattern similar to that described by Buchanan and Schumm (1990) in relation to observations of the 309 Niobrara River and by Cant and Walker (1978) in relation to the South Saskatchewan River in Canada. In 310 both publications, the authors described conditions under which the channels formed well-defined braided 311 thalwegs that meandered through the braid plain between large emergent sand flats. The term "sand flat" is 312 an apt description of the emergent sand areas in all Figure 2 reaches except for the AHR. In the AHR, the 313 channel continued to be dominated by linguoid or transverse bars at high discharges and large sand flats 314 did not form. Sand flat features were present in comparison reaches on other streams with higher and lower 315 peak discharges, and were steeper, flatter, wider and narrower than the contemporary AHR. This indicates 316 that their occurrence may be a function of differences in sediment transport as opposed to hydrology. It 317 should also be noted that large sand flats were absent from the earliest aerial photography of the central 318 Platte River (1938) as well as from descriptions of the pre-development morphology of the AHR (Chapter 319 320 1; Eschner et al. 1983).

#### 321 Management Implications for the Associated Habitat Reach

322 The similar morphology and physical proximity of the Loup River segments would have made them the best management analog to the contemporary AHR but species use of those segments was 323 relatively low. Species use was greater in the lower Platte River segments but hydrology was dissimilar 324 enough that it was difficult to draw useful comparisons. That left the Niobrara River as an analog, but it 325 differed from the AHR in sediment characteristics as well as the high variability in slope and width due, in 326 part, to the significant influence of bedrock on channel characteristics (Alexander et al. 2010). Because 327 none of the segments were ideal analogs, they were considered in aggregate to identify general differences 328 and the potential to manage to reduce those differences in hopes of improving habitat suitability. 329

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#### 331 Peak Flows

The segments with the lowest and highest median annual peak discharges exhibited the highest species use, which is an indication that peak magnitude alone is less important than the interactions between flow, sediment and species nesting ecology. For example, the median peak discharge date on the Niobrara River, which had the highest piping plover use, occurs prior to the piping plover nesting window. In all other segments, the median peak date occurs at the end of May. This is near the end of the piping plover nest initiation window when most nests have been initiated but few chicks have reached fledging age.

#### 338 Low Flows

Low flows during the nesting season are an area of significant contrast between the AHR and all other reaches except for the Loup River DS segment (Table 10). The AHR median of minimum flow per unit of channel width during the nest initiation period ranges from 16% to 50% of that of all other river segments. Median minimum flows of on the order of 600 to 800 cfs during nest initiation would be necessary in the AHR to produce unit discharges similar to the other segments. Achieving a minimum discharge of 600 cfs during the nesting season in all years 1980-2011 would have required augmentation of an average of 27,000 acre-feet of flow annually.

#### 346 Channel Width

Minimum and mean channel width in the Loup and Niobrara River segments are similar to the AHR but maximum channel widths are somewhat lower in the AHR. Overall, the AHR lacks the degree of linear variability in total channel width that was present in the other river segments. The AHR also contains four large-scale islands up to 15 miles long, producing split flow conditions in 50% of the reach. These large-scale flow splits were present historically and are not a recent phenomenon. Small vegetated islands are present in all segments but flow splits on the scale of the AHR are largely absent from other segments.

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In general, it is feasible to mechanically widen channels in the AHR to increase average width and introduce abrupt width changes for the purpose of encouraging sediment deposition. The degree of transitional widening that would be considered suitable to induce deposition has not been determined, but achieving the magnitude of width variation present in the other segments would be difficult. Regardless of the degree of widening deemed appropriate, ongoing mechanical management of in-channel vegetation in those reaches would likely be necessary, especially in locations with split flow.

#### 359 Bed Material Grain Size

The median bed material grain size of the AHR (0.96 mm) is roughly three to four times coarser than the other analysis segments (0.2-0.3 mm). Sieve analyses of alluvial sediment samples from Program sediment augmentation boreholes and monitoring wells in accreted channel areas that were active in 1938 indicate that sediments finer than 0.2 mm comprise only 10% of total sub-surface alluvium by weight. Shifting the median bed material grain size of the AHR into the range of the other segments would require augmentation of millions of tons of fine sand annually, which would have to be produced through mining and sorting of valley alluvium.

In 2012, the Program implemented a pilot-scale sediment augmentation experiment that included mining and sorting of valley alluvium to manage grain size distribution (The Flatwater Group Inc. 2014). The augmentation experiment results indicated that mining and sorting of augmentation material is technically feasible but quite labor intensive and expensive. Overall, the limited amount of suitable source material in relation to the volume of sediment necessary to shift grain size on a reach scale and cost of producing that material likely make it technically and economically infeasible to substantially shift the median bed material grain size of the AHR.

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#### 375 <u>Sandbar Area</u>

The large sandbars utilized by the species in all other river segments are completely absent from the AHR. As discussed previously, the absence is likely due to the significant difference in bed material grain size distributions, which appears to be somewhat intractable. As such, it is unlikely that the AHR would ever support the large-scale sand flats used by the species in the other segments unless they were mechanically created and maintained.

#### 381 <u>Management Implications in Relation to FSM Management Strategy</u>

The two most important segment-scale differences that could potentially be addressed in a meaningful way given Program land, water, and fiscal resources are 1) channel width and 2) magnitude of low flows during the nesting season. One of the hypothesized benefits of implementation of the FSM management strategy is an increase in channel width achieved through mechanical channel widening followed by implementation of short-duration high flow releases on a near annual basis. The FSM management strategy does not include management actions to improve low flow magnitude during the nesting season but USFWS flow targets for the AHR do provide for this management action.

The sediment component of the FSM strategy is focused on sediment augmentation to offset the 389 existing deficit due to clear water hydropower return flows at the upper end of the reach and restore the 390 reach to sediment balance. Oversupplying the AHR with fine sand through augmentation to shift bed 391 material grain size has not been attempted and it appears that the alluvium of the AHR lacks sufficient fine 392 sand deposits to do so. Consequently, it is unlikely that augmentation would be capable of shifting bed 393 material grain size distributions into the range of the other river segments. Overall, the findings of this 394 investigation are not a positive indicator for the Program's ability to manage flow and sediment to create 395 habitat conditions similar to other segments nor does it indicate that doing so would facilitate species use 396 on the magnitude of the proposed Lutey (2002) recovery objectives. 397



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APPENDIX A – Independent Peer Review Report

### Peer Review of *Platte River Recovery Implementation Program Tern and Plover Habitat Synthesis Chapters*

Summary Report

January 2015



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#### 1.0 INTRODUCTION

#### 1.1 Background

The Executive Director's Office (EDO) of the Platte River Recovery Implementation Program (PRRIP or Program) prepared a series of six chapters related to the habitat of and use by the interior least tern and piping plover on the central Platte River in Nebraska. The chapters present information and analyses intended to inform the use of Program resources to achieve one of the Program's management objectives: increasing production of the tern and plover from the Associated Habitat Reach (AHR) along the central Platte River. The Program is implementing an Adaptive Management Plan (AMP) to reduce uncertainties about proposed management strategies and learn about river and species response to management actions. Information presented in these chapters was obtained as part of the AMP through three different approaches: monitoring of physical and biological response to management treatments, predictive modeling, and retrospective analyses. These synthesis chapters represent multiple lines of evidence across a range of spatial and temporal scales. Several lines of evidence now indicate that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the stated management objective for least terns and piping plovers. Presenting these lines of evidence for broader examination is the primary objective of this publication.

#### 1.2 Purpose and Scope of Peer Review

The purpose of this review is to provide a formal, independent, external scientific peer review of the information presented in the six tern and plover habitat synthesis chapters. Reviewers were charged with evaluating the scientific merit of the chapters' technical analyses and conclusions; ensure any scientific uncertainties are clearly identified and characterized; and clearly identify the potential implications of the uncertainties on the technical conclusions.

Specifically, the PRRIP requested that reviewers consider and respond to the questions listed below, at a minimum, in their reviews.

#### General Questions

- Does the combined set of tern and plover habitat synthesis chapters adequately address the overall objective of the chapters, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for least terns and piping plovers?
- Do the authors of the tern and plover habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

- 3. Are there any <u>seminal</u> peer-reviewed scientific papers that the tern and plover habitat synthesis chapters omits from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.
- 4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?
- 5. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of these chapters and then discussed in the results and conclusion sections?

#### Chapter-Specific Questions

#### CHAPTER 3

- 6. Are the methods used to measure sandbar heights in the AHR appropriate? Do the results appear to be reasonable?
- 7. Is it reasonable to use distributions of observed sandbar height and area relative to peak stage along with reach stage-discharge relationships to infer the Program's ability to use the FSM management strategy to increase sandbar area and height to support sufficient use and reproductive success resulting in increases in the populations of terns and plovers within the AHR?

#### CHAPTER 4

8. Is the inferential caution issued by the authors (see lines 276-288), with respect to the confounding effect of colony nest site selection and the geomorphic process responsible for building islands, correct for this study?

#### CHAPTER 5

- 9. Are the methods used to predict the frequency of inundation for sandbars in this chapter appropriate?
- 10. Is it appropriate to use the MOVE.1 method to infer flow at Overton for the period of 1895-1916 and treat this as representative conditions for the Associated Habitat Reach?
- 11. Is the relationship of sandbar height (relative to peak flow stage) decreasing as sediment size decreases appropriate for the central Platte River based on observed sandbar heights in the central and lower Platte River and the available body of scientific literature?

- 12. Does the approach used to infer sandbar heights in the historical central Platte River appear to be reasonable? The historical river analysis period extended from 1895-1938.
- 13. On pages 19 and 25, piping plover/least tern nest initiation period is assumed to be the same historically as it is today. Is this a reasonable assumption?

#### CHAPTER 6

- 14. Is the conclusion that "implementation of FSM...will likely not create or maintain least tern and piping plover nesting habitat" appropriate and supported by the evidence presented?
- 15. Is the finding that indicates it is unlikely that the Program has the ability to manage flow and sediment to create habitat conditions that could support sufficient use and reproductive success and result in tern and plover population growth within the AHR supported by the data and information presented in these chapters?

#### 2.0 PEER REVIEW PROCESS

Louis Berger was retained by the PRRIP to facilitate the peer review process. Louis Berger' responsibilities in the peer review process included 11 steps:

- 1. Develop a clear understanding of the required expertise of each position;
- 2. Conduct a search for potential candidates;
- 3. Contact prospective candidates to screen for criteria and conflict of interest;
- 4. Obtain CVs/resumes, biographical sketch forms, and signed "no-conflict-of-interest" statements from all candidates;
- 5. Compile a summary report describing recruitment process and candidate qualifications;
- 6. Communicate with reviewers regarding the selection process;
- 7. Discuss the scope and charge with the EDO;
- 8. Participate in an organizational conference call with the reviewers;
- 9. Distribute materials and commence review;
- 10. Compile all peer review comments into a spreadsheet and summarize in a summary report; and
- 11. Submit spreadsheet and summary report to the EDO and facilitate communication between the EDO and reviewers.

#### 2.1 Selection of Reviewers

The Program requested peer review panel member candidates with big-picture awareness of the issues facing regulated sand bed rivers, such as the Platte, Missouri, Red and Mississippi rivers, as well as expertise in least tern and piping plover ecology in managed rivers of the Great Plains. Candidates should have a background in riverine restoration programs and synthesis issues. Disciplines and areas of expertise

may include tern and plover ecology, geomorphology, hydrology, riparian ecology and adaptive management.

In September 2014, Louis Berger submitted a report to the Program that summarized the qualifications of nine candidate reviewers. Between September and November 2014 the Program's Governance Committee selected four reviewers from that list. The panel comprised the following individuals (see Appendix C for biographical sketches):

Dr. Kate Buenau, tern and plover ecology Dr. Daniel Catlin, tern and plover ecology Dr. Mathias Kondolf, geomorphology Robert Wiley, tern and plover ecology

#### 2.2 Document Review and Report Development

Following final approval of the four reviewers, Louis Berger initiated the review by distributing the files to the reviewers, including: the tern and plover synthesis chapters to be reviewed; the scope of work for the peer review; files of all references cited in the chapters; State of the Platte reports for 2012 and 2013; and the Program's Adaptive Management Plan. Files were distributed via Dropbox. Louis Berger staff held individual conference calls in November with each of the four reviewers to discuss the scope of work, deliverables, and schedule, and answer any questions.

Reviewers conducted their independent desktop reviewers between November 4, 2014 and January 12, 2015. Each reviewer submitted three deliverables:

- 1. Responses to the general and chapter-specific questions listed in Section 1.2;
- 2. Ratings of the set of chapters in six different categories, as well as an overall recommendation; and
- 3. Specific comments on the text of chapters, by page and line number.

Upon receipt of the deliverables, Louis Berger compiled the specific comments into a spreadsheet, organized by chapter, page, and line numbers. Louis Berger summarized reviewer responses to the general and chapter-specific questions in this summary report, which also includes their ratings and recommendations. Individual reviewer comments are included as Appendix A.

Louis Berger submitted the draft report to the EDO for review on January 14, 2015. As described in Section 3.3, two reviewers (Dr. Kondolf and Mr. Wiley) recommended that the chapters be accepted with revisions. Louis Berger served as the link between the EDO and these two reviewers during several email exchanges in January to clarify the specific requested revisions. Once there was mutual understanding, the EDO requested that the summary report be finalized, including the content of those emails.

#### 3.0 RESULTS

#### 3.1 Responses to General Questions

Below are brief summaries of the individual reviewers' responses to the five general questions posed by the PRRIP. This section is not intended to be a comprehensive summary or to be redundant with the individual comments in Appendix A, but rather attempts to capture some of the primary comments in each reviewer's response to the individual questions, as well as any themes that emerged or comments that were raised by more than one reviewer independently. For the reviewers' full comments see Appendix A and the comments spreadsheet.

Question 1: Does the combined set of tern and plover habitat synthesis chapters adequately address the overall objective of the chapters, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for least terns and piping plovers?

The reviewers agreed that, in general, the combined set of chapters addresses the overall objective to present evidence that the FSM may not achieve the Program's tern and plover management objective. Dr. Buenau noted that while some components of the FSM management strategy were not quantitatively evaluated (e.g., vegetation management), those that were addressed are the most likely limiting factors. In response to this question, Dr. Catlin raised several points as a general assessment of the consolidated chapters, including the need for greater detail in several areas, as well as comments on how uncertainty is addressed. Dr. Kondolf cited concerns about whether the condition of sediment balance has been met, because if it has not, the FSM approach has not been fully implemented. Mr. Wiley also referred to other specific comments throughout the chapters on details and assertions related to this question.

# Question 2: Do the authors of the tern and plover habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

The reviewers agreed that overall the authors' conclusions are reasonable and scientifically sound. Both Dr. Buenau and Dr. Catlin refer to their other specific comments and responses to other questions that point out areas requiring greater clarification. They both specifically mention the authors' treatment of uncertainty, and Dr. Buenau noted instances where uncertainty analyses could be more complete or robust, though she pointed out that the analyses as performed are still reasonable and scientifically sound. Dr. Kondolf mentioned several issues discussed in his other specific comments, such as treatment of sediment deficit, whether the AHR ever had large sandbars, and the impacts of summer flooding on habitat, among others. Mr. Wiley found the conclusions to be well researched and well founded.

## Question 3: Are there any <u>seminal</u> peer-reviewed scientific papers that the tern and plover habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

Reviewer responses to this question varied. Dr. Buenau and Dr. Kondolf were not aware of any other papers that need to be considered at this time. Dr. Catlin noted that several works cited in Catlin et al. (2010) related to relationships between sandbar heights and flows were not included in the chapters. He said that while no seminal works specific to the region were omitted, the Program could benefit from placing its results within the larger context of the two species by broadening its literature use outside the specific area. Mr. Wiley referred to his response to Question 15 in which he suggested five additional papers (including citations) for the authors to review.

### Question 4: Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

Overall the reviewers concluded that, in general, these relationships are at least adequately described and validated, but several pointed out examples of areas that could benefit from further clarification. Dr. Buenau noted that the authors could explore, in greater detail, how the physical characteristics of the AHR contribute to the findings in the report, especially habitat formation processes. She offered suggestions to improve confidence in the report's use of limited evidence, though she acknowledged that it would probably not change the fundamental conclusions. Dr. Catlin provided four examples where clarification and/or justification would be helpful so the reader is not left to make assumptions (e.g., exclusion of data from the analysis because of mechanical alterations, use of fully parameterized models). Dr. Kondolf referred to caveats regarding the conclusion that FSM cannot work in the AHR, which are described in his specific comments. Mr. Wiley answered this question affirmatively, noting that the chapters were well explained and referenced, though some references were somewhat dated.

### Question 5: Are potential biases, errors, or uncertainties appropriately considered within the methods sections of these chapters and then discussed in the results and conclusion sections?

Three of the four reviewers (Buenau, Catlin, and Kondolf) expressed some similar comments in response to this question, indicating that this may be an area of weakness in the report. Dr. Buenau and Dr. Catlin agreed that the authors state and discuss a number of uncertainties in the chapters, and both some weaknesses in how uncertainties are analyzed and conveyed. Dr. Buenau pointed out the lack of quantitative analysis of uncertainties, and suggested that the authors conduct a sensitivity analysis on key assumptions to strengthen the utility of the information for decision makers. Dr. Catlin noted instances where the authors do not appropriately convey uncertainty, using language that overstates the degree of certainty (e.g., related to sandbar height). Both Drs. Buenau and Catlin also mention the inclusion of error measurements as another suggestion. Both reviewers acknowledge that addressing these comments

would improve the report, but they are not "fatal" or invalidating of the results. Dr. Kondolf stated that uncertainties are not always appropriately considered and discussed in the chapters (e.g., cumulative uncertainties about conclusion that sandbars were historically too low to provide viable habitat are not explicitly considered). Mr. Wiley answered this question affirmatively.

#### 3.2 Responses to Chapter-Specific Questions

Below are brief summaries of the individual reviewers' responses to the ten chapter-specific questions posed by the PRRIP. As noted above, these summaries are not intended to be comprehensive or redundant, but attempt to capture an overview of the reviewers' primary comments and identify any common themes. For the reviewers' full comments see Appendix A and the comments spreadsheet.

#### CHAPTER 3

## Question 6: Are the methods used to measure sandbar heights in the AHR appropriate? Do the results appear to be reasonable?

Reviewer responses to this question varied. Dr. Buenau responded that, within the uncertainties inherent in the modeling and sandbar delineations, the results and conclusions appear to be sound. She did note, however, that results from the 2011 and 2013 high flow events provide important lines of evidence given the limited data available, and suggest that "a wide range of outcomes is possible, though none may achieve objectives", thus a more thorough explanation of outcomes may be warranted. Dr. Catlin also commented on the exclusion of the 2011 and 2013 data from the discussion, and suggested that these results, combined with the 2010 data, "present a stronger case against the SDHF as it is currently conceived." If these data remain excluded, he suggests that the authors explicitly state their reasoning for doing so. Dr. Kondolf noted that "direct observation during high flows could be more feasible now with improved technology" and suggested the Program consider these technologies to obtain empirical data that may also be useful for model calibration. Mr. Wiley's comments suggest he does not completely agree with the appropriateness of the methods used in Chapter 3 because they do not consider the gauge data for the period of record and average conditions are not relevant to reproductive success. He noted that "nest success depends on whether there is a destructive (island-topping) flood event after egg laying and/or hatch" not total sandbar height, thus the gauge data could be analyzed for the period of record to identify the frequency of nondestructive breeding seasons.

Question 7: Is it reasonable to use distributions of observed sandbar height and area relative to peak stage along with reach stage-discharge relationships to infer the Program's ability to use the FSM management strategy to increase sandbar area and height to support sufficient use and reproductive success resulting in increases in the populations of terns and plovers within the AHR?

Reviewer responses to this question varied. Dr. Buenau stated that the 2010 results present a reasonably strong line of evidence against the hypothesis, but offered that, if possible, the authors may want to explore

other explanations and lines of evidence to determine whether a different specified flow may make the FSM management strategy more successful. Dr. Catlin questioned whether a clear conclusion can be reached based on the available data, but did not find fault with the interpretation of results. Dr. Kondolf agreed that the approach was reasonable, but reiterated that assumptions and uncertainties could be better summarized and presented. Mr. Wiley agreed that a direct relationship between stage and sandbar height is reasonable, and reiterated that the height needed for successful nesting depends on subsequent summer storm flows.

#### CHAPTER 4

# Question 8: Is the inferential caution issued by the authors (see lines 276-288), with respect to the confounding effect of colony nest site selection and the geomorphic process responsible for building islands, correct for this study?

Dr. Buenau responded that the inferential caution is reasonable, though the presence of absence of sandbars at particular locations may be less critical to the evaluating the hypothesis discussed in this chapter than other factors. Dr. Catlin questioned why the authors did not attempt to tease apart the width-sandbar interaction by evaluating the presence of sand in aerial photographs, and if that is not possible the authors should mention that in the methods. He also wondered why a greater comparison of the Loup River and the AHR was not included, given that the Loup has "used areas" with similar widths to those on the AHR. Dr. Kondolf found the discussion to be reasonable. Mr. Wiley said the inferential caution is not correct and referenced his extensive comments on this section. He also included a graph of least tern nest counts and distance from the forest edge in the Gavins Point segment of the Missouri River to indicate this relationship may be stronger than that between nest incidence and channel width.

#### CHAPTER 5

## Question 9: Are the methods used to predict the frequency of inundation for sandbars in this chapter appropriate?

Dr. Buenau noted that the methods assume sandbar height is driven by peak stage, which does not factor in the potential effects of peak stage duration or conditions before and after peak discharge. At a minimum, the uncertainties and their potential effects should be discussed. Dr. Catlin referenced his comments on this section, in particular the use of median sandbar heights, which does not account for the ability of chicks to move to higher elevations during rising waters. He acknowledged the possibility that he may have misinterpreted these methods, but if not, he suggested using the median value for nests and the maximum for chicks. Dr. Kondolf responded that the approach is reasonable, but is based on many calculations, assumptions, etc. Mr. Wiley responded that the correct approach was used, but there are uncertainties related to changes in precipitation patterns and future water demands that may affect predicted values.
### Question 10: Is it appropriate to use the MOVE.1 method to infer flow at Overton for the period of 1895-1916 and treat this as representative conditions for the Associated Habitat Reach?

In response to this question, Dr. Buenau listed six reasons that make it difficult to fully assess the appropriateness of using this method, and noted that while these concerns may not indicate the method is inappropriate, a discussion of uncertainty, validation, and alternative methods may increase confidence in the results. This question was outside of Dr. Catlin's area of expertise so he did not comment. Dr. Kondolf mentioned the Hirsch (1982) conclusion that MOVE.2 was more suitable for his tests than MOVE.1 and pointed out that the report does not mention MOVE.2 or why MOVE.1 was selected; however, this is outside his specific area of expertise. Mr. Wiley noted that the method appears to be the best available given limited datasets, and posed additional questions for clarification.

# Question 11: Is the relationship of sandbar height (relative to peak flow stage) decreasing as sediment size decreases appropriate for the central Platte River based on observed sandbar heights in the central and lower Platte River and the available body of scientific literature?

Both Dr. Buenau and Dr. Catlin responded that this question was outside of their areas of expertise. Dr. Kondolf noted that this relationship is reasonable, but cautioned that there are many influential factors, thus uncertainties should be explicitly recognized. In his response, Mr. Wiley summarized the relationships between bed load particle size, velocity, stage, and sandbar height, and noted that these relationships are not unique to the Platte River and are supported by the literature.

### Question 12: Does the approach used to infer sandbar heights in the historical central Platte River appear to be reasonable? The historical river analysis period extended from 1895-1938.

Dr. Buenau commented that if conditions in the historical AHR are similar to the LPR and/or contemporary AHR, then the approach seems reasonable; however, she raised some questions about assumptions and unclear decisions, and suggested a sensitivity analysis to inform the importance of these uncertainties. Dr. Catlin questioned whether there is a way to incorporate error measurements into prediction. As noted in his responses to the general questions, without measures of uncertainty the discussion conveys a false sense of certainty in the statistics. Dr. Kondolf responded that the explanation was somewhat unclear, and though he found the approach to be reasonable, it is not definitive. Mr. Wiley responded that both approaches appear to be sound.

### Question 13: On pages 19 and 25, piping plover/least tern nest initiation period is assumed to be the same historically as it is today. Is this a reasonable assumption?

Three of the four reviewers (Buenau, Catlin, and Wiley) generally agreed that this is a reasonable assumption based on available data. Dr. Buenau asked whether it would be possible to compare with data from the LPR that experiences a more frequent spring pulse to support the assumption that timing has not

changed. Dr. Catlin mentioned a few early studies of piping plovers on the Atlantic coast (Wilcox 1959, Cairns 1982) that could be compared to current monitoring to determine if any plovers have shifted their breeding times. Mr. Wiley questioned germaneness of this question, noting that a management plan for the Platte River cannot address this issue. Dr. Kondolf noted that this is outside of his area of expertise.

#### CHAPTER 6

### Question 14: Is the conclusion that "implementation of FSM...will likely not create or maintain least tern and piping plover nesting habitat" appropriate and supported by the evidence presented?

The reviewers concurred that, overall, that the evidence presented does not support the effectiveness of FSM. Dr. Buenau summarized the three main lines of evidence and concluded that they suggest the FSM methodology has limited chance of success. She also reiterated previous comments on the analysis' reliance on a single high flow event and the lack of a quantitative uncertainty analysis, which would strengthen the argument against FSM. Dr. Catlin also agreed that the available evidence does not support FSM, but restated that conclusions are based on a single natural experiment, thus claims about the "likelihood" of FSM creating habitat are too strong. Dr. Kondolf concluded that the evidence "casts doubt on the effectiveness of the methods," but noted that the assumption of sediment balance does not appear to be met, therefore the evidence is not a basis for concluding that FSM cannot work. Mr. Wiley agreed with the chapter's conclusion, but noted that the comparisons between the various segments in Chapter 6 are not convincing or useful and the case against FSM was best presented in Chapter 5.

#### Question 15: Is the finding that indicates it is unlikely that the Program has the ability to manage flow and sediment to create habitat conditions that could support sufficient use and reproductive success and result in tern and plover population growth within the AHR supported by the data and information presented in these chapters?

The reviewers generally agreed with the finding as stated in this question. Dr. Buenau listed several other points of evidence, in addition to those pertaining to the FSM strategy, that suggest conditions in the AHR are not ideal for successfully creating habitat as compared to other segments, though some of the consequences of those differences are not fully explained. She also mentioned several shortcomings of the report, including not addressing the feasibility of long-term flow management or whether the AM program allows for significant changes to flows in the future. Dr. Catlin noted the absence of evidence about population growth, and stated that without information on demographic consequences of habitat availability, words like "unlikely" are too strong. Dr. Kondolf agreed with the finding, given the caveats mentioned in his other responses and specific comments. Mr. Wiley listed several reasons why spending money to increase tern and plover productivity in the AHR is not wise and expressed his approval of the report's evaluations and conclusions. He noted a few aspects of tern and plover site selection that were not addressed in the report and suggested that the authors review several papers on these topics.

#### 3.3 Ratings and Recommendations

Reviewers rated the set of chapters using a rating system provided by the Program where 1 = Excellent; 2 = Very Good; 3 = Good; 4 = Fair; 5 = Poor. Below is a table summarizing each reviewer's ratings. Note that Mr. Wiley prepared individual ratings for each chapter and the conclusion (see Appendix A), which varied widely across chapters in some cases; the average for each category is presented below.

Table 3-1. Reviewer comprehensive ratings of combined set of chapters, by category.

Category	Buenau	Catlin	Kondolf	Wiley
Scientific soundness	2	3	1	1.9
Degree to which conclusions are supported by the data	2	2	1.5	1.6
Organization and clarity	3	3	1	1.6
Cohesiveness and conclusions	2	2	1.5	1.9
Conciseness	1	2	1	1.9
Important to objectives of the Program	1	2	1	1.9

Reviewers were then asked to provide their recommendation to either accept the chapters, accept them with revisions, or deem them unacceptable. Below are their recommendations and any explanations provided.

Table 3-2. Reviewer recommendations on combined set of chapters.

Recommendation	Buenau	Catlin	Kondolf	Wiley
Accept	Х	Х		X (Chapters 1-5 and Summary of Key Findings)
Accept with revisions			Х	X (Chapter 6)
Unacceptable				

Dr. Buenau said there are no "fatal flaws or major revisions that would significantly change the conclusions;" however, she noted a number of minor revisions that would strengthen the conclusions and provide greater clarity, thus she may be somewhere between "accept" and "accept with revisions." Dr. Kondolf described specific revisions related to a map showing river miles and other features, the basis for the sediment deficit and budget statements, and a discussion of how the AHR differs from other reaches. Comments regarding the sediment deficit and budget were clarified in subsequent emails, which are included with Dr. Kondolf's comments in Appendix A. Mr. Wiley recommended that all chapters be accepted except Chapter 6, which he did not find necessary; however, upon learning the rationale for Chapter 6 via subsequent emails, Mr. Wiley did not object to its inclusion. These comments are also included at the end of Mr. Wiley's comments in Appendix A.

#### 3.4 Other Specific Comments

The reviewers submitted 272 specific comments, by either inserting comments into the PDF version of the compiled chapters (Dr. Catlin), making track changes comments in the Word files (Mr. Wiley), or listing their comments by page and line number (Dr. Buenau, Dr. Kondolf). Louis Berger compiled all comments into a spreadsheet, organized by chapter, page, and line number, along with reviewer name; this spreadsheet will be used by the PRRIP in preparing responses to the comments. The reviewers often referred to these

specific comments in their responses to the questions above and in their full individual comments (Appendix A).

#### 4.0 REFERENCES

The following references were cited in Section 3.0 above. The citations for other references recommended by the reviewers are included in their individual comments in Appendix A.

Cairns, W.E. 1982. Biology and behavior of breeding piping plovers. Wilson Bulletin 94(4): 531-545.

Wilcox, L. 1959. A twenty year banding study of the piping plover. The Auk 76(2): 129-152.

#### 5.0 APPENDICES

Appendix A: Individual Reviewer Comments

#### APPENDIX A: INDIVIDUAL REVIEWER COMMENTS

#### Peer Review submitted by Kate Buenau

#### RATING

Please score each aspect of this set of chapters using the following rating system: 1 = Excellent; 2 = Very Good; 3 = Good; 4 = Fair; 5 = Poor

#### **Category Rating**

Scientific soundness \_\_2\_\_ Degree to which conclusions are supported by the data \_\_2\_\_ Organization and clarity \_\_3\_\_ Cohesiveness of conclusions \_\_2\_\_ Conciseness \_\_1\_\_ Important to objectives of the Program \_\_1\_\_

#### **RECOMMENDATION** (Check One)

Accept \_\_X\_\_\_ Accept with revisions \_\_\_\_\_ Unacceptable \_\_\_\_\_

Note: I chose Accept because I don't think there are fatal flaws or major revisions that would significantly change the conclusions. I do think there are a number of minor revisions that would strengthen conclusions and/or improve clarity and recommend that they be considered, so perhaps my recommendations would fall between "Accept" and "Accept with revisions."

#### Charge Questions

1. Does the combined set of tern and plover habitat synthesis chapters adequately address the overall objective of the chapters, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for least terns and piping plovers?

Yes, the chapters address evidence for key components of the FSM management strategy, including the ability of flows to build sandbars to sufficient elevation, the likelihood of sandbar inundation during the nesting interval and the consequent presence or absence of a habitat window for fledging of chicks, the effects of channel width on nest site selection and comparison of the physical characteristics of the AHR with the most similar river segments used for tern and plover nesting. Not every component of the FSM management strategy has been quantitatively evaluated (e.g. vegetation management), but those that have been addressed are likely the greatest limiting factors.

Implementation of one main component of the FSM strategy, flow consolidation, was determined to be infeasible; consequently evidence for or against the effectiveness of that action has not been presented. This need not weaken the assessment of the other aspects of the management strategy as long as it is recognized that the FSM strategy as initially envisioned cannot be and has not been implemented, potentially altering the effects of other

management actions that would have worked in conjunction with flow consolidation. The evidence as presented addresses the effectiveness of the remaining suite of actions.

2. Do the authors of the tern and plover habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

The conclusions are generally sound, though I have included a number of questions and comments intended to clarify details of the analyses. There are instances where uncertainty analysis would strengthen the ability to infer (or not) conclusions from specific data (discussed further in response to question 5); this is not to say that the analyses as performed are not reasonable or scientifically sound, but that they could be more complete and robust.

3. Are there any seminal peer-reviewed scientific papers that the tern and plover habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

None evident at this time.

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

Generally, yes. There is potential for more extensive exploration of how the physical characteristics of the AHR as described in the final chapter in relation to other rivers contribute to the findings in the report, particularly in relation to habitat formation processes. The evidence from the 2010 high flow event is addressed directly and reasonably, but as it is only a single event, a more mechanistic and thorough understanding of why program hypotheses were not supported by available evidence would support decision-making based on that limited evidence. Several key assumptions in the analysis rely on the applicability of the 2010 event to future flows, and some evidence exists that was not included in the quantitative assessment (2011 and 2013 high flows) because of the unusual circumstances of those events. It does not appear that the fundamental conclusions would change, but a strong conceptual framework would improve confidence in the use of limited evidence. If broader synthesis is out of the scope of this document, it may be a useful future step.

5. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of these chapters and then discussed in the results and conclusion sections?

A number of uncertainties are mentioned and discussed, and the reliance of the sandbar height analysis and the related models on the quantitative analysis of a single event is mentioned in several instances. There is little quantitative analysis of these uncertainties, however. It would be practical for at least some of the uncertainties to conduct sensitivity analysis on key assumptions. For example, the BAR HEIGHT variable in the habitat availability model is based upon a single event for the contemporary AHR, and extrapolated for the historical AHR based upon what is known about the relationship between that segment and the current AHR and LPR. It would be technically straightforward to conduct the same analysis with that parameter (or others) as random variables to understand the importance of accuracy on the results and conclusions. Given that there is empirical evidence for mismatches between the model predictions and historical observations, it seems important to include some error in the model and quantify its effects. The lack of uncertainty assessment does not necessarily invalidate the results of the assessments as they were performed, but weakens the utility of that information for decision making and identifying whether additional information is necessary.

I have mentioned several key uncertainties that may benefit from quantification in the chapter-specific questions and comments. Another key uncertainty is the accuracy of the historical flow record extension; it is possible more work was done than was reported about the effectiveness and suitability of the method, but given the potential for error and bias, particularly due to the short time interval of the available data compared to the projected data and the significance of extreme events, more treatment of uncertainty may be warranted.

#### Chapter-Specific Questions

#### CHAPTER 3

6. Are the methods used to measure sandbar heights in the AHR appropriate? Do the results appear to be reasonable?

The sandbar height analysis uses observed sandbar elevations after the 2010 high-flow event and 1-dimensional steady flow modeling to determine the height of the sandbars built by that flow event, in relation to the peak flow stage. The HEC-RAS stage-discharge curve was validated against the existing rating curve at Kearney and was found to have a significantly steeper slope across a range of channel widths than the curve used in developing the flow hypothesis, using a different model, that was not empirically validated. The 2010 event was used to test the hypotheses that short-duration high flows would build sandbars to the level of the peak flow stage, and that the sandbars thus formed would be high enough to support nesting, with an elevation of 1.5' above the stage at 1,200 cfs. The analysis found that sandbars were not formed to peak stage but rather 1.5' lower, and that this would only be 0.4-1' above water elevation at 1,200 cfs, and further, that they would be inundated for 67-76% of nesting flows.

Within any uncertainties inherent in the HEC-RAS modeling and/or sandbar delineations, which are not explored in the text, this conclusion appears to be sound.

The chapter includes an explanation of why the analysis could not be replicated with the 2011 and 2013 high flow events. The exclusion of those events seems reasonable; however they are still important lines of evidence, even qualitatively, given the limited data

available. The variability in outcome with these different events given the shape of the hydrograph, differing initial conditions, and differing subsequent events suggest that a wide range of outcomes is possible, though none may achieve objectives. A more thorough mechanistic exploration of why the observed outcomes may have occurred in those other years and what that would mean for other planned flow events may be warranted.

7. Is it reasonable to use distributions of observed sandbar height and area relative to peak stage along with reach stage-discharge relationships to infer the Program's ability to use the FSM management strategy to increase sandbar area and height to support sufficient use and reproductive success resulting in increases in the populations of terns and plovers within the AHR?

That event was of similar magnitude and longer duration than the planned SDHF management action, suggesting that the shortfall in habitat creation would be greater for the planned flow duration. Given that the flow hypothesis is specific to one flow action of given magnitude and duration, it is a reasonably strong line of evidence against the hypothesis. However, as it is only one data point, it may be valuable to explore, if possible, explanations for why the results did not match the hypothesis and to look for other applicable lines of evidence. For example were there features of that particular year and situation that may have caused the outcome; was magnitude and/or duration insufficient; is there a feature of the AHR that is inherently unsuited for flow events (e.g. river characteristics as described in chapter 6.) If this exploration is out of the scope of the chapter or report, it may be important in the overall AMP to determine whether conclusions only apply to the specified flow (or those within the bounds of the 2010 event) or whether they can be applied with any certainty to flow actions in general; that is, would a different specified flow make the FSM strategy more successful.

#### CHAPTER 4

8. Is the inferential caution issued by the authors (see lines 276-288), with respect to the confounding effect of colony nest site selection and the geomorphic process responsible for building islands, correct for this study?

The inferential caution is reasonable, though may be less significant together with other lines of evidence (e.g. morphological traits of studied river segments). As the goal of the chapter is to determine the effect of channel width directly, the presence or absence of sandbars at particular locations is not critically important for evaluating the hypothesis that nesting increases with total and/or consolidated channel width. In application it could be important, as the AHR has narrow channels and understanding why the birds avoid narrow channels elsewhere is important. However, given how limited or absent habitat is in the AHR, it may be less critical. (It is likely also important to understand how the factors that led the authors to not include the AHR in the analysis affect the application of the results to the AHR.)

CHAPTER 5

9. Are the methods used to predict the frequency of inundation for sandbars in this chapter appropriate?

Predicting inundation during the nesting season relies on 1) determining the height of sandbars during the nesting season, 2) determining the river flow and stage during the nesting season (which also affects sandbar height) and 3) relating availability to nesting patterns. The sandbar height model is based on observations from the central and lower Platte during a very limited number of high flow events. It also assumes that sandbar height is driven by peak stage. Using simply the peak discharge/stage, however, does not allow for the potential effects of duration of peak discharge, conditions prior to peak discharge, and erosional or depositional effects of flows after peak discharge. The qualitative evidence from the 2011 and 2013 high flow events mentioned but not analyzed in Chapter 3 suggest that conditions before and after peak discharge may have significant effects on habitat formation/persistence. There may also be evidence from other systems. A model that is more inclusive of these factors may be out of the scope of this assessment, but uncertainties and their potential effects should be discussed.

River flows during the contemporary periods are known from gage data. The historical period depends upon the accuracy of the method used to extend limited historical flows for the AHR; this process is discussed in question 10. Discharge-stage relationships appear to be reasonable for the locations studied, though as with other functions and parameters there is always potential for exploration of uncertainty. The nesting periods are based on 13 years of observational data on the Central Platte and appear to be used appropriately.

10. Is it appropriate to use the MOVE.1 method to infer flow at Overton for the period of 1895-1916 and treat this as representative conditions for the Associated Habitat Reach?

The MOVE.1 technique appears to have been used in a number of contexts and applications. It is difficult to fully assess whether this is the best or most appropriate method of inferring flow for several reasons: 1) lines 114-115 mention that other techniques were compared, but does not say which ones, and the comparison depends on how accuracy was tested. 2) lines 156-157 state that the performance was evaluated by using the MOVE.1 method to estimate observed flows at Overton for 1902-1906. However, if I understand the methods correctly, that was the data set used to parameterize the model, and thus not an independent validation (if not, clarification may be needed); 3) the available time period was rather short compared to the time period being estimated, and so it is hard to tell how representative that time period is (a figure of the hydrology from the different sources at the relevant time periods may help, as well as a quantification of interannual variability); 4) a review by Khali and Adamowski (2014) of record-extension techniques suggests that the MOVE methods may be less suitable than other methods for estimating extremes, and extreme hydrological events are of particular interest for this modeling; 5) A more minor point is that there is no reference (and none may exist) of the effect of the strength of correlation on results and whether the reported r values are high enough. 6) Overall, it is difficult to tell what degree of uncertainty is possible in the hydrological extension and with other competing methods, whether this uncertainty can be addressed, and whether potential variability in the hydrological extension would have any effect on

habitat model outcomes. Together, these concerns do not necessarily lead to the conclusion that the method is or is not appropriate, but some more discussion of uncertainty, validation, and alternative methodology may increase confidence in the outcomes.

11. Is the relationship of sandbar height (relative to peak flow stage) decreasing as sediment size decreases appropriate for the central Platte River based on observed sandbar heights in the central and lower Platte River and the available body of scientific literature?

It appears to agree with the literature cited. The literature on the topic is outside my area of expertise.

12. Does the approach used to infer sandbar heights in the historical central Platte River appear to be reasonable? The historical river analysis period extended from 1895-1938.

If the conditions in the historical AHR are indeed similar to the LPR and/or contemporary AHR, with sediment grain size intermediate between the two contemporary reaches, it seems reasonable to have a sandbar height intermediate between the heights measured in the two contemporary reaches. However this assumes that the fundamental dynamics haven't changed due to the significant narrowing of the channel, which had been much wider but with lower flow than the LPR. It is not entirely clear why the decision was made to use the contemporary AHR height rather than the LPR height; one could argue a conservative, risk-averse approach would be to assume that sandbars will be lower, as in in the LPR, rather than as in the contemporary AHR. As with other aspects of the analysis, an examination of the sensitivity of the assessment to the assumption of bar height would help determine the importance of this uncertainty.

13. On pages 19 and 25, piping plover/least tern nest initiation period is assumed to be the same historically as it is today. Is this a reasonable assumption?

It appears to be reasonable. While it is conceivable that nesting initiation could have shifted earlier due to the low flows, if there is no evidence to support that the current range seems reasonable. If it is possible to compare with data from the LPR that still experiences more of a spring pulse more often, it would support the assertion that timing has not changed (as it would not be an adaptive move in the LPR.)

#### CHAPTER 6

14. Is the conclusion that "implementation of FSM…will likely not create or maintain least tern and piping plover nesting habitat" appropriate and supported by the evidence presented?

The report has assembled several lines of evidence relevant to the FSM management strategy:

1) Flows greater in magnitude and extent than planned peak flows did not succeed in building sandbars to the height of peak stage in the AHR. When flows did build sandbars, they were not high enough to meet program

elevation requirements. Other flow events were analyzed only qualitatively, but were even less successful. There were no available lines of evidence for success of managed flows of the specified magnitude and duration.

- 2) In nearby rivers/segments with tern and plover nesting, 90% of nesting occurred on unbroken channels wider than 1,200 ft. The minimum channel width target for the FSM was 750 feet, for which evidence suggests the probability of nesting would be very low. The channel width analysis did not directly address habitat availability, but given the evidence against habitat building to suitable elevations in the AHR, it seems unlikely that the AHR would be an exception to conditions observed elsewhere in terms of providing suitable habitat in narrow channels. Channel widening to the extent necessary would require extensive work beyond that originally specified in the FSM management strategy and may not be feasible, nor may sufficient flow be available to provide the necessary magnitudes and variability for habitat formation.
- 3) The abandonment of flow consolidation as a management action means that the portions of the AHR broken by vegetated islands would be unlikely to recover to suitability. The effectiveness of flow consolidation actions was not addressed, but its absence would likely reduce the ability to develop sufficient channel characteristics and may also reduce the likelihood of effective flow regimes.

These lines of evidence suggest the FSM methodology, as defined, has limited chance of success. The effectiveness of sediment augmentation and mechanical vegetation removal were not explicitly explored. It was noted that sediment augmentation that would shift the distribution of sediment size to that seen in analogous river segments would require extensive sorting rather than using available sediment directly, and such provisioning was unlikely to be feasible.

Uncertainties remain in various aspects of the analysis, and many of the effects of these uncertainties have not been quantified. A large part of the analysis depends on findings from a single high flow event, in 2010, and a fully mechanistic explanation for the failure of that high flow event and quantification of uncertainties is not yet available. Understanding of the sensitivity of predictive models to key uncertainties would strengthen the argument against effectiveness of FSM. However, given the assembled evidence, it appears unlikely given the evidence collected that the FSM strategy as strictly defined, especially with the elimination of flow consolidation, would be effective in creating habitat.

15. Is the finding that indicates it is unlikely the Program has the ability to manage flow and sediment to create habitat conditions that could support sufficient use and reproductive success and result in tern and plover population growth within the AHR supported by the data and information presented in these chapters?

In addition to the evidence against the FSM strategy as specifically defined, the comparison of the AHR with other river segments suggests fundamental physical differences including

grain size and sediment transport which likely consider to the much smaller size of sandbars with nesting records. While the geomorphic consequences of these differences are not fully explained in the report (e.g. they could be related more thoroughly to sandbar height findings in chapter 3 and possible the habitat availability modeling in chapter 5, which would strengthen the arguments for conclusions based on limited data) it suggests that conditions are not ideal for emulating successful habitat-forming conditions as seen in other river segments.

The interactions between flow and channel width could also be explored further, but the report contains the information to suggest that intra-annual flow variability (the difference between peak and nesting-season flows) are not sufficient for sandbars to both build and be available for nesting in a sufficient proportion of years to support a population. Additionally, channel widths are not wide enough to match nesting preferences of birds observed elsewhere. Improving channel width would further reduce the difference in river stages between peak and summer discharges. Additionally, natural peak flows are late in the nesting season and greatly reduce the window for successful nesting in most years.

The report does not directly address the feasibility of managing flows well beyond the actions outlined in the FSM strategy, though water supply in most years and the comparison with likely historical discharges suggests that the necessary conditions might not be available frequently enough to support nesting habitat. The report does not specify whether the AM program allows for significant changes to the flow actions for future implementation. It does state that the extensive augmentation of finer sediments needed to shift the sediment balance and grain size is unlikely to be feasible.

#### **Questions/Comments**

Chapter 1:

Line 109, 8.5% figure for least tern nests does not match table. Also, it is apparent in Figure 2 that natural sandbars were used very rarely after ~1990 and constructed/managed sandbars were used only sporadically; it may help to note briefly here whether there was a lack of availability or lack of selection of those habitats leading to those results and heavy use of sandpit habitat, to provide context for the numbers.

Line 300: Mentions that least tern observations occur after significant alterations to the river had already occurred. This statement would also be true for plovers, correct?

#### Chapter 2:

Lines 272-274 states there was no species response to mechanical habitat available in 2013, likely because of low discharge; does this mean that the mechanical habitat was specifically unsuitable because of the low discharge or that it was unused because something else was available?

The Evaluate-Synthesis section beginning on line 282 states that actions and natural analogs met or exceeded implementation objectives and should be useful in evaluating the FSM hypothesis. As it was stated earlier that flow consolidation was determined to not be implementable, it is presumably not part of the implementation objectives. However if it was a fundamental component of the FSM strategy, how much might its removal affect the performance of the FSM strategy? Line 293 does mention the FSM strategy "as currently conceived" but it may help to discuss whether the lack of the flow consolidation component contributes to the observed lack of success of the strategy or whether some aspect of actually implemented actions is more likely responsible.

#### Chapter 3:

This chapter took a considerable amount of time to work through in order to connect the different parts of the analysis and confirm that the conclusions follow from the component parts. It may help readers to include a flowchart of the relationships between data sources and models and analyses, and I think it would definitely help to include a schematic of the datums and comparisons made with channel width, sandbar height, and river stage, (e.g. cross-section drawings of 750' and 1,200' channels with relative elevations of 1,200 cfs and 8,000 cfs, peak sandbar elevations, etc.) to explain and connect the key results in this chapter. It also seems that the comparisons made in lines 282-303 would benefit from having all key information in one diagram.

Figure 12: This figure would benefit from a more detailed explanation. My interpretation of the figure is that, given the stage-discharge relationships developed from the HEC-RAS models (initially presented in Figure 5), and then a single data point of the sandbars formed in 2010 with a three-day mean peak discharge of 8,200, with the remainder of the dashed-line curves extrapolated from the difference of that single observation. The extrapolated curves suggest what sandbar elevation may result from different peak discharges of similar duration, though it is not stated what the degree of certainty might be in the extrapolations and if there is evidence for the assumption that the relationship between peak flow and sandbar height would be constant for the range of flows. If this interpretation is correct, it may help to provide a more detailed explanation for the reader, and possibly indicate the empirical data points at the 8,200 flow to assist with interpretation.

Lines 308-310: Phrasing is confusing.

#### Chapter 4:

Lines 185-188: suggest brief explanation of why in-channel management makes this analysis unsuitable for the AHR, and (perhaps in discussion rather than methods) what the implications are for applying this information to the AHR.

Figure 5 caption: second sentence is ambiguous: available locations from 2012 only and nesting colonies for all years?

Figure 6: Are these plots using the best-fit model that does not include river segment?

Line 281: Is this meant to say tern AND plover? Have you looked at whether there is a species-specific effect?

Chapter 5:

Table 3: BAR HEIGHT refers to the median difference between peak stage and sandbar height as calculated earlier based upon observed heights that sandbars built to after a peak flow, correct? May help to reiterate that in the table as it is not the intuitive definition of bar height.

Line 266-270: Is there any consideration of duration of peak flow and the effect that might have on sandbar height or area? Also, the description of the procedure may benefit from a simple schematic of the relationship between the observed and predicted measurements.

Lines 302-303: not clear what period of time is referred to here—days not inundated within the initiation window? After? Both?

Lines 305-311: The requirement describes inundation after nest initiation; the text and dates focus on the July-August chick-rearing intervals—what about the nesting period? Is this assuming renesting if nests are inundated?

Lines 365-367: Peak stage in AHR is not high enough relative to mean annual stage. Because the channel width is so different, a plot like figures 7 and 8 but of stage rather than discharge would be useful.

Line 371: Is this consecutive emergent time or all emergent time?

Line 390: Incubation is mentioned here, but was not in the methods, and the time intervals begin in July. Why not include June (allowing that renesting may occur if inundation occurs in early June)?

Line 443: Is BARmax supposed to be BAR HEIGHT as listed in Table 3?

Line 445-446: I recommend sensitivity analysis to determine the sensitivity of modeling results to bar height to accommodate the estimation uncertainty for that parameter as well as likely variability due to duration of peak flows, initial conditions, variability in erosion after peak flows, etc.

Line 467: The 2013 event was the one mentioned in Chapter 3 as unsuitable for sandbar height analysis because of the low flows and vegetation growth prior to the event. That would explain why the bars were inundated even though the flow was lower than the model predicts would be necessary. This is an empirical example of the effects of uncertainty in the model due to initial conditions.

Lines 483-484: In line with my previous comments in the discussion, it seems that a further quantitative exploration of the uncertainty would be justified. If anything the sandbar

heights seem optimistic, rather than conservative, as there are several observed examples of sandbars being inundated when the model predicts they would not, if I understand this section correctly. The differences in discharge appear large, although the stage differences may not be (reporting those as well may help with understanding the magnitude of error.) Are there observations where the sandbars were *not* inundated when the model predicts that they would be?

504-506: Sentence appears incomplete, but I'm primarily commenting on this to note that there is an interesting potential point of discussion about channel width in relation to habitat suitability as discussed in Chapter 4. Birds select for wider channels but the wider channels in the historical AHR, even with higher historical flows, reduced the variability in stage to the extent that, given the assumptions in the habitat availability model, habitat would very rarely be available.

Chapter 6:

Lines 51-54: The Missouri River has experienced more "natural" habitat characteristics below Gavins Point following 2011, with minimal modification of flood-created habitat to date, though flows are still managed. The size of the system may make it less ideal a comparison than the other rivers considered, but there may be relevant comparisons.

Lines 78-82: How representative were the years for which population data was widely available? Is there possibility of comparing this year to other years within at least some of the comparison segments to understand if it is representative?

Tables 5 and 6: Density calculations of adults/river mile can't account for the differences in potential in-channel habitat areas between river segments, based upon channel width at least. It is possible to account for the different capacity of a river mile in different river segments?

Lines 169-176: Variability between years is mentioned here for the LPR—what about other segments?

Table 9: It is unclear what the footnote is referring to.

Line 251: How variable might this distribution be (understanding the limitations of rangewide data)?

Lines 269-270: Strictly speaking, only the objectives for total numbers are prorated, correct?

Line 274: CPR = AHR?

Lines 295-298 and 315-316: How do these differences in sediment transport mode relate to the differences in sandbar height with sediment grain size as described in Chapter 5? Do

these findings support or contradict the assumptions about sandbar height and/or habitat formation in the historical AHR?

Line 315: Clarify "steeper, flatter, wider and narrower"—does this mean that the differences between the AHR and other reaches cannot be explained by steepness or width because the AHR falls between other segments in those metrics? Does the "narrower" assessment account for the split channels? Additionally, what do the changes between the historical and contemporary AHR mean for future management? Was it more analogous in the past?

Lines 331-332: What about variability in peak magnitude as well as timing? Habitatcreating years followed by drought?

Lines 338: Increased low flows would reduce habitat availability, especially if peak flows are not sufficiently high, so what is the potential benefit of increasing low flows?

Line 347-348: states that the AHR lacks linear variability, yet the CV given in Table 11 is the highest of the river segments.

Line 352-357: Wouldn't channel widening further reduce stage variability and habitat creation potential?

Lines 390-392: "has not been contemplated" contradicts last paragraph on page 22 (appears to have been contemplated and deemed not feasible).

#### Peer Review submitted by Daniel Catlin

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Executive Director's Office Platte River Recovery Implementation Program

I have finished my review of the 'Tern and Plover Habitat Synthesis Chapters' and have provided my comments below to the general and specific questions posed in the peer review scope of work. I have also provided a marked PDF copy of the work where I have noted small edits, comments, questions, etc. Both general and specific comments and suggestions can be found in that document. Where possible I have incorporated major comments into this document. As you can glean from my overall ranking and recommendation (found on final page of this document), none of the comments specific or general constitute 'fatal' flaws. Neither do I feel that it is necessary for the authors to 'answer' any of my questions for me to fully evaluate the work. The questions were provided to the authors and the EDO in hopes that they would help create a clearer final product, pointing to areas of potential confusion or areas where additional information might improve the document. I commend the authors and the Program for their obviously significant efforts in producing this work.

#### **General Questions**

**1.** Does the combined set of tern and plover habitat synthesis chapters adequately address the overall objective of the chapters, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for least terns and piping plovers?

The combined chapters are directed at examining the FSM strategy and its potential to meet management objectives for terns and plovers on the Central Platte, and in general, it does achieve the goals listed in this question. I have provided a variety of comments, questions, and suggestions in this document as well as in the attached PDF in an effort to aid the authors in improving the chapters. My expertise is in the behavior and demography of the two listed species, so my review of the hydrological and geomorphological analyses and results should be viewed in that context. That being said, this document ought to be approachable and understandable for a wider audience than those with a degree in hydrological engineering or wildlife biology. I have attempted to point out in particular places where I had confusion, perhaps as a result of my lack of expertise, but these may be areas that the authors could focus their energies on clarifying their points.

Other than general comments, questions, and responses to the questions posed below, I felt that the following points were of note for a general assessment of the consolidated chapters.

- a. Although the documents were generally accessible and easy to understand, it seemed that the authors sacrificed descriptive detail in an effort to maintain a concise document in several locations. Since the readers of this document will likely vary widely in their knowledge and expertise, I have pointed out areas where it might be prudent to expand description, clarify meaning, etc.
- b. In the evaluation of the SDHF releases, the authors focus on a single event to form the basis of their further analysis. There were, however, at least 2 other flow events that met the general criteria of a SDHF flow, but failed to perform as the Program would have predicted. I was confused why these were not used as further proof that the SDHF as conceived may not achieve the goals of the Program. Further discussion of this point can be found in this document and on the marked PDF.
- c. Your interpretation of stage-discharge relationships, the methods you used to address concerns expressed in Catlin et al. 2010, and your evaluation of the appropriateness of your conclusions needs to be described in greater detail.
- d. Although the authors acknowledge the weaknesses in several of their analyses because of small samples, etc. They do not address these uncertainties in their abstracts, and periodically make statements that convey a greater amount of certainty than would be expected given the other statements about sample size (see below for specific examples).
- e. I am unaccustomed to seeing a scientific document without any measures of uncertainty (standard error, confidence intervals, etc.), particularly with as many predicted values as there are in these chapters.

# 2. Do the authors of the tern and plover habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

The authors do draw logically sound conclusions from the data and results as they are presented. Any places where I had some confusion, questions, or comments have been marked in the document or are addressed further below. I discuss specific issues in later questions and in the manuscript, but the interpretation of the data as it is presented appears logical. Issues with the treatment of uncertainty are discussed below as well.

#### 3. Are there any seminal peer-reviewed scientific papers that the tern and plover habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

Although this is outside of my area of expertise, I did note that the authors did not cite several works that were cited in Catlin et al. (2010) in reference to the height to which sandbars would be created during a given flow. See page 1077, right-hand column, second paragraph. The findings based on a single event in this study (1.5ft) were quite

different than the number cited relative to those works (1 cm). Perhaps there is a reason for ignoring those works? I mention it here because it stood out to a reader with little hydrological expertise, but a familiarity with the general debate.

To my knowledge, there were no seminal works that dealt directly with the region and the species that were missing from this document. I would, however, like to suggest that the Program broaden it's literature use outside of the specific area in future endeavors, particularly for the demographic analysis mentioned in the document. Although there are certainly differences among the various populations of plovers and terns in North America, a great deal of information can be gleaned from placing your own results within the larger context of the species. Given that the historical and current data are sparse for the AHR, it is likely that a broad literature review will help interpret and augment your results within the larger context of the species.

# 4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

Although the relationships in this document are generally adequately described, I think there are some areas where clarification would be helpful. For example, in chapter 5, lines 184–193, the authors refer to criticism of stage-discharge relationships and their use in relation to tern and plover nesting habitat. First, the authors don't fully describe the criticisms that were made in the Catlin et al. (2010) paper (pg. 1077, 'Morphological and Hydrological Issues,' in Catlin et al. 2010), distilling a nuanced argument into a single statement (relative to stage-discharge predictions). Immediately following they introduce a method 'to address this issue,' but they fail to say explicitly how it addresses the issue or what all the issues are. The reader is left to make assumptions about this rather important point. Given the importance of this factor for further modeling, the authors should consider a more indepth treatment of this section.

Another example can be found in chapter 4, lines 166-169, where the authors exclude data from the AHR because of mechanical alteration of the river. Although there is some description of the reasons behind not including the information from the AHR, the reader is left to make assumptions. Assumedly, the alterations to the width of the river were being used to attract birds to those locations, so I think there ought to be more justification for not including them in the analysis, particularly when you are using that analysis to predict the suitability of the AHR in general based on width. I am not arguing that they need to be included, but the reasons for exclusion should be more clearly laid out.

Also in chapter 4 (line 206), the authors choose to use fully parameterized (or minimum deviance at least) models, a method that does not account for over-fitting. More typically, some balance between over- and under-fitting is achieved by using AIC, BIC, etc. The authors do not describe their reasons for using fully parameterized models (or minimum deviance), and the reader is left to assume that the reasoning. I assumed it was to improve prediction, but that is tied to another issue – the lack of

measures of uncertainty (standard error, etc.). Typically predictions from highly parameterized models (minimum deviance) tend to have larger error rates, but the authors do not present measures of error for their predictions.

In chapter 5, figure 2 and line 192 the authors direct readers to 'visually examine' differences among stage-discharge relationships. There needs to be more description for the reader to visually examine these graphics. In general, references to figures could be clearer as well (see chapter 4, line 224 for an example). I have marked several locations where it would be helpful for the authors to 'walk' the readers through complex but important figures rather than assume that the reader is seeing what they meant.

Other sections where I had some confusion are marked on the PDF as questions or comments to that effect.

#### 5. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of these chapters and then discussed in the results and conclusion sections?

Yes, I believe that, in general, the authors state uncertainties, particularly in the discussion sections of the chapters. There are several places where statements with outsized certainty are used though. The fact is that an important part of this analysis is based on sandbar heights obtained from a single event. I appreciate that such events are rare, and that the Program does need to move forward with what information it has. Stating that there is uncertainty in one paragraph, however, and then stating results and firm conclusions without caveat in the next paragraph does not appropriately convey uncertainty. For example, in the abstract to Chapter 5, there is no mention of the uncertainty in one key factor, sandbar heights, and in line 13, the authors state that 'Model results *indicate*...' (emphasis added). I am not arguing that what results you do have point to limited potential, but as stated, you have substantially changed the level of certainty you have in your results considering your sample size for bar height is 1. In other places in the manuscript I point out areas where it might be possible to incorporate more of the uncertainty in the system into predictions, but several of these have to do with the hydrological modeling sections with which I have no expertise. To be clear, I don't see these as 'fatal' issues to the document, just areas where the message should be improved. Plainly, I think the message is, what we have *suggests* FSM will not provide the habitat needed, but as we move forward we need to continue collecting information and updating our models and assumptions.

On a different, but related topic I did note also that it is odd to see a scientific document without a single confidence interval or standard error. Presenting statistics without any error measures tends to convey a false sense of certainty. I might suggest you provide measures of error where appropriate or describe why you don't.

#### Chapter-Specific Questions CHAPTER 3

## 6. Are the methods used to measure sandbar heights in the AHR appropriate? Do the results appear to be reasonable?

This question is outside of my area of expertise, but as a naïve reader, I did not note any significant issues. I did have some comments/suggestions, again from a naïve reader, that can be found in the marked PDF. For example, I note that you have 3 natural events that mimic the SDHF hypothesized flows, but you reduce your discussion to only the one in 2010 because the 2011 and 2013 flows did not create bars as the 2010 flow did. It seems to me that this is further evidence of the inadequacy of the SDHF in performing its hypothesized goal. If in 2 out of 3 trials, something akin to the SDHF failed to even create habitat as predicted, what is the hope that the Program will be able to use this to create habitat? When taken with the failure of the 2010 event to create enough suitable habitat, I think you have a stronger case against the SDHF as it is currently conceived. If there is a specific reason that the document does not use this line of logic, it should be explicitly stated.

# 7. Is it reasonable to use distributions of observed sandbar height and area relative to peak stage along with reach stage-discharge relationships to infer the Program's ability to use the FSM management strategy to increase sandbar area and height to support sufficient use and reproductive success resulting in increases in the populations of terns and plovers within the AHR?

This question represents an important debate in these types of analyses: 'What constitutes enough data to make a conclusion?' I appreciate that events of this magnitude are rare and the Program needs to take advantage of them when possible. Above I mention that an alteration in thinking could essentially triple your sample size, assuming that I have not overlooked some detail as to why the 'failed' SDHF events do not constitute a test of the hypothesis. Otherwise, it is clear that the program needs to move forward with what information it has. That said, I'm not sure that a clear conclusion can be reached based on the information collected thus far, but I do not find fault in the interpretation of the result as it stands. In general, the authors have identified this uncertainty, but I do point out some areas where that uncertainty should be reaffirmed. For example, the caution that the analysis is based on sandbar heights from a single event is not in the abstract and probably should be. A simple statement to acknowledge that the conclusion rests on data from a single event would suffice, but to not include it in the abstract imparts a greater level of certainty than is likely warranted.

#### CHAPTER 4

#### 8. Is the inferential caution issued by the authors (see lines 276-288), with respect to the confounding effect of colony nest site selection and the geomorphic process responsible for building islands, correct for this study?

When I initially read this section, I immediately wondered why the authors had not attempted to quantify the presence of sandbars on the 'available' transects. I realize

that they likely could not assess the overall suitability of the sandbar, but Figure 3 clearly shows sandbars in the channel. Adding 'the presence of emergent sand' as a criteria for 'available' would get you much closer to the comparison you'd like to make than just saying anything is 'available' regardless of the amount of sand present. Open water is not an 'available' nesting site. Neither is a very low sandbar, but it is more available than open water. I commented on this section in the PDF as well, even before seeing these questions. In my mind, it seemed odd to not attempt to tease apart the width-sandbar interaction during this exercise. The empirical data from the Loup River already shows that the relationship between channel width and the presence of a colony is somewhat fungible (i.e., Table 2 shows much lower widths at Loup colonies). If evaluating even the presence of sand is impossible with the photography collected, then there should be some description of this in the methods.

In a similar vein, I commented the following at the end of this chapter: "I am left wondering why you don't do more comparison of the Loup and the AHR. You have laid a compelling case that the widths of the other river segments contribute to their having 'use' areas, but the Loup also has used areas that seem to be approximately the same width as sites on the AHR (based on Fig. 7 - though adding the AHR to Table 2 would go a long way in helping me evaluate this statement and the chapter as a whole). I don't disagree with the conclusions of this chapter, but I think that it absolutely begs for a comparison of the Loup and the AHR. I know that may not have been the main goal of this exercise, but it is what was 'stuck' in my head by the end. I'm fascinated with the differences. I know that nesting on the Loup is limited, but not nearly so as the AHR. Why? Having 'peeked' ahead, I know that one of the conclusions of this body of work is to question the feasibility of using quasi-natural processes to create tern and plover habitat. Perhaps later in the work you do the work of comparing these two reaches (as they seem most similar) to support or refute your case. Otherwise, however, there will be a specter hanging over that conclusion - why does the Loup differ from the AHR? I am clearly not as familiar with this system as the authors, so perhaps there is an 'easy' explanation or way of dismissing this comparison. If so, it should be explicitly said."

#### CHAPTER 5

### 9. Are the methods used to predict the frequency of inundation for sandbars in this chapter appropriate?

This is not my area of expertise, however, I did note a few areas in the marked manuscript where I had questions or thought that there was room for improving these approximations. In particular, lines 286–290 indicate that median sandbar heights were used, stating "nests are typically distributed across the higher portions of the sandbars but not necessarily at the highest elevation (Alexander et al. 2013)." If we assume that the median value (there actually is no justification for using median, especially when the justifying statement says 'higher' – presumably meaning above the 50<sup>th</sup> percentile) is correct for nests, the analysis does not take into account that chicks are mobile and would likely seek out the highest parts of a sandbar during

times of rising water. It's possible that I am misinterpreting these methods, but if so, then perhaps there is a need to clarify them. If not, it would likely improve your approximation to use the median for nests, but the maximum (maybe another measure) for the chicks.

