PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM (PRRIP -or- Program)
2024 PRRIP State of the Platte
REVIEW DRAFT as of May 28, 2024

PRRIP Science Plan Extension Big Question (EBQ) Assessments*

*As of the conclusion of calendar year 2023 (updated with 2023 data if available)

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Table of Contents

Table of Abbreviations

AF	Acre-Feet
AFY	Acre-Feet per Year
AHR	Associated Habitat Reach
AMP	Adaptive Management Plan
AMWG	Adaptive Management Working Group
AWB	Aransas-Wood Buffalo Whooping Crane Population
BPE	Breeding Pair Estimate
CLMU	Central Lowlands Management Unit
CPR	Central Platte River
EBQ	Extension Big Question
EDO	Executive Director's Office
FSM	Flow-Sediment-Mechanical
GC	Governance Committee
GPMU	Great Plains Management Unit
GTseq	Genotyping-in-Thousands by sequencing
IHMU	Interior Highlands Management Unit
ISAC	Independent Scientific Advisory Committee
J-2	Johnson-2 Hydropower Return
LPR	Lower Platte River
LT	Interior Least Tern
LTPP	Least Tern and Piping Plover
MUCW	Maximum Unobstructed Channel Width
NF	Nearest Forest
OCSW	Off-Channel Sand and Water
PP	Piping Plover
PRRIP or Program	Platte River Recovery Implementation Program
PS	Pallid Sturgeon
SDHF	Short-Duration High Flow
SDM	Structured Decision-Making
SIU	Southern Illinois University – Carbondale
SNPs	Single Nucleotide Polymorphisms
SoPR	State of the Platte Report
TAC	Technical Advisory Committee
TUCW	Total Unvegetated Channel Width
UNL	University of Nebraska – Lincoln
UOCW	Unobstructed Channel Width
USBR	Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WC	Whooping Crane

Introduction

The PRRIP EDO developed the 2024 SoPR for the Governance Committee (GC). It is intended to serve as a synthesis of Program monitoring data, research, analysis, and associated retrospective analyses to provide important information to the GC regarding key scientific and technical uncertainties. These uncertainties form the core structure of the Program's Extension Science Plan and are directly related to decisions regarding implementation of management actions, assessment of target species' response to those management actions, and how best the Program can utilize its resources (money, land, water).

A quick reference assessment for each of ten Extension Big Questions (EBQ) is provided in **Table 3**, followed by an assessment write-up for each EBQ. Each assessment includes information noting any updates or changes since publication of the last SoPR (in this case, the 2019 SoPR finalized as the Program's First Increment concluded). This document utilizes footnotes to identify key documents or data sets that are important to read and understand when reviewing this report. Those footnotes include hyperlinks to information available in the Public Library section of the PRRIP website.

Key Observations and Progress

The 2024 PRRIP SoPR includes assessments incorporating Program data primarily from years 2020-2023. This is the first SoPR generated during the Extension (years 2020-2032) and thus the first set of EBQ assessments largely reflect just the beginnings of Program learning. EBQ #1 is trending in a positive direction that may affirm important underlying hypotheses. EBQ#2-#9 are inconclusive at this time. The assessments for these questions come early in the Extension before key analyses and syntheses have been completed; in several instances, those analyses will begin later in 2024. EBQ #10, related to wet meadows, is a hold-over from the First Increment and is not stated as a question to be explored; rather, it will be addressed through peer review of the Wet Meadow Hydrology Report and internal Program discussions with the Technical Advisory Committee (TAC) about refining the Program's definition of wet meadows and what the implications are for future Program land acquisition and management.

The one-page summaries that follow provide broad updates on central Platte River form, function, and physical process issues, as well as the Program's target species (piping plover, whooping crane, and pallid sturgeon).

Channel Morphology and Vegetation

Roosting habitat suitability for whooping cranes is, in part, a function of the maximum unvegetated width of the main channel (MUCW). The total unvegetated width (TUCW) of the main channel is a geomorphic metric (versus a habitat metric) that is comparable to MUCW but a better response metric as it eliminates the randomness associated with MUCW in channels where the entire width of channel is not unvegetated.[1] **Figure 1** below shows change in mean TUCW of the main channel from 1998 through 2022 as well as the annual 40-day mean peak discharge during the same period.[2] In the early 2000s, TUCW declined rapidly as the basin descended into drought and peak flow magnitude decreased. A combination of phragmites spraying, mechanical vegetation control and recovering hydrology resulted in an increase in TUCW during the First Increment of the Program (2007-2019). Since 2019, TUCW has remained stable, despite a decline in peak flow magnitude similar to what occurred in the early 2000s. We infer that the stability in width despite a lack of peak flows is the result of germination suppression flow releases that are intended to inundate the channel during the germination period, preventing vegetation from becoming established. Ongoing germination suppression and phragmites research will help us better define the relationship between peak flow magnitude and channel inundating flows in maintenance of unvegetated channel width.

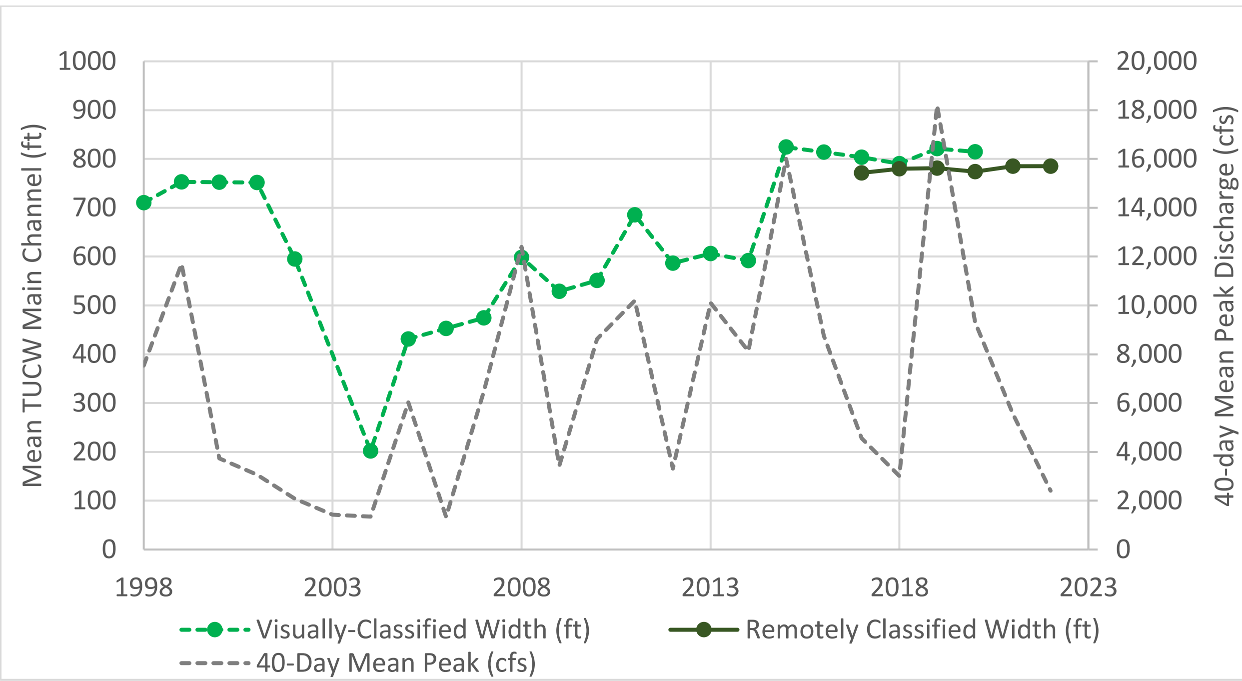


Figure 1. Mean of total main channel width unobstructed by dense vegetation (TUCW) through time plotted with 40-day mean peak discharge at the Grand Island gage. TUCW remained stable after 2019 despite a lack of peak flows. This contrasts with the narrowing observed in the early 2000s following a similar decline in discharge.

[1] For example, a channel with a TUCW of 1,000 ft bisected by a single vegetated island could have a MUCW ranging from 500 ft to 1,000 ft depending on the location of the island within the channel.

[2] First Increment research indicated that 40-day mean peak discharge was the best predictor of changes in TUCW during the First Increment.

Piping Plover (PP) Habitat, Use, and Productivity

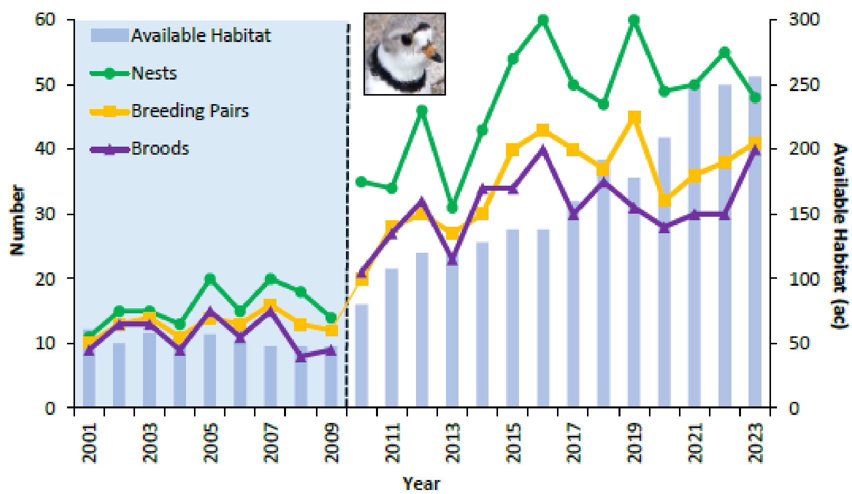


Figure 2. Annual variability in the total numbers of piping plover nests (green line), peak estimated breeding pairs (orange line), brood counts (purple line), and total on- and off-channel habitat available (acres; blue bars) observed within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska during 2001–2023. The black dotted line represents changes in protocol that occurred between 2009 and 2010, including an increase in monitoring effort. Data from 2001–2009 (shaded area) may not be comparable to data from 2010–2023. Due to access restrictions that limited monitoring at some sites, available habitat from 2001–2009 only included sites that were used in the reproductive and survival calculations each year.

The area of potential PP nesting habitat at off-channel sand and water (OCSW) sites has increased over time and remained at ~250 ac over the past three years (**Figure 2**). After the Program increased efforts to construct, manage, and maintain suitable off-channel nesting habitat beginning in 2010, there was an overall positive trend in the number of PP nests, estimated breeding pairs (BPE), and broods until these metrics peaked in 2016 (**Figure 2**). Since 2016, we have documented annual fluctuations in each of these metrics with some demonstrating wide interannual variability. The number of PP nests has ranged from 47 to 60 nests, and the estimated number of breeding pairs has varied between 32 and 45 pairs at OCSW sites (**Figure 2**). Overall, we have observed a significant, positive relationship between the estimated number of plover breeding pairs and area of potential nesting habitat at OCSW sites since 2001 (**Figure 2**).

Fledge ratios are one of the indicators used by the Program to measure reproductive success of PP over time and we have observed a positive trend in PP fledge ratios over the past several years after a low of 0.62 chicks/BPE in 2018. Plover fledge ratios at monitored sites during 2023 were 1.41 chicks/BPE, which represented a slight increase over the 1.37 chicks/BPE recorded during 2022 and a marked increase over the 2018 low. Through 2023, our PP monitoring efforts documented continued increases in PP nest productivity metrics. The number of PP fledglings and fledge ratios observed during 2023 were the highest since 2012 and 2014, respectively, which was shortly after the Program began constructing and adding more potential nesting habitat at OCSW sites. During 2023, we also documented the highest apparent nest success (0.83 successful nests/total nests) and number of chicks (143 chicks <15 days old) during the contemporary 2010–2023 monitoring period. These increases in nest success and productivity were likely attributable to fewer severe weather events during summer 2023 and a decrease in predation of nests and chicks relative to previous years.

