# Platte River Recovery Implementation Program

2017 Interior Least Tern and Piping Plover Monitoring and Research Report, Central Platte River, Nebraska



**Prepared for: Governance Committee Prepared by: Executive Director's Office** 

PLATTE RIVER

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# **Platte River Recovery Implementation Program**

### 2017 Interior Least Tern and Piping Plover Monitoring and Research Report, Central Platte River, Nebraska



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#### PREFACE

This is a report of the Platte River Recovery Implementation Program's (Program or PRRIP) monitoring and research efforts for interior least terns (least tern) and piping plovers during 2017. The report was prepared to inform Program partners, licensing agencies, and the general public of our activities and to provide a summary of results to fulfill the requirements of the Program's state (Nebraska Master Permit #1014) and federal (TE183430-0) monitoring permits. *Data analyses are not final and should be treated as such when citing information, data, or analyses found in this document.* 

#### TABLE OF CONTENTS

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This section describes on- and off-river land management practices used to facilitate nesting and actions taken to protect least tern and piping plover colonies and nests from predation and disturbance. This section also provides a summary of habitat availability and species response, 2007–2017.

#### Monitoring......10

This section presents data collected annually and includes the number of least tern and piping plover adults, breeding pairs, nests, chicks, and fledglings observed along the central Platte River during 2017. These data are collected and summarized in a form to allow comparisons across the entire range of each species and includes annual survey results.

#### 

survival methods.



#### INTRODUCTION

The Platte River Recovery Implementation Program (Program or PRRIP) was initiated on 1 January, 2007 as a result of a cooperative agreement negotiating process that started in 1997 between the states of Colorado, Wyoming, and Nebraska; the U.S. Department of the Interior (DOI); water users; and conservation groups. The Program is intended to address issues related to the Endangered Species Act and loss of habitat in the central Platte River between Lexington and Chapman, Nebraska by managing certain land and water resources following principles of adaptive management to provide benefits for four "target species" including the endangered interior least tern (*Sternula antillarum*) and the threatened piping plover (*Charadrius melodus*). The northern Great Plains population of piping plovers was listed as threatened on January 10, 1986. The least tern was listed as endangered on June 27, 1985; however, a recently completed five-year review recommends delisting least terns due to recovery. The U.S. 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 Program is led by a Governance Committee (GC) that is assisted by several standing advisory committees as well as an Executive Director (ED) and staff.

The Program has three main elements:

- Increasing stream flows in the central Platte River during relevant time periods through retiming and water conservation or supply projects. The first increment objective is to re-time and improve flows in the central Platte River to reduce shortages to target flows by an average of 130,000 – 150,000 acre-feet per year at Grand Island.
- Enhancing, restoring, and protecting habitat lands for the target species. The first increment objective is to protect, restore, and maintain 10,000 acres of habitat.
- Accommodating certain new water-related activities.

The data summarized in this report were collected in accordance with the Program's 2017 interior least tern and piping plover monitoring protocol. The primary objectives of protocol implementation include: 1) monitoring interior least tern (least tern) and piping plover (plover) use and productivity on midstream-river sandbars and sand and gravel mines; and 2) document habitat characteristics that are believed to influence nest site selection and nest and brood success along the central Platte River between Lexington and Chapman, Nebraska. The Program has also banded least tern and piping plover adults and chicks on the central Platte with three objectives: 1) quantify dispersal of adults between units of nesting habitat on the Central Platte River among years; 2) quantify colonization rate of newly constructed or managed nesting habitat by local versus immigrant adults; and 3) quantify frequency and location of renesting attempts by adults with failed nests. As such, banding least tern and piping plover adults and chicks was conducted for seven consecutive years on the central Platte River (2009-2016). 2017 marked the first year banding didn't occur; we plan to continue band resighting for one additional year. We anticipate a final report documenting results of those efforts will be available on the Program's online Public Library in 2019. Monitoring and research during 2017 was a collaborative effort between personnel of Headwaters Corporation (EDO or Program staff), Central Platte Natural Resources District (CPNRD), and Nebraska Public Power District (NPPD). Past data and analyses are reported in annual reports produced by West Incorporated (2001-2007) and Program staff (2008–2016) and are available in the Program's online Public Library. Least tern and piping plover activity and reproductive success during 2017 are summarized in this report.

#### STUDY AREA

Our study area encompassed the "PRRIP Associated Habitats" region of the central Platte River between Lexington and Chapman, Nebraska (~90 river miles, Figure 1) as well as off-channel and sandpit sites within three miles of the river in this reach. In the central Platte River system, least tern and piping plover habitat was located at both on- and off-channel sites. River or on-channel habitat included midstream sandbars used for nesting and open river channel used for foraging. Off-channel habitat included spoil piles of sparsely- or non-vegetated sand and associated sandpit lakes at sand and gravel mines. Least terns nested on managed sandpit spoil piles or river islands and foraged in sandpit lakes and open river channel. Piping plovers nested on managed sandpit spoil piles or river islands and foraged on low elevation river islands or along the waterline of sandpit ponds.

#### 2017 RIVER CONDITIONS

The number of low-elevation sandbars present within the PRRIP associated habitats region of the central Platte River is variable and dependent on seasonal and daily fluctuations in river flow. The size and distribution of non-vegetated, highelevation sandbars characteristic of least tern and piping plover nesting sites within the region has been dependent upon construction and vegetation management efforts.

Daily flows were slightly higher than normal during early April, dropped below normal by late April and early May; were



Surveying from the airboat searching for birds with bands

average during much of May before flows spiked in late May and early June, and then once again dropped to below normal levels by mid-June during 2017. The peak flow of the 2017 season at the Overton, Kearney, and Grand Island gages was just over 4,500 cubic feet per second (cfs).



**Figure 1.** Platte River Basins extending from Colorado and Wyoming through Nebraska. The study area for our least tern and piping plover monitoring and research efforts was the PRRIP Associated Habitats region of the Platte River located between Lexington and Chapman, Nebraska.



**Figure 2.** Mean daily discharge (ft<sup>3</sup>/second; cfs) at Overton (USGS gage 06768000), Kearney (USGS gage 06770200), and Grand Island, Nebraska (USGS gage 06770500) for 2017. Average across 2001–2017 from Kearney (USGS gage 06770200). See Figure 3 for the location of gage stations within our study area. Data available at: waterdata.usgs.gov/ne/nwis/current/?type=flowandgroup key=NONEandsearch site no station nm=platte%20river.

#### MANAGEMENT

Management actions designed to increase nesting habitat (bare sand) and productivity of least terns and piping plovers within Program associated habitats were taken at on- and off-channel sites during fall 2016 and spring 2017. Management activities were site specific and included: mechanical actions to create nesting habitat (dozers, scrapers, and backhoes), mechanical actions to improve nesting conditions and remove vegetative cover (disking, tree removal, mowing, and nest furniture distribution); chemical application to kill or prevent emergence of vegetation (spring or fall herbicide application); and predator control (fencing and trapping).