## 10. Is it appropriate to use the MOVE.1 method to infer flow at Overton for the period of 1895-1916 and treat this as representative conditions for the Associated Habitat Reach?

The answer to this question is outside of my area of expertise, and I do not think that I can contribute to the discussion here.

#### 11. Is the relationship of sandbar height (relative to peak flow stage) decreasing as sediment size decreases appropriate for the central Platte River based on observed sandbar heights in the central and lower Platte River and the available body of scientific literature?

The answer to this question is outside of my area of expertise, and I do not think that I can contribute to the discussion here.

# 12. Does the approach used to infer sandbar heights in the historical central Platte River appear to be reasonable? The historical river analysis period extended from 1895-1938.

This is not my area of expertise so the following comment should be taken in that context, but I was surprised to see that the authors did not take into account the variability in their predictions while moving forward. What I mean is that you tested your fit with known data sources (lines 159–167), and therefore should have known your error (in fact there was a measure of it presented), but is there no way to incorporate that error into your predictions? The presentations of the flow during that period are as if you knew the related stage with certainty, but you didn't because your measure of concordance was <1.0. I made a similar, general comment above, but it seems that presentation of these results without measures of uncertainty (error, confidence intervals, etc.) convey a false sense of certainty in the statistics presented even though they are based on predictions.

Additionally, this question is related to my general comment about the treatment of Catlin et al. 2010. If we assume that the assessment of height of the sandbars relative to peak flows is true (In truth, the authors ought to discuss their 1.5 ft below peak flow findings in relation to the citations provided in Catlin et al. 2010 where 1 cm was cited – pg. 1077 right-hand column, second paragraph) there still is a need to establish arguments for why this work addresses the concerns raised in Catlin et al. 2010. As elsewhere, I am not necessarily taking aim at the conclusion, but without description of how the issues were addressed, it is difficult to assess the conclusions fully.

## 13. On pages 19 and 25, piping plover/least tern nest initiation period is assumed to be the same historically as it is today. Is this a reasonable assumption?

This is an important question, but I think it also needs to be expanded to ask if assuming the initiation dates of birds on man-made habitat in the AHR (forming the basis of your estimate) are also representative of the historical river. In lines 85-88, I believe you address my question, saying 'Approximately 90% of the in-channel..." The lower Platte study has averages for on and off-river habitat, correct? You could simply compare those on the lower Platte and then make the case that if our dates match in-channel dates on the lower Platte, and the off- and in-channel dates are similar on the Lower Platte, then our dates are representative of in-channel dates at our site (or at least you have no reason to believe otherwise).

As for the initial question of timing relative to historical nesting, I don't see how you could assume otherwise. I suppose there is one possibility, which would allow you to at least confirm that overall dates have not shifted significantly for the species. The authors are correct that little early information is available for this location, but that is not generally true of piping plovers. There were a handful of early studies on the Atlantic coast (LeRoy Wilcox 1959 the Auk, and Cairns 1982 in the Wilson Bulletin come to mind) that could offer an answer to the broader question of whether plover initiation dates have shifted in the last century. Although it isn't clear from the question, I assume the question refers to climate shifts (or something akin to it) affecting the initiation dates over the last century. It might be possible to use the dates from some of the early studies compared to current monitoring to establish if ANY plovers have shifted their breeding times. We have examined contemporary initiation dates (within the last 25 years) on the Atlantic coast for the USFWS, and there was no clear evidence of a trend over that time. The Great Lakes and the USACE have > 20 year datasets as well. These would allow you to support your assumptions with data.

#### CHAPTER 6

# 14. Is the conclusion that "implementation of FSM...will likely not create or maintain least tern and piping plover nesting habitat" appropriate and supported by the evidence presented?

When I first read this question, I assumed that the statement was near the bottom of the chapter, but it was in fact on line 29. The reason I say this is that it seems the use of the word 'likely' was more appropriate after the data presented in Chapter 6 not before. As I have said in other areas of this document, what evidence you have doesn't seem to support the use of FSM, but you have pinned many of your conclusions on a single natural experiment, high flows in 2010. I am unaccustomed to seeing a word such as 'likely' used in such an instance. The content of chapter 6 does lend further support to this conclusion, but this statement comes well before any of that data is presented. Other than the odd placement of this statement and this particular question, I would say that my answer here is similar to those I have provided above regarding those conclusions; the evidence, such as it is, does support the general claim, but it is perhaps made too strongly. Given the amount of information you have,

I think that simply stating 'the evidence at hand does not support...' rather than making claims directly about likelihood based on a relatively small amount of data.

# 15. Is the finding that indicates it is unlikely the Program has the ability to manage flow and sediment to create habitat conditions that could support sufficient use and reproductive success and result in tern and plover population growth within the AHR supported by the data and information presented in these chapters?

I think that the conclusion with respect to habitat creation is in keeping with the results that are presented (albeit stated too strongly, 'unlikely,' as I have detailed several times in this document), but I do not see evidence presented about actual population growth in this document. In fact, there is reference to a later (2015) document that will explore this possibility using data collected by the Program. I assume this means demography data collected by the Program, which is really the only way the second part of this statement can be supported. I will admit that the prospects don't look good given what you have shown in this document, but without looking at the demographic consequences of your habitat availability information, you perhaps should not use words like 'unlikely.' Unlikely is a probabilistic statement, and you don't provide any statistics to defend that statement.

#### Peer Review Rating & Recommendation

*Rating:* 1 = Excellent, 2 = Very Good, 3 = Good, 4 = Fair, 5 = Poor

Category	Rating
Scientific soundness	3
Degree to which conclusions are supported by the data	2
Organization and clarity	3
Cohesiveness of conclusions	2
Conciseness	2
Important to objectives of the Program	2
<b>Recommendation</b>	(Check One)
Accept	Λ
Unacceptable	

#### Peer Review submitted by Matt Kondolf

#### **Comments on Platte River Recovery Implementation Program Data Synthesis Compilation**

G. Mathias Kondolf, PhD Berkeley California 10 January 2015

#### Introduction and Scope

I reviewed the Platte River Recovery Implementation Program Data Synthesis Compilation (hereafter, the "Report") and supporting documents and references as needed to follow up on questions raised the Report. I first present general themes, followed by some specific editorial points, and then answers to the questions posed in the format of the questions. I have adopted acronyms used in the Report without necessarily explaining each one, and have cited references that were already cited in the Report without repeating a list of full citations.

#### **Overview and General Themes**

Overall, I found this an excellent document: clearly written, attempting to explicitly identify assumptions, clearly spell out hypotheses, and interpret the implications of results of the adaptive management actions to date. However, the Report could be improved by more clearly articulating some assumptions with respect to conceptual models and hypotheses, by diagramming the logic train and arguments, and indicating exactly which points in the logical train are not supported by results of the studies undertaken to date. Some of the new arguments presented in the Report challenge the very basis of the BO and the restoration program, and if correct, should prompt a fundamental reconsideration of the program, not simply a shift to mechanical creation of off-channel habitat.

Some of the statements are not well supported. These may simply be a matter of presentation, and some of the missing points may have been covered by prior studies that I didn't read, but in any event, the Report is intended to be a stand-alone document, so presumably it needs to be complete.

#### Logic Train

The Report summarizes results of attempts to implement the FSM approach to restoring sandbars that can provide piping plover and least tern habitat. There is an explicit or implicit conceptual model, or logic train, which I summarize as follows:

The Biological Opinion (BO) (USFWS 2006) assumed that the birds used the AHR for reproduction, and that channel changes eliminated their habitat. The program hypothesized that the birds would nest on sandbars at least 0.25 ac in extent, at least 1.5 ft above the water surface at 1200 cfs, and occurring in active unvegetated channels at least 400 ft wide. The program further hypothesized that sandbars would build up to the water level during high flows, and specified flows required to build sufficiently high bars based on these assumptions.

The Report presents evidence that some of the hypothesized links between flows and sandbar construction were too optimistic:

Sandbars appear not to build to the level of the high flow water surface as earlier hypothesized, but only up to about 1.5 ft below that water surface (Chap 3 p.1). This implies that higher flows would be needed to build bars than previously hypothesized, but does not necessarily negate the overall approach.

The FSM approach assumed that the SDHFs would create suitable sand-bar habitat in reaches in "sediment balance" if certain flows were attained. There were two deliberate SDHFs, but these were exceeded by naturally-occurring high flows, so there was clearly sufficient flow to achieve the results sought. However, rather than building sandbars, sandbars were eroded and less habitat existed at the end of the period than before. It is not unusual to observe in natural rivers that some high flows are erosional overall, while others are depositional. Usually the difference is in sediment supply to the reach, such that if sediment supply exceeds energy available for sediment transport, the channel aggrades, while if transport energy exceeds sediment supply, the channel erodes. This raises the question of the sediment deficit in the AHR, and whether the reaches were "in balance".

#### Sediment Deficit

Chapter 2, p.5 states that the sediment deficit is "on the order of 150,000 tons", but does not provide a reference for this statement. Chapter 2 p.11 states that the sediment deficit is greatest downstream of the J-2 Hydropower return, but decreases downstream such that the lower half of the AHR (below Minden) is "in dynamic equilibrium", which presumably means the sediment supply is adequate to "balance" sediment transport capacity. Three references are provided for this statement: Holburn et al. 2006, Murphy et al. 2006, and HDR Engineering 2011. In Holburn et al. (2006), Table I.1 shows the reach just below the J-2 return, river mile (RM) 247-225, to be degrading, while RM 211-195 is stable (with local aggradation and degradation balancing out). Holburn et al. resurveyed multiple cross sections and interpreted past survey data to ascertain the status of various reaches, and the table appears to be based on empirical analysis of survey data. Holburn et al. does not present values of sediment transport or deficit that I could find.

The Report does not explain the basis of the statement that the river is in dynamic equilibrium in the lower half of the AHR. From a physical process perspective, this would seem to be possible only through contribution of sediment from a tributary (as clearly occurs downstream Columbus, where the Loup River joins the Platte), or in the absence of a major tributary, through erosion of the bed and banks at a rate sufficient to make up for the sediment deficit from the J-2 Diversion. I infer that the cross section resurveys of Holburn et al. (2006) showed the lower half of the AHR to be stable, but it would be nice to confirm how the RM numbers used in Holburn et al line up with the place names used in the Report. Assuming that Holburn et al.'s cross section analysis shows the lower half of the AHR has been stable, and that this is due to sediment supply from bed and banks, we would expect that this sediment input would accumulate gradually with distance downstream, so that he transition from sediment starved to sediment balance would be a gradual one. However, at a number of points (e.g., Chapter 3 p.2), the Report refers to the sediment deficit to balance is an

abrupt one. Without a major tributary as a significant point source of sediment or the influence of some other large feature, the transition from sediment deficit must perforce be gradual.

Moreover, as readily erodible sediment in a given reach is exhausted, the implication is that the transition point at which the river's sediment transport capacity is met by cannabalisation of its bed and bank deposits will migrate downstream with time.

Chapter 2 p.11 also states the "long-term average annual sediment deficit in the AHR is on the order of 150,000 tons with the majority of the deficit occurring during high-discharge years (HDR Engineering Inc. 2011)." Searching the HDR document for "150,000" or "deficit" yielded no returns, and I did not find a relevant section from a superficial read of the document. It may be that the citation was in reference only to the fact that the sediment deficit would be greater during high-flow years, which is something that might be gleaned from a modeling study such as conducted by HDR and in any event would be expected unless sediment supply was much greater during the wet years.

Thus, the stated deficit of 150,000 tons/year is not supported by the Report itself, nor the references it cites. I don't mean to say that it's not correct, only that at present it is an unsupported assertion.

#### Sediment Augmentation

If the sediment deficit does, in fact, average 150,000 tons/year, then the rate of sediment augmentation has been inadequate to compensate for the deficit. Total sediment augmentation from 2006-2012 was about 230,000 tons, or an average of about 32,000 tons/year. Augmentation in 2013 was 182,000 tons, greater than the estimated annual deficit of 150,000 tons.

As summarized in Chapter 3 p.2, the FSM strategy included "offsetting the average annual sediment deficit of approximately 150,000 tons in the west half of the AHR through augmentation of sand". This has not been done (based on the actual amounts added), and the Report argues elsewhere that sand of the correct size is not available in sufficient volumes to supply 150,000 tons per year.

#### Have the FSM Conditions Been Met?

Chapter 2 p. 17 states, "The scale of flow, sediment, and mechanical management actions and natural analogs during 2007-2013 met or exceeded implementation objectives for the First Increment in at least a portion of the AHR." This statement is true for flows, but not for sediment. The FSM approach is expected to work in reaches that are in "sediment balance". However, the Report states that at least the upper half of the AHR is not to be in sediment balance, and the rate of sediment augmentation was, until 2013, only about 20% of the sediment deficit. Recognizing that the upstream half of the AHR was not in sediment balance, the sandbar height analysis was confined to the lower half of the AHR "considered to be in sediment balance" (Chapter 3, p.9).

The observed erosion rather than building of sandbars would be consistent with a reach in sediment deficit. Thus, it is arguable that the conditions required for FSM approach have not been fully met: flows have been adequate but not sediment supply.

Chapter 3 p.21 states, "Flow releases of greater magnitude that SDHF would be likely increase the potential to produce sandbars meeting the minimum height criterion." However, if the reach is sediment starved, the greater flows may simply exacerbate the erosion of bars and thus make the problem worse.

#### Did the AHR Ever Have Large Sandbars?

In Chap 6, a new argument is introduced, that the AHR may never have had the large sandbars (or "sand flats") that are preferred by the birds, based on observations at analogous sites today (in the Loup, Lower Platte, etc), but rather its natural fluvial forms would be dominated by linguoid bars, or large subaqueous dunes. Aerial images of the current channels presented in Chap 6 p.19 effectively show the AHR having very different bedforms than the other reaches.

This argument is introduced rather late in the Report, and its implications would be profound: notably that the AHR was never very suitable for the birds because it would not naturally support large sandbars. Thus, if the logic train is spelled out, this argument would challenge the very assumptions on which the BO and the entire restoration program is based. The history of observations of bird use to too spotty to be able to confirm whether this reach was as much used by the target species as other river reaches in the region. However, even in the absence of reliable data on past bird use of the AHR, if the AHR has a fundamentally different geomorphology from the other reaches, this would be a strong argument that it may not have supported birds as did its sister reaches nearby. Thus, this idea deserves more focused exploration and testing, by scouring historical records for clues to its historical form, and through analysis of geomorphic processes.

The main difference in controlling variables cited by the Report was coarser grain size in the AHR (Chap 6 p.14). However, the Report states that the gradient of the AHR is 0.0012, which it described as being "slightly steeper than LPR Reach 1 and slightly flatter than the Niobrara River segment" (Chap 6 p.17). However, the gradient of the AHR is 1.5 times that of LPR Reach 1 (0.0012/0.0008 = 1.5, i.e., 50% greater. Presumably a 50% difference in gradient would have a noticeable influence on results of sediment transport modeling. Steeper slopes are commonly associated with higher bed material sizes, but there are many variables involved, so it would be too simplistic to say simply the AHR is steeper and therefore it has coarser bed material. In any event, the potential influence on bedforms of local slope combined with grain size deserves further exploration and analysis.

The AHR gradient falls in the midpoint of the Niobrara gradient reported of 0.0010-0.0015. The Loup River is consistently higher gradient, 0.0015.

To answer the question of why sandbars are smaller in the AHR and whether they could be and once were higher in the AHR, it would help to have a better understanding of the relations among sediment supply, transport capacity, grain size, reach gradient, peak flow water levels, and resulting sandbar height.

#### Channel Width

The Report does a nice job in articulating differences in definitions of "channel width" used by prior researchers and attempting to find a consistent approach to measuring channel width relevant to the birds' habitat requirements. The analysis of channel widths used by nesting birds appears to be solid.

#### Seasonal Hydrology

The Report presents a very interesting discussion of nesting in relation to the seasonal recession limb and subsequent summer high flows. The Report does a good job of articulating and examining prior assumptions based on Hardy (1957) that the birds nest on the receding limb, and that higher sandbars would be spared inundation in the summer (as stated in the EIS quote, Report Chapter 5 p.2). The question of whether hydrology was "unfriendly" to bird nesting had been debated in the literature with respect to the Missouri River, and as noted by Catlin et al. (2010), "Piping plovers and least terns have periodically high reproductive rates, long life spans, and high dispersal capabilities. Therefore, they can maintain viable populations without breeding at all possible locations each year."

The argument that these birds are ill-suited for sandbar habitats in rivers where they have long been reported because nests are periodically (even frequently) washed out is reminiscent of the arguments that because of documented redd scour, gravels in a given river are ill-suited for salmon despite the fish having thrived there for hundreds or thousands of years. Many large, healthy populations of salmon persist in rivers of the Pacific Northwest where their spawning gravels are documented to wash out in many years. In the case of Pacific salmon, one could make a similar statement that the species are able to maintain viable populations without successfully spawning at all possible locations every year

Thus, evidence that large sandbars do not (and never did) occur in the AHR would support the argument that the AHR never supported large populations of birds, but I find the argument about these being flooded too often less convincing.

The Report acknowledges the criticisms of using hydraulic relationships from stream gauges and presents rating curves for both gauge sites and two breeding sites, which are compared visually to support the conclusion that the frequency of inundation of surfaces of a given height at the stream gauges would be applicable to the other cross sections at which the birds breed. As this is a potentially important point, I would like to see the cross sections with inundation of different surfaces indicated, and exploration of whether there might be other factors involved that are not captured by the rating curves alone.

#### Historical Bed Material Size & Sandbar Heights

The sediment sampling conducted by Tetra-Tech for the contemporary AHR appears to be sound. The current grain size reported in Chapter 5, p.14 is consistent with Tetra-Tech (2013), but it was not obvious to me upon what basis the historical grain size was inferred, as no citations were provided.

Why is the sand now coarser in AHR? It is not unusual to see bed coarsening downstream of a dam or diversion that traps sediment. Could these coarser sizes be a result of the J-2 hydroelectric plant upstream trapping sand?

Chapter 5 p.14 states that historical sand-bar heights for the AHR "were estimated using the data from the contemporary AHR and LPR reaches." The subsequent sentences may be an explanation of how this estimation was done, but I did not find this passage to be clear. Perhaps this simply needs to be restated to be more convincing. If I infer correctly from the Report text, historical sand-bar heights were estimated as being 1.5 ft below the water surface, and from descriptions elsewhere in the Report (eg, Chapter 5 p.21), I understand the water surface for the historical channel was estimated from a hydraulic model assuming a wider historical channel. It is not clear to me how the grain size information (historical vs current) was used, nor the potential uncertainties of this approach. Chapter 5 p.21 reports that "Median heights [of sandbars] in the historical AHR were below mean annual river stage...", presenting this as fact, whereas earlier these heights are described as "estimated".

The argument advanced that the AHR was not suitable for the birds historically because its sandbars were too low to avoid summer inundation is certainly possible, but this deterministic conclusion is based on a long series of assumptions and calculations. The approach is certainly reasonable, but I would feel more comfortable if the considerable uncertainties embedded in this conclusion were highlighted and emphasized more, especially as these birds have long been observed to occupy these habitats. The argument that the hydrology is unfavorable would apply to other reaches as well according to the Report, and again we know these birds occurred in these reaches historically and some still.

#### Implied Shift to Mechanical Creation of Off-Channel Habitat

The Report notes that nesting is mostly in off-channel habitats such as sand pits (whether or not in-channel habitat is available), and cites historical accounts of off-channel nesting in "rainwater basins and along lake shorelines" (Chap 5 p.28). The Report notes that "Historically, off-channel habitat has been viewed as an inferior alternative to in-channel nesting habitat as in-channel habitat suitability declined over historical timeframes (Sidle et al 1993, National Research Council 2005)."

The Sidle reference presumably is to Sidle et al 1992 (labeled as "Sidle and Kirsch 1993" among the pdfs provided), which did not discuss off-channel habitat as an alternative to in-channel habitat. The NRC report was not included among the pdfs, but obtained online, this report included statements such as,

"Sandpits and reservoir edges with beaches may, under some circumstances, mitigate the reduction in riverine habitat areas. Because piping plovers are mobile and able to find alternative nesting sites, changes in habitat may not be as severe as they would be otherwise, but no studies have been conducted to support or reject this hypothesis...It is also now understood that off-stream sand mines and reservoir beaches are not an adequate substitute for natural riverine habitat." (NRC 2004, pp.9-10) The Report continues, "However, given what appears to be limited potential for successful inchannel nesting in all reaches and consistent use of off-channel habitats like sand mines, these [offchannel] habitats may have allowed the species to expand into and persist in a basin with hydrology not ideally suited to their reproductive ecology." (Chap 5 p.28)

With the failure of the FSM approach to produce suitable habitat to date, the implication is that efforts should instead be focused on expanding off-channel habitats. However, the Report does not explain how these off-channel habitats are protected from predators. Potential disturbance by predators in off-channel habitats is an issue brought up by the NRC<sup>1</sup> (2004) and quoted by the BO (USFWS 2006), and incorporated within an extended quotation in Chapter 1 p.12.

If I understand correctly, in the riverine environment, the birds prefer large, unvegetated, sandbars for nesting because these provide a long line-of-sight to see approaching predators, and because flowing water in multiple channels separates the bars from the river banks provides (at least partial) isolation from land-based predators. The original restoration plan called for sandbars at least 25 ac in size in river channels at least 400 ft wide, but observations of habitat utilization at other river reaches nearby suggest that the sandbars need to be bigger and the channels wider (>1200 ft) (Report Chapter 4).

The Report does not discuss the vulnerability of off-channel sand pits to predation, but this would seem to be a significant drawback of the off-channel habitat, located entirely in the uplands, without river channels to isolate the nest from terrestrial predators. The NRC (2004) discusses this question in more detail, noting prior studies indicating less food available for the birds, greater distance to water, and greater vulnerability to predation:

"Several studies have concluded that artificial habitats cannot provide the full complement of essential habitat requirements for piping plovers over the long term and therefore cannot substitute for riverine habitat...because sandpit sites are not isolated on islands, nests there are more vulnerable to predation...No studies have examined whether survival from fledging to first breeding is higher in natural or in artificial habitats. The contribution of alternative habitat to the survival and recovery of piping plovers can be summarized as follows: sandpits provide refuge and nesting substrate when water is high on the river, but they do not appear to provide the complete array of essential habitat elements required by piping plovers." (NRC 2004, p.190)

Thus, while the problems with the FSM approach detailed in the Report are for the most part probably valid, before giving up on the river and going to mechanical off-channel approaches, the issues associated with such off-channel habitats would need to be better understand and strategies devised to address them.

#### Adaptive Management

<sup>&</sup>lt;sup>1</sup> The NRC report *Endangered and Threatened Species of the Platte River* is labeled with publication date of 2004 on the version I downloaded from the website of the National Research Council. I assume this is the same report as referred to by the BO and the Report, but somehow different publication years were stated.

The adaptive management (AM) cycle shown in Fig 2 of Chapter 2 may be too simple, as it does not include the three levels of intervention possible: targeted research (to better define the problem and possible interventions - ie to decrease uncertainty), pilot projects (to test out possible approaches, further decreasing uncertainty), and full-scale implementation (once uncertainty is low enough to make large investments). These appear in the AM cycle as presented by Michael Healey<sup>2</sup> of UBC (Figure 1). Unfortunately the only version of this I have is from the CALFED Ecosystem Restoration Strategic Plan, but I can try to track down a better citation for it once my computer is fixed and I am back in the US with a reliable internet connection.

#### Maps

As I don't know the area or its place names well, I found myself frequently lost with references to multiple places names. I dug out my old AAA map of Nebraska and folded it to cover the big bend of the Platte and frequently referred to that to locate various place names and make notes on various localities referred to in the text. The maps included, such as Figure 1 of Chapter 2, are useful but not comprehensive in terms of all place names mentioned in the text, such as Minden, Elm Creek, etc. It might be useful to have a map that is confirmed to show all places mentioned in the text. Moreover, it is difficult to cross reference from data sources such as Table I.1 of Holburn et al. (2006), which indicates locations in RM. A master table of place names and their RM might be useful, or a map on which RM were indicated every 5 or 10 RM.

#### **Specific (Minor) Editorial Comments**

Chap 3 p.1, line 7: "...conducted observational studies" (delete "an")

Chap 3, p.14, line 219 "...and delineate unvegetated..."

Chap 3, p.15, line 239 "...peak flow stage."

Chap 3, Figure 12 and similar references: Rather than "750 ft channel" say "750-ft-wide channel", etc

Chap 4, p.1, line 6 "...colony incidence and open-channel width..." (suggest adding open to make clear that unvegetated, open channels are referred to)

Chap 4, Figure 6 For lower right diagram, modify label as "Central Platte River (excluding AHR)"

Chap 5 p.28, line 504-507 Run-on, can be fixed by deleting "Although..."

Chap 6 p.19. Presumably all 6 photo details are at the same scale such that the small box in the lower left of the top image (of CHR) represents 5 ac. A more standard way to graphically show

<sup>&</sup>lt;sup>2</sup> Unfortunately the only version of this I have is from the CALFED Ecosystem Restoration Strategic Plan (cited in the figure caption), but I can try to track down a better citation for it once my computer is fixed and I am back in the US with a reliable internet connection.
scale is using a scale bar, and I recommend a scale bar be included. If all 6 images are at the same scale, only one scale bar need be inserted, but the caption should include a statement that all images are at the same scale. If the scales differ among images, scales should be shown for each. Also include north arrows, dates, and flow on the dates of the photographs.

## Answers to Specific Questions Posed in Instructions

I have only a pdf of these, so to avoid wasting time extracting and re-formatting the text, I refer to the questions only by their numbers below.

1. Generally yes. One concern however, is whether the condition of sediment balance, assumed by the FSM approach, has been the case. If not, the approach has not been fully implemented. It may be that it cannot be properly implemented because of constraints in obtaining sediment, etc, but that is different from saying that the program has not worked.

One can hardly disagree with the question as it is phrased, i.e., whether the chapters "*present…evidence for broader examination of the conclusion* that implementation of...FSM management strategy *may not achieve* the Program's management objective for least tern and piping plovers" (emphasis mine). This is a "low bar" and it certainly has been met in this case. But there is arguably considerable uncertainty to resolve before reaching a conclusion that an FSM type approach should be abandoned in favor of off-channel habitats.

2. Overall yes. The chapters<sup>3</sup> are mostly well supported, but as per my comments above, there are issues with the sometimes seemingly confused treatment of the sediment deficit, whether the FSM approach has really been tested in light of the sediment deficit, whether the AHR ever had large sandbars or if it might have been a reach unsuitable to the birds within a larger landscape with river reaches that were more suitable, the impact of summer flooding on viability of the birds' use of the sandbar habitat, and whether the documented problems with the FSM approach should suggest a shift to mechanical approaches.

3. None come to mind.

4. Overall yes, though see caveats re concluding that FSM cannot work here. Program materials are very helpful, as are the referenced scientific reports.

5. Not always. For example (as discussed above), the conclusion that sandbars were historically too low to provide viable habitat is based on a long train of assumptions and calculations, and the cumulative uncertainties from these are not explicitly considered.

6. The method relies largely on modeling, but direct observation during high flows could be more feasible now with improved technology. I suggest the Program consider using innovative

<sup>&</sup>lt;sup>3</sup> The question refers to "tern and plover habitat synthesis chapters", which I assume refers to chapters 1-6, rather than a subset of these.

approaches with new aerial technologies to obtain more frequent mapping of areas inundated and exposed that could provide empirical data, valuable in their own right and potentially useful for model calibration. A good example of such approaches are those employed by the US Geological Survey to monitor changes in the former reservoirs sites and downstream channels of the Elwha River (Contact Andy Ritchie aritchie@usgs.gov).

7. As discussed above, this approach is reasonable, but embeds a number of assumptions and uncertainties, which could be better summarized and presented. Actual observations through expanded mapping during flows could resolve some of these uncertainties. Moreover, there is the question about the birds' ability to recover from inundation of nests in some years.

8. This discussion appears reasonable to me.

9. As noted above, the approach is reasonable but the result of a long train of calculations, assumptions, etc.

10. Hirsch (1982) concluded that the MOVE.2 method produces better results than MOVE.1, at least for the tests he conducted. The Report does not mention whether MOVE.2 was considered as an alternative, and if so, why MOVE.1 was ultimately selected instead. This kind of hydrograph extension is beyond my specific area of expertise, so I cannot weigh in further on the topic, but any such method will have its biases and peculiarities, so that its results should be interpreted with uncertainties in mind.

11. From a physical point of view (based on the research cited), it is reasonable to expect that sandbar height would be greater for coarser grain sizes, other factors being equal. My principal caution is that there are many factors that could affect sandbar height or even inundation of sandbars of a given height, so the deterministic approach used here should be taken with the proverbial 'grain of salt' (i.e., recognizing uncertainties).

12. I did not find this explanation to be 100% clear. As stated above, I understand that the wider historical channel was assumed and correspondingly shallower flows modeled, which would then inundate the bars, which were assumed to have heights 1.5-ft lower than the previous peak flows. It is a reasonable approach but not definitive.

13. This question is out of my area of expertise.

14. The evidence presented by the Report certainly casts doubt on the effectiveness of the methods utilized to date to create habitat with flows and sediment augmentation. However, as noted above, sediment augmentation has not matched the sediment deficit, so the assumption of "sediment balance" appears not to have been met. Moreover, there is considerable uncertainty associated with the estimates of sandbar inundation, etc.

Thus I conclude that the Report does an excellent job overall of summarizing the results of further research and implementation, but I don't think it provides a basis for concluding the FSM approach cannot work.

15. Yes, with the caveats noted above.

### Rating

### Category Rating

Scientific soundness \_\_Excellent overall\_\_\_\_ Degree to which conclusions are supported by the data \_\_Excellent-to-very good\_\_\_\_ Organization and clarity \_\_\_Excellent\_\_\_ Cohesiveness of conclusions \_\_Excellent-to-very good\_\_\_\_ Conciseness \_\_\_Excellent\_\_\_ Important to objectives of the Program \_\_Excellent\_\_\_\_

**RECOMMENDATION** (Check One)

Accept \_\_\_\_\_ Accept with revisions \_\_\_\_x\_\_\_ Unacceptable \_\_\_\_\_

*Specific revisions* required for the Report to be acceptable are detailed below:

### Мар

A map showing both RM and towns and other features along the river (or a table linking the two) should be included in the Report.

### Sediment Deficit & Sediment Budget

The Report should explicitly state the basis for the statement that the average annual sediment deficit below the J-2 Hydro Return is 150,000 tons, and develop a sediment budget for both pre-J-2 conditions and post-J-2 conditions. The Report should include a map showing the features of the J-2 project and where sediment deposits within the project. The sediment budget should include all relevant components, including downstream transport above and below the J-2 project, sedimentation within the J-2 project, sediment augmentation rates below the project, and estimated contribution of sediment from bed & bank erosion below J-2.

The basis of the statement that the eastern half of the AHR is in 'equilibrium' should be clearly spelled out, and physical process by which the reach changes from a 150,000-ton deficit to being in balance should hypothesized and tested to the extent possible.

### How AHR Differs from Other Reaches

The Report should include a better exploration of how the AHR differs geomorphically from other reaches, such as LPR, Niobrara, and Loup. The basis of the historical grain size reported should be spelled out (along with inherent uncertainties). The possible geomorphic reasons for coarser grain size currently should be explored and tested to the extent possible.

The argument that the AHR was historically unsuited to use by the birds is based on a long train of assumptions and calculations. The errors/uncertainties associated with each step should be acknowledged so that the final result can be stated with uncertainty bounds.



Figure 1. The Adaptive Management process as applied in the CALFED Ecosystem Restoration Program. Diamond shaped boxes show critical decision points in the process. Where the diagram indicates multiple decision choices, the choices are not mutually exclusive. Where the diagram indicates only one decision choice, the decision is whether to proceed to the next step. Simulation modeling of restoration options would normally be in the main decision line in formal adaptive management.

Source: Healey, M., W. Kimmerer, G.M. Kondolf, R. Meade, P.B. Moyle, and R. Twiss. 1998. *Strategic plan for the Ecosystem Restoration Program*. CALFED Bay-Delta Program, Sacramento, California.

### Addendum from Louis Berger:

Following receipt of the EDO's "Response to Kondolf requirements for acceptance of chapters" document (Appendix B), Dr. Kondolf responded via email as follows:

I've read through the response a couple of times. Can you clarify whether the document that I reviewed is intended as a stand-alone document or would the program not expect it to necessarily be understandable without reference to prior consulting reports?

The response document seems to be responding to my comments, explaining or referring me to prior documents, but I dont see how the report itself would be revised. (ie there is no text provided that would be inserted into the text, unless I missed something). The answer regarding sediment deficit on lines 41-55 is much more nuanced than the assertions in the report of a sediment deficit of 150,000, but also indicates enormous differences among estimates. The responses refer to prior reports extensively. Would this be appropriate to include multiple references to such grey literature in the revised report or would it there be an expectation for the material to be synthesized, as in a sediment budget?