Whooping Crane (WC) Habitat and Use

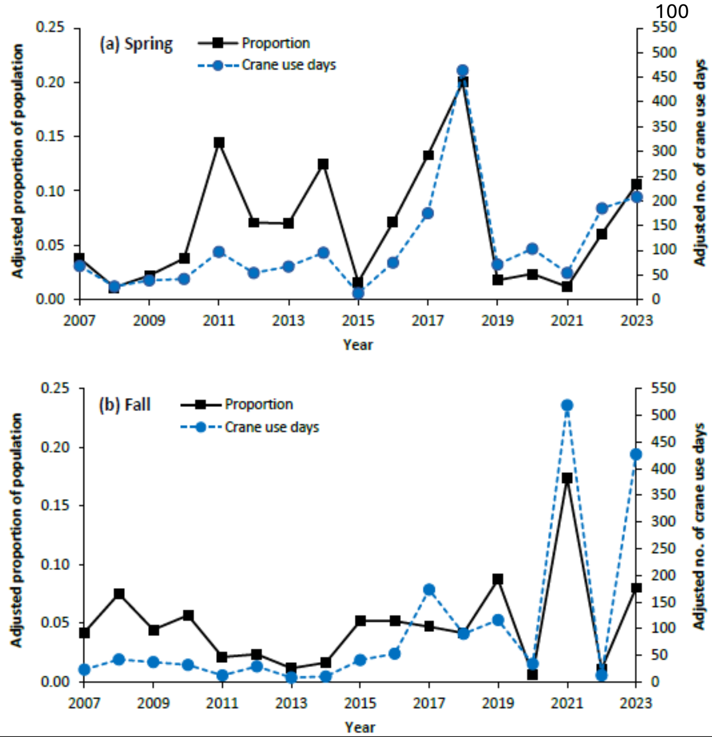


Figure 3(a & b). Annual variability in the proportion of the Aransas-Wood Buffalo (AWB) migratory whooping crane population that stopped on the AHR and the associated number of crane use days between 2007 and 2023 during the spring migration (a) and fall migration (b). Counts are adjusted to provide the proportion of the population and number of crane use days calculated only for dates constrained by the 5th and 95th percentiles of dates of spring and fall whooping crane group observations in Nebraska.

The Program's whooping crane (WC) management objective is to contribute to their survival during migration. Quantifiable metrics to help evaluate the success of this objective include the: (1) availability and area of suitable roosting and foraging habitat; (2) number of days WC were observed along the Associated Habitat Reach (AHR) during their migration (i.e., crane use days); and (3) proportion of the Aransas-Wood Buffalo (AWB) population that stops along the AHR during spring and fall migrations. Over the duration of the Program, the migratory AWB WC population increased from an estimated 237 birds in 2006–2007 to 536 birds in 2022–2023 based on surveys along the Texas coast of the Gulf of Mexico, USA wintering range. During the same period, WC spring and fall stopover metrics on the AHR as determined through PRRIP's systematic surveys demonstrated considerable annual variability.

During spring, the number of WC and proportion of population stopping on the AHR, and the number of crane use days increased over the past two years from recent observed lows during spring of 2019 through 2021 (**Figure 3a**). However, spring 2023 values remained within the ranges of annual variability of the metrics since 2007. The Program documented years of peak spring WC use of the AHR such as that which occurred during spring 2018 as well as years of low use before and after that peak. The high amount of variability in WC stopover metrics over time makes it challenging to quantify whether significant changes in these metrics have occurred. There was no relationship between the proportion of the AWB population stopping over on the AHR or the number of crane use days and year through spring 2023.

Fall WC stopover metrics demonstrated considerable annual variability. During three of the past five years, the Program observed the highest proportions of the population stopping on the AHR during fall since 2007 (**Figure 3b**). During fall of 2021 and 2023, the Program documented the highest number of crane use days since 2007. In between these years of high use, the Program observed historical fall lows in both stopover metrics. In part because of these recent years of high use, there was a significant, positive temporal trend in the number of fall crane use days during 2007–2023. However, there was no relationship between the proportion of the population stopping on the AHR during fall.

Pallid Sturgeon (PS) Habitat and Use

Ninety-four unique pallid sturgeon have been documented in the lower Platte River system since March, 2022. Pallid sturgeon use of the lower Platte River has been documented both above and below the Elkhorn River but use above the Elkhorn has been documented less frequently. Both reproductive and non-reproductive pallid sturgeon utilize the lower Platte River and its tributaries. Stage IV reproductive female pallid sturgeon have been documented in the lower Platte River and tributaries, including 4 miles up the Loup River, and more than 30 miles up the Elkhorn River. Evidence of potential spawning by a single stage IV female in 2023 was based upon departure time and recapture void of eggs, but to date no genetically confirmed pallid sturgeon embryos or larvae have been collected.

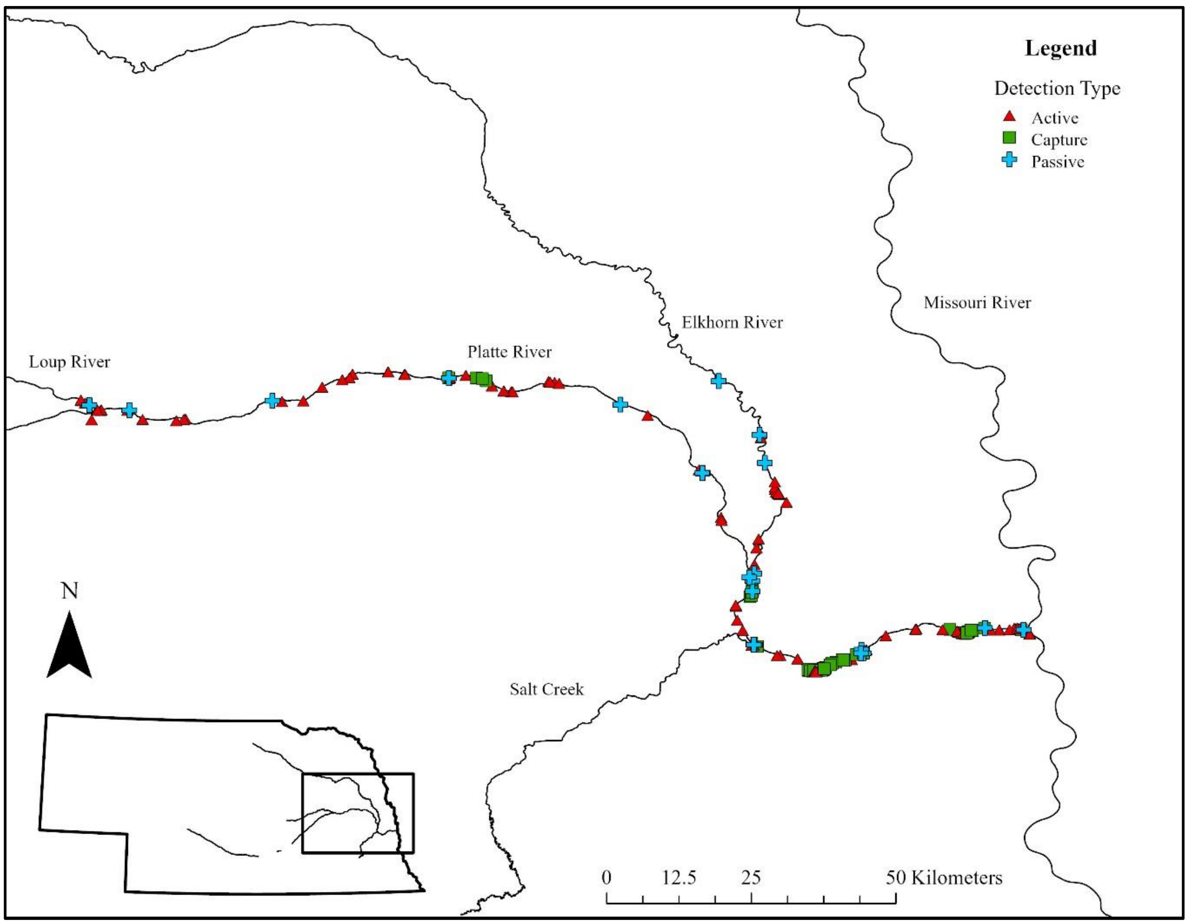


Figure 4. Map indicating locations of pallid sturgeon captures (green squares), active detections (red triangles), or passive detections (blue crosses) throughout the lower Platte River system from March 2022 through November 2023.

Independent Scientific Advisory Committee (ISAC) Comments on 2024 State of the Platte

Insert ISAC commentary after the 2024 Science Plan Reporting Session (responses to Discussion Questions)

Technical Advisory Committee (TAC) Comments on the 2024 State of the Platte

Insert TAC commentary after the 2024 Science Plan Reporting Session (responses to Discussion Questions)

Extension Starting Point: Summary of Key Learning from the First Increment (years 2007-2019)

The 2019 State of the Platte identified the following key learning observations from implementation of the Program's original Adaptive Management Plan (AMP) during the First Increment (years 2007-2019):

1) *Attempts to implement the flow-sediment-mechanical (FSM) management strategy generally produced poor results.*

- Short-duration high flows (SDHFs) (5,000-8,000 cfs for three (3) days at Overton, NE) are highly unlikely to create or maintain suitable least tern and piping plover nesting habitat or whooping crane roosting habitat.
- Flow consolidation is not feasible due to legal and permitting constraints.
- A sediment deficit exists in the south channel downstream of the J-2 Return. Five to seven years of full-scale sediment augmentation are necessary to assess efficiency and effectiveness in preventing downstream migration of incision and narrowing.
- First Increment learning occurred largely through natural flow events as the Program was unable to implement a true SDHF and was not able to conduct flow consolidation actions.

2) *Implementation of the mechanical creation and maintenance (MCM) management strategy produced mixed results.*

- Suitable on-channel whooping crane roosting habitat can be mechanically created and maintained on Program (or other managed) lands but off-channel palustrine wetland roosting habitat is not a viable alternative to on-channel habitat due to a lack of potential restoration sites and costs associated with the creation of new wetland sites.
- Off-channel tern and plover nesting habitat can be created and maintained using a variety of methods but on-channel nesting habitat is difficult to construct and erodes quickly.

3) *The target species responded to the implementation of Program management actions.*

- Least tern and piping plover populations in the AHR have increased significantly and proportionately to increases in habitat availability due to Program off-channel habitat creation efforts. Productivity on off-channel habitats has been sufficient to maintain stable to growing subpopulations.
- Based upon available data, least tern and piping plover productivity is insensitive to river flow. Periods of low flow have not reduced productivity due to a limitation in forage availability.
- Whooping crane use of the AHR has increased significantly and proportionally to increases in habitat suitability that are in part due to Program management actions.

4) *There was limited learning related to pallid sturgeon and the Program.*

- Translation of Program flow management actions from the central Platte to the lower Platte is difficult to detect and thus difficult to relate to effects on habitat and species response.
- Significant uncertainty relating to the life history of pallid sturgeon on the lower Platte (use, productivity, recruitment) has limited the ability of the Program to develop a clear set of testable hypotheses, management actions, monitoring protocols, and a plan for data analysis and synthesis.

These key learning observations were reflected in the final assessment of the First Increment Big Questions (see **Table 1**). As the Program developed the Extension Science Plan, the First Increment Big Questions were included as a link back to early Program learning and also to provide the context for routine check-ins based on new and expanded science learning during the Extension (see **Appendix A** for five-year check-in on WC roost site selection).

Table 1. First Increment Big Question Status Check-Ins.

PRRIP First Increment Big Questions	2019 Assessment	Check In Activities*
<u>Implementation</u> – Program Management Actions and Habitat		
1. *Will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?*	👎👎	On-channel monitoring to detect nesting on natural sandbar habitat following peak flow event(s)
2. *Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?*	👎👎	Relationship between flow and whooping crane habitat is an Extension focus – will be addressed directly.
3. *Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?*	👍	Big Question carried forward into Extension – will be addressed directly.
4. *Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?*	👍👍	Relationship between mechanical management actions and whooping crane habitat is an Extension focus – will be addressed directly.
<u>Effectiveness</u> – Habitat and Target Species Response		
5. *Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?*	👎👎	System-scale whooping crane monitoring. Whooping crane habitat selection analysis will be rerun on a five-year interval to identify changes in selection.
6. *Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?*	👍👍	Monitoring of piping plover breeding pairs and fledges in relation to habitat availability.
7. *Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?*	👎👎	Monitoring of piping plover nesting locations to detect an increase in on-channel nesting with corresponding decrease in off-channel nesting.
8. *Does forage availability limit tern and plover productivity on the central Platte River?*	👎👎	Monitoring to detect emaciated adults/chicks and/or drop in productivity (fledging) that is not attributable to weather or predation.
9. *Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?*	?	Pallid sturgeon questions will be directly addressed during the Extension as part of genetics and habitat research projects.
10. *Do Program management actions in the central Platte River cumulatively 1) produce detectable changes in the physical environment (i.e., habitat) and 2) result in a detectable increase in tern, plover, and whooping crane use of the Associated Habitats?*	**<u>LTPP Off-Channel</u>** Habitat: 👍👍 Species Response: 👍👍 **<u>WC On-Channel</u>** Habitat: 👍👍 Species Response: 👍👍	* LTPP Off-Channel: Monitoring of piping plover breeding pairs and fledges in relation to habitat availability. * WC On-Channel: Monitoring to detect a change in the distribution of WC use of the AHR as well as proportional use of Program properties.