#### SUMMARY OF HABITAT AVAILABILITY AND SPECIES RESPONSE, 2007-2017

#### **On-Channel Mechanical Habitat Creation and Maintenance**

Constructed on-channel habitat availability has been variable and somewhat limited during the First Increment of the Program (Table 1). Approximately 24 acres of constructed habitat were present in the Associated Habitat Reach (AHR) in 2007 as the result of efforts by other conservation organizations. That habitat was subsequently lost over the course of several years due to erosion during natural high flow events. The Program began large-scale on-channel habitat construction efforts at the Elm Creek complex in the fall of 2012 and was also able to create on-channel habitat at the Cottonwood Ranch and Plum Creek complexes as part of sediment augmentation activities. Much of that habitat was lost during a natural high flow event in the fall of 2013. On-channel island construction began at the Shoemaker Island complex following the fall 2013 event. A high flow event in June of 2014 eroded a portion of the habitat constructed in the fall of 2013, but the Program was able to construct a total of 28 acres of on-channel habitat during the fall of 2014 at the Elm Creek and Shoemaker Island complexes. However, all of it was lost due to erosion during the 2015 and 2016 high flow events. On-channel habitat construction by other conservation organizations has been very limited since 2007.

	On-C	hannel Habitat (a	ac)	<b>Off-Channel Habitat (ac)</b>					
Year	PRRIP	Others	Total	PRRIP	Others	Total			
2007	0	24	24	0	48	48			
2008	0	21	21	0	48	48			
2009	0	15	15	0	48	48			
2010	0	5	5	32	48	80			
2011	0	5	5	60	48	108			
2012	0	0	0	72	48	120			
2013	55	0	55	72	48	120			
2014	19	0	19	80	48	128			
2015	47	0	47	90	48	138			
2016	4	0	4	87	51	138			
2017	0	0	0	99	45	144			
Average	11.4	6.4	17.7	53.8	48.0	101.8			

Table 1. On- and off-channel nesting habitat in the Associated Habitat Reach by year, 2007–2017.

#### On- and Off-Channel Mechanical Habitat Creation and Maintenance

Approximately 48 acres of managed off-channel nesting habitat were present in the AHR at the beginning of the First Increment (Table 1). The Program began acquiring and restoring off-channel sites in 2009. Total managed off-channel habitat in the AHR increased to 144 acres during the period of 2009–2017 as the Program constructed and/or restored 99 acres of habitat. The Program plans to acquire or construct an additional 60 acres of off-channel habitat prior to the end of the First Increment in 2019. Mining at Follmer Alda and Newark East sites are still under way and more habitat should become available during the 2018 and 2019 nesting seasons.

#### SANDPIT SITES:

Eleven of the 15 off-channel sites monitored during 2017 were actively managed to increase least tern and piping plover reproduction. Program owned and/or managed sites are denoted with a superscript "P" (<sup>P</sup>) and managed sites are identified by a superscript "M" (<sup>M</sup>).

- <sup>M</sup> Lexington Pit A pre-emergent herbicide was applied during spring 2017, the woven-wire predator fence with offset electric wires along the west side of the nesting areas was maintained, and predator trapping occurred during 2017. No sand and gravel mining occurred during 2017.
- PM Dyer Pit A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2016. A pre-emergent herbicide was applied during spring 2017, a permanent 4-foot tall woven wire predator fences with offset electric wires across the south ends of each peninsula were electrified and predator trapping occurred during 2017. No sand and gravel mining occurred during 2017.
- PM Cottonwood Ranch OCSW A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2016, a pre-emergent herbicide was applied, and predator trapping occurred during 2017. A permanent 4-foot tall woven wire predator fence with offset electric wires was maintained in 2017. No sand and gravel mining occurred.
- <sup>M</sup> Blue Hole A pre-emergent herbicide was applied during spring 2017, the existing permanent predator fence was maintained, a temporary 4-foot tall electrified predator fence was installed along the southwest edge of the peninsula and electrified, and predator trapping occurred during 2017.
- <sup>M</sup> Johnson Pit A pre-emergent herbicide was applied during spring 2017, the woven-wire predator fence with offset electric wires along the west side of the nesting area was maintained and electrified, and predator trapping occurred during 2017. No sand and gravel mining occurred during 2017.
- PMBroadfoot South A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2016 and a pre-emergent herbicide was applied to the nesting area during spring 2017. A temporary 4-foot tall electrified predator fence was installed across the east end of the main peninsula, and predator trapping occurred during 2017. Sand and gravel mining occurred northwest of the main peninsula during 2017.
- PMBroadfoot South—Non-Access Islands A 4-foot tall hog-panel fence with chicken wire was placed across the land-bridge extending to one of the non-access islands located northwest of the main peninsula. Sand and gravel mining occurred directly east of the islands during 2017. 8 acres were available for least tern or piping plover nesting in 2017. Backson and set the set of the



Broadfoot South Non-access Islands

- PM Newark West A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2016. A pre-emergent herbicide was applied during spring 2017, permanent 4-foot tall woven wire predator fences with offset electric wires across the ends of each peninsula were electrified, and predator trapping occurred during 2017. No sand and gravel mining occurred during 2017.
- PM Newark East A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2016. A preemergent herbicide was applied during spring 2017. The west peninsula contains a permanent 4-foot tall woven wire predator fence with offset electric wires across the ends of the peninsula, which were electrified. A temporary 4-foot tall electrified predator



Newark East Nesting Site

fence was installed across the east peninsula. Sand and gravel mining and predator trapping occurred during 2017. 8 acres were available for least tern or piping plover nesting in 2017.

- PM Leaman East OCSW A contact herbicide was applied to kill existing vegetation along the waterline during fall 2016. A pre-emergent herbicide was applied to the nesting area during spring and predator trapping occurred during 2017. A permanent, 4-foot tall woven wire predator fence with offset electric wires was maintained in 2017. No sand and gravel mining occurred.
- PM Follmer-Alda Pit A contact herbicide was applied to kill existing vegetation along the waterline during fall 2016. A pre-emergent herbicide was applied to the nesting area during spring 2017. A temporary 4-foot tall electrified predator fence was installed across the west end of the main peninsula and predator trapping occurred during 2017. Sand and gravel mining occurred east of the main peninsula during 2017.

Trust Wild Rose East - Not managed during 2017 and no sand and gravel mining occurred.

DeWeese-Alda – Not managed. Sand and gravel mining occurred during 2017.

*Hooker Brothers - GI South East* – Not managed. Sand and gravel mining occurred during 2017.

Hooker Brothers - GI East – Not managed. Sand and gravel mining occurred during 2017.

#### **RIVERINE SITES:**

No on-channel sites had nesting habitat available during the 2017 monitoring season.

