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June 1, 2015

Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street NE
Washington, DC 20426

Subject: Loup River Hydroelectric Project
Comments on USFWS' Draft Biological Opinion
FERC Project No. 1256-031

Dear Secretary Bose:

Loup River Public Power District (Loup Power District or District) has reviewed the May 1, 2015, Draft Biological Opinion (Draft Opinion) prepared by the U.S. Fish and Wildlife Service (USFWS) regarding the relicensing of the District's Loup River Hydroelectric Project, FERC Project No. 1256 (Project) and provides the following comments for the Commission to forward to USFWS with its comments on the Draft Opinion. As documented below, the District believes that the Draft Opinion is fatally flawed and inconsistent with the requirements of the Endangered Species Act (ESA), the ESA regulations, and the guidelines of USFWS. Therefore, the Draft Opinion cannot be the basis for reasoned decision making by the Commission in this relicensing proceeding.

As a preliminary matter, the Draft Opinion incorrectly claims on pages 17 and 18 that the District has "committed to incorporating" flow modifications (Draft License Articles 404, 405, and 406) as conservation measures in the Staff Alternative. It should be noted that the District has not committed to these measures and rather has provided opposing comments to the Commission on June 23, 2014, identifying the substantial record evidence that documents that the proposed flow modifications are not justified or appropriate for a new license for the Project, and the District has also identified operational impediments to implementing the Staff's flow recommendations (see Attachment A, Operational Impediments to Implementing Flow Modifications Included in the Staff Alternative). Furthermore, the analysis of the Staff Alternative presented in the Draft Opinion acknowledges very small or unknown effects of the Staff Alternative compared to Current Operations, and in several instances uses Current Operations to evaluate the Staff Alternative, implying that there would be no difference between the two. Finally, the District is providing new research published by the Platte River Recovery Implementation Program (PRRIP) that disproves the fundamental framework of Draft License Articles 404 and 406 that flow and sediment management strategies will create and maintain habitat for Interior least terns and piping plovers. Based on this, the District requests that a meeting be held among Commission Staff, USFWS, and the District to discuss revisions to the draft license articles (and thus the Staff Alternative) prior to USFWS finalizing its Biological Opinion.

In addition, the District believes that the Draft Opinion does not comply with applicable ESA standards, is not well-reasoned, and regularly reaches conclusions that are not supported by evidence in the record of this relicensing proceeding, as noted below:

1. The Draft Opinion's definition of "environmental baseline" is inconsistent with ESA Section 7 regulations, the Endangered Species Consultation Handbook, and applicable case law, and, furthermore, is internally inconsistent within the Draft Opinion.
2. The Draft Opinion's major conclusions do not reflect reasoned decision making based on the evidence the Draft Opinion presents.
3. Many of the Draft Opinion's conclusions are assumptions, and furthermore, many other assumptions are presented as facts without record support; the Draft Opinion does not consider alternative assumptions that would be equally valid, nor does the Draft Opinion provide reasoned analysis to support its assumptions.
4. The Draft Opinion fails to use the best scientific and commercial data available and fails to comply with other information standards that are applicable.
5. The Draft Opinion uses a different assessment framework for each of the three species it considers, which creates the appearance of arbitrariness.
6. The Draft Opinion's Incidental Take Statement (ITS) does not comply with Congressional intent, USFWS regulations and policies, and case law.

Each of these general comments is described in more detail below. Additionally, specific comments related to the analysis contained in the Draft Opinion are included in Attachment B, Specific Comments on USFWS' Draft Opinion.

General Comment 1:

The Draft Opinion's definition of "environmental baseline" is inconsistent with ESA Section 7 regulations, the Endangered Species Consultation Handbook, and applicable case law, and, furthermore, is internally inconsistent within the Draft Opinion.

The Draft Opinion uses the term "environmental baseline" in ways that are internally inconsistent within the Draft Opinion and are also inconsistent with the way the term is defined in regulation, policy, and applicable case law. The Draft Opinion states that "1. The environmental baseline is defined as a) no diversion into the Project canal for the purpose of hydropower production; b) existing Project infrastructure remains in place; and c) current habitat conditions that have been formed through past Project operations represent a starting condition for the environmental baseline. 2. The environmental baseline will also include the following assumptions: a) species habitat conditions are expected to change under a no diversion baseline; and b) species status in the action area is expected to be different under a no diversion baseline" (Page 19, "Jeopardy Determination," bullet points 1 and 2; Appendix B, Page 153, bullet points 1 and 2). Throughout the Draft Opinion, the term "environmental baseline" is used as a synonym for environmental conditions as they might exist in the future without the project, which is pure speculation because there is no proposal for the Project to cease operation. This usage is incorrect given the regulatory definition of "environmental baseline," discussed below.

The term "environmental baseline" as used in the Draft Opinion conflicts with Section 7 regulations, the Endangered Species Consultation Handbook, (USFWS and National Marine Fisheries Service [NMFS] 1998), and case law. Section 7 regulations define "environmental baseline" as "The past and present *impacts* of all Federal, State, or private actions and other human activities in an action area, the anticipated *impacts* of all proposed Federal projects in an action area that have already undergone formal or early Section 7 consultation, and the *impact* of State or private actions that are contemporaneous with the consultation in process" (50 CFR §402.02; emphasis added).

The Endangered Species Consultation Handbook (USFWS and NMFS 1998) makes it clear that the "environmental baseline" is "an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area. *The environmental baseline is a 'snapshot' of a species' health at a specified point in time*" (Page 4-22, "Environmental Baseline," paragraph 1; emphasis added). Courts have repeatedly emphasized that the "environmental baseline" represents the "impact" of the suite of activities identified in the regulations [for example, see *Defenders of Wildlife* v *Babbitt* Civ No. 99-927 (D.C. D.C. 2001) and *Greenpeace* v *NMFS*, 80 F.Supp. 2d 1137, 1149 (W.D. Washington 2000)]; that the "environmental baseline" represents the species' "pre-action condition" [*National Wildlife Federation* v *NMFS*, 524 F.3d 917 (9th Cir. 2008) and *Wild Fish Conservancy* v *Salazar*, 628 F.3d 513, 531 (9th Cir. 2010)].

The regulatory definition of "environmental baseline" requires the Draft Opinion to evaluate the *beneficial* and *adverse impacts* of the Project on the current status of species. Treating the "environmental baseline" as representing river conditions that might exist if the Project had not been constructed effectively nullifies the beneficial impacts of the Project (specifically on Interior least terns and piping plovers).

General Comment 2:

> **The Draft Opinion's major conclusions do not reflect reasoned decision making based on the evidence the Draft Opinion presents.**

The Draft Opinion concludes that the Project is "not likely to jeopardize the continued existence" of pallid sturgeon, Interior least tern, and piping plover. The Draft Opinion supports these conclusions by presenting a series of arguments about the status of species, the "environmental baseline," and project effects. However, these arguments reach conclusions and make claims that do not follow logically from the reasoning and evidence the Draft Opinion presents to support them and many of these arguments are refuted by information the Draft Opinion itself presents and by evidence in the record of this relicensing proceeding.

Pallid Sturgeon
The arguments presented to support the “no jeopardy” conclusion for pallid sturgeon provide the best illustration of a conclusion that does not follow from the reasoning or evidence presented. The Draft Opinion claims that Project effects will result in fish kills that will result in the death of 3 pallid sturgeon, that another 4 pallid sturgeon will die during monitoring, and that 926 pallid sturgeon will be “harmed” (as discussed in Attachment B, Specific Comments on USFWS’ Draft Opinion, all of these claims either have no evidentiary support or are refuted by the Draft Opinion itself). Nevertheless, the Draft Opinion concludes that the Project is not likely to jeopardize the continued existence of pallid sturgeon because the population affected is relatively large (7,000 to 48,000 individuals) and the species is “stable” (Page 43).

However, the Draft Opinion presents evidence that suggests the pallid sturgeon is not “stable.” Page 25 (last paragraph) of the Draft Opinion establishes that natural recruitment within the pallid sturgeon population remains effectively nonexistent *in the wild*. Because, as the Draft Opinion explains, the term “jeopardize the continued existence of the species” refers to the species’ likelihood of survival and recovery *in the wild* (50 CFR 402.02), it seems critical to distinguish between “wild” pallid sturgeon and “stocked” pallid sturgeon. The Draft Opinion establishes that “wild” pallid sturgeon *are not* self-sustaining *in the wild*, and because they are not self-sustaining, the Pallid Sturgeon Augmentation Program exists to “stabilize” the species’ numbers. The Draft Opinion’s use of the word “stable” apparently refers only to the sturgeon’s numerical abundance, which has little relationship to the species’ likelihood of survival and recovery *in the wild*. A “wild” population that maintains its abundance through only “immigration” (in the form of hatchery releases) is better characterized as declining and not viable on its own (for example, see Thomas and Kunin 1999).

Similarly, based on the 1:19.5 ratio of wild to hatchery pallid sturgeon reported by Hamel (2013), the abundance of “wild” pallid sturgeon would range from about 360 to 2,462. This population size is not large enough to buffer the species from demographic processes that place species in danger of becoming extinct *in the wild* (the species’ risk of extinction in the wild explains the augmentation program). Nevertheless, the Draft Opinion does not discuss the demographic relationship between “wild” and hatchery releases, and how USFWS factored that relationship into its effects analyses and jeopardy analyses.

We don’t dispute the Draft Opinion’s “no jeopardy” conclusion, but note that the reasoning and evidence presented in the Draft Opinion does not support that conclusion. A “no jeopardy” conclusion would be supported by an effects’ analysis that considered the evidence available more fairly and thoughtfully. This analysis would not conclude that the Project was likely to result in fish kills (the 2012 fish kill was caused by regional drought conditions and was completely unrelated to the Project), would not conclude that Project effects on pallid sturgeon feeding and sheltering “harmed” the sturgeon (the Draft Opinion itself argues that these sturgeon would remain in “excellent condition”), and would not expect four pallid sturgeon to die as a result of monitoring (in part because monitoring is not necessary). Taken together, this evidence would support a “no jeopardy” conclusion and would result in a conclusion that the Project is not likely to “take” pallid sturgeon.

The Draft Opinion's conclusion about whether Project effects are likely to "take" pallid sturgeon exemplifies a conclusion that is refuted by information presented elsewhere in the Draft Opinion. The Draft Opinion states, "The Service has determined that the Staff Alternative would affect the feeding and sheltering of 926 pallid sturgeon in the Lower Platte River at some time during the 30 years of Project operations under the Staff Alternative; this effect would reduce the condition of affected individuals. *The fish affected* by the Staff Alternative in the Lower Platte River *are expected to maintain an excellent condition, higher than that described for individuals in the adjacent Missouri River*…." (Page 57, emphasis added). Given that the regulatory definition of "harm" means "an act which *actually kills or injures* wildlife" (50 CFR 17.3; emphasis added), a "reduction in condition" that leaves pallid sturgeon in "excellent condition" does not seem likely to also "kill or injure" them. Nevertheless, USFWS expects the Project to "take" pallid sturgeon through "harm" (Page 130, fourth paragraph).

Interior Least Tern & Piping Plover
The Draft Opinion's effects analyses for Interior least tern and piping plover suffers from a different problem; that is, lack of sound statistical analysis. The effects analyses for these species consist of comparisons between the Staff Alternative, Current Operations, and different "Environmental Baselines" (scenarios that attempt to be representative of different aspects of the environment "without the Project") for different river reaches (Loup River Bypassed Reach, Platte River Bypassed Reach, Lower Platte River, etc.). To set up these comparisons, the Draft Opinion uses current data from different river reaches and assumes that one set of data represents a "reference condition" while the other set represents the "effect." For each data set, USFWS calculates mathematical averages and assumes that any differences between pairs of mathematical averages, no matter how small, represent "effects" of the Project.

In practice, however, these analyses do not and could not reveal any effects of the Project. First, many differences in mathematical averages are merely mathematical artifacts and are not meaningful. Small sample sizes, random chance, sampling error, process error, and a host of other phenomena can create differences that are not meaningful; statistical analyses, including meta-analyses, are designed to separate differences that are spurious from differences that are significant (statistically or otherwise).

Although almost all of the data sets the Draft Opinion relies on would be considered small sample sizes (some are too small to allow any statistical analysis), the Draft Opinion does not employ any procedures that would allow USFWS to detect and filter out spurious differences. The Draft Opinion does not employ even basic descriptive statistics—standard deviations, variances, confidence intervals, etc.—to help distinguish between differences that are meaningful and those that are not. As a result, as detailed in Attachment B, Specific Comments on USFWS' Draft Opinion, most of the differences appear to be spurious upon further analysis.

More importantly, the Draft Opinion assumes that any difference between mathematical averages, no matter how small, represented an "effect" that was *caused* by the Project. Yet the Draft Opinion does not include analyses that would have distinguished between effects that are likely to be caused by the Project and those that are clearly unrelated to the Project. The Draft

Opinion makes no attempt to show that differences in the data sets are *correlated* with Project operations (as opposed to correlated with something else), and the Draft Opinion does not consider that the differences it discusses could be caused by random chance, normal variability in nest numbers, regional weather patterns, and similar phenomena that are unrelated to Project effects.

Had analyses been conducted, and even if differences were found, they would still only reveal mathematical differences in two data sets. They would not establish that the differences have any statistical or practical significance, and they would not distinguish between “effects” caused by the Project and “effects” that are unrelated to the Project. These analyses do not provide reasoned support for the Draft Opinion’s conclusions about the effects of the action or the amount or extent of “take” resulting from the Project, and reliance on that analysis is arbitrary and capricious.

General Comment 3:

> **Many of the Draft Opinion’s conclusions are assumptions, and furthermore, many assumptions are presented as facts without record support; the Draft Opinion does not consider alternative assumptions that would be equally valid, nor does the Draft Opinion provide reasoned analysis to support its assumptions.**

USFWS makes a number of assumptions to reach conclusions despite substantial uncertainty. However, rather than explaining why it makes an assumption, clearly identifying the assumption, and explaining why an assumption is a reasoned assumption (as opposed to alternative assumptions), USFWS presents its assumptions as outgrowths of formal analysis (“determinations”) or as facts.

This problem is most pervasive in the sections of the Draft Opinion that address pallid sturgeon. For example, the Draft Opinion states that USFWS “…*has determined* that the relative condition of individuals in the Lower Platte River will remain above 0.9…” (Page 54, paragraph 2; emphasis added); “…*has determined* that two pallid sturgeon would be harmed (i.e., fish kill mortality)…” by Project operations (Page 54, paragraph 3; emphasis added); “…*has determined* that take under Article 408 would not exceed the take permitted under the programmatic biological opinion…” (Page 55, last paragraph; emphasis added); “…*has determined* that the harm of seven (7) pallid sturgeon individuals (i.e., three from fish kills and four from monitoring) would not affect the status of the species throughout its range…” (Page 57, first sentence; emphasis added).

Each of these “determinations” represents a conclusion that should have been supported by a reasoned analysis of evidence in the record of this relicensing proceeding, but both the reasoning and citation to record evidence are missing from the Draft Opinion. For example, the Draft Opinion does not explain why or how USFWS determined that the Project would cause fish kills that “kill or injure” (“harm”) pallid sturgeon, or why or how USFWS concludes that any “take” would occur during monitoring required under Article 408, much less why or how it would not exceed the “take” exempted by the *Intra-Service Programmatic Section 7 Consultation on Region 6’s section 10(a)(1)(A) Permitting Program and Fish and Wildlife Service Initiated Recovery Actions*. In each of these cases, no reasoned analysis or cited evidence supports these “determinations”; they are either assumptions or reiterations of assumptions that were made earlier elsewhere in the Draft Opinion.

In other instances, assumptions are presented as facts or as outgrowths of formal analysis, again without reasoned analysis or supporting record evidence. For example, the Draft Opinion states that “the Service *has determined* that 926 individuals represent a reasonable estimate given actual captures of 137 individuals with only four recaptures. The small number of recaptures indicates more individuals are present than what is being captured by researchers” (Page 33; emphasis added). This sentence implies that USFWS analyzed mark-recapture data and those analyses confirmed Hamel’s (2013) rough abundance estimate (an estimate that was not based on an analysis of mark-recapture data). USFWS *assumes* that Hamel’s estimate is appropriate, but fails to explain why this assumption is necessary or appropriate, and why it is a reasoned assumption given the record evidence (as opposed to alternative assumptions).

Similarly, the Draft Opinion’s effects analyses for Interior least tern and piping plover make two critical assumptions: (1) that current data from different river reaches are representative of river conditions that might exist if the Project had never been constructed, and (2) that any difference between two mathematical averages (one representing a “without Project” condition, and the other representing the “with Project” condition) represents an “effect” of the Project. The Draft Opinion does not consider the possibility that these “effects” are mathematical artifacts and have no statistical or practical significance. As a result, the Draft Opinion does not employ even basic mathematical or statistical procedures that would have provided insight into whether mathematical differences were the result of statistical significance or whether they were the result of small sample sizes, random chance, sampling error, process error, and other phenomena that create mathematical differences that have no statistical or practical significance.

In addition, and as discussed in greater detail in General Comment 2, the Draft Opinion makes no attempt to show that differences in the data sets are correlated with Project operations (as opposed to correlated with something else). Further, the Draft Opinion does not consider that the differences it discusses could be caused by random chance, normal variability in nest numbers, regional weather patterns, and similar phenomena that are unrelated to Project effects. These analyses do not provide reasoned support for the Draft Opinion’s conclusions about the effects of the action or the amount or extent of “take” resulting from the Project.

General Comment 4:

The Draft Opinion fails to use the best scientific and commercial data available and fails to comply with other information standards that are applicable.

Section 7(a)(2) of the Endangered Species Act and Section 7 regulations require USFWS and action agencies to use the best scientific and commercial data available during consultations. This requirement has been expanded by the 1994 Interagency Cooperative Policy on Information Standards Under the Endangered Species Act (59 FR 34271; 1 July 1994) and the Endangered Species Consultation Handbook (USFWS and NMFS 1998; page xi). Among other things, these policies require USFWS to (a) “evaluate all scientific and other information used to ensure that it is reliable, credible, and represents the best scientific and commercial data available” and (b) “gather and impartially evaluate biological, ecological, and other information disputing official positions, decisions, and actions proposed or taken by the Services” (USFWS and NMFS 1998; page xi). The Draft Opinion does not comply with these standards.

For example, the Draft Opinion omits or neglects data and record evidence, particularly evidence that would support alternative conclusions to those assumed by USFWS. An example of record evidence that USFWS ignores is the temperature study in the Loup River Bypass Reach that the District conducted as part of the relicensing process, and for which the study report is included in the relicensing record on which the Draft Opinion is to be based. The data from this study show that there is a statistically significant relationship between water temperatures and ambient temperatures, that water temperatures upstream of the diversion are directly related to water temperatures downstream of the diversion, and that there is no statistical relationship between water temperature and flow rate —which establishes that the diversion does not increase temperatures downstream. The Draft Opinion effects analyses ignore these data and reach conclusions that would be refuted by these data. Additional discussion of these data is included in Attachment C, Omitted or Inapplicable Scientific Data.

The Draft Opinion similarly neglects data from general and specific studies of sedimentation patterns, alternative operations and sediment management, and flow depletion and flow diversion that the District conducted as part of the relicensing process—and which are in the record of this relicensing proceeding. Data from these studies refute conclusions the Draft Opinion reaches about sediment deficits in the Tailrace Return, sediment coarsening or degradation, undermining associated with the Tailrace Weir, influence of increased sediment transport on sandbar maintenance, and patterns of degradation/aggradation in the Loup River Bypassed Reach and the lower Platte River. Additional discussion of these data is included in Attachment C, Omitted or Inapplicable Scientific Data.

Another example of best available data that is ignored in the Draft Opinion is the recently published PRRIP Tern and Plover Habitat Synthesis Chapters prepared by the Executive Director’s Office for the Governance Committee of the Platte River Recovery Implementation Program, dated February 25, 2015. This peer reviewed document presents evidence that recent Central Platte River research and field testing of flow and sediment management strategies identical to those included in the Staff Alternative have resulted in significant scientific evidence that the strategies "cannot successfully manage flow and sediment to create and maintain suitable in-channel nesting habitat" (PRRIP 2015; Executive Summary, page 1) in the Loup and Lower Platte river reaches. Additional discussion of this recently published research is included in Attachment C, Omitted or Inapplicable Scientific Data.

A further example of omitted evidence is the recent paper by Guy et al. (2015), which directly links dam-induced changes in sediment transport in the Missouri River to reduced oxygen levels that affect the survival of embryonic pallid sturgeon. This paper implies that this causal link explains why pallid sturgeon are not recovering and is relevant to the opinion's analysis of the status of that species.

Throughout Attachment B, Specific Comments on USFWS' Draft Opinion, we highlight instances in which the Draft Opinion uses portions of larger data sets to reach conclusions rather than analyzes the entire data set. For example, the Draft Opinion analyzes data on Interior least tern nests from 2008 to 2014 although these data have been collected since at least 1987. Other analyses use only portions of larger data sets available for pallid sturgeon and piping plover. The framework of this analysis in the Draft Opinion does not use the best available data, as required, and constitutes arbitrary decision making.

General Comment 5:

> **The Draft Opinion uses a different assessment framework for each of the three species it considers, which creates the appearance of arbitrariness.**

The different endangered and threatened species might respond differently to the Project's effects on the Loup and Platte river systems, but the adverse and beneficial effects of Project operations on the river systems should be comparable for all of the species the Draft Opinion considers. That is, operating the Project would be not be expected to have different effects on the temperature regimes, flow regimes, hydrology, and geomorphology of the Loup and Platte rivers depending on the species being considered.

Nevertheless, the Draft Opinion portrays different project effects depending on which species it considers. For pallid sturgeon, Project effects are considered against a "no diversion" river condition (the so-called "environmental baseline"). For Interior least tern and piping plover, Project effects are sometimes represented by the Staff Alternative and sometimes represented by Current Operations (any differences between the two are unclear); both the Staff Alternative and Current Operations are compared against different river segments and river conditions; sometimes base conditions are labeled Current Operations, and sometimes they are referred to as something else. The different terms and points of reference used and differences in how the action area is sub-divided make it virtually impossible to compare Project effects across species. The result is an appearance of arbitrariness for the entire Draft Opinion.

General Comment 6:

The Draft Opinion's Incidental Take Statement (ITS) does not comply with Congressional intent, USFWS regulations and policies, and case law.

Estimates of the Amount of Extent of Take, Reasonable and Prudent Measures, and the proposed Terms and Conditions associated with the Incidental Take Statement (ITS) do not comply with Congressional intent, applicable regulations, policy, and case law. The ITS is not supported by the analysis in the Draft Opinion and reaches conclusions that conflict with evidence contained elsewhere in the Draft Opinion. As such, the ITS should be eliminated from the Final Opinion.

The extensive case law on ITSs has established clear requirements for these sections of biological opinions. The Draft Opinion ignores many of these requirements. Courts have repeatedly concluded that USFWS and NMFS should express the "amount or extent" of incidental take in terms of the number of individual animals "taken." If this is impractical, then USFWS and NMFS can express it in terms of the percentage of an affected population that would be "taken." If this is also impractical, then USFWS and NMFS can express it using an ecological surrogate or habitat marker.

If USFWS and NMFS use a surrogate, two standards apply: (1) USFWS and NMFS need to establish that the action they say is likely to incidentally take listed species is likely to cause the change in ecological surrogates rather than some other causal factor or agency (that is, they need to causally connect an effect to the action and disconnect it from other potential causal agents), and (2) USFWS and NMFS must somehow link the change in those surrogates to the "take" of the species (for example, see *Arizona Cattle Growers Association* v *USFWS*, 273 F.3d 1229 (9th Circuit 2001)). USFWS and NMFS codified some of these requirements in final regulations published on May 11, 2015 (80 CFR 26845).

The ITS does not comply with these requirements. For example, the ITS in the Draft Opinion requires the Commission to reinitiate formal consultation "when a) average <u>annual</u> stage and discharge differences at North Bend and Louisville is greater than described under Current Operations" and "b) average <u>seasonal</u> stage and discharge differences at North Bend and Louisville is greater than described under Current Operations" (Page 135, Term and Condition 1(d)). The ITS uses differences in average annual stage and discharge as a surrogate that implies that (in this case) Interior least tern would be "taken." However, the Draft Opinion does not establish that the change in average annual stage and discharge measured at North Bend and Louisville would have been caused by Project operations as opposed to some other causal agent (see General Comment 2 for additional discussion) nor does USFWS establish that changes in these parameters would result in "take" of the species. Term and Condition 1(d) for piping plover (Page 136) repeats this error and should also be deleted.

Section 7 regulations require action agencies to reinitiate formal consultation if "the amount or extent of incidental take *is exceeded*…." (50 CFR 402.16(a); emphasis added). In Pallid sturgeon RPM 3, Term and Condition 3(c), by requiring the Commission to reinitiate formal consultation when the amount or extent is *reached*, the first sentence of this Term and Condition conflicts with the regulatory requirement to reinitiate (see Page 137, Reinitiation Notice). This Term and Condition should be deleted, and the Draft Opinion should default to the Reinitiation Notice.

In addition, the last sentence of Term and Condition 3(c) requires all monitoring to *immediately cease* if more than four pallid sturgeon die (emphasis added). The U.S. Congress addressed this issue in the House Report to the 1982 Amendments; it wrote: "If the specified impact on the species is exceeded, the Committee expects that the Federal agency or permittee or licensee *will immediately reinitiate consultation* since the level of taking exceeds the impact specified in the initial section 7(b)(4) statement. In the interim period between the initiation and completion of the new consultation, *the Committee would not expect the Federal agency or permittee or licensee to cease all operations* unless it was clear that the impact of the additional taking would cause an irreversible and adverse impact on the species" (H.R. Report No. 567, 97th Congress, Second Session 27 (1982)).

In reference to this Congressional language, USFWS wrote "Exceeding the level of anticipated taking does not, by itself, require the stopping of an ongoing action during reinitiation of consultation. The Federal agency must make this ultimate decision, taking into consideration the prohibitions of sections 7(a)(2) and 7(d)" (51 FR 19954). USFWS does not have the authority to require the Commission to cease all monitoring activities associated with this action; therefore, this sentence should be deleted.

The ITS contains numerous other errors. For example, the ESA regulations require that reasonable and prudent measures be measures that are "necessary or appropriate to minimize the impact" of "take" (50 CFR 402.14(i)(1)(ii)). Nevertheless, the ITS of the Draft Opinion contains several RPMs that require the Commission to monitor "take" without minimizing their impact. For example, RPM 1 for Interior least tern is intended to ensure that Project hydrocycling operations affecting Interior least tern reproduction "will not result in take that exceeds 107 Interior least tern individuals over the 30 year license period." The Terms and Conditions that implement this RPM require the Commission to repeat the analyses from the District's hydrocycling study, with no information as to why this information would be relevant to minimizing take. Additionally, the Terms and Conditions require the Commission to develop and implement a plan that identifies and monitors the amount and frequency of inundation to Interior least tern, without explaining how the monitoring reduces the impact of the putative "take" of the species. RPM 1 for piping plover and its Terms and Conditions repeats this error. Further, those Terms and Conditions requires the Commission to commit to this 30-year research and monitoring program without regard for the cost (which would likely be substantially greater than $250,000/year), which the Endangered Species Consultation Handbook (USFWS and NMFS 1998; page 4-50) identifies as a factor that must be considered when ensuring that the Terms and Conditions of an ITS do not "alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes" (50 CFR 402.14(i)(2)).
Attachment B, Specific Comments on USFWS' Draft Opinion, contains additional specific comments related to errors in the Terms and Conditions of the ITS.

As documented above, the District believes that the Draft Opinion is fatally flawed and inconsistent with the requirements of the ESA, the ESA regulations, and the guidelines of USFWS. Furthermore, the District has shown that the flow modifications associated with Draft License Articles 404, 405 and 406 should not be included in the Staff Alternative because these flow modifications do not provide benefits to the species. Therefore, the Draft Opinion cannot be the basis for reasoned decision making by the Commission in this relicensing proceeding and should be revised.

If you have any questions regarding the District's comments or any information provided by the District, please contact me at (402) 564-3171 ext. 268.

Respectfully submitted,

Neal D. Suess
President/CEO
Loup Power District

cc: Eliza Hines, USFWS

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ATTACHMENT A

OPERATIONAL IMPEDIMENTS TO IMPLEMENTING FLOW MODIFICATIONS INCLUDED IN THE STAFF ALTERNATIVE

Attachment A
Operational Impediments to Implementing Flow Modifications
Included in the Staff Alternative

The following discussion was submitted by the District on June 23, 2014, as comments on FERC's Draft Environmental Assessment. Additional discussion related to operational impediments has been added in *blue italic text*.

The Draft EA recommendations should be modified to recognize the significant operational impediments to the proposed flow requirements.

The following are the District's comments regarding the operational impediments to implementing the Draft EA's flow recommendations.

The District reiterates that the Project does not have a dam that allows storage of inflow for use or distribution at a later time. Rather, all flow diverted into the Loup Power Canal is released from the Project within approximately one day's time. This operational condition makes it impossible for the District to comply with exact instantaneous flows of any sort.

Minimum Bypass Flows (Draft License Article 404)

Draft EA recommendation: The following measure regarding minimum flow in the Loup River bypass reach is recommended in the Draft EA:

> maintain a continuous minimum flow in the Loup River bypassed reach of 275 cfs or inflow, whichever is less, from April 1 through September 30, and of 100 cfs or inflow, whichever is less, from October 1 through March 31, as measured at the USGS stream gage located near Genoa, Nebraska (gage no. 06793000) to enhance downstream habitat of fish and the federally-listed interior least tern, piping plover, and whooping crane;

Loup Power District's response: Regulating a prescribed continuous minimum flow in the Loup River bypass reach, as measured at the existing USGS stream gage located near Genoa (gage no. 06793000), would be virtually impossible for the following reasons:

- Operation of the Project Headworks (that is, the intake gates, sluice gates, and Settling Basin) is an art, not a science, and providing precise instantaneous flows either into the Loup Power Canal or down the Loup River bypass reach cannot be achieved, rendering the proposed limitations to be technically infeasible. Passing additional flow beyond normal leakage at the Diversion Weir can be accomplished by raising one or more sluice gates, lowering one or more intake gates, or doing some combination of both but such operations do not allow for precision due to the lengthy feedback loop associated with gage readings. The additional flow can be released over the flashboards, under the sluice gates, over the sluice gates, or any combination of the three but such additional flows cannot be exactly calibrated due to the constant presence of sand bars at the Intake Structure and the variable amount of sand in the Settling Basin. Based on these factors, it would be technically impossible to maintain a set value of instantaneous flow either into the Loup Power Canal or down the Loup River bypass reach, and any flow requirements should include provision for a reasonable range of operation.

- There is no official stream gage within a reasonable distance upstream of the Diversion Weir that can be used to measure Loup River inflow to the Project. In the Draft EA, footnote 203, inflow is defined as "the instantaneous flow at the Genoa gage while the project is not diverting flow into the power canal."[1] The Genoa gage is approximately 6 miles downstream from the Diversion Weir and the time lag for water to travel between the Diversion Weir and the Genoa gage would result in an hours-long feedback loop, which would make refined management of minimum bypass flows very problematic and create opportunities for potential non-compliance issues.
- A variable and unregulated flow of water leaks over, through, and under the Diversion Weir at all times. Based on decades of experience and readings at the Genoa gage, Project operators estimate the leakage rate to be approximately 50 cfs during the summer low flow season, when the three steel sluice gates are fully closed and the wooden flashboards are fully in place along the crest of the concrete weir. Leakage flow is continually subject to variation resulting from debris accumulation or removal; deteriorated, damaged or missing flashboards; effectiveness of sluice gate settings on concrete sills; changes in pool elevation below the top of flashboards; current status of individual sluice gate seals (that is, new, worn, or badly deteriorated); and depth of sand and sediment accumulation immediately upstream of the Diversion Weir. Depending on the combined status of all listed variables, leakage can change from day to day without any change to gate settings.
- The USGS gage on the Loup River near Genoa does not have a hydraulic control structure to facilitate accurate and precise flow measurements *(instead this gage uses a radar transducer pointed at the current river channel).* The naturally braided river bottom at the gaging site is composed of continually shifting sand. This causes the principal thread of the stream (thalweg) to wander laterally back and forth between the channel banks. For these reasons, USGS personnel must frequently re-profile the river cross section and re-measure flow velocities along it. This information is continually evaluated to determine the need to recalibrate the stage-flow relationship that is used to calculate stream flow from a single stage reading per USGS protocol. *USGS does not re-profile the river with enough frequency to provide the level of accuracy needed to accurately monitor compliance. As an example, this gage was checked and/or adjusted twice between February 1, 2015, and May 18, 2015 (see Figure 1).*

[1] See the Draft EA, page 272.

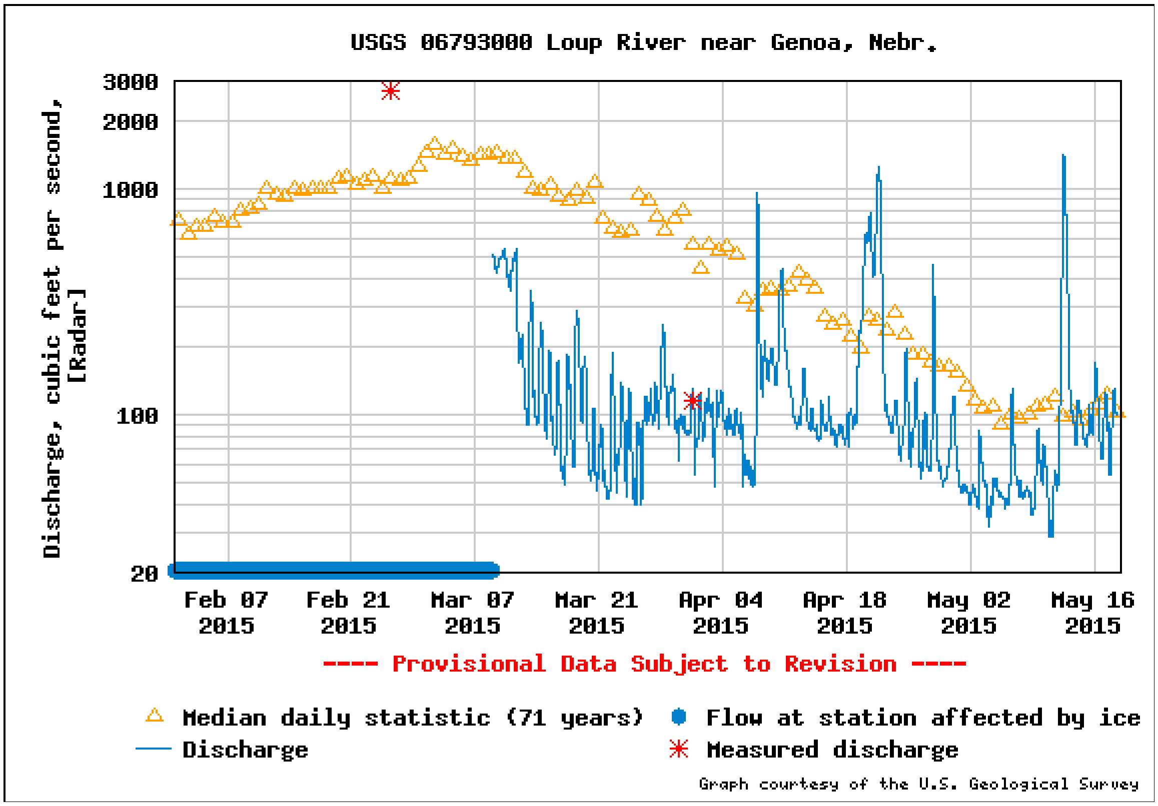

Figure 1. USGS Gage 06793000, Loup River Near Genoa, Nebr.

- The generally accepted flow measurement accuracy at USGS gages with fixed control structures (such as weirs, spillways, gates, and orifices) is +/- 5 percent at best. This compares with an accuracy range of +/- 10 to 15 percent for gages located at continually shifting natural river sections in sandy braided rivers. Furthermore, during low flow periods, gages on braided rivers often indicate low or no river flow when the thread of the stream has simply wandered away from the stage recorder. The measured values at this gage are typically *rated after each measurement as either* "fair" or "poor."[2]
- *All real-time data is provisional (see USGS provisional statement) and not made official until reviewed by and published through USGS. This can take up to 12 months. If the District's real-time operations are required to use this (provisional) data, the official/corrected data will likely indicate unavoidable periods of noncompliance or even overcompliance.*
- *All water flow gaging at USGS gages is accessed through the USGS website. There is no direct telemetering available from any of these instruments to the District's control systems. Failures due to internet or network issues; USGS collection, reporting, and hosting capabilities; and power failures would all adversely affect the District's ability to monitor compliance. The District uses and maintains gaging equipment at the Loup Power Canal Skimming Weir in addition to the USGS equipment (gage no. 06792500) for normal and critical operation decisions. Side-by-side comparisons help to provide the ability to differentiate between true and faulty or incorrect readings at the USGS gage.*

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2 See http://waterdata.usgs.gov/nwis/measurements/?site_no=06793000.

- Gage readings at USGS gages in the vicinity of the Project are often unavailable during the winter due to ice*. Typically real-time USGS readings are not available from late October through early March due to winter ice conditions (see Figure 1).*

Loup Power District's conclusion: Instantaneous compliance with a specified minimum bypassed flow rate would be virtually impossible to maintain, potentially creating non-resolvable compliance issues if strict limitations are imposed. Neither the Headworks infrastructure nor the USGS stream gage near Genoa is suited for the proposed degree of flow measurement and regulation. Attempting to comply with the specified minimum flow rates, on an instantaneous basis, would unfairly cause the District to bypass considerably more water than specified and put undue pressure on the District to report out-of-compliance readings. The District suggests that a technical conference be held to discuss the draft license articles to develop workable conditions that address compliance needs as well as operational limitations.

Lower Platte River Flows (Draft License Article 405)

Draft EA recommendation: The following measure regarding lower Platte River flows is recommended in the Draft EA:

> maintain a continuous minimum flow of 4,400 cfs or inflow, whichever is less, from May 1 through June 7 in the lower Platte River as measured at the USGS stream gage located at North Bend, Nebraska (gage no. 06796000) to provide longitudinal connectivity for pallid sturgeon;

Loup Power District's response: Instantaneous regulating of the Project to maintain a continuous minimum flow in the Platte River—as measured at the existing USGS stream gage located at North Bend (gage no. 06796000)—would be virtually impossible for several reasons, as follows:

- The USGS gage at North Bend is not located at a hydraulic control structure. Due to the variable nature of braided rivers, the flow measurements from the North Bend gage are not dependably accurate.
- The USGS gage at North Bend is located approximately 65 river miles downstream of the Diversion Weir and 34 miles downstream of the Columbus Powerhouse. The different lag times to North Bend for flows emanating from these two locations are approximately 24 to 36 hours long. In addition, variable inflow would come from the Platte River as well as from smaller tributaries. Requiring the District to regulate Project flows to instantaneously coordinate with all of these variables is unreasonable and excessively burdensome and technically infeasible. Additionally, the District should not be held responsible for natural dry or low flow watershed conditions that reduce native flows over 34 miles of watershed below the Columbus Powerhouse, or for similar naturally dry or abnormal flow conditions in the reach between the tailrace and the North Bend gage.
- *All real-time data is provisional (see USGS provisional statement) and not made official until reviewed by and published through USGS. This can take up to 12 months. If the District's real-time operations are required to use this (provisional) data, the official/corrected data will likely indicate unavoidable periods of noncompliance or even overcompliance.*

- In the Draft EA, footnote 204, inflow is defined as "the instantaneous flow at the North Bend gage while the project is operating in a non-peaking mode or is not diverting flow into the power canal."[3] The two operating conditions in this definition are neither mutually exclusive nor mutually inclusive because of the variable storage available in the Project regulating reservoirs. In addition, the definition does not address the time lags associated with changes in non-peaking power releases or flow diversion.
- *Generators at Columbus are typically operated based of turbine efficiency unless called upon for emergency conditions. Each turbine reaches 95 percent efficiency when operated at a wicket gate opening of 70 percent or about 14 MW output. At 14 MW, one generator is outputting an estimate of 1,700 cfs, two units 3,400 cfs, and three units 5,100 cfs. The turbine manufacturers advised that operations below 25 percent would lead to increased pitting and cavitation problems. Operations outside of the recommended efficiency range would also void equipment warranties. To achieve long life of the turbines and to reduce turbine maintenance and wear, the units are operated in the most efficient range of 11 to 14 MW. Wicket gate openings below 60 percent increase vibrations at the generator and penstock due to the less efficient water flow.*

<u>Loup Power District's conclusion:</u> Instantaneous compliance with a specified continuous minimum flow rate at North Bend would be impossible to achieve or maintain through Project operations. Neither the Project infrastructure nor the USGS stream gage(s) are suited for the proposed degrees of flow measurement and regulation. Attempting to comply with the specified minimum flow criteria would unreasonably require the District to constantly adjust Project flows and bypass water that could otherwise be productively used for power generation. The District suggests that a technical conference be held to discuss the draft license articles to develop workable conditions that address compliance needs as well as operational limitations.

Maximum Diversion into Loup Power Canal (Draft License Article 406)

<u>Draft EA recommendation:</u> The following measure regarding maximum diversion into the Loup Power Canal is recommended in the Draft EA:

> limit the maximum diversion of water into the power canal from March 1 through June 30 so as not to exceed an instantaneous rate of 2,000 cfs, as measured at the USGS stream gage located near Genoa, Nebraska (gage no. 06792500) to enhance downstream habitat of the federally-listed interior least tern, piping plover, and whooping crane;

<u>Loup Power District's response:</u> Instantaneously regulating Loup Power Canal inflow so as not to exceed a maximum value—as measured at the existing USGS stream gage located on the canal near Genoa (gage no. 06792500)—would be virtually impossible for several reasons, as follows:

- Operation of the Project Headworks is a complex and dynamic process involving many variables and limited feedback. Headworks operators must frequently adjust intake gate utilization and individual gate settings to manage both sand and water at the Intake Gate

[3] See the Draft EA, page 272.

Structure. In general, the operating procedures employed were established to maximize water flow into the Settling Basin while simultaneously discouraging admission of sand and debris. These procedures are complex and require skilled operators. The system is not suited for automated operation.

- *During the months of February through April, the Loup River is heavily loaded with ice and trash, which requires the District to divert as much water as possible to prevent damage to the river control structure. The ability to increase diversion limits damage from debris flowing over the control structure. The process also limits the amount of trash carried down river because it is removed at the intake gates. Limiting the flows in spring will prevent the District's ability to properly distribute sediment throughout the Settling Basin. Low diversion during the winter months typically increases sediment buildup in the upstream portion of the Settling Basin. The water from higher diversion flows in the spring increases channeling through the basin to fully distribute material and allow for maximum use/capacity of the basin. Blockage in the upstream section of the basin will inhibit the ability to divert water, especially during low flows. The reduced flows will lower the quantity of sand in the basin, resulting in a reduction in sand dredged into the North and South Sand Management Areas (SMAs). Blockage in the upstream portion of the basin will reduce the ability to engage sand for dredging to the North and South SMAs. The reduction of sand disposed at the North SMA will affect the recharging effect that produces habitat for the Interior least terns and piping plovers.*
- Accurately regulating inflow using gate rating tables or curves is not practical because of the continuous formation and reformation of sand bars both upstream and downstream of the Intake Gate Structure.
- The rate of flow from the Settling Basin to the canal is measured and recorded at USGS gage no. 06792500 on the Loup Power Canal near Genoa. This gage is located at the Skimming Weir, which functions as a stable hydraulic control structure and facilitates reasonably accurate flow measurement. However, the design flow velocity through the 2-mile-long Settling Basin is less than 1 foot per second. This translates to a 3 hour travel time from the Intake Gate Structure to the Skimming Weir. Therefore, Headworks operators must wait 3 hours to receive feedback on each and every adjustment they make. During that 3-hour period, debris may have obstructed a gate, dredging activity may have changed, other gate adjustments may have been necessary, or the natural project inflow may have changed.
- *All real-time data is provisional (see USGS provisional statement) and not made official until reviewed by and published through USGS. This can take up to 12 months. If the District's real-time operations are required to use this (provisional) data the official/corrected data will likely indicate unavoidable periods of noncompliance or even overcompliance.*
- *Daily upstream cycling trends seen on the Middle Loup gage 06785000 (see Figure 2) would require excessive and continual adjustments of the District's manually operated intake gates to consistently capture 2,000 cfs. This equipment is not made for this type of operational control. The intake and sluice gates would require redesign both mechanically and electrically to perform accurate regulation. Sophisticated process controls and accurate gauging telemetering inputs would be required to consistently account for the changes in river flow. Process/manual controls and telemetering of automatic intake gate controls would have to be connected to the Columbus Powerhouse*

along with local controls at the Headworks. The needed mechanical, electrical, and process upgrades would cost in excess of one million dollars to allow the precise operational control that would be needed to comply with the Commission-proposed flow modifications.