Please let me know about how the response sent would relate to actual revisions to the document

### The EDO responded as follows:

1) These chapters serve as a synthesis of many lines of evidence related to tern and plover productivity on the central Platte River as it relates to Program management actions and their potential impact on habitat. As such, particularly germane items like the sediment issue are discussed and related to other factors but it was not our intention to deeply describe every aspect of what the Program has learned about sediment transport and the sediment budget. The response we provided points to the full set of documents and projects that is the deepest window into the details of sediment on the central Platte. These are issues that have been research, discussed, and debated for decades so boiling it down to the highlights is tough but that is the approach we took.

2) To that end, we don't foresee adding in vast detail on sediment into the chapters. But, we propose taking our previous response to Matt (previously provided as a PDF) and dumping all of that material into an appendix to Chapter 2. We will beef up that information to paint a more robust picture and future readers can dig into that appendix for a more detailed discussion of various aspects of sediment transport and the sediment budget on the central Platte. We think this will give readers better insight into the more nuanced details of sediment on the central Platte without skewing from the original intent of the chapters.

3) We will add information about the sediment deficit/surplus in relation to sandbar height to Chapter 3. That is an easy addition and is something we should have done originally.

4) The issue of "…assertions in the report of a sediment deficit of 150,000 tons, but also indicates enormous difference among estimates" is something we can't do much about. References to historical sediment budget numbers must be taken with appropriate levels of confidence because there simply is no historical data and there is no way to create or find such data to do something like accurately and precisely estimate the pre-dam sediment budget in the central Platte. The 185,000-225,000 range estimated by the BOR was done as a part of the negotiation of the Program and is what we had to start with. The more recent estimate from modeling done by Tetra Tech of a deficit of about 150,000 tons/year was done to update the BOR number and is actually pretty close to the original BOR estimate. We only have the more recent data to work with and that is what we are building on. The fact that there is interannual variability in the sediment deficit is one challenge we are trying to work through in terms of management actions.

## Dr. Kondolf replied as follows:

Thanks to Chad for his response. Sorry if there was some misunderstanding about my comments. I did not intend to propose that the report "deeply describe every aspect of what the program has learned about sediment transport and the sediment budget" nor to add "vast detail on sediment". The Report currently has unsupported assertions about a sediment deficit of 150,000 tons in the upper half of the AHR, which then somehow disappears in the lower half of the reach, despite the lack of a major tributary whose sediment load could make up the difference. Any reader with a solid background in fluvial geomorphology would want some justification for these statements, and some explanation for how the sediment deficit to equilibrium must be gradual and that it would be shifting downstream over time, as readily accessible sediment supplies are exhausted from the channel. Moreover, the number 150,000 tons is repeated as a fact, when in reality it is only one of several estimates, and is based on model results, which we know are always subject to large errors and uncertainties.

It would seem to be a false dilemma that the Report must either limit itself to unsupported assertions about a 150,000-ton deficit and the downstream half of the AHR being in equilibrium, or "deeply describe every aspect" of sediment transport. I would think a few sentences could adequately sketch out the basis of these statements, including some indication of uncertainties surrounding the 150,000 tons and the conceptual model of bed and bank erosion to explain how the lower half of the reach can be in equilibrium in the absence of a large tributary sediment input. A simplified diagrammatic map could show the essential elements involved, such as the J-2 hydro diversion, which reaches of the bed show degradation vs those showing vertical stability, and the inferred reach of bed and bank erosion as source of sediment making up the deficit.

Chad's suggestion to add an appendix to Chapter 2 would be one way address these issues. I leave it to the program whether such an appendix would result in a document that "flows" and whether that would be as effective as adding sentences to explain the basis for assertions as they are introduced. I understand from the responses that the emphasis in these chapters was to be more on ecology. However, much of the argument about the suitability of the AHR for the birds seems to rest on geomorphology, so it would seem that the geomorphic and sediment processes would most logically be explained as they are introduced in the argument. It seems less clear to only assert the points about sediment deficit in the text with the expectation that the reader would go to an appendix and/or to consulting reports for treatment of context, uncertainty, etc, without providing a concise summary of these arguments and their basis. This page intentionally left blank

### Peer Review submitted by Robert Wiley

## General Questions

I saved all chapters as received, adding RLW to the document name and edited them in trackchanges mode. I have tried in my review to avoid wordsmithing but in some circumstances could not resist. Use my suggestions or not as you see fit. There are many substantive comments in the track-changes documents returned to you that do not end up in any summary. You may find use in these to clarifying some passages and clarifying some of your assumptions. I sometimes disagree with findings and assumptions and argue a bit, but the intent is conceptual improvement of understandings needed to manage these species and not argument in itself. Some of my concerns expressed are actually resolved in later chapters, particularly in Chapter 5.

1. Does the combined set of tern and plover habitat synthesis chapters adequately address the overall objective of the chapters, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for least terns and piping plovers?

I assume you mean chapters 2 and 3. I generally agree with the presentations and conclusions of these chapters but comment on some details and assertions. See my comments in track-changes mode for each returned chapter.

2. Do the authors of the tern and plover habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

I believe that the author's conclusions are well researched and well founded. Conclusions are reasonable from the assessments conducted.

3. Are there any seminal peer-reviewed scientific papers that the tern and plover habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

See Conclusion Question 15 for a list of additional documents and citations.

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

Yes. The chapters were well explained and referenced. Some of the references are a bit dated. Detailed comments addressing these issues may be found in the returned track-changes document. Also, see responses in question 15 below.

5. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of these chapters and then discussed in the results and conclusion sections?

Yes. Chapter 6 seems unnecessarily long and may be unnecessary to the overall document conclusions. The attempt to compare segments concluded that comparisons were not very convincing or useful for management. See additional comments in response to question 14 below.

## CHAPTER 3 Specific Questions

6. Are the methods used to measure sandbar heights in the AHR appropriate? Do the results appear to be reasonable?

The major factor in nest loss and reproductive failure is post-nest or post-hatch flooding. The methods used to assess sandbar height relationship to reproductive success do not consider the gauge data for the period of record for the stage-discharge data. Moreover, average conditions are not relevant. Here is why:

The likelihood for the occurrence of a successful nest (nest success: at least one fledged bird per season per nest) has little to do with stage-discharge averages or for the average of any selected 3-year period; in fact, the averages will assure flood loss of nests for most breeding seasons.

The total height of a sand bar is not a measurement of the risk of nest loss or reproductive success in any season. Nest success depends on whether there is a destructive (island over-topping) flood event after egg laying and/or hatch. You might analyze the gage data for the period of record to identify the number of times that spring high flow (prior to nest initiation) was exceeded (or not exceeded) by a higher flow afterwards during a nesting season. Consider the frequency of not destructive breeding seasons as a measure of potential productivity.

Data and analyses provided are not convincing that any particular magnitude of flow/stage can be achieved that will lead to increased seasonal reproduction.

7. Is it reasonable to use distributions of observed sandbar height and area relative to peak stage along with reach stage-discharge relationships to infer the Program's ability to use the FSM management strategy to increase sandbar area and height to support sufficient use and reproductive success resulting in increases in the populations of terns and plovers within the AHR?

It is reasonable to suggest that there is a direct relationship between stage and resulting height of sandbars. More work is needed to predict the magnitude. A high flow at the beginning of the breeding season will likely result in nestable sandbars. The height needed for successful nesting in any given breeding season is completely under control of subsequent storm flows. Gage data seem to suggest that such storm frequencies allow for reproduction 2-3 times a decade under present conditions, or 4-6 times during the life of a nesting pair. Is that enough? Why does the reproductive success have to increase? Is the present contribution of the Platte to the greater ILT and PPL populations important enough to make a population difference.

Surely, the likelihood of flood induced nest failure could be reduced by the creation of higher sandbars. It would seem an important questions as to whether sufficient water would ever be available to raise relative sandbar height to a point that reduces the frequency of summer storm flood-driven nest failure?

## CHAPTER 4 Specific Questions

8. Is the inferential caution issued by the authors (see lines 276-288), with respect to the confounding effect of colony nest site selection and the geomorphic process responsible for building islands, correct for this study?

NO! See extensive comments at and below those lines on the issue of nest site selection. Also, consider the following graph. This graph is are based on GPS located nest data ( $\sim$ n=4800) for least tern nests collected in the Missouri River between 1998 and 2006 and treeline delineations from 1998 and 2005 imagery.



Similar data summaries and graphs are available from the Technical Appendices to the EIS for Emergent Sandbar Mechanical Creation 2011 for both PPL and ILT for the Gavin's Point, Fort Randall, Garrison and Fort Peck Segments of the Missouri River. Contact the Omaha Office of the Corps of Engineers for actual graphs and data in spreadsheet form. Please also review the bibliographies for each section of the technical appendix. If you can get clearance from USACE Omaha (Kelly Crane), I would be glad to copy all relevant Missouri River data to a thumb drive and forward it to you.

## CHAPTER 5

9. Are the methods used to predict the frequency of inundation for sandbars in this chapter appropriate?

It was the correct approach to analyze the frequency of occurrence of sandbar availability using gage data, as was done. The value for prediction is uncertain due to unknowns for the changes in precipitation patterns for this region and how continued development of the basin will impose greater water demands.

10. Is it appropriate to use the MOVE.1 method to infer flow at Overton for the period of 1895-1916 and treat this as representative conditions for the Associated Habitat Reach?

MOVE1 appears to reveal the correlation between unconnected events (flow in two separate streams) driven by larger scale patterns (weather) and is probably the best that can be done with the incomplete data sets available. Application of the NSCE model indicates adequacy of correlation to be high. Statistically, the methods appear to be sound. That said, was the extension of the incomplete data set necessary?

Does the addition of the interpolated period to the larger data set alter the subsequent calculations for the frequency of occurrence of prohibitively shortened nesting years caused by late high water or the frequency of occurrence of storm-drive stages higher than the sandbar elevation resulting from the spring rise?

Additional questions arise concerning trends both before and after significant water extraction from the channel:

- Did the year to year (or decade to decade) frequencies of occurrence of the two events change over the assessment period? Are over-topping events becoming more or less frequent?
- Are season-shortening late spring flow recession event becoming more or less common?

11. Is the relationship of sandbar height (relative to peak flow stage) decreasing as sediment size decreases appropriate for the central Platte River based on observed sandbar heights in the central and lower Platte River and the available body of scientific literature?

There is a physical relationship between bed load particle size, velocity, stage and sandbar height. The higher the flow, the higher the stage, given a particular channel cross-section. The higher the flow the higher the velocity. The higher the velocity the larger the particle that can be moved by saltation or sheared from the bed, entrained and transported. Sandbar deposition is sensitively mediated by velocity and particle mass. More massive particles require higher velocities to be entrained and settle faster than smaller particles for a particular flow velocity. Smaller particles will remain entrained for a longer period and would be distributed over a greater area, resulting in lower sandbar heights for a given rate of flow reduction.

Sandbar heights (and cross-sections) tend to mirror the shape of the hydrograph that created them. Sandbar composition (as particle size) is a function of shear and entrainment velocity (power) of the flow event to entrain and then deposit a given particle size. If a given flood can only entrain 0.4 mm size sand, then that size class will compose the resulting bar forms. These are not phenomena that are unique to any of the Platte segments but are supported by the literature. These factors are better elucidated in the follow Chapter 6.

12. Does the approach used to infer sandbar heights in the historical central Platte River appear to be reasonable? The historical river analysis period extended from 1895-1938.

Both approaches appear to be sound.

13. On pages 19 and 25, piping plover/least tern nest initiation period is assumed to be the same historically as it is today. Is this a reasonable assumption?

It has to be because we have no other empirical data. If the birds follow meteorological cues they likely shift their specific breeding window to fit the phenology of a locale. The finding that ILT also breed in the southern hemisphere spring suggests that they have great flexibility. Why is this question germane? If the birds fail to synchronize with the Platte phenology they will fail to reproduce. They will either utilize better habitat in other rivers and the limited breeding habitat on the Platte will fail to contribute to the populations. A management plan for the Platte cannot rationally address this issue.

## CHAPTER 6

14. Is the conclusion that "implementation of FSM will likely not create or maintain least tern and piping plover nesting habitat" appropriate and supported by the evidence presented?

### YES

The comparison between the various segments is not convincing in Chapter 6. The strong case for the prediction of FSM failure was best made in Chapter 5.

If the same methods were used to compare segments of any river, would the outcome not be the same? Wouldn't the finding be that there is little similarity longitudinally as well because of the continual variation in cross-section, bedrock influence, contributing drainage area, bed load composition, slope, etc. It may not be that these or any set of metrics reveals meaningful comparison as it may facilitate bird reproduction.

Birds nest in many segments of many rivers, as well as along lake and beach shorelines and in wet prairies, sand mines and rooftops. There are some natural circumstances that create habitat upon which these birds successfully breed sometimes. There are some areas that may support successful breeding in 10 out of 10 years. There are some sites that make successful breeding habitat available for 1 out of 10 years. Their relative contribution to maintenance of the population varies year to year.

There is a schema of physical and temporal conditions defined by the reproductive timing of the species and their nest site selection criteria that can occur at thousands of locations throughout their continental range during most breeding seasons. The bird's longevity militates against the importance of seasonal loss of production at any or all locations.

The segment comparison in Chapter 6 does not provide useful information for management because it rightly concludes that the comparison of some arbitrarily selected comparison criteria are relatively meaningless.

## SUMMARY OF KEY FINDINGS

15. Is the finding that indicates it is unlikely the Program has the ability to manage flow and sediment to create habitat conditions that could support sufficient use and reproductive success

and result in tern and plover population growth within the AHR supported by the data and information presented in these chapters?

### Yes

The findings particularly as presented in Chapter 5 suggest that spending money on increasing ILT and PPL productivity is not a good use of limited resource management funds. There are several reason:

- The AHR (and the Platte in total) historically contributed to the range wide population of these species on an infrequent basis (less than 3 years out of 10). It is likely that even without management that the Platte will provide some breeding habitat in some years and that some birds will successfully use it.
- The contribution to the range wide populations by the AHR (and the Platte) has never been a very large portion of the range wide populations. Whether its contribution to the range wide population will be missed if not managed needs to be better addressed.
- The magnitude of creation of seasonal potential breeding habitat is directly controlled by difference in the spring high flow and the magnitude of subsequent summer storm flows.
- Damming and water extraction have reduced the likelihood that the infrequent alignment of events (spring high flow, dry following summer and paucity of high runoff storms) will occur. The water lost (particularly in the spring) cannot easily be replaced. While getting water allocated to increase spring flow may be aspirational, the likelihood seems low due to continual increase human pressures on water supplies in the basin.
- The magnitude of test flows identified in Chapter 3 are demonstrated to be ineffective in creating sufficiently high sandbars by the findings in Chapter 5.

Over all I concur with the findings that management money would not achieve FSM objectives. The cost potentially associated with maintaining or increasing ILT and PPL breeding success on the Platte or the AHR would be very high and the overall benefit very low. I think that the evaluation of flow, stage, sandbar creation and late season over topping potential are well done and the conclusion well justified by modeling. I have personally tackled these problems and while approaching them a bit differently, came to the same conclusions for several other river segments used by the species of concern.

Some areas of importance for ILT/PPL site selection and use were not addressed in the document These include elucidation of the factors affecting longevity of a productive site (erosion and vegetal colonization) and the importance to both site selection and egg/chick camouflage that is rendered by aeolian processes (wind ablation, armoring, color/pattern creation). I could elaborate on all of these but have already done so in several documents not reviewed by the authors of this document.

I suggest the authors review the following:

- Carlos C.J. and C.E. Fedrizzi. 2013. History, distribution, and seasonal abundance of the Least Tern Sternula antillarum (Aves: Charadriiformes: Sternidae) in Brazil. ZOOLOGIA 30 (2): 135–142, Sociedade Brasileira de Zoologia. http://dx.doi.org/10.1590/S1984-46702013000200003.
- Lott, C.A. and R.L. Wiley. 2011. Effects of dam operations on Least Tern nesting habitat and reproductive success below Keystone Dam on the Arkansas River. US Army Corps of Engineers Research and Development Center. 3909 Halls Ferry Road, Vicksburg, MS 39180-6199. 172 pp.

- Lott, C.A. and R.L. Wiley. 2012. Sandbar Nesting Habitat for Interior Least Tern (*Sternula antillarum*) on The Red River Below Denison Dam, 2008. Final Report to the Tulsa District USACE. American Bird Conservancy, The Plains, VA
- Lott, C.A., R.L. Wiley, R.A. Fischer, P.D. Hartfield and J.M. Scott. 2013. Least Terns (*Sternula antillarum*) breeding distribution and population ecology: implications for monitoring, research, and the evaluation of alternative management strategies on large, regulated rivers. Ecology and Evolution 3(9). Published online, August 26, 2013. doi: 10.1002/ece3.726.
- Wiley, R.L. and C.A. Lott. 20??. Riparian vegetation, natural succession, and the challenge of maintaining bare sandbar nesting habitat for Least Terns. US Army Corps of Engineers Research and Development Center. 3909 Halls Ferry Road, Vicksburg, MS 39180-6199. 17 pp. <u>Pending review</u>.

The authors should also review technical appendix B and all of its attachments to the EIS for Mechanical Creation of Emergent Sandbar Habitat in the Missouri River finally published by the Omaha District USACE in 2011. Review of the documents in the bibliographies to those appendices and attachments would beneficially expand those in the present document. A table of peer review follows on the next page.

	Chapters/Sections Ratings							
Category	1	2	3	4	5	6	Conclusion	
Scientific soundness	2	1	1	3	1	4	1	
Degree to which conclusions are								
supported by the data	1	2	2	2	1	2	1	
Organization and clarity	1	2	2	1	1	2	2	
Cohesiveness of conclusions	1	2	2	2	1	4	1	
Conciseness	1	3	3	2	1	2	1	
Important to objectives of the								
Program	1	1	1	3	1	5	1	

## **Review Rating & Recommendation**

RECOMMENDATION							
Accept							$\checkmark$
Accept with revisions	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	
Unacceptable							

Note: Mr. Wiley clarified his recommendations to state that only Chapter 6 should be "accepted with revisions," as described in the addendum below. This revision is reflected in Table 3-2 on page 11 of this report.

### Addendum from Louis Berger:

# Louis Berger contacted Mr. Wiley to ask him to provide the specific revisions he feels are necessary to accept the chapters. His response was as follows:

Comments made to chapters 1 through 5 are minor corrections and clarifications. I saw no fatal flaws. I made no comments on the summary chapter because it accurately reported the findings of the various chapters. If findings change due to revisions, I would expect the conclusion to change accordingly.

Chapter 6, the attempt to compare with other similar rivers cannot be truly fixed because the basic concept is wrong. The idea of defining similar rivers suggests an initial presumption that some planform or volumetric comparison can tell us something about bird nesting behavior. While there is no substantiation for such an assumption other than someone thought it a good idea, the assessment itself demonstrates that the comparison notion was spurious. I think that this whole chapter fails to serve the objectives of the document as a whole. Your basic points and findings are made without it. My suggestion is to drop it.

If you wanted to carry out a broad discussion that would support the narrative of chapters 1 through 5, you might recast chapter 6 to describe the physical conditions that result in annual successful nesting habitat throughout the range of the birds. You have identified the chief characteristic; the absence of a sandbar over-topping flood after there has been nesting, hatching, and fledging on a sandbar. Other characteristics include a paucity of vegetation, distance from a shoreline (really tall trees), and the presence of a predator moat (although the importance of this feature has not been proven through experimentation). You could include the limitation of prey, but only if you can demonstrate a food limitation anywhere in the range. I suggest you also consider desiccation leading to aeolian ablation and the formation of a camouflaging pavement, as another important condition.

The combination of these conditions occurs somewhere throughout the ranges of the birds almost every year. It occurs very frequently in some locations (Mississippi and Red River sandbars and the marine coastlines) and very infrequently on other river segments (the Platte, the upper Missouri and the Niobrara). The precise conditions change exact location, shape and suitability on a continual basis, but they do recur and develop somewhere and these two species have been finding them for millennia. Changing your discussion to summarize the frequency of occurrence of the serendipitous convergence of conditions better supports your findings that the Platte Plan will not meet its objectives.

The following report might assist in such an effort.

Lott, C.A., S.F. Railsback, and C.J.R. Sheppard. 2012. TernCOLONY 1.0 model description. ERDC/EL CR-12-3. Vicksburg, MS: U.S. Army Engineer Research and Development Center. <u>http://www.leasttern.org</u>. The EDO clarified that Chapter 6 was specifically requested by the USFWS and ISAC and that it will not be dropped from the report, and asked Mr. Wiley if there was anything in that chapter that needed to be fixed (i.e., specific revisions). Mr. Wiley responded as follows:

Other than any minor revisions or clarifications noted for Chapter 6, I see no fatal flaws in the process. It conducts the comparison with a straight face and reaches a conclusion based on the presentation of the evidence that the author chose to evaluate. If chapter 6 satisfies a scope of work requirement for the author of the chapter then why must I approve of it? The author went about it in a workman like manner and chose an array of potentially meaningful comparisons. If the client was seeking an assessment of whether such comparison was meaningful for a management plan, then the author provided a pretty clear answer that comparison was of limited value. The finding is a worthwhile outcome to what was essentially an unfounded opinion that there is something systematic about a river segment. The chapter did not answer a scientific question that aids in management of the Platte, whereas each of the other chapters did so.

### APPENDIX B: EXECUTIVE DIRECTOR'S OFFICE RESPONSE TO KONDOLF REQUIREMENTS FOR ACCEPTANCE OF CHAPTERS

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- **1** Response to Kondolf requirements for acceptance of chapters:
- 2 Sediment Deficit & Sediment Budget
- 3 The Report should explicitly state the basis for the statement that the average annual sediment deficit
- 4 below the J-2 Hydro Return is 150,000 tons, and develop a sediment budget for both pre-J-2
- 5 conditions and post-J-2 conditions. The Report should include a map showing the features of the J-2
- 6 project and where sediment deposits within the project. The sediment budget should include all
- 7 relevant components, including downstream transport above and below the J-2 project,
- 8 sedimentation within the J-2 project, sediment augmentation rates below the project, and estimated
- 9 contribution of sediment from bed & bank erosion below J-2.
- 10 These requests indicate that the reviewer will not accept the chapters in absence of detailed analyses of
- sediment transport in the historical and contemporary AHR. The Program has completed these analyses.
- 12 As with many aspects of the PRRIP monitoring and research program, this subject was given superficial
- 13 treatment due to the focus on the target species. Investigations of sediment supply and transport include:
- HDR Inc. in association with Tetra Tech, Inc. and The Flatwater Group, Inc. 2011. 1-D Hydraulic and
   Sediment Transport Model Final Hydraulic Modeling Technical Memorandum. Prepared for Platte
   River Recovery Implementation Program.
- Holburn, E.R., Fotherby, L.M, Randle, and D.E. Carlson. 2006. Trends of Aggradation and Degradation
   along the Central Platte River: 1985 to 2005. United States Bureau of Reclamation.
- Murphy, P.J., T.J. Randle, L.M. Fotherby, and J.A. Daraio. 2004. "Platte River channel: history and
   restoration". Bureau of Reclamation, Technical Service Center, Sedimentation and River Hydraulics
   Group, Denver, Colorado.
- Murphy, P.J., T.J. Randle, L.M. Fotherby, and R.K. Simons. 2006. Platte River sediment transport and
   vegetation model. Bureau of Reclamation, Technical Service Center. Denver, Colorado.
- Randle, T.J. and Samad, M.A. 2003. Platte River flow and sediment transport between North Platte and
   Grand Island, Nebraska (1895-1999). Bureau of Reclamation, Technical Service Center,
   Sedimentation and River Hydraulics Group, Denver, Colorado.
- Simons & Associates, Inc. and URS Greiner Woodward Clyde. 2000. Physical history of the Platte River
   in Nebraska: Focusing upon flow, sediment transport, geomorphology, and vegetation. Prepared for
   Bureau of Reclamation and Fish and Wildlife Service Platte River EIS Office, dated August 2000.
- The Flatwater Group, Inc., HDR Engineering, Inc., and Tetra Tech, Inc. 2010. Sediment augmentation
   experiment alternatives screening study summary report. Prepared for the Platte River Recovery
   Implementation Program.
- The Flatwater Group, Inc., HDR Engineering, Inc., and Tetra Tech, Inc. 2014. Sediment augmentation
   final pilot study report. Prepared for the Platte River Recovery Implementation Program.



38 *Responses to specific issues in the comment include:* 

### The Report should explicitly state the basis for the statement that the average annual sediment deficit below the J-2 Hydro Return is 150,000 tons...

- 41 The mean annual sediment deficit was estimated to be on the order of 185,000 T by the Bureau of
- 42 Reclamation using SedVeg, a 1-dimensional numerical sediment transport model (Murphy et al. 2006).
- 43 The Program subsequently funded the development of a HEC-6T numerical sediment transport model to
- 44 update sediment deficit predictions and facilitate the evaluation of sediment augmentation alternatives
- 45 (HDR Inc. 2011). That modeling effort produced a slightly lower mean deficit estimate on the order of
- 46 150,000 T (The Flatwater Group Inc. 2010). However, as mentioned in Chapter 2, the deficit appears to
- 47 *be highly variable from year to year.*

### 48 ...and develop a sediment budget for both pre-J-2 conditions and post-J-2 conditions.

- 49 Simons and Associates Inc. (2000) developed a crude pre-development sediment transport of on the order
- 50 of 7.8 million T per year based on a flow/sediment regression analysis and an estimate of sediment
- 51 trapping in reservoirs. Contemporary sediment loads were estimated to be on the order of 1 million T per
- 52 year. Murphy et al. (2004) estimates of pre-development sediment transport were much lower at 1-2
- million T per year. Contemporary sediment load estimates were on the order of 400,000 800,000 T per
- 54 *year.* As indicated by the difference in these estimates, there is a high degree of uncertainty related to
- *sediment loads in the historical AHR.*
- The Report should include a map showing the features of the J-2 project and where sediment deposits within the project.
- 58 This can easily be added to the report.
- 59 The Report should include a map showing the features of the J-2 project and where sediment deposits 60 within the project.
- 61 Simons and Associates Inc. (2000) and Murphy et al. (2004) both include maps showing irrigation
- infrastructure in the Platte River watershed. Simons and Associates Inc. (2000) specifically addresses
   sediment deposition in irrigation reservoirs.
- 64 The sediment budget should include all relevant components, including downstream transport above
- and below the J-2 project, sedimentation within the J-2 project, sediment augmentation rates below
- 66 the project, and estimated contribution of sediment from bed & bank erosion below J-2.
- The Flatwater Group Inc. (2010 and 2014) provide discussions of the specific sediment transport components presented in the comment.
- 69 The basis of the statement that the eastern half of the AHR is in 'equilibrium' should be clearly spelled
- out, and physical process by which the reach changes from a 150,000-ton deficit to being in balance
- 71 should hypothesized and tested to the extent possible.
- 72 The statement that the eastern half of the AHR is in equilibrium is based on several lines of evidence:



- Holburn et al. (2006) concluded that the AHR channel transitioned from degrading to stable near
   RM 202 near Gibbon (see Figure 7.1) based on repeat transect surveys.
- Murphy et al. (2006) concluded that the AHR channel transitioned from degrading to stable
   downstream of RM 202.2 near Gibbon (see Table 5.8) based on sediment transport modeling.
- The HDR Engineering Inc. (2011) HEC-6T model indicated that predicted changes in bed
   elevation stabilized (IE no more degradational trend) near RM 2010 at Minden (see Figures 4.8 and 4.9).
- 4) Analysis of transect survey and sediment transport measurement data (Tetra Tech Inc. 2014) for 80 the period of 2009-2013 strongly indicates that the portion of the reach upstream from Kearney 81 was degradational during that period, with an average annual sand deficit in the range of 82 100,000 tons. Considering results from the surveys and the independent analysis done by both the 83 Bureau of Reclamation and Tetra Tech (see above 1-3), the portion of the reach downstream from 84 Kearney was most likely aggradational. There are, however, contradictory lines of evidence; 85 thus, this conclusion is only weakly supported by the data. Tetra Tech also noted that it is very 86 important to recognize that the sediment loads along the reach vary significantly from year to 87 year due primarily on the magnitude and duration of the flows, and the overall sediment balance 88 may change depending on the type of flow year. While long-term planning based on average 89 annual estimates may provide a sound basis for certain decisions, changes during extreme years 90 may actually overwhelm the anticipated changes from evaluation of the average annual sediment 91 balance (See 2.7 on pg. 226). 92
- The physical processes by which the reach transitions from deficit to balance are discussed in most of the
  documents referenced in this discussion. In short, there are no major tributaries in the AHR that
- 95 *contribute sediment to the river. The deficit is made up by erosion of channel bed and bank materials.*
- 96 This is the primary motivation for sediment augmentation. The Program recognizes that without
- 97 augmentation, the upper portions of the reach are likely to continue to degrade and narrow and that
- 98 *degradation will gradually move downstream.*
- 99 How AHR Differs from Other Reaches
- 100 The Report should include a better exploration of how the AHR differs geomorphically from other
- reaches, such as LPR, Niobrara, and Loup. The basis of the historical grain size reported should be
- spelled out (along with inherent uncertainties). The possible geomorphic reasons for coarser grain
- 103 size currently should be explored and tested to the extent possible.
- The requirement for a better exploration of how the AHR differs geomorphically from other reaches is
  vague. We are unsure how to address this requirement unless it relates specifically to bed material grain
  size. That issue is addressed below.
- 107 The historical grain size of 0.4 mm was based on a very limited number (<10) of bed material samples
- reported in U.S. Army Corps of Engineers  $(1931)^{1}$ . Accordingly, there is high (and undefinable)
- 109 uncertainty in relation to this estimate. Program subsurface sediment cores taken in areas of the channel

<sup>&</sup>lt;sup>1</sup> U.S. Army Corps of Engineers, 1931, Silt investigation in the Missouri River basin, mainstem of Missouri River and minor tributaries, appendix XV, supplement V, Sediment characteristics of the Platte River.

- that were unvegetated active channel in the 1930s indicate a median grain size closer to 0.7 mm
   (unpublished data).
- 112 The geomorphic reasons for coarser grain size can be viewed at two different scales. First, the majority
- of the difference between grain size in the AHR and other river segments evaluated in Chapter 6 can be
- attributed to differences in sediment supply source. The majority of the sediment in the Niobrara, Loup,
- and lower Platte (from Loup) is supplied from the portions of those segments that flow through the
   sandhills region of central Nebraska. That region is typified by fine, wind-deposited sands. The sediment
- sandhills region of central Nebraska. That region is typified by fine, wind-deposited sands. The sediment supply of the AHR is derived, ultimately, from the North and South Platte River headwaters in the Rocky
- supply of the AHR is derived, ultimately, from the North and South Platte River headwaters in the Rock
   Mountains. The main stem of the Platte River passes south of the southern boundary of the sandhills
- region. As such, it lacks the supply of 0.2 mm and finer sands found in the watersheds of the other
- 120 segments.
- 121 At a reach scale, the sediment deficit in the AHR caused by clear water hydropower returns has resulted
- in winnowing of fine sediments in degradational reaches. The fining of bed material grain size
- downstream through the reach is apparent in Tetra Tech Inc. (2014). The influx of sediment during high
- discharge years like 2011 appears to temporarily reverse coarsening (Tetra Tech Inc. 2014).
- 125 The argument that the AHR was historically unsuited to use by the birds is based on a long train of
- assumptions and calculations. The errors/uncertainties associated with each step should be
- acknowledged so that the final result can be stated with uncertainty bounds.
- 128 We assume that the reviewer is referring to the statement in Chapter 5 that the historical AHR appears to
- have been less suitable for nesting than the contemporary lower Platte River. The analyses in that chapter
- 130 *utilized 1) stage-discharge relationships, 2) discharge records, 3) sandbar height estimates, and 4) nest*
- exposure data from the AHR. The stage-discharge relationship for the historical AHR was derived from a
- 132 *HEC-RAS model developed from a channel transect survey from the 1920s. Roughness values in that*
- model were derived from calibrated models of the contemporary river. We are not aware of a way to
- numerically quantify the error in the modeled stage-discharge relationship other than to state that there
- *is some uncertainty.*
- 136 *The discharge records for the historical AHR were derived from a combination of existing flow records*
- 137 and a flow record extension exercise to adjust flow records from a gage upstream of the AHR. If the Nash
- Sutcliffe Coefficient of Efficiency (NSCE) for the analysis of 0.75 is interpreted as an approximation of  $r^2$ ,
- 139 uncertainty in discharge estimates for the estimated portion of the historical AHR flow record could be on
- 140 *the order 25%. The distribution of the error is not known.*
- 141 The sandbar height estimate was based on observed sandbar heights in the contemporary AHR. No
- sandbar data is available for the historical AHR other than qualitative descriptions that agree well with
- 143 *classifications of contemporary sandbar morphology (see Chapter 1). The contemporary AHR sandbar*
- 144 height was used in an effort to develop conservatively-high estimates of sandbar height. The rationale,
- 145 based on published relationships between bed material grain size and sandbar heights, is presented in the
- 146 *text.* We are not aware of a way to numerically quantify the error in the sandbar height estimates other
- 147 *than to say we attempted to be conservative.*
- 148 No nest exposure data is available for the historical AHR because the first species observations in the
- 149 AHR did not occur until the 1940s. These first observations post-date the completion of major irrigation



infrastructure in the basin. To our knowledge, there is no way to quantify the uncertainty associated with
 this assumption.