#### MONITORING

In 1997, the DOI and the States of Nebraska, Colorado, and Wyoming adopted the "Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitats" (Cooperative Agreement). In 2001, the Cooperative Agreement coordinated a standardized protocol for monitoring reproductive success and reproductive habitat parameters of least terns and piping plovers in the central Platte River from Lexington to Chapman, Nebraska. The standardized protocol was implemented by CNPPID, CPNRD, NPPD, and USFWS-GI during 2001–2006. In 2007, the Program assumed responsibilities of the protocol; Program staff, contracted personnel, and cooperators have since implemented it. The protocol was revised prior to the 2010 nesting season and again prior to the 2017 nesting season (PRRIP 2017).

#### SEMI-MONTHLY RIVER AND SANDPIT SURVEYS:

#### **METHODS**

We conducted 7 semi-monthly surveys (1 and 15 May, June, and July and 1 August) of the central Platte River between Chapman and Lexington, Nebraska (river surveys). In addition, we surveyed all sandpits within Program Associated Habitats that met the Program's minimum habitat criteria (sandpit surveys) to document adults, breeding pairs, nests, chicks, and fledglings during 2017. We derived least tern and piping plover breeding pair estimates (BPE; Baasch et al. 2015) by adding the number of active, or recently failed nests to the number of active, or recently failed or fledged broods observed on a given date. We obtained least tern breeding pair estimates by assuming: 1) least tern nests did not hatch within 21 days of being initiated; 2) least terns did not re-nest within 5 days of losing a nest or brood; 3) least tern chicks fledged at 21 days of age (fledging age 2010-2017); 4) least tern chicks that survived to 15 days of age (fledging age 2007–2009) also fledged; and 5) least terns did not re-nest after fledging chicks. We determined piping plover breeding pair counts by assuming: 1) piping plover nests did not hatch within 28 days of being initiated; 2) piping plovers did not re-nest within 5 days of losing a nest or brood; 3) piping plover chicks fledged at 28 days of age (fledging age 2010–2017); and 4) piping plover chicks that survived to 15 days of age (fledging age 2007-2009) also fledged. We included summaries of the total number of adults, breeding pairs, nests, chicks, and fledglings observed during river surveys, sandpit surveys, and a combination of river and sandpit surveys (semimonthly survey totals) to provide 7 snap-shots of the numbers observed during the 2017 nesting seasons. All counts of adults, breeding pairs, nests, chicks, and fledglings reported during semimonthly surveys represent minimums present.

*Semi-monthly River Surveys* – Program staff and technicians conducted semi-monthly river surveys between the J2 Return and the Chapman Bridge on 2-4 May; 16-18 May; 27 May and 30 May - 1 June; 13-14 June; 27-28 June; 11-12 July; and 1-3 August during 2017. We used an airboat to survey all channels wider than 75 yards between Lexington and Chapman, NE that could be safely navigated and documented all observations of least tern and piping plover adults, breeding pairs, nests, chicks, and fledglings located within this reach of river.

Semi-monthly Sandpit Surveys – We conducted semi-monthly surveys from outside the nesting colony at 15 sandpit sites to count individual birds and document least tern and piping plover adults, breeding pairs, nests, chicks, and fledglings. Semi-monthly sandpit surveys were conducted outside the nesting area on 1-4 May; 15-16 May; 29 May – 2 June; 14-16 June; 29 May – 1 July and 5 July, 13-14 and 17 July; and 31 July and 2 August during 2017. Program staff, technicians and personnel from CPNRD and NPPD conducted semi-monthly sandpit surveys during 2017.

*Semi-monthly Survey Totals* – To obtain an estimate of numbers of least tern and piping plover adults, breeding pairs, nests, chicks, and fledglings within the Program Associated Habitat Area throughout the 2017 nesting season, we summed numbers detected during semi-monthly river and sandpit surveys nearest 1 and 15 May, June, and July and 1 August. We derived least tern and piping plover breeding pair estimates (BPE) by adding the number of active, or recently failed nests to the number of active, or recently failed or fledged broods observed on a given date (Baasch et al. 2015).

#### RESULTS

Semi-monthly River Surveys – Each of the 7 semi-monthly river surveys between Lexington and Chapman, Nebraska during 2017 required 2–3 days to conduct. We observed the most least tern adults (40) on the river during the 1-August river survey. The most piping plover adults (25) were observed on the river during the 1-May river survey in 2017 (Table 2). We observed no least tern or piping plover breeding pairs during 2017 river surveys. All least tern and piping plover adults and fledglings observed during semi-monthly river surveys in 2017 were either known (banded) or were presumed (near areas with sandpits that fledged chicks) to be associated with nearby sandpit nesting sites.

Table 2. Number of Least Tern and Piping Plover adults, breeding pairs (pair), nests, chicks, and fledgli	ings observed
during semi-monthly airboat surveys of the Platte River between Lexington and Chapman, Nebraska, ir	n 2017.

	ast Tern	Piping Plover								
Survey	Adults	Pair*	Nests	Chicks	Fledglings	Adults	Pair*	Nests	Chicks	Fledglings
1-May	0	0	0	0	0	25	0	0	0	0
15-May	23	0	0	0	0	5	0	0	0	0
1-Jun	16	0	0	0	0	7	0	0	0	0
15-Jun	12	0	0	0	0	7	0	0	0	0
1-Jul	23	0	0	0	0	5	0	0	0	1
15-Jul	17	0	0	0	0	9	0	0	0	5
1-Aug	40	0	0	0	12	3	0	0	0	2

\* Pair represents the number of breeding pairs, as defined above, present on river islands on 1 and 15 May, June, and July, and 1 August. Breeding pair counts were obtained using the Program's Breeding Pair Estimator (BPE). Quantities of Nests may be different from Breeding Pair because semi-monthly surveys occurred over several days and Breeding Pair counts were determined on the 1<sup>st</sup> or 15<sup>th</sup> of the month.

Semi-monthly Sandpit Surveys – Each of the 7 semi-monthly sandpit surveys from outside the nesting area required 2–4 days to conduct in 2017. Similar to past years, most least tern and piping plover breeding pairs, nests, and chicks were observed on sandpit sites where management activities occurred prior to the nesting seasons. We did, however, observe 1 piping plover breeding pair and 1 nest at the Trust sandpit; the nest hatched 4 chicks and 1 fledged. We also observed 12 least tern breeding pairs and 13 nests and 1 piping plover breeding pair and 3 nests on the Broadfoot South non-access islands; 4 least tern nests hatched which resulted in 5 chicks and no fledglings while all piping plover nests failed. We observed the most adult least terns during the 15-June (106) sandpit survey and the most least tern breeding pairs (75) during the 1-July sandpit survey when there were 22 active nests and 46 chicks observed (Table 3). We observed the most piping plover breeding pair (39) during the 15-June sandpit survey, when there were 19 active nests and 43 chicks present across

all sandpit sites. The most piping plover active nests (26) occurred during the 1-June sandpit survey. A total of 15 sites were monitored during each of the semi-monthly survey periods.

	ast Tern	Piping Plover								
Survey	Adults	Pair*	Nests	Chicks	Fledglings	Adults	Pair*	Nests	Chicks	Fledglings
1-May	0	0	0	0	0	15	2	2	0	0
15-May	11	0	0	0	0	50	22	20	0	0
1-Jun	50	17	16	0	0	39	34	26	6	0
15-Jun	106	61	66	0	0	58	39	19	43	0
1-Jul	91	75	22	46	0	45	29	10	27	9
15-Jul	73	68	24	39	10	21	18	2	9	7
1-Aug	39	51	6	15	18	1	5	0	1	2

**Table 3.** Number of least tern and piping plover adults, breeding pairs (pair), nests, chicks, and fledglings documented from outside the nesting area during semi-monthly sandpit surveys in 2017.