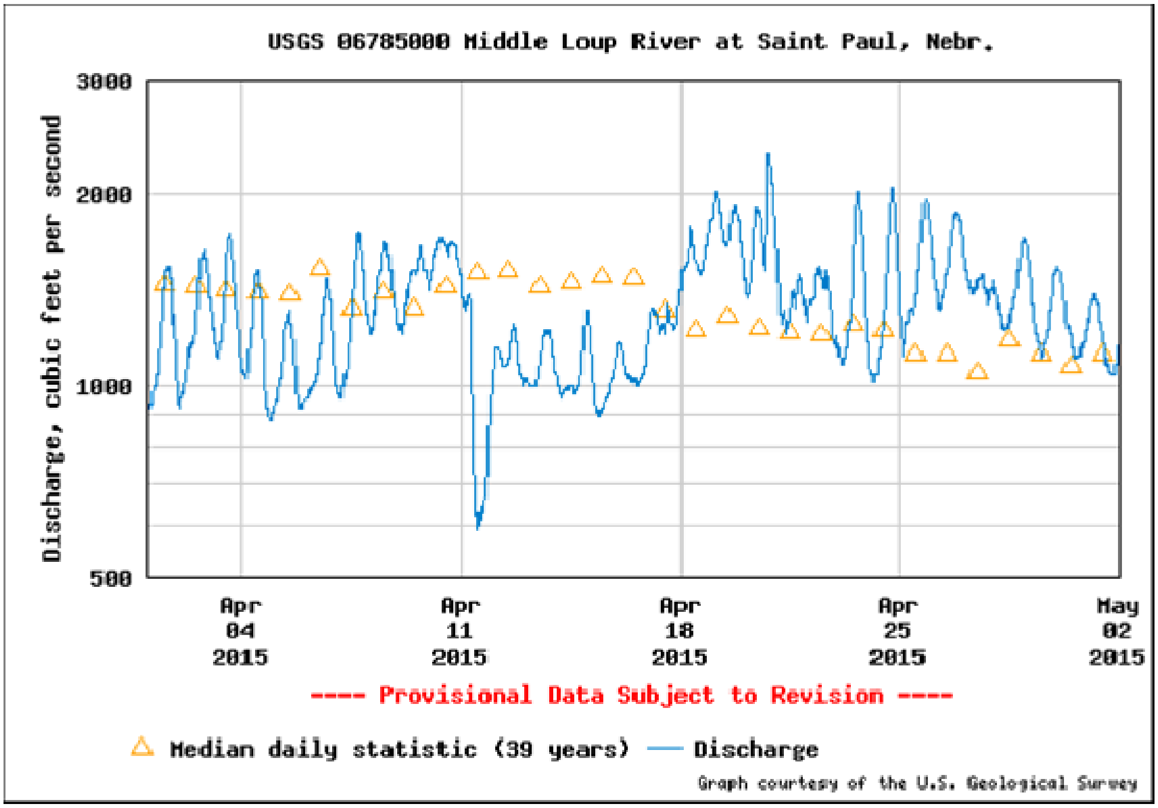

Figure 2. USGS Gage 06785000, Middle Loup River at Saint Paul, Nebr.

<u>Loup Power District's conclusion:</u> Even with reasonably accurate USGS gage flow data, instantaneous compliance with a specified maximum diversion rate would be virtually impossible to maintain. Neither the Headworks infrastructure nor its established operating procedures are well suited to compliance with an instantaneous maximum inflow limitation. Attempting to comply with the specified maximum diversion rate, using a significantly delayed feedback loop, would unfairly cause the District to divert less than the allowable instantaneous flow. Every eligible cubic foot per second not diverted would unnecessarily reduce energy production at both the Monroe and Columbus Powerhouses. The District suggests that a technical conference be held to discuss the draft license articles to develop workable conditions that address compliance needs as well as operational limitations.

ATTACHMENT B

SPECIFIC COMMENTS ON USFWS' DRAFT OPINION

Attachment B
Specific Comments on USFWS' Draft Opinion

Page 6, "Species Determinations," first paragraph: Date of the Commission's request for formal consultation is incorrect – the date should be October 20, 2014.

Page 8, second paragraph: The "action area" is not clearly identified in the text or figures, nor is the rationale for what the action area includes, nor why the action area extends from the Project tailrace to the Platte River's confluence with the Missouri River since Project effects cannot be meaningfully detected or measured that far downstream of the Project.

Page 13, fourth paragraph, second sentence: The Draft Opinion states, "Sand is mined at the North SMA by Preferred Sands, a commercial entity whose operations are wholly contained within the Commission's boundaries."

This statement is incorrect. Preferred Sands removes sand from the District's North Sand Management Area (SMA), which is wholly contained within the Commission's boundaries, and pumps it to their processing facility located outside of the Project boundary between the Nebraska Central Railroad and Nebraska Highway 22.

Pages 17-18, fifth and second paragraphs, respectively: As discussed in our *General Comments,* the Draft Opinion incorrectly claims that the District has committed to incorporating flow modifications (Draft License Articles 404, 405, and 406) as conservation measures in the Staff Alternative. The District has not committed to these measures and rather has provided opposing comments to the Commission on June 23, 2014, identifying the substantial record evidence that documents that the proposed flow modifications are not justified or appropriate for a new license for the Project, and the District has also identified operational impediments to implementing the Staff's flow recommendations (see Attachment A, Operational Impediments to Implementing Flow Modifications Included in the Staff Alternative).

Page 19, "Jeopardy Determination," numbered item 1: As discussed in our *General Comments*, the Draft Opinion incorrectly defines the "environmental baseline" as environmental conditions as they would exist without the Project or action; whereas, case law has established that environmental baselines are supposed to focus on capturing the "pre-action condition" of the endangered or threatened species (or designated critical habitat) that occur in the action area for a consultation.

Page 33, "Present Status of Pallid Sturgeon Population for the Platte River," third paragraph: This paragraph states: "Hamel (2013) estimated that approximately 926 pallid sturgeon are present in the Lower Platte River during the study. This estimate provides a coarse estimate for a dynamic Platte River population with individuals from the CLMU migrating into and out of the Platte River (Chojnacki et al. 2014; Peters and Parham 2008). However, the Service has determined that 926 individuals represent a reasonable estimate given actual captures of 137 individuals with only four recaptures (Hamel et al. 2014a). The small number of recaptures indicates more individuals are present than what is being captured by researchers."

It is important to note that Hamel (2013) “estimated” the number of pallid sturgeon by multiplying the estimated number of shovelnose sturgeon in the lower Platte River by the ratio of pallid sturgeon to shovelnose sturgeon in catches conducted from 2009 to 2012 (1 pallid sturgeon: 30 shovelnose sturgeon), rather than analysis of mark-recapture data. Hamel (2013) reported that “An estimated 30,870 ± 2,270 shovelnose sturgeon occurred in the lower Platte River throughout this study period” (citing unpublished data from J.J. Hammen; page 187, third bulleted point).

A 1:30 ratio between pallid sturgeon and shovelnose sturgeon should produce a pallid sturgeon estimate of 1,029 (953 to 1,105), so Hamel’s estimate must have included an additional variable (or used a 1:33 ratio). The Draft Opinion does not provide the reasoning that led USFWS to determine that this estimate represented the best scientific and commercial data available (as opposed to alternative estimates based on different ratios; for example, the ratios presented in Steffensen et al. (2014)).

Page 36, first paragraph: The second sentence of this paragraph states: “The Service has adopted a population size of 926 pallid sturgeon in the Lower Platte River that will serve as the baseline population for the 30 year evaluation period of this Opinion.” There is no explanation of why the USFWS concluded that 926 pallid sturgeon occur in the lower Platte River, why all of those sturgeon are likely to be exposed to Project effects, and why it does not expect that population to change in size (grow or decline or both) over the next 30 years.

Page 40, last paragraph: This paragraph notes two deceased pallid sturgeon from a fish kill on July 19, 2012 and identifies one deceased pallid sturgeon as occurring near the confluence of Salt Creek and the Platte River, but the location of the second deceased pallid sturgeon is not identified. Without locational information for this dead fish, it is not possible to determine what caused this sturgeon mortality. Without some causal linkage, it would be inappropriate to assume that this sturgeon died as a result of its exposure to Project effects.

Page 41, third paragraph: This paragraph states, “It is reasonable to assume that Lower Platte River exceedances of high stream temperatures are likely to increase over the life of the Project license…Lower Platte River streamflow, even under the No Diversion condition, will be subject to future declines as a result of water development not associated with the Project…Thus, it is reasonable to conclude that pallid sturgeon mortalities in the Lower Platte River would increase as a result of projected increased high temperature events and lower stream flow” (page 57, first bullet). This paragraph argues that USFWS expects pallid sturgeon mortalities in the future to occur even under the No Diversion condition and for reasons unrelated to Project effects; yet USFWS arbitrarily concludes that Project effects (temperature increases) will cause pallid sturgeon mortalities. This conclusion does not follow from the evidence presented.

Page 48, fourth paragraph, second sentence: This sentence incorrectly notes an increase in total streamflow; this should be a decrease.

Page 50, Stream Temperature Under the Staff Alternative: The second sentence of this paragraph states, “Given the 30-50 year evaluation time frame for this Opinion…” and *Page 53, second paragraph:* The third sentence of this paragraph states, “the Service finds it reasonable to suggest that Staff Alternative would affect all of the 926 pallid sturgeon in the Lower Platte River at some point in the 30-50 years of Project operations under the Staff Alternative." These statements identify time interval inconsistent with time intervals identified elsewhere in the Draft Opinion (for example, pages 30, 36, 43, 44, 54, 57).

Page 54, second paragraph: This paragraph determines that the relative condition (currently 0.99 to 0.95) of pallid sturgeon in the Lower Platte River will decrease due to more frequent departures (compared to the fictional environmental baseline) into the lower Missouri River (where relative condition ranges from 0.86 to 0.97); however, the current relative condition of pallid sturgeon of 0.99 to 0.95 in the Lower Platte River already accounts for departures into the lower Missouri River under hydrocycling conditions; therefore, there is no reason to expect the relative condition of lower Platte River pallid sturgeon to decrease.

Page 55, first full paragraph: This paragraph states, "However, the Project significant reduces streamflow in the *Platte River Bypass Reach* from July through February. The reduced streamflow in Platte River Bypassed Reach, under the Staff Alternative, *will* increase the likelihood lethal stream temperatures which *could* harm individuals. The Service has determined that Project diversions affecting individuals in the Platte River Bypassed Reach is small given the expected low species use in the reach and the infrequent occurrence of kill reported for the Platte River Bypassed Reach. Because of the low species use and infrequent fish kill observations in the Platte River Bypassed Reach, the Service expects *one* individual will be harmed (i.e., fish kill mortality) by Project operations within the 30 duration of the Project license" (emphasis added).

The Draft Opinion does not explain why USFWS concludes that Project effects will increase the likelihood of lethal stream temperatures and why it expects one pallid sturgeon to be "harmed" (killed); the conclusion does not appear to follow from the evidence presented. There have been no documented occurrences of pallid sturgeon in the Platte River Bypassed Reach; therefore, the logical conclusion should be that no pallid sturgeon would be harmed or killed in the Platte River Bypass Reach. The Draft Opinion's conclusion that one pallid sturgeon would be harmed does not follow logically from the reasoning and evidence presented and does not fairly consider and thoughtfully respond to evidence that would lead to alternative conclusions.

This "analysis" in the Draft Opinion appears to be arbitrary and does not explain why either "determination" logically follows from the evidence presented. The Draft Opinion notes the low incidence of pallid sturgeon mortalities in the Lower Platte River and concludes that two pallid sturgeon would be killed. The Lower Platte River Bypassed Reach is also noted to have a low incidence of pallid sturgeon mortalities, yet the conclusion is that one pallid sturgeon will be killed. USFWS came to two different conclusions using the same evidence, thus making arbitrary conclusions. If the fish kills that have occurred on the lower Platte River have no causal relationship to Project operations or their effects, the Draft Opinion cannot treat them as effects of the Project.

Page 55, Pallid Sturgeon Monitoring Plan Under Staff Alternative, last paragraph on that page: The last sentence of this paragraph states, "…the Service in this Opinion has determined that take under Article 408 would not exceed the take permitted under the programmatic biological opinion; specifically, mortality associated with monitoring activities under Article 408 is anticipated to be no more than four fish."

The Draft Opinion does not explain why it expects four pallid sturgeon to be killed during monitoring activities, and the Draft Opinion's conclusion does not follow logically from the reasoning and evidence presented and does not fairly consider and thoughtfully respond to evidence in the record of the relicensing proceeding that would lead to alternative conclusions. Without that explanation, there is no rational basis for USFWS' conclusion.

Pages 56 and 57, Pallid Sturgeon - Conclusion: The first sentence of this conclusion states that "After reviewing the current status of the pallid sturgeon, the environmental baseline for the action area, the effects of the Staff Alternative, and the cumulative effects, it is the Service's Opinion that the Staff Alternative is not likely to jeopardize the continued existence of pallid sturgeon."

The Draft Opinion reaches seven substantive conclusions about the Project's probable effects on pallid sturgeon: (1) every pallid sturgeon that occurs in the lower Platte River (reportedly, 926 individuals) would be exposed to these effects; (2) exposing all of these individuals to Project effects would affect their feeding and sheltering at some point over the next 30 years; (3) the magnitude of effects on feeding and sheltering would reduce the "condition" of all of these individuals; (4) the magnitude of this reduction in "condition" will "harm" these individuals; (5) three pallid sturgeon will die as a result of being exposed to Project effects; and (6) four pallid sturgeon will die during monitoring; but (7) the Project is not likely to jeopardize the continued existence of pallid sturgeon because the population affected is relatively large (7,000 to 48,000 individuals) and the species is "stable." These conclusions are not logically constructed from the evidence presented in the Draft Opinion as noted in previous comments.

Page 57, first bullet: The first sentence of this bullet states, "The Service has determined that the harm of seven (7) pallid sturgeon individuals (i.e., three from fish kills and four from monitoring)…."

Two statements that appear earlier in the Draft Opinion supposedly support this conclusion. Page 54 describes the number of pallid sturgeon that are reported to have died in a fish kill on the lower Platte River in 2012, then concludes that "[G]iven the low incidence of pallid sturgeon mortalities in the *Lower Platte River*, the Service has determined that *two* pallid sturgeon would be harmed (i.e., fish kill mortality) by Project operations within the 30-year operational period of the license" (emphasis added).

These statements raise several questions. First, the fish kill that occurred in the lower Platte River in 2012 was caused by high regional temperatures associated with extended drought conditions throughout the state of Nebraska; those temperatures were not caused by Project operations or the effects of those operations. Given that the fish kill was not caused by the Project, there is no reasonable justification to treat the fish kill as if it were an effect of the Project.

Page 57, third bullet: The first sentence of this bullet states, "The Service has determined that the Staff Alternative would affect the feeding and sheltering of 926 pallid sturgeon in the Lower Platte River at some time *during the 30 years of Project operations* under the Staff Alternative; this effect would reduce the condition of affected individuals" (emphasis added). There are two problems with this conclusion.

First, the Draft Opinion does not explain why USFWS concluded that 926 pallid sturgeon occur in the lower Platte River, why all of those sturgeon are likely to be exposed to Project effects, and why it does not expect that population size to change (grow or decline or both) over the next 30 years. Further, the Draft Opinion does not explain why Project effects are expected to affect *all* pallid sturgeon in the lower Platte River equally, regardless of their distance from the Project and regardless of the intensity of those effects.

Page 75, first paragraph: The fifth sentence of this paragraph states, "We considered data primarily since 2008 which provides the most recent and best available nesting data compared to historic surveys conducted since between 1987 and 2007 for varying years and river segments."

Several authors have suggested that 10 years of census data should be considered the minimum amount of data necessary to provide a qualitative sense of a population's status and trend, particularly when observation error is considered (Morris and Doak 2002, also citing Elderd et al. 2002, Meir and Fagan 2000). If data on Interior least tern nesting are available since 1987, the Draft Opinion should reach conclusions based on an analysis of the entire time series rather than just the last 7 years of it. USFWS provides no explanation for why the data prior to 2008 is not suitable for inclusion in the analysis.

Page 75, Table 4: The number of Interior least tern nests on the Loup River Bypassed Reach (32 nests) is incorrect. The correct number is 34 nests for the reasons noted below for Table 5. The number of Interior least tern nests on the lower Platte River (709 nests) is incorrect. The correct number is 697, which is derived from Draft Opinion Tables 6, 9, and 10. Table 9 includes incorrect numbers, as discussed below. Additionally, USFWS conducted surveys along the Loup River in 2013 and 2014 (as noted in the Table 4 footnote), yet these data were not included in the analysis in the Draft Opinion, even though the additional data would have increased the sample size by 50 percent, although the larger sample size is not likely to address the problems with sample size and small effects.

The mean number of nests per year and the 95% confidence interval around that mean would provide more insight into the Interior least tern's status in the action area than the total number of nests (particularly given the wide year-to-year variance in census counts shown in Figure 16). The totals presented in the table cannot support any conclusions about the stability or variability of nesting in these areas.

Page 76, last paragraph: The last sentence of this paragraph states, "The Loup River upstream of the diversion provides a reference for conditions that could be expected under the environmental baseline." As discussed in our *General Comments*, this is an inappropriate use of the term "environmental baseline." It would be more appropriate to just refer to the Loup River upstream of the diversion as a "reference condition."

Page 78, second full paragraph: This paragraph discusses and interprets the data presented in Table 5 (Page 79) but does not provide the 95% confidence intervals (or other confidence interval) associated with the mean values presented in this paragraph.

Using the corrected nest count data as noted below, with 95 percent confidence intervals, the results above the diversion would be: mean = 14.0; 95% CI = 5 to 24; below the diversion the mean = 8.5; 95% CI = 1 to 16. These confidence intervals overlap, which is not surprising given the short time series and small effect sizes. This overlap implies that the differences between these data would not be statistically significant (at $p = 0.05$); that the Project's effect are small, if the Project has an effect on Interior least tern nests; and, more importantly, that the sample size is insufficient to detect the effect the Draft Opinion attempts to assess.

The Draft Opinion presents data on Interior least tern nests from 2008 to 2014 and implies that survey data have been collected since at least 1987. Rather than attempting to detect an effect using a portion of the larger data set, it would be more appropriate to analyze the entire time series. If data on Interior least tern nesting are available since 1987, the Draft Opinion should reach conclusions based on an analysis of the entire time series rather than just the last 7 years of it. USFWS provides no explanation for why the data prior to 2008 is not suitable for inclusion in the analysis.

Page 79, Feeding/Fitness: The Draft Opinion should revise the second sentence to clarify the meaning of the term "maximum likelihood of effect."

Page 79, Table 5: For 2010, the number of nests on the Loup River below the diversion (reported as 7 in the Draft Opinion) should be 8 based on the USFWS 2010 report, Table 3. The number of nests downstream of the diversion (reported as 3 in the Draft Opinion) does not include a nest at Colony I, which is shown in the USFWS 2012 report on page 18. Inclusion of Colony I results in 4 nests downstream of the diversion based on the USFWS 2012 report, Tables 6 and 7. Additionally, USFWS conducted surveys along the Loup River in 2013 and 2014 (as noted in the Table 4 footnote), yet these data were not included in the analysis in the Draft Opinion, even though the additional data would have increased the sample size by 50 percent, although the larger sample size is not likely to address the problems with sample size and small effects.

Page 81, third paragraph: This paragraph presents USFWS' estimates of the maximum potential effect of the Project on Interior least tern nesting in the Platte River Bypassed Reach based on nest survey data from North Bend to Leshara (we assume it references data presented in Table 6, Page 85; Table 7, Page 86; and Table 8, page 87). We have several comments on these analyses.

First, nesting survey data have been collected since at least 1987. Rather than base an analysis on data collected in the last seven years, it would be more appropriate and informative to analyze the entire time series or explain why the entire time series is not representative of patterns that have occurred in the past seven years.

Second, the mean for the data presented in Tables 6 and 7 for North Bend to Leshara is 13 (95% CI = 0 to 26); dividing this mean by 23 miles (the distance from North Bend to Leshara) results in an average of 0.57 nests per mile (95% CI = 0 to 1.14). However, the Draft Opinion states that nests per mile average 0.56 to 0.63 (Page 81, third paragraph, first sentence). This suggests that these averages were not calculated from the data in Table 6 or the method was different. The Draft Opinion should explain how these averages were calculated, what data were used in the calculation, and why the data in the table support the conclusion that USFWS reached.

Third, multiplying the maximum number of nests per mile (0.63) by the length of the Platte River Bypassed Reach would not only produce a maximum estimate of the number of nests that might be expected in that river segment, it would overestimate that number because it assumes that nests should be uniformly distributed along the river reach and that the entire 2.1-mile length supports habitat (on Page 81, the Draft Opinion reports that a large, permanently forested island occurs along most of the first mile of the reach below the confluence and that USFWS expected improved habitat conditions to occur in the 1.25 miles downstream of this forested island, so dividing by 2.1 assumes that the entire reach provides suitable habitat). Treating the mean number of nests per mile as the rate variable in a Poisson distribution avoids this assumption; based on that analysis (and assuming a mean value of 0.63), the probability of no nests occurring along the Platte River Bypassed Reach in any given year would be 53.3%; the probability of one nest occurring along the reach would be 33.6%; and the probability of two nests occurring would be 10.6%. The probability of no nests occurring along the Platte River Bypassed Reach (assuming a mean value of 0.63) is 1.2 times greater than the probability of any nests.

Using the mean value calculated from the data in Tables 6 and 7 (0.57 nests per mile), the probability of no nests occurring along the Platte River Bypassed Reach in any given year would be 56.6%; the probability of one nest occurring along the reach would be 32.2%; and the probability of two nests occurring would be 9.2%. The probability of no nests occurring along the Bypassed Reach (assuming a mean value of 0.57) is 1.8 times greater than the probability of any nests.

For comparison, there is also a 56.6% probability of encountering no least tern nests along seven miles of the 23-mile length of the Lower Platte River from North Bend to Leshara. These data suggest that the differences in nest counts in the Platte River Bypassed Reach and North Bend to Leshara are adequately explained by chance and don’t reveal any particular effect of the Project.

More importantly, these analyses could only establish that there are differences in the number of nests in the two river reaches. Because these differences could have been caused by random chance, normal variability in nest numbers, regional weather patterns, and similar phenomena that are unrelated to Project effects, these analyses do not establish that these differences are caused by Project effects.

Page 86, second paragraph: This paragraph presents part of the analyses USFWS conducted to estimate the maximum average difference in nest counts resulting from the Staff Alternative and the “environmental baseline.” We have several comments on these analyses.

First, the Draft Opinion does not present confidence intervals for its mean estimates, which would provide more information. Using the data presented in Table 7, the estimate from the Tailrace to North Bend is mean: 0.38 nests per mile (95% CI = 0.14 to 0.61); from North Bend to Leshara the estimated mean is 0.62 nests per mile (95% CI = 0.00 to 1.25). Because the estimate from the former (Tailrace to North Bend) is entirely encompassed in the latter, there is no statistically significant difference in these data (at $p = 0.05$). If there is a difference between least tern nesting in these two river reaches, these data cannot reveal it.

More importantly, these analyses could only establish that there are differences in the number of nests in the two river reaches. Because these differences could have been caused by random chance, normal variability in nest numbers, regional weather patterns, and similar phenomena that are unrelated to Project effects, these analyses do not establish that these differences are caused by Project effects.

Page 87, Table 8 and associated text: This table and the associated text continues the analyses USFWS conducted to estimate the maximum average difference in nest counts resulting from the Staff Alternative and the "environmental baseline."

As we commented previously, the analyses would have been more informative if the Draft Opinion presented confidence intervals for its mean estimates. Using the data presented in Table 8 (and ignoring the many problems that result from taking averages of averages), the estimate from the Tailrace to North Bend is mean: 0.43 nests per mile (95% CI = 0.14 to 0.73); from North Bend to Leshara the estimated mean is 0.57 nests per mile (95% CI = 0.00 to 1.13). As with the data presented in Table 7, the estimate from the former (Tailrace to North Bend) is entirely encompassed in the latter so there is no statistically significant difference in these data (at $p = 0.05$). If there is a difference between least tern nesting in these two river reaches, these data cannot reveal it.

More importantly, these analyses could only establish that there are differences in the number of nests in the two river reaches. Because these differences could have been caused by random chance, normal variability in nest numbers, regional weather patterns, and similar phenomena that are unrelated to Project effects, these analyses do not establish that these differences are caused by Project effects.

Page 89, Table 9 and associated text (Pages 88 to 89 & 91): This table and the associated text contain the analyses used to estimate the number of least tern nests that might be lost to inundation in the Lower Platte River from the Project Tailrace to North Bend and from North Bend to the Missouri River. There are several problems with this analysis.

First, the total number of nests reported in Table 9 for 2008, 2009, and 2011 (reported in the Draft Opinion as 124, 228, and 96, respectively) are incorrect. According to the Brown and Jorgensen 2008 report, Table 2, 114 Interior least tern nests were found from Fremont to the confluence of the Missouri River (which is approximate RM 60 to RM 0). According to the Brown and Jorgensen 2009 report, Table 3, 225 Interior least tern nests were found from Fremont to the confluence of the Missouri River. Finally, according to the Brown, Jorgensen, and Dinan 2011 report, Table 5, 97 Interior least tern nests were found from Fremont to the confluence of the Missouri River. Therefore, the correct total of Interior least tern nests from Fremont to the confluence of the Missouri River is 580.

Second, the analyses ignore the fact that, in most years (57%), no nests are lost to inundation. Because of the variance in the inundation data, the analyses should consider the 95% confidence interval, which is (using corrected data) mean = 0.132 (95% CI = 0.093 to 0.240). We conducted a one-sample z-test to the data on the proportion of nests inundated (the equivalent of a one-sample t-test that applies to proportions) to determine if the average (0.132) proportion was significantly different from zero (at both p = 0.05 and p = 0.01), and it is not statistically different from zero. That statistical result means that these data can be explained by chance or random variation.

More importantly, these analyses only establish that there is a chance of least tern nests being inundated in the lower Platte River from the Tailrace to North Bend. Because nests can be inundated for reasons unrelated to Project effects, such as random chance, regional weather patterns, and similar phenomena, these analyses do not establish that these differences are caused by Project effects.

Page 90, second paragraph: USFWS discounts the inundation study performed by the District and instead uses inundation probabilities developed by NGPC. The District rebutted NGPC's objections to the District's study and also identified flaws in NGPC's concept of inundation probability, specifically with respect to Project operations, in a response to comments on the Second Initial Study Report, dated May 11, 2011.

Page 95, Summary of Effects: The first sentence of this section states, "When comparing effects of the Staff Alternative to the Environmental Baseline for all areas within the Project action area, we combined the estimated reduction in nesting at the Loup River Bypassed Reach, Platte River Bypassed Reach and Lower Platte River (tailrace to North Bend), and compared it with the estimated increase in nesting under the Staff Alternative at the North SMA."

As discussed in our *General Comments* and previously in our comments, this statement misrepresents the analyses contained in the Draft Opinion. The Draft Opinion did not actually compare these effects. Instead, the Draft Opinion used data from different reference areas that it treated as proxies for things like the Staff Alternative, "Environmental Baseline," Current Operations, etc. The "comparisons of effects" consisted of analyses of differences in mathematical averages between paired data sets for the stream reaches the Draft Opinion used as proxies. In some cases, these analyses detected differences between mathematical averages; in other cases, they did not. In most cases, the data sets were not actually different (the "effects" data set was encompassed within the confidence interval of the "reference" data set) or the differences were statistically insignificant. In the balance of cases, most differences would be too small to be detected by comparing mathematical averages.

Regardless, the analyses in the Draft Opinion detected differences between two data sets but they could not identify the cause of those differences. As we have noted repeatedly in our comments, many of the differences almost certainly resulted from the small data sets used in the analyses. Even when the data sets were large enough to represent an adequate sample, the Draft Opinion made no attempt to show that differences in the data sets were correlated with Project operations (as opposed to correlated with something else), which would have been a prerequisite for establishing that the differences were caused by the Project. Therefore, this analysis is not relevant.

The analytical approach the Draft Opinion uses — depending exclusively on mathematical averages without other descriptive statistics or confidence intervals — does not establish that the differences detected are not due to sampling error, process error, or chance. The Draft Opinion did not consider that the differences it discusses could have been caused by random chance, normal variability in nest numbers, regional weather patterns, and similar phenomena that are unrelated to Project effects.

Page 96, first full paragraph: The fifth and sixth sentences of this paragraph states, “Under the Staff Alternative, we estimate 1.19 nests/year would be lost to inundation. This estimate accounts for inundation above that expected to occur naturally under the Environmental Baseline.”

The information used to develop this estimate has been discounted in our previous comments. Regardless, the analyses in the Draft Opinion only (erroneously) establish that there is a chance of 1.08 least tern nests being inundated from North Bend to the confluence of the Missouri River per year. Regardless of the validity of the estimates, because nests can be inundated for reasons unrelated to Project effects, such as random chance, regional weather patterns, and similar phenomena, these analyses do not establish that these differences are caused by Project effects.

Page 110, Table 13: The numbers of piping plover nests on Lower Platte River sandbars in 2009 and 2011 (reported in the Draft Opinion as 46 and 10, respectively) are incorrect. According to the Brown and Jorgensen 2009 report, Table 3, and in the text on pages 29 and 38, 47 piping plover nests were observed on sandbars in the lower Platte River. According to the Brown, Jorgensen, and Dinan 2011 report, Table 5 and Figures 10 and 12, and in the text on page 23, 11 piping plover nests were observed on sandbars in the lower Platte River.

Page 112, Table 14: The number of piping plover nests on Lower Platte River sandbars in 2009 (reported in the Draft Opinion as 48) is incorrect. According to the Brown and Jorgensen 2009 report, Table 3, and in the text on pages 29 and 38, 47 piping plover nests were observed on sandbars in the lower Platte River. This changes the total to 70 and the mean to 17.5. Because the number of piping plover nests on Lower Platte River sandbars in 2009 was incorrect, the total nests and maximum number of nesting piping plover are also incorrect. The total nests should be 53, with a total of 90 and a mean of 22.5. The maximum number of nesting piping plover should be 106, with a total of 180 and a mean of 45.0.

Page 114, Table 15: This table calculates the mean number of piping plover nests reported from Loup River above and below the diversion weir. A four-year time series (small sample size) is too short to establish differences above and below the diversion with any degree of confidence, particularly when the size of the effect appears to be very small (the difference between 1 and 2, 0 and 3, 1 and 4, and 0 and 1). We can illustrate this problem by calculating confidence intervals for these data. With 95 percent confidence intervals, the data above the diversion would be: mean = 2.5, 95% CI = 1 to 4; below the diversion, the results would be: mean = 0.5, 95% CI = 0 to 1 (although these values should be rounded to whole numbers because it's impossible to have half a nest).

These confidence intervals overlap, which is not surprising given the short time series and small effect sizes. This overlap implies that the differences between these data would not be statistically significant (at p = 0.05) and, more importantly, that the sample size is insufficient to detect the effect the Draft Opinion attempts to assess. Rather than analyze this small amount of data, it would be more appropriate to approach the issue qualitatively or abandon the analysis entirely.

Additionally, it should be noted that USFWS conducted surveys along the Loup River in 2013 and 2014 (as noted in the Table 4 footnote), yet these data were not included in the analysis in the Draft Opinion, even though the additional data would have increased the sample size by 50 percent, although the larger sample size is not likely to address the problems with sample size and small effects.

Page 116, Platte River Bypassed Reach - Reproduction: Because of the small sample size and year-to-year variation in the number of reported nests, these analyses should also consider the standard deviation and confidence interval associated with the sample mean. With 95 percent confidence intervals, the results above the diversion would be: mean = 2.5, 95% CI = 1 to 4 (although these values should be rounded to whole numbers because it's meaningless to discuss half a nest). The confidence intervals for mean number of nests above and below the diversion overlap, so the differences between them would not be statistically significant (at p = 0.05).

The comparable 95% confidence interval for nests per mile (above the diversion) is 0.0363 to 0.1107. This confidence interval overlaps with the average number of nests estimated for the lower Platte River (0.048 nests per mile), so the differences between these reaches would not be statistically significant either.

The third paragraph of this subsection estimates that 0.16 piping plover nests that would be "lost" under current operations (0.074 nests per mile times 2.1 miles = 0.154; the 95% confidence interval for this estimate would be 0.076 to 0.233). As with the other estimates, this estimate is not significantly different from zero. At a rate of 0.074 nests per mile, the probability of encountering no nests in a 2.1-mile area is 92.87% (95% CI = 89.52 to 96.43%; calculated from a Poisson distribution). In most cases, these values would be rounded to zero.

Page 118, Table 16: This table calculates the frequency and density of piping plover nests in a river reach that represents a "reference condition" (North Bend to Leshara) and "effect condition" (Tailrace to North Bend). However, the sample sizes (n = 1 versus n = 2) are too small to facilitate meaningful analysis or support any inference. Dividing one number by a second number does not produce an "average" if the numerator is not a sum (a sum of at least two values). It would have been more appropriate to conclude that the data available are insufficient to support meaningful analysis than to conduct the "analyses" presented in this table.

The data in this table suggest one thing: from 2008 to 2012, piping plover rarely nested in either river reach (10 of 13 surveys reported no nests). However, the time series is too short to make any stronger statement. These data could be manipulated to suggest (as the Draft Opinion does) that nest density is 54 percent lower between the Tailrace Return and North Bend (as the Draft Opinion does), but they could also be manipulated to suggest (unlike the Draft Opinion) that piping plover nest twice as frequently between the Tailrace Return and North Bend. These data are insufficient to support the Draft Opinion's conclusion that Project effects make piping plover less likely to nest in Tailrace to North Bend reach. The appropriate conclusion is that there are insufficient data to support any conclusion even assuming the data represent the "best scientific and commercial data available."

Pages 120, Table 17: This table calculates the number of piping plover nests in the lower Platte River and inundated from Fremont to the confluence with the Missouri River as a prelude to estimating the number of piping plover nests that would be inundated in the lower Platte River. As with the earlier table (Table 16), the data in this table also suggest that piping plover nest so rarely from Tailrace to North Bend (n = 2) or North Bend to Fremont (n = 1) that the only appropriate conclusion is that there are insufficient data to support meaningful analysis.

Nevertheless, the Draft Opinion "analyzes" a sample represented by a single number and attempts to compare it with a sample represented by two numbers. Ignoring the data insufficiency problem for the moment, the analyses in the Draft Opinion divide a single value (the 2 nests reported from North Bend in 2009) and presents the result as an "average" (which, as discussed in the previous comment, it is not).

Third, the analyses fails to consider the standard deviation and confidence interval for the various sample means it presents. With 95 percent confidence intervals, the results from Tailrace to North Bend would be: mean = 0.67, 95% CI = 0 to 2; North Bend to Fremont would be: mean = 0.33, 95% CI = 0 to 1; Fremont to the Missouri River: mean = 11.3, 95% CI = 0 to 24; Total number of nests in Lower Platte: mean = 12.1, 95% CI = 0 to 24; Nests inundated: mean 4.29, 95% CI = 0 to 8. If the estimate of the average number of nests inundated per year considered the 95% confidence interval, the result would be: mean = 0.25, 95% CI = 0 to 0.60.

At best, the analyses contained in the Draft Opinion could illustrate the potential magnitude of Project effects, but they could not determine the effects themselves. However, even as an illustration, the confidence intervals for all of these estimates encompass zero (in some cases, because there is so much year-to-year variance), so there is no statistically significant difference between the mean estimates and zero (at $p = 0.05$). This further demonstrates that the data in this table are insufficient to support meaningful analysis or detect meaningful differences. The appropriate conclusion is that there are insufficient data to support any conclusion even assuming the data represent the "best scientific and commercial data available."

Finally, the cell labeled "Total due to hydrocycling 0.62" is incorrect. The number "0.62" represents the sum of all of the values presented in the bottom row; however, the column labeled "Total # Nest in Lower Platte" already sums the values in columns 2 through 4 of the table (0.017+0.009+0.29 = 0.31). By summing all values in the bottom row, the cell labeled "Total due to hydrocycling 0.62" double counts the values in columns 2 through 4.

Page 121, second full paragraph (beginning "We recognize…."): This is a fair acknowledgment of the limitations of the data presented in Table 17. However, if the "best scientific and commercial data available" consists of a sample represented by a single number and a second sample represented by two numbers, the data are insufficient to support meaningful analysis or detect meaningful differences. Rather than analyze this small amount of data, it would have been more appropriate to approach the issue qualitatively or abandon the analysis entirely.

Page 122, North Bend to Confluence of Missouri River - Reproduction: As discussed in our last two comments, the information presented by USFWS as the "best scientific and commercial data available" consists of a sample represented by a single number and a second sample represented by two numbers. These data are insufficient to support meaningful analysis or detect meaningful differences. Rather than analyze this small amount of data, it would be more appropriate to approach the issue qualitatively or abandon the analysis entirely.

Page 124, North Sand Management Area - Feeding/Fitness: The first sentence of the first paragraph states, "The North SMA is analogous to other off channel plover nesting sites such as sand and gravel mines and housing developments."

This is incorrect. The North SMA is only analogous to gravel mines and housing developments in that it provides habitat characteristics that plovers find suitable for nesting. Daily human activities differ substantially between the North SMA, and gravel mines and housing developments.

Page 124, Summary of Effects: The third sentence states, "Under the Staff Alternative, we anticipate that the Loup River Bypassed Reach will result in a maximum average decrease of approximately 2.0 nests/year, the Platte River Bypassed Reach to result in a maximum average decrease of approximately 0.16 nest/year, and the Lower Platte River (tailrace to North Bend) to result in a maximum average decrease of approximately 0.33 nests/year."

As discussed in preceding comments, the data that form the basis for the estimates in this sentence are insufficient to support meaningful analysis or any conclusion.

Page 125, first full paragraph: The first sentence of this paragraph states, "The reported reduction in the number of nests on the Loup and Platte Rivers within the Project action area is not indicative of an actual reduction in nests, chicks or young at the local or regional population level."

This sentence indicates that the analysis in the Draft Opinion is hypothetical and is not based on evidence of actual "take" of the species. It should be noted that since listing of the species, there have been zero incidences of "take" associated with Project operations; in fact, as documented in the Draft Opinion, the Project's North Sand Management Area has resulted in successful nesting year after year.

Page 125, second full paragraph (beginning with "We expect hydrocycling…."): The fifth and sixth sentences of this paragraph state "Under the Staff Alternative, we estimate 0.63 nests/year would be lost to inundation. This estimate accounts for inundation above that expected to occur naturally under the Environmental Baseline."

As we have discussed previously, it is impossible to conduct a meaningful comparison of a sample represented by a single number and a second sample represented by two numbers. At best, the analyses contained in the Draft Opinion illustrate the potential magnitude of Project effects, but they could not determine the effects themselves. However, even as an illustration, the confidence intervals for the inundation estimates all encompass zero (in some cases, because there is so much year-to-year variance), so there is no statistically significant difference between those estimates and zero (at $p = 0.05$). The data the Draft Opinion uses cannot detect the effect this sentence implies.

In addition, as discussed in our comments on Table 17 (above), the estimate of "0.63 nest/year" represents a double count of the estimated number of nests from the Tailrace to the Missouri River confluence. The "correct" number would be "0.31 nests/year."

Page 128, first bullet: As discussed in preceding comments, the data that form the basis for the estimates in this sentence are insufficient to support meaningful analysis or any conclusion.

In addition, as discussed in our comments on Table 17 (above), the estimate of "0.62 nest/year" represents a double count of the estimated number of nests from the Tailrace to the Missouri River confluence. The "correct" number would be "0.31 nests/year."

Page 128, second bullet: As discussed in preceding comments, the data on which the estimates in this bullet are based are insufficient to support meaningful analysis.

Page 130, Amount or Extent of Take (Pallid Sturgeon), first paragraph: The Draft Opinion states, "The Service has determined that Project hydrocycling under the Staff Alternative *will result in the harm of two* individuals in the Lower Platte River via fish kill mortality. *One pallid sturgeon* in the Platte River Bypassed Reach *will be harmed* as a result of death due to lethal water temperatures from reduced flows under the Staff Alternative" (emphasis added).

The Draft Opinion presents the death of these three pallid sturgeon as if they are certain to occur when they are not. The first "estimate" is based on assumptions (that future operations of the Project "will" cause fish kills, that pallid sturgeon "will" die in those fish kills, and that the number of pallid sturgeon that die "will" be the same as the number that died in the 2012 fish kill on the Platte River)—all without causal connection documentation and without record support per the District's comments above. Further, the basis for the second "estimate" was never explained and is not justified by the record evidence.

Page 130, Amount or Extent of Take (Pallid Sturgeon), second paragraph: the Draft Opinion states, "The Service has determined that the Staff Alternative would affect the feeding and sheltering of 926 pallid sturgeon in the Lower Platte River at some time during the 30 years of Project operations under the Staff Alternative; this effect would reduce the condition of affected individuals. *The fish affected* by the Staff Alternative in the Lower Platte River *are expected to maintain an excellent condition, higher than that described for individuals in the adjacent*

Missouri River. Therefore, the Service has concluded that the expected condition of individuals under the Staff Alternative, would not limit the self-sustaining status of the species (i.e., limit species recruitment)" (emphasis added). Nevertheless, the Draft Opinion expects the Project to "take" pallid sturgeon through "harm."

The regulatory definition of "harm" means "an act which *actually* kills or injures wildlife. Such act may include significant habitat modification or degradation *where it actually kills or injures wildlife* by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 CFR 17.3; emphasis added).

The Draft Opinion does not explain why it expects pallid sturgeon exposed to Project effects "…to maintain an excellent condition, higher than that described for individuals in the adjacent Missouri River" only to conclude that Project effects are expected to "actually kill or injure" those sturgeon by "significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." A reduction in "condition" that nevertheless leaves pallid sturgeon in "excellent condition" does not seem likely to also "actually kill or injure" them. The conclusion (the Project will "harm" pallid sturgeon) does not follow from the reasoning or evidence the Draft Opinion provides; in fact, it seems more appropriate to conclude that Project effects on sturgeon feeding and sheltering would not be expected to "take" pallid sturgeon.

Page 130, Amount or Extent of Take (Pallid Sturgeon), third paragraph: The Draft Opinion does not explain why it expects four pallid sturgeon to be killed during monitoring activities and the conclusion does not appear to follow from the evidence the Draft Opinion presents. The Draft Opinion does not identify what aspect of the proposed monitoring program is likely to kill pallid sturgeon or why USFWS expects those activities to kill up to four pallid sturgeon. Without a more reasoned explanation to support it, this expectation is arbitrary and its inclusion in the incidental take statement is neither warranted nor appropriate.

Page 131, Terms and Condition 1(a): The Draft Opinion does not establish a causal connection between Project operations and water temperatures at the Louisville gage. Furthermore, the District's Water Temperature study identified a statistically significant relationship between ambient temperature and water temperature and identified no relationship between flow and water temperature; thus water temperature at Louisville is irrelevant to the Draft Opinion analysis.

Page 131, Terms and Conditions 1(b) and 1(c): These conditions imply that water temperature is a surrogate for pallid sturgeon mortality. As noted in our *General Comments*, if the Services uses a surrogate, two standards apply: (1) the Services need to establish that the action they say is likely to incidentally take listed species is likely to cause the change in ecological surrogates rather than some other causal factor or agency (that is, they need to causally connect an effect to the action and disconnect it from other potential causal agents) and (2) the Services must somehow link the change in those surrogates to the "take" of the species (for example, see Arizona Cattle Growers Association v USFWS, 273 F.3d 1229 (9th Circuit 2001)). The Services codified some of these requirements in final regulations published on May 11, 2015 (80 CFR 26845). The analysis in the Draft Opinion does not does not meet these requirements with respect to Term and Condition 1(b) or 1(c).

Page 132, Terms and Condition 1(d): The Commission is not responsible for monitoring fish kills, this responsibility lies with the Nebraska Department of Environmental Quality (NDEQ). USFWS can, and does, get fish kill reports from NDEQ.

Page 132, Terms and Condition 1(e): Section 7 regulations require Action Agencies to reinitiate formal consultation if "the amount or extent of incidental take *is exceeded*…." (50 CFR 402.16(a); emphasis added). By requiring the Commission to reinitiate formal consultation when the amount or extent is *reached*, this Term and Condition conflicts with this regulatory requirement to reinitiate (see Page 137, Reinitiation Notice). This Term and Condition should be deleted and the opinion should default to the Reinitiation Notice.

Page 132, Terms and Conditions of RPM 2: Given that the Draft Opinion concludes that pallid sturgeon are expected to maintain an excellent condition, regardless of Project effects on feeding and sheltering (Page 57), Project effects on sturgeon feeding and sheltering are not likely to "actually kill or injure" pallid sturgeon; therefore, the Commission and District would not require an incidental exemption for these effects. As a result, RPM 2 and associated Terms and Conditions are unwarranted and inappropriate, and should be deleted.

Page 133, Terms and Conditions of RPM 3: Given that the Draft Opinion does not explain why USFWS concluded that monitoring activities under Article 408 are likely to kill any pallid sturgeon, this RPM and its associated Terms and Conditions are unwarranted and inappropriate, and should be deleted.

Page 133, Amount or Extent of Take (Interior Least Tern): As we have commented repeatedly, the Draft Opinion only establishes that current nesting data from different river reaches is different and *assumed* that difference between two mathematical averages (one representing a "without Project" condition, the other representing the "with Project" condition) represents an "effect" of the Project. However, the Draft Opinion does not present any evidence that suggests these "effects" had any statistical or practical significance, were caused by the Project, were not caused by small sample sizes, random chance, sampling error, process error and other phenomena, or were not caused by other phenomena that are unrelated to Project effects.