*Check in activities are habitat and target species monitoring activities continued through the Extension that will provide information relevant to the previous/existing conclusions on the First Increment Big Questions for consideration by the Governance Committee.

Extension Science Priorities

During the Extension, Program science activities will center around two broad categories of learning as an organizing concept for relating scientific data and conclusions to decision-making. These priorities are the seed source for the Extension Big Questions and focused implementation and evaluation under the Extension Science Plan.

1) Active Learning – management action experiments

This Program science priority will focus on the design and implementation of specific Program management actions to learn how river form/function and the target bird species (primarily whooping cranes) respond. For the Extension, this science priority includes evaluation of:

- The effectiveness of Program water management in creating and/or maintaining suitable whooping crane habitat through suppression of channel vegetation germination (river channels with ≥650-ft widths unobstructed by dense vegetation are highly suitable for WC roosting).
- The effectiveness of Program management actions (flow and mechanical tools) in controlling the spread of channel vegetation, particularly *Phragmites australis*, as means of creating and/or maintaining suitable WC habitat.
- The role of Program sediment augmentation in the south channel of the Platte River below the J-2 Return in creating and/or maintaining suitable WC habitat.
- The relationship between WC use and flow and the seasonal effects of flow on WC use.
- The effect of Program flow management actions to benefit WC, PP, and LT in the central Platte River on pallid sturgeon use of the lower Platte River.

2) Maintenance Learning – improving and sustaining ongoing Program management actions

This Program science priority will focus on applying Program science to provide incremental refinements to ongoing Program management actions (primarily for piping plovers). For the Extension, this science priority includes:

- Investigating the effects of predation (mammals, reptiles, birds) on piping plover productivity (fledging) at Program-managed nesting sites.
- Evaluating effectiveness of Program management at mitigating losses of piping plover productivity due to predation.
- Complete research to provide a deeper understanding of the physical processes through which hydrological and meteorological variables affect groundwater levels to impact wet meadows.

Extension "Big Questions"

The following set of Extension Big Questions (EBQ), organized by science priority categories, are intended to serve as common organizing questions for addressing key areas of uncertainty for the Program and also to serve as a device for communicating with the GC on how science learning connects to decision-making. New EBQ or additional specific hypotheses may be added over time once questions are conclusively answered or if science learning points the Program in a different direction.

To assist the GC with quickly evaluating the 2024 EBQ assessments, the icons in **Table 2** are used to visually summarize the basic conclusion for each question. Thumbs up (**green**) or down (**red**) indicate a trend in the affirmative or negative and may point to the need to re-evaluate management actions based on collected data and analysis. A question mark (**black**) is used when there is not enough evidence to indicate a trend in either direction or more time is needed to collect appropriate data and conduct analyses. These icons are intended to provide the GC with a quick and visual means to see where the Program stands each year in moving towards resolution of the most significant scientific questions as they relate to management decision-making.

Table 2. Quick Reference Legend Explaining Icons Used to Assess EBQs.

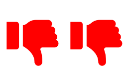
Icon	Trend or Answer Explained by Icon
	• EBQ and underlying hypotheses **answered conclusively** in the **affirmative** • Foundational documents, analysis, and other references on which this assessment is based have undergone peer review through the PRRIP peer review process and/or publication in refereed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

Table 3 summarizes 2024 Assessments from the PRRIP Executive Director's Office (EDO) for each of the EBQs. The table also includes brief reasoning for each EBQ Assessment and an indication of the likely timing of more in-depth EBQ evaluation.

Table 3. 2024 Extension Big Question (EBQ) Assessments.

PRRIP Extension Big Questions	2024 Assessment	Basis for Assessment
Extension Science Priority – Active Learning		
1. How effective is it to use Program water to maintain suitable WC roosting habitat?		Trending positive; formal data analysis in 2024.
2. How effective is Program management of Phragmites for maintaining suitable whooping crane roosting habitat?	?	Messy data; seeking continued implementation of formal study from 2024-2025, with possible extension of data collection depending on initial data analysis and reporting in 2025.
3. Is sediment augmentation necessary to create and/or maintain suitable whooping crane habitat?	?	*Peer review* of Sediment Augmentation Data Synthesis Compilation ongoing, complete in 2024; reducing this uncertainty is difficult, PRRIP may make decision to act to reduce potential risk.
4. What factors influence WC decision to stop or fly over the AHR?	?	Delay in accessing telemetry data, will be part of larger telemetry data analysis.
5. What factors influence WC stopover length within the AHR?	?	Delay in accessing telemetry data, will be part of larger telemetry data analysis.
6. Why is spring WC use of the AHR greater than fall WC use?	?	Delay in accessing telemetry data, will be part of larger telemetry data analysis.
7. What effect do Program flow management actions to benefit WC, PP, and LT in the central Platte River have on pallid sturgeon use of the lower Platte River?	?	Dual research projects underway, Program activity regarding this EBQ is tied to these projects (genetics + habitat/use), working through Pallid Sturgeon Agreement Framing Document (2021).
Extension Science Priority – Maintenance Learning		
8. How much of an effect does predation have on PP productivity (fledging)?	?	Have collected data on predation, productivity impact analysis in 2024.
9. How effective is Program management at mitigating losses of PP productivity due to predation?	?	Have conducted predator management experiment and collected data, effectiveness analysis in 2024.
10. Wet meadows research (NOTE: this is a carryover task from the First Increment to specifically address the physical processes involved in wet meadow hydrology)	n/a	*Peer review* of Wet Meadow Hydrology Report ongoing, complete in 2024; internal (EDO + TAC) discussion about Program definition of wet meadows to occur in 2024.

Structured Decision-Making (SDM)

During the First Increment, the Program utilized SDM as a framework for integrating quantitative and qualitative learning to adjust management for the interior least tern and piping plover (Compass Resource Management Ltd., 2016). As part of that process, First Increment science learning was used to develop habitat and species response models (tools) for the purpose of estimating consequences of management alternatives. Extension Science Plan activities have been designed to inform a second, broader SDM process that will be used to help facilitate negotiation of Second Increment implementation activities. We anticipate SDM planning and tool development (based on learning reported in this report each year) to begin as early as 2024 with implementation of the formal SDM process to begin in 2028.

Extension Science Priority – Active Learning

EBQ #1 – *How effective is it to use Program water to maintain suitable* WC roosting habitat?*

*Channels with ≥ 650 ft maximum width unobstructed by dense vegetation (MUCW) are highly suitable for whooping crane roosting.

2024 Assessment:

- Germination suppression flow releases appear to have been effective in maintaining MUCW of the main channel in segments where enough flow is sufficiently consolidated to inundate the channel during the release. Vegetation establishment did occur in segments with substantial flow splits (>40% of flow in side channels) and high channel width relative to flow. Vegetation was mechanically removed in those segments. The first formal assessment of effectiveness is scheduled for 2024.

What the science says in 2024:

- Based upon 2017-2022 data, MUCW has remained relatively stable across the AHR with limited mechanical intervention in 2021-2022. This despite declining flows and the absence of peak flows of a magnitude sufficient to scour in-channel vegetation. This is a much different response than the early 2000s when declining flows were followed by large reductions in MUCW (**Figure 5**).
- The smallest reductions in MUCW occurred in segments where germination suppression flow release was sufficient to inundate the channel. The largest reductions in MUCW occurred in segments where flow splits in combination with historical channel management (widening) resulted in incomplete channel inundation during the release.
- Mechanical management and *Phragmites* spraying are potentially confounding factors in evaluation of release effectiveness. The 2024 assessment will explicitly include and control for these activities.

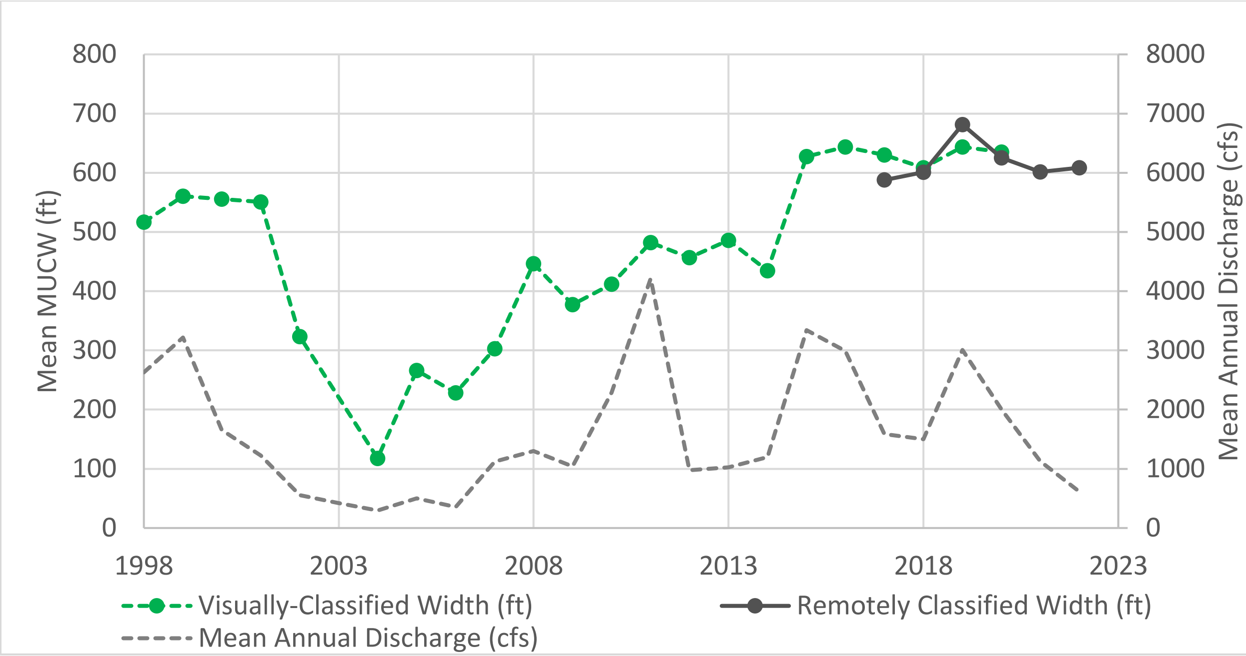


Figure 5. Mean of maximum unobstructed channel width (MUCW) through time plotted with mean annual discharge at the Grand Island gage. MUCW remained stable after 2019 despite decreasing river discharge. This contrasts with the narrowing observed in the early 2000s following a similar decline in discharge.

We estimate with confidence that:

- Better addressed upon completion of first round multi-year assessment.

Answering EBQ #1 during the Extension:

- First multi-year evaluation of effectiveness is scheduled for 2024.
- At that point, a decision will be made to continue germination suppression release flows as currently being implemented and as water allows or design a new flow management experiment.
- A second multi-year assessment is scheduled for 2028.

Management implications:

- At locations like Rowe Sanctuary, where a channel flow split diverted water away from a mechanically widened channel (reducing the amount of the channel inundation during the flow release) germination suppression releases were ineffective at maintaining MUCW.

Extension Science Priority – Active Learning

EBQ #2 – *How effective is Program management of Phragmites for maintaining suitable whooping crane roosting habitat?*

2024 Assessment:

- Benefits for slowing *Phragmites* expansion into the active channel have been seen where bankline patches are inundated by deep, fast-flowing water.
- The first formal assessment of effectiveness is scheduled for 2025.

What the science says in 2024:

- *Phragmites* stolon growth into the channel begins in May.
- June flow releases tend to change the direction of growth where water is deep and fast-flowing, confining stolon networks along downstream banklines. Areas of low or no velocity do not benefit from this management action in terms of confining *Phragmites* expansion.
- Expansion continues initially along the bankline, but periods of low flow and exposed sand following flow releases provide an opportunity for *Phragmites* to expand across the channel once again (**Figure 6**).
- Repeated years of implementation may slow growth across the channel to help maintain unvegetated channel width.
- The effect of herbicide application has been difficult to measure as applications have been inconsistent with study design.