\* Pair represents the number of breeding pairs, as defined above, present on sandpits on 1 and 15 May, June, and July, and 1 August. Breeding pair counts were obtained using the Program's Breeding Pair Estimator (BPE). Quantities of Nests may be different from Breeding Pair because semi-monthly surveys occurred over several days and Breeding Pair counts were determined on the 1<sup>st</sup> or 15<sup>th</sup> of the month.

*Semi-monthly Survey Totals* – Semi-monthly survey totals include both sandpit and river survey counts of adults, breeding pairs, nests, chicks, and fledglings observed during the 7 semi-monthly sandpit and river surveys and represent an estimate of the overall numbers present within Program Associated Habitats during 7 time periods in the 2017 nesting season. In 2017, we observed 66 active least tern nests during the 15-June survey when 118 adults and 61 breeding pairs were observed (Table 4). We observed 29 least tern fledglings during the 15-July survey. In 2017, we observed 26 active piping plover nests during the 1-June survey when 46 adults and 34 breeding pairs were observed. A total of 15 sandpit sites and the river were surveyed each semi-monthly survey period (Table 4).

	/			0							
	l	Interior	Least To	erns	Piping Plovers						
Survey	Adults	Pair*	Nests	Chicks	Fledglings	Adults	Pair*	Nests	Chicks	Fledglings	
1-May	0	0	0	0	0	40	2	2	0	0	
15-May	34	0	0	0	0	55	22	20	0	0	
1-Jun	66	17	16	0	0	46	34	26	6	0	
15-Jun	118	61	66	0	0	65	39	19	43	0	
1-Jul	114	75	22	46	0	50	29	10	27	10	
15-Jul	90	68	24	39	10	30	18	2	9	12	
1-Aug	79	51	6	15	30	4	5	0	1	4	

**Table 4.** Number of least tern and piping plover adults, breeding pairs (pair), nests, chicks, and fledglings observed within Program Associated Habitats during semi-monthly surveys of sandpits and the river in 2017.

\* Pair represents the number of breeding pairs, as defined above, present on river islands on 1 and 15 May, June, and July, and 1 August. Breeding pair counts were obtained using the Program's Breeding Pair Estimator (BPE). Quantities of Nests may be different from Breeding Pair because semi-monthly surveys occurred over several days and Breeding Pair counts were determined on the 1<sup>st</sup> or 15<sup>th</sup> of the month.



Figure 3. Study area including sandpits and river channels monitored for least tern and piping plover nesting and foraging activities during 2017. Names of sites are located in Table 7.
PRRIP 2017 Tern and Plover Report Page 13 of 49

#### MID-MONTH AND SEMI-MONTHLY SURVEYS

*River Surveys, 2001–2017:* We observed slight use of the river by least terns and piping plovers throughout the nesting season. Counts of least tern and piping plover adults observed during river surveys in 2017 were generally similar to numbers observed prior to Program implementation (2001–2006; Figure 4). The trend in numbers of adult least terns and piping plovers observed during mid-month river surveys of the central Platte River were generally lower during 2017 than they had been during 2010-2015. It is important to note, however, that several surveys were not completed because of low or no flow conditions in the river. The increase in numbers of least tern and piping plover adults observed during the river surveys can likely be attributed to an overall increase in numbers of adults and breeding pairs observed within the Program Associated Habitat Area.



**Figure 4.** Numbers of least tern (top) and piping plover (bottom) adults observed during mid-month and semi-monthly surveys of the Platte River between Lexington and Chapman, Nebraska, 2001-2017. \* indicates minimum numbers present as several river surveys were not completed due to a lack of flow in the channel.

*Sandpit Surveys, 2001–2017:* We observed slightly less piping plover adults on sandpits within the Program Associated Habitat Area in 2017 than we did the previous two years (Figure 5). Least tern counts on sandpit sites during 2017 was down from counts observed in 2015 and 2016. We observed the most adult least terns (106) during semi-monthly sandpit surveys that occurred during the 15-June. We observed the most adult piping plovers (58) during the 15-June semi-monthly sandpit survey.



**Figure 5.** Numbers of least tern (top) and piping plover (bottom) adults observed during mid-month and semi-monthly surveys of sandpits along the Platte River between Lexington and Chapman, Nebraska, 2001–2017.

*Sandpit-River Surveys, 2001–2017:* We observed similar numbers of least tern adults within the Program Associated Habitat Area in 2017 as we did the past 6 years (Figure 6). We observed fewer piping plover adults during 2017 bi-monthly surveys than we did the previous two years. The most adult least terns (118) and piping plovers (65) were observed during the mid-June semi-monthly sandpit and river surveys. The river was used exclusively for foraging by both species as all least tern and piping plover nests were located on off-channel sandpits.



**Figure 6.** Numbers of adult least tern (top) and piping plover (bottom) adults observed during mid-month and semimonthly surveys of sandpits and central Platte River channels between Chapman and Lexington, Nebraska, 2001– 2017. Counts represent minimum numbers present as several river surveys were not completed due to a lack of flow in the channel (see Figure 4).

Numbers of adult least terns and piping plovers observed during midmonth surveys of the Program Associated Habitat Area declined sharply after 2007, but have since rebounded to where counts observed during 2017 were similar or higher than numbers observed prior to Program implementation (Figure 7). Program analyses indicate least tern and piping plover adult and breeding pair counts are positively correlated with habitat availability, however, analyses of future data will be used to confirm the relationship between breeding pair counts and available habitat.





Fledgling Least Tern



Figure 7. Trends (lines) in peak counts of least tern (red bars) and piping plover (blue bars) adults observed during mid-month and semi-monthly surveys of sandpits (light blue and light red bars) and the Platte River (dark blue and dark red bars) between Lexington and Chapman, Nebraska, 2001-2017.

#### NEST AND CHICK MONITORING

#### **METHODS:**

In addition to semi-monthly surveys, we monitored all sites with active nests or broods on a semiweekly basis throughout the nesting season. We attempted to observe nests and chicks twice per week until the nest or brood failed or the chicks fledged. We conducted surveys of adults, nests, chicks, and fledglings from both outside the nesting area. Program staff and technicians and Program partners monitored nesting sites during 2017.

We recorded date, temperature, observation start and stop times, and the number of least tern and piping plover adults, nests, broods, chicks, and fledglings present during each semi-weekly site visit. We used a GIS to determined distances to predator perch, nearest waterline and elevation of each nest above the waterline. When chicks or fledglings were observed, we estimated the date of hatching or fledging based on current and previous chick observations. We determined the amount of nesting habitat available at each site using a GIS. Summaries of the habitat metrics for Offchannel least tern and piping plover nests from 2007–2017 can be found in Tables 12-13 under the Research portion of this report. This data can also be found in the habitat selection study that was finalized in 2017 (Baasch et al. 2017).