As discussed in our *General Comments*, the extensive case law on incidental take statements has established clear requirements for Incidental Take Statements. In particular, courts have required the Services to causally connect an effect to the action and disconnect it from other potential causal agents before treating that effect as "take" (for example, see *Arizona Cattle Growers Association* v *USFWS*, 273 F.3d 1229 (9th Circuit 2001)). The Services codified this requirement in final regulations they published on May 11, 2015 (80 CFR 26845).

The Commission and the District would not require an exemption for eggs and chicks that die for reasons that are unrelated to the Project. Nevertheless, the Draft Opinion establishes that there is a chance of least tern nests being inundated in the lower Platte River from North Bend to the Missouri River confluence. Although nests can be inundated for reasons unrelated to Project effects, such as random chance, regional weather patterns, and similar phenomena, the Draft Opinion does not establish that these differences are caused by Project effects; the Draft Opinion does not even consider the possibility of other causes. Without evidence or reasoning that establishes that Project effects are likely to cause the inundation that results in the loss of Interior least tern nests, an incidental take exemption for this alleged “take” is unwarranted and inappropriate.

Page 134, RPM 1: Given that the Draft Opinion does not explain why USFWS concluded that the Project is likely to cause the inundation that results in the loss of Interior least tern nests, this RPM and its associated Terms and Conditions are unwarranted and inappropriate, and should be deleted.

In addition, this RPM and its terms and conditions do not minimize the impact of potential nest loss on Interior least terns. Instead it requires the District to fund and conduct a 30-year monitoring study of river flows and stages that replicates studies the District conducted as part of the relicensing process. These studies could not establish that Project effects cause the inundation that supposedly results in the “take” of least tern nests; requiring the District to repeat those studies will not serve the RPM’s purposes and will not minimize the impacts of inundation on least terns. This RPM and its associated Terms and Conditions are unwarranted and inappropriate, and should be deleted.

Page 135, Amount or Extent of Take (Piping Plover): Our comments on this section of the ITS repeat our comments on the Interior least tern section of the ITS: the Draft Opinion does not establish that Project effects cause the “take” of piping plover. The Commission and the District would not require an exemption for piping plover that die for reasons that are unrelated to the Project. Without evidence or reasoning that establishes that Project effects are likely result in the “take” of piping plover, an incidental take exemption for this alleged “take” is unwarranted and inappropriate, and should be deleted.

Page 135, RPM 1: Given that the Draft Opinion does not explain why USFWS concluded that the Project is likely to cause the inundation that results in the “take” of piping plover, this RPM and its associated Terms and Conditions are unwarranted and inappropriate, and should be deleted.

In addition, this RPM and its terms and conditions do not minimize the impact of potential nest loss on Interior least terns. Instead it requires the District to fund and conduct a 30-year monitoring study of river flows and stages that replicates studies the District conducted as part of the relicensing process. These studies could not establish that Project effects cause the inundation that supposedly results in the alleged “take” of piping plover; requiring the District to repeat them will not serve the RPM’s purposes and will not minimize the impacts of inundation on least terns. This RPM and its associated Terms and Conditions are unwarranted and inappropriate, and should be deleted.

Page 137, Reinitiation Notice: The third sentence of the Reinitiation Notice states, “In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.” For the reasons discussed in our *General Comments*, USFWS does not have the authority to require the Commission to cease all monitoring activities associated with this action; therefore, this sentence should be deleted.

Appendix E, Extended Discussion on Project Hydrocycling: It is unclear how the information in Table 3 is calculated. USFWS needs to provide clarification on the derivation of this information so it can be confirmed.

Appendix E, Extended Discussion on Project Hydrocycling: In Table 5, the range values at North Bend and Louisville are reversed (that is, the listed North Bend values are actually the Louisville values from Table 3, and vice versa).

Appendix F, Literature Cited: The list of literature cited in the Draft Opinion, presented in Appendix F, is extensive, but no District studies are included. The District conducted studies on sedimentation, hydrocycling, water temperature, and flow depletion and flow diversion, among others, as part of the relicensing process. The District submitted the results of these studies in an Initial Study Report, a Second Initial Study Report, an Updated Study Report, and included a compilation of all studies in Volume 3 of its Final License Application, but USFWS did not cite any of these documents in its Draft Opinion.

In addition, there are many inaccuracies in the list of literature cited and in the in-text citations provided throughout the Draft Opinion. Several documents in the list of literature cited are not actually cited in the text of the Draft Opinion. In addition, several references are cited in the text of the Draft Opinion but are not included in the list of literature cited.

There is also an inconsistency in how text copied from other sources is cited. Some text in the Draft Opinion appears to have been copied from the USFWS Interior Least Tern 5-year Review, but the citations for that text are inconsistent. Sometimes the text is referenced as USFWS 2014 and sometimes the in-text citations from the Interior Least Tern 5-year Review have been copied along with the text.

Finally, source information should be provided for all tables in the Draft Opinion. Although the source of the table data is sometimes mentioned in the paragraph prior to the table, it would be clearer to provide a citation to the source underneath each table, similar to what was done for the figures in the Draft Opinion.

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ATTACHMENT C

OMITTED OR INAPPLICABLE SCIENTIFIC DATA

Attachment C
Omitted or Inapplicable Scientific Data

Section 7(a)(2) of the Endangered Species Act and Section 7 regulations require USFWS and action agencies to use the best scientific and commercial data available during consultations. This requirement has been expanded by the 1994 Interagency Cooperative Policy on Information Standards Under the Endangered Species Act (59 FR 34271; 1 July 1994) and the Endangered Species Consultation Handbook (USFWS and NMFS 1998; page xi). Among other things, these policies require USFWS to (a) “evaluate all scientific and other information used to ensure that it is reliable, credible, and represents the best scientific and commercial data available” and (b) “gather and impartially evaluate biological, ecological, and other information disputing official positions, decisions, and actions proposed or taken by the Services” (USFWS and NMFS 1998; page xi). The Draft Opinion does not comply with these standards. The following discussion highlights available data and information that the Draft Opinion does not incorporate and/or address as well as data used in the Draft Opinion that are inapplicable.

Interior Least Tern and Piping Plover Nest Surveys

USFWS conducted surveys along the Loup River in 2013 and 2014 (as noted in the Draft Opinion, Table 4 footnote, Page 75), yet these data were not included in the analysis in the Draft Opinion.

Interior Least Tern and Piping Plover On- and Off-Channel Nesting

USFWS fails to acknowledge that the majority of successful Interior least tern and piping plover nesting has occurred at off-channel locations. On December 18, 2014, Mr. Casey Lott provided comments to the Commission (the District submitted supplemental information to the Commission on January 12, 2015) on the draft Environmental Assessment that also pertains to the Draft Opinion. Mr. Lott is a nationally recognized expert on Interior least tern who has published numerous research studies and journal articles. Mr. Lott was the lead researcher on the 2005 Interior least tern range-wide survey (Lott 2006) and was also a peer reviewer on USFWS’ 5-year Review of the listing status of the Interior least tern, completed in 2013.

Mr. Lott’s letter from the American Bird Conservancy states the following with respect to on- and off-channel nesting:

> Locally, most production for either species occurs on off-channel sand management areas and sand pits adjacent to the Loup River channel, with adequate foraging resources (on the pits themselves, the Loup River in places, and the Platte River for terns) to support successful nesting. Regionally, the vast majority of all tern and plover nesting within the Platte river system occurs on sand pits, with the exception of the Lower Platte River below the confluence with the Loup where some individuals of both species periodically nest on riverine sandbars. (American Bird Conservancy Statement; page 1, paragraph 3)

Mr. Lott’s letter is consistent with the studies and literature reviews that were completed by the District for relicensing and have been submitted into the record in this relicensing proceeding. In addition, Mr. Lott's letter is consistent with findings of the Platte River Recovery Implementation Program (PRRIP) in its Tern and Plover Habitat Synthesis Chapters (Synthesis Report) (PRRIP 2015). The PRRIP performed in-channel and off-channel nest incidence monitoring between 2007 and 2013 (PRRIP 2015). As shown in the Synthesis Report, Chapter 2, Table 5, the amount of suitable sandbar area ranged from 0 to 55 acres between 2007 and 2013 for constructed sandbars, and 0 acres for natural sandbars. Chapter 2, Table 6 shows the total in-channel nest incidence between 2007 and 2013 for the Interior least tern and piping plover was 41 and 23, respectively. Of those, 14 Interior least tern nests and 9 piping plover nests were successful. Conversely, Chapter 2, Table 7 shows the total off-channel nest incidence between 2007 and 2013 for the Interior least tern and piping plover was 489 and 184, respectively. Of those, 282 Interior least tern nests and 127 piping plover nests were successful. The PRRIP notes

> During this period, nesting incidence and production declined on in-channel habitat as constructed nesting islands were eroded away by high flow events. With the exception of one sandbar that was disked to remove vegetation, was subsequently overtopped by flow and a piping plover nested on it, sandbars created by flow events in 2008, 2010 and 2011 were not used by the species and no sandbars created by the flow events met the Program's minimum suitability criteria. (PRRIP 2015)

District Dredging Quantities

In several places in the Draft Opinion, USFWS indicated that the District removes 1,793,500 tons per year of sediment. As noted in the District's Study 1.0, Sedimentation, Table 4-4, the average annual sediment dredged is 2,005,000 tons per year. The material dredged to the South SMA, 561,000 tons per year, is returned to the Loup River Bypass Reach. In addition, according to the Missouri River Basin Commission (1975), approximately 350,000 tons per year is returned to the lower Platte River from the Loup Power Canal. Approximately 911,000 tons per year of the 2,005,000 tons per year are returned to the either the Loup River Bypass Reach or the lower Platte River. Therefore, the maximum sediment removed by Project operations is 1,094,000 tons per year.

Water Temperature

USFWS' analysis determined that "take" of pallid sturgeon would result from water temperature related fish kills (Page 44). In its analysis, USFWS fails to consider the results of the District's Study 4.0, Water Temperature in the Project Bypass Reach (the results of which were filed with the Commission on February 11, 2011, and also restated in the District's June 23, 2014, letter to the Commission). This study determined that during normal operations, there is a greater volume of water upstream of the diversion than the Loup River Bypass Reach downstream of the diversion. As detailed in Study 4.0, the results of the site-specific study indicated a statistically significant 1:1 relationship between the temperature upstream and downstream of the diversion; there is a statistically significant relationship between ambient temperature and water temperature; and there is NOT a statistically significant relationship between water temperature and flow rate. Even though there is greater volume of flowing water upstream of the diversion, the measured temperatures were statistically the same upstream and downstream of the diversion.

USFWS' temperature analysis relies on research conducted by Sinokrot and Gulliver, which is not applicable to Project operations. Sinokrot and Gulliver simulated via a temperature model the addition of "potentially cool water" from Lake McConaughy to the Platte River, and how this addition would impact water temperature. The results indicated that supplementing Platte River flow with cooler water out of Lake McConaughy would reduce the number of days that 32° C would be exceeded. However, the conditions modeled by Sinokrot and Gulliver are very different from those that exist at the Project's diversion structure (as described below). Sinokrot and Gulliver's analysis is not relevant to water temperature conditions in the lower Platte River for the following reasons:

- The invert of the Lake McConaughy "outlet" (the penstock intake structure) is elevation 3130 feet (Personal correspondence with Central Nebraska Public Power and Irrigation District [CNPPID] staff, May 27, 2015). Assuming the reservoir is at 50 percent capacity, the pool elevation is 3230 feet (CNPPID 2015). At 50 percent reservoir capacity, the depth of water above the outlet is approximately 100 feet. The average release temperature between May and September (2009 to 2014) is approximately 15.4°C (60° F).
- The District does not have a large reservoir (rather they have a diversion structure with a maximum depth of water behind the diversion structure of 6 to 8 feet) to provide cold water releases to the Loup River Bypass Reach and eventually to the lower Platte River to provide the cooling effects modeled by Sinokrot and Gulliver.
- Additionally, the District's Study 4.0, Water Temperature in the Project Bypass Reach, showed that there is a statistically significant relationship between ambient temperature and water temperature. It stands to reason that this same relationship would hold for discharges downstream in the lower Platte River (that is, water temperature is directly related to ambient temperature).

Additionally, USFWS' analysis in its Draft Opinion on Page 57 argues that pallid sturgeon mortalities are expected to occur in the future even under the No Diversion condition and for reasons unrelated to Project effects. This paragraph states, "It is reasonable to assume that Lower Platte River exceedances of high stream temperatures are likely to increase over the life of the Project license…Lower Platte River streamflow, even under the No Diversion condition, will be subject to future declines as a result of water development not associated with the Project…Thus, it is reasonable to conclude that pallid sturgeon mortalities in the Lower Platte River would increase as a result of projected increased high temperature events and lower stream flow." Yet USFWS concludes that Project effects (temperature increases) will cause pallid sturgeon mortalities. This conclusion does not follow from the evidence presented.

Sediment Deficit

USFWS makes several references in its Draft Opinion (Pages 35, 38, 43, 48, 82-84, 117, 176-177, 181, 196) to a sediment deficit at the Tailrace Return relative to analysis for pallid sturgeon, Interior least tern, and piping plover, which is contrary to the record evidence. The District has refuted this claim by USFWS and the Commission on numerous occasions, including its June 23, 2014, comments on the Draft Environmental Assessment, information that USFWS has ignored in the Draft Opinion:

1. Physical data at the Tailrace Return do not indicate the presence of a sediment deficit at the Tailrace Return.
    a. As documented in Attachment B of a December 6, 2012, letter from the District to the Commission, cross sections at the ungaged sites upstream and downstream of the Tailrace Return showed aggradation between measurements (the District's Study 2.0, Hydrocycling).
    b. U.S. Geological Survey (USGS) bed, bank, and sandbar sediment samples in 2010 just downstream of the Tailrace Return are finer than the samples near Duncan and are consistent with the gradations near North Bend, Ashland, and Louisville, suggesting that there is no coarsening or degradation occurring (see Attachment B of District letter dated November 23, 2011, in response to comments on the Updated Study Report).
    c. The Tailrace Weir has not experienced any undermining since Project inception, nor has the District ever implemented any erosion countermeasures (i.e., riprap). Site photos included in Attachment B of a December 6, 2012, letter from the District to the Commission show no sign of scour or sediment deficit.
    d. Aerial photos from 2003 through 2010 (Figures 1 through 7) provided in Attachment B of a November 23, 2011, letter to the Commission show there has been no change over time to in-channel features just downstream of the Tailrace Return. In addition, the same braided pattern of the sandbars persists year after year, in addition to the bedforms. If a deficit existed and coarsening was occurring, this braiding and permanent features would not exist.
2. In addition, the site-specific studies performed for the FLA and the supporting literature clearly show that the lower Platte River is in dynamic equilibrium (neither aggrading nor degrading) and is not supply limited. The following references from the District's Study 1.0, Sedimentation, support the District's conclusion that there is not a sediment deficit in the vicinity of the Tailrace Return.
    a. <u>Sediment Budget</u>: Section 5.2.3, Figure 5-9, shows that the reach, including ungaged Sites 3 and 4 (upstream and downstream of the Tailrace Return) has sediment supplies far in excess of the sediment transport capacity.
    b. <u>Sediment Transport Indicators</u>: The reach and site-specific sediment transport indicators, and the associated channel characteristics of width, depth, and flow area, are consistent with natural river processes. As shown in Section 5.2.3, Figures 5-13 through 5-15, ungaged Sites 3 and 4 (upstream and downstream of the Tailrace Return) have consistent relationships relative to equilibrium width and depth as with the gaged sites upstream and downstream.
    c. <u>Regime Analysis</u>: Section 5.2.3, Figures 5-19 and 5-20, show Ungaged Sites 3 and 4 (denoted as Loup Upstream of Tailrace and Downstream of Tailrace, respectively) are well seated within the braided morphology, with no indication of transitioning to another morphology.
    d. <u>Specific Gage Analysis</u>: Section 5.3.1, the specific gage analysis in Figures 5-23 through 5-28, and the supporting Kendall Tau Analysis in Tables 5-12 through 5-14, show that the lower Platte River is neither aggrading nor degrading.

e. Studies by Others: Section 5.3.2 details studies by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation (USBR), and USGS that conclude that the lower Platte River is in dynamic equilibrium (that is, not aggrading or degrading).

Additionally, in the Draft Opinion, USFWS incorrectly references the sediment deficit at CNPPID's Johnson 2 (J-2) return as a reference related to the supposed sediment deficit at the Project's Tailrace Return. USFWS states, "We believe this may provide a useful reference because similar condition occur at both locations (J-2 return and Project tailrace return)" (Page 82).

The sediment deficit resulting in channel incision and degradational effects at the J-2 Return are well documented in the PRRIP Final Environmental Impact Statement (USBR and USFWS 2006). According to the FEIS, over a 13- to 18-year period from 1989 to 2002, the depth of degradation was about 6 feet near the J-2 Return. The channel downstream of the return has exhibited degradation (see Figure 1) as indicated by mean bed elevation measurements at Overton (The Flatwater Group et al. 2014). These effects are visible by the erosion at the end of the J-2 Return and extensive revetment placement (see Photos 1a and b below) and channel coarsening along the south channel (see Photo 2 below).

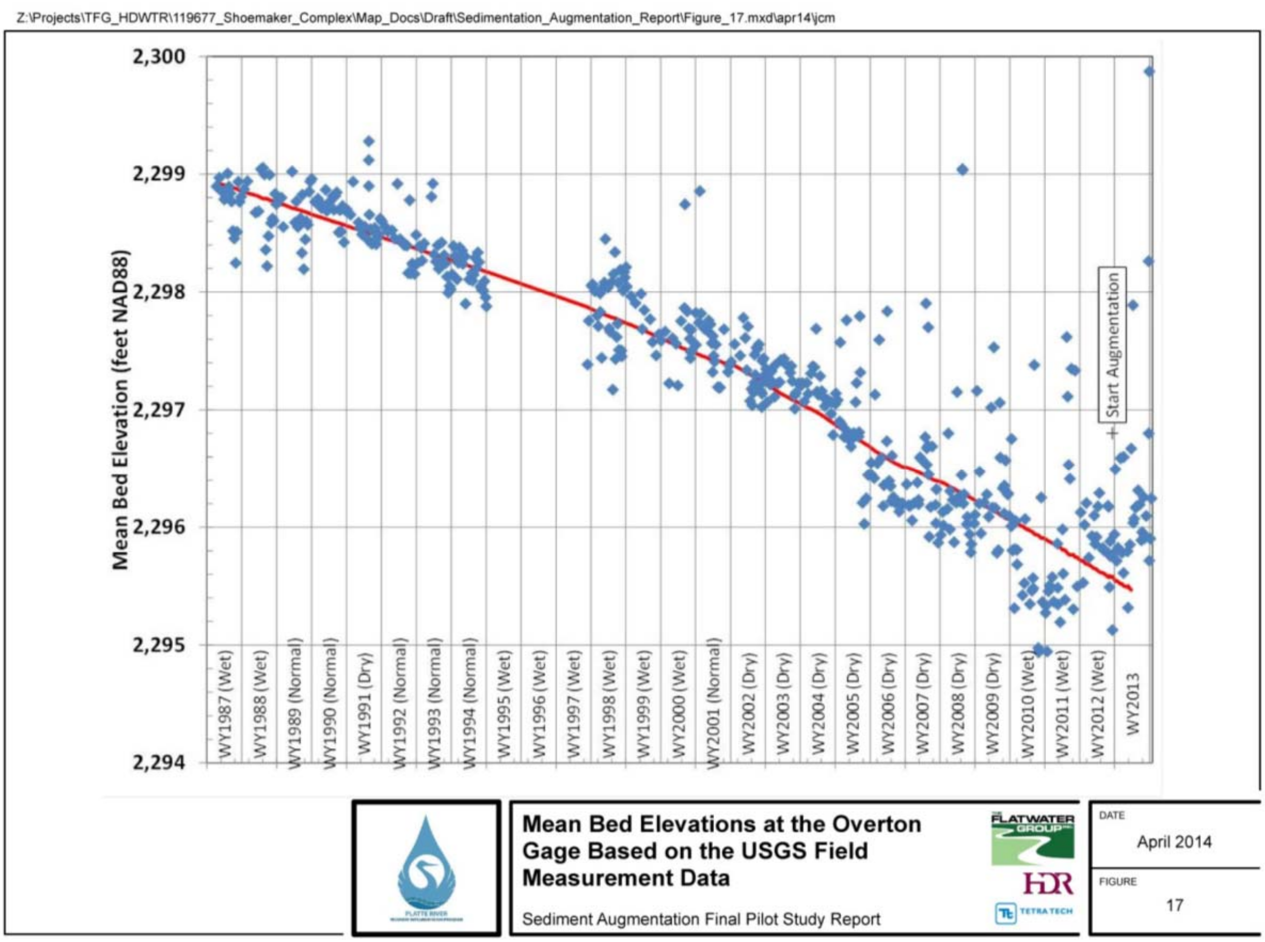

Figure 1. Mean Bed Elevations at the Overton Gage. Source: The Flatwater Group et al. 2014.

Photo 1a. J-2 Return looking downstream.

Photo 1b. Riprap placement at the end of the J-2 Return apron.

Photo 2. Central Platte River channel downstream of the J-2 Return.

To the contrary, the District's Tailrace Return has not experienced either local-scour erosion or channel incision and degradational effects as noted in items 1 and 2, above. Additionally, photographic evidence submitted in Attachment B of the District's December 6, 2012, letter to the Commission and repeated below (see Photos 3 and 4) shows that the Tailrace Weir has not experienced any undermining since Project inception, nor has the District ever implemented any local-scour erosion countermeasures (that is, riprap). Based on the evidence presented, the J-2 Return along the central Platte River is significantly different from the District's Tailrace Return in terms of sediment deficit and degradation in that there is a degradation problem at J-2 but the Tailrace Return shows no sign of sediment deficit or degradation. Thus, there is no comparable or scientific basis for USFWS to "believe this [the J-2 return] may provide a useful reference" for the Tailrace effects.

Photo 3. Aerial Photo of Tailrace Weir, July 2012.

Photo 4. Ground-Level Photo of Tailrace Weir, September 2012.

Failure to Acknowledge Site-Specific Studies and Conditions

On numerous occasions, USFWS references literature articles to describe Project effects and ignores the results of site-specific studies performed by the District in support of relicensing, studies on which USFWS provided input during development and implementation (see examples below) and for which study reports are in the record for this relicensing proceeding, upon which the Draft Opinion should be based. Additionally, several of the USFWS references are related to dams; there is no dam associated with the Project, and the effects of an 8-foot-high diversion structure that does not provide storage cannot reasonably be compared to dams where large volumes of water and sediment are stored indefinitely in reservoirs with depths several orders of magnitude higher than the Project's diversion structure.

- *Page 27:* The Draft Opinion describes hydrocycling effects on the lower Platte River, noting that "oscillations cause drastic changes in river stage level," and references Hamel 2013 but does not cite any of the results of the District's Study 2.0, Hydrocycling, that was performed specifically to identify the effects of hydrocycling.
- *Page 82, first paragraph:* The Draft Opinion indicates that the channel from North Bend to Leshara is better habitat than from the Tailrace to North Bend. The record clearly shows that the hydraulic characteristics between the two reaches are similar. The spatial analysis conducted in the District's Study 1.0, Sedimentation (Section 5.2.3), indicates that equilibrium flow widths, flow depths, and flow areas vs. effective and dominant discharge are very similar between Study Site 4 (just downstream of the Tailrace Return), North Bend, and Leshara (see Study 1.0, Figure 5-13 through 5-15).
- *Page 177 and Page 183, third paragraph*: The Draft Opinion indicates that an increase in sediment will be accommodated by an increase in width. The District's Study 14.0, Alternative Project Operations and Sediment Management, clearly states on page 44 that the increase in sediment causes an increase in slope: "For each increase in augmentation at Site 4, the modeling showed a slight aggradational trend and an increase in channel slope. The increase in slope is necessary to convey the increased sediment load." On pages 45 of Study 14.0, the discussion states that since the dominant discharge is relatively unaffected, the equilibrium channel geometries would also be unchanged from current operations. "Because the dominant discharges for all of the augmentation scenarios at Site 4 are essentially the same as the current-operations values, no adverse or beneficial changes in channel geometry would likely occur."
- *Appendix D, Page 181:* The Draft Opinion mentions Horn et al., suggesting effects of flow and sediment transport. the District's Study 1.0, Sedimentation, provides site-specific information on the Project's effects on flow and sediment transport.
- *Appendix D, Page 181, last sentence:* USFWS states that additional studies (such as Schmidt and Wilcock) were evaluated to determine the longitudinal extent of Project effects on lower Platte River channels, but the findings of the site-specific spatial analysis performed in the District's Study 1.0, Sedimentation, Section 5.2.3, were ignored.
- *Appendix D, Page 192:* USFWS indicates that the No Diversion condition would result in an increase in sediment transport. Site-specific results from the District's Study 1.0, Sedimentation, show little change under the run of river hydraulic properties.

Platte River Recovery Implementation Program Tern and Plover Habitat Synthesis Chapters

The 2006 Final Platte River Recovery Implementation Program Adaptive Management Plan. describes the PRRIP as follows:

> On the central Platte River, a cooperative effort between the states of Colorado, Nebraska, and Wyoming, the U.S. Department of Interior, water users from the states, and environmental groups resulted in the development of the Platte River Recovery Implementation Program (PRRIP). The PRRIP was developed to offset historic and ongoing affects [*sic*] to endangered species (including Interior least tern) on the central Platte River (USFWS 2006b, as cited in PRRIP 2006).

It further states, "Actions undertaken by the PRRIP to benefit the Interior least tern include increasing stream flows in the central Platte River during relevant times as well as enhancing, restoring and protecting habitat for Interior least tern" (PRRIP 2006).

PRRIP has invested the last 6 years in implementing an adaptive management plan to reduce the uncertainties associated with proposed management activities to increase production of the Interior least tern and piping plover along the central Platte River. One management strategy that was under evaluation was known as the flow-sediment-mechanical (FSM) strategy.

On March 17, 2015, the Executive Director's Office for the Governance Committee of PRRIP released a synthesis of research conducted by PRRIP related to Interior least tern and piping plover habitat (referred to as PRRIP Tern and Plover Habitat Synthesis Chapters, or Synthesis Report). Based on 6 years of evaluation, Synthesis Report states, "In short the Executive Director's Office of the Program concludes that implementation of the FMS strategy will not produce or maintain suitable in-channel nesting habitat for these species" (PRRIP 2015; Executive Summary, page 1). This peer-reviewed document presents evidence that is highly relevant to conclusions in the Draft Opinion as well as to the Commission's Draft License Articles 404 and 406 related to flow modifications for Interior least tern and piping plover habitat, on which the Draft Opinion relies. The analysis in the Synthesis Report disproves the fundamental framework of the Draft Opinion (and Draft License Articles 404 and 406) on habitat creation and maintenance for these species. In the Draft Opinion, Appendix D, USFWS states that "In absence of a direct evaluation of the Staff Alternative, the Service applied the best scientific and commercial data available define [*sic*] the effects of the Staff Alternative." The failure of USFWS to incorporate the results presented in the Synthesis Report into the Draft Opinion is an egregious error given the direct relevance of the research to the Project and USFWS' ongoing involvement on the PRRIP Technical Advisory Committee, which reviewed drafts of the synthesis research. The District provides the following summary of the synthesis findings and has included the complete document as Attachment D.

The District's position on Draft License Articles 404 and 406 is that recent central Platte River research and field testing, documented in the Synthesis Report, of flow and sediment management strategies identical to those proposed in the Commission's Draft License Articles for the Project have resulted in significant scientific evidence that the strategies "cannot successfully manage flow and sediment to create and maintain suitable in-channel nesting habitat" (PRRIP 2015; Executive Summary, p. 1) in the Loup and lower Platte river reaches. The basis of the District's objection is, among other concerns, (1) recent scientific publications reveal that the hypotheses underlying the assumed physical processes of the Draft License Articles as related to sandbar development have been exposed as erroneous, and (2) peer-reviewed publications have recently shown that the hydrology of the subject reaches has been exposed to be "not ideally suited to tern and plover reproductive ecology" (PRRIP 2015; Chapter 5, page 30).

The Draft Opinion is flawed because it fails to include analysis of the implications of the findings in the Governance-Committee-approved Synthesis Report regarding its numerous references to the failure of FSM strategies, which included analysis of short-duration high flow (SDHF) strategies and their unlikely success in "other regional reaches" (specifically including the lower Platte River).

Because the Draft Opinion does not mention the Synthesis Report, the District is providing a detailed explanation of our concerns that the significance and relevance of the findings described in the Synthesis Report, which are inconsistent with Draft License Articles 404 and 406 on which the Draft Opinion relies, have not yet been addressed by USFWS in the Draft Opinion.

February 25, 2015, PRRIP Tern and Plover Habitat Synthesis Chapters

On March 17, 2015, the PRRIP's Executive Director's Office for the Governance Committee publically released its Final Statement noting that it has accepted as FINAL (their emphasis) the PRRIP Tern and Plover Habitat Synthesis Chapters, dated February 25, 2015 (Synthesis Report). The released report had been reviewed by PRRIP's Independent Science Advisory Committee as well as by an external panel of peer reviewers. It is clearly scientifically relevant.

One foremost management activity that has been evaluated by PRRIP over those 6 years is the FSM strategy. According to the Synthesis Report, the FSM is "river centric with a focus of restoring channel width, improving sediment supply, and increasing annual flow magnitudes to increase sandbar height and maintain width." (PRRIP 2015; Chapter 1, page 17). Draft License Articles 404 and 406 evaluated as part of the Staff Alternative are similar to the FSM strategy in that they periodically increase flow down the bypass reach in an attempt to enhance habitat for threatened and endangered birds. The most noteworthy synthesis finding is that these strategies have failed to accomplish this goal in the central Platte River. As a result, the District believes that they should not be mandated in the Draft License Articles.

The Synthesis Report, prepared by staff of the Executive Director's Office, describes the results of 6 years of "implementing an Adaptive Management Plan (AMP) to evaluate, in part, the Program's ability [using FSM strategies] to improve the productivity of least terns and piping plovers in the Associated Habitat Reach (AHR)" (PRRIP 2015; Executive Summary, page 1). It concludes that the FSM strategy, primarily because of inappropriate initial hypotheses regarding physical processes and other reasons, failed to meet habitat objectives.

The Synthesis Report states that "Several lines of evidence now indicate that implementation of the Program's FSM strategy may not achieve the stated management objective for least terns and piping plovers" (PRRIP 2015; Preface, page i). Six years of in-river testing of the FSM strategy involving significant expenditures, have shown that FSM has not been effective in the central Platte. The report confirms that the FSM and SDHF strategies have failed, and that even further testing with higher flows is not considered feasible, even in light of a number of events exceeding both the magnitude and duration of the previously hypothesized targets.

The PRRIP Synthesis Report also includes a meta-analysis to evaluate the relationship between tern and plover nesting incidence and channel width in several Nebraska river segments used by the species. The study evaluated the lower Platte River (downstream of the Loup River confluence), the Loup River, and the Niobrara River. The study concluded that 70 percent of nesting colony incidence occurred in channels with a maximum unvegetated width greater than 1,200 feet. According to the Synthesis Report, Figures 4 and 5, the majority of the Loup River (both upstream and downstream) has a maximum unvegetated channel width less than 1,200 feet. In addition, the Synthesis Report, Table 12, indicates that the 90th percentile unvegetated width for the Loup River is less then 1,100 feet. This study suggests that the Loup River unvegetated channel width both upstream and downstream of the diversion does not have unvegetated channel widths to support nest incidence.

PRRIP's Findings on Errors Committed Regarding Physical Processes of Habitat Development in the Platte River

The Synthesis Report discloses that among the primary causes of failure of the FSM strategies was the long-existing (but never tested or proven) hypothesis that sandbars build to the water surface level, which presumed that in order to create suitable heights (in accord with minimum height suitability criteria) of sandbars, one would need only to pass flows causing river stages (surface levels) to rise to the target sandbar heights. The same hypothesis is integral to the strategies proposed in the Draft Opinion (based on the Draft License Articles proposed by the Commission). The Synthesis Report reveals that this critical tractive condition ensues, on average, when the sandbar level reaches average levels of 1.5 feet below the water surface in the central Platte (and accordingly 2.0 feet in the lower Platte, per the Synthesis Report).

In either river system, creation of target sandbar heights would require flows of magnitudes that reach stage levels 1.5 or 2.0 feet above the target heights to be sufficient to meet the minimum height suitability criterion. In both cases, the flow-discharge rating curves are typically flat, especially at high flows, requiring huge increases in flow rate to cause even small increases in stage. The Synthesis Report notes that doubling the previously assumed flow rates might be required to add the 1.5-foot margin, and further notes that flood restrictions, at least in the central Platte, prohibit these levels.

District's Position on the Draft Opinion – USFWS Needs to Reconcile the Proposed Draft License Articles and the Staff Alternative with the Synthesis Report Findings

The District believes that the Draft Opinion is fatally flawed because it fails to include analyses of the implications of the findings in the independently peer reviewed Governance-Committee-approved Synthesis Report regarding its numerous references to the failure of FSM strategies, which included analysis of SDHF strategies and their unlikely success in "other regional reaches" (specifically including the lower Platte River) because of, among many other reasons, hydrology that is "not ideally suited to their [tern and plover] reproductive ecology" (PRRIP 2015; Chapter 5, page 30).

Because the physical processes are identical throughout the region and because the Synthesis Report unmistakably translates its findings on physical processes to the lower Platte segment, thereby making it relevant to the Project segments (see detailed comments below in the section titled "The Synthesis Report is Relevant to the District's Application in the Loup and Lower Platte Reaches"), neither USFWS nor the Commission can justify producing a Draft Opinion with no mention of the highly relevant conclusions in the Synthesis Report. In its Draft Opinion, USFWS clearly did not use all information that had been made available to it as early as February 25, 2015,, namely the Synthesis Report. The Commission has included flow modifications in the Staff Alternative (at the request of USFWS) in an attempt to benefit Interior least terns and piping plovers. The District believes that resolution of whether or not these flow modifications would be successful must be addressed in light of findings to the contrary elaborated in the Synthesis Report.

The Draft Opinion does not reference the Synthesis Report, yet USFWS identifies benefits of flow and sediment management allegedly provided by the Draft License Articles that are based on the same faulty FSM and SDHF rationales. The FSM strategy and its SDHF tests didn't work in the central Platte, and there is no explanation of why they would work at the Project. Yet USFWS continues to advocate that the FSM assumptions and strategies be included in Draft License Articles 404 and 406, which have clearly failed in the central Platte River. In numerous places, the Synthesis Report compares causes and results of the failed FSM strategy in the central Platte to the lower Platte, including assessments of similar lower Platte and Loup River habitat, species uses, inundation of nests, dual spring rises in hydrology, sandbars building to only 1.5 to 2.0 feet below the surface, re-nesting of terns, etc. The Synthesis Report adds tremendous empirical scientific value to the issues surrounding tern and plover habitat in the Project reaches.

As the primary basis for the District's position on its relevance, the Synthesis Report concludes that "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 PRRIP can successfully manage flow and sediment to create and maintain suitable in-channel nesting habitat" (PRRIP 2015; Executive Summary, page 3; emphasis added).

The obvious relevance of this paragraph to requirements of Draft License Articles 404 and 406 on which the Draft Opinion is based needs to be addressed in a completely revised Draft Opinion. The Draft License Articles suggest that unfounded attempts are being made to force terns and plovers to nest on the river where there are "intractable physical conditions" for "successful management of flow and sediment to create and maintain suitable in-channel nesting habitat" (PRRIP 2015; Executive Summary, page 3). It is also relevant that the FSM strategy attempted by the PRRIP has no long-term future without funding for long-term vegetation removal. In light of this, the PRRIP concludes that the focus in 2015 will be on "off-channel enhancements," which relates directly to the District's North Sand Management Area that the

Draft Opinion determined provides an average of 16 Interior least tern and 5 piping plover nests per year.

USFWS, as a member of PRRIP's Technical Advisory Committee, also reviewed and was knowledgeable of the information in the Synthesis Report long before it was finalized in February and released in March 2015. The District believes that the findings are relevant to the District's application and should have been fully addressed by USFWS prior to issuance of the Draft Opinion.

The Draft Opinion Erroneously Describes Habitat Management in the Platte River as "Successful"

Instead of echoing the failures reported by PRRIP in the Synthesis Report, the Draft Opinion incorrectly concludes that "…the Platte River Interior least tern habitat has been successfully managed and protected since listing. In summary, management has been successfully implemented within the Upper Missouri River South population (Platte, Loup, Niobrara, Missouri Rivers)" (Pages 66-67). With regard to the Platte River, this "conclusion" was apparently reached prior to information that PRRIP's management strategies were not only failing at the time, but instead species use of in-channel habitats declined from a high of 25 nests (20 Interior least tern and 5 piping plover) in 2008 to 0 nests in 2013 (PRRIP 2015; Executive Summary, page 1).

Platte River management strategies over the past 6 years have clearly not been a "success." The District requests a complete revision to the Draft Opinion, incorporating the findings of the Synthesis Report and justifications demonstrating why it is hypothesized that the Draft Opinion's mandates represented in the Commission's Draft License Articles would be effective in the Loup and lower Platte rivers when they failed to work after 6 years of effort in the central Platte where, among other things, it was concluded that FSM strategies "will almost certainly not create suitable least tern and piping plover nesting habitat… in the AHR *and other regional river systems* that are used by these species" (PPRIP 2015; Executive Summary, page 3; emphasis added). The District has serious reservations on the efficacy of requiring flow and sediment management strategies in the Loup and lower Platte rivers with the same underlying assumptions that have been cited as "almost certain" to fail "in other regional systems."

The Synthesis Report is Relevant to the District's Application in the Loup and Lower Platte Rivers

Another objective of PRRIP was to examine the hydrology and physical characteristics of "other regional river segments" (PRRIP 2-15; Executive Summary, page 2). The District asserts that the Synthesis Report is entirely relevant to the Project relicensing proceedings because, among other reasons, the report itself identifies and compares numerous similarities of central Platte AHR species uses, inundation of nests, dual spring rises in hydrology, sandbars building to only 1.5 feet below the surface, re-nesting habits of terns, and sediment supply conditions to similar conditions in the lower Platte and Loup rivers. Detailed comparisons of these similarities between the AHR reach and the lower Platte and Loup rivers are provided in the Synthesis Report and summarized here.

The Preface to the Synthesis Report states, "… the Program's Independent Science Advisory Committee (ISAC) and various stakeholders also requested the [Executive Director's Office] 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," (PRRIP 2015; emphasis added), and the report states, "The lower Platte River segment was an obvious choice for comparison given the presence of viable species subpopulations" (PRRIP 2015; Executive Summary, page 2). The report then describes this as its second main objective. This clearly demonstrates that PRRIP's staff and Executive Director's Office consider that their findings are relevant to other regional reaches.

A parallel, valid reason that the Draft Opinion must be significantly modified is that other regional segments were in fact analyzed by PRRIP, and their findings regarding FSM strategies in the central Platte would be equally applicable to the Loup and lower Platte river. The following paragraph from the Synthesis Report (and in numerous other descriptions of the lower Platte) clearly states that PRRIP's staff and Executive Director's Office considers that the findings are relevant to the lower Platte River, evidenced by the italicized statement:

> The timing of the late spring rise is especially problematic for piping plovers and *it does not appear 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 success of renesting following the late spring rise. Given the challenges to maintaining adequate productivity, these findings suggest that use and success on novel habitats like in-channel sand spoil piles and off-channel sand mines may be necessary to allow these species to persist in a river basin with 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 habitats. (PRRIP 2015; Executive Summary, page 2; emphasis added)

As another example of the relevance of the findings to the District's project area, the Synthesis Report describes the shortfalls of physical hydrologic conditions in the lower Platte and states that the primary reason for use by the species in the lower Platte River is that the off-channel habitats caused the species to "expand" into a reach where "hydrology [is] not ideally suited to their reproductive ecology." (PRRIP 2015; Chapter 5, pages 29-30) This is also affirmed in the Synthesis Report, Appendix A, in Mr. Berger's peer review comments on Questions 14 and 15. Both sets of statements show the fallacy in the FSM strategy, which are readily transferrable to the lower Platte and Loup rivers. The existence of this Governance-Committee-approved Synthesis Report and its numerous rebuttals to USFWS' long-standing positions that FSM is beneficial to, and presumably required for, creation of in-channel habitat mandate that the PRRIP's findings be assessed by USFWS and their relevance to the Draft License Articles be assimilated in a revised Draft Opinion.

PRRIP Synthesis Corroborates District Study Results

The findings of the PRRIP corroborate the studies performed by the District as part of the relicensing proceeding. The record evidence in the relicensing proceeding shows that increasing flow even greater than that recommended by the Commission Staff in the Draft License Articles would have an immeasurable influence on sediment transport indicators and consequently on the associated changes in width, area, velocity, and depth in the Loup River Bypass Reach (the District's Study 14.0, Alternative Project Operations and Sediment Management, Section 5.2.2 Table 5-4 and Section 5.2.3 Table 5-5, and a June 23, 2014, letter to the Commission). The record evidence in the relicensing proceeding does not support the assumption by USFWS in the Draft Opinion that increasing flows or sediment transport would help maintain existing sandbars. The site-specific studies and literature cited all indicated that the Loup River Bypassed Reach is currently maintaining existing sandbars as evidenced by it being in dynamic equilibrium (neither aggrading nor degrading) and being well-seated in the braided river zones. As shown in the District's Study 1.0, Sedimentation, Section 5.2.4 (Figures 5-16 through 5-20), regime analysis indicates that the Loup River Bypass Reach is well-seated in the braided river zones, with neither the gaged or ungaged sites being near any thresholds of transitioning to another morphology.

In addition, the District's Study 1.0, Sedimentation, specific gage analysis (Figure 5-21) and Kendall Tau analysis (Table 5-10) indicate that the Loup River Bypass Reach is neither aggrading or degrading, and in Section 5.3.2, literature by USGS document that there is no evidence of aggradation or degradation occurring in the Loup River Bypass Reach. The results of the regime analysis in Section 5.2 and the specific gage analysis in Section 5.3 show that the Loup River Bypass Reach is in dynamic equilibrium.

Studies in the central Platte River and site-specific studies on the Loup and lower Platte rivers indicate that increasing flow will not produce or maintain suitable habitat for terns and plovers. Therefore, any project modification associated with increasing flows for the intent of producing, enhancing, or maintaining habitat for the Interior least terns and piping plovers should not be considered, given that they are contrary to the evidence in the record of the relicensing proceeding and similar studies within the basin simply do not support this proposed strategy.

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ATTACHMENT D

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
TERN AND PLOVER HABITAT SYNTHESIS CHAPTERS

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).

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Data Synthesis Compilation

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

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

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

(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.

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

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 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.

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 and contrast the physical characteristics of the AHR and other regional river segments in an effort to glean additional management insights. The lower Platte River segment was an obvious choice for comparison given that the presence of viable species subpopulations in the historical AHR was inferred, in part, from contemporary species use of that segment of the river. Both species arrive and begin initiating nests prior to the late-spring runoff which typically occurs in mid-June in the Platte basin. Given sandbar heights in relation to stage-discharge relationships in both the central and lower Platte, nests initiated prior to the late 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 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 success of renesting following the late spring rise. Given the challenges to maintaining adequate productivity, these findings suggest that use and success on novel habitats like in-channel sand spoil piles and off-channel sand mines may be necessary to allow these species to persist in a river basin with 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 habitats.

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

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.

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

Abstract

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 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 by irrigation infrastructure and the channel was actively narrowing in response to changing flow, sediment and disturbance regimes. Given the lack of species observations in the central Platte prior to hydrologic 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 of the Platte River and other regional river segments. A collaborative adaptive management approach is being used to test two management strategies to improve productivity of least tern and piping plover from the AHR.

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).

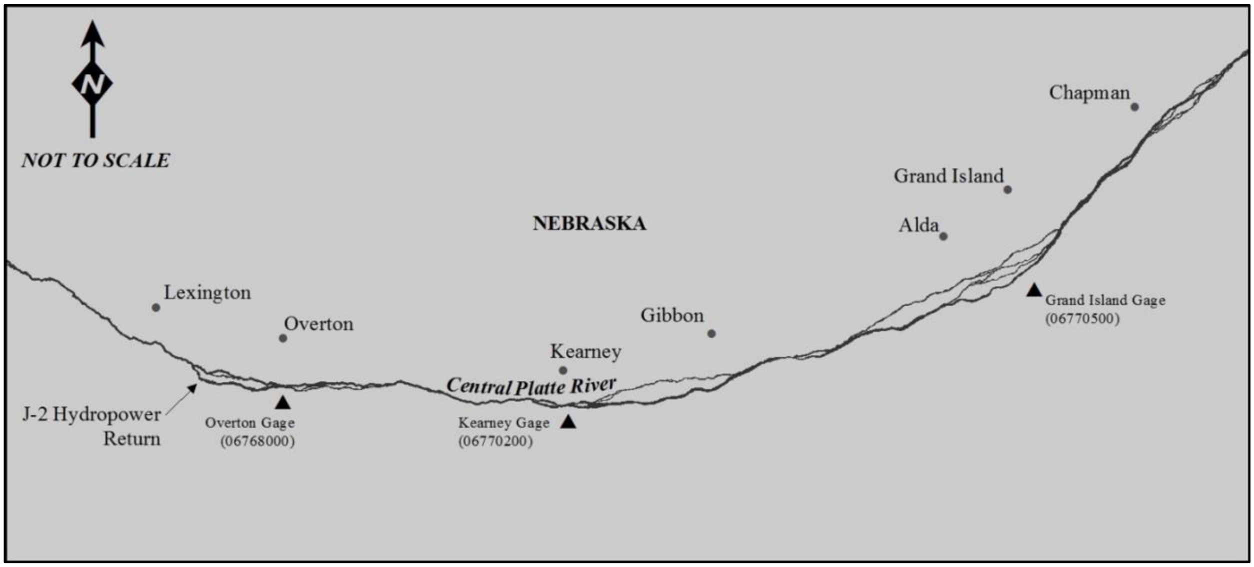

Figure 1. Associated Habitat Reach of the central Platte River in Nebraska extending from Lexington downstream to Chapman.