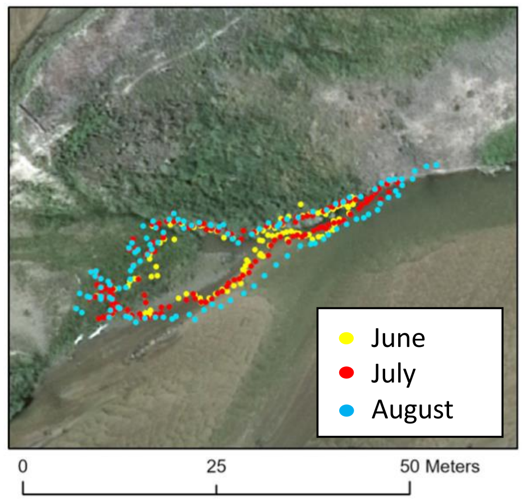


Figure 6. *Phragmites* patch expansion along bankline from June to August.

We estimate with confidence that:

- Better addressed upon completion of first round multi-year assessment.

Answering EBQ #2 during the Extension:

- First multi-year evaluation of effectiveness is scheduled for 2025.
- At that point, a decision will be made to continue June channel inundation as currently being implemented and as water allows or design a new flow management experiment.

- A desktop exercise using past data collected by the Program to evaluate the effects of high and low flows with and without herbicide application is also expected to provide information on the effectiveness of herbicide application and potential incremental benefits water may provide to effectively control *Phragmites* expansion and maintain channel width.
- A second multi-year assessment is scheduled for 2028.

Management implications:

- June germination suppression flow releases may reduce *Phragmites* expansion across the active channel when peak flows are absent.
- The channel inundation flow experiment can identify areas (proportion of active channel) where water will be more effective and where herbicide application can be reduced.
- Efforts to target herbicide application at a site scale have been unsuccessful.

Extension Science Priority – Active Learning

EBQ #3 – *Is sediment augmentation necessary to create and/or maintain suitable whooping crane habitat?*

2024 Assessment:

- This assessment is based off the draft sediment augmentation data synthesis report that is currently undergoing peer review. Results subject to change.
- The south channel reach from the J2 Return to the Overton bridge is incising and narrowing due to the sediment imbalance from clear water hydropower returns. The rate of incision is episodic and much slower than predicted. This due to increased rates of lateral erosion that are offsetting the deficit.
- Full-scale sediment augmentation (2017-2022) decreased bed erosion in the J2 Return channel by approximately 50% and had no effect on lateral erosion (**Figure 7**).
- Downstream from Overton, the channel appears to be in dynamic equilibrium with no trend of incision immediately prior to (2009-2016) or during (2017-2022) the sediment augmentation experiment. Although it did not incise, the channel widened substantially prior to and, to a lesser extent, during the augmentation experiment via lateral erosion of bars and banks.
- Absent augmentation of sediment into the J2 Return Channel, incision and narrowing may progress downstream past the Overton bridge at some point in the future. The timing and magnitude of the impact to whooping crane habitat is highly uncertain.

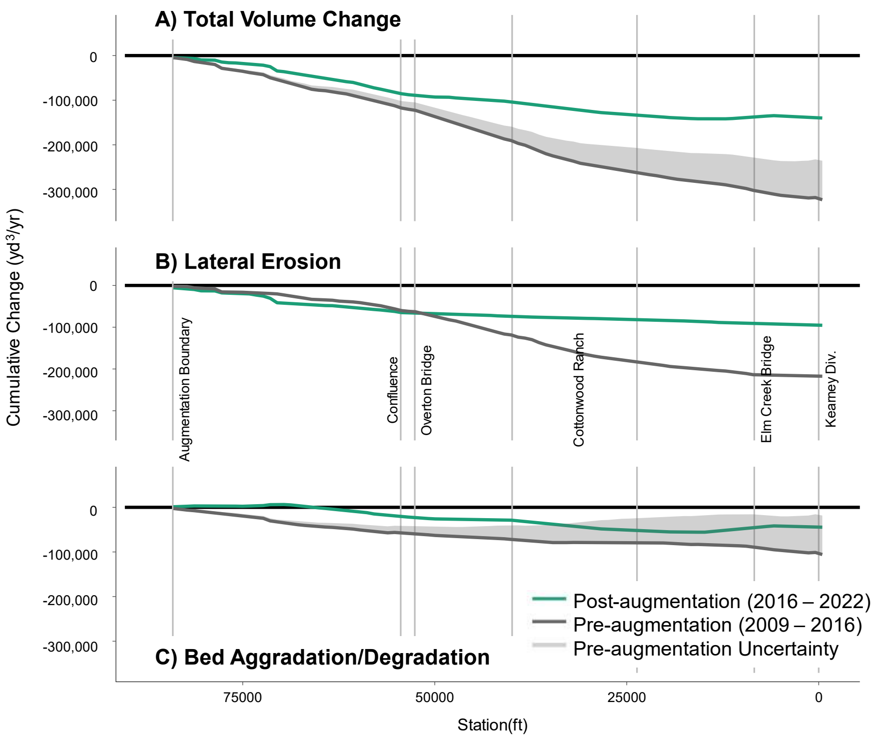


Figure 7. Comparison of cumulative volume change through sediment augmentation experiment reach prior to and during the sediment augmentation experiment.

What the science says in 2024:

- Prior to the augmentation experiment (2009-2016), average annual bed volume change in the J2 Return Channel was between -42,000 and -60,000 yd^3. During the experiment period of 2017 – 2022, an average volume of 43,000 yd^3 was augmented annually below the J2 Return. Mean annual bed erosion during this period was -18,300 yd^3 indicating augmentation potentially reduced bed erosion by 50%. Mean lateral erosion remained stable at -63,000 yd^3 prior to augmentation and -59,800 yd^3 during the augmentation experiment.
- Annual bed volume change in the J2 Return Channel was highly variable during the augmentation experiment ranging from approximately -77,000 yd^3 to +3,000 yd^3, with variability related primarily to flow volume through the J2 Return Channel with increased bed erosion during high flow years. Channel incision likewise varied with flow volume with incision occurring during high flow years followed by recovery during low flow years.
- During the augmentation experiment, an area of thalweg incision occurred mid-way between the J2 Return and Overton bridge (Station 70,000). Much of this incision occurred during 2019, when J2 Return Channel flows were elevated. Sediment deposited in this area in 2021-2022, filling in much of the thalweg erosion that occurred in 2016.
- Downstream of Overton, annual bed volume change was also highly variable but the average volume change during the augmentation experiment (-16,000 yd^3) fell within the pre-augmentation range (-46,100 to 23,700 yd^3). Mean annual lateral erosion volume (-57,000 yd^3) was lower during augmentation than prior to augmentation (-200,000 to -131,000 yd^3). This difference can be attributed to a large natural peak flow event in 2015 that substantially widened the channel.

We estimate with confidence that:

- On average, 40,000 yd^3 of sediment augmentation is sufficient to offset all bed erosion in dry years and approximately half of bed erosion (~20,000 yd^3) on average although the majority of bed erosion is episodic, occurring in high flow years.
- Channel incision and narrowing, accompanied by planform change (braided to wandering) is occurring locally in the J2 Return Channel during high flow years, although some recovery has been observed during dry years when augmentation supply exceeds sediment transport capacity.
- Overall, lateral erosion in the wandering section of the J2 Return Channel is supplying adequate sediment (with or without augmentation) to prevent incision (and associated planform change) from rapidly progressing downstream through the Overton Bridge. Sediment supply from the north channel confluence upstream of the bridge also provides a buffer against incision migrating downstream. Accordingly, there is no incising/narrowing trend downstream of the Overton bridge.
- Over the long term, the stability of the lower portion of the J2 Return Channel will be highly sensitive to the sediment volume recruited into the channel through lateral erosion. If lateral erosion is impeded or channel evolution results in less meander migration, we would expect the rate of progression of incision and narrowing to increase.

Answering EBQ #3 during the Extension:

- The first sediment augmentation experiment has been completed and is currently undergoing peer review. The results of the peer review process will be used to determine if another experiment is necessary to address outstanding uncertainties.

Management implications:

- In the near term, sediment augmentation is likely not necessary to prevent incision and narrowing to progressing downstream through the Overton bridge. This is especially true if the basin remains in drought in the near future. Over the long term, there is a higher risk of downstream impacts if 1) this reach experiences a series of high flow years either due to J2 Return flows or flood flows across Jeffery Island and/or 2) continued channel evolution decreases the volume of lateral erosion, which plays a critical role in sediment supply and downstream channel stability.
- PRRIP stakeholders have voiced a preference to transition to implementation of some degree of active or passive augmentation to buffer against potential future risks. The location, volume and method of augmentation have not been determined and are a focus area for 2024 study.

Extension Science Priority – Active Learning

EBQ #4 – *What factors influence WC decision to stop or fly over the AHR?*

2024 Assessment:

- Delay in acquiring the cellular telemetry dataset required to address this question pushed the assessment originally scheduled for 2023 back to begin in 2024.

What the science says in 2024:

- The Program has not been able to directly test the importance of flow at the time of whooping cranes making stopover decisions, since Program monitoring efforts typically collect data only after the birds have made that decision and are on the ground.
- A preliminary Platte-specific analysis using cellular telemetry locations of 49 individual birds within 100 km of the central Platte River from fall 2017 – fall 2020 provided only 9 stopovers to compare with 108 flyovers, with 5 of those stopovers occurring within a single season. That preliminary analysis indicated that time of day was a better predictor of stopovers along the Platte than either unobstructed channel width or river flow (**Figure 8**).
- The small number of telemetry birds that stop along the AHR limits the confidence we have in preliminary analyses and may limit the ability to examine the relative effect size of multiple factors involved in stopover decisions.

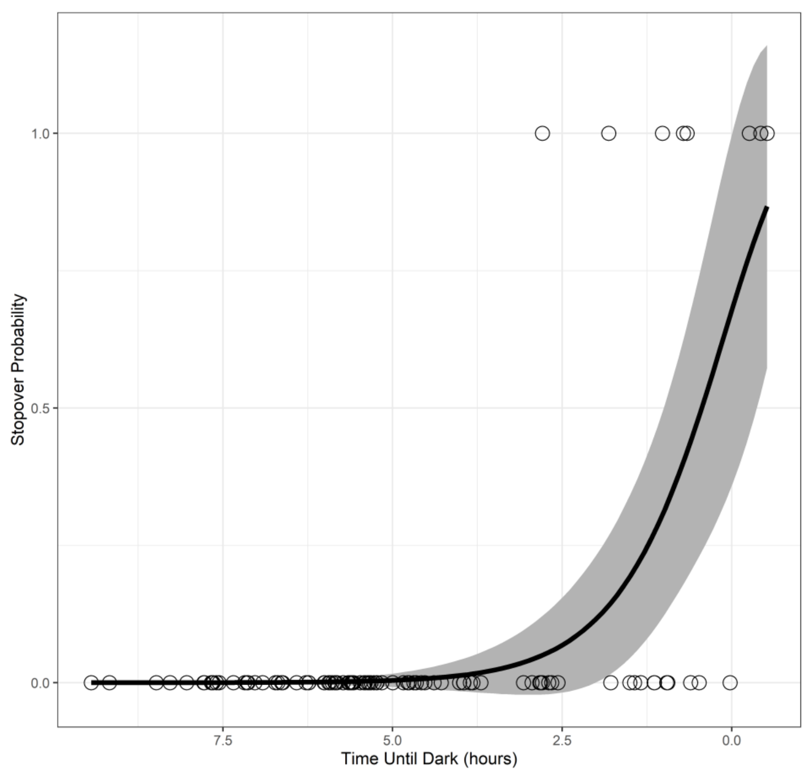


Figure 8. Predicted probability of an Associated Habitat Reach stopover in response to time until dark (sunset plus 30 minutes) of cellular telemetry marked whooping cranes from fall 2017 – spring 2020. Open circles represent whooping crane stopovers (y=1) and flyovers (y=0).

We estimate with confidence that:

- Better addressed once the WC telemetry data is in hand and the EDO can complete data analysis in a manner that addresses this EBQ.

Answering EBQ #4 during the Extension:

- This will be investigated as a desktop exercise utilizing cellular telemetry data to explore the effects of instantaneous flow on the decision to stopover as WC encounter the AHR.
- We estimate receiving a cellular telemetry dataset by February of 2024 with data analysis being completed by early 2025.
- Second round of evaluation scheduled for 2027

Management implications:

- If desktop analyses demonstrate flow to be important for WC stopover decisions, the Program may want to move toward a management hypothesis and perform flow experiments on the ground as water is available to test WC decision to stopover based upon flows during WC migration.
- Information on the relative importance of factors the Program can control (flow, channel width) compared to those it cannot (time of day, weather, distance since last stopover) can be used to help predict changes in WC use of the Program AHR that might be expected in response to Second Increment management alternatives as part of a structured decision-making process.