*Outside Monitoring* – Outside surveys were performed using binoculars and/or spotting scopes, at a distance great enough to not cause disturbance to nesting birds (usually >165 ft., but closer or farther as terrain dictated), and for at least 1/2 hour. Observations were conducted from multiple locations to provide as complete of coverage of the site as possible. Nests and chicks were often located by observing adult birds.

Survival – We calculated daily and incubation-period nest survival rates using Program MARK (Version 5.1). We included nests located at sandpit and riverine sites that were monitored during 2017 by Program staff and technicians and personnel from CPNRD and NPPD to determine survival rates. Nest success was defined as any nest that hatched  $\geq 1$  chick. We considered the incubation period for least terns and piping plovers to be 21 and 28 days, respectively, from when nests were determined to have been initiated. When the fate of a nest was unknown, we assigned a "failed" status to the nest if the date of determination (date first observed inactive) was <21 days (least tern) or <28 days (piping plover) after the date the nest was initiated and we failed to observe chicks of appropriate age near the nest bowl. For example, if a piping plover nest, observed to be active and intact 12 days after it was initiated was found to be empty (no eggs) 16 days after it was initiated with no sign of chicks of appropriate age in the area, we censored the nest at 14 days (midpoint of the 2 observation periods) and assigned a "failed" status to the nest as it likely did not hatch within 16 days of initiation. If, however, a piping plover nest with an unknown fate was last observed to be active 25 days after it was initiated, but 29 days after it was initiated we observed an empty nest bowl and no sign of chicks of appropriate age in the area, we assigned the fate of the nest to be 27 days (midpoint of the 2 observation periods) and assigned a "successful" status to the nest. Our assumption was that, on average, we discarded survived and failed intervals in the same proportion they existed in the data.

We also used Program MARK to determine daily and brooding-period survival rates for broods of chicks. As the exact date of hatching was occasionally unknown, we considered the brooding period for least tern and piping plover chicks to be 21 and 28 days from the date we first observed nestlings, respectively. A successful brood was defined as any brood with  $\geq 1$  chick that was observed fledged or that survived 21 days (least terns) or 28 days (piping plovers). Similar to nest survival methods, when the fate of a brood was unknown, we assigned the fate of the broods to be the midpoint of when a brood was last observed active and first documented as an "unknown" status and assigned a failed status to a brood if the date of fate determination was <21 or <28 days after we first observed least tern or piping plover chicks, respectively, and a successful status to the brood otherwise.

We also calculated Mayfield estimates of daily and incubation-period or brooding-period survival rates for all least tern and piping plover nests and broods because, only Mayfield estimates were reported in the past (2001–2007). We calculated Mayfield estimates of daily nest survival (S) using:  $S = 1 - N_f / E_s$ , where  $N_f$  is the number of nests that failed and  $E_s$  is exposure days or number of days that elapsed between when the nest was first observed and when it was observed to have hatched or failed; losses occurring between visits were assumed to have occurred at the midpoint between visits. We calculated incubation-period survival rates for nests by raising the daily survival rate to the 21<sup>st</sup> or 28<sup>th</sup> power for least tern and piping plover nests, respectively. For example, if the daily survival rate for least tern nests was 0.97, the incubation-period survival rate would be approximately 0.53 (0.97<sup>21</sup>). The same process was used to obtain estimates of daily and brooding-period survival rates for least tern and piping plover broods and chicks. We calculated standard errors (SE<sub>s</sub>) and 95% confidence intervals (CI<sub>95</sub>) for survival estimates using: SE<sub>s</sub> = ([S-

 $S^2]/E_S)^{1/2}$  where  $E_S$  was the total number of exposure days used to calculate S and  $CI_{95} = S \pm 1.96(SE_S)$ . The 95% confidence intervals for the corresponding Mayfield incubation-period and brood-rearing period estimates were calculated by raising the confidence limits for S to the power of 21 or 28 for least terns and piping plovers, respectively.

#### **RESULTS:**

*Mortality:* We observed no research-related mortality during 2017. Weather was attributed as the cause of 1 piping plover nest (2%) and 2 least tern nest (2%) failures during 2017. One piping plover nest (2%) failed due to heavy rain, which caused flooding. Predation was documented as the cause of loss for 2 piping plover nests (4%) and as well suspected in the loss of several additional least tern and piping plover nests and chicks during 2017. One piping plover nest (2%) was determined abandoned. Twenty-two least tern (26%) and 5 piping plover (22%) nest failures were attributed to unknown causes. Because inside monitoring was not preformed this year, determining nest fates was not as precise as previous years. Several nest fates that were declared unknown outcomes could have been attributed to weather and/or predation related events.

Least Terns: Least tern nests were observed and monitored at 9 of the 15 sandpits monitored during 2017 (Table 7, Figure 8). All counts of adults, nests, chicks, and fledglings reported in Table 5 represent maximum numbers observed from outside the nesting colony during all surveys. The first observation of a least tern nest occurred on 25 May, 2017 and the last nest was first observed on 25 July, 2017. The first observation of a least tern chick occurred on 22 June, 2017 and the last nest known to hatch did so on 10 August, 2017. At least 1 egg from 53% (63/118) of least tern nests hatched which resulted in which resulted in 129 chicks and an overall nest-success rate of 1.09 chicks/nest or 1.68 chicks/breeding pair (129 chicks/77 breeding pairs) during 2017 (Table 5). Average daily survival rate of least tern nests during 2017 was 0.9753 (range = 0.9606-1.0000; Appendices 1 & 9) with at least one significant difference observed between sites [ $\chi^2(8, N = 118)$ ] = 16.404; p = 0.0370]; average survival rate over the 21-day incubation period was 0.6070 (range = 0.4476 - 1.0000). We observed the first least tern fledgling on 6 July, 2017 and the last known least tern chick to fledge did so on 24 August, 2017. Apparent fledge success at all sites monitored was 0.64 fledglings/nest (76 fledglings/118 nests) or 0.99 fledglings/breeding pair (76 fledglings/77 breeding pairs) with all nests occurring on sandpit sites during 2017. Average daily survival rates for least tern broods across all sites during 2017 was 0.9712 (range = 0.6723 - 1.0000; Appendices 2 & 10) with at least one significant difference observed between sites [ $\gamma^2(4, N = 63)$ ] = 65.929; p < 0.0001]; average brooding-period survival rate across all sites was 0.5572 (range = 0.0004-1.0000).

We tested for an effect of ownership (i.e., Program or other) on nest and brood survival rates during 2017. Least tern incubation period survival was slightly higher at non-Program sites and Program owned and/or managed nesting areas, 0.6978, 0.5715 respectively, but the difference not significant at  $\alpha$ =0.05 level (Appendices 5 & 13). Brooding period survival rates were similar at non-Program sites and Program owned and/or managed nesting areas, 0.5684 and 0.5534 respectively, and the difference was not significant at  $\alpha$ =0.05 level (Appendices 6 & 14).