The Program is entering its seventh year implementing an adaptive management program to test strategies for improving least tern and piping plover productivity in the AHR. Subsequent chapters of this document present analysis and interpretation of modeling, research, and monitoring efforts to date. The objective of this introductory chapter is to provide a brief overview of the large body of relevant Platte River literature and outline regulatory actions that led to the formulation of the Program. The chapter begins with a review of least tern and piping plover monitoring and research in the AHR. Changes in hydrology 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 being evaluated by the Program.

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 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 five-year 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 (USFWS 2009). Piping plovers breed in North America and Canada and winter along the Atlantic and Gulf coast and in the Bahamas and West Indies. Three breeding populations of piping plovers are recognized; 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 tributaries in North and South Dakota and Nebraska. Piping plovers on the breeding grounds generally forage on insects and spiders. This species nests from early April to early August and draws predators away from nests and young using an injury feigning broken-wing display (USFWS 2009).

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).

Least tern and piping plover observations in the Associated Habitat Reach of the central Platte River prior to systematic monitoring

Historical records of least tern occurrence in Nebraska were compiled by Ducey (1985, 2000) and Pitts (1988). The first recorded observation of least terns in what is now Nebraska was made near the mouth of the Platte River in 1804 by the Lewis and Clark expedition as they traveled up the Missouri River. The next recorded observations were made by Duke Paul Wilhelm at the mouth of the Platte River in 1823. Subsequent observations in the 19th 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, Pitts 1985). Least terns were next observed nesting on the South Platte River near the city of North Platte in 1926-1929 with 57 nests recorded as well as documentation of foraging movements to the North Platte River and sand pit lakes when the South Platte River went dry (Tout 1947).

The next recorded least tern observation on the Platte River occurred near Columbus in 1941, the same year that Lake McConaughy, the largest reservoir in the basin, was completed. Ten nests were 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. Ray S. Wycoff. Dr. Wycoff studied the colony for 17 years and observed nesting on a low sandbar in the channel, high in-channel island created by sand mining, and at adjacent sandpits (Wycoff 1960). In 1943, 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 3:244).

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 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 references list the species as a common migrant that breeds in scattered spots along lakes and rivers in the state (Wolcott 1909, Moser 1942, Tout 1951, Nebraska Bird Review 1955, Rosche 1979). The first quantitative observations of adults occurred near Omaha and at Capitol Beach in Lincoln in the early 1940s (Moser 1942). Pitts' (1988) review of adult and nest observations by county (1804-1984) identified six years prior to the beginning of systematic survey efforts when adults were observed near the upper end of the AHR (1950-1952, 1954-1956), one year in the middle portion of the reach (1957), and two years in the downstream portion of the reach (1954, 1959).

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 nesting habitat.

Table 1. Central Platte River nest incidence by habitat type for the period of 1979-2013.

Habitat Type	Interior Least Tern Count	Interior Least Tern Percent	Piping Plover Count	Piping Plover 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%**

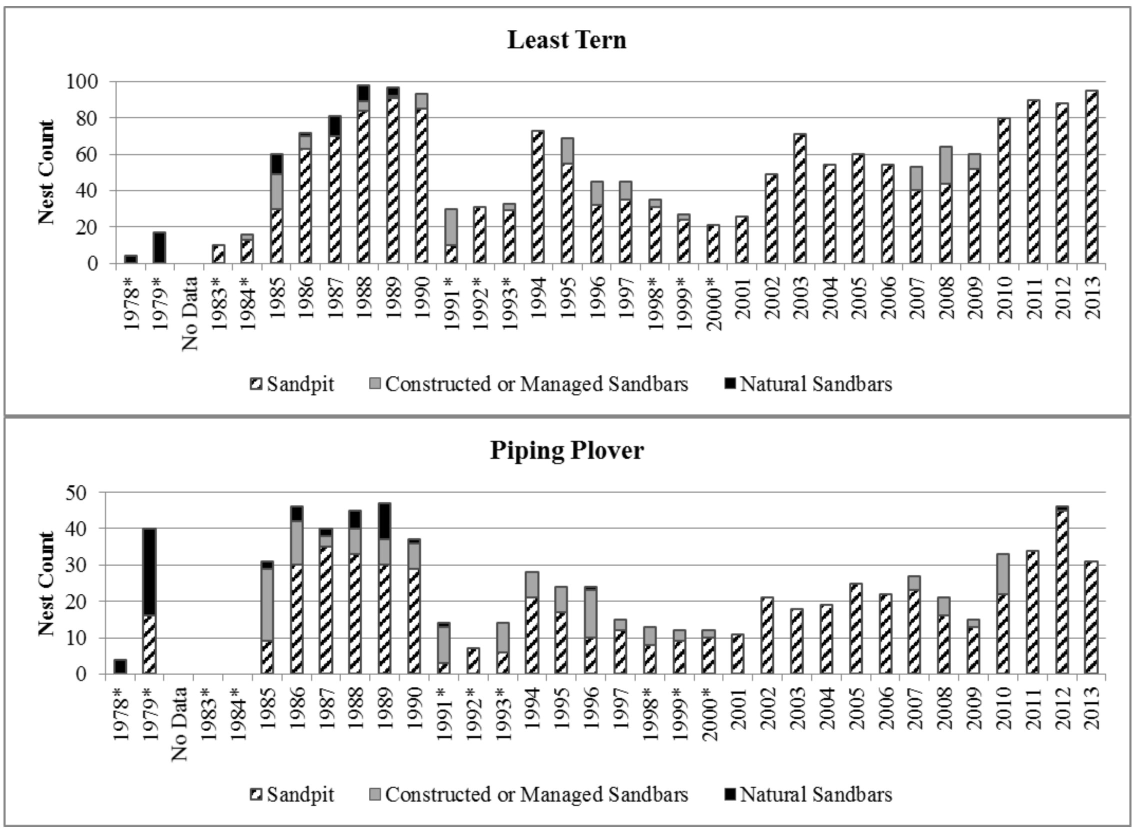

Figure 2. Central Plate River least tern and piping plover nest incidence 1978-2013 by year and habitat type. Asterisks indicate periods when monitoring effort changed significantly.

In-channel habitat selection and productivity investigations

Two on-channel habitat selection and productivity analyses were conducted in the AHR during the late 1970s and mid-1980s when the species were observed utilizing natural sandbar habitat (Faanes 1983, 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).

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

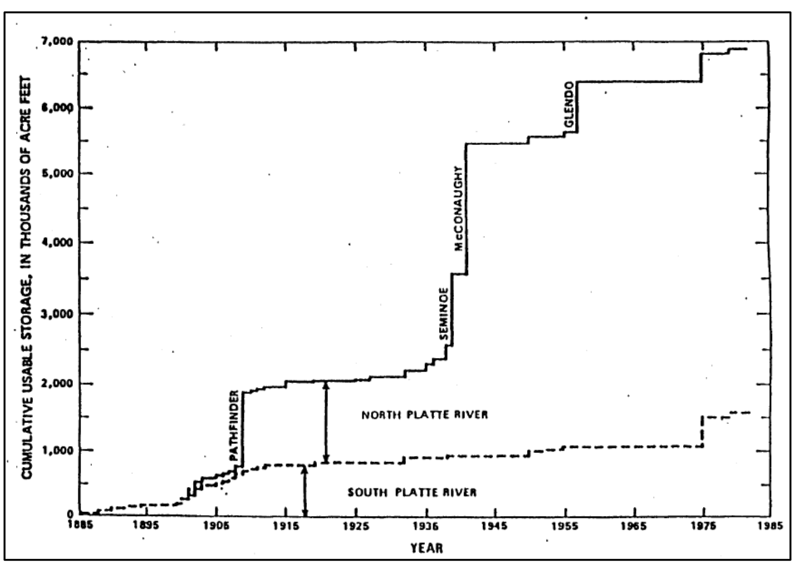

Figure 3. Cumulative usable storage in reservoirs in the Platte River basin (Simons and Associates Inc. 2000).

Table 2. Mean annual discharge and mean annual peak discharge at Overton gage adapted from Stroup et al. (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

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

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

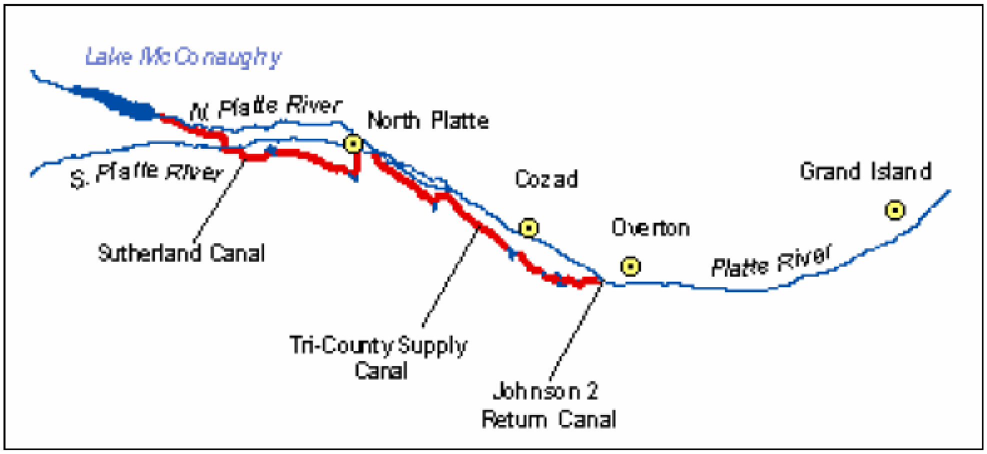

Figure 4. Map of Lake McConaughy, Tri-County Supply Canal and J-2 Return Canal. Figure reproduced from Department of the Interior (2006).

Changes in Associated Habitat Reach channel morphology over historical timeframes

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

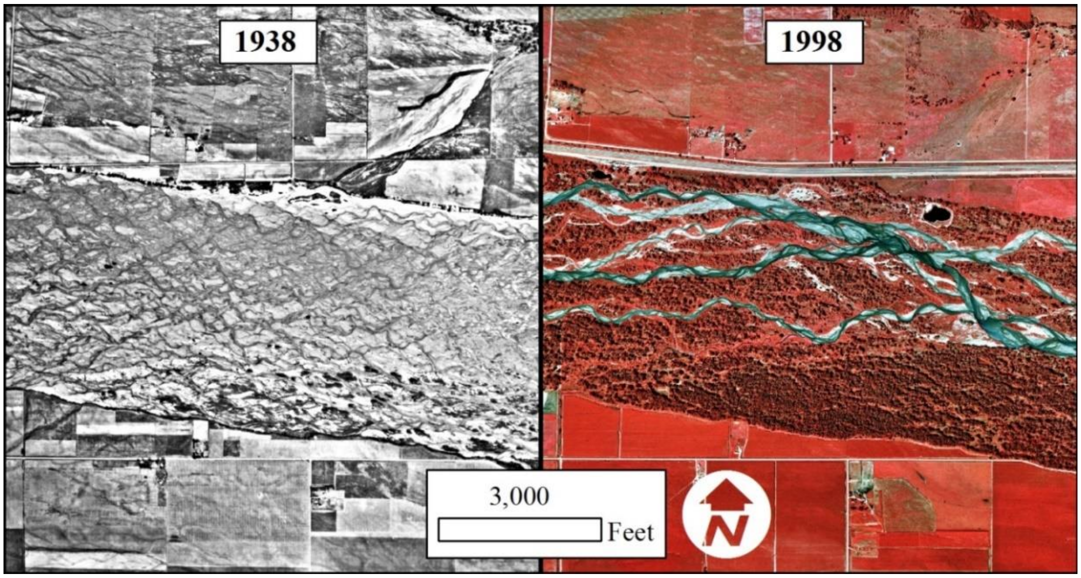

Figure 5. Comparison of 1938 and 1998 aerial photographs of the Associated Habitat Reach at River Mile 218 in the Odessa to Kearney bridge segment. Much of the 1938 channel area is occupied by riparian cottonwood forest.

The surveyed bank-to-bank or total width of the channel in the 1860s excluding large permanent islands was highly variable and averaged 3,800 ft (Figure 6). The proportion of the total width of the 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 2,600 ft. By 1998, average unvegetated width was 900 ft. Johnson (1994) evaluated the rate of change in active channel width in the AHR from 1938 to 1988 and found the majority of narrowing occurred during the 1940s and 1950s with channel area stabilizing by the 1980s (Figure 7).

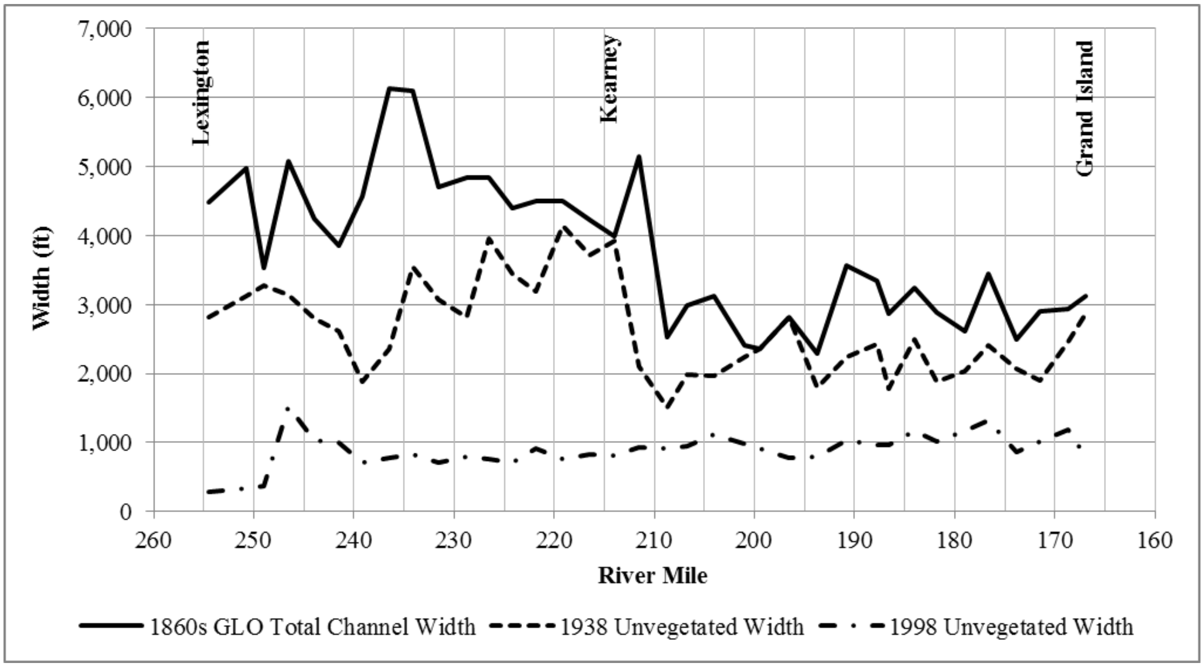

Figure 6. Total channel width in the Associated Habitat Reach from the 1860s General Land Office (GLO) survey, total unvegetated width in 1938 aerial photographs and total unvegetated width in 1998 aerial photographs.

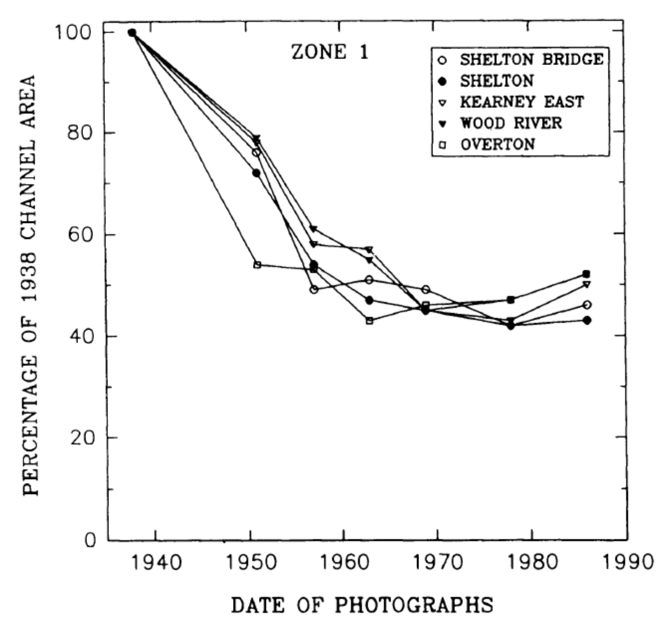

FIG. 8. Changes in active channel area in Zone 1 reaches from 1938 through 1986. Starting channel area in 1938 was set equal to 1.

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

The drivers of woody vegetation expansion were explored in many of the channel width analyses with investigators generally concluding the change was due to alterations in hydrology caused by water development in the basin. Alternative hypotheses of the specific mechanisms of narrowing include:

1) a reduction of peak flow magnitude and associated ability to scour vegetation (Williams 1978, O'Brien and Currier 1987, Murphy et al. 2004),
2) a reduction in flow during the cottonwood germination period leading to increased recruitment (Johnson 1994, Simons and Associates 2000), and
3) a decrease in desiccation mortality of seedlings in summer as the river transitioned from ephemeral to perennial due to irrigation return flows (Schumm 2005).

Although changes in AHR channel width have been widely studied and debated, sandbar characteristics in the historical river are not well documented. Several investigations include brief descriptions of sandbars and islands recorded by travelers in the 19th Century (Eschner et al. 1983, Simons and Associates 2000, Murphy et al. 2004). The most descriptive observation of bedforms was contained in Mattes (1969) who reproduced a quote from a Mr. Evens in 1848 describing the Platte River near Kearney as "running over a vast level bed of sand and mica *** continually changing into short offsets like the shingled roof of a house***." Other travelers generally characterized the bed of the river as being comprised of innumerable sandbars continually shifting and moving downstream (James 1823, Mattes 1969).

The first detailed characterization of AHR sandbar morphology was provided by Ore (1964) who classified Platte River bedforms as transverse bars. Further attempts to characterize sandbar morphology identified dominant bedforms as transverse/linguoid bars (Smith 1971, Blodgett and Stanley 1980), macroforms (Crowley 1981 and 1983), or a combination of both types (Horn et al. 2012). The historical accounts of Platte River bedforms appear to agree well with contemporary descriptions of transverse/linguoid bars.

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 Act in 1985 and the piping plover was listed as threatened in 1986. Soon after listing, the USFWS made the determination that these species were threatened by upstream impoundments and diversions that reduced the magnitude of the annual spring runoff credited with historically creating and maintaining suitable sandbar nesting habitat on a near-annual basis (Freeman 2010, Department of the Interior 2006). The following excerpt from the Biological Opinion for the Platte River Recovery Implementation Program (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.

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

(2005) further stated that loss of habitat along the river appears to be forcing birds to use alternative sites that are less secure from predators and other sources of disturbance.

Periodically, flooding of sufficient magnitude to scour perennial vegetation off sandbars and form new barren sandbars does occur. However, sandbars that develop under current 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 throughout the nesting season, and are unsuitable for nesting under current conditions (Sidle et al. 1992). An aerial videography study conducted by Ziewitz et al. (1992) documented moderately vegetated sandbars and sandbars that were slightly exposed in the central Platte River. The differences between the central and lower reaches of the Platte River were readily apparent. In the central Platte River, mean nest elevations were lower than the mean sandbar elevation, which was the opposite of the relative elevations observed on the lower reach (Ziewitz et al. 1992). Little suitable nesting habitat was observed in videos taken of the central reach of the Platte River (Ziewitz et al. 1992).

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. 1992, Kirsch and Sidle 1999). However, habitat changes along the Platte described by Eschner et al. (1981), Sidle et al. (1989), USFWS (1981), and Williams (1978), have occurred faster than flora or fauna have been able to adapt. Water resource development has taken place at a substantial rate, as has the narrowing and forestation of the Platte River. The effects of groundwater withdrawal have also contributed to degradation of in-channel and floodplain habitat. Releases from the J-2 Return near Lexington exacerbate flooding when coupled with local thunderstorms (Lingle 1993b). Under current channel *conditions, many releases from upstream water control structures can result in flooding, and further exacerbate natural flooding events.*

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

As indicated in the excerpt, a decline in AHR least tern and piping plover habitat suitability has been inferred from:

1) 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 productivity in 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 further affect the hydrology of the AHR. These jeopardy opinions prompted the states of Wyoming, Colorado, and Nebraska and the Department of the Interior to enter into a Cooperative Agreement in 1997 for the purpose of negotiating a program to conserve threatened and endangered species habitat in the AHR while accommodating certain ongoing water development activities in the basin. Through the negotiation process, it became apparent that uncertainty and disagreements about species habitat requirements and 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 disagreements as uncertainties related to two competing management strategies.

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-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 river-centric 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 and supported viable sub-populations of both the least tern and piping plover prior to the onset of water 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 occurring during the period of 1940-1970 (Johnson 1994). However, least tern and piping plover observations in the AHR began after the bulk of water development had already occurred and the channel was narrowing. Consequently, a decline in habitat suitability could not be inferred from a corresponding decline in species use or productivity.

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

Abstract

Adaptive management is being implemented at a large scale on the Platte River to reduce uncertainty regarding the response of the central Platte River to management actions. Monitoring suggests 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 produce suitably high sandbars for interior least tern and piping plover nesting. Effectiveness monitoring of channel morphology following flow releases and natural high flow events indicates a decline in the amount of suitable habitat over time as constructed islands eroded. Validation monitoring of in-channel species use indicates a corresponding decline in in-channel nest incidence. The decline in suitable habitat and nest incidence despite Program management and natural events hypothesized to produce suitable habitat is an indication that the FSM strategy, as currently conceived, will not improve production of least tern and piping plover from the central Platte River.

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).

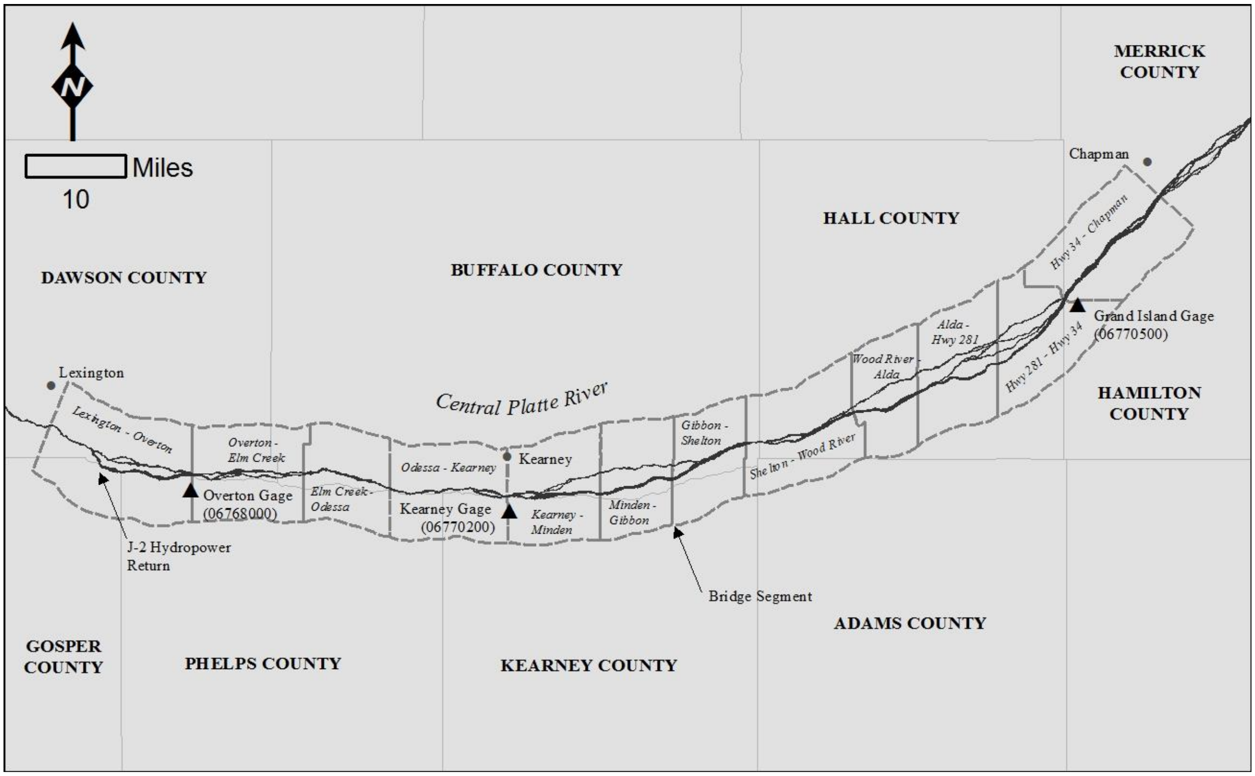

Figure 1. Associated Habitat Reach of the central Platte River in Nebraska extending from Lexington downstream to Chapman including bridge segments.

During the First Increment of the Program (2007-2019), stakeholders committed to working toward this management objective by acquiring and managing land (10,000 acres) and water (130,000-150,000 acre-feet/year) resources to benefit the species. However, there is 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 two competing management strategies to achieve, in part, the objective of improving production of least tern and piping plover from the central Platte River (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 decision-making 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.

Adaptive Management Implementation Approach

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.

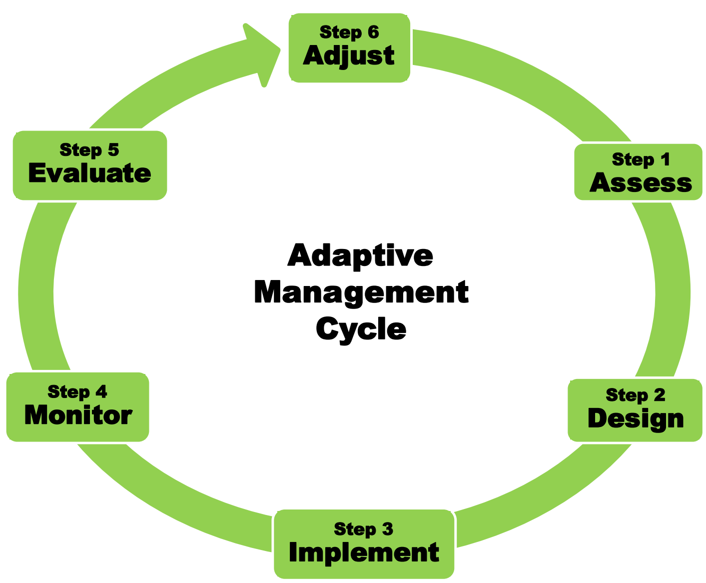

Figure 2: Adaptive management cycle.

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

Assess

Program participants developed conceptual ecological models (CEMs) as a first step in assembling the AMP (Program 2006). Those CEMs provide a basic visual framework for the hypothesized understanding 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, and data evaluation detailed in the AMP are an extension of the relationships identified in the CEMs. The 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, often referred to as "Clear-Level-Pulse". Management actions include:

- Mechanical
    a. Consolidate the flow and river channels to maximize stream power and help induce braided channel characteristics;
    b. Mechanically cut banks and lower islands to a level that will be inundated by anticipated annual peak flows; and
    c. Mechanically clear vegetation from islands and banks in the single channel as needed to aid in the widening process and make sediment available for recruitment to the river. Minimum channel width target is 750 feet.

- Sediment
  a. Mechanically place sediment into the river from banks, islands and out-of-bank areas at a rate that will eliminate the sediment deficiency and restore a balanced sediment budget.
- Flow
  a. Use Environmental Account water from Lake McConaughy to generate short-duration near-bankfull flows (Short-Duration High Flows or SDHF) of 5,000 to 8,000 cfs in the habitat reach for three days in the springtime or other times outside of the main irrigation season. The intent is to achieve these flows on an annual or near-annual basis.

The FSM management strategy is river-centric as indicated by the management actions and hypothesized beneficial effects. The alternative Mechanical Creation and Maintenance (MCM) or "Clear-Level-Plow" approach focuses on mechanical creation and maintenance of both in- and off-channel nesting habitats. MCM management actions include construction of in-channel nesting islands, restoration of degraded off-channel sandpit nesting habitat, and the construction of new off-channel sandpit nesting habitat.

The focus of this chapter is on our evaluation of the ability of the FSM strategy to improve production of least tern and piping plover on the central Platte River. The hypothesized beneficial effects of the FSM strategy include:

- Hypothesis PP-1: Flows of 5,000 to 8,000 cfs magnitude for a duration of three days (defined in the AMP as a "short-duration high flow" or "SDHF") are needed with both mechanical actions of consolidating flow and river widening to raise sandbars to an elevation suitable for least tern and piping plover nesting habitat.
- Hypothesis PP-2: Sediment augmentation is required in conjunction with increases in flows and contributes to wider sustainable channels, contributes to increases in occurrence of sandbars,

restores stream bed elevation, and over time will promote the occurrence of a braided plan form in 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.

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.

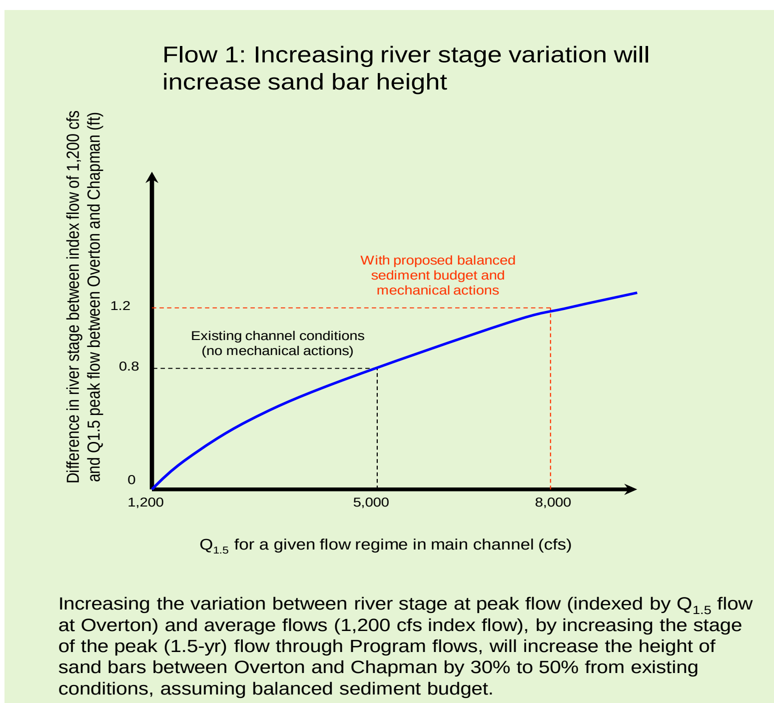

Figure 3. Priority hypotheses Flow #1, as detailed in the AMP (Program 2006).

Design and Implementation

The priority least tern and piping plover management uncertainties to be evaluated through implementation of the AMP include: 1) the ability of the FSM strategy to produce and maintain riverine sandbars that are suitably high for nesting; 2) whether or not the species will select in-channel habitats over off-channel habitat; and 3) differences in productivity between the two habitat types. To date, the Program's focus has largely been on evaluating the ability of the FSM strategy to produce suitable nesting habitat. The Program's AMP provides the following approach to implementing and evaluating the management actions:

1. Begin with efforts at a sufficient scale to test concepts, to generate anticipated effects large enough to measure, but at a scale unlikely to cause undesirable impacts to third parties.
2. Monitor the effects of actions on key indicators of resource management objectives, and on indicators of undesirable consequences.
3. Determine if the same management action should be scaled up, or if the management action should be modified or abandoned.
4. Assuming management actions are resulting in desired outcomes, and as safety and efficacy of actions are established, increase scale to accomplish key management objectives by the end of the Program First Increment.

The AMP includes an Integrated Monitoring and Research Plan (IMRP) that presents the Program's approach to evaluating species and physical process response to Program management actions and natural events on system, reach, and project scales (Program 2006). The approach consists of monitoring (e.g., baseline data and long-term trend detection), experimental research (e.g., to determine cause-and-effect relationships), simulation modeling (e.g., to provide a tool to design experiments and test scientific 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 two-dimensional 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).

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)

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 management actions are being implemented according to design requirements and standards. Effectiveness monitoring of physical habitat performance indicators is conducted to determine if management actions are achieving or moving towards management experiment performance criteria. Validation monitoring of species use and selection determines if species are responding to management actions and/or if the Program is making progress towards achieving species management objectives. A review of monitoring that is specific to testing the ability of FSM to create suitably high nesting habitat (Hypothesis PP-1) follows.

Mechanical

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).

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

Bridge Segment	**Length 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	

Sediment

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 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 direction with approximately the lower half of the reach (downstream of Minden) in dynamic equilibrium.[1] There are no major tributary inputs of sediment in the AHR. Accordingly, the deficit is made up by erosion of channel bed and bank materials (Holburn et al. 2006, Murphy et al. 2006, HDR Engineering Inc. 2011).

The long-term average annual sediment deficit in the AHR is on the order of 150,000 tons[2] with the majority of the deficit occurring during high-discharge years (The Flatwater Group Inc. 2010, HDR 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 has since expanded those efforts including the addition of a second augmentation site upstream of the Overton Bridge (Table 3).

[1] 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.

[2] 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 vriable from year to year with the highest deficits occurring during high flow years.

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

Water Year	Total Annual Discharge at Overton (Acre-ft)	Sediment Augmented (tons)	Total Sediment Load at Overton (tons)	Total Sediment Load at Kearney (tons)	Total Sediment Load at Shelton (tons)	Total Sediment Load at Grand Island (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

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.

Flow

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 Program inception in 2007 has provided natural high flows of similar magnitude and greater duration than 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 discharge at Grand Island exceeded 5,000 cfs in five out of seven years and 8,000 cfs in four out of seven years (Figure 4; Table 4). Overall, the shift in basin hydrology has resulted in a seven-year period (2007-2013) with peak flow frequency, magnitude, and duration that significantly exceed what could have been achieved during the 2000-2006 period under full FSM implementation.

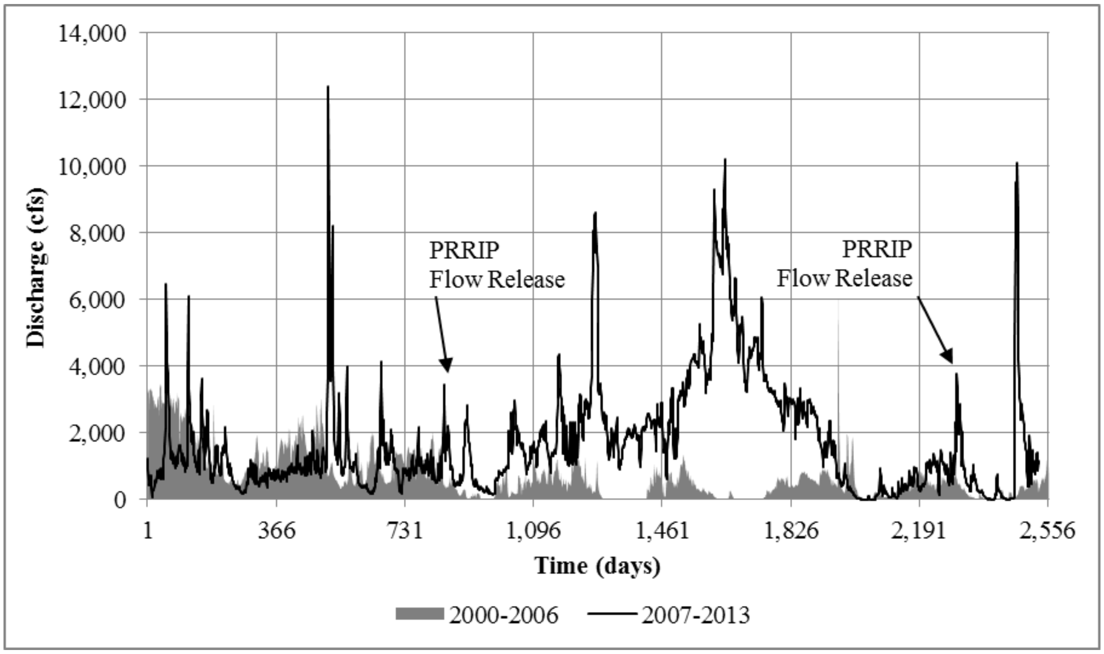

Figure 4. Comparison of mean daily discharge for periods of 2000 – 2006 and 2007-2013 at Grand Island (USGS Gage 06770500) including identification of Program flow releases in 2009 and 2013.

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.

Year	Three-Day Mean Peak Discharge (cfs)	Days > 5,000 cfs	Days > 8,000 cfs	Total Event Volume* (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

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

The overall status of FSM management action implementation during the first seven years of Program 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.

Evaluate – Effectiveness Monitoring

The Program's fundamental sandbar performance criterion is mid-channel bars greater than 0.25 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 (Program 2012). These criteria represent the minimums thought necessary for initiation of in-channel nesting in the AHR. Sandbar height is hypothesized to respond to a single flow event (Program 2006). Therefore, physical channel response data collected by the Program in areas of sediment balance (at a minimum) should be useful in testing the ability of FSM management strategy to provide the hypothesized beneficial effects.

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

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.

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 in-channel 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.

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

	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**

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

Table 7. Least tern and piping plover off-channel nesting incidence by year, 2007-2013.

	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**

Evaluate – Synthesis

The scale of flow, sediment, and mechanical management actions and natural analogs during 2007-2013 appear to have met or exceeded implementation objectives for the First Increment in at least a portion of the AHR. Specifically, fully consolidated portions of the AHR downstream of Kearney. During this same 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 hypothesis that the FSM strategy will create suitable in-channel nesting habitat and increase the productivity of least terns and piping plovers. During this period, nesting incidence and production declined on in-channel habitat as constructed nesting islands were eroded away by high flow events. With the exception of one sandbar that was disked to remove vegetation, was subsequently overtopped by flow and a piping plover nested on it, sandbars created by flow events in 2008, 2010 and 2011 were not used by the species and no sandbars created by the flow events met the Program's minimum suitability criteria.

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 another avenue for evaluation of the potential effects of sediment balance on the presence/absence of suitable sandbar nesting habitat. That investigation found the Platte River at Odessa stream gage (upstream portion of the AHR) to be degrading at a rate of approximately 0.1 m per decade. The lower Platte River at the Louisville gage was 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. 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 completely offsetting the sediment deficit in the AHR during the period of 2009-2013 would have substantially changed observed sandbar 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.

Adjust

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

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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

Abstract

Analyses of the ability of Short-Duration High Flow (SDHF) releases to create suitably-high nesting habitat for least terns and piping plovers assumed that sandbars build to the peak flow stage during 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 event appear to provide the most conservative (high) estimate of sandbar height potential. Observed mean sandbar heights following that event were on the order of 1.5 feet below the peak flow stage. At that height, sandbars produced by an SDHF release would typically not meet the Program's minimum sandbar height suitability criterion for interior least tern and piping plover nest initiation and would likely be inundated during the nesting season in most years.

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).

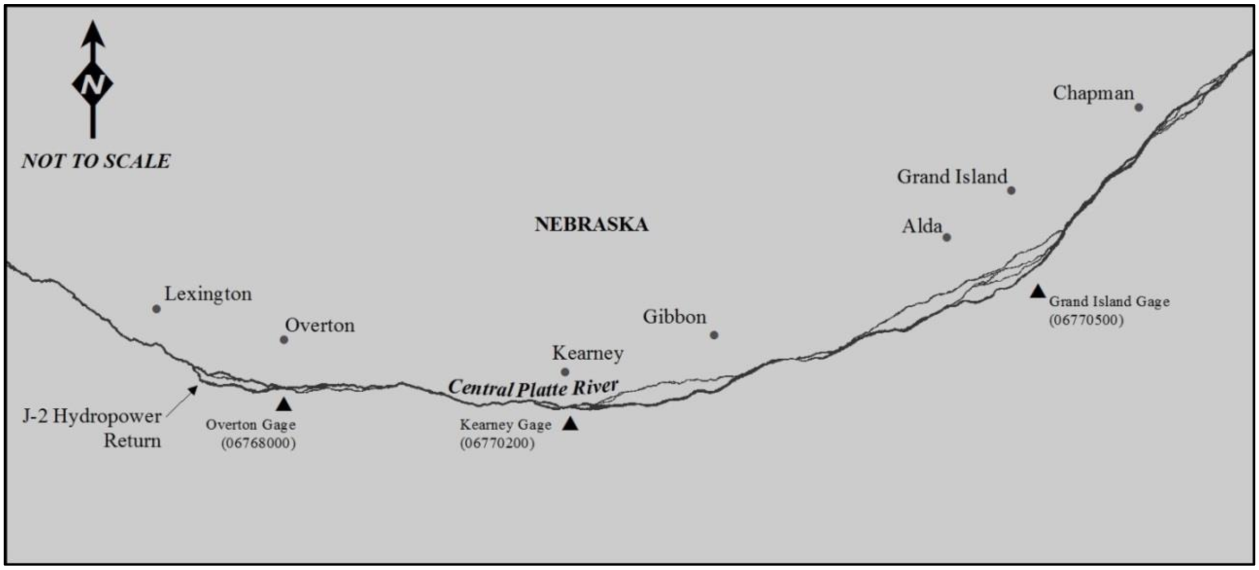


Figure 1. Associated Habitat Reach of the central Platte River extending from Lexington downstream to Chapman, NE.

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 a science-based 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. Proposed actions include:

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

3) 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.

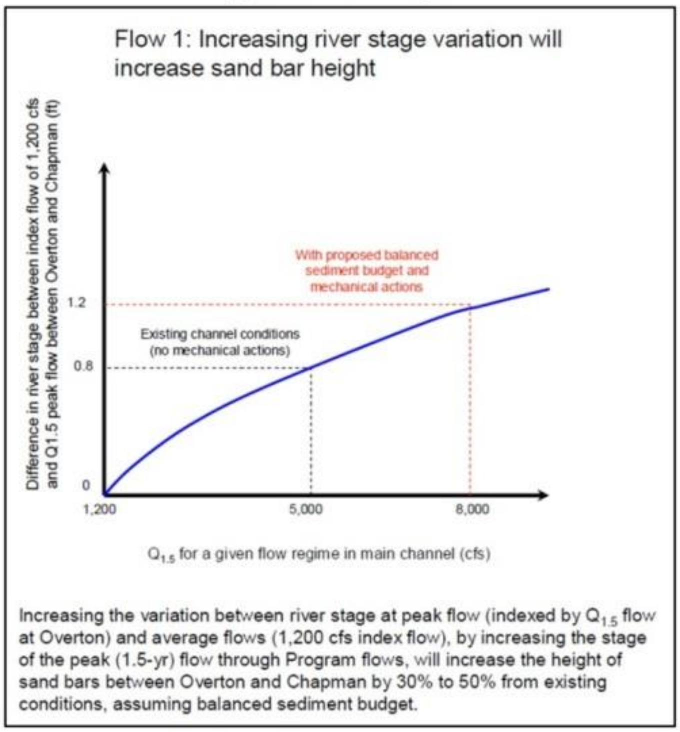
The programmatic Environmental Impact Statement (EIS) analyses of the potential benefits of the FSM strategy assumed that sandbars build to the water surface during peak flow events in areas of sediment balance (DOI 2006, USFWS 2006). Consequently, the modeled increase in $Q_{1.5}$ stage of 30% to 50% from existing conditions was used as an indicator that SDHF releases would increase maximum sandbar heights by 30% to 50% in reaches with a balanced sediment budget. This assumption is reflected in the X-Y graph for detailed hypothesis Flow #1 in the Program's AMP (Figure 2). The detailed hypothesis is linked to 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 $Q_{1.5}$ stage was used solely as an index of sandbar height and was not linked directly to actual sandbars or nest sites. A monitoring program was determined to be necessary to evaluate the ability of flows to build sandbars of suitable height for nesting (USFWS 2006; pg. 5-113).

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.

Hypothesis X-Y Graph:



Alternative Hypothesis Flow #1 (Part 1):
Flow magnitudes and channel compilations are insufficient to generate bars high enough to provide habitat for LT and PP.

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).

Although the concept of suitability was included in hypothesis PP-1, no performance criteria were defined beyond the general objective of creating and maintaining ten (10) acres of habitat per river mile (Program 2006). The Program attempted to address the lack of a descriptive definition of suitable habitat by convening a workshop of stakeholders and species experts in 2009 to establish minimum suitability criteria for in- and off-channel habitat (Program 2009). The criteria were developed based on professional judgment and a limited body of published nest site selection data for the AHR (Table 1). The Program's minimum suitability criteria represent minimum conditions deemed necessary for nest initiation. The frequency of habitat availability for nesting and/or risk of inundation at the minimums were determined to 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	≥ 0.25-acre sandbars of suitable height & ≥ 1.5 acres of bare sand per ¼ 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	≥ 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	≥ 50 feet	Professional opinion of minimum width of water necessary to buffer nest sites from shoreline.
Distance to Predator Perch	≥ 200 feet	Typical distance observed at on- and off-channel nest locations in the AHR (Unpublished data)

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. However, since the criteria were developed there has been a decline in availability of in-channel habitat meeting the minimum suitability criteria and a corresponding decrease in species nesting on in-channel habitats despite the occurrence of several natural high flow events that exceeded the SDHF in magnitude and duration (see Chapter 2). The corresponding declines in availability of suitable habitat and species' use support the inferences that the decline in in-channel species use is a result of loss of in-channel habitat, the minimum criteria are generally representative of conditions necessary for selection of in-channel habitat, and flows exceeding SDHF in magnitude and duration did not produce suitable species nesting habitat.