Extension Science Priority – Active Learning

EBQ #5 – *What factors influence WC stopover length within the AHR?*

2024 Assessment:

- Delay in acquiring the cellular telemetry dataset required to address this question pushed the assessment originally scheduled for 2023 back to begin in 2024.

Figure 9. Record stay length of 73 days on the Platte River for two adult whooping cranes from Oct 30, 2023 to Jan 10, 2024.

What the science says in 2024:

- The Program has not addressed the influence of flow on WC stopover length at this point (**Figure 9**). This question will be addressed as part of the telemetry analysis once data are acquired.

We estimate with confidence that:

- Better addressed once the WC telemetry data is in hand and the EDO can complete data analysis in a manner that addresses this EBQ.

Answering EBQ #5 during the Extension:

- This will be investigated as a desktop exercise utilizing PRRIP monitoring data and telemetry data to further explore the effects of flow on WC stopover lengths within the AHR.
- We estimate receiving a cellular telemetry dataset by February of 2024 with data analysis being completed by early 2025.
- Second round of evaluation scheduled for 2027

Management implications:

- If desktop analyses demonstrate flow to be important for WC stay lengths, the Program may move toward a management hypothesis and perform flow experiments on the ground as water is available to test WC stopover lengths in response to flows during WC migration, starting by filling data gaps for WC tolerance to low flows.
- Information on the relative importance of factors the Program can control (flow, channel width) compared to those it cannot (length of stay at previous stopover, weather, season, proportion of migration completed, group composition, association with sandhills) can be used to help predict changes in WC use of the Program AHR that might be expected in response to Second Increment management alternatives as part of a structured decision-making process.

Extension Science Priority – Active Learning

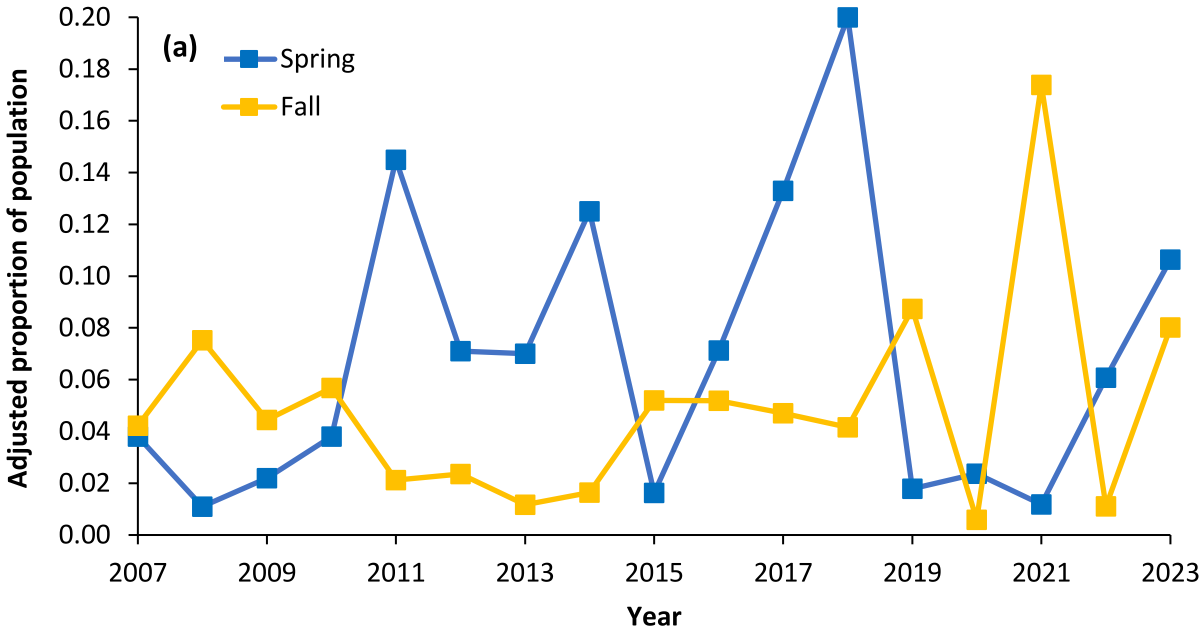
EBQ #6 – *Why is spring WC use of the AHR greater than fall WC use?*

2024 Assessment:

- Delay in acquiring the cellular telemetry dataset required to address this question pushed the assessment originally scheduled for 2023 back to begin in 2024.

What the science says in 2024:

- The Program typically observed greater use of the AHR during the spring migration compared to the fall migration prior to 2021 (**Figure 10**).
- During 2007–2020, the median number of crane use days was significantly higher during the spring compared to the fall migration using the nonparametric paired Wilcoxon signed rank test (p = 0.041). Similarly, the mean number of crane use days was 49 days greater during spring than fall using a paired t-test (p = 0.093) with 95% confidence intervals (CIs) including, but not centered on 0 (95% CI = -9.5, 108).
- There was no difference in the median proportion of the population stopping on the AHR in spring compared to fall (paired Wilcoxon signed rank test, p = 0.268) during 2007–2020. Likewise, there was no difference in the mean proportion of the population stopping in spring compared to fall (paired t-test, p = 0.151) during 2007–2020.
- The Program recently documented two years (2021; 2023) of record high use of the AHR during the fall migration (Figure 8). As a result of adding data from 2021 through 2023, there was no difference in either the median number of crane use days (paired Wilcoxon signed rank test, p = 0.246) or mean number of crane use days (paired t-test, p = 0.801) between spring and fall during 2007–2023. Additionally, there was no difference in either the median proportion of the population stopping on the AHR (paired Wilcoxon signed rank test, p = 0.353) or mean proportion of the population stopping on the AHR (paired t-test, p = 0.344) between spring and fall during 2007–2023.
- The Program has not addressed the influence of flow on seasonal use of the AHR. This question will be addressed as part of the telemetry analysis once data are acquired.



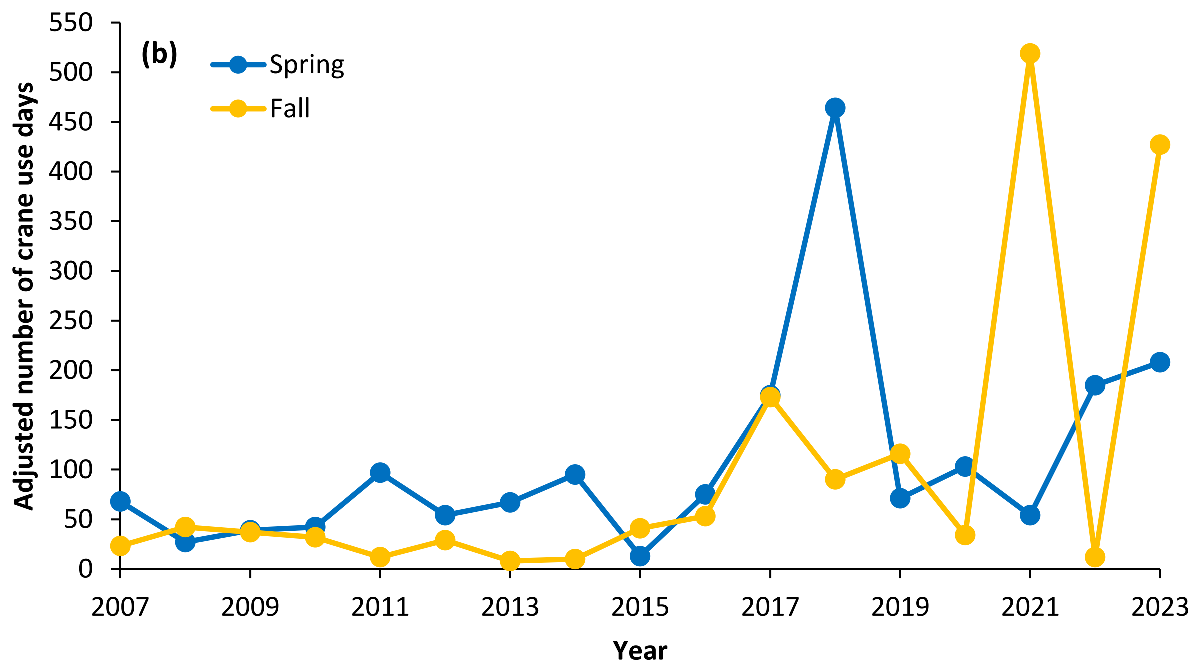


Figure 10. Annual variability in the (a) proportion of the AWB migratory whooping crane population that stopped on the Associated Habitat Reach of the central Platte River during spring and fall between 2007 and 2023, and (b) number of crane use days during the spring and fall migrations between 2007 and 2023. Counts are adjusted to provide the proportion of the population and number of crane use days calculated only for dates constrained by the 5th and 95th percentiles of dates of spring and fall whooping crane group observations in Nebraska.

We estimate with confidence that:

- Better addressed once the WC telemetry data is in hand and the EDO can complete data analysis in a manner that addresses this EBQ.

Answering EBQ #6 during the Extension:

- This will be investigated as a desktop exercise utilizing PRRIP monitoring data and telemetry data to further explore the effects of flow on WC use of the AHR in the spring vs. fall.
- We estimate receiving a cellular telemetry dataset by February of 2024 with data analysis being completed by early 2025.
- Second round of evaluation scheduled for 2027

Management implications:

- If desktop analyses demonstrate flow to be important for explaining differences in WC use of the AHR, the Program may move toward a management hypothesis and perform flow experiments on the ground as water is available to test WC response to spring vs. fall flows, starting by filling data gaps for WC tolerance to low flows.
- Information on the relative importance of factors the Program can control (flow, channel width) compared to those it cannot (staging prior to encountering the AHR, conditions at prior stopovers, weather, group composition, associations with sandhills) can be used to help predict changes in WC use of the Program AHR that might be expected in response to Second Increment management alternatives as part of a structured decision-making process.

Extension Science Priority – Active Learning

EBQ #7 – *What effect do Program flow management actions to benefit WC, PP, and LT in the central Platte River (CPR) have on PS use of the lower Platte River (LPR)?*

2024 Assessment:

- The Program is working its way through the Pallid Sturgeon Framing Document and is actively engaged in two research collaborations in 2022 to gather more information on pallid sturgeon (PS) habitat in the lower Platte River (University of Nebraska, Lincoln, UNL) and to establish new genetic baselines for PS species identification and hybridization (Southern Illinois University, Carbondale, SIU).

What the science says in 2024:

UNL Habitat and Spawning Research

- Ninety-four PS have been documented in the lower Platte River system and its tributaries in 2022-2023.
- Seasonality of movement into (immigration) the lower Platte River appears evident and may be greatest during spring and fall. Initial model results suggest discharge and temperature may also influence immigration.
- Emigration out of the lower Platte River was less clear, but some increased activity did occur during the post-spawning window in May and June.
- Movement into the lower Platte River is not limited to locations below the Elkhorn River confluence but extends the entirety of the system, albeit with lesser frequency moving upstream.
- Both reproductive and non-reproductive PS appear to regularly move into the lower Platte River and its tributaries. Stage IV reproductive female PS have been documented in the lower Platte River and tributaries. In 2023 the crew gathered evidence of potential spawning by a single female PS, based on departure time and no eggs present upon recapture.
- Spawning has been very difficult to verify due to the inability to track reproductively ready fish 24/7 and inability to collect genetically identifiable embryos/larvae. Despite high effort toward verifying spawning, we estimate a low probability of success.

SIU Genetic Research

- SNP genetic markers combined with GTseq technology provides improved ability to distinguish between pallid, shovelnose, and hybrid sturgeon reducing uncertainty around species identification and allowing for quicker, more efficient, and more accurate genetic assignments.
- Fifty-seven fin clips have been collected from fish captured by UNL with a single clip coming from a fish kill event in 2023. Two were samples from wild caught fish in 2022 (one a pallid, the other a hybrid), with the other fifty-five being of hatchery origin. Of the 57 fin clips, GTseq markers identified 50 as PS, 3 as shovelnose sturgeon, 2 as hybrids, and 2 samples came from triploid individuals that could not be identified.
- No genetically identifiable PS free embryos or larvae have been collected from the lower Platte River over the two years of the study. Of the six free embryos/eggs collected, two could be identified as shovelnose sturgeon, but there was not enough DNA from the other four to allow for genetic identification.
- GTseq markers found small but significant differences between the Great Plains management unit (GPMU) and either the Central Lowland (CLMU) or Interior Highlands (IHMU) management units, but no significant differences between the CLMU and IHMU. These results are consistent with current microsatellite results.

We estimate with confidence that:

- Better addressed upon completion of multi-year assessment in 2026.