**Figure 8**. Distribution and numbers of least tern and piping plover nests, chicks, and fledglings observed within Program associated habitats during 2017 surveys of sandpits and naturally occurring river islands. Least tern nests and chicks were observed and monitored at 9 of the 15 sandpits and piping plover nests and chicks were observed and monitored at 11 of the 15 sandpits monitored during 2017. **Table 5.** Summary of least tern reproductive success at sandpit and river-island sites on the central Platte River in Nebraska, 2007–2017. Sitespecific details on numbers of adults, nest, chicks, and fledglings observed during 2017 are provided in Table 7. Site-specific details of daily, incubation- and brooding-period survival rates for 2017 are provided in Appendices 1-2 and 5-6 (Program Mark estimates) and Appendices 9-10 and 13-14 (Mayfield estimates).

			Least	Tern							
Reproductive Parameter	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Maximum Adults Observed	132	80	97	123	125	116	136	166	224	157	118
Breeding Pairs	39	37	42	53	60	64	58	98	141	88	77
Total Nests Observed	53	64	60	76	90	88	95	145	188	119	118
Successful Nests (≥1 egg hatched)	22	27	37	43	52	63	51	80	116	74	63
Apparent Nest Success	0.42	0.42	0.62	0.57	0.58	0.72	0.54	0.55	0.62	0.62	0.53
Daily Nest Survival Rate (All sites)	0.97	0.98	0.99	0.98	0.97	0.99	0.97	0.97	0.98	0.98	0.98
Incubation-period Survival Rate (All sites)	0.55	0.61	0.73	0.64	0.58	0.76	0.56	0.52	0.63	0.71	0.61
Chicks Observed (<15D)	50	54	71	105	124	144	118	180	258	170	129
Hatch Ratio (Chicks/Nest)	0.94	0.84	1.18	1.38	1.38	1.64	1.24	1.24	1.37	1.43	1.09
Hatch Ratio (Chicks/Breeding Pair)	1.28	1.46	1.69	1.98	2.07	2.25	2.03	1.84	1.83	1.93	1.68
Chicks (≥15D)	40	44	48	67	98	95	70	104	158	91	78
Fledglings (21D)	A			64	89	84	64	91	146	80	76
Historic Fledge Ratio (15D Chicks/Nest)	0.75	0.69	0.80	0.88	1.09	1.08	0.74	0.72	0.84	0.76	0.66
Fledge ratio (21D Chicks/Nest)				0.84	0.99	0.95	0.67	0.63	0.78	0.67	0.64
Historic Fledge Ratio (15D Chicks/Breeding Pair)	1.03	1.19	1.14	1.26	1.63	1.48	1.21	1.06	1.12	1.03	1.01
Fledge Ratio (21D Chicks/Breeding Pair)				1.21	1.48	1.31	1.10	0.93	1.04	0.91	0.99
Daily Brood Survival Rate (All sites)		0.98	0.98	0.98	0.99	0.99	0.97	0.98	0.98	0.98	0.97
Brooding-period Survival Rate (All sites) <sup>B</sup>		0.75	0.79	0.72	0.89	0.81	0.59	0.69	0.68	0.61	0.56

<sup>A</sup> "-----" indicates these data were not reported. <sup>B</sup> Brood survival rates reported in the table are not comparable because estimates are reported as survival for a 15-day interval for least tern chicks during 2007–2009 and in 2010 the Program began to use 21 days as the fledge age for least tern chicks.

*Piping Plovers*: Piping plover nests were observed at 11 of 15 sandpits monitored during 2017 (Table 7; Figure 8). The first observation of a piping plover nest was made on 3 May, 2017 and the last nest was first observed on 23 June, 2017. The first observation of a piping plover chick occurred on 29 May, 2017 and the last successful nest observed hatched on 10 July, 2017. At least one egg from 59% (30/51) of piping plover nests hatched, which resulted in 92 chicks and an overall nest-success rate of 1.80 chicks/nest or 2.30 chicks/breeding pair (92 chicks/40 breeding pairs) during 2017 (Table 6). Piping plover daily nest survival



Piping plover chicks and egg

rate across all sites during 2017 was 0.9816 (range = 0.9309–1.0000; Appendices 3 & 11) with no difference observed between sites at an  $\alpha$ =0.05 level; average incubation-period survival rate was 0.6058 (range = 0.1449–1.0000). We first observed a piping plover fledgling on 26 June, 2017 and the last known piping plover chick to fledge did so on 7 August, 2017. We observed an apparent nest-based fledging rate of 0.92 (47 fledglings/51 nests) and a pair-based fledging rate of 1.18 (47 fledglings/40 breeding pairs) at all sites monitored during 2017 (Table 6). Average daily survival rates for piping plover broods across all sites during 2017 was 0.9831 (range = 0.9333–1.0000; Appendices 4 & 12) with no difference observed between sites at an  $\alpha$ =0.05 level; average brooding-period survival rate across all sites was 0.6316 (range = 0.1552–1.0000).

We tested for an effect of ownership (i.e., Program or other) on nest and brood survival rates during 2017. Piping plover incubation period survival rates were slightly higher at non-Program sites than at Program owned and/or managed nesting areas, 0.7078, 0.5657, but the difference was not significant at  $\alpha$ =0.05 level (Appendices 7 & 15). Piping plover brooding period survival rates were lower at Program sites than at non-Program owned and/or managed nesting areas, 0.4896, 0.8876 respectively, [ $\chi^2(1, N = 30) = 4.36$ ; p = 0.0368; Appendices 8 & 16].

**Table 6.** Summary of piping plover reproductive success at sandpit sites along the central Platte River in Nebraska, 2007–2017. Site-specific details on numbers of adults, nest, chicks, and fledglings observed during 2017 are provided in Table 7. Site-specific details of daily, incubation- and brooding-period survival rates for 2017 are provided in Appendices 3-4 and 11-12 (Program Mark estimates) and Appendices 7-8 and 15-16 (Mayfield estimates).