The analysis calculations are straightforward (IE, reading stage from a stage-discharge curve for a given 152 discharge) so we assume the reviewer is primarily concerned with the effects of uncertainty in metric 153 values on analysis results. We frankly cannot numerically bound most of the uncertainties for the reasons 154 described above. Accordingly, it is up to the reader to come to their own conclusions about whether or 155 not the analysis assumptions appear to be reasonable. We feel that they are reasonable enough to support 156 the conclusion that the historical AHR was not an analog of the contemporary Lower Platte and was 157 likely less suitable for nesting. That is the only assertion made in Chapter 5 regarding the historical AHR. 158 Given the lack of species use data and the uncertainties described above, we will never be able to reach 159 definitive conclusions about the suitability of the historical AHR. We do believe, however, that the 160 inferences used to conclude that the historical AHR was highly suitable are not supported by the limited 161 data that are available. Specifically, we find no evidence that physical conditions in the historical AHR 162 were similar to those in the contemporary lower Platte. 163

### 164 *General comment to reviewer:*

- 165 We understand and appreciate the reviewer's concern with reaching conclusions about the effectiveness
- 166 *of FSM in creating tern and plover habitat prior to full implementation of sediment augmentation. Most*
- 167 of the concerns center on the concept of sediment balance. This is an issue we wrestle with internally and
- as such would like to share a couple of thoughts that were not included in the tern and plover chapters.
- 169 There appears to be a concern that the sediment deficit has precluded creation of sandbars suitable for
- nesting even when hydrology (peak flow magnitude and duration) have exceeded Program flow release
- targets. As discussed in Chapter 3, sandbars are present in the AHR following peak flow events (n=1,263
- in the downstream half of the reach in 2010). The limiting factor in relation to habitat suitability has not
- been the absence of sandbars but sandbar height in relation to river stage. Specifically, stage increase
- during peak flow events (in relation to maximum sandbar heights) is not sufficient to produce bars high
- enough to be suitable for nesting and/or are safe from inundation during the summer or the spring rise in
  the following year.<sup>2</sup>
- *Full-scale sediment augmentation would increase the sediment supply to the reach by 15% in a year on*
- average. We have attempted to evaluate the potential effects of a 15% percent increase in sediment supply
- (or conversely the negative effects of a 15% deficit) on sandbar heights in the reach. There appears to be
- 180 little literature that addresses this situation other than the Germanoski and Schumm (1993) investigation
- 181 of changes in braided river morphology under aggrading and degrading conditions.<sup>3</sup> That investigation
- 182 indicated a temporary increase in sandbar heights as channel incision around bar forms decreased water
- 183 *surface elevations relative to those forms.*

<sup>&</sup>lt;sup>2</sup> Sandbar area is also an issue but is secondary in that area means little if sandbars are inundated frequently enough to preclude productivity.

<sup>&</sup>lt;sup>3</sup> Germanoski, D., Schumm, S.A., 1993. Changes in braided river morphology resulting from aggradation and degradation. J. of Geology, 101 (4), 451–466.



- 184 The Chen et al. (1999) analysis of channel gradation trends in Nebraska provides another avenue for
- 185 evaluation of the effects of sediment balance on the presence/absence of sandbar nesting habitat.<sup>4</sup> That
- investigation found that the Platte River at Odessa stream gage (upstream portion of the AHR) is
- degrading at a rate of approximately 0.1 m per decade. The lower Platte River at the Louisville gage is
- degrading at a rate of 0.1 m per decade and the Niobrara River at Spencer was degrading at a rate of 0.4
- m per decade prior to gage discontinuation in the late 1960s. As indicated in Chapter 6, large areas of
- sandbar habitat are present and the target species nest at much higher levels in both of these reaches
- than in the AHR. Accordingly, we have little confidence that adding sediment to eliminate the
- 192 degradational trend in the AHR will result in the production of suitable sandbar habitat. However, as
- 193 mentioned previously we do concur that sediment augmentation is necessary to slow channel incision and
- 194 *narrowing*.

<sup>&</sup>lt;sup>4</sup> Chen, A.H., Abraham, H., Rus, D.L., Stanton, C.P., 1999. Trends in channel gradation in Nebraska streams, 1913-95. USGS Water-Resources Investigations Report: 99-4103, (134 pp.).

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## APPENDIX C: REVIEWER BIOGRAPHICAL SKETCHES

# **Proposed Peer Review Panel Member for** Platte River Recovery Implementation Program Kate Buenau Name Title Scientist Affiliation Pacific Northwest National Laboratory Address 1529 W Sequim Bay Rd, Sequim, WA, 98382 Phone # 360-681-4590 E-mail kate.buenau@pnnl.gov B.S. Biology, Arizona State University; PhD Ecology, University of Education California Santa Barbara Unique Qualifications -Member of the Missouri River Recovery Program Adaptive Management Working Group beginning in 2009, responsible for data assessment and modeling for least terns and piping plovers, as well as AM planning and implementation support. -Bird team lead for the Missouri River Recovery Management Plan Effects Analysis, which is estimating and predicting the effects of current and potential management actions on least terns and piping plovers. Short Biography of Proposed Peer Review Panelist Dr. Kate Buenau is an ecological modeler and guantitative ecologist with the Marine Sciences Laboratory at Pacific Northwest National Laboratory. Her experience includes assessing and modeling species interactions and species-habitat relationships in large rivers, estuaries, and nearshore habitats. She has worked on effects analysis of stressors and management actions on threatened and endangered species, models of the growth of individuals or populations on restored habitat, and techniques for analyzing uncertainty and quantifying the value of information. She has developed quantitative decision support tools for adaptive management programs and on the development of indicators for monitoring ecosystem health. She has worked with the Missouri River Recovery Program since 2009 on modeling, data analysis, and adaptive management for least terns, piping plovers, and pallid sturgeon. She has also worked with habitat restoration programs on the Lower Columbia River Estuary and in Puget Sound.

## Proposed Peer Review Panel Member for Platte River Recovery Implementation Program

 Name
 Daniel H. Catlin

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 Research Assistant Professor

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Education Ph.D. Wildlife Science, Virginia Tech

### **Unique Qualifications**

- Worked with Piping Plovers throughout their summer and winter ranges over the last 10 years

-Studied piping plover and least tern demography for the last 10 years -Evaluated the USACE habitat creation program (2005–2009)

### Short Biography of Proposed Peer Review Panelist

Dan is a quantitative ecologist and Research Assistant Professor in the Departemnt of Fish and Wildlife Conservation at Virginia Tech and one of the directors of the Virginia Tech Shorebird Program. Dan received his Ph.D. in Wildlife Science from Virginia Tech in 2009. His work and that of his students has focused on the demographic responses of piping plovers and least terns to a variety of managment techniques used by the USACE as well as natural factors affecting their demography. Currently, Dan and his colleagues are studying the response of plovers and terns to the historic flooding in 2011. In addition to his work on the Missouri River, Dan oversees research involving piping plovers nesting on Long Island and Cape Hatteras, looking at the effects of emergency breech filling and human disturbance, respectively. Dan also works with plovers and other shorebirds along the Gulf coast and Atlantic southeast. He spearheaded the effort to monitor the response of piping plovers to the Deepwater Horizon Oil spill in April 2010, and he continues to work closely with the USFWS in the Atlantic southeast, evaluating the effects of USACE beach modifications and disturbance on wintering birds.

## **Proposed Peer Review Panel Member for** Platte River Recovery Implementation Program Name G. Mathias Kondolf Title Professor Affiliation University of California, Dept Landscape Architecture Address 202 Wurster Hall, Berkeley CA 94720 Phone # 510 579 6438 E-mail kondolf.berkeley@gmail.com PhD Geography & Environmental Engineering, Johns Hopkins U, MS Earth Education Sciences UC Santa Cruz, AB Geology Princeton U **Unique Qualifications** Research focus on downstream effects of dams and strategies for restoration, including restoration of flow regimes, passing sediment through/around reservoirs, and dealing with vegetation encroachment. Some experience with relevant agencies, including the US Army Corps Short Biography of Proposed Peer Review Panelist G. Mathias (Matt) Kondolf is a fluvial geomorphologist and environmental planner, specializing in environmental river management and restoration. As Professor of Environmental Planning at the UC Berkeley, he teaches courses in hydrology, river restoration, and environmental science, and serves as Chair of the Department of Landscape Architecture and Environmental Planning. His research concerns human-river interactions broadly, with emphasis on management of flood-prone lands, sediment management in reservoirs and regulated river channels, downstream effects of dams, and river restoration. Current research areas include the Mekong, Lower Colorado, Trinity and Klamath Rivers, and Mediterranean-climate rivers in California and the Mediterranean basin. He has provided expert testimony before the US Congress, the California legislature, California Water Resources Control Board, the International Court of Justice (the Hague), and in various legal proceedings in the US. He has published extensively in international peer-reviewed journals and his book Tools in Fluvial Geomorphology (Wiley 2003, second edition forthcoming) is the reference work for methods in the field. He has received two Fulbright awards, the Merit Award from the Council of Educators of Landscape Architecture, and appointments as Clarke Scholar at the Institute for Water Resources in Washington, fellow of the Landscape Architecture Foundation, and served on two National Academy of Science panels, the Environmental Advisory Board to the Chief of the US Army Corps of Engineers, the Calfed Ecosystem Restoration Program Science Board, and the Independent Science Board for the Russian River

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	DIA	Propo	osed Pee	er Review	Panelist	for Drogram				
Platte River Recovery Implementation Program										
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Education	Assoc. Fore	stry, BS Bo	tany/Geolo	gy, MS Land	scape Arch	itecture				
Unique Qu	alifications							1		
I have stu	idied sandbar	habitat in l	arge Missi	ssippi draina	ge area rive	ers since 20	)04,			
particular	rly with focus	on the crea	ition and lo	oss of sandba	ar habitat fo	or interior l	east tern			
(ILT) and	pipingplover	(PPL). Thav	/e conduct	ed in-field su	urveys of sa	indbar hab	itat in the			
Mississip	pi , Missouri,	Arkansas, R	ed and Cin	narron Rivers	s. I have aut	thoredorc	0-			
authored	several tech	nical docum	ients orjo	urnal articles	s on sandba	ir habitat ai	nd or ILT			
populatio	on dynamics (	see list in at	tached CV	).						
Short Biog	raphy of Pro	posed Pee	r Review	Panelist						
I have nea	rly 42 years'	experience	in natural i	resource data	a collection,	analysis a	nd the appl	lication of		
technical s	pecialist in va	rious aspec	ts of resou	rce manager	nent (forest	managem	ent soil			
conservatio	n, mine recla	mation).	have serve	d as an envir	onmental e	engineer for	r a large mi	ining and		
power gene	eration compa	any, managi	ing surface	operations f	for a 70,000	) acre coal	operation i	n central		
Utah. I hav	ve served as	an ecologica	al services	section man	ager for a l	arge interna	ational cons	sulting		
firm in its V	Vashington D	Coffice. I h	have for mu	uch of the las	t 20 years	worked as	a technical			
Engineero	IOF ecosystem	n restoration	and wate	r resource pi	anning for t	the US Arm	iy Corps of	) voore		
Engineers (USACE) at locations across the United States. In doing, I have for more than 10 years worked with the Omaha, Kansas City and Tulsa LISACE Districts in characterizing and resolving river.										
resource management conflicts particularly those associated with minimizing impacts to ILT and PPL.										
I continue this work with ILT/PPL related issues through USACE contracts, with the American Bird										
Conservancy and as a member on the US Fish and Wildlife Services ILT 5-year review (ESA) team										
managed f	rom their Jack	kson, MS of	fice. I prep	ared the tech	nnical appe	ndix (B) for	the Final			
Programma	atic Environme	ental Impac	t Statemer	nt for the Med	chanical an	d Artificial (	Creation an	d Divor		
August 201	1 USACE C	)maha Distr	ict In doir	ne Rivenne na Lanalyzeo	d more than	12 000 II -	T/PPI nest	ina		
records col	llected betwee	en 1996 and	d 2006 and	trended the	ir locations	and distribut	utions with	manv		
river physic	cal factors. I a	also mapped	d the Miss	ouri River hal	bitat for all	free-flowing	segments	between		
Fort Peck I	Dam, MT and	Ponca Stat	te Park, NE			Ū	-			
Lourropthy	racida in Atha	ne County (	Obio and a	ontinuo to da	livor tooboi			ing		
services as	s president of	an Ohio-ha	sed corpor	ation. Good	Ground 11	C. Thave	recently ac	cepted a		
position wit	th the Ohio U	niversity Vo	inovich Sc	hool of Leade	ership and	Public Affai	rs as a proi	ect		
director and	d lecturer on	ecosystem	restoration.	I also serve	on the boa	ards of the	Raccoon C	creek		
Partnership	o (a watershed	d managem	ent group)	and the App	alachian O	hio Alliance	e (a land tru	ust) in		
charge of r	natural resour	ce data coll	ection for t	he 7000 acre	es of proper	ty with our	program.			
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**APPENDIX B – Executive Director's Office Responses to Independent Peer Review Comments** 

PRRIP - ED OFFICE DRAFT

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### PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM EDO Response to Peer Review Comments – General Questions PRRIP Tern and Plover Habitat Synthesis Chapters

5 The format of these EDO responses are as follows:

- 6 Original question to peer reviewers in bold text
- 7 Louis Berger summarized responses from peer reviewers in standard text
- 8 EDO response in italicized red text

Question 1: Does the combined set of tern and plover habitat synthesis chapters adequately address the overall objective of the chapters, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for least terns and piping plovers?

The reviewers agreed that, in general, the combined set of chapters addresses the overall objective to present 15 evidence that the FSM may not achieve the Program's tern and plover management objective. Dr. Buenau 16 noted that while some components of the FSM management strategy were not quantitatively evaluated (e.g., 17 vegetation management), those that were addressed are the most likely limiting factors. In response to this 18 question, Dr. Catlin raised several points as a general assessment of the consolidated chapters, including 19 the need for greater detail in several areas, as well as comments on how uncertainty is addressed. Dr. 20 Kondolf cited concerns about whether the condition of sediment balance has been met, because if it has 21 not, the FSM approach has not been fully implemented. Mr. Wiley also referred to other specific comments 22 throughout the chapters on details and assertions related to this question. 23

Dr. Catlin's comments regarding uncertainty were addressed by 1) amending the Chapter 3 sandbar analysis table to include the standard error estimate for 2010 sandbar measurements and 2) adding a sensitivity analysis to Chapter 5 to address questions about the sensitivity of model results to variability in stage-discharge and sandbar height variables. Dr. Kondolf's concerns about sediment transport and sediment balance were addressed by adding supplemental information and references to Chapters 2 and 3 to address his concern that these topics were not treated adequately in the chapters. Mr. Wiley's comments are addressed in the attached comment/response matrix.

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Question 2: Do the authors of the tern and plover habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

35

The reviewers agreed that overall the authors' conclusions are reasonable and scientifically sound. Both 36 Dr. Buenau and Dr. Catlin refer to their other specific comments and responses to other questions that point 37 out areas requiring greater clarification. They both specifically mention the authors' treatment of 38 uncertainty, and Dr. Buenau noted instances where uncertainty analyses could be more complete or robust, 39 though she pointed out that the analyses as performed are still reasonable and scientifically sound. Dr. 40 Kondolf mentioned several issues discussed in his other specific comments, such as treatment of sediment 41 deficit, whether the AHR ever had large sandbars, and the impacts of summer flooding on habitat, among 42 others. Mr. Wiley found the conclusions to be well researched and well founded. 43

Concerns about uncertainty analysis generally concerned 1) the use of sandbar heights from a single high
 flow event and 2) the lack of an uncertainty analysis in relation to the emergent sandbar model in Chapter

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- 5. The chapters were augmented to clarify that 1) the EDO evaluated sandbars formed during three high 46 flow events and chose to use sandbar heights from the event that produced the highest bars in an effort to 47 develop conservative (high) estimates of potential for productivity and 2) a sensitivity analysis was added 48 49 to Chapter 5 as discussed above. Dr. Kondolf's concerns about the lack of references and detail in relation to sediment dynamics were addressed by 1) clarifying maps, 2) adding a discussion about historical 50 sediment transport and changes in sediment transport to Chapter 1, 3) adding a discussion of sediment 51 investigations and monitoring to Chapter 2, and 4) adding a discussion of the relationship between 52 sediment balance and sandbar height to Chapter 2. 53
- Question 3: Are there any seminal peer-reviewed scientific papers that the tern and plover habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.
- 57

Reviewer responses to this question varied. Dr. Buenau and Dr. Kondolf were not aware of any other papers that need to be considered at this time. Dr. Catlin noted that several works cited in Catlin et al. (2010) related to relationships between sandbar heights and flows were not included in the chapters. He said that while no seminal works specific to the region were omitted, the Program could benefit from placing its results within the larger context of the two species by broadening its literature use outside the specific area. Mr. Wiley referred to his response to Question 15 in which he suggested five additional papers (including citations) for the authors to review.

- The works cited in Catlin et al. (2010) were not included in the chapters because we believe they are generally not applicable to bar formation processes in unconfined sand bed rivers. Specifically, the authors of Catlin et al. (2010) cited Andrews and Nelson (1989), Schmidt and Rubin (1995), and Andrews et al. (1999) to support the assertion that "bars can grow upward to within a centimeter of the water surface if stage is held for a sufficient duration." Each citation is addressed below.
- Andrews and Nelson (1989) presents the results of a nonlinear numerical modeling exercise to 70 predict topographic change of a single sandbar in the Green River, Utah in response to three 71 modeled discharges. The model was not calibrated or validated and the study did not report 72 observations of sandbar heights following peak flow events. It merely included the conclusion that 73 "model calculations predict that sediment will be deposited on the bar crest at all discharges large 74 75 enough to cover the entire bar to a depth of several centimeters or more." We do not believe that the modeling exercise or conclusion above provides evidence that that bars grow to the water 76 surface in unconfined sand bed rivers like the Platte. In fact, Program attempts to model 77 78 topographic change using state-of-the-art 2-dimensional mobile bed hydrodynamic and sediment transport models like SRH-2DS have been largely unsuccessful. 79
- Schmidt and Rubin (1995) focused on describing large-scale geomorphic attributes of canyons with abundant debris fans. The paper describes attributes of bars upstream from constrictions within backwaters of debris fans and downstream of eddies (i.e. whirlpools or vortexes). We do not believe that the bar formation processes associated with debris fan complexes in confined canyons (e.g. Colorado River in Grand Canyon) are an appropriate analog for sandbar mechanics in unconfined alluvial rivers like the Platte.
- Andrews et al. (1999) deals with the topographic evolution of sandbars in the Grand Canyon during
   a controlled flood. As with Schmidt and Rubin (1995) we do not believe that sandbar attributes
   associated with debris fans and lateral separation eddies in a confined canyon can reasonably be

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applied to an unconfined alluvial channel that completely lacks the features (debris fans, eddies) that drive bar formation in confined canyons.

We are familiar with all of the additional references provided by Mr. Wiley. The unpublished manuscript 91 92 on maintenance of riparian vegetation on sandbar habitat includes discussions of many of the same riparian vegetation control methods being tested and/or used by the Program. The Carlos and Fedrizzi (2013) and 93 Lott et al. (2013) publications may be useful in future meta-population modeling efforts. Lott and Wiley 94 (2011 and 2012) outline alternative approaches to evaluation of relationships between hydrology, sandbar 95 habitat, and tern and plover productivity on the Red and Arkansas rivers. The availability of Program 96 hydraulic modeling and LiDAR topography data allowed for a different type of analysis than was possible 97 98 in those studies.

#### Question 4: Is the relationship between management actions, riverine processes, species habitat, and 99 species response clearly described, and do Program monitoring, research, and referenced materials help 100 to verify and/or validate this relationship? 101

102

Overall the reviewers concluded that, in general, these relationships are at least adequately described and 103 validated, but several pointed out examples of areas that could benefit from further clarification. Dr. Buenau 104 noted that the authors could explore, in greater detail, how the physical characteristics of the AHR 105 contribute to the findings in the report, especially habitat formation processes. She offered suggestions to 106 improve confidence in the report's use of limited evidence, though she acknowledged that it would probably 107 not change the fundamental conclusions. Dr. Catlin provided four examples where clarification and/or 108 justification would be helpful so the reader is not left to make assumptions (e.g., exclusion of data from the 109 analysis because of mechanical alterations, use of fully parameterized models). Dr. Kondolf referred to 110 caveats regarding the conclusion that FSM cannot work in the AHR, which are described in his specific 111 comments. Mr. Wiley answered this question affirmatively, noting that the chapters were well explained 112 113 and referenced, though some references were somewhat dated.

The comment and response matrix includes descriptions of changes that were made to clarify and improve 114 the text of the chapters. The EDO response to Question 2 (above) provides a summary of additions that 115 were made to address Dr. Kondolf's concerns about the lack of evidence to support conclusions about 116 sediment balance. 117

### Question 5: Are potential biases, errors, or uncertainties appropriately considered within the methods 118 sections of these chapters and then discussed in the results and conclusion sections? 119

120

Three of the four reviewers (Buenau, Catlin, and Kondolf) expressed some similar comments in response 121 to this question, indicating that this may be an area of weakness in the report. Dr. Buenau and Dr. Catlin 122 agreed that the authors state and discuss a number of uncertainties in the chapters, and both some 123 weaknesses in how uncertainties are analyzed and conveyed. Dr. Buenau pointed out the lack of quantitative 124 analysis of uncertainties, and suggested that the authors conduct a sensitivity analysis on key assumptions 125 to strengthen the utility of the information for decision makers. Dr. Catlin noted instances where the authors 126 127 do not appropriately convey uncertainty, using language that overstates the degree of certainty (e.g., related to sandbar height). Both Drs. Buenau and Catlin also mention the inclusion of error measurements as 128 another suggestion. Both reviewers acknowledge that addressing these comments would improve the report, 129 but they are not "fatal" or invalidating of the results. Dr. Kondolf stated that uncertainties are not always 130 131 appropriately considered and discussed in the chapters (e.g., cumulative uncertainties about conclusion that

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sandbars were historically too low to provide viable habitat are not explicitly considered). Mr. Wileyanswered this question affirmatively.

A number of modifications were made to address concerns about uncertainties in analyses. As described
above, a sensitivity analysis was added to Chapter 5. Error estimates for other analysis components
including LiDAR topography, hydraulic model stage-discharge relationships, and sandbar heights were
also added to the text. The EDO also reviewed the text and in some instances, modified statements that Dr.
Catlin did not think appropriately conveyed uncertainty. We also developed and submitted a response to
Dr. Kondolf to address his concerns about uncertainty in relation to the historical channel. That response
is included in Appendix B of the peer review report.

# Question 6: Are the methods used to measure sandbar heights in the AHR appropriate? Do the results appear to be reasonable?

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Reviewer responses to this question varied. Dr. Buenau responded that, within the uncertainties inherent in 144 the modeling and sandbar delineations, the results and conclusions appear to be sound. She did note, 145 however, that results from the 2011 and 2013 high flow events provide important lines of evidence given 146 the limited data available, and suggest that "a wide range of outcomes is possible, though none may achieve 147 objectives", thus a more thorough explanation of outcomes may be warranted. Dr. Catlin also commented 148 on the exclusion of the 2011 and 2013 data from the discussion, and suggested that these results, combined 149 with the 2010 data, "present a stronger case against the SDHF as it is currently conceived." If these data 150 remain excluded, he suggests that the authors explicitly state their reasoning for doing so. Dr. Kondolf 151 noted that "direct observation during high flows could be more feasible now with improved technology" 152 and suggested the Program consider these technologies to obtain empirical data that may also be useful for 153 model calibration. Mr. Wiley's comments suggest he does not completely agree with the appropriateness 154 of the methods used in Chapter 3 because they do not consider the gauge data for the period of record and 155 average conditions are not relevant to reproductive success. He noted that "nest success depends on whether 156 there is a destructive (island-topping) flood event after egg laving and/or hatch" not total sandbar height. 157 thus the gauge data could be analyzed for the period of record to identify the frequency of non-destructive 158 breeding seasons. 159

The EDO used 2010 high flow event sandbar heights in an effort to develop a conservatively high estimate
of sandbar height potential. As mentioned above, use of 2011 and/or 2013 data would have reduced
sandbar formation and/or height estimates. Dr. Kondolf's comment about direct observation is well taken.
We will investigate those technologies. Mr. Wiley's comments are also well taken. However, the objective
of Chapter 3 was to evaluate assumptions in Program Hypothesis Flow #1, not to analyze gage data to
identify the frequency of non-destructive breeding seasons. That analysis was undertaken in Chapter 5.

166 Question 7: Is it reasonable to use distributions of observed sandbar height and area relative to peak 167 stage along with reach stage-discharge relationships to infer the Program's ability to use the FSM 168 management strategy to increase sandbar area and height to support sufficient use and reproductive 169 success resulting in increases in the populations of terns and plovers within the AHR?

170 Reviewer responses to this question varied. Dr. Buenau stated that the 2010 results present a reasonably

strong line of evidence against the hypothesis, but offered that, if possible, the authors may want to explore

- other explanations and lines of evidence to determine whether a different specified flow may make the FSM
- management strategy more successful. Dr. Catlin questioned whether a clear conclusion can be reached



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- based on the available data, but did not find fault with the interpretation of results. Dr. Kondolf agreed that
- the approach was reasonable, but reiterated that assumptions and uncertainties could be better summarized and presented. Mr. Wiley agreed that a direct relationship between stage and sandbar height is reasonable,
- and reiterated that the height needed for successful nesting depends on subsequent summer storm flows.
- and renorated that the norgan needed for successful hosting depends on subsequent summer storm nov
- Dr. Buenau's comments are well taken. However, the objective of the synthesis chapters was to assess the
  FSM strategy as currently defined. Evaluation of other flow management actions was beyond the scope of
  these analyses and is the sole purview of the GC. Efforts to improve the presentation of uncertainties are
  outlined in previous responses.
- 182 Question 8: Is the inferential caution issued by the authors (see lines 276-288), with respect to the 183 confounding effect of colony nest site selection and the geomorphic process responsible for building 184 islands, correct for this study?
- 185

Dr. Buenau responded that the inferential caution is reasonable, though the presence of absence of sandbars 186 at particular locations may be less critical to the evaluating the hypothesis discussed in this chapter than 187 other factors. Dr. Catlin questioned why the authors did not attempt to tease apart the width-sandbar 188 interaction by evaluating the presence of sand in aerial photographs, and if that is not possible the authors 189 should mention that in the methods. He also wondered why a greater comparison of the Loup River and the 190 AHR was not included, given that the Loup has "used areas" with similar widths to those on the AHR. Dr. 191 Kondolf found the discussion to be reasonable. Mr. Wiley said the inferential caution is not correct and 192 referenced his extensive comments on this section. He also included a graph of least tern nest counts and 193 194 distance from the forest edge in the Gavins Point segment of the Missouri River to indicate this relationship may be stronger than that between nest incidence and channel width. 195

The authors did not attempt to tease apart the width-sandbar interaction due to the lack of both sandbar 196 197 data and detailed nest site locations. Greater comparison to the Loup River was also not included because of the low levels of predicted and observed species use in that segment. The Program tern and plover 198 objectives for the AHR could not be met at nest densities and productivity observed on the Loup. Mr. Wiley 199 indicated that the inferential caution is not correct because the analysis should have been based on nest 200 distance from gallery forest instead of channel width at colony locations. We agree that the analysis he 201 proposed would be valuable. However, we did not perform that analysis because 1) we were addressing a 202 203 specific stakeholder concern about channel width and 2) we do not have access to detailed nest location data in the various segments that would allow us to perform the analysis he requested. Overall, it appears 204 that his concern is that the authors analyzed the wrong habitat metric, not that the analysis that was 205 undertaken was performed incorrectly. 206

# 207 Question 9: Are the methods used to predict the frequency of inundation for sandbars in this chapter 208 appropriate?

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Dr. Buenau noted that the methods assume sandbar height is driven by peak stage, which does not factor in the potential effects of peak stage duration or conditions before and after peak discharge. At a minimum, the uncertainties and their potential effects should be discussed. Dr. Catlin referenced his comments on this section, in particular the use of median sandbar heights, which does not account for the ability of chicks to move to higher elevations during rising waters. He acknowledged the possibility that he may have misinterpreted these methods, but if not, he suggested using the median value for nests and the maximum for chicks. Dr. Kondolf responded that the approach is reasonable, but is based on many calculations,



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assumptions, etc. Mr. Wiley responded that the correct approach was used, but there are uncertainties
 related to changes in precipitation patterns and future water demands that may affect predicted values.

Dr. Buenau's comment regarding sandbar height and peak stage is correct. We would ultimately like to incorporate other factors like antecedent conditions and peak duration into sandbar height predictions but currently lack the data necessary to do so. Reach-scale FSM Proof of Concept projects may provide some of the information necessary to incorporate these factors. In absence of the ability to do so, we used the highest observed median sandbar heights during the period of 2010-2013 in an effort to develop conservative estimates of potential for species productivity.

In relation to Dr. Catlin's comments, median sandbar heights were used in an effort to develop an index of potential for productivity across the entire AHR during the nesting season as a whole. On average, maximum sandbar heights in 2010 (highest 3ft X 3ft area) were 0.3 ft higher than median heights. Given the limited height differential and propensity for lateral erosion of emergent portions of bars during peak

flow events, we feel that adding this additional complexity to the emergent sandbar model would not provide

substantially better estimates of potential for productivity. If the Program ever elects to develop an
 individual-based, sandbar-scale productivity model, sandbar height-area relationships and pair-based nest

- 231 Inativatual-based, sanabar-scale productivity model, sanabar neight-an
   232 exposure windows could be accommodated.
  - In relation to Dr. Kondolf's response, we do agree that the emergent sandbar model involves many 233 calculations and the selection of each model input value involves the assumption that the value is 234 appropriate. We attempted to clearly state the rationale for selection of input values and included a 235 sensitivity analysis to provide an indication of the potential consequences of errors in those selections. In 236 general, we are not aware of another way to address the complex relationships and interactions between 237 hydrology, hydraulics, sandbar morphology, and species ecology in absence of a large, long-term, 238 consistent, systematically-collected in-channel species use and productivity dataset. To our knowledge, this 239 data does not exist for the Platte, Loup, or Niobrara Rivers. 240

We also agree with Mr. Wiley that future hydrology will almost certainly vary from what has been observed.
That is why we indicated that the emergent sandbar model results should be taken as an index of the
potential for species productivity and not an absolute prediction of the future.

# Question 10: Is it appropriate to use the MOVE.1 method to infer flow at Overton for the period of 1895 1916 and treat this as representative conditions for the Associated Habitat Reach?

In response to this question, Dr. Buenau listed six reasons that make it difficult to fully assess the 247 appropriateness of using this method, and noted that while these concerns may not indicate the method is 248 inappropriate, a discussion of uncertainty, validation, and alternative methods may increase confidence in 249 250 the results. This question was outside of Dr. Catlin's area of expertise so he did not comment. Dr. Kondolf mentioned the Hirsch (1982) conclusion that MOVE.2 was more suitable for his tests than MOVE.1 and 251 pointed out that the report does not mention MOVE.2 or why MOVE.1 was selected; however, this is 252 outside his specific area of expertise. Mr. Wiley noted that the method appears to be the best available given 253 limited datasets, and posed additional questions for clarification. 254

- 255 Dr. Buenau's specific concerns are addressed in the comment/response matrix. We evaluated the MOVE.1,
- 256 MOVE.2, and MOVE.3 (improvement on MOVE.2) method. MOVE.1 was ultimately selected because it
- 257 performed slightly better than the MOVE.3 (NSCE difference of 0.01) and required less computation.



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258 Question 11: Is the relationship of sandbar height (relative to peak flow stage) decreasing as sediment 259 size decreases appropriate for the central Platte River based on observed sandbar heights in the central 260 and lower Platte River and the available body of scientific literature?

Both Dr. Buenau and Dr. Catlin responded that this question was outside of their areas of expertise. Dr. Kondolf noted that this relationship is reasonable, but cautioned that there are many influential factors, thus uncertainties should be explicitly recognized. In his response, Mr. Wiley summarized the relationships between bed load particle size, velocity, stage, and sandbar height, and noted that these relationships are not unique to the Platte River and are supported by the literature.

As discussed previously, we concur that there are many factors that influence sandbar dynamics many of which are poorly understood and largely absent from the literature. Accordingly, we chose to base the model on observed sandbar height-area relationships instead of theoretical relationships. We also chose to use the most conservative (highest) distribution of heights observed during the period of 2010-2013.

# 271 Question 12: Does the approach used to infer sandbar heights in the historical central Platte River 272 appear to be reasonable? The historical river analysis period extended from 1895-1938.