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).

Methods

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).

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.

Stage-Discharge Relationships

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

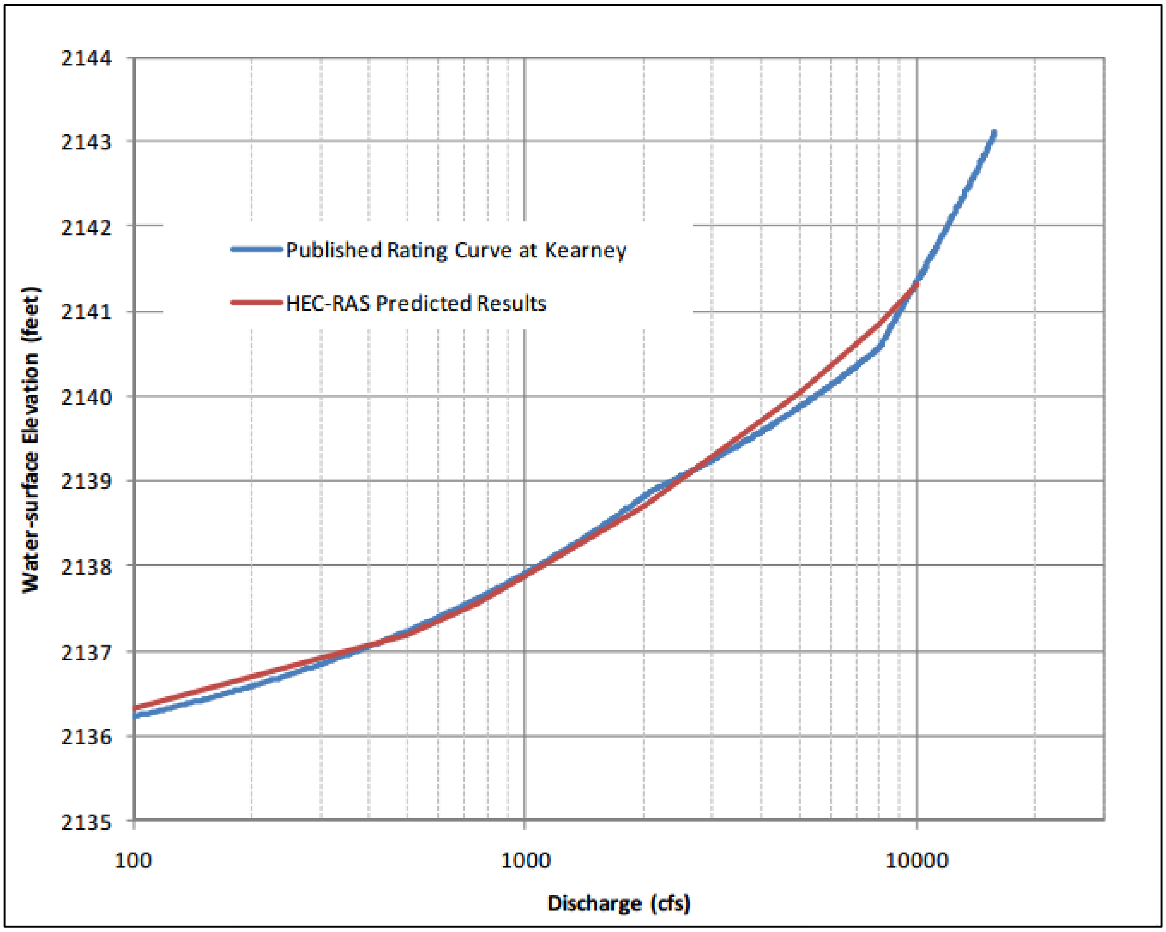


Figure 3. Comparison of water surface elevations predicted by HEC-RAS and published rating curve for USGS Gage No. 06770200 near Kearney, NE (HDR Inc. 2011).

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

Sandbar Height

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

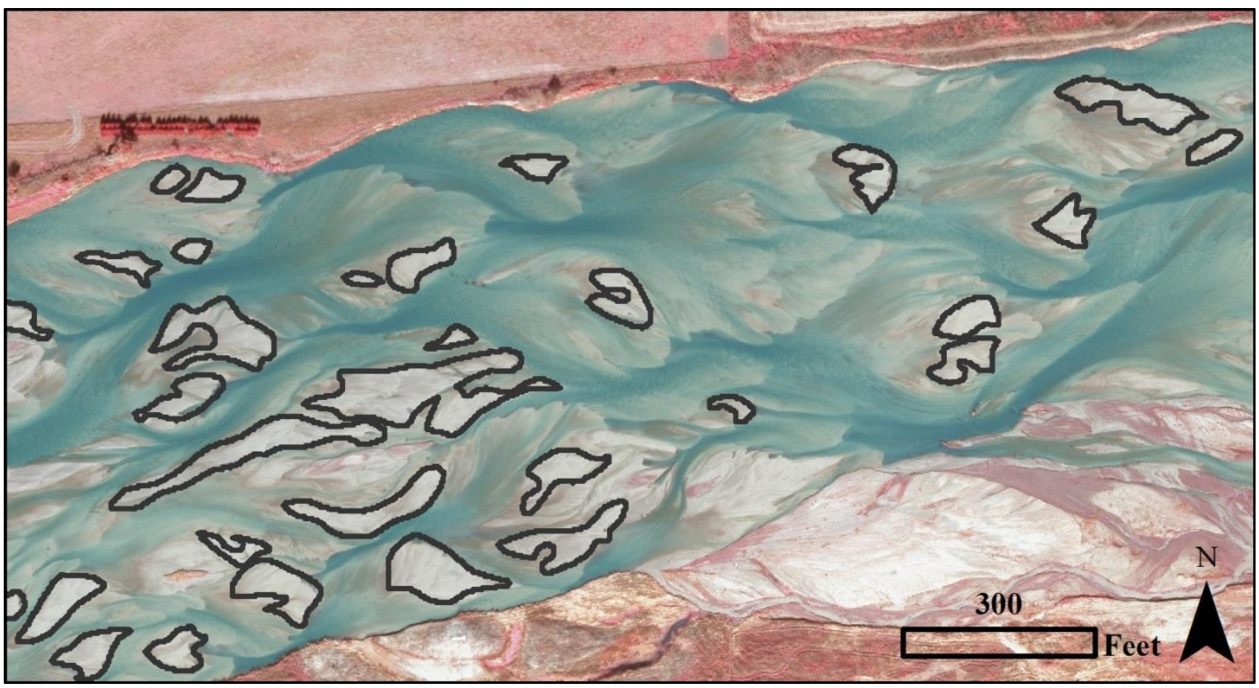


Figure 4. Example of mid-channel unvegetated emergent sandbar area delineations from fall 2010 aerial imagery. Discharge at imagery collection was approximately 850 cfs.

Detailed hypothesis Flow #1 includes the assumption of a balanced sediment budget (Figure 2). As a consequence, the sandbar height analysis area was confined to the lower 58 miles of the AHR (Kearney – Chapman) that is considered to be in long-term sediment balance (Holburn et al. 2006, HDR Inc. 2011;

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 for the 2010 event (8,200 cfs) and a DEM of the modeled peak water surface elevation was exported to ArcMAP. The three-day mean peak discharge was used to standardize height data to the targeted Program peak-flow release duration. The ArcMAP Raster Calculator was used to calculate the difference between bare earth and water surface elevation DEMs. The resultant 3 foot by 3 foot raster layer was converted to a polygon layer (Raster to Polygon function) and raster cells were dissolved into individual sandbars. The new polygon layer was spatially joined to the height values stored in the original raster layer (the result of the raster calculator) and the area of each sandbar was calculated.

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.

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

Results

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

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

Channel Width	1,200 cfs Stage (ft)	5,000 cfs Stage (ft)	8,000 cfs Stage (ft)	Increase from 5,000 cfs (ft)	Increase from 5,000 cfs (%)
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%

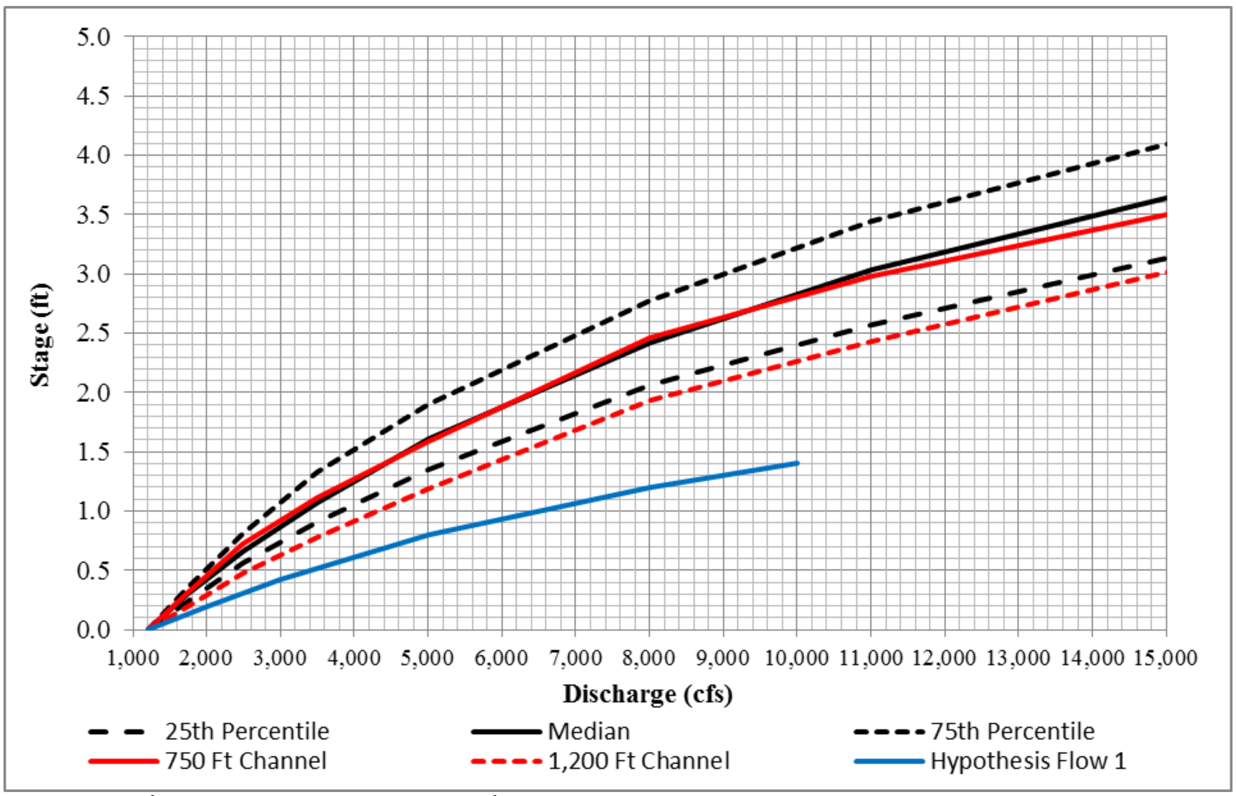


Figure 5. 25th percentile, median and 75th percentile HEC-RAS stage-discharge relationships for AHR channels exceeding 400 ft in width. HEC-RAS stage-discharge relationship for 750 ft and 1,200 ft wide channels. Hypothesis Flow 1 stage-discharge relationship. All relationships are normalized to a datum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

Sandbar Height

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).

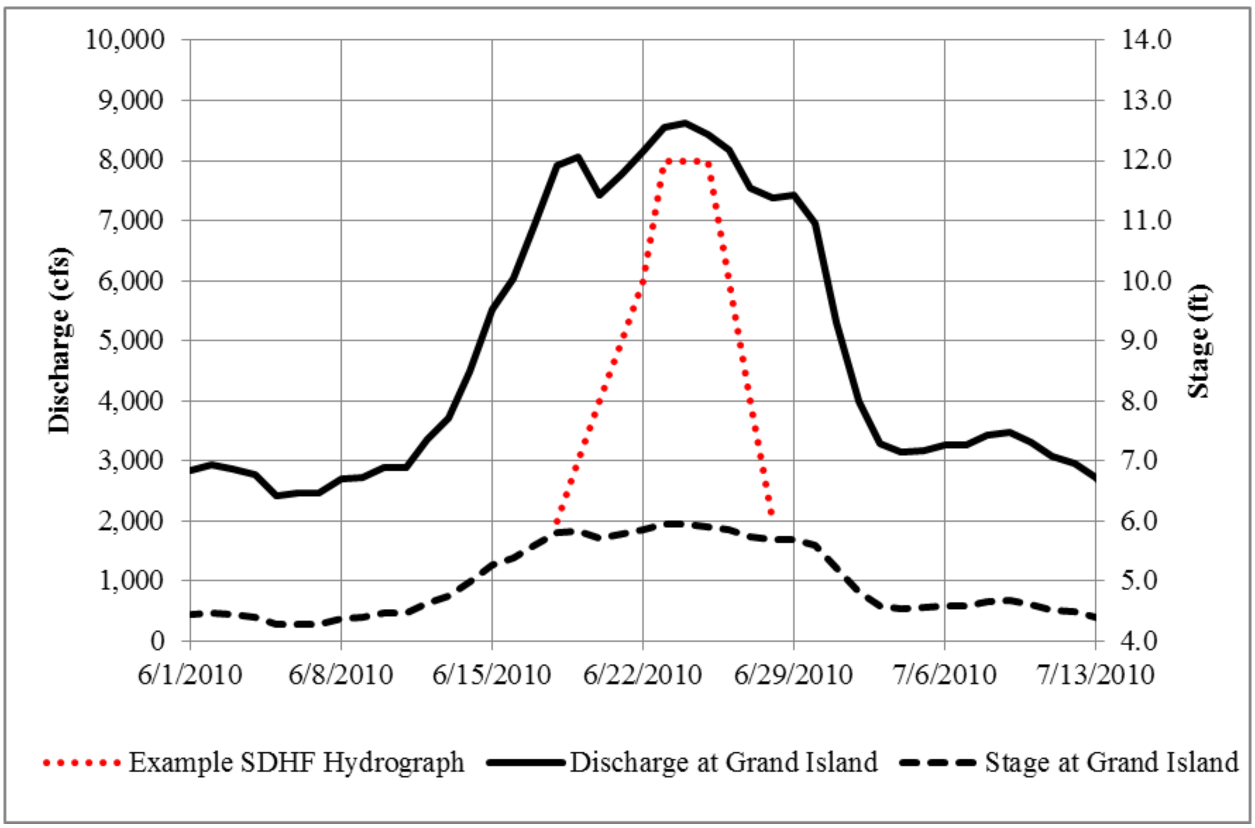


Figure 6. June 2010 natural high flow event hydrograph and example hydrograph for a Short-Duration High Flow release.

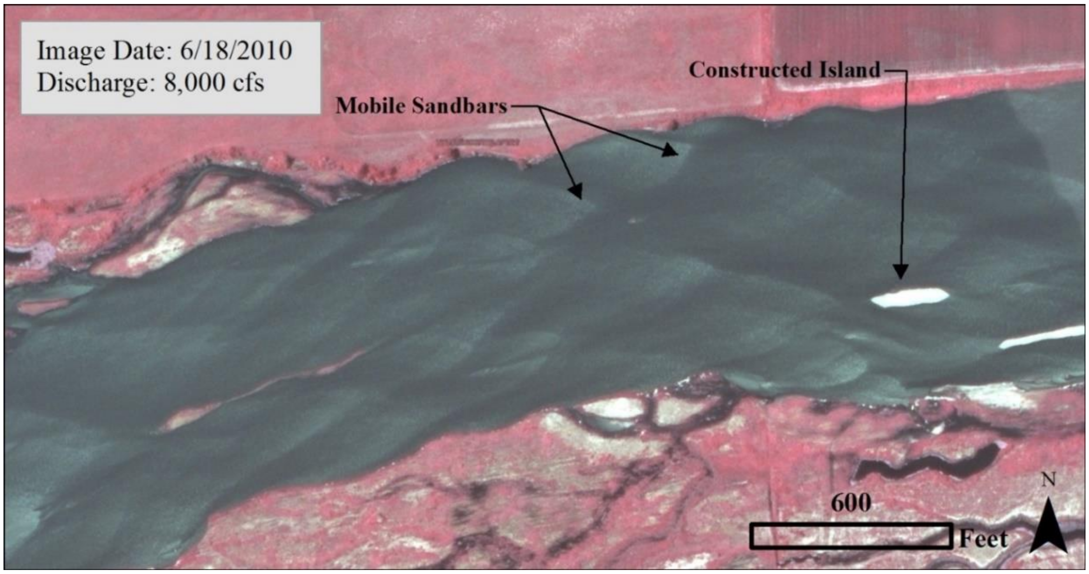


Figure 7. June 2010 aerial imagery at River Mile 206. Submerged mobile sandbars and constructed island habitat are visible in the image.

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

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

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).

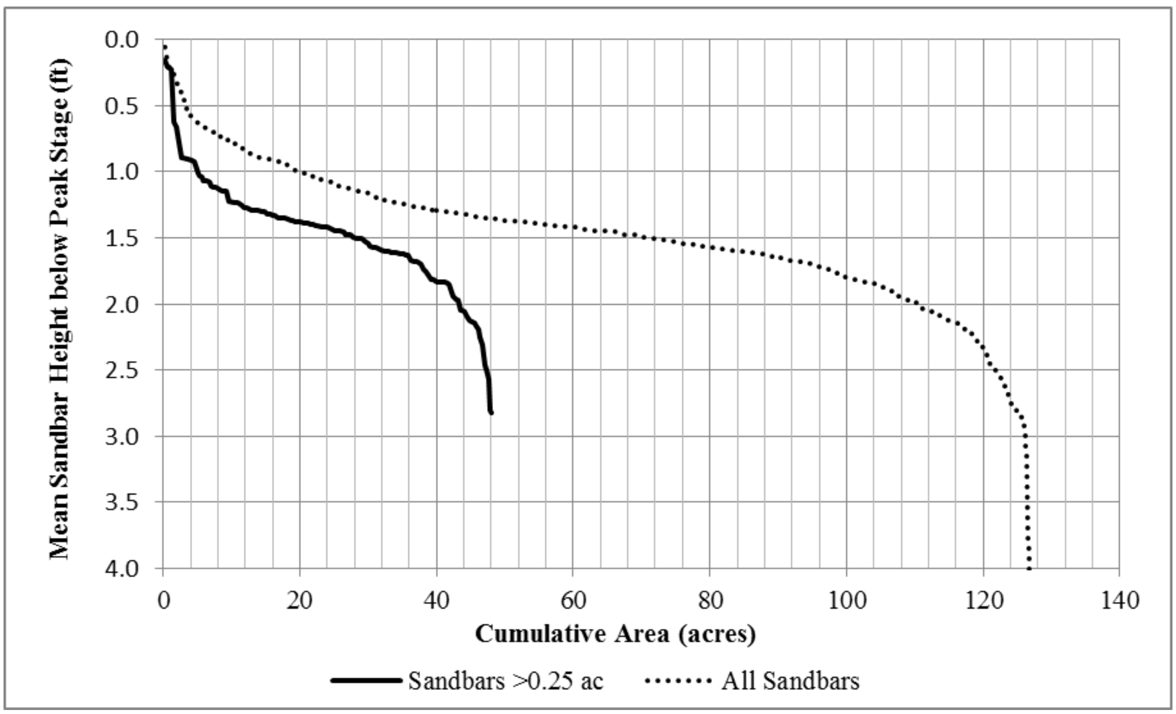


Figure 8. Cumulative distributions of sandbar area below peak stage following the 2010 natural high flow event.

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.

Comparison of Analysis Results with 2011 and 2013 Natural High Flow Event Hydrology and Sandbar Response

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).

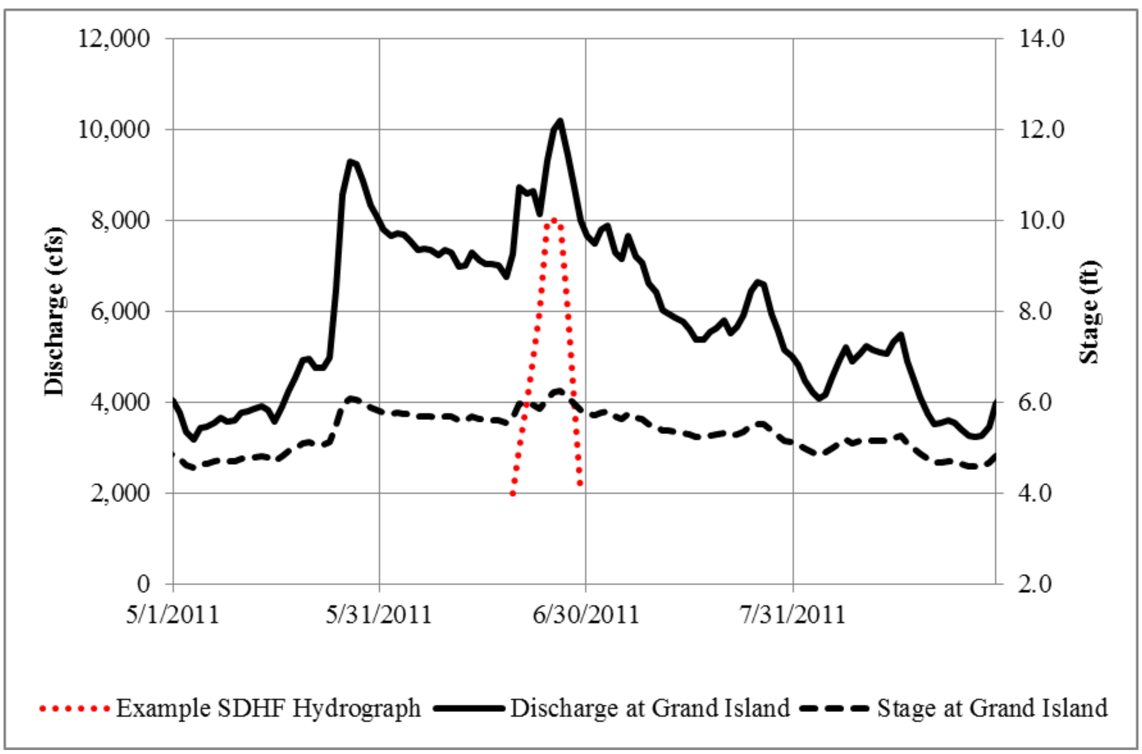


Figure 9. 2011 natural high flow event hydrograph and example hydrograph for a Short-Duration High Flow release.

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.

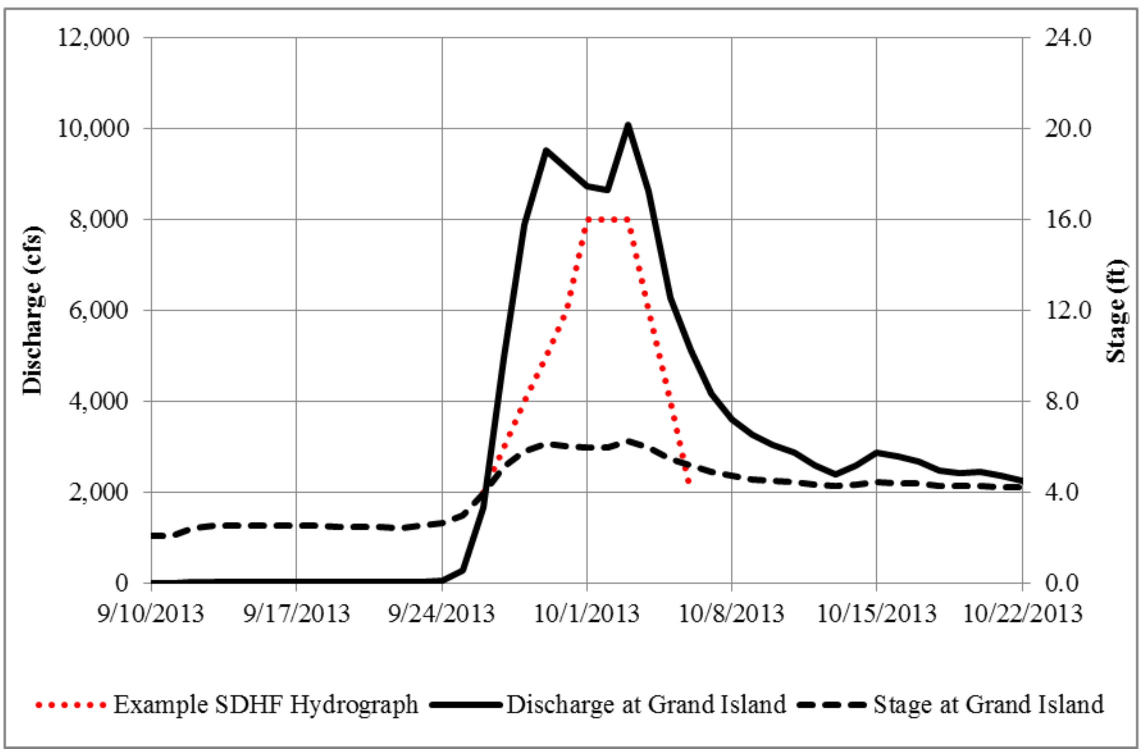


Figure 10. 2013 natural high flow event hydrograph and example hydrograph for Short-Duration High Flow release.

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 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.

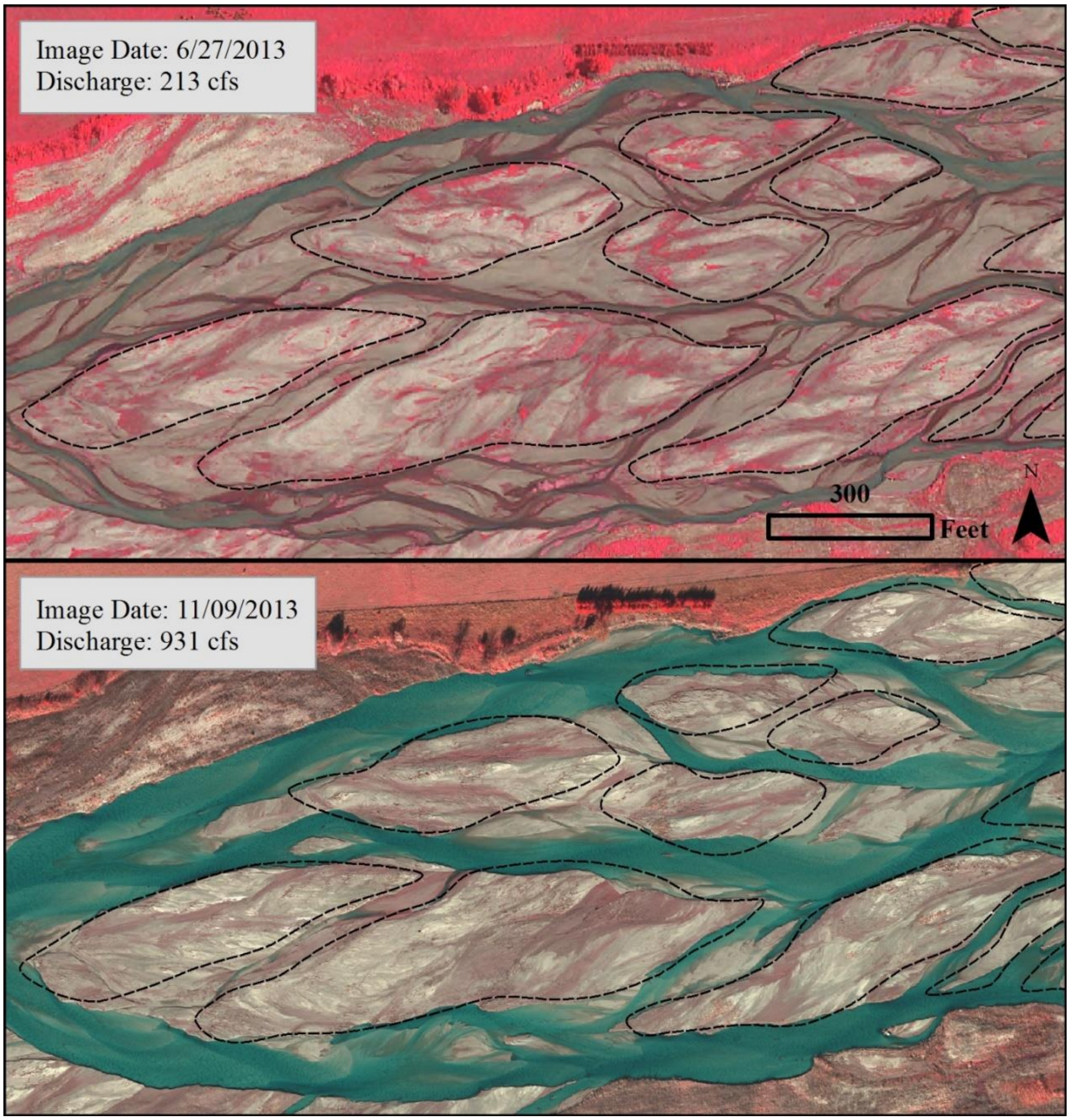


Figure 11. Comparison of bedforms at River Mile 204 before and immediately following the fall 2013 natural high flow event. The high-flow even degraded the unvegetated thalweg and deposited sediment on existing vegetated sandbars.

Potential for SDHF to Produce Suitably-High Sandbars

Sandbar Height in Relation to the Program's Minimum Height Suitability Criterion

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. Based on previously discussed stage discharge relationships and average sandbar height of 1.5 ft below peak stage, a full SDHF magnitude release of 8,000 cfs would be expected to produce mean sandbar heights 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 channels (Figure 12). Predicted mean bar heights at both the minimum (750 ft) and maximum (1,200 ft) channel width targets are somewhat below the minimum suitability criterion.

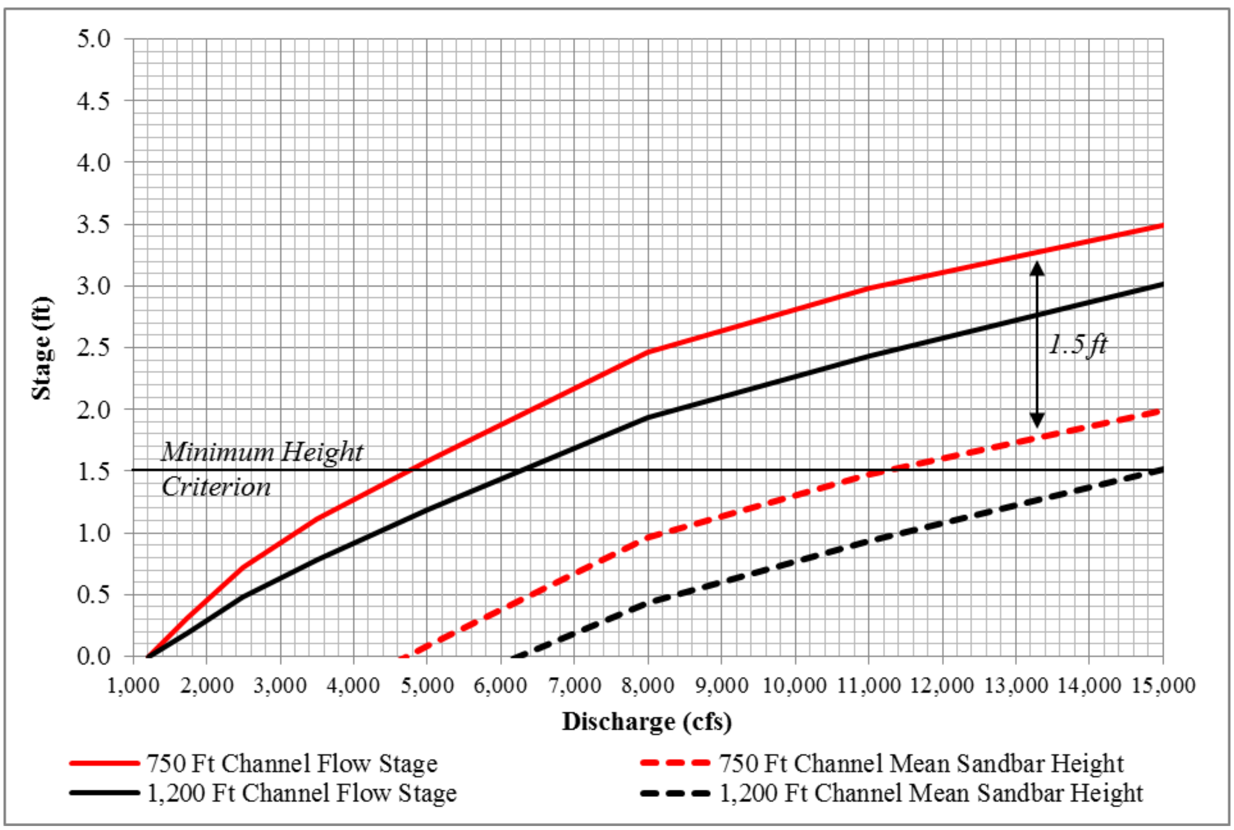


Figure 12. Stage-discharge and mean sandbar height relationships in comparison to the Program's minimum height suitability criterion of 1.5 ft above 1,200 cfs stage. The extrapolated sandbar height 1.5 ft below peak stage is based on observations following the 2010 high flow event.

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).

Table 4. Discharge exceedance at mean SDHF sandbar stage for the period of 1942-2013.

Channel Width	Mean SDHF Sandbar Stage (ft)	Discharge at Mean SDHF Sandbar Stage (cfs)	Percent of Years Discharge Exceeded (1942-2013)			
			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%

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 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 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 initiated on sandbars created as a result of SDHF releases, they would likely be inundated during the nesting season in many years. Flow releases of greater magnitude than SDHF would likely increase the potential to produce sandbars meeting the minimum height criterion. Based on the stage-discharge and mean sandbar 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 contemplated peak flow releases of this magnitude.

As previously discussed, the sandbar height-area distribution used in this analysis was derived from a single natural high flow event that was similar in magnitude to a SDHF release, but was two weeks longer in duration. The reliance on a single flow event is an obvious limitation of the analysis given that event magnitude, duration and hydrograph shape may all influence sandbar area-height distributions in the AHR. However, we believe that use of observed heights from even one event facilitates the development of more realistic and defensible predictions of the potential for species productivity than the assumption that bars 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 height potential in the AHR over the remainder of the First Increment of the Program.

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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

Abstract

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

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).

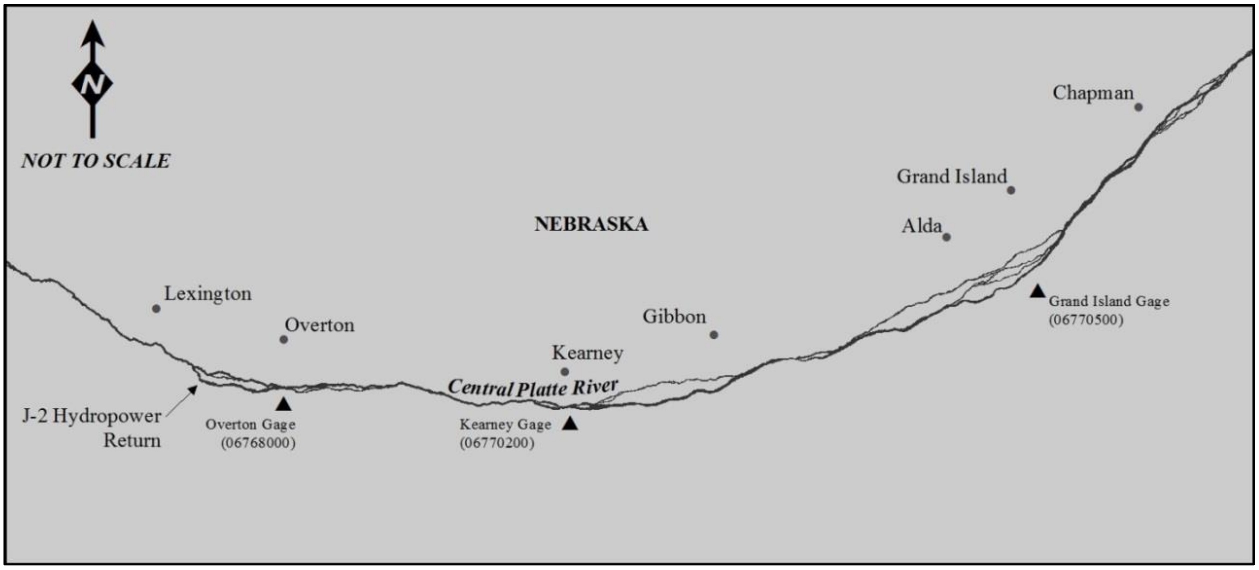

Figure 1. Associated Habitat Reach of the central Platte River extending from Lexington downstream to Chapman, NE.

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),

2) offsetting the average annual sediment deficit of approximately 150,000 tons in the west half of the AHR through augmentation of sand (Sediment), and

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

Each of the three cited investigations had unique objectives and employed a different definition of channel width (Figure 1) which influenced the authors' methods and interpretations of analysis results. In Ziewitz et al. (1992), mean channel widths were area-based and excluded permanently vegetated islands from the calculation and the authors concluded the species used wide channels with large areas of dry, bare sand. Elliott (2011) included vegetated islands in channel width calculations and concluded narrower channels, with less potential for occurrence of vegetated islands, were more suitable for tern and plover 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 and the species did not use anabranch (side) channels. These differences made it difficult for the EDO to conclude with confidence these three analyses collectively point to species selection for wide channels. In 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 inference that can be drawn from such studies (see Discussion).

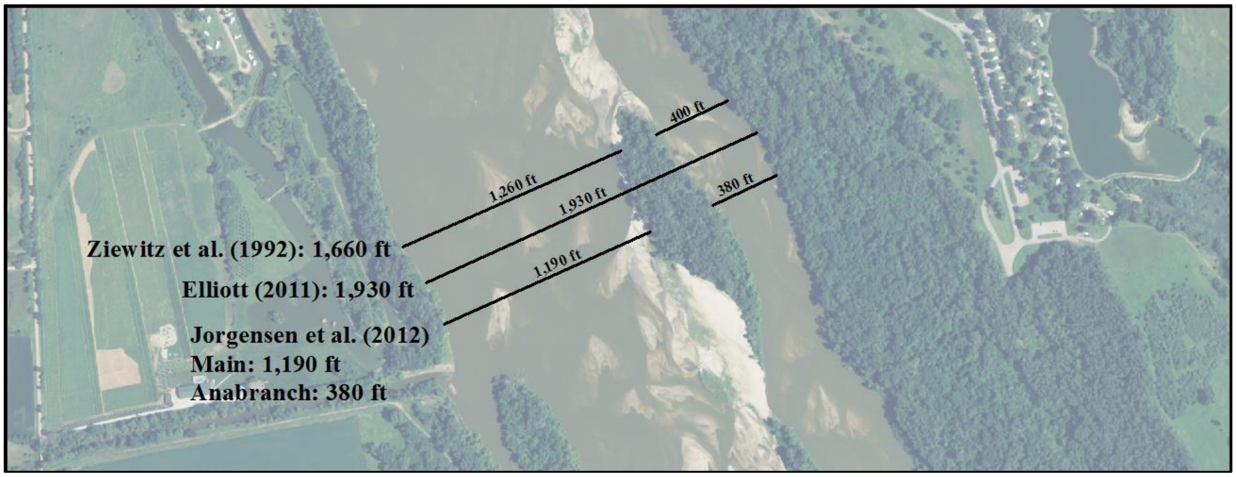

Figure 1. Example of influence of different width definitions on channel width measurements. The 'channel width' in the example ranged from 380 ft to 1,930 ft depending on whether the Jorgensen et al. (2012) or Elliot (2011) definition was used.

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

Methods

Study Location

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

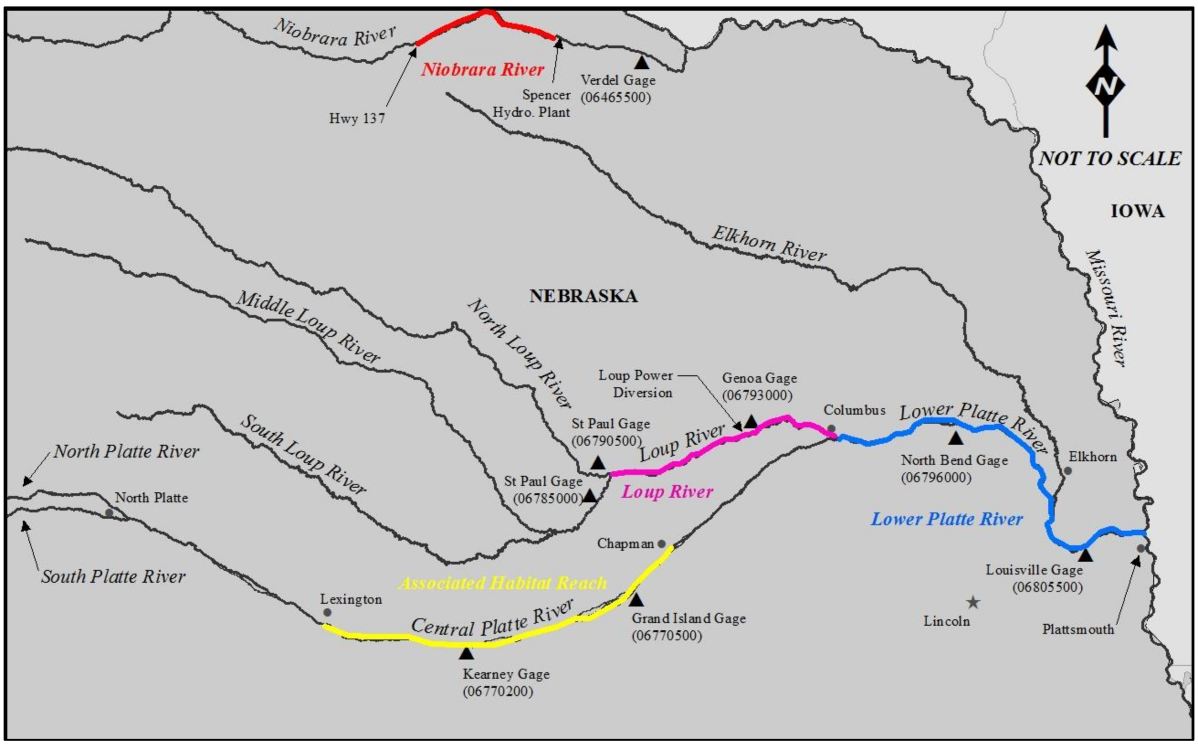

Figure 2. Study location map showing analysis segments on the Niobrara, Loup, Associate Habitat Reach of the central Platte River and lower Platte River.

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 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 ≥ 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.

Aerial Imagery

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

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

Nest Data Year	NAIP Imagery Year Used for Analysis		
	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

Channel Width Measurements

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

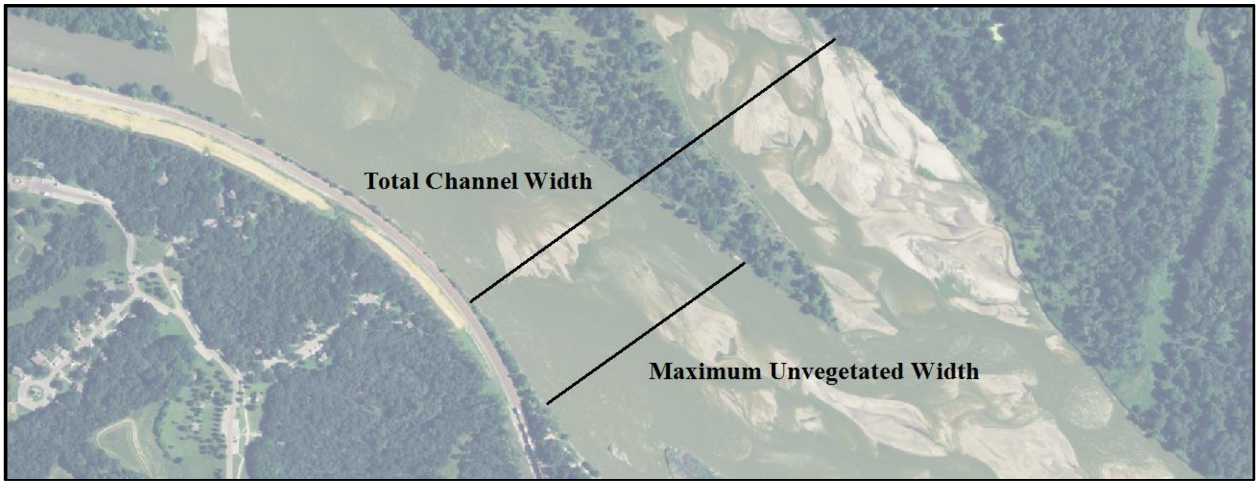

Figure 3. Examples of total and maximum unvegetated channel width metrics used in our investigation.

Data assimilation and processing

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

Relationship between total channel width and maximum unvegetated width

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

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

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.