Answering EBQ #7 during the Extension:

- The Program's commitment to PS during the Extension is achieved through implementation of a three-step science learning process formalized by the GC in a June 2021 Framing Document.
- **Step 1:** (2022-2026) In 2022 two inter-related PS research projects were initiated in collaboration with the University of Nebraska, Lincoln (UNL) and Southern Illinois University, Carbondale (SIU). UNL is leading general habitat and spawning research in the LPR to identify how and how much CPR flow management is likely to influence general PS use in the LPR. Genetics research led by SIU involves genetic identification of PS tagged as part of UNL research. Genetics research will be used to assess PS hybridization, population structure, and effective population size.
- (2023-2024) Hydraulic modeling bridges the gap between Step 1 and Step 2 by 1) translating flows from the central Platte to the LPR, 2) modeling changes in LPR flow-dependent metrics due to Program flow management, and 3) providing the ability to predict PS response to those changes.
- **Step 2:** (2026-2027) Hydrologic modeling will be included as a task in a flow management study to route central Platte flow to (and through) the LPR for the purpose of identifying potential impacts and benefits to PS in the LPR. The EDO will be responsible for defining potential water management/operations scenarios.

Management implications:

- (2028-2030) Technical work products from Steps 1 and 2 will be synthesized into a predictive modeling framework that can be used in a stand-alone structured decision-making (SDM) process or as part of a broader SDM process to inform allocation of defined contributions during a Second Increment. As part of the SDM process, policy makers will identify operational rules for CPR flow management that will minimize/avoid impacts and provide benefits to PS in the Second Increment (and possibly remainder of Extension).

- **Step 3:** (2031 forward) Manage water in accordance with operational rules during Extension and Second Increment.

Extension Science Priority – Maintenance Learning

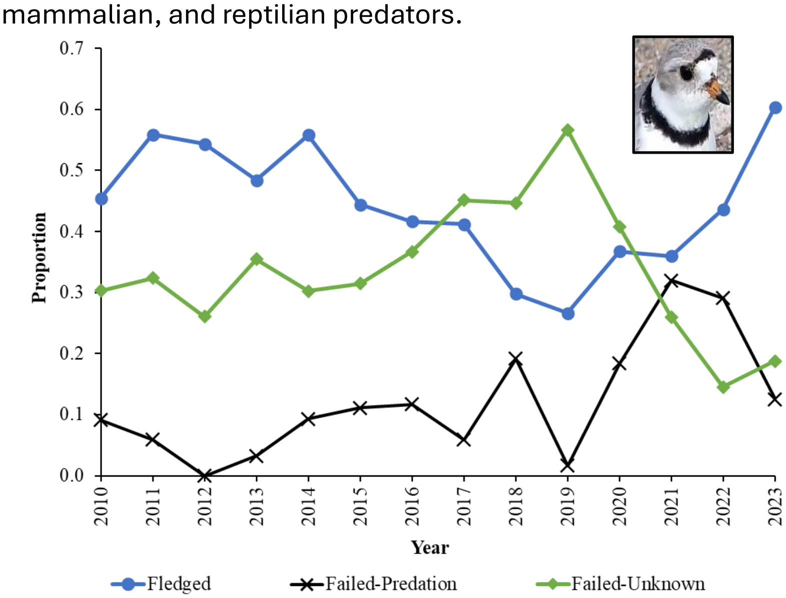
EBQ #8 – *How much of an effect does predation have on PP productivity (fledging)?*

2024 Assessment:

- From 2021-2023 the Program has documented 26 plover nests that failed due to predation and the loss of 98 plover eggs. In addition, 8 plover chicks have been documented as lost to predation.
- The first formal assessment of how losses to predation impact future PP productivity from the Program's AHR is scheduled for 2024.

What the science says in 2024:

- Plover fledge ratios have improved, with a three-yr. running average of 1.25 fledges/breeding pair from 2021-2023, since the low fledge ratios observed in 2018 (0.62 fledges/breeding pair) and 2019 (0.67 fledges/breeding pair).
- From 2021-2023 an average of 25% of nests across the AHR were documented to have failed due to predation. Documentation was largely due to the placement of remote cameras at plover nests during incubation.
- Though 28% of broods failed over this period, only 4% of those could be traced back to predation. Remote cameras have not been able to capture predation events on mobile chicks. Thus, the impact of predation on broods remains a gap in our learning.
- The predators responsible for losses at nests varies across sites and years, and includes documented predation by avian, mammalian, and reptilian predators.
- In 2019 prior to nest camera monitoring, 57% of plover nests failed due to unknown causes (**Figure 11**). The number of unknown losses dropped to a low of 15% in 2022 due in large part to information gathered at the nest by remote cameras.
- As unknown losses dropped, the number of nests we were able to accurately fate as lost to predation increased. Only 2% of nests were fated as failed to predation in 2019 compared to 32% in 2021 (**Figure 11**).



We estimate with confidence that:

Figure 11. Proportion of piping plover nests that fledged, failed due to predation, and failed due to unknown causes by year during 2010–2023 across the AHR.

- The impact of predation on nest success varies across sites and years, ranging from 4 to 15 predated nests across the AHR each season from 2021-2023.

Answering EBQ #8 during the Extension:

- We will continue to implement additional predator management and remote camera monitoring through the 2024 nesting season.
- First multi-year evaluation of impact is scheduled for 2024.
- At that point, a decision will be made to continue additional predator management and remote camera monitoring as currently being implemented or design a new management experiment.
- A second multi-year assessment is scheduled for 2027.

Management implications:

- Predation continues to impact plover productivity but is highly variable across sites and years. Losses to predation will help inform mitigation decisions (see Extension Big Question #9 below).

Extension Science Priority – Maintenance Learning

EBQ #9 – *How effective is Program management at mitigating losses of PP productivity due to predation?*

2024 Assessment:

- First formal assessment of the effectiveness of Program predator management for mitigating losses of PP productivity is scheduled for 2024.

What the science says in 2024:

- The predator exclusion fence installed along the interior shoreline at Kearney Broadfoot South has been effective at reducing known losses to predation at this site. Plover fledge ratios at this site were higher in 2022 and 2023 than they have been since 2014, peaking at 1.63 fledges/breeding pair in 2023 (**Figure 12**). No plover nests or broods were documented as lost to predation in 2022 or 2023 at this site.
- Fencing installed outside the nesting peninsula together with predator deterrent lighting on the nesting peninsula at Newark West has been less effective and highly variable from year to year.
- Lighting alone may not be an effective deterrent for avian predators. Cameras documented the insensitivity of owls to this deterrent. Leaman lost all nests to predation by owls in 2021 following implementation of lighting. In 2022 all nests failed due to severe storm events, providing no data on lighting effectiveness for that year. Leaman had only a single plover nest in 2023, which was successful.

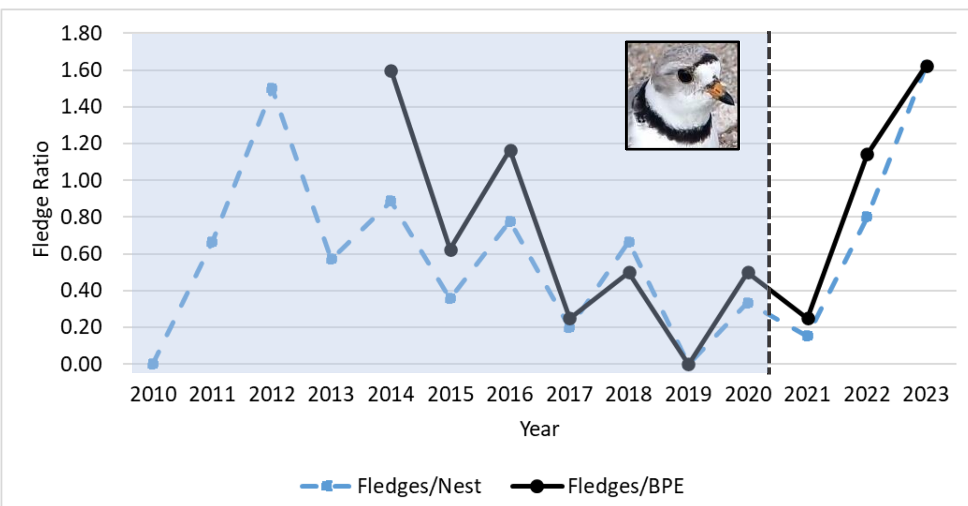


Figure 12. Piping plover fledge ratios at Kearney Broadfoot South OCSW nesting site prior to (blue shaded region) and following (no shading) implementation of additional predator management (interior predator fence and deterrent lighting).

We estimate with confidence that:

- Fencing along interior shorelines has been effective in reducing losses to predation.

Answering EBQ #9 during the Extension:

- We will continue to implement additional predator management and remote camera monitoring through the 2024 nesting season.
- First multi-year evaluation of impact is scheduled for 2024.
- At that point, a decision will be made to continue additional predator management and remote camera monitoring as currently being implemented or design a new management experiment.
- A second multi-year assessment is scheduled for 2027.

Management implications:

- High year to year variability in predation pressure across sites will make it hard to predict ahead of time which targeted management actions might be most appropriate for deployment at each site each season.
- Predator control with broader applicability such as fencing that not only reduces predator presence on nesting sites but also reduces the number of other species (e.g. geese and turtles) that nest there to attract predators may be an effective strategy.

Extension Science Priority – Maintenance Learning

EBQ #10 – *Wet meadows research (NOTE: this is a carryover task from the First Increment to specifically address the physical processes involved in wet meadow hydrology)*

What the science says in 2024:

- Wet meadows in the central Platte River valley exhibit highly variable groundwater depths and inundation frequency, in part due to local variations in topography and relative elevation differences between the river and adjacent valley floor. Because groundwater and vegetation are tightly linked, this variability has important implications for management and restoration of wet meadow sites (**Figure 13**).

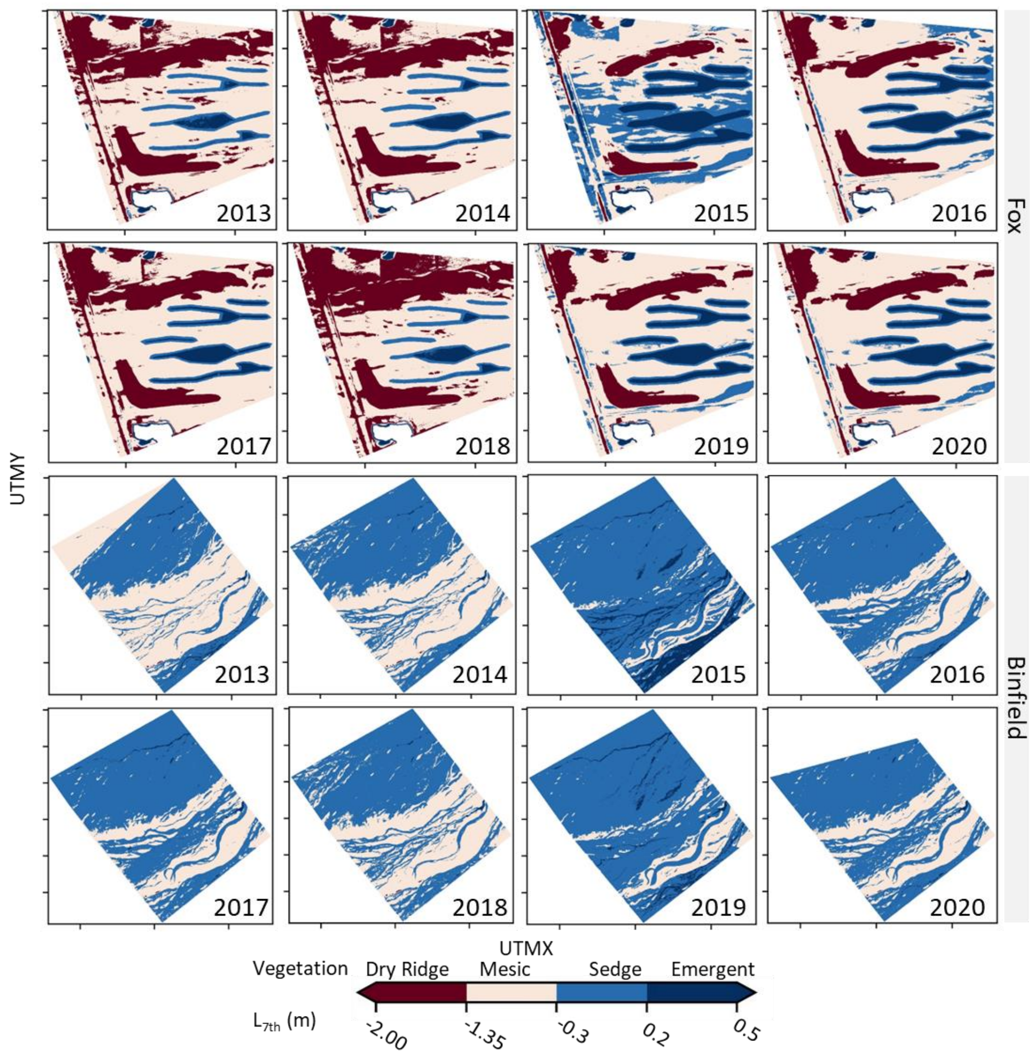


Figure 13. Yearly wet meadow vegetation type predicted from annual groundwater depth statistics (L_{7th}) at the Fox (top) and Binfield (bottom) sites. Vegetation categories and methodology after Henszey et al., (2004). Truncated surface in 2020 due to missing data.