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Dr. Buenau commented that if conditions in the historical AHR are similar to the LPR and/or contemporary 274 AHR, then the approach seems reasonable; however, she raised some questions about assumptions and 275 unclear decisions, and suggested a sensitivity analysis to inform the importance of these uncertainties. Dr. 276 277 Catlin questioned whether there is a way to incorporate error measurements into prediction. As noted in his responses to the general questions, without measures of uncertainty the discussion conveys a false sense of 278 certainty in the statistics. Dr. Kondolf responded that the explanation was somewhat unclear, and though 279 he found the approach to be reasonable, it is not definitive. Mr. Wiley responded that both approaches 280 appear to be sound. 281

# We addressed the questions and concerns described above by 1) clarifying the rationale for decisions and 2) developing a sensitivity analysis to explore the implications of model input uncertainties on model output.

# 284 Question 13: On pages 19 and 25, piping plover/least tern nest initiation period is assumed to be the 285 same historically as it is today. Is this a reasonable assumption?

Three of the four reviewers (Buenau, Catlin, and Wiley) generally agreed that this is a reasonable assumption based on available data. Dr. Buenau asked whether it would be possible to compare with data from the LPR that experiences a more frequent spring pulse to support the assumption that timing has not changed. Dr. Catlin mentioned a few early studies of piping plovers on the Atlantic coast (Wilcox 1959, Cairns 1982) that could be compared to current monitoring to determine if any plovers have shifted their breeding times. Mr. Wiley questioned germaneness of this question, noting that a management plan for the Platte River cannot address this issue. Dr. Kondolf noted that this is outside of his area of expertise.

- 294 We did compare AHR data to LPR data and indicate in the text that LPR data falls within the nest initiation
- 295 period used in the Chapter 5 analysis. However, the distribution of nest initiation dates within that window
- could not be compared because LPR nest initiation data is collected opportunistically (i.e., the date of
- 297 *initiation of monitoring, monitoring effort, and date of conclusion of monitoring varies between years). We*
- have been unable to locate a copy of Wilcox (1959) but have reviewed Cairns (1982). That publication
- indicates peak plover hatch dates occurred during the second and third week of June. During the period of
   2001-2013, median hatch date in the AHR was 20-June.



## 301 *Question 14: Is the conclusion that "implementation of FSM…will likely not create or maintain least* 302 *tern and piping plover nesting habitat" appropriate and supported by the evidence presented?*

303

The reviewers concurred that, overall, that the evidence presented does not support the effectiveness of 304 FSM. Dr. Buenau summarized the three main lines of evidence and concluded that they suggest the FSM 305 methodology has limited chance of success. She also reiterated previous comments on the analysis' reliance 306 on a single high flow event and the lack of a quantitative uncertainty analysis, which would strengthen the 307 argument against FSM. Dr. Catlin also agreed that the available evidence does not support FSM, but restated 308 that conclusions are based on a single natural experiment, thus claims about the "likelihood" of FSM 309 creating habitat are too strong. Dr. Kondolf concluded that the evidence "casts doubt on the effectiveness 310 of the methods," but noted that the assumption of sediment balance does not appear to be met, therefore the 311 evidence is not a basis for concluding that FSM cannot work. Mr. Wiley agreed with the chapter's 312 conclusion, but noted that the comparisons between the various segments in Chapter 6 are not convincing 313 or useful and the case against FSM was best presented in Chapter 5. 314

As mentioned previously, Dr. Kondolf's concerns about the lack of documentation of sediment balance have
been addressed in the chapters as well as in a memorandum included in Appendix B of the peer review
report.

# 318 15: Is the finding that indicates it is unlikely that the Program has the ability to manage flow and 319 sediment to create habitat conditions that could support sufficient use and reproductive success and 320 result in tern and plover population growth within the AHR supported by the data and information 321 presented in these chapters?

322

The reviewers generally agreed with the finding as stated in this question. Dr. Buenau listed several other 323 points of evidence, in addition to those pertaining to the FSM strategy, that suggest conditions in the AHR 324 are not ideal for successfully creating habitat as compared to other segments, though some of the 325 consequences of those differences are not fully explained. She also mentioned several shortcomings of the 326 report, including not addressing the feasibility of long-term flow management or whether the AM program 327 allows for significant changes to flows in the future. Dr. Catlin noted the absence of evidence about 328 population growth, and stated that without information on demographic consequences of habitat 329 availability, words like "unlikely" are too strong. Dr. Kondolf agreed with the finding, given the caveats 330 mentioned in his other responses and specific comments. Mr. Wiley listed several reasons why spending 331 money to increase tern and plover productivity in the AHR is not wise and expressed his approval of the 332 report's evaluations and conclusions. He noted a few aspects of tern and plover site selection that were not 333 addressed in the report and suggested that the authors review several papers on these topics. 334

335 We appreciate Dr. Buenau's concerns over the lack of an assessment of the feasibility of long-term flow

management and the ability of the Program to change flow management in the future. These are important

issues but are outside of the scope of the chapters and are the sole purview of the GC. We also appreciate

338 *Dr. Catlin's comment about the absence of evidence related to population growth. Development of tern and* 339 *plover population models are a work item for 2015.* 



## 340 *Peer reviewer ratings and recommendations:*

Dr. Buenau said there are no "fatal flaws or major revisions that would significantly change the 341 conclusions;" however, she noted a number of minor revisions that would strengthen the conclusions and 342 343 provide greater clarity, thus she may be somewhere between "accept" and "accept with revisions." Dr. Kondolf described specific revisions related to a map showing river miles and other features, the basis for 344 the sediment deficit and budget statements, and a discussion of how the AHR differs from other reaches. 345 Comments regarding the sediment deficit and budget were clarified in subsequent emails, which are 346 included with Dr. Kondolf's comments in Appendix A. Mr. Wiley recommended that all chapters be 347 accepted except Chapter 6, which he did not find necessary; however, upon learning the rationale for 348 Chapter 6 via subsequent emails, Mr. Wiley did not object to its inclusion. These comments are also 349 included at the end of Mr. Wiley's comments in Appendix A. 350

As discussed previously, several revisions were made to the chapters to address Dr. Buenau's comments,

mostly related to the treatment of uncertainty. After additional discussion with Dr. Kondolf, additional

maps and detail related to sediment transport, sediment deficit calculations, and sandbar dynamics were

added to the chapters to address his concerns about the lack of detail in those areas.

Comment ID	Chantes/Castien	Dene #	Line #	Deviewer	Comment	
#	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
						General PRRIP response to Missouri River comments: The PRRIP purposely excluded data from the Missouri River segment downstream of
						Gavins Point Dam from the analyses presented in these chapters. The primary two considerations were: 1) the physical scale of the Missouri River
						is so much larger that it becomes difficult to develop meaningful
						segment effectively decouples habitat and species response from hydrology
						and other physical process relationships.
						The width analysis was completed to address stakeholder concerns that previous analyses did not place enough emphasis on that specific metric.
1	Cover and Preface	3	42-43	Robert Wiley	The issue is not just width. Width, depth and planform play into segment depositional versus erosional conditions. Such factors such as attachment to shoreline, elevation above seasonal high flows and,	We agree that other factors are involved in nest site selection but disagree
					importantly, the distance to large tree lines are stronger and more explanatory factors in nest site selection.	nesting in the AHR.
						Noted. Maps have been clarified.
					As I don't know the area or its place names well, I found myself frequently lost with references to multiple places names. I dug out my old AAA map of Nebraska and folded it to cover the big bend of the Platte and	
	Maps and Location				frequently referred to that to locate various place names and make notes on various localities referred to in the	
2	References (throughout chapters			Matt Kondolf	names mentioned in the text, such as Minden, Elm Creek, etc. It might be useful to have map that is confirmed	
	(				to show all places mentioned in the text. Moreover, it is difficult cross reference from data sources such as Table I.1 of Holburn et al. (2006), which indicates locations in RM. A master table of place names and their RM	
					might be useful, or a map on which RM were indicated every 5 or 10 RM.	
3	1	2	24-25	Robert Wiley	A little more context information would be useful on this figure: major roads, some political boundaries, etc.	Noted.
4	1	2	38	Robert Wiley	By shallow diving; it's a body mass thing. They can only go so deep.	Noted.
					They also feed in brackish and saline environments for more than half the year while they are south. You should consider the whole annual and life cycle, not just the behavior while on the Platte. These birds are	species use of the central Platte River and the path that led to PRRIP.
5	1	2	39	Robert Wiley	opportunistic nester that live 15-20 years and range over a continental scale. A bad year on the Platte may be	
6	1	3	57	Dan Catlin	a great year for the same bird on the Mississippi, the Arkansas, the Red or the Missouri	Change made
0		3	57	Dan Gatiin	On the breeding grounds.	We concur that variability in monitoring effort and methods likely have
						strongly influenced detection. As such, the PRRIP has not made an effort to evaluate population trends prior to the implementation of a standard
7	1	5	105-106	Robert Wilev	Are detection limits inherent in "variable" methods accounted for in quantification and any trending efforts?	monitoring protocol in 2001. Variability in monitoring methods since 2001 (IE inside vs. outside pest counts) has likely also influenced detection
		-		,	······································	probability. Efforts are underway to develop correction factors that can be
						applied to improve assessment of trends after 2001.
						Many of these comments are addressed in subsequent chapters. In
					Could these distributions by habitat types be related to the relative abundance of each habitat type? Have these numbers been compared to annual hydrologic data to assess habitat building and sandbar over topping	general, the distributions by habitat types likely are relative to the abundance of each habitat type. Quantitative estimates of habitat
8	1	5-6	107-111	Robert Wiley	in natural conditions. Has there been an increase in sand pits during the assessment period? Is it easier to	availability are not available prior to 2007, however, nesting islands were
					water management strategies during this period?	resulted in no productivity or nesting.
						Correction made. The distributions by habitat types likely are relative to
0	1	-	100	Koto Ruopou	8.5% figure for least tern nests does not match table. Also, it is apparent in Figure 2 that natural sandbars were used very rarely after ~1990 and constructed/managed sandbars were used only sporadically; it may help to	abundance but data are not available to make that statement with a reasonable degree of confidence. However, nesting islands were
9	1	5	109	Kale Duenau	note briefly here whether there was a lack of availability or lack of selection of those habitats leading to those results and heavy use of conduit babitat to provide context for the numbers	maintained by NPPD and the Crane Trust from 2001-2006 and resulted in
					······································	Excellent question with no easy answer. However, river hydrology did not
10	1	6	114	Dan Catlin	I just 're-looked' at this graphic after compiling all of my comments, etc. Why was there so much more nesting on the river in these two years? (1978, 1979)	differ markedly from subsequent years so it is difficult to conclude that it was
11	1	7	122	Dan Catlin	I believe you mean 1992.	Correction made.
12 13	1	7	122-123 125	Robert Wiley Robert Wiley	Sounds like sandbars built by low stage and short duration flooding! Have you evaluated rate of vegetation encroachment?	Noted. Addressed briefly later in the text of the chapter. See Figure 7.
14	1		149	Don Cotlin	It seems odd to say 'with the exception of' and not say what that exception was. Perhaps it's not important,	Change made. Parsons (2003) asserted that there has not been a change
14	1	0	140	Dan Gatiin	reword or present Parsons' conclusion too.	
15	1	8	149-150	Robert Wiley	And why did cottonwood, a dry land riparian dominant move into the channel?	Addressed later in the text of the chapter. The term 'scour' was used by the authors of various studies to describe the
16	1	10	172	Robert Wiley	Vegetation "scouring is a non-happening. It's either overtopping by new sediments or erosion of the sander in	removal of in-channel vegetation via peak flow events. We generally concur with the removal mechanisms described in the comment although we would
10	,	10	173	Robert wiley	total due to high flows.	add that bars are often only partly removed through lateral erosion.
-			┝──┤	-	This seems a bit backwards. Reduced flows would increase the area not flooded. Cottonwood mortality on	Noted.
47		40	477 470	Debert Wiley	sandbars is more due to drowning than desiccation. Their roots extend very quickly to follow falling seasonal	
17	1	10	1/7-1/8	RODER WIEY	levels. A return of water in the late season would only be beneficial, normally a period of desiccation. I think a better understanding of cotton wood physiology and growth is needed here. I'll send a bibliography on the	
40		44	407 400	Debert Wiley	subject. CITATIONS NEEDED	See Chapter 6.
10	1	11	107-192	Dan Catlin	A more intensive review of geology, geomorphology and sumcar materials sources would help this discussion. You should define these for the hydrologically challenged	Noted
10			1.02	San odulin	While the understanding of causes and effects is a bit dated, the changes are directly linked to magnitude of	Noted. However, statement assumes that the pre-development river
20	1	12	203	Robert Wiley	water. If water volumes are decreased, the river as a conduit and product of erosion and aggradation, must	provided suitable nesting habitat. This assumption is addressed in Chapter 5.
				Í	practical way to reverse the trends in nesting habitat loss for a sand nesting species.	
21	1	13	243	Robert Wiley	What in the world can that mean? This notion can be linked quantitatively to changes in the hydrograph	Noted.
22	1	13	246-247	Robert Wiley	or erosion of the substrate, both controlled by the range and magnitude of flows before, during and after each	NUIGU.
			050.071	Data	breeding season. Reword sentence as follows: Periodic high flows are necessary to create sandbar habitat suitable for	This is an excerpt from the PRRIP Biological Opinion. It cannot be
23	1	14	200-259	Robert Wiley	successful nesting. And on other nearby sandhar habitats in other river. It is not a big jump for any of these long-distance fliors to	reworded. Noted.
24	1	14	261	Robert Wiley	move to a whole new basin, and do so! While there has been some published work showing low site return	
			┞──┦		moenty, these onliss are opportunistic on a continential scale.	We respectfully disagree with this statement. Recent CPR narrowing due to
25	1	14	264-269	Robert Wiley	and its effect on river morphology. There is no need to infer anything.	phragmites proliferation is a good example of a control on channel morphology that does not proceed from hydrology.
26	1	15	277	Robert Wiley	Delete extra "that"	Change made.
27	1	16	300	Kate Buenau	Mentions that least tern observations occur after significant alterations to the river had already occurred. This statement would also be true for plovers, correct?	Correct. Piping plover added to text.
28	2	1	5	Dan Catlin	Why is this 'true?' I'd suggest rewording.	"True" removed from sentence. The six-step AM cycle is a common representation of AM and the one used
					The adaptive management (AM) cycle shown in Fig 2 of Chapter 2 may be too simple, as it does not include the three levels of intervention possible: targeted research (to better define the problem and possible	by the Program. Targeted research, pilot projects, and full-scale
29	2	3	51	Matt Kondolf	interventions - ie to decrease uncertainty), pilot projects (to test out possible approaches, further decreasing	implementation are all tool that are being used by the Program in the course of implementing the AM Plan and fit within the six general steps. Given the
					appear in the AM cycle as presented by Michael Healey of UBC (Figure 1 in individual comments - Appendix A	six-step cycle is the figure currently recognized within the Program the figure will not be changed.
			$\vdash$	ļ	or summary report).	
30	2	5	70	Matt Kondolf	states that the sediment deficit is "on the order of 150,000 tons", but does not provide a reference for this	Text revised to remove the deficit estimate. Deficit discussed in more detail later in the chapter including estimates of pre- and post-development
30	2	5	13	man NUTIQUIT	statement.	sediment loads, references for sediment deficit estimates, and a discussion of sediment sources.
					Regarding "three days": Arbitrary? Likely way to short. Stage controls height of sandbar. Duration at stage	These issues are addressed in Chapters 3, 5 and 6.
31	2	5	83	Robert Wiley	controls size. The shape of the sandbar is recapitulated by the shape of hydrograph. Study past and present hydrologic data to identify mean characteristics of the annual early spring runoff event in both stage and	
32	2	5	84	Robert Wiley	duration. Use these findings as a basis for management flows. Why? What is your rationale? Is this linked to vegetation encroachment?	Yes.
	-				· · · · · · · · · · · · · · · · · · ·	Hypotheses were developed by PRRIP stakeholders based on their experience and expertise. The term (channel width) trainable refers to the
33	2	5	99	Robert Wiley	What is the basis for believing width of channel is key? What do you mean specifically by width of channel? Thalweg?, 2-year storm, top of bank, 100 year flood?? Do you mean sustained by post development flows??	width of channel that can be maintained in a braided morphology free of
						vegetation.

Comment ID	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
34	2	6	100-101	Robert Wiley	Why?? ILT/PPL use all forms and distributions of sand. The issue is whether it stays above flood levels after egg laying. Have you any data linking "anastomosing" pattern with anything? You might link it with planform, sediment budget and flow as long as but to make the deposition pattern a goal is a 'cargo culture" approach. Maybe a different deposition pattern is more "sustainable" under present flow regime?	There is no evidence that "ILT/PPL use all forms and distributions of sand" in the CPR. It that were true, we would expect to see more in-channel nesting. In general, the hypotheses were developed by PRRIP stakeholders based on their experience and expertise. Anastomosed sections of the CPR are typically narrower and are dominated by permanently vegetated slands. Stakeholders hypothesized that a wider, unvegetated channel planform dominated by unvegetated sandbars was more consistent with species habitat needs.
35	2	6	102-103	Robert Wiley	Reword sentence as follows: "The mechanical action of consolidating flows may shift the river to a braided condition (or not), which may widen the river and may create more elevated sandbars." Note: Sandbars continue to be created with every change in river stage. They are just not high and dry enough.	This is a statement of a PRRIP hypothesis. The alternative hypothesis, which was not reproduced in this summary, states that consolidating flows will not have the desired effects on planform and/or sandbars.
36	2	6	103-104	Robert Wiley	If there is not enough water to fill the widened river, you will be doomed to chopping vegetation forever.	Noted.
37	2	6	110-111	Robert Wiley	Did anyone look at the results from the "Spring Rise" program done on the Missouri River 8-10 years ago?	
38	2	8	123	Dan Catlin	I wonder if you ever discuss the implications of the final part of this statement.	Yes we do. All PRRIP actions are taken within the context of our good neighbor policy.
39 40	2	9	151 151	Dan Catlin Robert Wiley	Effectiveness? Effectiveness?	Yes. Change made. Yes. Change made.
41	2	10	159	Robert Wiley	Do you mean creation of a single channel? You should review the USACE attempts to improve sandbar habitat by these means in the Missouri River. As	Yes. Consolidation of multiple anabranches into a single channel. Noted.
42	2	10	169-177	Robert Wiley	of 2007 they had not been successful. Did anyone measure success of these efforts?	Yes. We monitor channel morphology and vegetation annually.
44	2	11	183-186	Matt Kondolf	[See preceding commentary in individual comments - Appendix A to summary report] The Report does not explain the basis of the statement that the river is in dynamic equilibrium in the lower half of the AHR. From a physical process perspective, this would seem to be possible only through contribution of sediment from a tributary (as clearly occurs downstream Columbus, where the Loop River joins the Platel), or in the absence of a major tributary, through resistion of the bed and banks at a rate sufficient to make up for the sediment deficit from the J-2 Diversion. I Infer that the cross section resurveys of Holburn et al. (2006) showed the lower half of the AHR to be stable, but it would be nice to confirm how the RM numbers used in Holburn et a.	There are no major tributary inputs. The second mechanism mentioned in the comment is correct. The defacit is made up through erosion of bed and banks in upstream reaches. Additonal detail has been added to the text of the chapter.
45	2	11	187-188	Matt Kondolf	al line up with the place names used in the Keport. states the 'long-term average annual sediment deficit in the AHR is on the order of 150,000 tons with the majority of the deficit occurring during high-discharge years (HDR Engineering Inc. 2011). <sup>1</sup> Searching the HDR document for "150,000" or 'deficit' yielded no returns, and I did not find a relevant section from a superficial read of the document. It may be that the diation was in reference only to the fact that the sediment deficit would be greater during high-flow years, which is something that might be gleaned from a modeling study such as conducted by HDR and in any event would be expected unless sediment supply was much greater during the wet years. Thus, the stated deficit of 150,000 tons/year is not supported by the Report itself, nor the references it cites. I don't mean to say that it's not correct, only that at present it is an unsupported assertion.	A citation was accidentally omitted. The Flatwater Group Inc. (2010) feasibility study of sediment augmentation alternatives should have been included as a reference. That study presents the modeling results that support the mean deficit estimate. Additional text was added to the chapter to explain the sources for the sediment deficit estimate and the sediment sources that result in the declining deficit in the upper half of the reach.
46	2	14	229	Dan Catlin	By my reading there was a 0 year in 2012, and the range of values is a little misleading since the next highest value after 182k was 50,000.	Statement clarified in text.
47	2	14	237	Robert Wiley	What is the basis of this number [less than 25%]. Zero is best. 25% is at the outer limit.	This number was established based on expert elicitation. Concur that 25% is the outer limit which is why it was established as a maximum value.
48	2	16	272-274	Kate Buenau	states there was no species response to mechanical habitat available in 2013, likely because of low discharge; does this mean that the mechanical habitat was specifically unsuitable because of the low discharge or that it was unused because something else was available?	Text added to clarify that low discharges reduced the suitability of in-channel habitat.
49	2	16	275	Dan Catlin	They both look like they are increasing. I see no evidence of 'stable.'	Stable was included in an effort to be conservative. The Program is currently developing methods to address the potential effects of changes in detection probably over time due to improvements in monitoring methods.
50	2	17	282	Kate Buenau	The Evaluate-Synthesis section beginning on line 282 states that actions and natural analogs met or exceeded implementation objectives and should be useful in evaluating the FSM hypothesis. As it was stated earlier that flow consolidation was determined to not be implementable, it is presumably not part of the implementation objectives. However if it was a fundamental component of the FSM strategy, how much might its removal affect the performance of the FSM strategy? Line 293 does mention the FSM strategy as currently conceived" but it may help to discuss whether the lack of the flow consolidation component contributes to the observed lack of success of the strategy or whether some aspect of actually implemented actions is more likely responsible.	Approximately 1/3 of the CPR is fully consolidated. To date, we have not observed different implementation or effectiveness responses in those reaches. The text has been modify to clarify that there are portions of the AHR that are consolidated.
51	2	17	282-283	Matt Kondolf	states, "The scale of flow, sediment, and mechanical management actions and natural analogs during 2007- 2013 met or exceeded implementation objectives for the First Increment in at least a portion of the AHR." This statement is true for flows, but not for sediment. The FSM approach is expected to work in reaches that are in "sediment balance". However, the Report states that at least the upper half of the AHR is not to be in sediment balance, and the rate of sediment augmentation was, until 2013, only about 2006; of the sediment deficit. Recognizing that the upstream half of the AHR vas not in sediment balance, the sandbar height analysis was confined to the lower half of the AHR "considered to be in sediment balance" (Chapter 3, p.9). The observed encoisn rather than building of sandbars would be consistent with a reach in sediment deficit. Thus, it is arguable that the conditions required for FSM approach have not been fully met: flows have been adequate but not sediment supply.	Text was added to Chapter 2 to address these issues. Specifically, text was added to clarify the Program's understanding of sediment balance during the First Increment. A discussion of the relationship between sediment balance and sandbar characteristics was also added. Sediment augmentation would, on average, increase the sediment bad in the AHR by 15%. We could find ne evidence in the literature to support the assertion that a 15% increase in sediment bad would change sandbar heights. In addition, the channel gradation analyses at Nebraska stream gages (Chen 1999) indicate that the lower Platte and other inver segments with higher species use are actually more strongly degradational than the AHR.
52	2	17	290-291	Robert Wiley	Should you wait for normal years and re-assess before taking any actions?	This comment is not clear.
53	2	17	293	Dan Catlin	Conceived or as implemented? You did not achieve all of the goals of implementation, so is it a problem with the conception? I am not saying one way or the other, but it does seem odd to 'blame' the conception. What would have been the difference if flow consolidation had not been precluded? What about the effect of a flood of historic proportions in 2010 and particularly 2011 - twice the average discharge from '42-'11?	Pupping the provide the provided and the
54	3	Overall		Kate Buenau	This chapter took a considerable amount of time to work through in order to connect the different parts of the analysis and confirm that the conclusions follow from the component parts. It may help readers to include a flowchart of the relationships between data sources and models and analyses, and I think it would definitely help to include a schematic of the datums and comparisons made with channel width, sandbar height, and river stage, (e.g. cross-section drawings of 750' and 1,200' channels with relative elevations of 1,200 cfs and 8,000 cfs, peaks andhar elevations, etc.) to explain and connect the key results in this chapter. It also seems that the comparisons made in lines 282-303 would benefit from having all key information in one diagram.	Noted. The referenced flowchart, schematic, and other tools may be considered if these chapters are moved into a formal publication form.
55	3	1	6	Robert Wiley	Ur to some elevation below depending on velocity. It is unlikely that any additional deposition occurs at maximum stage because velocity (carrying capacity) has declined below the ability to entrain sand at some point well below peak flow stage.	Ins was a statement of the assumption used in the original analysis. The validity of the assumption is addressed in the text of the chapter.
57	3	1	7-8	Robert Wiley	Replace "conducted an observational studies of with "measured." How did you measure sandbar heights?	Change made. Change made. The methods section of the chapter describes how sandbar beintis were measured
58	3	1	10	Robert Wiley	This specification conflicts with above "build to the peak flow stage." Also, replace "ft" with "feet."	This conflict is the major point of the chapter. The original analysis of FSM assumed that bars build to the peak stage during high flow events. We have not observed sandbars building to the peak stage.
59	3	1	12-13	Robert Wiley	I have personally observed nest initiation at less than 4 inches above river stage in the Missouri, the Mississippi and the Red. Regarding inundation during nesting season: Why? Mid-summer thunderstorms??	See Table 1 for discussion of minimum habitat criteria. Inundation potential is discussed in this chapter and in Chapter 5.
60	3	1	18	Robert Wilev	What kind of productivity? Chick survival per nest? Nests per river mile? Chicks per reach??? You might	Change made.
61	3	1	20	Robert Wiley	Replace "NE" with "Nebraska."	Change made.
62	3	1	21	Robert Wiley	Regarding three and one half miles: Why? Figure 1: Add some roads, other rivers, county lines Something to better inform one of the locale. This	Negotiated during Program development. Noted.
ხკ	3	Z	23-24	KUDELL MILEA	comment applies to all similar figures.	