Results

Relationship between total channel and maximum unvegetated widths

The modeled relationship between total channel and maximum unvegetated width (Figure 4) for the lower Platte River segment indicated the majority of channels are consolidated and free of vegetated 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 there was a high degree of variability present in the segment width data. In the lower Platte River segment, channels as narrow as 1,100 ft were broken (i.e., contained vegetated islands) and channels as wide as 2,300 ft were fully consolidated (i.e., no vegetated islands; Figure 4). The majority of consolidated channels, 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 overall total channel widths were much narrower. Most fully-consolidated channels in the Loup River segment occurred when total channel width was <1,200 ft.

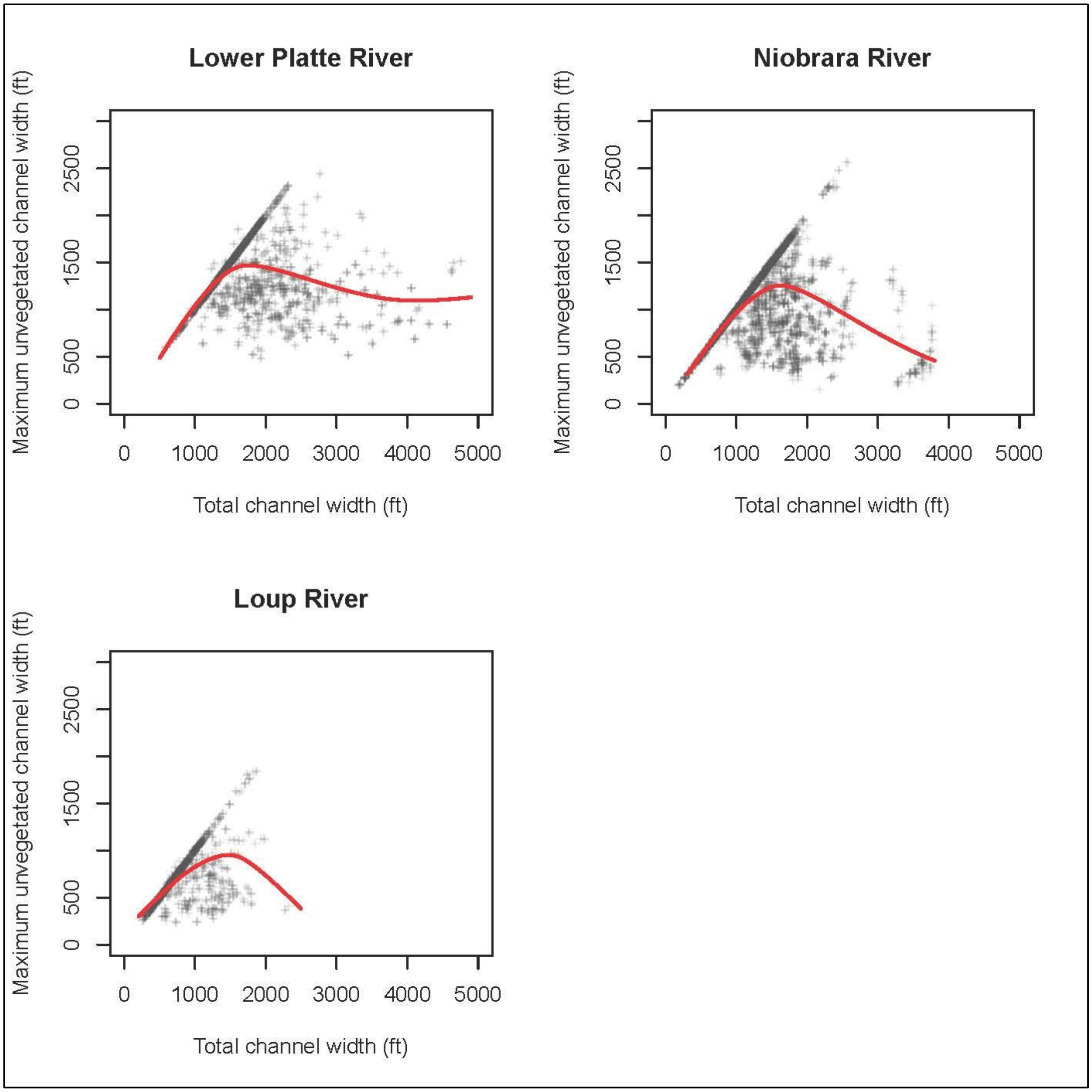

Figure 4. Relationship between total channel width and maximum unvegetated width for the lower Platte, Niobrara, and Loup River segments.

Relationship between nest incidence and channel width

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 70% occurred in channels with a maximum unvegetated width >1,200 ft. The majority (57%) of nest sites 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 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	

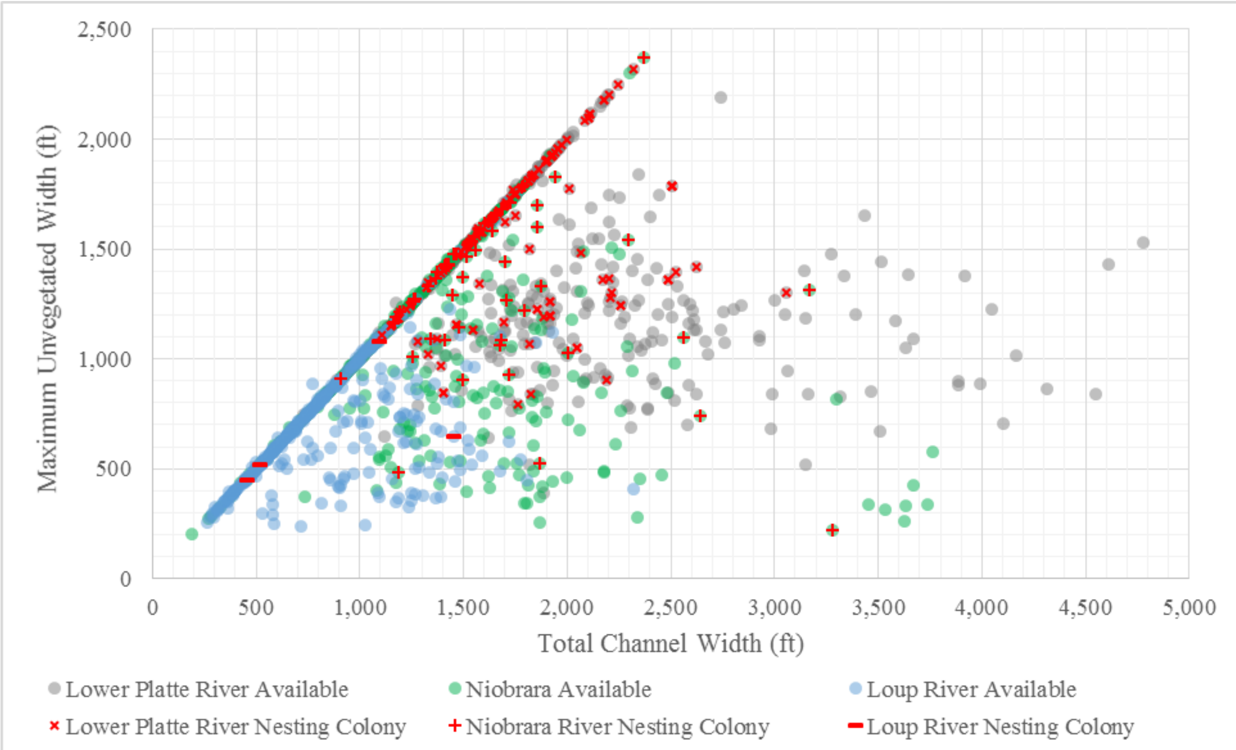

Figure 5. Total channel width and maximum unvegetated width at available and species nesting colony locations in the lower Platte River, Niobrara River, and Loup River segments. Note, nesting colony locations are shown for all years. Available locations from only 2012 are shown to simplify visual comparisons.

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

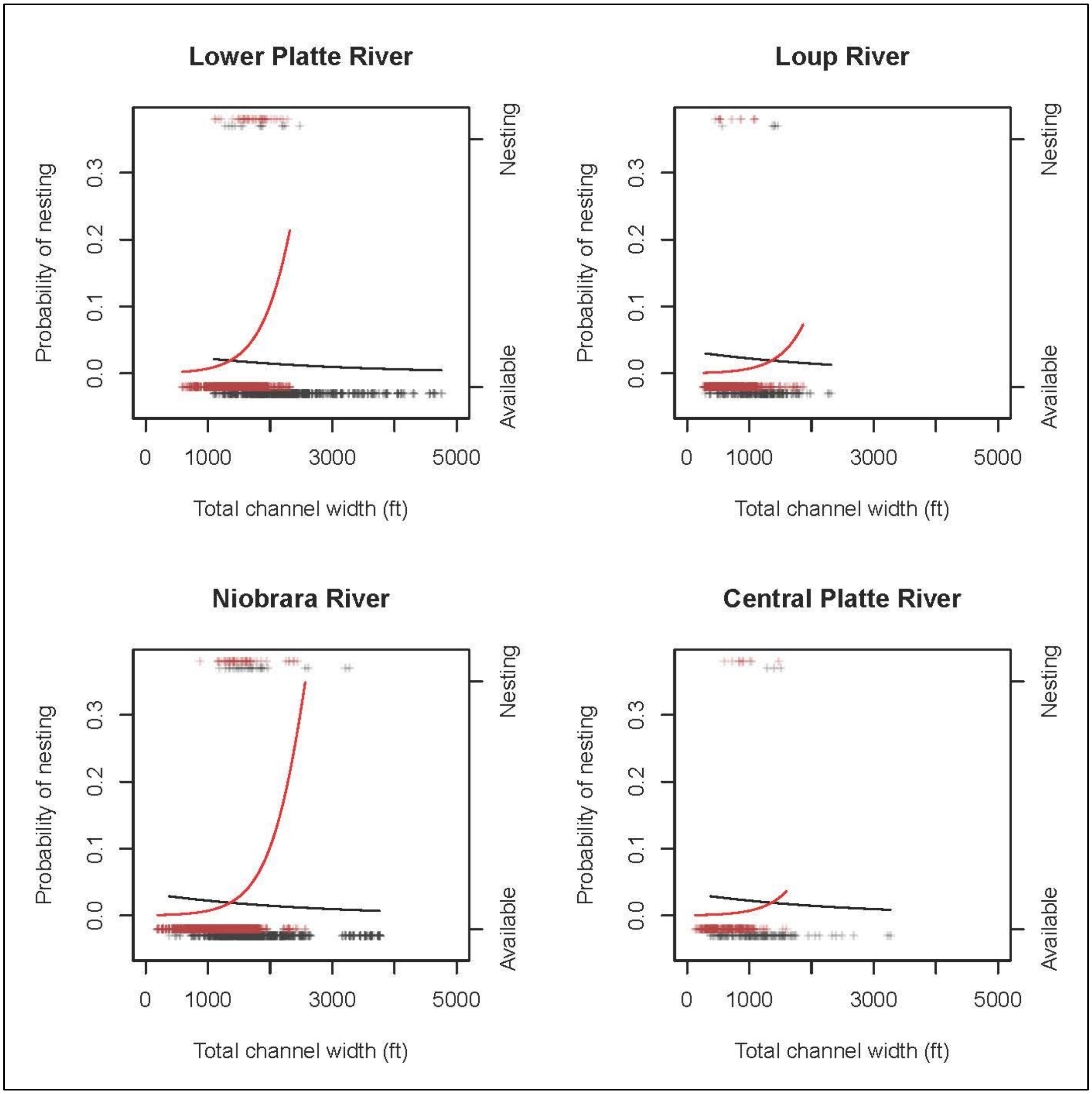

Figure 6. Predicted probability of nesting for channel segments that occur as one continuous unbroken width (red) and broken width (black) for the lower Platte (upper left), Loup (upper right), and Niobrara (lower left) from best-fit model. Note the predicted probability of nesting is only plotted over 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.

In the AHR segment, there were few unbroken channel segments where total channel width exceeded 1,000 ft and most of those occurred in managed reaches. As a result, most of the AHR segment would have a very low probability of nest initiation (see Figure 6). This is evident in the limited overlap between channel widths in the main channel of the AHR and channel widths selected by the species in the other river segments (Figure 7).

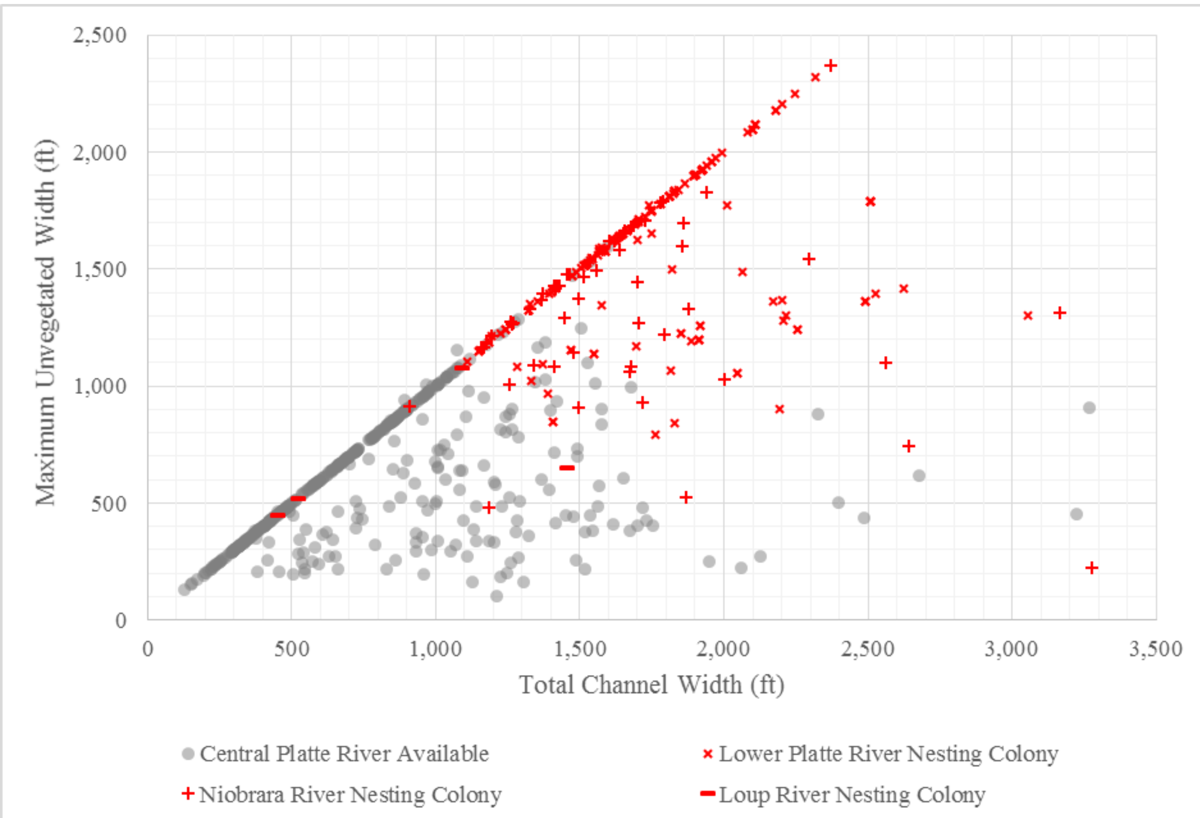

Figure 7. Comparison of available total channel widths in the main channel of the Associated Habitat Reach of the central Platte River and species nesting colony locations in the lower Platte River, Niobrara River and Loup River segments. Note channel measurements at available locations were obtained from 2012 NAIP imagery and nesting colony locations were obtained from all study years (see table 1).

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 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 present at the available or nonuse locations. The implication is that we cannot determine from our data if colony nest site selection depends on channel width or if terns and plovers choose these sites because suitable sandbars for nesting only occur in wide channels. It is also possible that the presence of nesting colonies is due to some combination of both sandbar forming and habitat selection process that are responsible for the relationship between colony incidence and channel width. This caution of inference, however, is not unique to our study and is also a potential confounding factor in Ziewitz et al. (1992), Elliot (2011) and Jorgensen et al. (2012).

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:

1. 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.
2. Probability of nest incidence increased with increasing channel width as long as channels were not broken by vegetated islands.
3. In channels broken by vegetated islands, probability of nest incidence was low and did not increase 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.

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.

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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APPENDIX A – DATA ANALYSIS DOCUMENTATION

Electronic copies of data, analysis code, and a data analysis tutorial are available to Program participants at:

https://www.platteriverprogram.org/sites/Intranet/NonPublicProgramLibrary/Chapter%204%20Width%20Analysis%20Data%20and%20R%20code.zip

Others may obtain this data from the Executive Director's Office by emailing Jason Farnsworth at farnsworthj@headwaterscorp.com 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

Abstract

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

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 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).

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

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

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.

Methods

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).

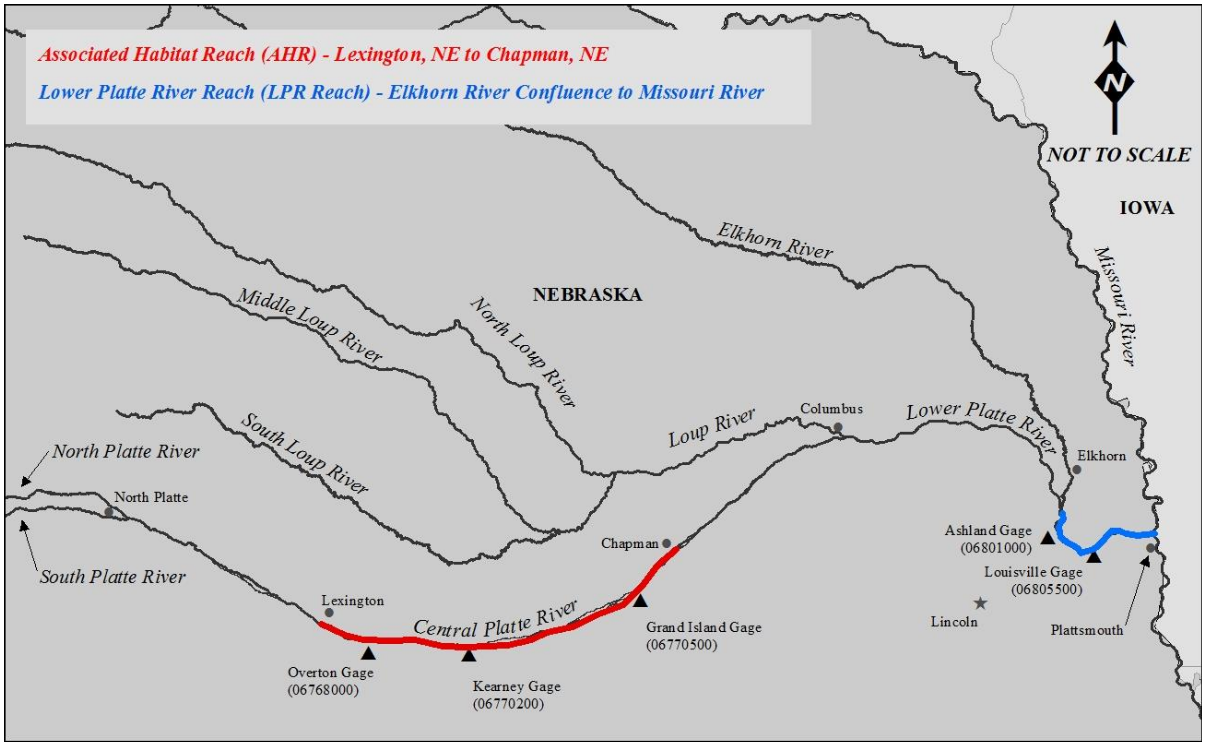

Figure 1. Map of study area identifying analysis reaches and stream gages.

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

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).

Least Tern and Piping Plover Nest and Brood Exposure Data

Least tern and piping plover nest initiation dates were compiled from central Platte River monitoring data for the period of 2001-2013 (Baasch 2014). Standardized Program nest exposure periods (nest initiation to chick fledging) were used to establish the range in the nesting and brood rearing period for each species. The 5th and 95th percentile nest initiation dates were used to define the nesting and brood rearing season. Using the 5th and 95th percentile dates eliminated the disproportionate effect of early and late nests on season length. The nesting and brood rearing season length for piping plovers was 1 May 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 2008-2013 fell within the windows described above (Brown and Jorgensen 2008, 2009, and 2010, Brown et al. 2011, 2012, and 2013).

Table 1. Associated Habitat Reach (AHR) 90th 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 ≥1 egg) was first observed or by egg floating techniques.
***Hatch date was determined by observations of ≥1 chick or was estimated based on chick age.
****Fledge date was determined by earlier date between first observing sustained flight and a predefined 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.

Historical Central Platte River Flow Record Extension

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 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 of 1910 near North Platte and 1913 to 1914 above Lake McConaughy (Stroup et al., 2006). As such, a flow record extension technique (Maintenance of Variance Extension Type 1; Hirsch 1982) was used to estimate warm season mean daily flows on the Platte River near Overton, Nebraska from 1895 to 1914 using mean daily flows from the North Platte River near North Platte and above Lake McConaughy. Estimating flows within the AHR from North Platte River flow data was justified because the large majority of historical flows through the Platte River have been provided by the North Platte River (Stroup et al., 2006). A high correlation existed between the logarithm of mean daily flow on the Platte River at Overton and on the North Platte River near North Platte (r = 0.72) and above Lake McConaughy (r = 0.72) during the 1902 to 1906 period of concurrent flow observations.

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_1 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:

$$\tilde{y}_i = a + bx_i \quad [1]$$

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:

$$\tilde{y}_i = m(y_1) + \left[\frac{s(y_1)}{s(x_1)}\right][x_i - m(x_1)] \quad [2]$$

where $m(y_1)$ is the sample mean of the observed daily flows at the location of interest during N_1, $s(y_1)$ is the sample standard deviation of the observed daily flows at the location of interest during N_1, $s(x_1)$ is the sample standard deviation of the observed daily flows at the alternative location during N_1, and $m(x_1)$ is the sample mean of the observed daily flows at the alternative location during N_1. 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 1914 for the Platte River near Overton, Nebraska. The first application was to use the North Platte River near North Platte, Nebraska as the alternative location, which allowed for estimates to be made for all years of interest at Overton with the exception of 1910. The second application was to fill in the 1910 void at Overton using the North Platte River above Lake McConaughy as the alternative location. The calculated parameter values used in Equation 2 when applying the MOVE.1 method have been shown in Table 2 for both applications and were calculated using concurrent N_1 observed data at each of the locations. The slight differences in parameter values at the location of interest calculated from observed N_1 flows were attributed to different dates of concurrent flows between the location of interest and both alternative locations. More than 5 years of overlap in flow observations at each location were available during later time periods, and thus available for inclusion in the N_1 period of flows used to calculate model parameters. It was assumed on and off-channel development (e.g., storage, accretions, and depletions) were at a minimum during the earliest flows, making them the most useful.

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

Application 1:		**Application 2:**	
North Platte River near North Platte, Nebraska		North Platte River above Lake McConaughy, Nebraska	
N_1	1902 - 1906	N_1	1902 - 1906
N_2	1895 - 1901 1907 - 1909 1911 - 1914	N_2	1910
$m(y_1)$	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

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

Modeling the Availability of Emergent Sandbars

Discharge

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

Stage-Discharge Relationships

The use of hydraulic relationships at gage locations for least tern 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 (Jorgensen 2009, Catlin et al. 2010). Comparisons of stage-discharge relationships at gage locations and nest sites were developed to address this issue. During the period of 2007-2013, in-channel nesting occurred in the AHR at River Mile 199 and 230 on sandbars that had been disked and subsequently overtopped by peak flow events. Modeled HEC-RAS stage-discharge relationships at these locations (See Chapter 3 for a description of the model) were compared to USGS stage-discharge relationships at the Kearney and Grand Island gages (Figure 2). Based on a visual comparison, the stage-discharge relationship at the Grand Island gage (06770500) appears to be representative of the relationships at the two observed nesting locations.

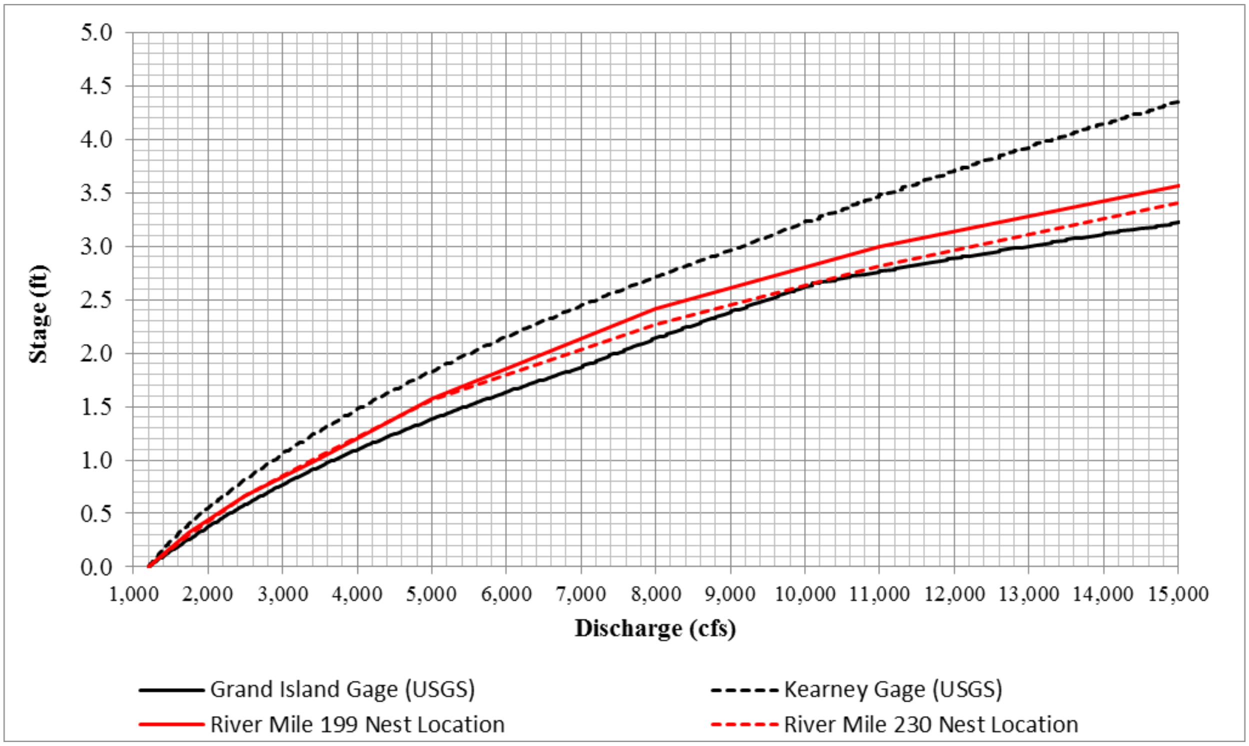

Figure 2. Comparison of Grand Island (06770500) and Kearney (06770200) stream gage stage-discharge relationships and HEC-RAS model stage-discharge relationships at River Mile 199 and 230 nest locations in the AHR. All relationships normalized to a stage of 0.0 ft at 1,200 cfs for comparison. The stage-discharge relationship at the Grand Island gage is within 0.3 ft of the relationships at the nest locations throughout the discharge range and the shape of the curves is very similar.

In the LPR Reach, a Federal Emergency Management Agency (FEMA) HEC-2 hydraulic model was used to make a similar comparison (HDR Inc. 2009). Stage-discharge relationships at the Louisville and Ashland gages were compared to modeled stage-discharge relationships in the Cedar Creek and Gun Club reaches, which have consistently supported nesting (Brown and Jorgensen 2008, 2009, and 2010, 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 highest discharges (Figure 3).

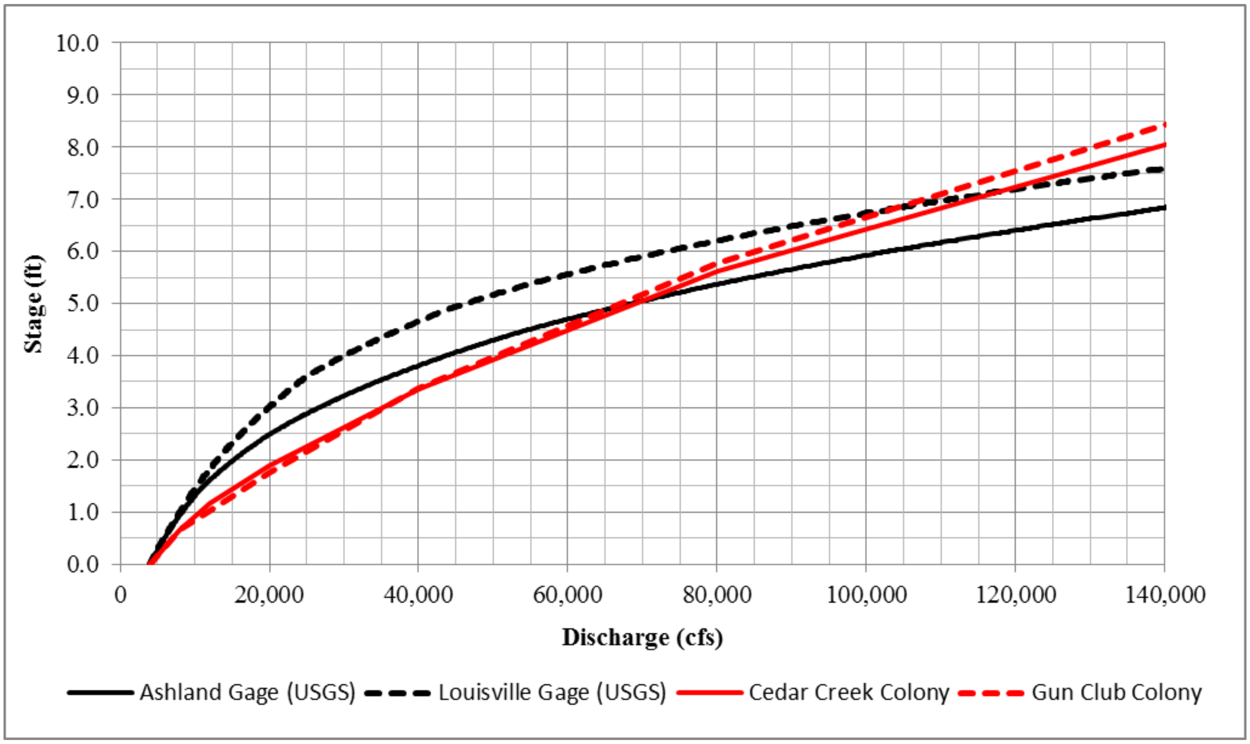

Figure 3. Comparison of Louisville (06805500) and Ashland (06801000) stream gage stage-discharge relationships and FEMA HEC-2 model stage-discharge relationships at Cedar Creek and Gun Club species colony locations in the LPR Reach. All relationships normalized to a stage of 0.0 ft at 4,000 cfs for comparison.

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

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

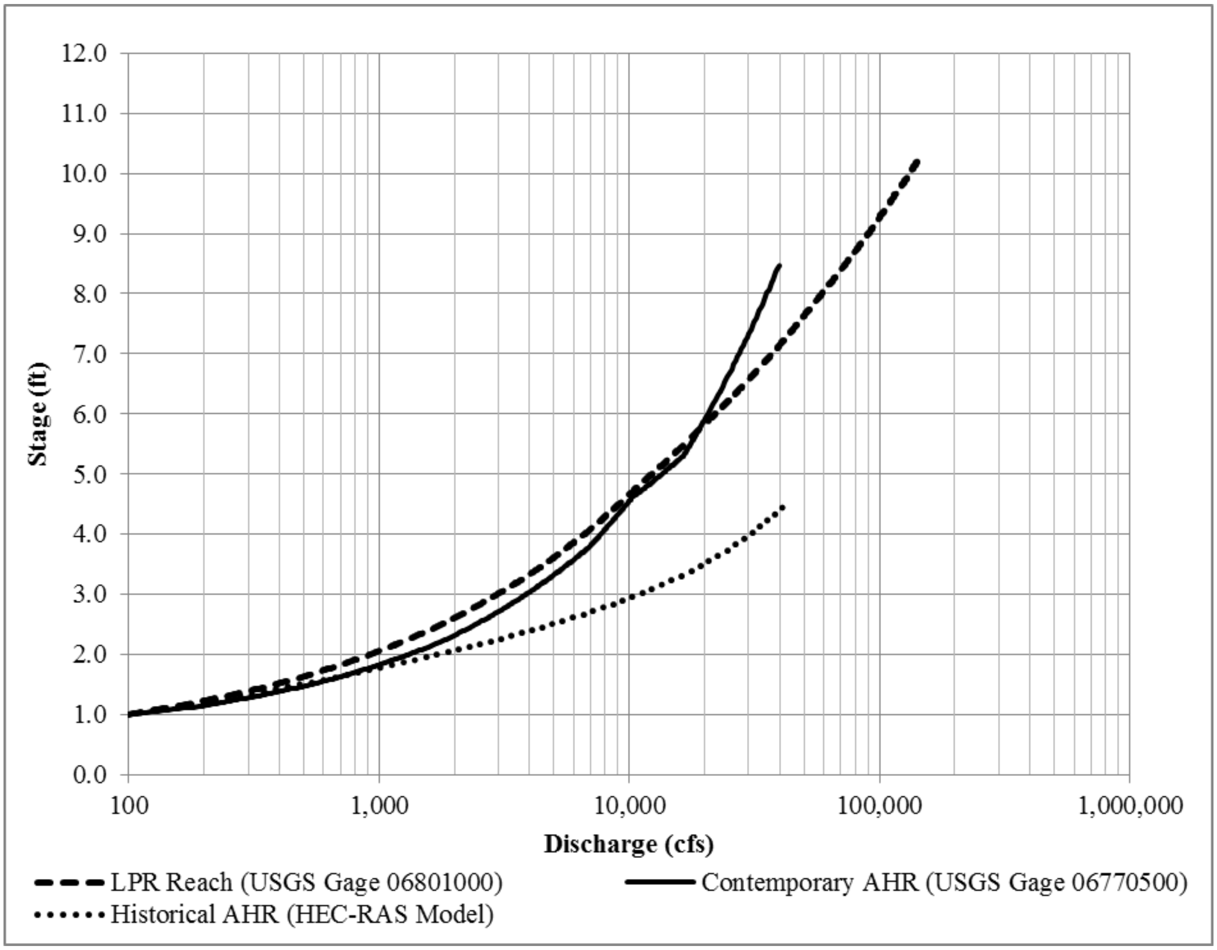

Figure 4. Stage-discharge relationships used for model reaches. All relationships normalized to a stage of 1.0 ft at 100 cfs for comparison.

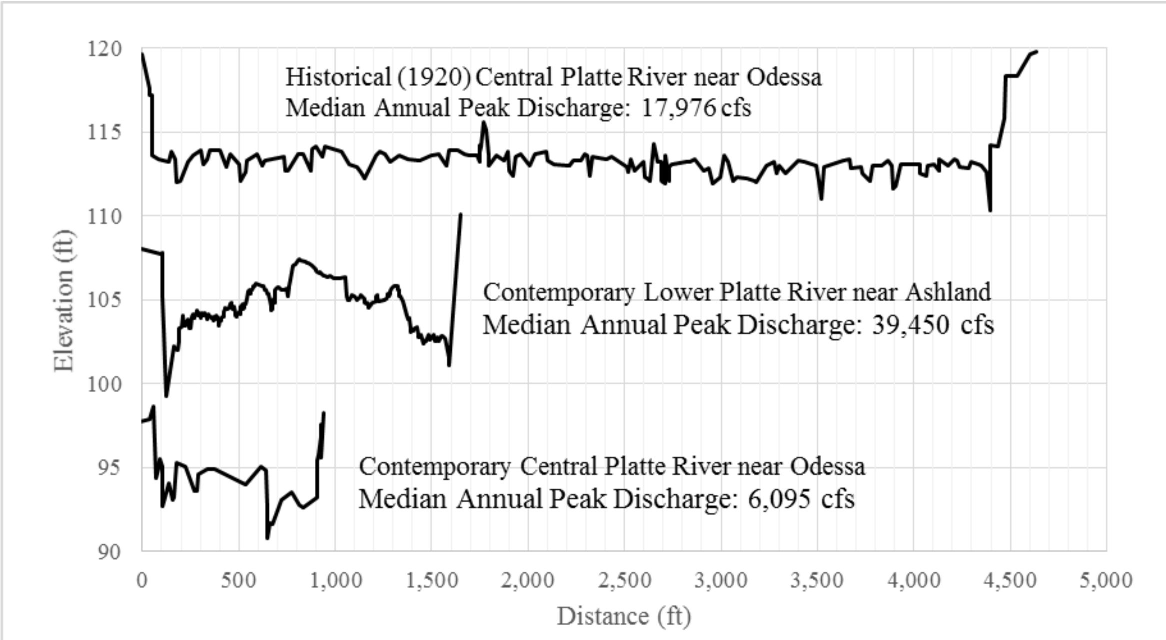

Figure 5. Channel width and median annual peak discharge comparison for model reaches. Note, the historical AHR was substantially wider than the contemporary LPR Reach and median annual peak flow was much lower.

Sandbar Heights

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

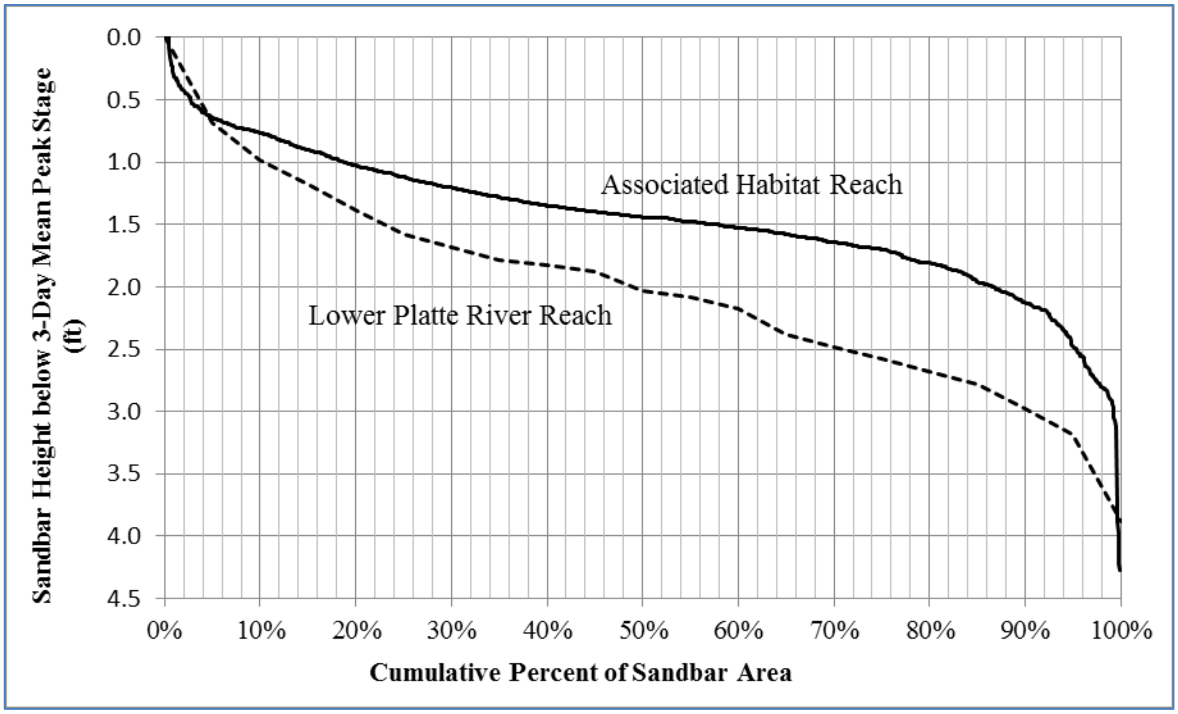

Figure 6. Cumulative distribution of heights of sandbars formed during the 2010 natural high-flow event for model reaches.

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

Emergent Sandbar Availability Model

A simple spreadsheet model was developed to estimate the annual availability of emergent sandbar habitat during the nesting season using discharge records, stage-discharge relationships, and observed sandbar heights in the central and lower Platte River segments. The modeling approach was similar to the habitat analysis performed for the Program EIS (DOI 2006) with the exception that assumption of sandbars building to annual peak stage was replaced with sandbar heights following the 2010 natural high-flow event (See Chapter 3). Results were evaluated against the USFWS flow requirements for nesting to infer how 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	
$DISCH_{HAB}$	Maximum of mean daily flow (cfs) from 1 January of the previous year through 1 July of analysis year. Considered to be the discharge that controlled sandbar height in analysis year
$STAGE_{HAB}$	River stage (ft) associated with $DISCH_{HAB}$
BAR HEIGHT	Sandbar height (ft) below peak stage.
$STAGE_{BAR}$	Stage (ft) of sandbars
$DISCH_{DAILY}$	Daily river discharge (cfs)
$STAGE_{DAILY}$	Daily river stage (ft)
Model Output Variables	
SUCCESS $WINDOW_{PLOVER}$	Number of days when piping plover nests could be initiated, incubated, and hatch and the chicks successfully fledged without being inundated.
SUCCESS $WINDOW_{TERN}$	Number of days when least tern nests could be initiated, incubated, and hatch and the chicks successfully fledged without inundation.

The model included the following calculations for each analysis year:

1. The maximum daily discharge for the period beginning 1 January in the year prior to each analysis year and ending on 1 July of the analysis year was identified. This was considered to be the habitat-forming discharge ($DISCH_{HAB}$) that controlled the height of sandbars in the analysis year. The 1.5 year period for identification of $DISCH_{HAB}$ allowed for sandbar persistence through two growing seasons.

2. Stage-discharge relationships (Figure 6) were used to determine the stage ($STAGE_{HAB}$) of the habitat-forming discharge.
3. Sandbar height (BAR HEIGHT) relative to peak stage for each reach was subtracted from $STAGE_{HAB}$ to determine the stage of sandbar height ($STAGE_{BAR}$).
4. Stage-discharge relationships were used to convert daily discharge ($DISCH_{DAILY}$) to daily stage ($STAGE_{DAILY}$) during the least tern and piping plover nesting and brood rearing seasons of each year.
5. Daily river stage ($STAGE_{DAILY}$) was compared to sandbar stage ($STAGE_{BAR}$) to determine if bar height exceeded river stage (i.e., were emergent).
6. The maximum number of contiguous days during the nesting and brood rearing seasons when bar height exceeded stage was identified.
7. The period for successful nesting and brood rearing (64 days for piping plovers and 49 for least terns; Table 1) was subtracted from this total to determine the number of days during each nesting season when a nest could have been initiated and successfully fledge chicks without 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.

Analysis of Model Sensitivity to Stage-discharge Relationships and Sandbar Height

Model stage-discharge relationships (stage per unit discharge) and BAR HEIGHT values were increased and decreased by increments of 25% and 50% to evaluate the sensitivity of model output (SUCCESS WINDOW) to each of these model inputs separately and in combination. The percent of analysis years when successful nesting was possible (SUCCESS WINDOW > 0) was calculated along with percent change from baseline model results. Sensitivity analysis matrices are located in Appendix A.

Analysis of Model Results in Relation to Flow Requirements for Nesting

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

The flow requirement for creation of "high" sandbars (DOI 2006) is ambiguous. Accordingly, the analysis of this requirement was limited to a simple comparison of sandbar height relative to mean annual river stage. Mean annual discharge was calculated for each analysis year and the stage associated with that discharge was compared to sandbar stage ($STAGE_{BAR}$). Box plots were developed to facilitate a comparison of reaches.

<u>Requirement 2 – Flow recede early in the nesting season to allow birds to initiate nests</u>

The number of consecutive days at the end of each annual nest initiation period with sandbar stage ($STAGE_{BAR}$) exceeding river stage was identified. Annual values were binned to identify the number of years when sandbars were emergent for various periods of time.

<u>Requirement 3 – Flows need to remain low enough to avoid inundation after nest initiation</u>

Much of the observed species brood rearing occurs during the months of July and August. (Table 1). Accordingly, the analysis for requirement 3 focused on identifying the frequency of sandbar inundation during those months. Daily river stage was compared to sandbar stage ($STAGE_{BAR}$) 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 each analysis period.

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.