- We demonstrate a method for developing hydrologic management and restoration targets that integrate the characteristic mosaic of vegetation (i.e., emergent, sedge meadow, mesic prairie, and dry ridge) and the corresponding groundwater depths that are found at natural, functioning wet meadows.
- Relative elevation differences between the river channel and adjacent valley floor suggest that the eastern AHR may have 'wetter' conditions necessary for supporting functional wet meadows as compared to the western AHR.
- Relative elevation differences between river surface and valley surface provide useful hydrologic indicator maps, comparable to those generated using detailed groundwater datasets, for assessing hydrology at potential wet meadow sites.

We estimate with confidence that:

- Tools developed in this study can guide management and restoration targets and help land managers identify sites with greater hydrologic potential for supporting wet meadows.

Answering EBQ #10 during the Extension:

- The wet meadow hydrology study has been completed and is currently undergoing peer review. The results of the peer review process will be used to determine if further work is necessary to address outstanding uncertainties.

Management implications:

- The Program's native Binfield site has shallower groundwater to support a typical wet meadow community over a large proportion of the site.
- The Program's restored Fox site is able to support wet meadow vegetation in an area limited to the edges of excavations that bring the surface closer to groundwater. Substantial excavation would be required across the site to reduce depth to groundwater enough to support wet meadow vegetation across 50% of the site. Surface recharge was a more viable option than increasing river stage at this site to raise groundwater enough to support wet meadow vegetation over 50% of the site.
- We provide a suite of hydrological variables linked to wet meadow vegetation that can be used to evaluate the likelihood that a given site will have the appropriate hydrology or could be managed to improve the hydrology enough to support a wet meadow on some proportion of the site.
- We also provide a remotely sensed tool for assessing a site's hydrologic potential for supporting a wet meadow.
- Program stakeholders will integrate learning from this study, continued analyses on the importance of wet meadows for whooping cranes, and vegetation response to Program land management to assess whether there is a need to redefine wet meadows for integration into Program science and management.

Appendix A: Five-year Check-Ins on First Increment Learning

First Increment Big Question #5 – *Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?*

2024 Assessment:

- Whooping cranes select river channels with unobstructed views of at least 650 ft and distance to nearest forest approximately 550 ft more often than predicted by availability.
- Whooping cranes also select riverine roosts in areas without roads or urban/suburban development within 0.77 miles more often than predicted by availability.

What the science says in 2024:

- Roost selection by whooping cranes is largely determined by in-channel characteristics including unobstructed views and distance to nearest forest.
- Whooping crane selection of roosts was statistically similar for unobstructed channel widths of 515 ft to 1102 ft due to overlapping confidence intervals (**Figure 14**). Any gains in whooping crane roosting can be expected to be smaller and more uncertain as channel width increases beyond 515 ft.
- Although several off-channel landcover metrics were evaluated, only development significantly influenced riverine roost site selection.
- Similar patterns of roost selection were found when roosts were identified by other systematic monitoring techniques (i.e., cellular telemetry data).

We estimate with confidence that:

- Suitable whooping crane roosting habitat has at least 650 ft of unobstructed channel width and allows the crane to roost 550 ft away from nearest trees.
- Any development near the river channel decreases suitability for roosting by whooping cranes.

Answering First Increment Big Question #5 during the Extension:

- The Extension Science Plan includes 5-year check ins on learning about whooping crane roosting habitat.
- Our first multi-year analysis, including data from 2001 – 2022, has been completed, integrating a finer scale landcover product from which to measure habitat metrics and including both on- and off-channel variables to explain roost site selection.
- A second-round analysis is scheduled for 2027.

Management implications:

- Program stakeholders are currently evaluating results to determine if a change in the Program's criteria for suitable WC roosting habitat to increase unobstructed channel widths from ≥650 ft to 1100 ft is warranted.

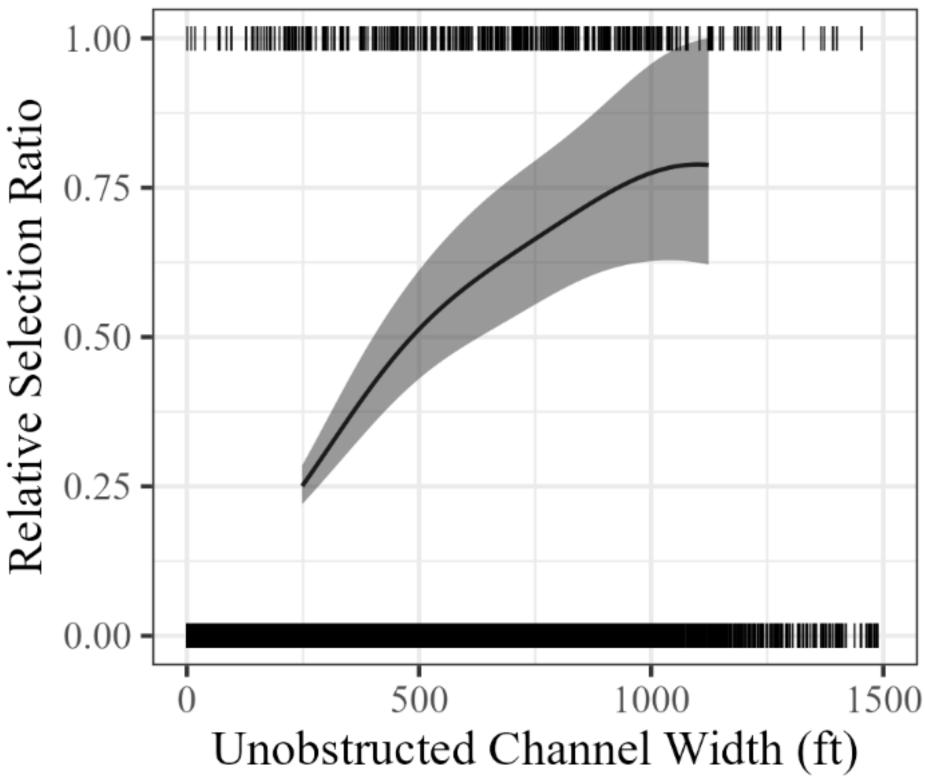


Figure 14. Relative selection ratios of whooping crane roosts collected by systematic aerial monitoring from spring 2001 – spring 2022 on the central Platte River in the Associated Habitat Reach. The solid line represents the average relationships between the 5th and 95th percentile of unobstructed channel width at roost locations, while the shaded area represents the 90% confidence interval. Tick marks at y=1 show values of unobstructed channel width at roosts and ticks at y=0 show available location values.

Appendix B: PRRIP Publications

Compass Resource Management Ltd. August 2016. Structured Decision Making for Interior Least Tern and Piping Plover Habitat on the Platte River – Final Report. Prepared for the Platte River Recovery Implementation Program, Kearney, NE.

Farrell PD and Baasch DM. 2020. Reducing effort when monitoring shorebird productivity. Waterbirds 43(2): 123-133. https://doi.org/10.1675/063.043.0201

Keldsen KJ. 2021.Efficacy of predator exclusion methods and ID of nest predators for interior least terns and piping plovers at off-channel nesting sites along the central Platte River, Nebraska, USA. MS Thesis, Biology Department, University of Nebraska, Kearney, NE. ProQuest Dissertations Publishing 28645869.

Platte River Recovery Implementation Program (PRRIP). 2023. Wet Meadow Hydrology Study (2013-2021) – in peer review.

Platte River Recovery Implementation Program (PRRIP). 2023. Sediment Augmentation Data Synthesis Compilation – peer review.

Appendix C: Additional Relevant Publications, Reports, and other Scientific Documents

Baasch, DM., Caven AJ, Jorgensen JG, Grosse R, Rabbe M, Varner DM and LaGrange T. 2022. Whooping Crane (*Grus americana*) use patterns in relation to an ecotope classification in the Central Platte River Valley, Nebraska, USA. Avian Conservation and Ecology 17(2):35. https://doi.org/10.5751/ACE-02311-170235

Baasch DM, Rabbe M, Medaries AH, Schaaf MR, Ostrom BL, Wiese JD, Malzahn JM, Smith TJ. 2023 Record-sized flock of Whooping Cranes (*Grus americana*) observed staging in the central Platte River valley during autumn 2021. Waterbirds 45(4): 484-491. https://doi.org/10.1675/063.045.0413

Brinley Buckley EM, Caven AJ, Wiese JD, Harner MJ. 2021 Assessing the hydroregime of an archetypical riverine wet meadow in the central Great Plains using time-lapse imagery. Ecosphere 12(11):e03829. https://doi.org/10.1002/ecs2.3829

Caven AJ, Mosier MM, Stoner KJ, Taddicken B, Krohn B, Gramza A, Allen CR, Carter M, Koch M, Schroeder KD, Bailey S, Walters R, Chaffin BC, Gnuse E, Jones A and Bird K. 2022. A long-term vision for an ecologically sound Platte River. Lincoln, Nebraska: Zea Books. https://digitalcommons.unl.edu/zeabook/128/

Caven AJ, Pearse AT, Brandt DA, Harner MJ, Wright GD, Baasch DM, Brinley Buckley EM, Metzger KL, Rabbe M R, Lacy AE. Whooping Crane stay length in relation to stopover site characteristics. Proceedings of the North American Crane Workshop 15:6-33. https://digitalcommons.unl.edu/nacwgproc/397/

Swift RJ, Anteau MJ, Ellis KS, MacDonald GJ, Ring MM, Sherfy MH, Toy DL. 2023. Estimating population viability of the northern Great Plains piping plover population considering updated population structure, climate change, and intensive management. Frontiers in Bird Science 2:1157682. https://doi.org/10.3389/fbirs.2023.1157682

U.S. Fish and Wildlife Service. 2023. Biological report for the northern Great Plains piping plover population (*Charadrius melodus circumcinctus*). U.S. Fish and Wildlife Service Missouri River Recovery Office.

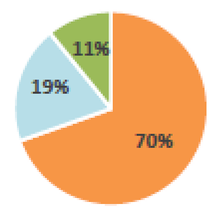
Appendix D: PRRIP Progress – Land & Water Milestone Summaries

Land Milestone Summary

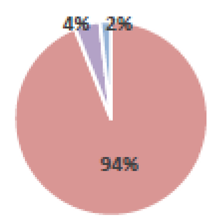
Program land interests (in the form of acquisitions, sponsorship/lease, and management agreements) now total 13,810 acres, exceeding the 10,000-acre First Increment land objective (**Figure 15**). The Program has nearly met the Extension "plus-up" objective of 1,500 acres of complex habitat with 183.5 acres still to be acquired. Most of the Program's habitat lands are located in blocks referred to as habitat complexes. The Program manages just under 13,000 acres of complex habitat in eight primary habitat complexes (Plum Creek, Cottonwood Ranch, Elm Creek, Jerry F. Kenny Pawnee, Fort Kearny, Clark Island, Shoemaker Island, and Chapman;) with additional complex habitat in two other bridge segments (Minden to Gibbon, Alda to Grand Island) (**Figure 16**). The Program also manages just over 841 acres of non-complex habitat (**Figure 17**).