Comment ID	Chanter/Castion	Deme #	1	Deviewer	Comment	
#	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
64	3	2	38-39	Matt Kondolf	Assuming that Holburn et al.'s cross section analysis shows the lower half of the AHR has been stable, and that this is due to sediment supply from bed and banks, we would expect that this sediment input would accumulate gradually with distance downstream, so that he transition from sediment starved to sediment balance would be a gradual one. However, at a number of points (e.g., Chapter 3 p.2), the Report refers to the sediment deficit to in the westem half of the AHR as though the transition from sediment deficit to balance is an aburg to ne. Without a major tributary as a significant point source of sediment or the influence of some other large feature, the transition from sediment deficit must perforce be gradual. Moreover, as readily erodible sediment in a given reach is exhausted, the implication is that the transition point at which the river's sediment transport capacity is met by cannabalisation of its bed and bank deposits will migrate downstream with time.	The sediment deficit does decrease downstream gradually. Several analyses have indicated that the river transitions from degradational to stable in the Kearney to Gibbon reach. Accordingly, the west half the reach is said to be in deficit. We concur that the transition point will migrate down river over time in absence of an increase in sediment supply. This is one of the major reasons for sediment augmentation as a management action.
65	3	2-3	37-41	Robert Wiley	Will you test each one of these independently and in different combinations? How long will each be tested? What is your reference or control? How will you add sediment?	They are intended to be implemented together as a suite of actions. Unfortunately, there is no such thing as 'control' or 'reference' when implementing large-scale management experiments on a single river system. Sediment is added by sand pumping and/or mechanical pushing.
66	3	3	49	Robert Wiley	Sandbars do not accrue to water surface.	Noted. Change not made. This is a discussion of the content of the PRPIP FIS
67	3	3	56-58	Robert Wiley	Newtour sentence as futures. A sample and the sentence in pogram is necessary to evaluate the relacionship between the magnitude of flows and the resultant height needed to reduce the likelihood of over-topping later in the nesting season or after the controlled high flow event. <sup>8</sup> Note: You have already assumed that flowing water has the ability to entrain, transport and deposit sand from one place to another. What you need to measure is how much height for how much flow	Grange for made. This is a discussion of the content of the Trickin Ello.
68	3	5	67	Robert Wiley	There is a need to refer to documents after 2009.	This comment is not clear.
69	3	5	70	Robert Wiley	I do not believe that species management objectives relative to the ESA requirements given the continental range of these birds is achievable by this very limited program for local management of nesting habitat.	Noted.
	-	_				Noted.
70	3	5	Table 1	Robert Wiley	Regarding sandbar area: L1 will successfully nest on much small bars. PPL seem to require multiple acres. Regarding sandbar area values: Why? How do you measure this? Rivers do not allocate sand by river mile. Perhaps area of sand per entire segment is meaningful. The time component is extremely important. Every year? Every five years? No river provides a given amount of habitat for every year. But some river or other	Noted. See response to comment 62.
	3	5	Table I	Robert Wiley	sandy substrate within the flight range of these birds does provide suitable habitat for most years. Your plan does not seem to recognize that the Platte is a small fraction of the available habitat with the range of ILT & PPL.	The rationale for the CPR minimum sandbar height criterion was observed
72	3	5	Table 1	Robert Wiley	Regarding rationale for sandbar height: On the Garrison and Fort Randall Segments of the Missouri, nesting distance above ordinary stage is as little as 4 inches>	nest locations in the CPR. In general, the minimum height criterion is less important than inundation potential which is discussed at length in this chapter.
73	3	5	Table 1	Robert Wiley	Regarding total channel width: This is such a function of Thalweg width, planform and incident flow as to be a meaningless standalone construct.	not be correct but we contend that width is a meaningful habitat metric.
74	3	5	Table 1	Robert Wiley	Regarding rationale for water barrier: No water barriers work to dissuade predators. Survey any sand island any distance from shoreline and you will find wildlife access paths from at least the low energy side of the island. Large expanses of dry sand seem to be most protective due to chick and egg carnouflage.	Noted.
75	3	5	Table 1	Robert Wiley	Regarding rationale for distance to predator perch: There are now several published references for this data. See for example: Wiley, R.L. and C.A. Lott. 2006-2011. Appendix B: Analysis of Spatial, Topographic, Hydrologi, Substrate and Nesting Data from the Upper Missouri River. Six sub-sections, 486 pp. Prepared in support of the Final Programmatic Environmental Impact Statement for the Mechanical and Anticial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River. August 2011. Using ArcGIS we digitized the entire tree line along 800 miles of the Missouri River. Using a USACE database of 7800 CFS located ILT and PP nests, we did a nearest neighbor analysis for nest distance to tree lines. The distribution by distance is graphed. We also measured similarly the distances to an array of other features such as bridges, docks, water intakes, large buildings etc. These findings might be useful to you.	The PRRIP currently used measured distance to predator perches in the ARR to develop this minimum criterion. We have discussed this issue at length with Casey Lott and it appears that these species nest much closer to predator perches in the AHR than on the Missouri River.
76	3	5	74	Dan Catlin	Remove hyphen ("and-off") in last row.	Change made.
76 77 78	3 3	5 6 6	74 75 76-80	Dan Catlin Robert Wiley Robert Wiley	Remove hyphen ("and-off") in last row. But there is much more data out there, particularly between 2010 and 2014. Both ILT and PPL have a range of behavioral variability to accommodate the highly variable site conditions of sandbar nesting sites throughout the sand river segments of the Mississippi Basin. I think you try to make too much of the limited and limiting conditions in the Platte. The only truly important consideration is whether there is an occurrence of post-nest building flooding. I do not think the characteristics or availability of the Platte sandbar habitat is significant to species whose form and behaviors have evolved at multi-continental scales. Are you for example asserting that there is a Platte River population of ILT or PPL that return frequently enough to develop behaviors different from the population? What is the physical characteristic of the Platte that would segregate it from the national population?	Change made. Noted. The potential for post-nest building flooding is discussed in this chapter and in Chapter 5. Comments about significance of the AHR to the species noted.
76 77 78 79	3 3 3 3	5 6 6	74 75 76-80	Dan Catlin Robert Wiley Robert Wiley Robert Wiley	Remove hyphen ('and-off') in last row. But there is much more data out there, particularly between 2010 and 2014. Both ILT and PPL have a range of behavioral variability to accommodate the highly variable site conditions of sandbar nesting sites throughout the sand river segments of the Mississippi Basin. I think you try to make too much of the limited and limiting conditions in the Platte. The only truly important consideration is whether there is an occurrence of post-nest building flooding. I do not think the characteristics or availability of the Platte sandbar habitat is significant to species whose form and behaviors have evolved at multi-continental scales. Are you for example asserting that there is a Platte River population of ILT or PPL that return frequently enough to develop behaviors different from the population? What is the physical characteristic of the Platte that would segregate it from the national population? Replace "observational studies" with "observations" and insert "relative to stage" after "heights."	Change made. Noted. The potential for post-nest building flooding is discussed in this chapter and in Chapter 5. Comments about significance of the AHR to the species noted. Changes made.
76 77 78 78 80 84	3 3 3 3 	5 6 6 6	74 75 76-80 86 93	Dan Catlin Robert Wiley Robert Wiley Robert Wiley Robert Wiley	Remove hyphen ("and-off") in last row. But there is much more data out there, particularly between 2010 and 2014. Both ILT and PPL have a range of behavioral variability to accommodate the highly variable site conditions of sandbar nesting sites throughout the sand river segments of the Mississippi Basin. I think you try to make too much of the limited and limiting conditions in the Patter. The only truly important consideration is whether there is an occurrence of post-nest building flooding. I do not think the characteristics or availability of the Platte sandbar habitati is significant to species whose form and behaviors have evolved at multi-continneal scales. Are you for example asserting that there is a Platte River population of ILT or PPL that return frequently enough to develop behaviors different from the population? What is the physical characteristic of the Platte that would segregate it from the national population?	Change made. Noted. The potential for post-nest building flooding is discussed in this chapter and in Chapter 5. Comments about significance of the AHR to the species noted. Changes made. This comment is not clear.
76 77 78 78 80 81 82	3 3 3 3 <u>3</u> 3 3	5 6 6 6 6	74 75 76-80 93 94 94-95	Dan Catin Robert Wiley Robert Wiley Robert Wiley Robert Wiley Robert Wiley	Remove hyphen ("and-off") in last row. But there is much more data out there, particularly between 2010 and 2014. Both ILT and PPL have a range of behavioral variability to accommodate the highly variable site conditions of sandbar mesting sites throughout the sand river segments of the Mississippi Basin. I think you try to make too much of the limited and limiting conditions in the Platte. The only truly important consideration is whether there is an occurrence of post-nest building flooding. I do not think the characteristics or availability of the Platte sandbar habitat is significant to species whose form and behaviors have evolved at multi-continential scales. Are you for example asserting that there is a Platte River population of ILT or PPL than terum frequently enough to develop behaviors different from the population? What is the physical characteristic of the Platte that would segregate it from the national population? Replace "observational studies" with "observations" and insert "relative to stage" after "heights." Downstream of? Explain briefly for those not familiar with the Platte. Regarding "heavily influenced": Do you mean reduced? Also, add a period after "diversions." Start new sentence with 'A large" after "diversions." Regarding "large proportion": What fraction?? Regarding "total annual discharge": Distribution of volumes throughout the nesting season is the only time of interest.	Change made. Noted. The potential for post-nest building flooding is discussed in this chapter and in Chapter 5. Comments about significance of the AHR to the species noted. Changes made. This comment is not clear. "Heavily influenced" includes magnitude and timing. Sentence has been revised.
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76 77 78 78 80 81 82 83 83	3 3 3 3 3 3 3 3 3	5 6 6 6 6 6 7 7	74 75 76-80 93 94 94-95 97-101 101-102	Dan Catlin Robert Wiley Robert Wiley Robert Wiley Robert Wiley Robert Wiley Robert Wiley Robert Wiley	Remove hyphen ("and-off") in last row. But there is much more data out there, particularly between 2010 and 2014. Both ILT and PPL have a range of behavioral variability to accommodate the highly variable site conditions of sandbar nesting sites throughout the sand river segments of the Mississippi Basin. I think you try to make too much of the limited and limiting conditions in the Platte. The only truly important consideration is whether there is an occurrence of post-rest building flooding. I do not think the characteristics or availability to the Platte sandbar habitat is significant to species whose form and behaviors have evolved at multi-continental scales. Are you for example asserting that there is a Platte River population of ILT or PL that return frequently enough to develop behaviors different from the population? What is the physical characteristics or the Platte that would segregate it from the national population? Replace "observational studies" with "observations" and insert "relative to stage" after "heights." Downstream of 2. Explain briefly for those on tamiliar with the Platte. Regarding "heavily influenced": Do you mean reduced? Also, add a period after "diversions." Start new sentence with "A large" after "diversions." Regarding "large proportion": What fraction?? Regarding "total annual discharge": Distrbution of volumes throughout the nesting season is the only time of interest. Why is it important to mention these two thing together? You might mention first the nature of the data needed to assess stage, discharge- bar height relationships. How do you use these data to assess? How does this relate to flow stage and bar height? What difference does off-channel habitat use to do with thow models?	Change made. Noted. The potential for post-nest building flooding is discussed in this chapter and in Chapter 5. Comments about significance of the AHR to the species noted. Changes made. This comment is not clear. "Heavily influenced" includes magnitude and timing. Sentence has been revised. Noted. This paragraph provides information on the spatial and temporal resolution of data that are available to address the priority hypotheses. Nest initiation dates are germain to discussions of habitat availability and use regardless of habitat type.
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Comment ID	Chantes/Castien	Dama	Line #	Daviewas	Communi	
#	chapter/Section	rage #	Line #	Reviewer		See general Missouri Piver commont
101	4	1	12-13	Robert Wiley	vonsume marge distance to repror percent even is more important man absolute channel width. In the Fort Peck segment of the Missouri, nests were observed in segment less than 400 feet in channel width, but only in areas where the gallery cottorwoods were absent.	
102	4	3	52	Robert Wiley	Is this really an alternative hypothesis? USFWS does not say that width is important and relative height not important. This is an additive or supporting factor in nest site selection.	See general Missouri River comment.
103	4	3	55	Robert Wiley	Regarding Ziewitz et al. (1992): This is way out of date. See Lott, C.A., R.L. Wiey, R.A. Fischer, P.D. Harffield and J.M. Scott. 2013, Lott, and Lott, C.A. and R.L. Wiley. Sandbar Nesting Habitat for Interior Least Tern (Stermula antiliarum) on The Red Neve Below Denison Dam, 2008. Also see EIS for mechanical sandbar creation prepared by the Omaha District USACE 2011. In these we analyzed nest distances from treeline and nest locations for more than 7000 nest locations and hundreds of colony sites.	Text revised. It is a viewpoint more than a hypothesis.
104	4	4	70-71	Robert Wiley	l agree with Jorgensen	This paragraph addresses investigations specific to the Platte River.
105	4 4	7	94 123-124	Robert Wiley	Accuracy is a major concern. 528 feet provides a great deal of uncertainty. GPS located nets would be more	Change made.
107	4	9	162	Dan Catlin	Need another sentence to further explain this.	Clarified in text.
108	4	9	167	Dan Catlin	I guess this bint a competing reason to ment to be excluded in thy minu. Leter that naving data from the reach in question would help ground your estimates and predictions in the context of your area, but perhaps clarification of the reason you left it out?	Another approach would be to test how well the model predicts for the AHK data. We did not do this because our sample size is likely so small that it wouldn't be worthwhile.
109	4	10	185-188	Kate Buenau	suggest brief explanation of why in-channel management makes this analysis unsuitable for the AHR, and (perhaps in discussion rather than methods) what the implications are for applying this information to the AHR.	
110	4	11	198	Dan Catlin	most? You should provide some justification for the models that you did select and those that you did not. By saving	No. Clarified in text
111	4	11	199	Dan Catlin	The should prove senting balanced in or the histons that you do select and index task you during the senting most and then presenting a few of the possibilities, the reader is left wondering why these and not those. I'm sure you had your reasons, provide them.	
112	4	11	206	Dan Catlin	By using only the deviance, where was your control for over-parameterization? AIC, BIC, etc. all control for over- parameterization with a penalty term, you seem to be ignoring a penalty. Any particular reason? Looking for the tightes fit regardless? I could imagine that in a predictive setting, you'd rather have a good mean estimate at the cost of precision, but you don't mention why you select models in this fashion. The same comment could be made above for the 'gam' models.	We did not use the deviance. We used the predictive deviance. The predictive deviance is calculated on independent "test" data (i.e., data that was not used to fit the model or estimate parameters). The predictive deviance is essentially what penalized likelihood measures such as AIC, BIC, et are trying to approximate. Using the predictive deviance you get a measure of model fit that accounts for the dimensionality of the model without making the assumptions implicit with measures such as AIC or BIC (0f course this approach requires that some of the data be used for model selection). This is a very common approach for model selection in machine learning or Bayesian model analyses (e.g., see (Hastie, Tbshirani, & Friedman, 2000, Hoden and Hobbs 2015). Hastie, T., Tbshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mirnig, Interence, and Prediction (2nd ed., p. 745). New York, New York, USA: Springer. Hooten, M. B., & Hobbs, N. T. (2015). A guide to Bayesian model selection for ecologists. Ecological Monographs, in press. doi:10.1890/14-0661.1
113	4	12	224	Dan Catlin	I commented on it there too, but you will need to do a better job of describing the figure in the legend if you are going to send the reader to them to grasp the information that you provided. I "think" I understand the figure	Noted.
114	4	13	227	Dan Catlin	Your figure legends need a little more meat. For example, what is the red line? I assume that the crosses are the data? Perhaps it's the off but I can hardly see the data	Yes the "+" are the raw data.
115	4	14	237	Dan Catlin	Were any of these variables significant in the regression? The Lower Platte use data actually looks like it doesn't differ from the available data, but one can't tell because you don't provide any of the standard metrics by which you can evaluate that. Even if you provided them in an appendix?	We provide a discussion of which variables are "significant" beginning on line 247. "The logistic regression model with the lowest predictive deviance (highest predictive ability) contained the main effects of total channel with channel break." We did not report the predictive deviance scores (akin to ALC scores) in the main paper. We did this to be concise. These are now located in an appendix. If the reviewer is referring to some other test of "significance," we believe that such additional test (given our model selection procedure) would be inappropriate.
116	4	14	238-239	Robert Wiley	You simply must include the data from the Missouri in this comparative assessment.	See general Missouri River comment.
118	4	15	242	Kate Buenau	Figure 5 caption: second sentence is ambiguous: available locations from 2012 only and nesting colonies for all	Caption clarified.
119	4	16	254	Kate Buenau	Figure 6: Are these plots using the best-fit model that does not include river segment?	Yes. Caption clarified.
120	4 4	16	254 281	Dan Catlin	Figure 6: For lower right diagram, modify label as "Central Platte River (excluding AHR) and plovers	Lext clarified. Change made.
122	4	18	281	Kate Buenau Dan Catlin	Is this meant to say tem AND plover? Have you looked at whether there is a species-specific effect? It seems as though you could have teased this out, right? It is obviously not just channel width. Without nesting habitat, there will be no nesting. But the real question is, do sandbars form more readily in these wider sections, which leads to nesting, or are sandbars as likely at other widths, but the birds choose the wider ones? Do you have enough data to do this? That seems to be the real question as you point out here.	res. Inere is insumcent data to evaluate the presence or a species-specified. Effect. This analysis could not be performed because annual sandbar availability data is not available for the other river segments. It, we would need a sample of "available" points that truly represented "available" habitat (at minimum this would be the location of all islands). If we had these data, there would be two analyses we could conduct that would: 1) determine the relationship between channel width and the presence of "available" nesting habitat; and 2) Determine the relationship between colony nest selection and channel width at "available" islands.
124	4	18	287-288	Robert Wiley	This is because the islands included large raptor perching trees! Every incidence of trees re-set the nest site calcoling options. Both the model using the location of the treation or your distance to option feature.	Detailed nest location data is not available for the other river segments in the analysis. Accordingly, we could not perform this analysis.
125	4	18	291	Dan Catlin	serection setuate. Nerry the industrial and to be added to the treatment of the destination of the destinati	Width selection is similar across all segments (IE. there is no 'river' effect). Species nest occurrence is not because widths vary between segments.
126	4	18	291-292	Robert Wiley	Disagree that ILT and PPL have different selection modes for these river than the populations at large selecting sites on bigger rivers and beaches throughout North America and the Caribbean. This would suggest that there are sub population of the species that select for only small rivers. There is no data whatsoever to	This analysis indicates that probability of nest incidence increases with increasing channel width. We do not see how this leads to the inference that there is a sub population of the species that select only small rivers.
127	4	18	293-294	Robert Wiley	Then perhaps it about the vegetation not the channel width. Channel width and distances to forest edges is strongly correlated. If you use just forest edge and actual nest locations, it results in a stronger cleaner graph. We found that 50% of nests occurred between 400 and 1300 feet of tree lines and that 90% of nests occurred at distances of 2000 feet from tree lines.	This analysis could not be performed due to the lack of nest location data. We agree that channel width and distance to forest metrics would be highly correlated and provide similar results.
128 129	4 4	18 18	295-296 300	Robert Wiley Dan Catlin	IBID just say 1400 and get rid of generally.	See above. Change made.
130	4	19	301-303	Robert Wiley	Measurements made with actual nest locations provide a much stronger case for the importance of tree line distance. I believe that it is a critical requirement for nest selection	Agree. However, nest location data was not available for this analysis.
131	4	19	303	Dan Catlin	Were the predictions in keeping with the data from the Loup? There are birds nesting there even though the widths are narrow relatively speaking, correct?	Yes. The model predicts low levels of nesting on the Loup. Few birds nest on the Loup.
132	4	19	309	Dan Catlin	Why not? I kept asking myself this throughout the chapter. Is there any indication why this stretch and the Loup are narrower than the other 'sister' reaches? It might be instructive to understand the differences in river monthology if they are known.	See Chapter 6.
133	4	19	321	Dan Catlin	Just cite what the mean is.	Change not made.
134	4	19	322	Dan Catlin	am left wondering why you don't do more comparison of the Loup and the AHR. You have laid a compelling case that the widths of the other river segments contribute to their having 'use' areas, but the Loup also has used areas that seem to be approximately the same width as sites on the AHR (based on Fig. 7 - though adding the AHR to Table 2 would go a long way in helping me evaluate this chapter). I don't disagree with the conclusions of this chapter, but link that it absolutely begs for a comparison of the Loup and the AHR. I know that may not have been the main goal of this exercise, but it is what was 'stuck' in my head by the end. I'm fascinated with the differences. I know that nearing on the Loup is limited, but not nearly so as the AHR. Whyy Having 'peeked' ahead, I know that one of the conclusions of this body of work is to guestion the feasibility of using quasi-natural processes to create tern and plover habitat. Perhaps later in the work you do the work of the sample site of the subtrobard is a specter hanging over that conclusion - why does the Loup differ from the AHR? I have comparing these two reaches (as they seem most similar) to support or refute your case. Otherwise, however, there will be a specter hanging over that conclusion - why does the Loup differ from the AHR? I am clearly not as familiar with this system as the authors, so perhaps there is an easy' explanation or way of dismissing this comparison. If so, it should be explicitly said.	Interes appears to use the Loup out in Yery tow numbers. Ine YKRIP has been charged with improving productivity from the AHR and the species use of the Loup does not provide confidence that creating Loup-like conditions would meaningfully improve productivity. Chapter for presents a comparison of physical characteristics of the two river segments. Probably the most important difference is sediment. The mean bed material grain size in the Loup River is much smaller than the AHR.
135	5	1	9-10	Robert Wiley	Samuans su no emerge, reword semence as tollows:sandbar habitat model was developed to assess potential correlation of reproductive success with hydrologyV. Also, please clarify this term (reproductive success); i.e.; a fledged chick per breeding pair? 3 chicks? Borbarn the une of their ones one of hydrox encoders that the units is successifier. This with the semi-	Ine term "emergent refers to sandbars that are exposed above water surface. Reproductive success has been defined as "fledglings per breeding pair."
136	5	1	11-13	Robert Wiley	n emape une use or men eyes see and ordins recognize mar me water is receating. I his would be an evolved	

Comment ID	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
137	5	1	13	Dan Catlin	Delete "in" before "on".	Change made.
138	5	2	26-33	Robert Wiley	Make tern singular. ILT and PPL migrate for hundreds of miles. ILT have been found to migrate from the upper Missouri River to the mouth of the Amazon (Carlos and Fedrizzi 2013). By getting into wind streams they can move across the landscape for distances of hundreds of miles per day. These birds next in the larger, nearly parallel, east flowing sand rivers between the Missouri in Montana and the Sabine in Texas. Each of these rivers respond asynchronously to the characteristics of their water shed. When one river is high, another may be low. It may not be a great effort for these long distance filers to just pick up and move to the next watershed (Red to Cimarron, Cimarron to Arkansas, Arkansas to Platte, alt to Mississippi). The likelihood that there is a Platte River population, physiologically or behaviorally adapted to its annual flow patterns is likely to be a false premise.	Change made. Noted.
140	5	2	39	Robert Wiley	While the USFWS frequently state this it is not a documented process, Sandbars, including the vegetation on them, simple erode. Others vegetated sandbar may retard flow, allowing sand to bury vegetation.	Noted.
141	5	2	46-47	Robert Wiley	And when they don't these long lived birds either try again next year or move to an adjacent basin. Carlos and Fedrizi? 2013 report ILT next in Brazil during the southern hemisphere spring. Reparation "receal to avaid fundation of pacts". This the key factor. Success is completely dependent upon	Noted.
142	5	2	48-49	Robert Wiley	the absence of an overtopping flood at a nest site during the includation to fledging period.	Noted
143	5	2	49-50	Robert Wiley	There is no evidence that ILT or PPL are limited by absence of prey. Both fish and bugs occur nearly avanuated	Noted.
145	5	2	52	Robert Wiley	You should also review Lott et al 2013 and the technical appendices to the Missouri River EIS fro mechanical sandhar habitat creation)	See general Missouri River comment.
146	5	3	53-55	Robert Wiley	A failure to consider these birds from a range wide perspective will lead to disappointment trying to manage the Platte for improving local nest success.	Noted.
147	5	3	54	Robert Wiley	Regarding "ecology": Behavior?	Yes.
148	5	4	83-88	Robert Wiley	Why mask the full variably in nesting behavior? The full range suggests that the birds can vary nesting behavior to accommodate year to year river stage variability.	The Frogram data indicates nests that are initiated very early or late in the Program data indicates nests that are initiated very early or late in the nesting season have a low probably of successfully fledging chicks. Thus, increasing the length of the nesting season by adding very early or very late nests would lead to an overly-optimistic opinion of potential for productivity in the AHR.
149	5	4	88	Dan Catlin	This is an important point, and I am not sure it is in the right location. At least you should revisit it in the Discussion section when assessing your results. I	Noted.
150	5	5	90	Dan Catlin	It would be helpful if you defined these [nest exposure metrics] and how they were determined. For example, the definition of Hedge's as whilly important. If it is observed fledge, then I would suspect it is conservative (i.e., the probability of a bird fledging and being seen flying is lower than just reaching fledging, so the observed fledge dates would be later than the fledge dates.	Definitions included as footnotes to Table 1.
151 152	5	5 5	92-94 96	Robert Wiley Dan Catlin	Please clarify. Did you create data to fill in expectations? Were the values in that table from river colonies or from off-river colonies?	No. This was poor word choice. They were plotted together. Both.
153 154	5 5	5 5	98 102-103	Robert Wiley Robert Wiley	Regarding "in the historical AHR": When was this determined to be? This also captures the entire breeding season for both birds	1895-1938 added to text. Noted.
155	5	6	107-109	Robert Wiley	Can you show a table of flow magnitudes to demonstrate this statement? End sentence after citation and start new sentence with "A high correlation"	Stroup et al., 2006 includes tables that demonstrate this statement.
156	5	6	112	Dan Catlin	I don't know much about this, but is there variability accounted for in these models, and if so, is it carried through to the other parts of the analysis?	The variance of the flows used to estimate the model parameters are conserved in the MOVE: 1 methodology. A preliminary analysis of the errors in the modele sky observed flows indicates that the model skyfully overestimated low flows and under estimate high flows. The weakest model performance was during large flood events (especially if the event originated on the South Platte as both alternative gages were on the North Platte).
157	5	7	137-138	Robert Wiley	Why did you pick this period? Isn't there a gage near the Missouri Confluence with a longer and more consistent period of record. The small data set used does not impart great confidence that the findings are meaningful.	This was the only period of record available for the analysis. To our knowledge, there is not a gage near the Missouri River confluence with a longer period of record. The period of record is not lengthy but model performance was satisfactory (see page 8 of chapter).
158	5	9	184-187	Robert Wiley	Potentially is the key word here. These data may also be representative of variability. Location, location, location. This is an unnecessary straw man that you knock down in the next paragraph. Why preface with this?? Just say that you did identify representativeness.	This was included because it is an important issue for some people (IE, see comment 159).
159	5	9	187	Dan Catlin	I do not think you spend enough time describing the issues that Catlin et al. 2010 presented. You state that your method is in response to 'criticism' but you spend no time saying what that criticism was, and why your method is better. If you think you have addressed the issues in that paper, you need to clearly state what those issues are, and how specifically what you did answers them. I assume that you mean to say that the two nesting areas are representative of the reach as a whole, possibly because of their location? A reader should not have to assume that, and you should clearly defend using a method that has been called into question. Even if that is true, I fail to see how concordance with stage relationship at two locations is any better than Jorgensen 2009. This is the last time that you mention any controversy/uncertainty in using this methodology too.	The text (lines 194-186) state that 'the use of hydraulic relationships at gage locations for least term and piping plover nesting habitat analyses has been criticized as potentially being not representative of the geomorphic variability of the river system, specifically in reaches with nesting least terns and piping plovers.' To address that concern, we demonstrated that the stage- discharge relationships at the stream gages were very similar to the stage- discharge relationships at the stream gages were very similar to the stage- discharge relationships at the stream gages users. We do not understand how demonstrating that the relationships at a gage locations are representative of the relationships at nest colory locations is no better than not doing so when the criticism was that they are potentially not representative?
160	5	9	192	Dan Catlin	This is not my forte, but isn't there a more robust way to test this rather than 'visually.'	We could perform a simple correlation analysis but that would likely not be meaningful as the two curves would be highly correlated. A sensitivity analysis was performed and added to the chapter that provides an indication of the importance of discrepancies of stage. In general, large stage differences (IE 50%) are necessary to produce substantial changes in potential for nest success.
161	5	10	197	Dan Catlin	from your description and the legend, it is difficult to know what I am comparing visually. I think that you need to do a better job of bringing the reader along since this is such a critical part of your modeling. Am I supposed to glean that they are between the two lines? Or are the dotted lines supposed to match up with one another? Is it true that there isn't some sort of concordance statistic for this? Ok, I see, I'm to compare the Grand Island Gage. But if the Kearney gage isn't representative, what does that mean? Also, do you incorporate any of this uncertainty into your later analysis.	Text added to the legend to clarify.
162	5	10	205	Dan Catlin	I think you make the assumption that the reader is more familiar with these type of data and figures than perhaps you should. I suspect that this document is also for an audience that doesn't have a degree in hydrological engineering. For example, my first hough its that O.5 it is pleny to ferro for a nest to survive or not based on some prediction, but without a better description of how you make your conclusions, I can't be sure.	A sensitivity analysis was added to Chapter 5 to address the reviewers concerns about the effects of variability in stage-discharge relationships on species productivity.
163	5	11	Figure 3	Dan Catlin	This graphic seems much less derensione It looks like the this UK at the middle but not at the tails. Is there really no measure of how these compare to one another? I have trouble believing that.	See response to comment 162.
165	5	12	247	Robert Wilev	you cannot see the difference between LPK and AFK in your legend. Smaller particles are entrained at lower velocities, thus carried and distributed over greater portion of the bed.	Noted.
	-				The sediment sampling conducted by Tetra-Tech for the contemporary AHR appears to be sound. The current	The historical grain size was obtained from a 1931 USACE publication.
166	5	14	244-252	Matt Kondolf	grain size reported in Chapter 5, p.14 is consistent with Tetra-Tech (2013), but it was not obvious to me upon what basis the historical grain size was inferred, as no citations were provided. Why is the sand now coarser in AHR? It is not unusual to see bed coarsening downstream of a dam or diversion that traps sediment. Could these coarser sizes be a result of the J-2 hydroelectric plant upstream trapping sand?	U.S. Army Corps of Engineers, 1931, Sill investigation in the Missouri River basin, mainteen of Missouri River and mion tribularies, appendix XV, supplement V, Sediment characteristics of the Plate River. We apologics for omitting that citation. Sediment coarsening is likely due to mainstream reservoir construction upstream of the AHR as well as clear-water hydropower returns.
167	5	14	244-252	Matt Kondolf	Crapter 5 p.14 states that historical sand-bar heights for the AHR 'were estimated using the data from the contemporary AHR and LPR reaches.'' The subsequent sentences may be an explanation of how this estimation was done, but I did not find this passage to be clear. Perhaps this simply needs to be restated to be more convincing. If linfe correctly from the Report text, historical sand-bar heights were estimated as being 1.5 ft below the water surface, and from descriptions elsewhere in the Report (eg. Chapter 5 p.21), I understand the water surface for the historical channel was estimated from a hydraulic model assuming a wider historical channel. It is not clear to me how the grain size information (historical vs current) was used, nor the potential uncertainties of this approach. Chapter 5 p.21 reports that 'Median heights [of sandbars] in the historical AHR were below mean annual river stage, presenting this as fact, whereas earlier these heights are described as 'estimated'. Sandbar restimated.''	reak uses been mooneo to mprove clarity. There is no information on historical sandbar heights in the AHR. In regards to Chapter 5 p. 21, the intent was not to present that statement as fact. The prior sentence in the text states that the authors were presenting model predictors. It, the model predicts that median heights were below mean annual river stage. Noted.
	v				water trom nest initiation through fledging. Take care to distinguish. Table 3: BAR HEIGHT refers to the median difference between peak stage and sandbar height as calculated	Change incorporated.
169	5	15	264	Kate Buenau	earlier based upon observed heights that sandbars built to after a peak flow, correct? May help to reiterate that in the table as it is not the intuitive definition of bar height. Is there any consideration of duration of peak flow and the effect that might have on sandbar height or area?	This analysis does not take peak flow duration into consideration. Sufficient
170	5	15	266-270	Kate Buenau	Also, the description of the procedure may benefit from a simple schematic of the relationship between the	data is currently not available to do so.

Comment ID #	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
171	5	15	270	Dan Catlin	Isn't that only true if this height were higher than last year's height? How do you account for this? Is that the growing season statement. Clarify.	This question is not clear. The calculation for period for DISCHHAB begins on 1-Jan in the year prior to the analysis year. The maximum discharge between that date and 1-Jul of the analysis year is the DISCHHAB.
172	5	16	272	Robert Wiley	"sandbar" forming? There is a conflicting statement in Ziewitz. I believe the statement was that the nests were on the highest	Correct. Text revised to state that nests are not always located at the highest
173	5	16	288	Robert Wiley	portions of the bar. You should state that uncertainty. This is the same thing found in the Missouri River work the mechanical sandbar creation FIS.	elevation. Noted
175	5	16	290	Dan Catlin	OK, there is one problem I see. Even if the nests were at the median height or not at the highest point, once the chicks hatch they will move to those points as the water rises. Wouldn't it be a better approximation to use the median (actually why not mean?) for the nesting period and the max for the chick rearing period? I'm also a little confused about this 'median.' Is this the 1.5t below stage median? If so, why are you discussing within sandbar elevations? Given the difficultly that I ve had here, I think you should consider clarifying your methods. I assume that not everyone reading is an expert on the subject.	The analysis used the mean height for the entire sample of sanchars in the analysis reach not the median. The text of the chapter has been corrected. In order to separate incubation and brood rearing, we would need to shift to a sanchar scale analysis where the mean and maximum elevations of each bar are included in the model. We chose to keep the model simple and point out that the results should be interpreted as an index of potential for reproductive success as opposed to an absolute prediction of success. If a bar-scale analysis were undertaken, maximum sanchar height in 2010 was, naverage, 0.29 thigher than the mean. Accordingly, there is little opportunity for chicks to survive flood events by retreating to the highest portion of the sandbars.
176	5	17	296-299	Robert Wiley	Delete "somewhat." Why not identify potentially successful reproductive events that had a spring high stage that was not exceed later in each year. Comparison to the mean may only suggest which years to examine closely but does not define which years had no late season stage exceedances.	Removed "somewhat." See requirement 2 and 3 analyses.
177	5	17	302-303	Kate Buenau	not clear what period of time is referred to here-days not inundated within the initiation window? After? Both?	Text revised. Number of consecutive days at the end of the initiation window.
178	5	17	305-311	Kate Buenau	The requirement describes inundation after nest initiation; the text and dates focus on the July-August chick- rearing intervals—what about the nesting period? Is this assuming renesting if nests are inundated?	Correct. This analysis was limited to the time when most of the broods have hatched but not fledged.
179	5	18 18	310-311	Robert Wiley	Now you have it! Agree! This double peak is visible in most east-flowing tributaries to the Mississioni	Noted.
181	5	20	Figure 8	Dan Catlin	I hope that somewhere in this chapter you point out that your records for nesting are from artificial habitat in	We state in the Methods section that all on- and off-channel nest records
182	5	21	360	Robert Wiley	sandpits and mines Regarding "shift" Mobilize?	Change made.
183	5	21	365-367	Kate Buenau	Peak stage in AHR is not high enough relative to mean annual stage. Because the channel width is so different, a plot like figures 7 and 8 but of stage rather than discharge would be useful	Noted.
184	5	22	371	Kate Buenau	Is this consecutive emergent time or all emergent time?	Consecutive
185 186	5	22 22	371 377-378	Robert Wiley Robert Wiley	Change to either "Flows recede" or "Flow recedes." This suggests that the Platte is not critically important to sustain the overall populations for these birds.	Change made. Noted.
187	5	22	378-382	Robert Wiley	This construction seems overly complex and backward. Why not quickly get to the percentage of years that successful breeding could have occurred for each species?	Noted. We attempted to develop a graphic that conveyed more information than a simple percentage of years when successful nesting could have occurred. For example, a simple percentage would give the same weight to a year with season-long potential for success and a year with one day when a nest could have been initiated and successfully fledged.
100	5	23	300	Robert wiley		June was not included because one could assume that renesting would
189	5	23	390 410-413	Kate Buenau Robert Wiley	Incubation is mentioned here, but was not in the methods, and the time intervals begin in July. Why not include June (allowing that renesting may occur if inundation occurs in early June)? Yes!	occur and inundation during that period was not as critical as later in the nesting season.
191	5	24	413	Dan Catlin	I wonder how frequently that occurred in the record. I don't think it needs to be addressed here, but it will be	Noted.
102	E	24	414 420	Robert Wiley	This assertion is unnecessary to your findings. The birds do it, ergo they must be adapted either	Noted.
192	5	24	414*420	Robert Wiley	physiologically, emotionally or psychologically to do it. It is trivial.	Noted
193	5	25	425-426	Robert Wiley	Yes! The birds behaviors have developed over millennia to accommodate continental size breading habitats of high variability. Their breading stratageme either If the site and there is success or they do not and there is breading failure. It has apparently proven likely that some location in their range provides habitat upon which to succeed most years. Their ability to fly very long distances and their longevity favors breading successes on constantly changing rivers and shorelines during their reproductive lives.	rojeg.
194 195	5	25 25	428 439	Robert Wiley Robert Wiley	Regarding "renesting": On the Platte only! Regarding "late-spring rise": The absence of high stage from late season storm events is critical.	Noted.
196	5	25	443	Dan Catlin	This is somewhat troubling as you point out, but before and after this paragraph, you make statements that belie this uncertainty. Look to line 432. You use the word 'indicated.' I tend to think that indicated should be used in cases when uncertainty is low. If n=1, uncertainty is high.	The analysis included a sample size of 1,263 sandbars measured following one storm event. We also evaluated two other events and determined that the 2010 event provided a conservatively-high estimate of sandbar height.
197 198	5	25 25	443 445-446	Kate Buenau Robert Wiley	Is BARmax supposed to be BAR HEIGHT as listed in Table 3? However, the phenomenon is common through the range.	Yes. Correction made. Noted
					The 2013 event was the one mentioned in Chapter 3 as unsuitable for sandbar height analysis because of the	That is one potential explanation. Another is that sandbar height was lower
199	5	25	447	Kate Buenau	though the flow was lower than the model predicts would be necessary. This is an empirical example of the	than the median value used to denne bar heights in the reach.
200	5	26	467	Robert Wiley	effects of uncertainty in the model due to initial conditions. Need end parenthesis after *10.100 cfs*.	Not clear.
201	5	27	480	Dan Catlin	I would say the difference between 33k and 55k is more than 'slightly.' The differences were between 60 and 70% (actual/predicted; done admitted) quickly as I read). That seems as though the predictions are off substantially. That means that your predictions in Table 4 are 60-70% too liberai, right? Meaning that there would be even LESS a chance of nesting? By saying slightly I think you downplay that your evidence successful nesting was sufficient and the data for the AHR was historically an 'overflow' area for the LPR and associated reaches that had more consistent nesting	Removed 'slightly' from the text. Model predictions were conservative.
202	5	27	483-484	Kate Buenau	In line with my previous comments in the discussion, it seems that a further quantitative exploration of the uncertainty would be justified. If anything the sandbar heights seem optimistic, rather than conservative, as there are several observed examples of sandbars being inundated when the model predicts they would not, if I understand this section correctly. The differences in discharge appear large, although the stage differences may not be (reporting those as well may help with understanding the magnitude of error.) Are there observations where the sandbars were not inundated when the model predicts that they would be?	Noted. The text usage of conservative = optimistic. IE, the model provides a conservative/high probability obsuccessful nearing. We are not aware of observations where sandbars were not inundated when the model predicts that they would be.
203	5	28	497	Dan Catlin	You will have to do more to make this conclusion. I don't deny that it is possible, but without looking at the actual demographic consequences, I think this is an overstatement. For example, work out of the Missouri shows outsized reproductive success following a large flood, and it is similar on coastal habitats. I have no idea if the increase in reproductive success would have been enough to allow the population to limp along or if the AHR or LPR were just overflow locations for birds in those good years, but I don't think you know either, not without applying the demographic models to this.	Agree that we cannot definitively make this conclusion from the analysis alone. Text has been modified to clarify.
204	5	28	502-507	Matt Kondolf	The argument advanced that the AHR was not suitable for the birds historically because its sandbars were too low to avoid summer inundation is certainly possible, but this deterministic conclusion is based on a long series of assumptions and calculations. The approach is certainly reasonable, but I would feel more comfortable if the considerable uncertainties embedded in this conclusion were highlighted and emphasized more, especially as these birds have long been observed to occupy these habitats. The argument that the hydrology is unfavorable would apply to other reaches as well according to the Report, and again we know these birds occurred in these reaches historically and some still.	The conclusion in the chapter was that the historical AHR was not an analog of the contemporary LPR and likely had lower potential for nest success. We concur that the conclusion was based on assumptions and calculations. There is frankly no data available to approach the analysis in any other way. We would also point out that these birds have not "long been observed" to occupy in-channel habitats in the AHR (See Chapter1). No in-channel use was observed in the AHR prior to the development of major irrigation infrastructure. Since that time, use has been infrequent and unproductive.
205	5	28	504-506	Kate Buenau	Sentence appears incomplete, but I'm primarily commenting on this to note that there is an interesting potential point of discussion about channel width in relation to habitat suitability as discussed in Chapter 4. Birds select for wider channels but the wider channels in the historical AHR, even with higher historical flows, reduced the variability in stage to the extent that, given the assumptions in the habitat availability model, habitat would very rarely be available.	Text clarified.
206	5	28	504-507 516-518	Matt Kondolf	Run-on, can be fixed by deleting "Although" The Sidle reference presumably is to Sidle et al 1992 (labeled as "Sidle and Kirsch 1993" among the pdfs provided), which did not discuss off-channel habitat as an alternative to in-channel habitat. The NRC report was not included among the pdfs, but obtained online, this report included statements such as, "Sandpils and reservoir edges with beaches may, under some circumstances, mitigate the reduction in riverine habitat areas. Because piping plovers are mobile and able to find alternative nesting sites, changes in habitat may not be as severe as they would be otherwise, but no studies have been conducted to support or reject this hypothesis It is also now understood that off-stream sand mines and reservoir beaches are not an adequate substitute for natural riverine habitat." (NRC 2004, pp.9-10)	Change made. The reference should have been Sidle and Kirkh 1993. We recognize that the NRC Report contained statements about the suitability of off-channel habitat. However, those statements are not supported by species use and productivity on off-channel habitats in the AHR. Species productivity at off-channel habitat has exceeded proposed recovery objectives (Lutey 2002) in almost every year.