Results

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

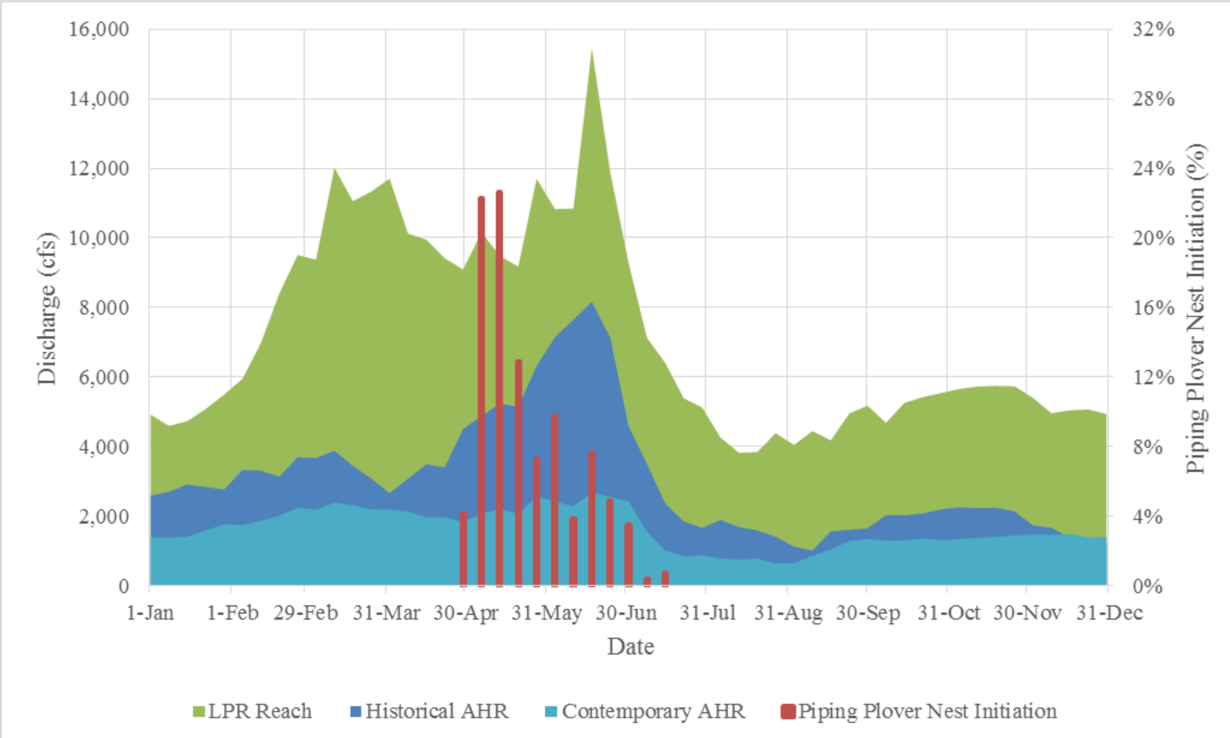

Figure 7. Distribution of AHR piping plover nest initiation dates (2001-2013) in relation to the annual hydrographs of the LPR Reach (1954-2012), contemporary AHR (1954-2012) and historical AHR (1895-1938).

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

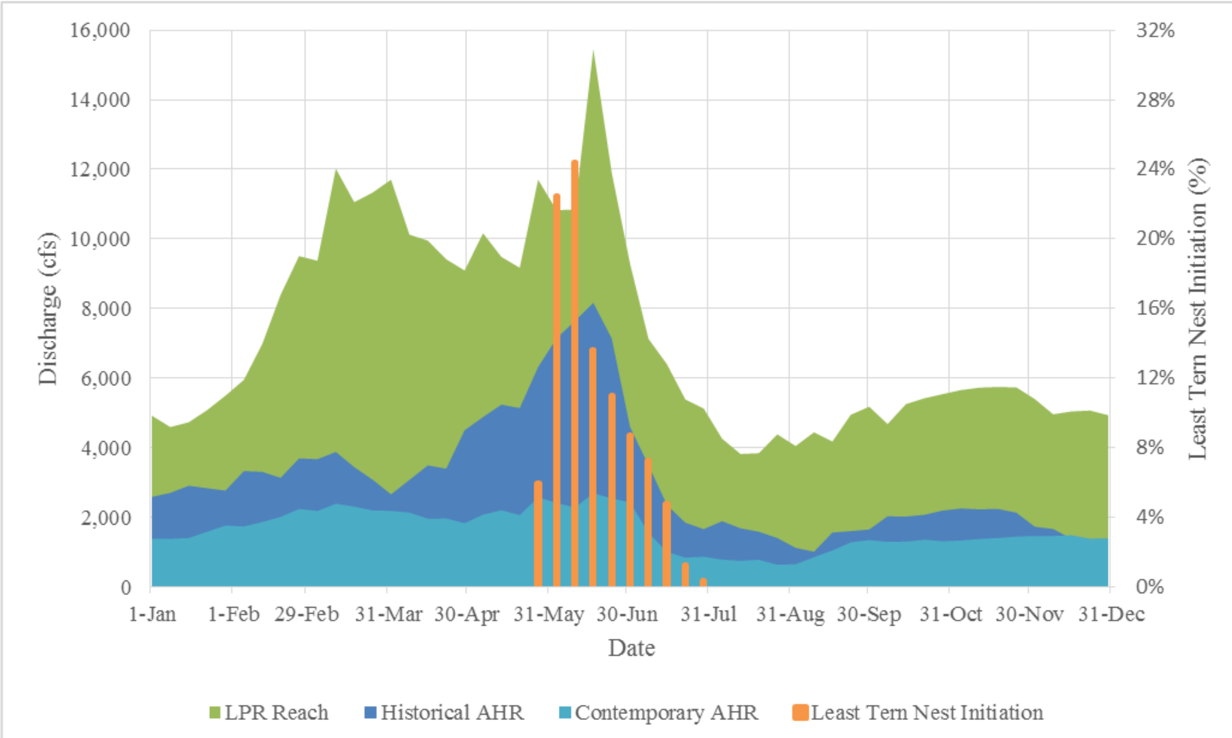

Figure 8. Distribution of AHR least tern nest initiation dates (2001-2013) in relation to the annual hydrographs of the LPR Reach (1954-2012), contemporary AHR (1954-2012) and historical AHR (1895-1938).

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 late-spring rise.

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 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:

<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).

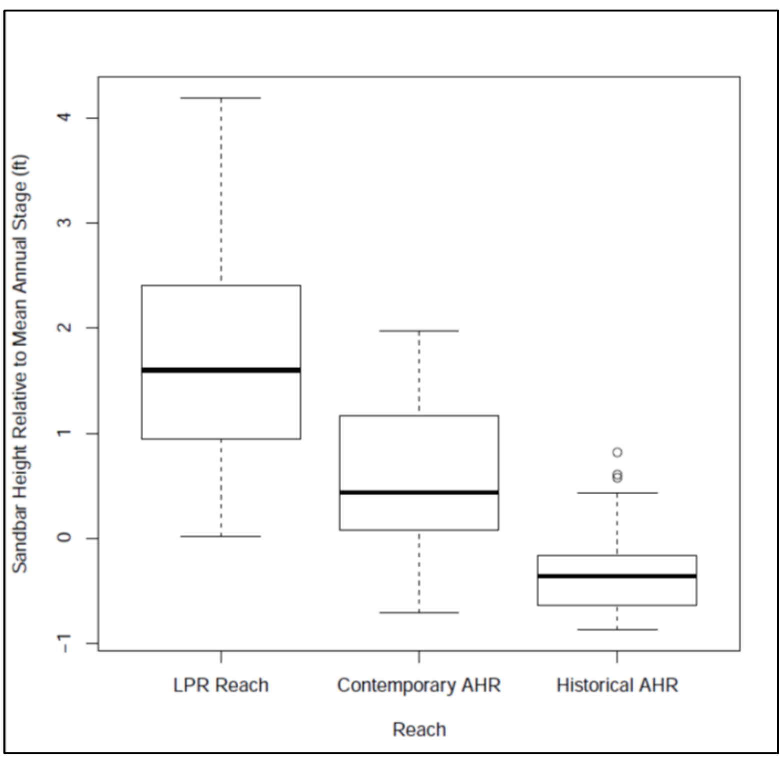

Figure 9. Box plot of median sandbar height relative to mean annual stage.

<u>Requirement 2 – Flows recede early in the nesting season to allow birds to initiate nests</u>

The second flow requirement is for the spring rise to recede early enough in the nesting season for the species to initiate nests. The percent of time (consecutive) that sandbars were emergent during species nest initiation windows was calculated for each reach. Modeled emergent sandbar availability was greater in the LPR Reach than the contemporary or historical AHR. Availability was also greater during the least tern nest initiation window than during the piping plover nest initiation window. Overall, the model indicates that years of limited habitat availability 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 period in approximately 55% of years in the contemporary reaches and 89% of years in the historical AHR. Sandbars were available for less than 14 days during the least tern nest initiation period in approximately 22% of years in the LPR Reach, 39% of years in the contemporary AHR, and 68% of years in the historical AHR.

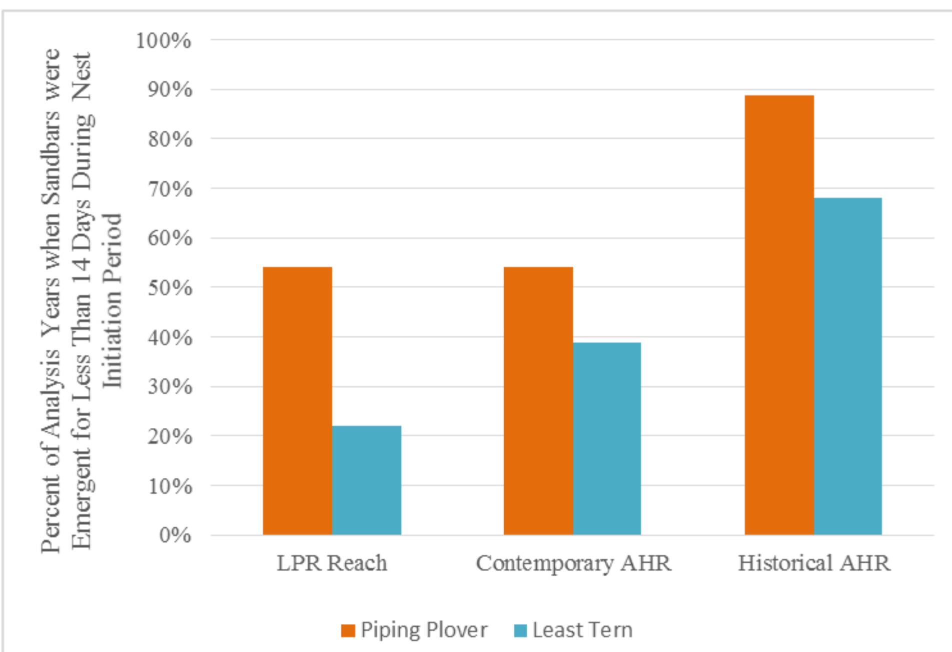

Figure 10. Percent of analysis years when model predicted sandbars were emergent for less than 14 days during the nest initiation period.

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.

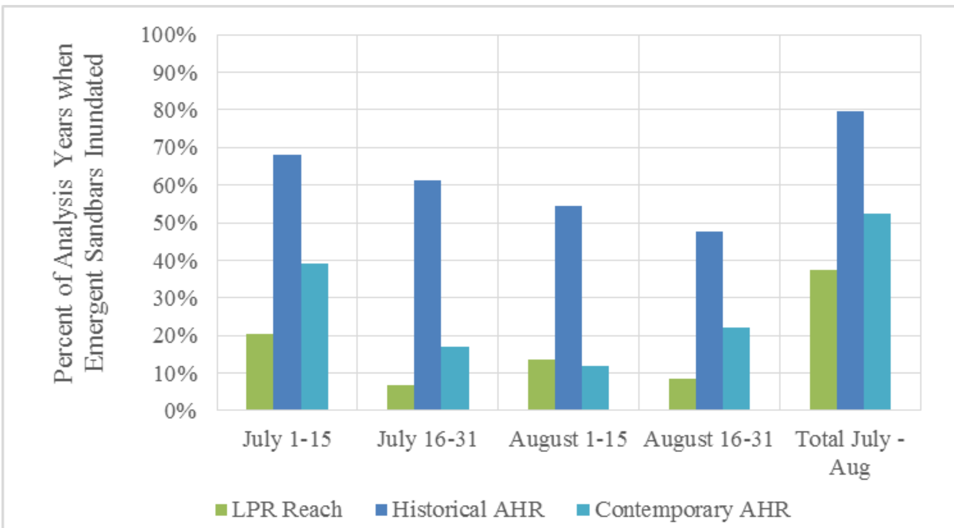

Figure 11. Percent of years when emergent sandbars were predicted to inundated during the months of July and August.

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.

Table 4. Emergent sandbar habitat model output by reach.

	Median SUCCESS WINDOW (days)		*No SUCCESS WINDOW (% of years)*		*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%*

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.

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 limited availability of emergent sandbars during nest initiation and high potential for inundation during the summer months equated to a high proportion of analysis years when there was little to no potential for successful nesting. This was especially true for piping plover and is supported by the low incidence of successful in-channel nesting in the lower Platte River reach (Brown and Jorgensen 2008, 2009, and 2010, Brown et al. 2011, 2012, and 2013). The modeling exercise did suggest that drought years following high flow years provide the greatest potential for successful nesting without inundation. This because suitably-high nesting habitat is present and the lack of an appreciable late-spring rise limits inundation potential. The 2012 nesting season in the LPR reach is an excellent example of this scenario. See Brown et al. (2012) for a discussion of species use and productivity under those conditions.

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 the historical AHR is a major uncertainty in the analysis. Ideally, model predictions of inundation mortality and potential for fledging success would have been evaluated using species monitoring data. This was not possible because: 1) systematic monitoring data was not available for the historical AHR, 2) the monitoring data for the contemporary AHR was of limited utility given the limited amount of in-channel nesting, and 3) the LPR Reach monitoring data was also of limited utility because annual monitoring often began after the beginning of the nest initiation period and ended prior to chicks reaching fledging age. Although validation was not possible, specific instances of observed inundation were evaluated.

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.

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.

LPR Reach

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

Observed instances of nest inundation in the contemporary AHR and LPR reaches indicate that sandbar overtopping and nest loss occurred at discharges lower than were predicted by the model. This is consistent with the effort to use conservatively-high sandbar height values in this analysis. The specific dates and discharges associated with inundation in the historical AHR were not recorded but the highest discharge recorded during the nesting season was significantly below the habitat-forming peak discharge 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 sandbar height values would have a substantial negative effect on potential for productivity.

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.

Central Platte River Management Implications

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

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.

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

Development of AHR species population models would allow the Program to further explore use and productivity in- and off-channel habitats. Development of those models is a priority work item in 2015. An expanded analysis of AHR hydrology and physical characteristics in relation to other rivers used by the species also provides further opportunity to identify characteristics that may be important for species use 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 and A-2 present the sensitivity analysis stage-discharge relationships along with the relationships at LPR and contemporary AHR stream gages and nest colony locations presented in the text. Figure A-3 provides the sensitivity analysis stage-discharge relationships along with the hydraulic model stage-discharge relationship used in the historical AHR analysis. Table A-1 presents the SANDBAR HEIGHT values used in the sensitivity analysis for each segment.

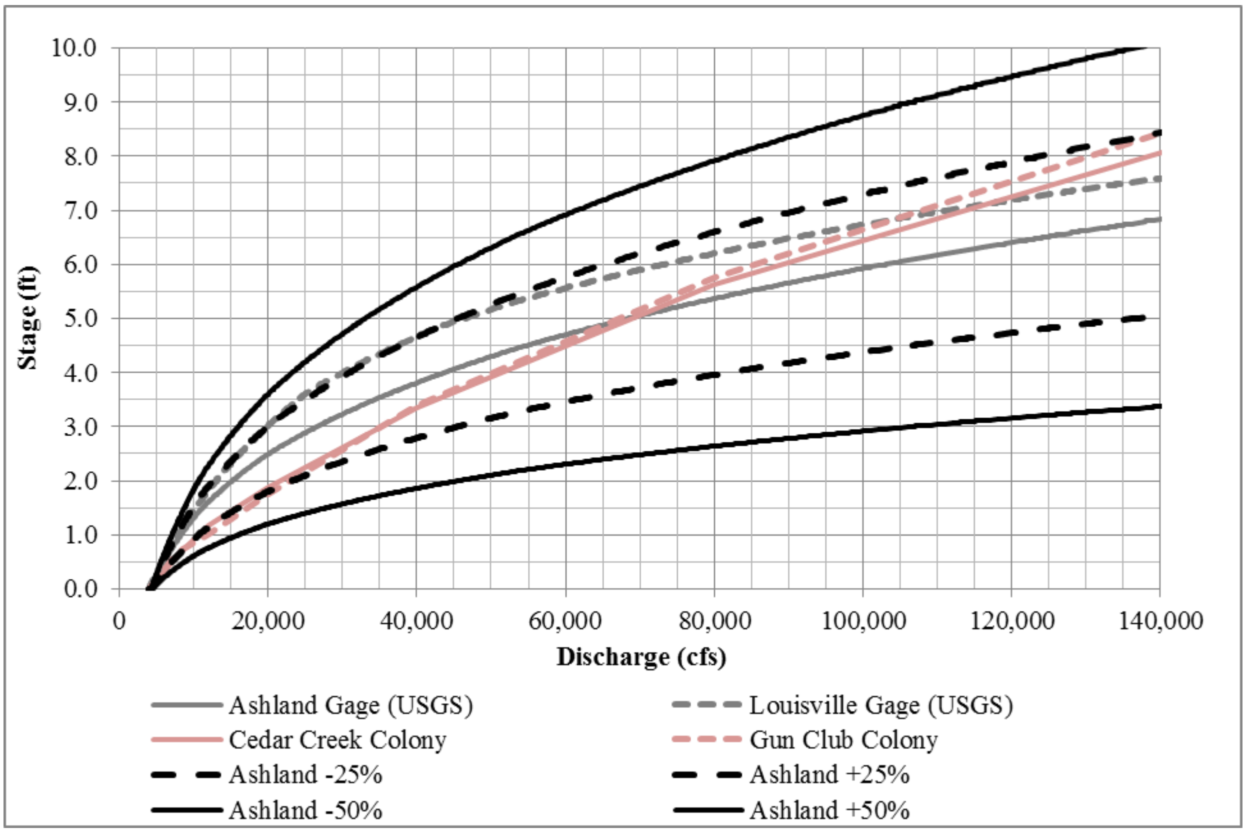

Figure A-1. LPR Reach sensitivity analysis stage-discharge relationships in comparison to the Ashland gage relationship used in the model, Louisville gage relationship, and relationship at nesting colonies.

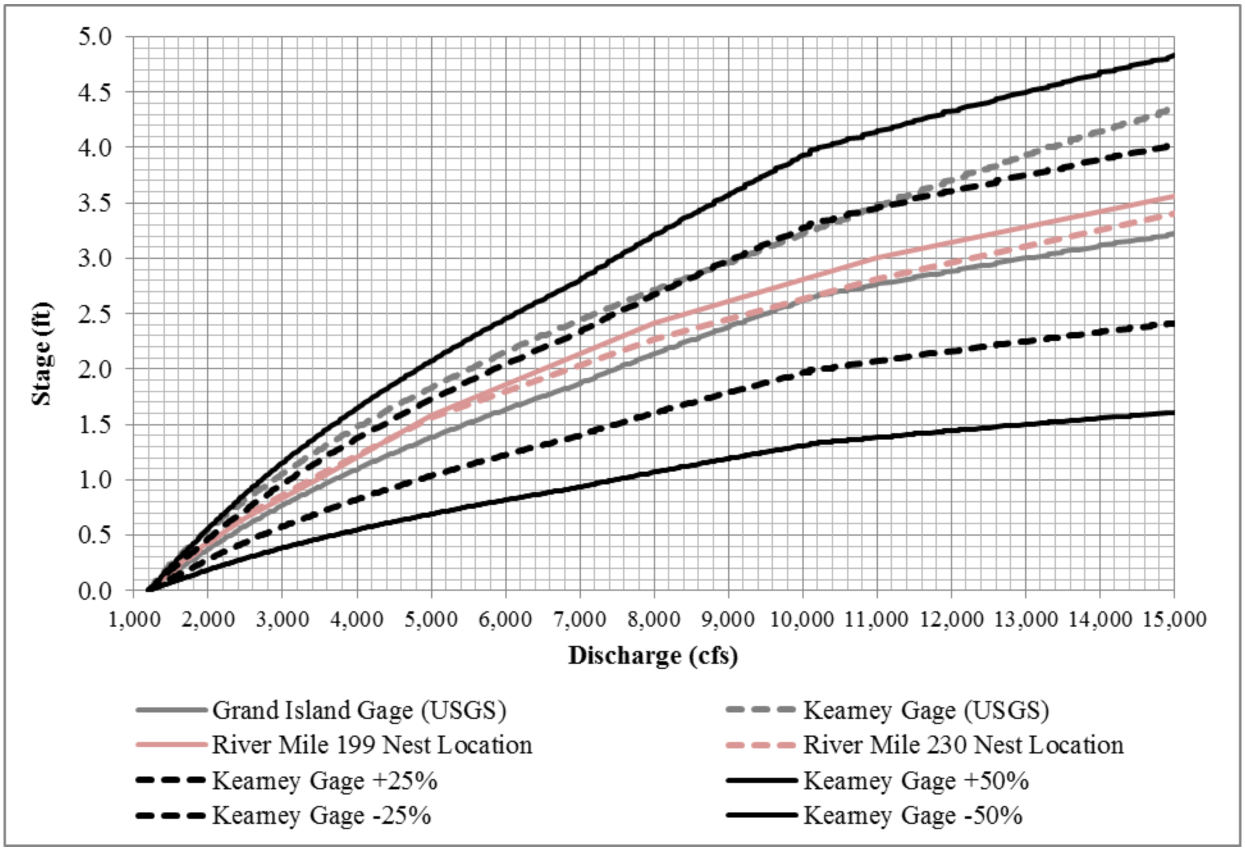

Figure A-2. Contemporary AHR sensitivity analysis stage-discharge relationships in comparison to the Kearney gage relationship used in the model, Grand Island gage relationship, and relationship at nesting colony locations.

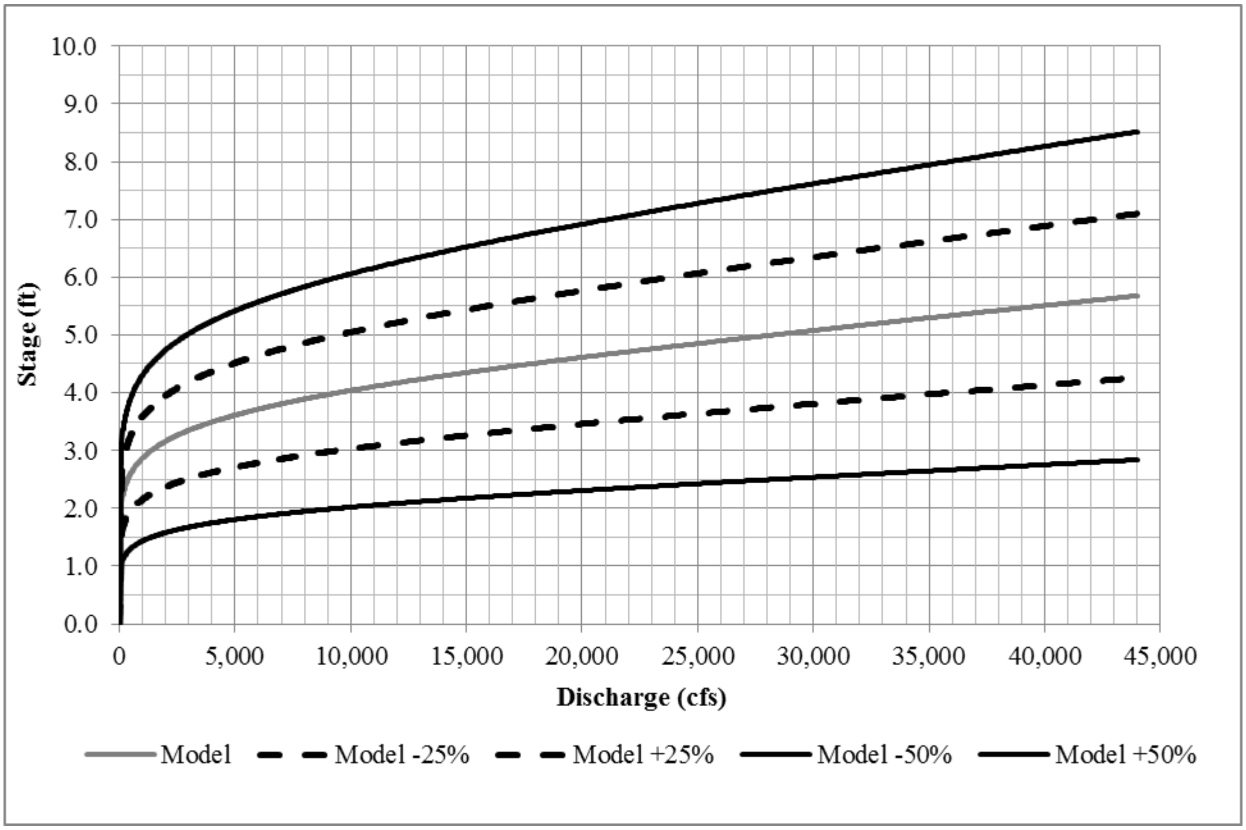

Figure A-3. Historical AHR sensitivity analysis stage-discharge relationships in comparison to the modeled relationship used in the analysis.

Table A-1. Sensitivity analysis SANDBAR HEIGHT values for the LPR Reach

Sensitivity Run	SANDBAR HEIGHT Value		
	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

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.

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

TERN - Percent of Years w/ SUCCESS WINDOW >0

		Stage Discharge				
		-50%	-25%	0	25%	50%
Bar Height	50%	83%	93%	98%	98%	100%
	25%	53%	83%	88%	95%	98%
	0%	32%	64%	83%	88%	93%
	-25%	7%	46%	66%	83%	88%
	-50%	3%	32%	53%	69%	83%

TERN - Change in % of Years w/ SUCCESS WINDOW >0

		Stage Discharge				
		-50%	-25%	0	25%	50%
Bar Height	50%	0%	10%	15%	15%	17%
	25%	-31%	0%	5%	12%	15%
	0%	-51%	-19%	0%	5%	10%
	-25%	-76%	-37%	-17%	0%	5%
	-50%	-80%	-51%	-31%	-14%	0%

PLOVER - Percent of Years w/ SUCCESS WINDOW >0

		Stage Disch				
		-50%	-25%	0	25%	50%
Bar Height	50%	58%	68%	81%	81%	83%
	25%	29%	58%	68%	73%	81%
	0%	12%	39%	58%	68%	68%
	-25%	3%	24%	44%	58%	64%
	-50%	0%	12%	29%	47%	58%

PLOVER - Change in % of Years w/ SUCCESS WINDOW >0

		Stage Disch				
		-50%	-25%	0	25%	50%
Bar Height	50%	0%	10%	24%	24%	25%
	25%	-29%	0%	10%	15%	24%
	0%	-46%	-19%	0%	10%	10%
	-25%	-54%	-34%	-14%	0%	7%
	-50%	-58%	-46%	-29%	-10%	0%

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

TERN - Percent of Years w/ SUCCESS WINDOW >0

		Stage Disch				
		-50%	-25%	0	25%	50%
Bar Height	50%	71%	93%	98%	100%	100%
	25%	47%	71%	88%	93%	98%
	0%	31%	56%	71%	86%	93%
	-25%	14%	37%	58%	71%	85%
	-50%	8%	31%	47%	61%	71%

TERN - Change in % of Years w/ SUCCESS WINDOW >0

		Stage Disch				
		-50%	-25%	0	25%	50%
Bar Height	50%	0%	22%	27%	29%	29%
	25%	-24%	0%	17%	22%	27%
	0%	-41%	-15%	0%	15%	22%
	-25%	-58%	-34%	-14%	0%	14%
	-50%	-63%	-41%	-24%	-10%	0%

PLOVER - Percent of Years w/ SUCCESS WINDOW >0

		Stage Disch				
		-50%	-25%	0	25%	50%
Bar Height	50%	47%	66%	76%	80%	81%
	25%	22%	47%	58%	71%	76%
	0%	8%	25%	47%	58%	66%
	-25%	2%	15%	29%	47%	56%
	-50%	0%	8%	22%	32%	47%

PLOVER - Change in % of Years w/ SUCCESS WINDOW >0

		Stage Disch				
		-50%	-25%	0	25%	50%
Bar Height	50%	0%	19%	29%	32%	34%
	25%	-25%	0%	10%	24%	29%
	0%	-39%	-22%	0%	10%	19%
	-25%	-46%	-32%	-19%	0%	8%
	-50%	-47%	-39%	-25%	-15%	0%

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

TERN - Percent of Years w/ SUCCESS WINDOW >0

Bar Height	Stage Disch -50%	-25%	0	25%	50%
50%	30%	63%	79%	86%	88%
25%	16%	30%	56%	70%	79%
0%	12%	19%	30%	49%	63%
-25%	9%	14%	21%	30%	47%
-50%	2%	12%	16%	21%	30%

TERN - Change in % of Years w/ SUCCESS WINDOW >0

Bar Height	Stage Disch -50%	-25%	0	25%	50%
50%	0%	33%	49%	56%	58%
25%	-14%	0%	26%	40%	49%
0%	-19%	-12%	0%	19%	33%
-25%	-21%	-16%	-9%	0%	16%
-50%	-28%	-19%	-14%	-9%	0%

PLOVER - Percent of Years w/ SUCCESS WINDOW >0

Bar Height	Stage Disch -50%	-25%	0	25%	50%
50%	14%	35%	47%	60%	65%
25%	9%	14%	19%	37%	47%
0%	9%	9%	14%	16%	35%
-25%	9%	9%	12%	14%	16%
-50%	2%	9%	9%	14%	14%

PLOVER - Change in % of Years w/ SUCCESS WINDOW >0

Bar Height	Stage Disch -50%	-25%	0	25%	50%
50%	0%	21%	33%	47%	51%
25%	-5%	0%	5%	23%	33%
0%	-5%	-5%	0%	2%	21%
-25%	-5%	-5%	-2%	0%	2%
-50%	-12%	-5%	-5%	0%	0%

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

Abstract

The hydrology and physical characteristics of the contemporary Associated Habitat Reach (AHR) of the central Platte River were compared to other regional river segments used by least terns and piping 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. Important differences between the AHR all other segments include much coarser bed material and the likely related absence of large sand flats used by the species. The Platte River Recovery Implementation Program's ability to manage the AHR to shift the bed material grain size distribution into the range of the other segments is limited. Other differences, such as comparatively lower minimum discharges during the nesting season, may be more easily addressed.

Introduction

The interior least tern (*Sterna antillarum athalassos*; least tern) and piping plover (*Charadrius melodus*; piping plover) nest sympatrically on several major river systems in the northern Great Plains 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 threatened in 1986. Soon after listing, the United States Fish and Wildlife Service (USFWS) concluded that alteration of the flow regime of the Big Bend reach of the Platte River caused a decline in the availability of suitable nesting habitat and threatened the continued existence of these species (Department of the Interior 2006).

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

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 and maintain least tern and piping plover nesting habitat (Program 2006). The first six years of Adaptive Management Plan implementation have provided indications that full implementation of the FSM management strategy will likely not create or maintain least tern and piping plover nesting habitat on an annual or near annual basis as was initially hypothesized (See Chapters 2 & 3). In 2013, the Program's Independent Science Advisory Committee recommended that the Program compare physical conditions in the Associated Habitat Reach (AHR) to other systems in the region with least tern and piping plover nesting in an effort to glean potential management insights (Program 2013a). This sentiment was echoed by the USFWS (Hines 2014).

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.

Methods

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 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 River, history of species use, and similar channel morphologies. The Missouri River segment downstream of Gavin's Point Dam was omitted from the comparison because the significant proportion of species use on created and managed habitat (US Army Corps of Engineers 2006, 2007) provided limited opportunity to evaluate use in relation to naturally-occurring channel characteristics. The Niobrara River reach below the Spencer Hydropower dam was omitted because of the delta effect caused by backwater from Lewis and Clark Lake (Alexander et al. 2010).

Table 1. Physical comparison river segments

Segment Name	Length (mi)	Description
Contemporary Associated Habitat Reach (Contemporary AHR)	90	Lexington, NE to Chapman, NE
Historical Associated Habitat Reach (Historical AHR)	90	Lexington, NE to Chapman, NE circa 1900
Lower Platte River Reach 1 (LPR Reach 1)	33	Elkhorn River confluence to the Missouri River
Lower Platte River Reach 2 (LPR Reach 2)	70	Loup River confluence to the Elkhorn River Confluence
Loup River Upstream of Diversion (Loup River US)	38	Confluence of North Loup River to Loup Power Diversion
Loup River Downstream of Diversion (Loup River DS)	34	Loup Power Diversion to Platte River
Niobrara River Upstream of Spencer (Niobrara River)	40	Highway 137 to Spencer Hydropower Plant

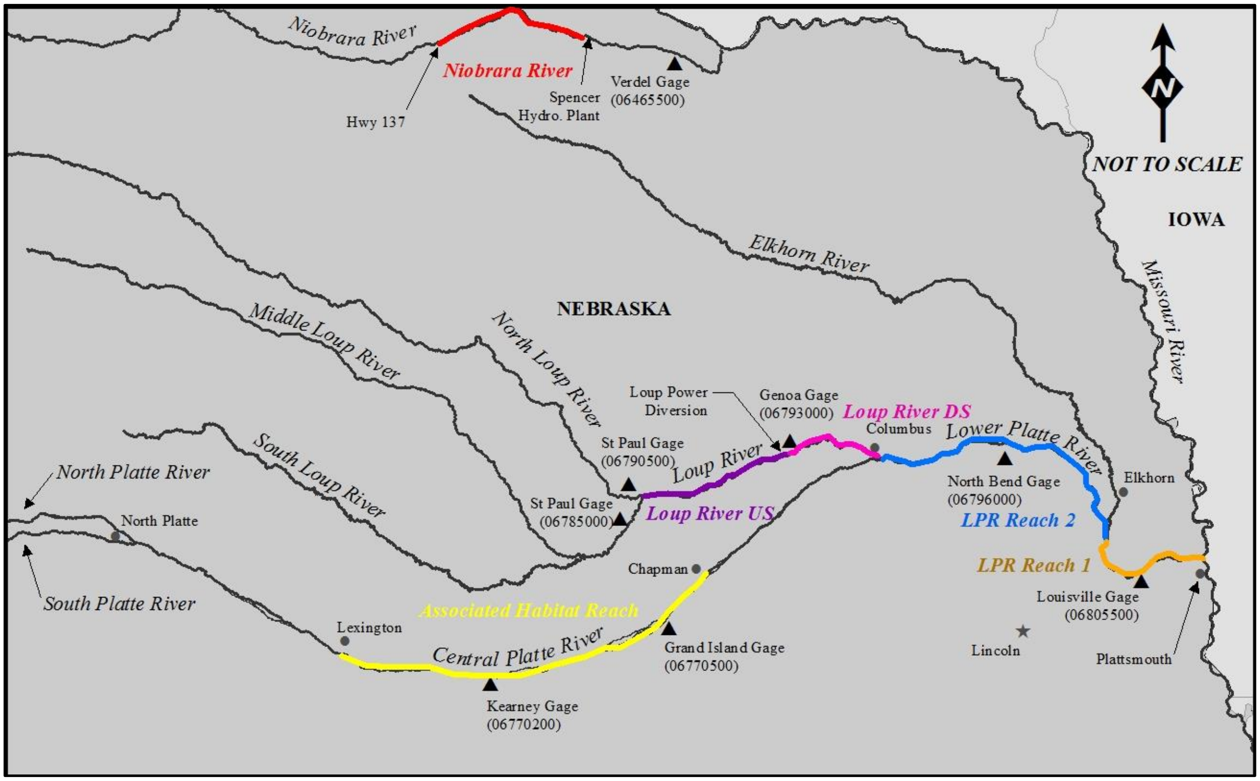

Figure 1. Map of study area identifying physical comparison river segments.

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

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

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).

Range-Wide Population Densities

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

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

Loup 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.

Hydrologic Comparisons

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

Table 2. United States Geological Survey stream gages used in hydrologic comparison of river segments.

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 River US)	North Loup River near St. Paul (06790500) + Middle Loup River at St. Paul (06785000)
Loup River Downstream of Diversion (Loup River DS)	Loup River near Genoa (06793000)
Niobrara River Upstream of Spencer (Niobrara River)	Niobrara River near Verdel (06465500)

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 5th and 95th 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.

Physical Characteristics Comparison

River segment channel slope, bed material grain size, and area of sandbars used by the species were 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 in the comparisons. In the case of sandbar areas in the Loup River segments, sandbars with nests observations were identified from approximate locations reported by the USFWS in 2010-2012 (Lackey and Runge 2010, Lackey 2011, 2012). Once identified, the bars were delineated and measured in ArcMAP from Farm Service Agency (FSA) National Aerial Imagery Program (NAIP) aerial photography, which were collected during June and July.

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

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

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

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)

in a geomorphic classification of the lower Platte River. Widths for the LPR Reaches were recalculated because Elliott e al. (2009) did not report values for the individual segments contained in this comparison. Total channel width was measured at 1,000 foot intervals from aerial images for river segment in ArcMAP. Mean widths and coefficient of variation were calculated for each channel segment.

Results

Range-Wide Population Estimates

Piping Plover

Within the Great Plains/Prairie region, piping plovers nested on five river systems in 2006 with approximately 16% of the total population nesting on riverine habitat (Elliott-Smith et al. 2009). River survey segments from Elliott-Smith et al. (2009) and were generally similar to the physical comparison reaches in this investigation. The highest density of approximately five piping plovers per river mile occurred on the Missouri River below Gavin's Point Dam (Table 5). However, 83% of piping plover adults in that reach (in 2006) nested on created and/or managed riverine habitat (US Army Corps of Engineers 2007). The decoupling of species habitat from hydrology and physical process relationships in that segment 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	River Miles	Adults per Mile*
Lutey (2002) Objective for AHR	***79***	***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***

*This is a general description of adult density. Adults were likely not evenly distributed throughout the survey segments.

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 reported piping plover populations on both the lower Platte and Loup Rivers were on the order of 22% (0.2 adults/mile) of the proposed AHR recovery objective. However, it should be noted that the number of piping plover observed on the lower Platte has been highly variable over time. During the period of 1988 to 2009, the number of adult piping plovers observed on the lower Platte below Columbus ranged from 0 to approximately 160 (0 to 1.6 adults/mile) with an average of approximately 50 adults (0.5 adults/mile; Brown and Jorgensen 2009). This was approximately 55% of the proposed AHR recovery objective density.

Least Terns

In 2005, least terns were observed on 14 interior river systems (Lott 2006). Survey segments from Lott (2006) and were similar to the physical comparison reaches in this investigation with the exception that the lower Platte and Loup River segments were not divided into multiple segments. The highest densities of least terns occurred on the Mississippi, Missouri, Arkansas and Niobrara Rivers (Table 6). Overall, the results were similar to piping plovers. A limited proportion of least tern nesting on the Missouri 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 (2002) objective of 2.1 adults/mile for the AHR occurred on the Niobrara River.

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.

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

River Segment	Adults	River Miles	Adults per 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 survey segments.

Regional Scale Nest Densities and Fledge Ratios

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.

River Segment	Period of Nest Records	Reach Length (mi)	Mean Plover Nests	Nests per Mile	Mean Tern Nests	Nests per Mile
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

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.

River Segment	Monitoring Years	Plover Fledge Ratio	Tern Fledge 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

Physical Conditions Comparison

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 Platte River, lower Platte River, Loup River and Niobrara River.

River Segment	Analysis Period	Median Annual Peak Discharge (cfs)	Maximum Annual Peak Discharge (cfs)	Median Date of Annual Peak Discharge	Percent of Annual Peaks Occurring outside of Plover Nesting Window (5/1-8/26)	Percent of Annual Peaks Occurring outside of Tern Nesting Window (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%

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

River Segment	Analysis Period	Mean Annual Discharge (cfs)	Number of Years with Zero Discharge Days	Median of Minimum Disch. (cfs) During Entire Species Nest Season (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.

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

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.

River Segment	Channel Slope	Mean Total Channel Width (ft)	Coeff. of Variation Total Channel Width	Median Bed Material Grain Size (mm)	Flow Depth at Median Peak Disch. (ft)	u_* /ω	Sediment Transport Mode	Mean Area of Sandbars with Nesting Records (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

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.

Discussion

Species Population Objectives in Relation to other River Segments

In 2006, 84% of the Great Plains/Prairie region population of piping plover occurred on non-riverine 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 occurred on the Mississippi, Missouri, Arkansas and Niobrara Rivers (Table 6). Similar to the piping plover, the only regional unmanaged river segments with least tern densities that approximated proposed AHR objective occurred on the Niobrara River (Table 3). However, the average number of least terns observed on the lower Platte River during the period of 1987-2009 was on the order of 230 birds, which was much higher than the 2005 count and similar to the proposed AHR recovery objective. Although the mean lower Platte River segment had adult count was similar to the proposed AHR recovery objective, nest counts of 0.5 nests per pair (adult count divided by two) were lower than expected. This can likely be attributed to observations of least terns that nested on off-channel habitat foraging on the river (and imperfect nest detection). This behavior is common in the AHR (Sherfy et al. 2012).

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.

River Segment Physical Conditions Comparison

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

Table 13. Summarization of physical conditions in the central Platte River Associated Habitat Reach (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 (cfs)	6,095	5,655	39,450
Maximum Annual Peak Discharge (cfs)	23,500	22,200	138,000
Median Date of Annual Peak Discharge	5-May	15-Apr	1-Jun
Annual Peaks Outside of Piping Plover Nest Window	47%	59%	34%
Annual Peaks Outside of Least Tern Nest Window	66%	66%	50%
Mean Annual Discharge (cfs)	1,895	1,887	8,505
Number of Years with Zero Discharge Days	5	0	0
Median of Minimum Discharge During Nesting Season (cfs)	265	815	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 (mm)	0.96	0.24	0.22
Flow Depth at Median Peak (ft)	3.3	3.9	7.1
u_* / ω 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

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.

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

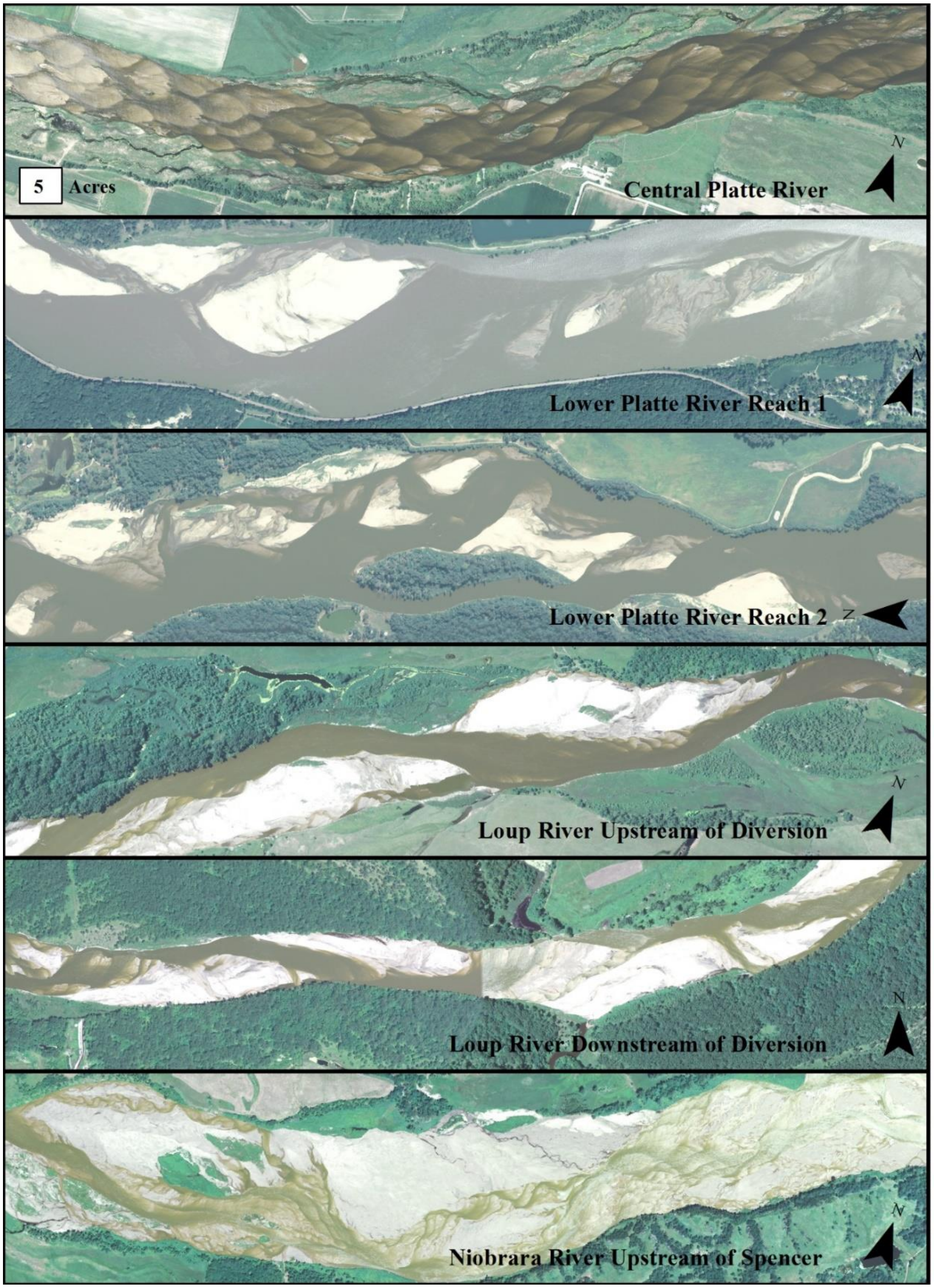

Figure 2. NAIP aerial imagery showing sandbars in physical comparison reaches during the summer of 2010. Sandbars significantly exceeding five acres in area were present in all segments except for the central Platte River.

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

Management Implications for the Associated Habitat Reach

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 relatively low. Species use was greater in the lower Platte River segments but hydrology was dissimilar enough that it was difficult to draw useful comparisons. That left the Niobrara River as an analog, but it differed from the AHR in sediment characteristics as well as the high variability in slope and width due, in part, to the significant influence of bedrock on channel characteristics (Alexander et al. 2010). Because none of the segments were ideal analogs, they were considered in aggregate to identify general differences and the potential to manage to reduce those differences in hopes of improving habitat suitability.