Summary of Progress Towards Land Milestone & Extension Plus-Up
(Acquisitions Completed or Under Contract)

Ownership Interest	Acres	Cost
Purchased	9,613.0	$ 27,270,769
Sponsorship / Lease	2,697.0	$ 37,500
Management Agreements	1,500.0	$ 9,000
Total	**13,810.0**	**$ 27,317,269**



Habitat Type	Acres	Cost
Complex (9,200 ac)	12,968.7	$ 23,518,570
Non-Complex OCSW (400 ac)	587.3	$ 2,843,699
Non-Complex Palustrine Wetland (400 ac)	254.0	$ 955,000
Total	**13,810.0**	**$ 27,317,269**



First Increment Objective and Plus-Up	Acres	Ac. Remaing to Goal	Cost	Remaining Budget[1]
First Increment Land Objective (10,000 ac)	12,493.5	0.0	$ 21,269,829	$ 1,630,171
First Increment Extension Plus-Up (1,500 ac)	1,316.5	183.5	$ 6,047,440	$ 3,012,560
Total	**13,810.0**		**$ 27,317,269**	**$ 4,642,731**

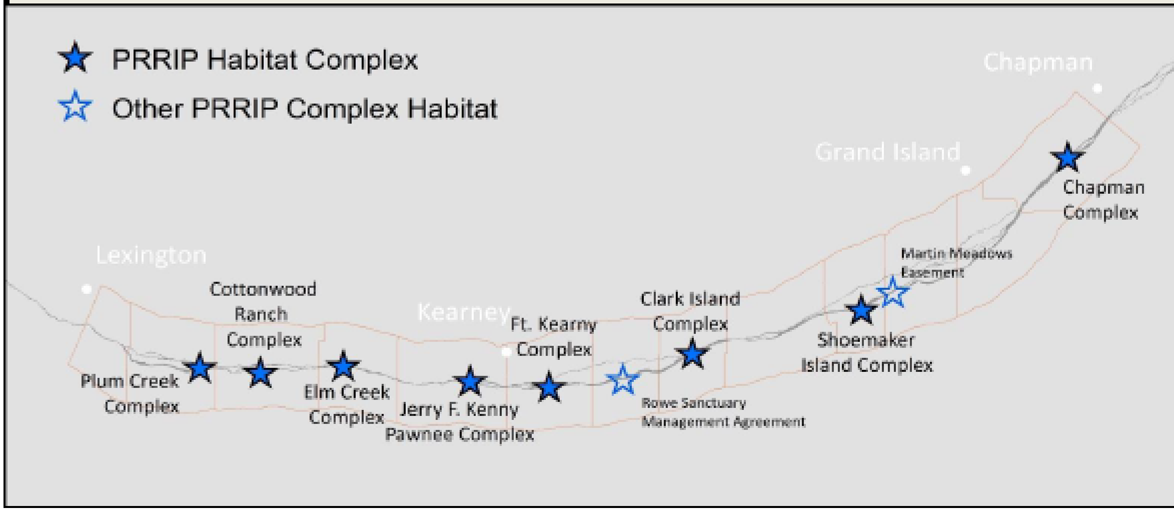
[1]Unindexed Acquisition Budgets

Summary of Progress Towards 60 Acre Off-Channel Sand and Water Additional Habitat Goal

	Tract Acres	Cost	Est. OCSW Ac.	Rem. Ac. To Goal
New Habitat Counting towards 60 Ac. Goal	196.1	$ 1,000,000	80.0	0.0

Figure 15. PRRIP Land Milestone Summary, as of December 31, 2023.

Map of PRRIP Habitat Complexes and Complex Habitat Not Associated with a Habitat Complex



Summary of Complex Habitat Ownership Interests

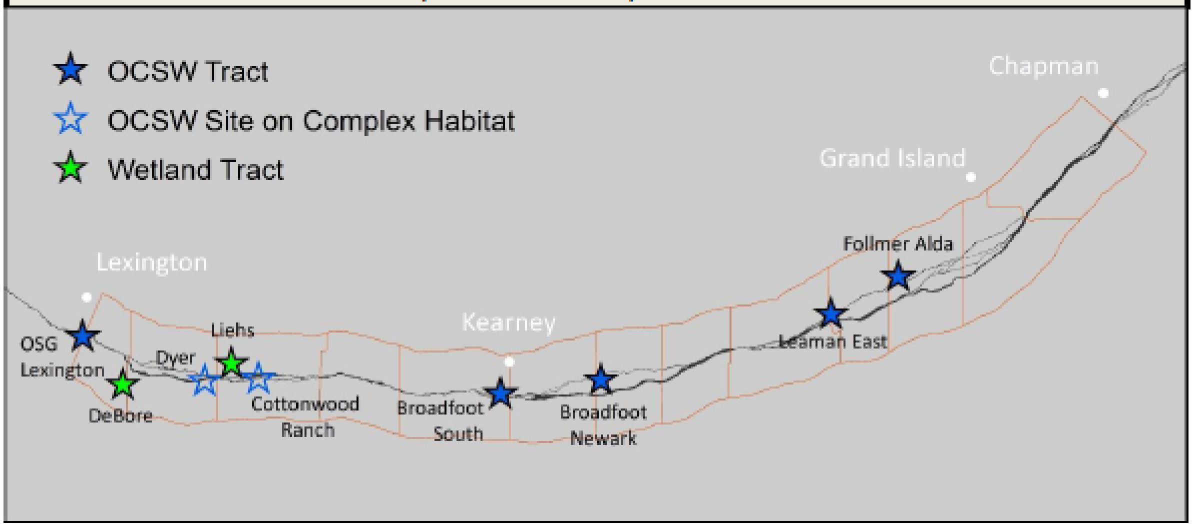
Complex Habitat Identification	Acres			
	Purchased	*Sponsorship/Lease*	*Agreement*	*Total*
Plum Creek Complex	716.3	-	150.0	866.3
Cottonwood Ranch Complex	902.0	2,650.0	-	3,552.0
Elm Creek Complex	1,170.7	-	135.0	1,305.7
Jerry F. Kenny Pawnee Complex	473.9	-	268.0	741.9
Ft. Kearny Complex	2,190.1	-	-	2,190.1
Rowe Sanctuary Management Agreement	-	-	834.0	834.0
Clark Island Complex	783.8	14.0	-	797.8
Shoemaker Island Complex	1,118.4	-	84.0	1,202.4
Martin Meadows Easement	286.0	-	-	286.0
Chapman Complex	1,145.5	18.0	29.0	1,192.5
Total	8,786.7	2,682.0	1,500.0	12,968.7

Location of First Increment Extension Plus-Up Complex Habitat Acres

Complex Habitat Identification	Total Acres	Plus-Up Acres	Percent of Tot.
Clark Island Complex	797.8	120.0	15%
Chapman Complex	1,192.5	1,145.5	96%
	Total	1,265.5	

Figure 16. PRRIP Complex Habitat.

Map of PRRIP Non-Complex Habitat Sites



Summary of Non-Complex Habitat Ownership Interests

Palustrine Wetland Sites	Total Acres	Type	Wetland Acres
DeBore	100.7	Purchased	30.0
Liehs	153.3	Purchased	40.0
Subtotal	*254.0*		*70.0*

Baseline Off-Channel Sand and Water Sites	Total Acres	Type	Nesting Acres
Dyer	N/A	OCSW on Complex	21.0
Cottonwood Ranch	N/A	OCSW on Complex	17.0
Broadfoot South	15.0	Lease	-
Broadfoot Newark	216.2	Purchased	-
Leaman East	85.0	Purchased	6.0
Follmer Alda	75.0	Purchased	-
Subtotal	*391.2*		*44.0*

New Off-Channel Sand and Water Sites[1]	Total Acres	Type	Nesting Acres
OSG Lexington	196.1	Purchased	80.0
Subtotal	*196.1*		

	Total Acres
Total for All Non-Complex Habitat	**841.3**

Figure 17. PRRIP Non-Complex Habitat.

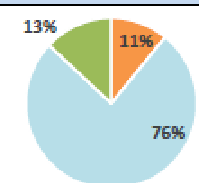
Water Milestone Summary

The Program's First Increment water objective (the Water Milestone) was to reduce deficits to U.S. Fish and Wildlife Service (Service) target flows for the Platte River near Grand Island by an annual average of 130,000 – 150,000 acre-feet (AF). The Program did not achieve that Milestone by the end of 2019 and that served as the impetus for the Extension (years 2020-2032). The water objective as refined for the Extension is to achieve at least 120,000 AF of annual reductions to target flow deficits as soon as possible and then implement Program science in manner that would provide insight as to whether an additional 10,000 AF of target flow deficit reductions is justified.

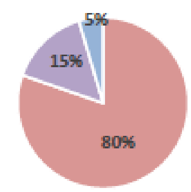
The current Program Extension water strategy—a combination of operational projects, operational projects with an uncertain future, and project concepts—is estimated to achieve about 125,000 AF (**Figure 18**) of annual target flow deficit reductions if fully implemented. That strategy includes storage water from Nebraska and Wyoming that is credited to the Lake McConaughy Environmental Account, groundwater recharge in Colorado and Nebraska, and recapture projects to maximize the benefit to the Platte River from recharged water (**Figure 19**).

Summary of Progress Towards Water Milestone of 130,000 - 150,000 Acre-Feet (AF)
Extension Directive: get to 120,000 AF ASAP and determine if expense of last 10,000 AF is justified

Water Projects by Status	Estimated Score (AF)	Estimated Cost 2022-2032
Concept	13,700	$ 14,474,200
Operational	96,110	$ 20,514,000
Operational - Uncertain Future	16,480	$ 20,237,800
Total	**126,290**	**$ 55,226,000**



Water Projects by Category	Estimated Score (AF)	Estimated Cost 2022-2032
Storage Water	101,390	$ 34,245,200
Recharge Water	19,100	$ 15,980,800
Recharge Recapture	5,800	$ 5,000,000
Total	**126,290**	**$ 55,226,000**



Extension Water Supply Strategy	Storage (AF)	Recharge (AF)	Recapture (AF)	Total (AF)
Included Current Water Strategy	100,680	18,200	5,800	124,680
Not Included in Current Water Strategy	710	900	-	1,610
	101,390	**19,100**	**5,800**	**126,290**

Summary of Estimated Extension Water Costs and Cash Expenditures

Extension Water Supply Strategy	Concept	Operational	Oper. Uncertain Future	Total
	Estimated 2022 - 2032 Water Costs by Project Type			
Included in Extension Water Supply Strategy	*$ 14,474,200*	*$ 20,514,000*	*$ 17,127,000*	*$ 52,115,200*
Not Included in Extension Water Strategy	$ -	$ -	$ 3,110,800	$ 3,110,800
	$ 14,474,200	**$ 20,514,000**	**$ 20,237,800**	**$ 55,226,000**

Estimated Extension Expenditures	
2020 - 2021 Water Expenditures	$ 6,760,000
2022-2032 Water Costs (Extension Strategy)	*$ 52,115,200*
Total Estimated Extension Water Cost	$ 58,875,200
Less Remaining First Increment J-2 Funds	$ 10,900,000
Estimated Extension Water Cash Expenditure	**$ 47,975,200**

2019 Extension Water Budget	Extension Water Cash Ceiling
$89,110,000	$95,862,000

[1]2021 Indexing

Figure 18. PRRIP Water Milestone Summary, as of December 31, 2023.

Storage Water Projects					
Project Name	Status	Ext. Water Supply Strategy	Score	Score Status	2022-2032 Cost
Lake McConaughy & Pathfinder EA	Operational	YES	70,000	Approved	$ -
No-Cost NCCW	Operational	YES	260	Approved	$ -
Pathfinder Municipal Lease	Operational	YES	6,350	Approved	$ 5,434,000
CPNRD Surface Water Exchange	Op - Uncert. Future	YES	12,000	Estimated	$ 13,860,000
NPPD Surface Water Exchange	Op - Uncert. Future	YES	2,870	Estimated	$ 3,267,000
CNPPID Irrigator Lease	Op - Uncert. Future	NO	710	Estimated	$ 1,210,000
CNPPID NCCW Lease	Concept	YES	9,200	Estimated	$ 10,474,200
Total			101,390		$ 34,245,200

Recharge and Recapture Projects					
Project Name	Status	Ext. Water Supply Strategy	Score	Score Status	2022-2032 Cost
Tamarack Recharge	Operational	YES	10,000	Approved	$ -
Elwood Recharge	Operational	YES	2,800	Approved	$ 10,250,000
Phelps Recharge	Operational	YES	2,700	Approved	$ 2,630,000
Cottonwood Ranch Broad-Scale Recharge	Operational	YES	2,700	Estimated	$ 1,200,000
Recapture Well Pilot (w/ Cook)	Operational	YES	1,300	Estimated	$ 1,000,000
Future Recapture (Wells/Elwood Outlet)	Concept	YES	4,500	Estimated	$ 4,000,000
NPPD Canal Recharge	Op - Uncert. Future	NO	900	Estimated	$ 1,900,800
CPNRD Canal Recharge	Op - Uncert. Future	NO	-	Estimated	$ -
Total			24,900		$ 20,980,800

No-Cost State Contributions

Figure 19. PRRIP Water Projects (storage, recharge, and recapture).