Comment ID	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
#			540 504	Debert Wiley	Great summation! Also, these long-distance fliers are extreme opportunists. They are flying over anyway, on	Noted.
208	5	29	518-521	Robert Wiley	the way to Missouri and Mississippi sandbars. With the failure of the FSM approach to produce suitable habitat to date, the implication is that efforts should instead be tocused on expanding off-channel habitats. However, the Report does not explain how these off- channel habitats are protected from predators. Potential disturbance by predators in off-channel habitats is an issue brought up by the NRC (2004) and quoted by the BO (USFWS 2006), and incorporated within an advanded agricuits in a Chancer 1 a 12	See response to comment 207. The Program intensively traps and manages (electrified fencing, tree removal, etc.) for predators at off-channel habitat sites. That is one of the reasons that productivity is quite good at off- channel sites. The Program also traps and removes trees near in-channel sites, but use and productivity have been low on in-channel habitat.
209	5	29	518-521	Matt Kondolf	The Report does not discuss the valuerability of off-channel sand pits to predation, but this would seem to be a significant drawback of the off-channel habitat, located entirely in the uplands, without river channels to isolate the nest from terrestrial predators. The NRC (2004) [p. 190] discusses this question in more detail, noting prior studies indicating less food available for the birds, greater distance to water, and greater vulnerability to predation.	
					Thus, while the problems with the FSM approach detailed in the Report are for the most part probably valid, before giving up on the river and going to mechanical off-channel approaches, the issues associated with such off-channel habitats would need to be better understand and strategies devised to address them.	
210	5	29	522-523	Dan Catlin	Yes.	Noted. Noted.
211	5	29	522	Robert Wiley	There can be no AHR population of ILT and PPL. These birds have a continental or hemispheric population. They have a breading behavior that includes selection of sites that favor reproductive success. Reproductive failure is a possibility for any site but it based first on the choices made by the birds and secondly by random chance after nests are established. It is grand hubris to assert that we can manage either of those factors.	
212	6	Overall		Matt Kondolf	[See preceding commentary in individual comments - Appendix A to summary report] This argument [that the AHR may never have had large sandbars preferred by birds] is introduced rather late in the Report, and its implications would be profound: notably that the AHR was never very suitable for the birds because it would not naturally support large sandbars. Thus, if the logic train is spelled out, this argument would challenge the very assumptions on which the BO and the entire restoration program is based. The history of observations of bird use to too sport) to be able to confirm whether this reach was as much used by the target species as other river reaches in the region. However, even in the absence of reliable data on past bird use of the AHR, if the AHR has a fundamentally different geomorphology from the other reaches, this would be a strong argument that it may not have supported birds as did its sister reaches nearby. Thus, this idea deserves more focused exploration and testing, by socuring historical records for clues to its historical form, and through analysis of geomorphicity processes.	Ine purpose of mese chapters is to provide a symmese or data to help the Program address its "Bg Questions" and related hypotheses. This information will be presented to the Governance Committee (GC) for use in the decision-making process and it will be up to the GC to decide if questions and hypotheses are answered and if so what implications that will have for altering management actions. It will be up to the Service to assess what the implications of all this are on the current BO, how to assess the performance of the Program against that BO, and what, if any, changes to make to the BO for an extended First increment or a Second Increment. Additional back-casting analyses of historical geomorphology records are beyond the scope of these chapters. The GC would have to direct the EDO to pursue these analyses.
213	6	Overall		Matt Kondolf	[See preceding commentary in individual comments - Appendix A to summary report] Thus, evidence that large sandbars do not (and never did) occur in the AHR would support the argument that the AHR never supported large populations of birds, but I find the argument about these being flooded too often less convincing. The Report acknowledges the criticisms of using hydraulic relationships from stream gauges and presents rating curves for both gauge sites and two breeding alles, which are compared visually to support the conclusion that the frequency of inundation of surfaces of a given height at the stream gauges would be would be an effect on the stream gauges would be would be and the stream gauges and the stream gauges would be would be and the stream gauges and the stream gauges would be would be and the stream gauges and the stream gauges would be would be and the stream gauges and the stream gauges would be would be and the stream gauges and the stream gauges would be would be an effect on the stream gauges and the stream gauges would be would be an effect on the stream gauges and the stream gauges would be would be an effect on the stream gauges and the stream gauges would be would be an effect on the stream gauges and the stream gauges would be would be an effect on the stream gauges and	Noted. Aerial photograph sequences could be added to Chapter 3 or Chapter 5 to show inundation at various discharges. However, we currently don't have the within-year photography sequences that would be necessary to complete this analysis. We would need further clarification to understand what other factors the reviewer is interested in.
214	6	1	5-13	Robert Wiley	applicable to the other cross sections at which the birds breed. As this is a potentially important point, I would like to see the cross sections with inundation of different surfaces indicated, and exploration of whether there might be other factors involved that are not captured by the rating curves alone. The exclusion of other data sets from other rivers is a false binning. The breeding behaviors of each species varies little across their hemispherical range. The set of physical conditions that favor reproductive success vary little across the birds hemispherical range varies little. It would seem that the assessment should include all rivers to define the physical signatures that favor the birds and then looking for the reasons for the occasional occurrence of success on these occasionally producing rivers. The similarity of UFFWS policial objectives for the Bittle (these are not existed) bead objectives for the Bittle these are not existed.	Noted. The inclusion of all rivers was beyond the scope of this exercise.
					comparisons.	
215	6	1	24	Robert Wiley	What they are doing is not species recovery. It is Platte River Habitat recovery and its programmatic significance to the recovery or sustenance of the species populations at large must be contextualized.	Noted.
216	6	2	30	Robert Wiley	Regarding "an annual or near annual basis": There is no reason to believe that the Platte ever contributed at this level. This policy notion was well discredited in Chapter 5 of the document.	Noted.
217	6	2	46	Robert Wiley	You must review Lott et al 2013.	This sentence relates to piping plover population estimates. Unless I am mistaken, Lott et al. 2013 is an analysis of least term productivity on managed niver systems.
218	6	3	51-54	Kate Buenau	The Missouri River has experienced more "natural" habitat characteristics below Gavins Point following 2011, with minimal modification of flood-created habitat to date, though flows are still managed. The size of the system may make it less ideal a comparison than the other rivers considered, but there may be relevant comparisons.	See general Missouri River comment.
219	6	3	51-54	Robert Wiley	That is not true! The majority of the nesting data derives from bird activities data collected after a high flow event in 1998. The habitat declined with time (erosion and occupation by vegetation). Created habitat rose in importance between 2007 and 2010 until another high flow event refreshed the non-constructed sands bars in 2011. The Gavin's Point segment has the best and largest dataset for nest establishment, loss, fledging as well a developed relationships between nesting phenomena flooding, bar height vegetation occupation rates and vegetation management efforts of any river segment in the continental ranges of the species.	See general Missouri River comment.
220	6	3	Table 1	Robert Wiley	So why did you reject the extensive datasets available for the Fort Randall, Garrison and Fort Peck Segments?	See general Missouri River comment.
221	6	5	78-82	Kate Buenau	How representative were the years for which population data was widely available? Is there possibility of comparing this year to other years within at least some of the comparison segments to understand if it is representative?	There is no way of determining if the initiation and fledging data collected during 2001-2013 are representative of data collected prior to this timeframe. Different monitoring protocols and minimal monitoring effort were expended to collect similar data prior to 2001.
222	6	5	79-80	Robert Wiley	How can this be a sound rational? Was it selected because the length was easy to pull from the GIS data? None of this discussion is convincing for limiting comparisons as has been done here.	See last sentence in paragraph.
223	6	5	87	Robert Wiley	Segment length is not a selection factor that has been document to be used by ILT or PPL.	Dividing total population by segment length provided a way to compare the population in a 50 mile segment to the population in a 500 mile segment. We did not ascert that it is a selection factor.
225	6	5	89	Robert Wiley	Due to the high variability of survey method effectiveness and the sketchy interpolations needed to "normalize" data for this assessment, the whole discussion discounts the validity of the comparison. It is all an artificial	We do not understand how comparing species populations in various river segments is a 'faux comparison.'
226	6	7	126	Robert Wiley	construct designed (athough inadvertently) to create a faux comparison. Insert "an insurmountable" before "degree." My opinion but I have done a good bit of sediment sampling. It requires a good bit of sediment sampling, the comparability of which that can be foiled by circumstance, sample site opportunity and collection method. Determination of the areas of sandbars actually used has very high technical difficulty due to the stage interpolations required to normalize aerial imagery collected at different stages, the lack of nest point location data and the lack of agreement on which phase of reproductive behavior represents a finding that "use" is occurring. Review the Gavin's Point discussions (EIS for Mechanical Sandbar Creation USACE Omaha 2010) concerning various attempts to define use areas by using nearest neighbor GIS models with GPS located nests.	It is difficult to address this comment given the lack of specificity. We agree that these analyses are difficult. However, it is unclear if the reviewer is pointing to specific issues with this analysis.
227	6	7	131	Robert Wiley	Did you know the river stage for each image used? Same time of year is not enough to normalize.	The images were collected during the nesting season at approximately the same time within a single year. We believe that is sufficient for comparative purposes when the objective is comparison of bare sand area between segments.
228 229	6 6	8 9	147 149	Robert Wiley Dan Catlin	Regarding "large": More definition needed to assess bias. Add the "t" to "et"	Clantied in text. Change made.
230	6	9	151	Robert Wiley	Insert "from images reviewed" after "segment."	Text modified. See general Missouri River comment.
231	6	9	163-164	Robert Wiley	Agree	Noted.
233	6	9, 11	165, 191	Kate Buenau	Tables 5 and 6: Density calculations of adults/river mile can't account for the differences in potential in-channel habitat areas between river segments, based upon channel width at least. It is possible to account for the different capacity of a river mile in different river segments?	Agree. Unfortunately no data was available to help account for differences in habitat area. We could have normalized based on the combination of length * width but that would make comparisons even more tenuous.
234 235	6	10 10	169-176 181	Kate Buenau Robert Wilev	Variability between years is mentioned here for the LPR—what about other segments? Also see Lott et al 2013 and Lott and Wiley 2011 for the Red River numbers.	Little of that data is available for other river segments. Noted.
236	6	10	183	Robert Wiley	Because the very productive habitat created by the 1998 high flow event had either eroded or became	See general Missouri River comment.

190         6         11         100	Comment ID	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
Bits         Bits         Bits         Bits         Bits         Bits         Bits         Bits           202         I. S.	237	6	11	Table 6	Robert Wiley	Regarding "Mississippi River (Helena, AR - Greenville, MS)" row: Explained by very large and high sandbars on	Noted.
Substract         Substract <t< td=""><td>238</td><td>6</td><td>11</td><td>198-200</td><td>Robert Wiley</td><td>groin neids. Or perhaps not really comparable at all</td><td>Why?</td></t<>	238	6	11	198-200	Robert Wiley	groin neids. Or perhaps not really comparable at all	Why?
Image: Add term           124         6         4         32         Image: Add term         Image: Add	239	6	12	Table 8	Robert Wiley	Because of the variable observation methods and the detection problem, these may be the most meaningless ratios ever calculated	We respectfully disagree. Hedge ratio is a commonly-reported metric for these two species and given our direction to compare river systems "Bedge ratio" is a priority metric for comparison. We agree that methodologies for calculating fledge ratios among river systems, programs, etc. vary but that is not a problem solvable by the PRRIP. Furthermore, we are unaware of another metric calculated on these river systems that could be compared to Program data.
Att         0         0         0         0         0         0         0         Mode         Mode           24         0         0         16         0 <td< td=""><td>240</td><td>6</td><td>13</td><td>217</td><td>Kate Buenau</td><td>Table 9: It is unclear what the footnote is referring to.</td><td>Footnote removed.</td></td<>	240	6	13	217	Kate Buenau	Table 9: It is unclear what the footnote is referring to.	Footnote removed.
1         0         1         0         0         0         0         0         0         0           1	241	6	14	226	Dan Catlin	more opportunity to pull off a successful nest for both species	No response necessary.
Justice         Justice <t< td=""><td>242</td><td>6</td><td>14</td><td>230</td><td>Dan Catlin</td><td>This table legend should be expanded. For example, you don't define u*/w here (though it is defined in the text).</td><td>Noted.</td></t<>	242	6	14	230	Dan Catlin	This table legend should be expanded. For example, you don't define u*/w here (though it is defined in the text).	Noted.
Here         Here         Here         Non- transmission (mp) (mp) (mp) (mp) (mp) (mp) (mp) (mp)	243	6	14, 17	235, 288	Matt Kondolf	The main difference in controlling variables cited by the Report was coarser grain size in the AHR (Chap 6 p 1/a). However, the Report states that the gradient of the AHR is 0.0012, which described as being "alightly steeper than LPR Reach 1 and sightly failer than the Niobrara River segment" (Chap 6 p 17). The gradient is 50% greater than that of LPR Reach 1 (0.0012,0.008 = 1.5) and in the micpoint of the Niobrara gradient reported of 0.0010-0.0015. (However, the Loup River is consistently higher gradient, 10.0015.) Presumably a 50% difference in gradient would have a noticeable influence on results of sediment transport modeling. Steeper slopes are commonly associated with higher bed material sizes, but there are many variables involved, so it would be too simplistic to say simply the AHR is steeper and therefore it has coarser bed material. In any event, the potential influence on bedforms of local slope combined with grain size deserves further exploration and analysis. To answer the question of why sandbars are smaller in the AHR and whether they could be and once were higher in the AHR, it would help to have a better understanding of the relations among sediment supply.	We concur. The word 'sightly' has been removed from the text. Ongoing reach-scale investigations at the Em Creek and Shoemaker Island habitat complexes are intended to address some of the issues presented in the comment. Those efforts will be completed in 2015 and 2016.
266 $6$ $6$ $56$ $56$ $56$ $56$ $56$ $56$ $16$ $166$	244	6	15	243	Robert Wiley	transport capacity, grain size, peak flow water levels, and resulting sandbar neight. Yes!	Noted
266         6         15         250         Due Case         Interfact and multiply appoints. This is a multiply of provide. If many display and provide	245	6	15	251	Kate Buenau	How variable might this distribution be (understanding the limitations of range-wide data)?	We do not believe the variability in this distribution has been evaluated on a
101010100<	246	e	15	256	Dan Catlin	of the? and I'm not sure what your point is. This is a rehach of the require I think you need to clorify your point	Text clarified.
$\frac{1}{200}$ $\frac{1}{20}$ <td>240</td> <td>6</td> <td>15</td> <td>250</td> <td>Dan Catlin</td> <td>or imperfect detection of nests? Or both</td> <td>Text clarified</td>	240	6	15	250	Dan Catlin	or imperfect detection of nests? Or both	Text clarified
200         6.6         17.         Make Develop         OPER-ARRING         Market Develop         Market Develo	247	6	16	269-270	Kate Buenau	Strictly speaking, only the objectives for total numbers are prorated, correct?	Text clarified.
1         1         200-20         Non-two we produced and produced the general stage. There are stage. Regarding "symbol and produced and general stage.         Non-two produced and general stage.           251         6         7         200-20	249	6	16	274	Kate Buenau	CPR = AHR?	Yes. Text modified.
21         6         17         20         DBC GMA         6.2 MM the field from both reserves and heads.         In particular from both reserves and heads.         In particular from both reserves and heads.           222         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         6         17.2         252.2         7         252.2         7         252.2         252.2         18.2         252.2         18.2         252.2         18.2         252.2         18.2         252.2         18.2         252.2         18.2         252.2<	250	6	17	286-287	Robert Wiley	Regarding "braided sand bed channels": So are all other sand rivers at some stage. Regarding "although bedrock influences": Which is a very important difference that greatly tries the notion of comparability.	
B         B         S	251	6	17	290	Dan Catlin	vs.? what for the other reaches, or the Niobrara at least.	Text added.
Abs         No.         315-36         Nome based         Single state based on Longing 1, Single state Longistin Longing 1, Single state Longing	050		47.00	295-298,	K	How do these differences in sediment transport mode relate to the differences in sandbar height with sediment	In general, the relationship between sediment grain size, transport mode, and sandhar dynamics are poorly understood. Efforts are underway to
250         6         17         28-50         Relearities         Instrument of the standard of and source in the control of and source in the	252	6	17, 20	315-316	Kate Buenau	grain size as described in Chapter 5? Do these findings support or contradict the assumptions about sandbar height and/or habitat formation in the historical AHR?	better quantify these relationships in the AHR.
254         6         19         303         Mark Konzel         Figure 2. Presumably all ghores deals are after same scale with the the near test by involved and the scale of the scal	253	6	17	295-296	Robert Wiley	Just a thought Is there a difference in the characteristic of sand sources in the locations?	Yes.
255         6         20         313         Robert Way, Repert Way, Repert Way,         Robert Way, Repert Way, Repert Way, Repert Way,         Robert Way, Repert Way, Repe	254	6	19	303	Matt Kondolf	Figure 2: Presumably all 6 photo details are at the same scale such that the small box in the lower left of the top image (of CHR) represents 5 ac. A more standard way to graphically show scale is using a scale bar, and I recommend a scale bar be included. If all 6 images are at the same scale, only one scale bar need be inserted, but the caption should include a statement that all images are at the same scale. If the scales differ among images, scales should be shown for each. Also a north arrows, dates, and flow on the date of the obtoorranb.	All images are at the same scale. We agree that a scale bar would typically be used in this slutation. However, we used an area box given that the discussion focus on sandbar area.
Image: Second	255	6	20	313	Robert Wiley	Regarding "large": Size is related to duration of flow at a stage	This is likely true on the Missouri River but we would argue that duration does not necessarily increase size on river systems like the Niobrara where total stage change is less than three or four feet. Size is likely more closely related to mode of sediment transport.
257         6         20         315-316         Robert Wiley         Softment tamport is why holy dory??? Please cirrly, would the outcome to be the same?         Clarified.           258         Robert Wiley         Softment tamport is why holy dory??? Please cirrly, would the outcome to be the same?         Noted.         Noted.           258         Robert Wiley         Softment tamport is why doright paragona.         Noted.         Noted.         Noted.           258         Softment tamport is why doright paragona.         Noted.         Noted.         Noted.         Noted.           258         Softment tamport is why doright paragona.         Noted.         Noted.         Noted.         Noted.           258         Softment tamport is why doright paragona.         Noted.         Noted.         Noted.         Noted.           259         Softment tamport is why doright paragona.         Noted.         Noted.         Noted.         Noted.           260         Softment tamport is why doright paragona.         Noted.         Noted.         Noted.         Noted.         Noted.           270         Softment tamport is why doright paragona.         Noted.         Noted.         Noted.         Noted.         Noted.           280         Softment tamport is why doright paragona.         Noted.         Noted.	256	6	20	315	Kate Buenau	Clarify "steeper, flatter, wider and narrower"—does this mean that the differences between the AHR and other reaches cannot be explained by steepness or width because the AHR falls between other segments in those metrics? Does the "narrower" assessment account for the split channels? Additionally, what do the changes between the historical and contemporary AHR mean for future management? Was it more analogous in the past?	Yes to the first two questions. Median grain size appears to have been slightly lower in the historical river but still two to three times larger than the other river segments. So, it was closer but not comparable.
25862026-28Robert Was Provide standard standar	257	6	20	315-316	Robert Wiley	Sediment transport is via hydrology??? Please clarify.	Clarified.
259       6       21       331-33       Kate Buenau       What about variability in peak magnitude as well as timing? Habitat-creating years followed by droubn?)       Agree that these could also be important.         260       6       21       331-33       Robert Wiley       Yest This is because the shape of the bash shape of the bash created. Very high spring peaks create very high sandbars. The higher the peak it, you shave of the peaks by water extraction or off went will       Noted.         261       6       21       338       Kate Buenau       Increased low flows would reduce habitat availability, especially if peak flows are not sufficiently high, so what is here of the peaks by water extraction or off went will       Flows can be so low that the river is essentially dry during the nest initiation period.         262       6       21       347       Kate Buenau       Increased low flows would reduce habitat availability, especially if peak flows are not sufficiently high, so what is period.       Flows can be so low that the river is essentially dry during the nest initiation period.         262       6       21       347-348       Kate Buenau       states that the AHR lacks linear variability, especially if peak flows are not sufficiently high, so what is essentially dry during the nest. In other segments there are somewhat abrupt changes in width troughout the react. Noted         263       6       22       352-357       Kate Buenau       valeth the AHR lacks linear variability, get the CV given in Table 11 is the highest of the river segments	258	6	20	326-328	Robert Wiley	It the same methods were used to compare segments of any newr, would the outcome not be the same? Wouldn't the finding be that there is little similarly longituriality a well because of the continual variation in cross-section, bedrock influence, contributing drainage area, bed load composition, slope, etc. It may not be that these or any set of metrics reveals meaningful comparison. Birds nest in many segments of many rives, as well as along lake and beach shorelines. There are some circumstances that create habitat upon which these birds successfully breed sometimes. There are some areas that may support successful breeding in 10 out of 10 years. There are some mesites that make successful breeding habitat available for 1 out of 10 years. There are some sites that make successful breeding habitat available for 1 out of 10 years. There are some sites that make successful breeding habitat available for 1 out of 10 years. There are some sites that make successful breeding habitat available for 1 out of 10 years. There are some sites that make successful breeding babitat available for 1 out of 10 years. There are some sites that make successful breeding babitat available for 1 out of 10 years. There are some sites that make successful breeding babitat available for 1 out of 10 years. There are some sites that make successful breeding babitat available for 1 out of 10 years. There are some sites that make successful breeding babitat available for 1 out of 10 years. The babitat available for the species and their nest site selection criteria that can occur at thousands of locations throughout their continental range during most breeding seasons. The birds longevity mitigates against the seasonal loss of production at any or al locations. The foregoing comparison does not provide useful information for management.	(10)001.
260       6       21       31-33       Robert Wiley       pass andbars. The higher the pack, the issues key that a following storm under every back the pack the	259	6	21	331-332	Kate Buenau	What about variability in peak magnitude as well as timing? Habitat-creating years followed by drought? Yes! This is because the shape of the bydrograph mirrors the shape of the bar created. Vary high partice	Agree that these could also be important.
261621338Kate BuenaIncreased low flows would reduce habitat availability, especially if peak flows are not sufficiently high, so with the potential banefit of increasing low flows?Flows can be so low that the river is essentially dy during the next initial period.26262232-357Kate Buenaustates that the AHR lacks linear variability, etp the CV given in Table 11 is the highest of the river segments.AHR variability occurs from one end of the reach to the other. Narrow channels occur in the west and validor channels in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are somewhat abrupt changes in which throughout the esgments there are an under some and in the solution of the solution of the solution of the solution of the solution of the solution of the solution of the solution of the solution of the solution of the solution of the solution of the solution of the solution of th	260	6	21	331-333	Robert Wiley	Thes: In its to because use shape of use in injuring aprimitions are shape of use of cleared. Very right spring peaks create very high sandbars. The higher the peak, the less likely that a following storm runoff event will create a flow that over-tops the bars created. If you shave off the peaks by water extraction or damming, the likelihood that storm runoff will over top is increased. This relationship applies to every river and every beach that these birds use.	(N)KU.
262       6       21       347-348       Kate Buenau       states that the AHR lacks linear variability, yet the CV given in Table 11 is the highest of the river segments.       AHR variability occurs from one end of the reach to the other. Narrow channels occur in the west and vider channels in the east. In other segments there are somewhat abrupt changes in width throughout the reach.         263       6       22       352-357       Kate Buenau       Wouldn't channel widening further reduce stage variability and habitat creation potential?       Yes.         264       6       22       356-357       Robert Wiley       Again Yes!       Noted.         265       6       22       355       Dan Catlin       Out of curiosity, do we know why the grain size is so dramatically different here?       Yes. Different sediment supply. Other segments there as adments and hills.         266       6       22       378-379       Robert Wiley       Yes! Yes! Yes!       Noted.         267       6       23       385       Robert Wiley       Regarding 'near annual basis': You have well established that the Plate was unlikely to offer successful breading sites during most years in Chapter 5. To me that falls into a category of 'ndf sad'.       Noted.         268       6       23       389       Robert Wiley       Regarding 'near annual basis': You have well established that the Plate was unlikely to offer successful breading sites during most years in Chapter 5. To me that falls into a c	261	6	21	338	Kate Buenau	Increased low flows would reduce habitat availability, especially if peak flows are not sufficiently high, so what is the potential benefit of increasing low flows?	Flows can be so low that the river is essentially dry during the nest initiation period.
263       6.6       22       352-357       Kate Buenau       Would'n thannel widening further reduce stage variability and habitat creation potential?       Yes.       Noted.         264       6.6       22       356-357       Robert Wiley       Again Yes!       Noted.       Yes. Different sediment supply. Other segments derive a large portion of their sediment from the Nebraska sanchalis.         265       6.6       22       371       Robert Wiley       Again Yes!       Noted.         266       6.0       23       378-379       Robert Wiley       Yes! Yes! Yes!       Noted.       Noted.         267       6.6       23       378-379       Robert Wiley       Yes! Yes! Yes!       Noted.       Noted.         268       6.6       23       378-379       Robert Wiley       Again yes!       Noted.       Noted.         269       6.0       23       38-8       Robert Wiley       Regarding 'near annual basis': You have well established that the Platte was unlikely to offer successful breiding sites during most years in Chapter 5. To me that falls into a category of 'nuff said'.       Noted.         269       6.0       23       38-9       Robert Wiley       Regarding 'near annual basis': You have ell established that the Platte was unlikely to offer successful breiding sites during most years in Chapter 5. To me that falls into a category of 'nuff sai	262	6	21	347-348	Kate Buenau	states that the AHR lacks linear variability, yet the CV given in Table 11 is the highest of the river segments.	AHR variability occurs from one end of the reach to the other. Narrow channels occur in the west and wider channels in the east. In other segments there are somewhat abrupt changes in width throughout the reach.
260       360       12       360-30       Robert Wiley       Year Heat       Protect         266       6       22       371       Robert Wiley       Vest Vest Vest       Noted.         267       6       23       378-379       Robert Wiley       Again, yes!       Noted.         268       6       23       378-379       Robert Wiley       Again, yes!       Noted.         269       6       23       385       Robert Wiley       Regarding 'near annual basis': You well established that the Platte was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of 'nuff said'.       Noted.         269       6       23       389       Robert Wiley       Regarding 'near annual basis': You sediment free? Low sediment entrainment?       Return flows are virtually sediment free.         270       6       23       390-392       Kate Buenau'       Kate Buenau'       To not that falls into a category of 'nuff said'.       Poor word choice. Revised.	263	6	22	352-357	Kate Buenau Robert Wiley	Wouldn't channel widening further reduce stage variability and habitat creation potential?	Yes.
266     6     23     371     Robert Wiley     Yest Yest     Yest Yest     Noted.       267     6     23     378-379     Robert Wiley     Again, yest     Noted.       268     6     23     385     Robert Wiley     Regarding 'near annual basis': You well established that the Platte was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of 'nuff said'.     Noted.       269     6     23     389     Robert Wiley     Regarding 'clear': Sediment free? Low sediment for You falls into a category of 'nuff said'.     Noted.       270     6     23     390-392     Kate Buenau fall motion to the platter was unlikely to fall said'.     Return flows are virtually sediment free.	265	6	22	365	Dan Catlin	Out of curiosity, do we know why the grain size is so dramatically different here?	Yes. Different sediment supply. Other segments derive a large portion of
267         6         23         378-379         Robert Wiley         Again, yes!         Noted.           268         6         23         385         Robert Wiley         Regarding 'near annual basis': You have well established that the Platte was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of 'nuff said'.         Noted.           269         6         23         389         Robert Wiley         Regarding 'cear': Sediment free? Low sediment entrainment?         Return flows are virtually sediment free.           270         6         23         390-392         Kate Buenau' temper during most peer contemplated' contradicts last paragraph on page 22 (appears to have been contemplated and the plate in the falls into a category of 'nuff said'.         Poor word choice. Revised.	266	6	22	371	Robert Wilev	Yes! Yes! Yes!	their sediment from the Nebraska sandhills. Noted.
268     6     23     385     Robert Wiley     Regarding "near annual basis": You have well established that the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".     Notesting       269     6     23     389     Robert Wiley     Regarding "cear": Sediment free? Low sediment rentrainment?     Return flows are virtually sediment free.       270     6     23     390-392     Kate Buenau "free monte on tenspiled" contradicts last paragraph on page 22 (appears to have been contemplated and to fassible).     Rotor All the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".     Rotor All the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".     Rotor All the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".     Rotor All the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".     Rotor All the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".     Rotor All the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".     Rotor All the Plate was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said".	267	6	23	378-379	Robert Wiley	Again, yes!	Noted.
270 6 23 390-392 Kate Buenau demonstration of testible).	268	6	23	385	Robert Wiley	Regarding "near annual basis". You have well established that the Platte was unlikely to offer successful breeding sites during most years in Chapter 5. To me that falls into a category of "nuff said". Reparating "clear". Sediment free? Low sediment entrainment?	Return flows are virtually sediment free
DODUDU DU DU DUDUDU	270	6	23	390-392	Kate Buenau	"has not been contemplated" contradicts last paragraph on page 22 (appears to have been contemplated and deemed not feasible)	Poor word choice. Revised.

Comment ID #	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
271	6	23	396	Robert Wiley	One factor not considered in your assessment of grain size is the composition of coarse fragment and their role in creating aeolian pavements as important to egg and chick camouflage effectiveness nest site selection. See the attachment to the technical appendix in the Mascun River EIS addressing the importance of aeolian process to finishing the nest site. Also see Lott and Wiley 2010 on aeolan pavement formation on the Red, Cimarron and Arkansas Rivers.	We don't disagree aeolian pavement processes may appear to be important, or may in fact be important in systems were nesting occurs on river islands created by natural flow processes where there is a gradation of sediment size. However, there has been very limited nesting on Islands create by livo on the central Platte River where sediment gradations would be present. Rather, s90% of nests on central Platte River islands occurs on habitat created by bulicozers using existing aschiment gradations would be present. Rather, s90% of nests on central Platte River islands occurs liskcharge which prohibited deposition of larger sediment sizes on the slands, by design, were constructed as to not be overtopped by bark-full discharge which prohibited deposition of larger sediment sizes on the slands. This notion is also not supported by the fact >85% of all nests on the central Platte River have been on off-channel sandpit sites that do not contain aeolian pavement areas. These sites are created whi 100% line accurators where larger sediments (grave) are present. Nesting densities on these sites, however, are comparable to sites that were created through the sand and gravel mixing industry where on/fine sediments are reation. Nesting and productivity tapered off as the habitat aged which is when aeolian processes would have coarsened the surface material.
272	Summary of Key Findings	3	60	Dan Catlin	no uncertainty?	Text modified. Our assessment is that there is low uncertainty in this conclusion.

PRRIP - ED OFFICE FINAL

2/25/2015



Prepared by staff of the Executive Director's Office

for the Governance Committee of the Platte River Recovery Implementation Program