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.

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.

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.

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.

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.

Sandbar Area

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.

Management Implications in Relation to FSM Management Strategy

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

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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

Louis Berger

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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

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?

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.

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 non-destructive 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	X	X		X (Chapters 1-5 and Summary of Key Findings)
Accept with revisions			X	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 range-wide 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? Habitat-creating 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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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 in-depth 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 50th 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

Recommendation	(Check One)
Accept	X
Accept with revisions	
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 in the western half of the AHR as though the transition from 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 in-channel nesting in all reaches and consistent use of off-channel habitats like sand mines, these [off-channel] 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[1] (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

[1] 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[2] 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

[2] 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[3] 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

[3] 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:

Map
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.

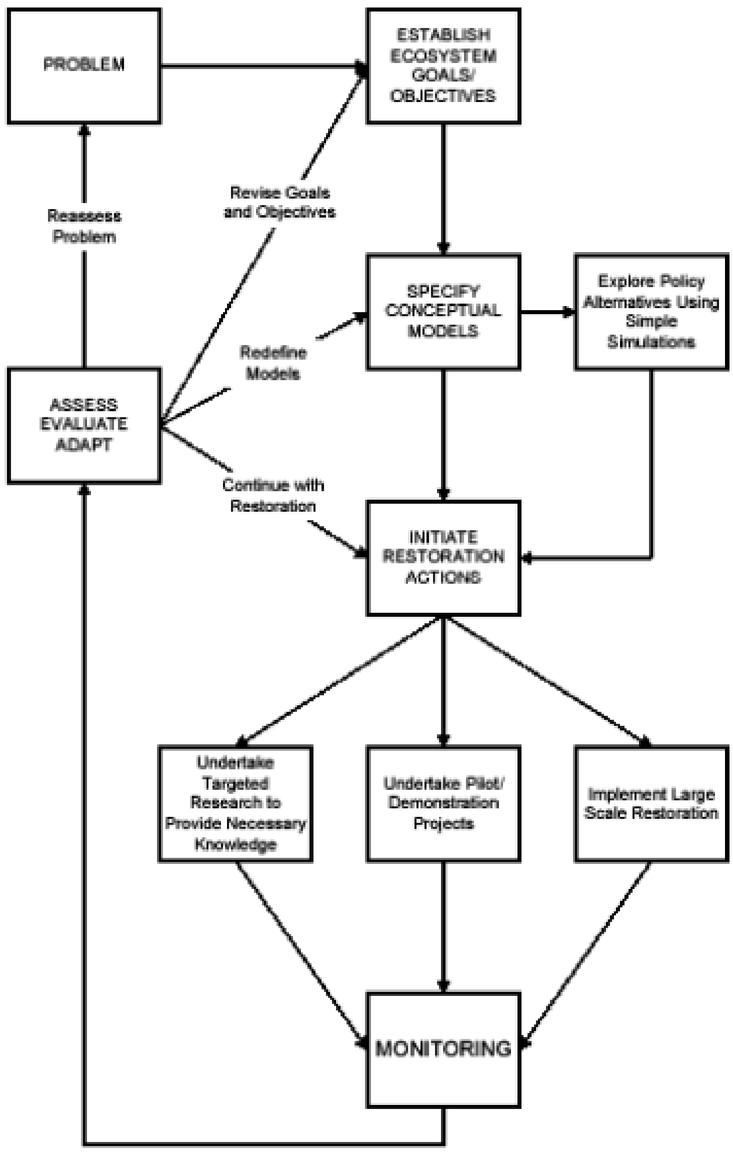

Figure 1. The Adaptive Management process as applied in the CALFED Ecosystem Restoration Program. Diamond shaped boxes show critical decision points in the process. Where the diagram indicates multiple decision choices, the choices are not mutually exclusive. Where the diagram indicates only one decision 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.

<u>Addendum from Louis Berger</u>:

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 goes away. If it is from erosion of the bed and banks, that implies that the transition from 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.

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Peer Review submitted by Robert Wiley

General Questions

I saved all chapters as received, adding RLW to the document name and edited them in track-changes 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?

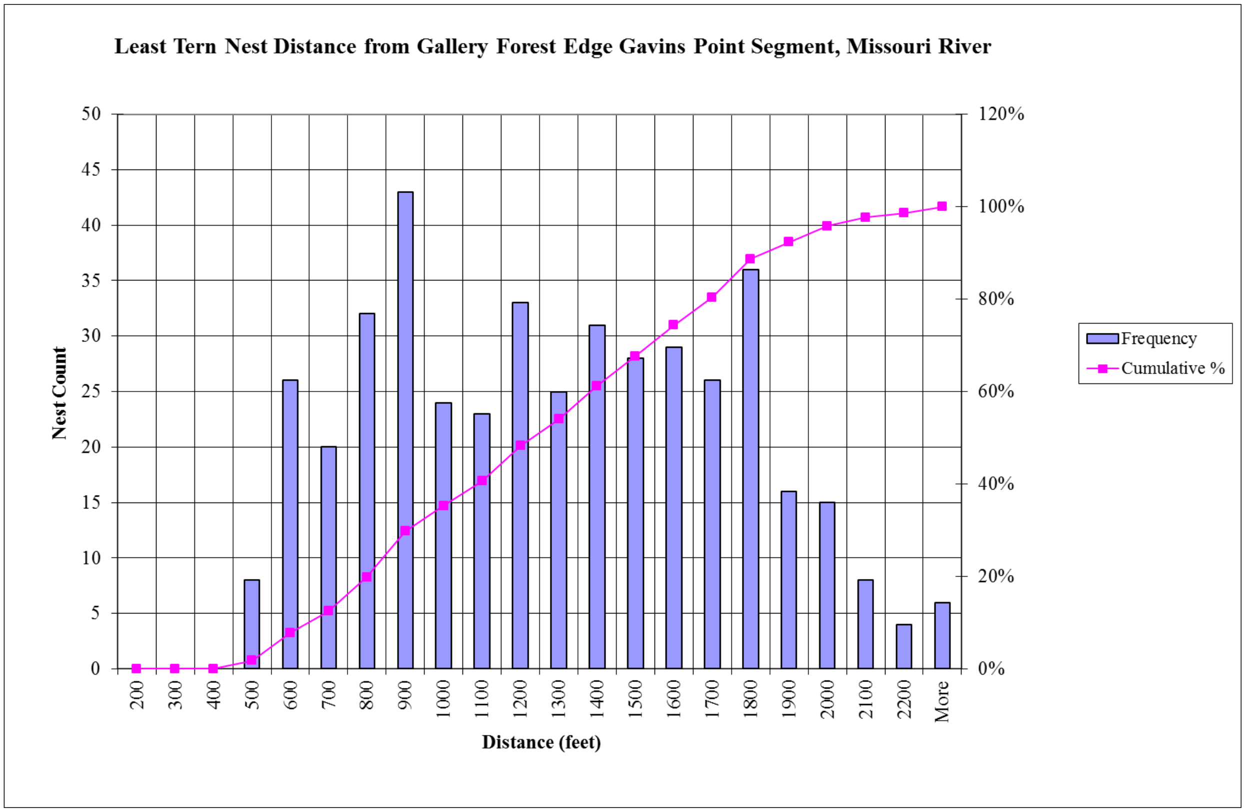
It is reasonable to suggest that there is a direct relationship between stage and resulting height of sandbars. More work is needed to predict the magnitude. A high flow at the beginning of the breeding season will likely result in nestable sandbars. The height needed for successful nesting in any given 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 (~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. Pending review.

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.

Review Rating & Recommendation

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

RECOMMENDATION							
Accept							✓
Accept with revisions	✓	✓	✓	✓	✓	✓	
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. http://www.leasttern.org.

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

Response to Kondolf requirements for acceptance of chapters:

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.

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. As with many aspects of the PRRIP monitoring and research program, this subject was given superficial 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.

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…

The mean annual sediment deficit was estimated to be on the order of 185,000 T by the Bureau of Reclamation using SedVeg, a 1-dimensional numerical sediment transport model (Murphy et al. 2006). The Program subsequently funded the development of a HEC-6T numerical 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 T (The Flatwater Group Inc. 2010). However, as mentioned in Chapter 2, the deficit appears to be highly variable from year to year.

…and develop a sediment budget for both pre-J-2 conditions and post-J-2 conditions.

Simons and Associates Inc. (2000) developed a crude pre-development sediment transport of on the order of 7.8 million T per year based on a flow/sediment regression analysis and an estimate of sediment trapping in reservoirs. Contemporary sediment loads were estimated to be on the order of 1 million T per 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 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.

This can easily be added to the report.

The Report should include a map showing the features of the J-2 project and where sediment deposits within the project.

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.

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 Flatwater Group Inc. (2010 and 2014) provide discussions of the specific sediment transport components presented in the comment.

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.

The statement that the eastern half of the AHR is in equilibrium is based on several lines of evidence:

1) *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.*
2) *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.*
3) *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 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. Considering results from the surveys and the independent analysis done by both the Bureau of Reclamation and Tetra Tech (see above 1-3), the portion of the reach downstream from Kearney was most likely aggradational. There are, however, contradictory lines of evidence; thus, this conclusion is only weakly supported by the data. Tetra Tech also noted that it is very important to recognize that the sediment loads along the reach vary significantly from year to year due primarily on the magnitude and duration of the flows, and the overall sediment balance may change depending on the type of flow year. While long-term planning based on average annual estimates may provide a sound basis for certain decisions, changes during extreme years may actually overwhelm the anticipated changes from evaluation of the average annual sediment balance (See 2.7 on pg. 226).*

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 contribute sediment to the river. The deficit is made up by erosion of channel bed and bank materials. This is the primary motivation for sediment augmentation. The Program recognizes that without augmentation, the upper portions of the reach are likely to continue to degrade and narrow and that degradation will gradually move downstream.

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 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.

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) uncertainty in relation to this estimate. Program subsurface sediment cores taken in areas of the channel

[1] *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).

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 supply of the AHR is derived, ultimately, from the North and South Platte River headwaters in the Rocky 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 segments.

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).

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.

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 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 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.

The discharge records for the historical AHR were derived from a combination of existing flow records 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, uncertainty in discharge estimates for the estimated portion of the historical AHR flow record could be on the order 25%. The distribution of the error is not known.

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 classifications of contemporary sandbar morphology (see Chapter 1). The contemporary AHR sandbar height was used in an effort to develop conservatively-high estimates of sandbar height. The rationale, based on published relationships between bed material grain size and sandbar heights, is presented in the text. We are not aware of a way to numerically quantify the error in the sandbar height estimates other than to say we attempted to be conservative.

No nest exposure data is available for the historical AHR because the first species observations in the 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 discharge) so we assume the reviewer is primarily concerned with the effects of uncertainty in metric values on analysis results. We frankly cannot numerically bound most of the uncertainties for the reasons described above. Accordingly, it is up to the reader to come to their own conclusions about whether or not the analysis assumptions appear to be reasonable. We feel that they are reasonable enough to support the conclusion that the historical AHR was not an analog of the contemporary Lower Platte and was likely less suitable for nesting. That is the only assertion made in Chapter 5 regarding the historical AHR. Given the lack of species use data and the uncertainties described above, we will never be able to reach definitive conclusions about the suitability of the historical AHR. We do believe, however, that the inferences used to conclude that the historical AHR was highly suitable are not supported by the limited data that are available. Specifically, we find no evidence that physical conditions in the historical AHR were similar to those in the contemporary lower Platte.

General comment to reviewer:

We understand and appreciate the reviewer's concern with reaching conclusions about the effectiveness of FSM in creating tern and plover habitat prior to full implementation of sediment augmentation. Most 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. 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.[2]

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 little literature that addresses this situation other than the Germanoski and Schumm (1993) investigation of changes in braided river morphology under aggrading and degrading conditions.[3] *That investigation indicated a temporary increase in sandbar heights as channel incision around bar forms decreased water surface elevations relative to those forms.*

[2] Sandbar area is also an issue but is secondary in that area means little if sandbars are inundated frequently enough to preclude productivity.

[3] Germanoski, D., Schumm, S.A., 1993. Changes in braided river morphology resulting from aggradation and degradation. J. of Geology, 101 (4), 451–466.

The Chen et al. (1999) analysis of channel gradation trends in Nebraska provides another avenue for evaluation of the effects of sediment balance on the presence/absence of sandbar nesting habitat.[4] *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 degradational trend in the AHR will result in the production of suitable sandbar habitat. However, as mentioned previously we do concur that sediment augmentation is necessary to slow channel incision and narrowing.*

[4] 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

Name	Kate Buenau
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

Education	B.S. Biology, Arizona State University; PhD Ecology, University of 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 quantitative 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
Title	Research Assistant Professor
Affiliation	Department of Fish and Wildlife Conservation, Virginia Tech
Address	134 Cheatham Hall, Blacksburg, VA 24060
Phone #	540-231-1692
E-mail	dcatlin@vt.edu
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

Education	PhD Geography & Environmental Engineering, Johns Hopkins U, MS Earth 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

Proposed Peer Review Panelist for Platte River Recovery Implementation Program

Name	Robert L. Wiley
Title	President
Affiliation	Good Ground, LLC
Address	3050 Glennfinnan Drive, Albany OH 45710
Phone #	740-590-6900
E-mail	rlwiley@goodground-llc.com
Education	Assoc. Forestry, BS Botany/Geology, MS Landscape Architecture

Unique Qualifications

I have studied sandbar habitat in large Mississippi drainage area rivers since 2004, particularly with focus on the creation and loss of sandbar habitat for interior least tern (ILT) and piping plover (PPL). I have conducted in-field surveys of sandbar habitat in the Mississippi , Missouri, Arkansas, Red and Cimarron Rivers. I have authored or co-authored several technical documents or journal articles on sandbar habitat and or ILT population dynamics (see list in attached CV).

Short Biography of Proposed Peer Review Panelist

I have nearly 42 years' experience in natural resource data collection, analysis and the application of findings to resource management. I have been employed by both state and federal government as a technical specialist in various aspects of resource management (forest management, soil conservation, mine reclamation). I have served as an environmental engineer for a large mining and power generation company, managing surface operations for a 70,000 acre coal operation in central Utah. I have served as an ecological services section manager for a large international consulting firm in its Washington DC office. I have for much of the last 20 years worked as a technical consultant for ecosystem restoration and water resource planning for the US Army Corps of 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 USACE 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 from their Jackson, MS office. I prepared the technical appendix (B) for the Final Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River. August 2011. USACE Omaha District. In doing, I analyzed more than 12,000 ILT/PPL nesting records collected between 1996 and 2006 and trended their locations and distributions with many river physical factors. I also mapped the Missouri River habitat for all free-flowing segments between Fort Peck Dam, MT and Ponca State Park, NE.

I currently reside in Athens County Ohio and continue to deliver technical ecological consulting services as president of an Ohio-based corporation, Good Ground, LLC. I have recently accepted a position with the Ohio University Voinovich School of Leadership and Public Affairs as a project director and lecturer on ecosystem restoration. I also serve on the boards of the Raccoon Creek Partnership (a watershed management group) and the Appalachian Ohio Alliance (a land trust) in charge of natural resource data collection for the 7000 acres of property with our program.

APPENDIX B – Executive Director's Office Responses to Independent Peer Review Comments

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
EDO Response to Peer Review Comments – General Questions
PRRIP Tern and Plover Habitat Synthesis Chapters

The format of these EDO responses are as follows:

- **Original question to peer reviewers in bold text**
- Louis Berger summarized responses from peer reviewers in standard text
- *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 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.

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.

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.

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

5. The chapters were augmented to clarify that 1) the EDO evaluated sandbars formed during three high flow events and chose to use sandbar heights from the event that produced the highest bars in an effort to develop conservative (high) estimates of potential for productivity and 2) a sensitivity analysis was added 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 sediment transport and changes in sediment transport to Chapter 1, 3) adding a discussion of sediment investigations and monitoring to Chapter 2, and 4) adding a discussion of the relationship between sediment balance and sandbar height to Chapter 2.

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.

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 predict topographic change of a single sandbar in the Green River, Utah in response to three modeled discharges. The model was not calibrated or validated and the study did not report observations of sandbar heights following peak flow events. It merely included the conclusion that "model calculations predict that sediment will be deposited on the bar crest at all discharges large 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 surface in unconfined sand bed rivers like the Platte. In fact, Program attempts to model topographic change using state-of-the-art 2-dimensional mobile bed hydrodynamic and sediment transport models like SRH-2DS have been largely unsuccessful.*
- *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*

> *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 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 Lott et al. (2013) publications may be useful in future meta-population modeling efforts. Lott and Wiley (2011 and 2012) outline alternative approaches to evaluation of relationships between hydrology, sandbar habitat, and tern and plover productivity on the Red and Arkansas rivers. The availability of Program hydraulic modeling and LiDAR topography data allowed for a different type of analysis than was possible in those studies.

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.

The comment and response matrix includes descriptions of changes that were made to clarify and improve the text of the chapters. The EDO response to Question 2 (above) provides a summary of additions that were made to address Dr. Kondolf's concerns about the lack of evidence to support conclusions about sediment balance.

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.

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?

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 non-destructive breeding seasons.

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.

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.

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.

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.

The authors did not attempt to tease apart the width-sandbar interaction due to the lack of both sandbar 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 objectives for the AHR could not be met at nest densities and productivity observed on the Loup. Mr. Wiley indicated that the inferential caution is not correct because the analysis should have been based on nest distance from gallery forest instead of channel width at colony locations. We agree that the analysis he proposed would be valuable. However, we did not perform that analysis because 1) we were addressing a 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 that his concern is that the authors analyzed the wrong habitat metric, not that the analysis that was undertaken was performed incorrectly.

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.

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 exposure windows could be accommodated.

In relation to Dr. Kondolf's response, we do agree that the emergent sandbar model involves many calculations and the selection of each model input value involves the assumption that the value is appropriate. We attempted to clearly state the rationale for selection of input values and included a sensitivity analysis to provide an indication of the potential consequences of errors in those selections. In general, we are not aware of another way to address the complex relationships and interactions between hydrology, hydraulics, sandbar morphology, and species ecology in absence of a large, long-term, consistent, systematically-collected in-channel species use and productivity dataset. To our knowledge, this data does not exist for the Platte, Loup, or Niobrara Rivers.

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 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.

Dr. Buenau's specific concerns are addressed in the comment/response matrix. We evaluated the MOVE.1, MOVE.2, and MOVE.3 (improvement on MOVE.2) method. MOVE.1 was ultimately selected because it performed slightly better than the MOVE.3 (NSCE difference of 0.01) and required less computation.

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.

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.

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.

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.

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.

We did compare AHR data to LPR data and indicate in the text that LPR data falls within the nest initiation 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 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.

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.

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.

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.

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 Dr. Catlin's comment about the absence of evidence related to population growth. Development of tern and plover population models are a work item for 2015.

Peer reviewer ratings and recommendations:

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.

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.

PRRIP RESPONSE TO INDIVIDUAL PEER REVIEW COMMENTS

Comment ID #	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 comparisons with the AHR and 2) the intensive management in that segment effectively decouples habitat and species response from hydrology and other physical process relationships.
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, importantly, the distance to large tree lines are stronger and more explanatory factors in nest site selection.	The width analysis was completed to address stakeholder concerns that previous analyses did not place enough emphasis on that specific metric. We agree that other factors are involved in nest site selection but disagree that they are necessarily 'stronger and more explanatory' in relation to nesting in the AHR.
2	Maps and Location References (throughout chapters			Matt Kondolf	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 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.	Noted. Maps have been clarified.
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.
5	1	2	39	Robert Wiley	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 opportunistic nester that live 15-20 years and range over a continental scale. A bad year on the Platte may be a great year for the same bird on the Mississippi, the Arkansas, the Red or the Missouri….	We generally concur. However, this chapter was focused on historical species use of the central Platte River and the path that led to PRRIP.
6	1	3	57	Dan Catlin	On the breeding grounds.	Change made.
7	1	5	105-106	Robert Wiley	Are detection limits inherent in "variable" methods accounted for in quantification and any trending efforts?	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 monitoring protocol in 2001. Variability in monitoring methods since 2001 (IE. inside vs. outside nest 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.
8	1	5-6	107-111	Robert Wiley	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 in natural conditions. Has there been an increase in sand pits during the assessment period? Is it easier to perform counts at landlocked sand pits as opposed to natural islands? Has there been a change in large-scale water management strategies during this period?	Many of these comments are addressed in subsequent chapters. In general, the distributions by habitat types likely are relative to the abundance of each habitat type. Quantitative estimates of habitat availability are not available prior to 2007, however, nesting islands were also maintained by NPPD and the Crane Trust from 2001-2006 and resulted in no productivity or nesting.
9	1	5	109	Kate Buenau	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.	Correction made. The distributions by habitat types likely are relative to abundance but data are not available to make that statement with a reasonable degree of confidence. However, nesting islands were maintained by NPPD and the Crane Trust from 2001-2006 and resulted in no productivity or nesting.
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)	Excellent question with no easy answer. However, river hydrology did not differ markedly from subsequent years so it is difficult to conclude that it was the result of differences in habitat availability.
11	1	7	122	Dan Catlin	I believe you mean 1992.	Correction made.
12	1	7	122-123	Robert Wiley	Sounds like sandbars built by low stage and short duration flooding!	Noted.
13	1	7	125	Robert Wiley	Have you evaluated rate of vegetation encroachment?	Addressed briefly later in the text of the chapter. See Figure 7.
14	1	8	148	Dan Catlin	It seems odd to say 'with the exception of…' and not say what that exception was. Perhaps it's not important, than I would just say 'the majority think…' Maybe you discuss below, but I suggest that if you do not, you reword or present Parsons' conclusion too.	Change made. Parsons (2003) asserted that there has not been a change in channel width over time.
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.
16	1	10	173	Robert Wiley	Vegetation "scouring is a non-happening. It's either overtopping by new sediments or erosion of the sander in total due to high flows.	The term 'scour' was used by the authors of various studies to describe the removal of in-channel vegetation via peak flow events. We generally concur with the removal mechanisms described in the comment although we would add that bars are often only partly removed through lateral erosion.
17	1	10	177-178	Robert Wiley	This seems a bit backwards. Reduced flows would increase the area not flooded. Cottonwood mortality on sandbars is more due to drowning than desiccation. Their roots extend very quickly to follow falling seasonal 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 subject. CITATIONS NEEDED	Noted.
18	1	11	187-192	Robert Wiley	A more intensive review of geology, geomorphology and surficial materials sources would help this discussion.	See Chapter 6.
19	1	11	192	Dan Catlin	You should define these for the hydrologically challenged.	Noted.
20	1	12	203	Robert Wiley	While the understanding of causes and effects is a bit dated, the changes are directly linked to magnitude of water. If water volumes are decreased, the river as a conduit and product of erosion and aggradation, must change to fit the changed flow regime. Unless the water can be returned to pre-development levels, there is no practical way to reverse the trends in nesting habitat loss for a sand nesting species.	Noted. However, statement assumes that the pre-development river provided suitable nesting habitat. This assumption is addressed in Chapter 5.
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	People use this term [vegetation scouring] as though it were a real phenomenon. It is either covering by sand or erosion of the substrate, both controlled by the range and magnitude of flows before, during and after each breeding season.	Noted.
23	1	14	258-259	Robert Wiley	Reword sentence as follows: Periodic high flows are necessary to create sandbar habitat suitable for successful nesting.	This is an excerpt from the PRRIP Biological Opinion. It cannot be reworded.
24	1	14	261	Robert Wiley	And on other nearby sandbar habitats in other river. It is not a big jump for any of these long-distance fliers to move to a whole new basin, and do so! While there has been some published work showing low site return fidelity, these birds are opportunistic on a continental scale.	Noted.
25	1	14	264-269	Robert Wiley	The strongest case can be developed using measured flow reductions. All changes proceed from that cause and its effect on river morphology. There is no need to infer anything.	We respectfully disagree with this statement. Recent CPR narrowing due to 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.
29	2	3	51	Matt Kondolf	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 of UBC (Figure 1 in individual comments - Appendix A of summary report).	The six-step AM cycle is a common representation of AM and the one used by the Program. Targeted research, pilot projects, and full-scale 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 six-step cycle is the figure currently recognized within the Program the figure will not be changed.
30	2	5	79	Matt Kondolf	states that the sediment deficit is "on the order of 150,000 tons", but does not provide a reference for this statement.	Text revised to remove the deficit estimate. Deficit discussed in more detail later in the chapter including estimates of pre- and post-development sediment loads, references for sediment deficit estimates, and a discussion of sediment sources.
31	2	5	83	Robert Wiley	Regarding "three days": Arbitrary? Likely way to short. Stage controls height of sandbar. Duration at stage 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 duration. Use these findings as a basis for management flows.	These issues are addressed in Chapters 3, 5 and 6.
32	2	5	84	Robert Wiley	Why? What is your rationale? Is this linked to vegetation encroachment?	Yes.
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??	Hypotheses were developed by PRRIP stakeholders based on their experience and expertise. The term 'channel width' typically refers to the 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. If 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 islands. 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?	See general Missouri River comment.
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	2	9	151	Dan Catlin	Effectiveness?	Yes. Change made.
40	2	9	151	Robert Wiley	Effectiveness?	Yes. Change made.
41	2	10	159	Robert Wiley	Do you mean creation of a single channel?	Yes. Consolidation of multiple anabranches into a single channel.
42	2	10	169-177	Robert Wiley	You should review the USACE attempts to improve sandbar habitat by these means in the Missouri River. As of 2007 they had not been successful.	Noted.
43	2	11	178	Robert Wiley	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 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.	There are no major tributary inputs. The second mechanism mentioned in the comment is correct. The deficit 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	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.	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 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.	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 load in the AHR by 15%. We could find no evidence in the literature to support the assertion that a 15% increase in sediment load would change sandbar heights. In addition, the channel gradation analyses at Nebraska stream gages (Chen 1999) indicate that the lower Platte and other river 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?	Approximately 1/3 of the CPR is fully consolidated. We have not observed different implementation or effectiveness responses in those reaches. As discussed in Chapter 3, sandbar height is a function of peak flow magnitude and duration. The peak flows in 2010 and 2011 exceeded the magnitude and duration hypothesized to be necessary to produce sandbars exceeding the minimum height criterion. No suitable sandbars were created during that event. Those events essentially served as high-contrast flow experiments. If they were not sufficient to create suitable habitat, we have little confidence that lesser flows will.
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, 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.	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	Or 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.	This was a statement of the assumption used in the original analysis. The validity of the assumption is addressed in the text of the chapter.
56	3	1	7	Matt Kondolf	"…conducted observational studies" (delete "an")	Change made.
57	3	1	7-8	Robert Wiley	Replace "conducted an observational studies of" with "measured." How did you measure sandbar heights?	Change made. The methods section of the chapter describes how sandbar heights 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 Wiley	What kind of productivity? Chick survival per nest? Nests per river mile? Chicks per reach??? You might define productivity first here.	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?	Negotiated during Program development.
63	3	2	23-24	Robert Wiley	Figure 1: Add some roads, other rivers, county lines…. Something to better inform one of the locale. This comment applies to all similar figures.	Noted.

Comment ID #	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 in the western half of the AHR as though the transition from 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.	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.
67	3	3	56-58	Robert Wiley	Reword sentence as follows: "A sandbar measurement program is necessary to evaluate the relationship 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." 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	Change not made. This is a discussion of the content of the PRRIP EIS.
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.
70	3	5	Table 1	Robert Wiley	Regarding sandbar area: ILT will successfully nest on much small bars. PPL seem to require multiple acres.	Noted.
71	3	5	Table 1	Robert Wiley	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 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.	Noted. See response to comment 62.
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>	The rationale for the CPR minimum sandbar height criterion was observed 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.	We respectfully disagree with this statement. The minimum width value may 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 camouflage.	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, Hydrologic, 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 Artificial 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 GPS 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 AHR 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.
77	3	6	75	Robert Wiley	But there is much more data out there, particularly between 2010 and 2014.	Noted.
78	3	6	76-80	Robert Wiley	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?	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.
79	3	6	86	Robert Wiley	Replace "observational studies" with "observations" and insert "relative to stage" after "heights."	Changes made.
80	3	6	93	Robert Wiley	Downstream of? Explain briefly for those not familiar with the Platte.	This comment is not clear.
81	3	6	94	Robert Wiley	Regarding "heavily influenced": Do you mean reduced? Also, add a period after "diversions."	"Heavily influenced" includes magnitude and timing.
82	3	6	94-95	Robert Wiley	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.	Sentence has been revised.
83	3	7	97-101	Robert Wiley	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?	Noted. This paragraph provides information on the spatial and temporal resolution of data that are available to address the priority hypotheses.
84	3	7	101-102	Robert Wiley	How does this relate to flow stage and bar height? What difference does off-channel habitat use to do with flow models?	Nest initiation dates are germain to discussions of habitat availability and use regardless of habitat type.
85	3	9	137-138	Robert Wiley	Well below 1200 cfs. How is this relevant?	The figure shows the emergent sandbars that were present following the 2010 peak flow event.
86	3	12	193	Dan Catlin	I don't think you need the double emphasis on "if".	Change made.
87	3	12	193	Robert Wiley	But that cannot occur. It is always lower	Noted.
88	3	14	219	Matt Kondolf	"…and delineate unvegetated…"	Change made.
89	3	14	222	Dan Catlin	I'm curious, is there any information about the size of sandbars prior to impoundment? Has this characteristic changed dramatically?	There is no information about sandbar size beyond what was presented in Chapter 1.
90	3	15	239	Dan Catlin	Stage is missing an "e".	Change made.
91	3	15	239	Matt Kondolf	"…peak flow stage."	Change made.
92	3	18	273	Dan Catlin	I'm confused. If this was most like the SDHF plan, and it didn't 'work,' why aren't you examining it more closely? Perhaps there is more about this later, but it seems that this is a significant piece of evidence that your proposed flows would not achieve your goals.	Agree that this is evidence that proposed flows will not work. However, it is not useful for examining sandbar height relationships in the AHR because sandbars were not produced by the event. That is why it was not examined more closely in the context of the objectives of this chapter.
93	3	19	289	Kate Buenau	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.	Clarification added to the figure caption.
94	3	19	289	Matt Kondolf	Figure 12 and similar references: Rather than "750 ft channel" say "750-ft-wide channel", etc	Noted.
95	3	20	308-310	Kate Buenau	Phrasing is confusing.	Modified text and added reference to Table 2.
96	3	21	314	Dan Catlin	I'd say very conservative when in at least one year, the SDHF didn't even create sandbars.	Noted.
97	3	21	321-322	Matt Kondolf	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 [see earlier comments], the greater flows may simply exacerbate the erosion of bars and thus make the problem worse.	Noted.
98	4	1	6	Matt Kondolf	"…colony incidence and open-channel width…" (suggest adding open to make clear that unvegetated, open channels are referred to)	Noted.
99	4	1	7	Robert Wiley	Agree! Both species are opportunistic. Both species should have evolved similar nesting site selection models.	Noted.
100	4	1	7-8	Robert Wiley	Why did you ignore the Missouri? There you have a wider variety of conditions a much larger dataset??	Noted.

Comment ID #	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
101	4	1	12-13	Robert Wiley	Consider that the distance to raptor perch trees is more important than 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 cottonwoods were absent.	See general Missouri River comment.
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. Wiley, R.A. Fischer, P.D. Hartfield and J.M. Scott. 2013, Lott, and Lott, C.A. and R.L. Wiley. Sandbar Nesting Habitat for Interior Least Tern (Sternula antillarum) on The Red River 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	I agree with Jorgensen	This paragraph addresses investigations specific to the Platte River.
105	4	5	94	Dan Catlin	the what?	Noted.
106	4	7	123-124	Robert Wiley	Accuracy is a major concern. 528 feet provides a great deal of uncertainty. GPS located nets would be more telling. Use the Missouri River datasets.	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 isn't a compelling reason for them to be excluded in my mind. I feel that having 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 AHR 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.	Clarified in text.
110	4	11	198	Dan Catlin	most?	No.
111	4	11	199	Dan Catlin	You should provide some justification for the models that you did select and those that you did not. By saying '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.	Clarified in text.
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 tightest 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, etc 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 (Of 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, Tibshirani, & Friedman, 2009, Hooten and Hobbs 2015). Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, 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 relative to your statements, but it took me a few minutes.	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 pdf, 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 width, channel break and the interaction of total channel width and channel break." We did not report the predictive deviance scores (akin to AIC 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.
117	4	14	240	Dan Catlin	I found myself wanting to find the 'available' measures for the AHR in this table. Can you provide?	Change made.
118	4	15	242	Kate Buenau	Figure 5 caption: second sentence is ambiguous: available locations from 2012 only and nesting colonies for all years?	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	16	254	Matt Kondolf	Figure 6: For lower right diagram, modify label as "Central Platte River (excluding AHR)"	Text clarified.
121	4	18	281	Dan Catlin	and plovers	Change made.
122	4	18	281	Kate Buenau	Is this meant to say tern AND plover? Have you looked at whether there is a species-specific effect?	Yes. There is insufficient data to evaluate the presence of a species-specific effect.
123	4	18	286	Dan Catlin	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.	This analysis could not be performed because annual sandbar availability data is not available for the other river segments. IE, 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 selection setback. Retry the model using the location of the treeline as you distance to colony 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	Your predictions for the Loup are much lower than those for the other reaches and so this seems out of place.	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 suggest such.	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	4	18	295-296	Robert Wiley	IBID	See above.
129	4	18	300	Dan Catlin	just say 1400 and get rid of generally.	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 morphology 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	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 chapter). 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.	These species do use the Loup but in very low numbers. The PRRIP 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 6 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	Sandbars do not emerge. Reword sentence as follows: "…sandbar habitat model was developed to assess potential correlation of reproductive success with hydrology…" Also, please clarify this term [reproductive success]; i.e.; a fledged chick per breeding pair? 3 chicks?	The 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	Perhaps the use of their eyes see and brains recognize that the water is receding. This would be an evolved physiological response.	Noted.

Comment ID #	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
137	5	1	13	Dan Catlin	Delete "in" before "on".	Change made.
138	5	1	18	Robert Wiley	Make tern singular.	Change made.
139	5	2	26-33	Robert Wiley	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 nest 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 fliers to just pick up and move to the next watershed (Red to Cimarron, Cimarron to Arkansas, Arkansas to Platte, all 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.	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 Fedrizzi 2013 report ILT nest in Brazil during the southern hemisphere spring.	Noted.
142	5	2	48-49	Robert Wiley	Regarding "recede to avoid inundation of nests": This the key factor. Success is completely dependent upon the absence of an overtopping flood at a nest site during the incubation to fledging period.	Noted.
143	5	2	49	Robert Wiley	Regarding "terrestrial predators": A very small loss continentally. It is occasionally locally important.	Noted.
144	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 everywhere.	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 sandbar 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 Program's objective is to improve productivity in the AHR. A review of 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 'fledge' is awfully 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	5	5	92-94	Robert Wiley	Please clarify. Did you create data to fill in expectations?	No. This was poor word choice. They were plotted together.
152	5	5	96	Dan Catlin	Were the values in that table from river colonies or from off-river colonies?	Both.
153	5	5	98	Robert Wiley	Regarding "in the historical AHR": When was this determined to be?	1895-1938 added to text.
154	5	5	102-103	Robert Wiley	This also captures the entire breeding season for both birds	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 modeled vs observed flows indicates that the model slightly overestimated low flows and under estimated 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 tern 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 nesting colony locations. We do not understand how demonstrating that the relationships at gage locations are representative of the relationships at nest colony 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 thought is that 0.5 ft is plenty of error 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 defensible… It looks like the fit is OK 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.
164	5	12	Figure 4	Dan Catlin	you cannot see the difference between LPR and AHR in your legend.	Figure Revised.
165	5	14	247	Robert Wiley	Smaller particles are entrained at lower velocities, thus carried and distributed over greater portion of the bed.	Noted.
166	5	14	244-252	Matt Kondolf	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?	The historical grain size was obtained from a 1931 USACE publication. 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. We apologize 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	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".	Text has been modified to improve 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 predictions. IE, the model predicts that median heights were below mean annual river stage.
168	5	15	256-257	Robert Wiley	Sandbar nesting habitat is different from just sandbar, it being just the upper portion that remained out of the water from nest initiation through fledging. Take care to distinguish.	Noted.
169	5	15	264	Kate Buenau	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.	Change incorporated.
170	5	15	266-270	Kate Buenau	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.	This analysis does not take peak flow duration into consideration. Sufficient data is currently not available to do so.

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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?	Correct.
173	5	16	288	Dan Catlin	There is a conflicting statement in Ziewitz. I believe the statement was that the nests were on the highest portions of the bar. You should state that uncertainty.	Text revised to state that nests are not always located at the highest elevation.
174	5	16	288	Robert Wiley	This is the same thing found in the Missouri River work the mechanical sandbar creation EIS.	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 1.5ft below stage median? If so, why are you discussing within sandbar elevations? Given the difficulty 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 sandbars 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 sandbar 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 sandbar height in 2010 was, on average, 0.29 ft higher 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	310-311	Robert Wiley	Now you have it!	Noted.
180	5	18	321-323	Robert Wiley	Agree! This double peak is visible in most east-flowing tributaries to the Mississippi.	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 sandpits and mines…	We state in the Methods section that all on- and off-channel nest records were included in the analysis.
182	5	21	360	Robert Wiley	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	5	22	371	Robert Wiley	Change to either "Flows recede" or "Flow recedes."	Change made.
186	5	22	377-378	Robert Wiley	This suggests that the Platte is not critically important to sustain the overall populations for these birds.	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.
188	5	23	388	Robert Wiley	This is the critical issue	Noted.
189	5	23	390	Kate Buenau	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)?	June was not included because one could assume that renesting would occur and inundation during that period was not as critical as later in the nesting season.
190	5	24	410-413	Robert Wiley	Yes!	Noted.
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 very important for the later endeavor that is mentioned in this document.	Noted.
192	5	24	414-420	Robert Wiley	This assertion is unnecessary to your findings. The birds do it, ergo they must be adapted either 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 breeding stratagems either fit the site and there is success or they do not and there is breeding 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 breeding successes on constantly changing rivers and shorelines during their reproductive lives.	Noted.
194	5	25	428	Robert Wiley	Regarding "renesting": On the Platte only!	Noted.
195	5	25	439	Robert Wiley	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	5	25	443	Kate Buenau	Is BARmax supposed to be BAR HEIGHT as listed in Table 3?	Yes. Correction made.
198	5	25	445-446	Robert Wiley	However, the phenomenon is common through the range.	Noted.
199	5	25	447	Kate Buenau	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.	That is one potential explanation. Another is that sandbar height was lower than the median value used to define bar heights in the reach.
200	5	26	467	Robert Wiley	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 admittedly 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 liberal, 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 unlikely in all but flood/drought pairings. This makes me think that 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 conservatively-high probability of successful nesting. 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	Matt Kondolf	Run-on, can be fixed by deleting "Although…"	Change made.
207	5	29	516-518	Matt Kondolf	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 reference should have been Sidle and Kirsh 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. See Baasch (2014) for off-channel productivity data in the AHR. Species productivity at off-channel habitat has exceeded proposed recovery objectives (Lutey 2002) in almost every year.

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208	5	29	518-521	Robert Wiley	Great summation! Also, these long-distance fliers are extreme opportunists. They are flying over anyway, on the way to Missouri and Mississippi sandbars.	Noted.
209	5	29	518-521	Matt Kondolf	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 (2004) and quoted by the BO (USFWS 2006), and incorporated within an extended quotation in Chapter 1 p.12. 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) [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.	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.
210	5	29	522-523	Dan Catlin	Yes.	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 breeding 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.	Noted.
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 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 purpose of these chapters is to provide a synthesis of data to help the Program address its "Big 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 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.	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	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 political objectives for the Platte (these are not scientifically based objectives) should limit the scope of site use comparisons.	Noted. The inclusion of all rivers was beyond the scope of this exercise.
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 tern productivity on managed river 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	82	Robert Wiley	Also see Lott et al, 2013.	Noted.
224	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 assert 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 construct designed (although inadvertently) to create a faux comparison.	We do not understand how comparing species populations in various river segments is a 'faux comparison.'
226	6	7	126	Robert Wiley	Insert "an insurmountable" before "degree." My opinion but I have done a good bit of sediment sampling. It requires a good understanding of planform and geomorphology, 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	6	8	147	Robert Wiley	Regarding "large": More definition needed to assess bias.	Clarified in text.
229	6	9	149	Dan Catlin	Add the "t" to "et"	Change made.
230	6	9	151	Robert Wiley	Insert "from images reviewed" after "segment."	Text modified.
231	6	9	161-162	Robert Wiley	So limit the comparison to 1998 through 2006 when the majority nested on non-mechanically-created habitat.	See general Missouri River comment.
232	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	6	10	169-176	Kate Buenau	Variability between years is mentioned here for the LPR—what about other segments?	Little of that data is available for other river segments.
235	6	10	181	Robert Wiley	Also see Lott et al 2013 and Lott and Wiley 2011 for the Red River numbers.	Noted.
236	6	10	183	Robert Wiley	Because the very productive habitat created by the 1998 high flow event had either eroded or became vegetated by 2006. Use the data between 1998 and 2006!	See general Missouri River comment.

Comment ID #	Chapter/Section	Page #	Line #	Reviewer	Comment	PRRIP Response
237	6	11	Table 6	Robert Wiley	Regarding "Mississippi River (Helena, AR - Greenville, MS)" row: Explained by very large and high sandbars on groin fields.	Noted.
238	6	11	198-200	Robert Wiley	Or perhaps not really comparable at all…	Why?
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. Fledge ratio is a commonly-reported metric for these two species and given our direction to compare river systems "fledge 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.
240	6	13	217	Kate Buenau	Table 9: It is unclear what the footnote is referring to.	Footnote removed.
241	6	14	226	Dan Catlin	without looking below yet, is this enough to contribute to higher densities? I assume this means that there's more opportunity to pull off a successful nest for both species…	No response necessary.
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.
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.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). The gradient is 50% greater than that of LPR Reach 1 (0.0012/0.0008 = 1.5) and in the midpoint of the Niobrara gradient reported of 0.0010-0.0015. (However, the Loup River is consistently higher gradient, 0.0015.) 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, transport capacity, grain size, peak flow water levels, and resulting sandbar height.	We concur. The word 'slightly' has been removed from the text. Ongoing reach-scale investigations at the Elm 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.
244	6	15	243	Robert Wiley	Yes!	Noted.
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 range-wide basis.
246	6	15	256	Dan Catlin	of the? and I'm not sure what your point is. This is a rehash of the results. I think you need to clarify your point.	Text clarified.
247	6	16	267	Dan Catlin	or imperfect detection of nests? Or both.	Text clarified.
248	6	16	269-270	Kate Buenau	Strictly speaking, only the objectives for total numbers are prorated, correct?	Text clarified.
249	6	16	274	Kate Buenau	CPR = AHR?	Yes. Text modified.
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.	Noted.
251	6	17	290	Dan Catlin	vs.? what for the other reaches, or the Niobrara at least.	Text added.
252	6	17, 20	295-298, 315-316	Kate Buenau	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?	In general, the relationship between sediment grain size, transport mode, and sandbar dynamics are poorly understood. Efforts are underway to better quantify these relationships in the AHR.
253	6	17	295-296	Robert Wiley	Just a thought… Is there a difference in the characteristic of sand sources in the locations?	Yes.
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 photograph.	All images are at the same scale. We agree that a scale bar would typically be used in this situation. However, we used an area box given that the discussion focus on sandbar area.
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.
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.
257	6	20	315-316	Robert Wiley	Sediment transport is via hydrology??? Please clarify.	Clarified.
258	6	20	326-328	Robert Wiley	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. 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 sites that make successful breeding habitat available for 1 out of 10 years. 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 birds longevity mitigates against the seasonal loss of production at any or all locations. The foregoing comparison does not provide useful information for management.	Noted.
259	6	21	331-332	Kate Buenau	What about variability in peak magnitude as well as timing? Habitat-creating years followed by drought?	Agree that these could also be important.
260	6	21	331-333	Robert Wiley	Yes! This is because the shape of the hydrograph mirrors the shape of the bar created. Very high 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.	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 the potential benefit of increasing low flows?	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, 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.
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	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 their sediment from the Nebraska sandhills.
266	6	22	371	Robert Wiley	Yes! Yes! Yes!	Noted.
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 "clear": Sediment free? Low sediment entrainment?	Return flows are virtually sediment free.
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 Missouri River EIS addressing the importance of aeolian process to finishing the nest site. Also see Lott and Wiley 2010 on aeolian 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 flow on the central Platte River where sediment gradations would be present. Rather, >90% of nests on central Platte River islands occurred on habitat created by bulldozers using existing sand in the channel. These islands, by design, were constructed as to not be overtopped by bank-full discharge which prohibited deposition of larger sediment sizes on the islands. This notion is also not supported by the fact >95% 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 with 100% fine sand spoil material that contains little variability in grain size. Furthermore, the Program has created off-channel nesting areas using bulldozers and excavators where larger sediments (gravel) are present. Nesting densities on these sites, however, are comparable to sites that were created through the sand and gravel mining industry where only fine sediments are present. Also, high densities and proportions of nests on the Missouri River on emergent sandbar habitat occurred during the first few years after creation. 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.

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Prepared by staff of the Executive Director's Office

for the Governance Committee of the Platte River Recovery Implementation Program