	Piping Plover										
<b>Reproductive Parameter</b>	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Adults Observed	52	23	31	46	55	60	68	69	74	64	65
Breeding Pairs	19	13	12	20	27	30	27	30	39	43	40
Total Nests Observed	27	21	15	33	34	46	31	43	54	60	51
Successful Nests (≥1 egg hatched)	15	8	9	21	27	32	23	34	34	40	30
Apparent Nest Success	0.56	0.38	0.60	0.64	0.79	0.70	0.74	0.79	0.63	0.68	0.59
Daily Nest Survival Rate (All sites)	0.99	0.98	0.99	0.98	0.99	0.99	0.99	0.99	0.98	0.99	0.98
Incubation-period Survival Rate (All sites)	0.71	0.58	0.67	0.54	0.77	0.69	0.73	0.77	0.64	0.69	0.61
Chicks Observed (<15D)	44	26	27	76	87	99	80	116	119	120	92
Hatch Ratio (Chicks/Nest)	1.63	1.24	1.80	2.30	2.56	2.15	2.58	2.70	2.2	2.00	1.80
Hatch Ratio (Chicks/Breeding Pair)	2.32	1.24	2.25	3.80	3.22	3.30	2.96	3.87	3.05	2.79	2.30
Chicks (≥15D)	27	10	18	53	61	68	43	67	73	70	53
Fledglings (28D)	A			42	45	59	28	55	52	55	47
Historic Fledge Ratio (15D Chicks/Nest)	1.00	0.48	1.20	1.61	1.79	1.48	1.39	1.56	1.35	1.17	1.04
Fledge ratio (28D Chicks/Nest)				1.27	1.32	1.28	0.90	1.28	0.96	0.92	0.92
Historic Fledge Ratio (15D Chicks/Breeding Pair)	1.42	0.77	1.50	2.65	2.26	2.27	1.59	2.23	1.87	1.63	1.33
Fledge Ratio (28D Chicks/Breeding Pair)				2.01	1.67	1.97	1.04	1.83	1.33	1.28	1.18
Daily Brood Survival Rate (All sites)		0.94	0.98	0.99	0.99	0.99	0.98	0.99	0.99	0.98	0.98
Brooding-period Survival Rate (All sites) <sup>B</sup>		0.42	0.79	0.70	0.73	0.78	0.62	0.69	0.68	0.55	0.63

<sup>A</sup> "-----" indicates these data were not reported.

<sup>B</sup> Brood survival rates reported in the table are not comparable because estimates are reported as survival for a 15-day interval for piping plover chicks during 2007–2009 and in 2010 the Program began to use 28 days as the fledge age for piping plover chicks.

**Table 7.** Site-specific numbers of adults, nests, chicks, and fledglings observed while monitoring sandpits for least tern and piping plover reproduction during 2017. Chick and fledgling counts represent numbers documented as being produced from each site. See the Management Section of this report for a detailed description of management actions taken at each site. Site numbers correspond with Figure 3.

					Least tern				Piping plover											
Site #/Name	Habitat Type <sup>A</sup>	Management <sup>A</sup>	Surveys	Survey Time (hr.)	Breeding Pairs <sup>B</sup>	Bre. Pair (Max) <sup>B</sup>	Adults (Max) <sup>B</sup>	Nests	Nests Hatched	Chicks 0-14 Days	Chicks 15-21 D.	Fledglings	Breeding Pairs <sup>B</sup>	Bre. Pair (Max) <sup>B</sup>	Adults (Max) <sup>B</sup>	Nests	Nests Hatched	Chicks 0-14 Days	Chicks 15-28 D.	Fledglings
1 Lexington Pit	SP	PFT	23	33	9	10	20	11	4	11	10	10	4	4	10	4	3	5	5	5
2 Dyer Pit	SP	PFTGH	34	33	7	11	15	11	11	25	23	21	4	4	8	4	2	6	4	3
3 Cottonwood Ranch OCSW	OC	PFTH	24	12	0	0	1	0	0	0	0	0	1	1	2	1	1	4	1	1
4 Blue Hole	SP	PFT	24	42	9	16	23	17	9	18	16	16	10	10	17	13	9	26	20	20
5 Johnson Pit	SP	PFT	17	17	7	7	16	7	6	12	0	0	1	1	1	1	0	0	0	0
6 Broadfoot South	SP	PFTH	30	45	18	21	26	31	16	27	7	7	8	9	12	10	6	18	2	2
7 Broadfoot South - Non-Access Islands <sup>C</sup>	SP	PFT	30	13	12	12	15	13	4	5	0	0	1	2	2	3	0	0	0	0
8 Newark West	SP	PFTH	28	22	11	11	18	15	6	15	11	11	7	8	11	8	6	21	11	11
9 Newark East	SP	PFTH	33	15	2	9	14	10	5	12	11	11	1	1	3	1	1	4	4	4
10 Leaman East OCSW	OC	PFTH	23	18	2	3	5	3	2	4	0	0	2	4	7	5	1	4	2	0
11 Follmer-Alda Pit	SP	PFTH	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 Trust Wild Rose East	SP	Ν	18	10	0	0	0	0	0	0	0	0	1	1	4	1	1	4	4	1
13 Deweese – Alda Pit	SP	NM	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Hooker Brothers – GI South East Pit	SP	NM	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Hooker Brothers – GI East Pit	SP	NM	8	4	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0

<sup>A</sup> Habitat types include sandpits (SP), off-channel sand and water (OC), or river islands (RI). Management actions applied to each site following the 2016 nesting season and prior to the 2017 nesting season could include: mowed (M), burned (B), disked (D), graded (G), tree/vegetation removal (R), or contact herbicide (H) during fall 2016; pre-emergent herbicide (P), predator fencing (F), predator trapping (T), or Nest Furniture Distribution (S) during spring 2017; active sand/gravel mining within primary nesting peninsula (M), no management (N); unknown (U); or construction (C) which include monitored sites that were considered non-habitat prior to June 15 due to construction activities.

<sup>B</sup> Breeding pair counts were determined on 23 June for least terns and 12 June for piping plovers when numbers observed within the Program Associated Habitat area first peaked. Breeding pair counts, however, do not necessarily represent maximum numbers of least tern or piping plover breeding pairs observed at any site throughout the year as some adults are known to have re-nested at different sites after losing their first nest or brood. Bre. Pairs (Max) represents the maximum number of pairs at a site during the nesting season, regardless of Breeding Pair peak dates. Adults (Max) represent the maximum number adults observed during any single survey at the site.

<sup>c</sup> Includes 1 least tern nest was outside the managed nesting areas and thus not surrounded by electrified fence and water. The nest was determined to be failed.



Least Tern Chicks

*Breeding Pair Counts:* We estimated numbers of least tern and piping plover breeding pairs by adding the number of active and recently (within five days) failed nests to the number of active and recently failed least tern and piping plover broods and recently fledged least terns and fledged piping plovers observed on each day of the nesting season (Baasch et al. 2015). Least tern breeding pair counts peaked at 77 pairs on 23 June, 2017. Piping plover breeding pair counts peaked at 40 pairs 12 June, 2017. Similar to nest and adult counts, least tern breeding pair counts have increased steadily since 2001 (Figure 9). Piping plover breeding pair counts increased slightly from 2001–2007, declined during 2008 and 2009, and have since increased

(Figure 10). We observed a decrease in least tern and piping plover breeding pairs in 2017; however, counts are still at or above counts observed during the years prior to the Program implementation. Though nesting has occurred on riverine sandbars, off-channel sandpits have provided the most consistent nesting habitat for both species to date.



**Figure 9.** Comparison of cumulative numbers of least tern nests, Program-defined breeding pairs, maximum nest and brood quantities, and the mid-June nest and brood quantities observed within the Program Associated Habitat Area, 2001-2017.



**Figure 10.** Comparison of numbers of piping plover cumulative nests, Program defined breeding pairs, maximum nest and brood quantities, and the mid-June nest and brood quantities observed within the Program Associated Habitat Area, 2001–2017.

#### Species Response to Habitat Creation and Maintenance

The total number of breeding pairs has increased for both species during the First Increment of the Program (Table 8). In 2017, a total of 77 least tern and 32 piping plover breeding pairs were

observed in the AHR (Figure 11). Most of the nesting in the AHR during the First Increment of the Program has occurred on managed off-channel habitats (Figures 12 and 13). The limited amount of on-channel nesting observed at the beginning of the First Increment declined as on-channel habitat was lost during several high flow events (Table 1). Off-channel habitat accounts for most of the nesting in the AHR and the number of breeding pairs has generally increased over the course of the First Increment as the Program has constructed additional off-channel habitats (Tables 1 and 10). Overall, the Program has observed a species response to off-channel habitat construction



Sun breaking through on an active mine site habitat

(Figure 14), while the species response to on-channel habitat construction is still undetermined.

			Leas	st Tern		Piping Plover					
Year	Br.* Pairs	Nests	Succ. Nests	Fledglings	Fledglings Per Pair	Br. Pairs	Nests	Succ. Nests	Fledglings	Fledglings Per Pair	
2007	42	53	22	40	0.95	21	27	15	25	1.19	
2008	39	64	27	44	1.13	14	21	8	10	0.71	
2009	43	60	36	46	1.07	12	15	9	12	1	
2010	51	80	44	64	1.25	22	33	22	46	2.09	
2011	62	90	53	89	1.44	28	34	27	45	1.61	
2012	66	88	63	84	1.27	30	46	32	59	1.97	
2013	63	95	51	64	1.02	27	31	23	28	1.04	
2014	98	145	54	91	0.93	30	43	25	59	1.97	
2015	141	188	116	146	1.04	39	54	34	52	1.33	
2016	88	119	74	80	0.91	43	60	40	55	1.28	
2017	77	118	63	76	0.99	40	51	30	47	1.18	
Mean	70	100	55	75	1.09	28	38	24	40	1.40	

Table 8. Least tern and piping plover on- and off-channel nesting incidence by year, 2007–2017.

\*Breeding pairs within table 8 represent numbers of breeding pairs present on in-channel islands and off-channel sites the day breeding pairs within the system were maximized; therefore, nests and fledglings per breeding pair are occasionally disproportionately large.

Table 9. Least tern and piping plover on-channel nesting incidence and productivity by year, 2007–2017.

			Leas	st Tern		Piping Plover						
Year	*Br. Pairs	Nests	Succ. Nests	Fledglings	Fledglings Per Pair	*Br. Pairs	Nests	Succ. Nests	Fledglings	Fledglings Per Pair		
2007	11	13	2	2	0.18	1	4	2	7	7		
2008	10	20	7	9	0.9	3	5	1	3	1		
2009	3	8	5	4	1.33	2	2	1	1	0.5		
2010	0	0	0	0	0	4	11	4	10	2.5		
2011	0	0	0	0	0	0	0	0	0	0		
2012	0	0	0	0	0	1	1	1	4	4		
2013	0	0	0	0	0	0	0	0	0	0		
2014	0	2	0	0	0	1	2	1	4	4		
2015	8	14	3	0	0	5	7	1	1	0.2		
2016	2	2	0	0	0	2	2	1	1	0.5		
2017	0	0	0	0	0	0	0	0	0	0		
Mean	3.09	5.36	1.55	1.36	0.44	1.73	3.09	1.09	2.82	1.63		

\*Breeding pairs within table 9 represent numbers of breeding pairs present on in-channel islands the day breeding pairs within the system were maximized; therefore, nests and fledglings per breeding pair are occasionally disproportionately large.

			Least '	Tern		Piping Plover						
Year	*Br. Pairs	Nests	Succ. Nests	Fledglings	Fledglings Per Pair	*Br. Pairs	Nests	Succ. Nests	Fledglings	Fledglings Per Pair		
2007	31	40	20	38	1.23	20	23	13	18	0.90		
2008	29	44	20	35	1.21	11	16	7	7	0.64		
2009	40	52	31	42	1.05	10	13	8	11	1.10		
2010	51	80	44	64	1.25	18	22	18	36	2.00		
2011	62	90	53	89	1.44	28	34	27	45	1.61		
2012	66	88	63	84	1.27	29	45	31	55	1.90		
2013	63	95	51	64	1.02	27	31	23	28	1.04		
2014	98	143	54	91	0.93	29	41	24	55	1.90		
2015	133	174	113	146	1.09	34	47	33	51	1.50		
2016	86	117	74	80	0.93	42	58	39	54	1.29		
2017	77	118	63	76	0.99	40	51	30	47	1.18		
Mean	67	95	53	74	1.13	26	35	23	37	1.37		

Table 10. Least tern and piping plover off-channel nesting incidence and productivity by year, 2007–2017.

\*Breeding pairs within table 10 represent numbers of breeding pairs present on sandpit sites the day breeding pairs within the system were maximized. See Table 8 for maximum off-channel breeding pairs by site.



**Figure 11.** Comparison of total least tern (blue bars) and piping plover (red bars) nests within the Program Associated Habitat Area, 2001-2017.



Figure 12. Comparison of least tern off-channel (blue bars) and on-channel (red bars) nests within the Program Associated Habitat Area, 2001-2017.



**Figure 13.** Comparison of piping plover off-channel (blue bars) and on-channel (red bars) nests within the Program Associated Habitat Area, 2001-2017.



**Figure 14.** Comparison of numbers of least tern (dotted line) and piping plover (dashed line) breeding pairs and availability of managed off-channel habitat (solid line) within the Program Associated Habitat Area, 2001-2017.

#### RESEARCH

In addition to implementation of the Program's surveillance monitoring protocol, conservation monitoring and directed research will be conducted during the course of the Program's First Increment to provide data to evaluate the Program's management objectives and priority hypotheses. Design and implementation of research activities will be guided by the ED Office and the TAC, will be reviewed by the Program's Independent Scientific Advisory Committee (ISAC) and ultimately approved by the Program's Governance Committee (GC).

#### FORAGING HABITS STUDY

The first directed research project related to least terns and piping plovers on the central Platte River began in 2009 with the implementation of the Foraging Habits Study. A contract to conduct this study over two field seasons (2009–2010) was awarded to the USGS-NPWRC. The research was jointly funded by the Program and the USGS-NPWRC. Final results of the Foraging Habits Study can be found in the Program Library at the following link:

https://www.platteriverprogram.org/PubsAndData/ProgramLibrary/Forms/DispForm.aspx?ID=158

#### HABITAT COLONIZATION STUDY

In 2011, the Program and the USGS entered into an agreement for the USGS to conduct a study to evaluate Habitat Colonization and Productivity of Least Terns and Piping Plovers Nesting on Central Platte River sandpits and sandbars. This study was designed to address three specific objectives contributed to the understanding of habitat use by least terns and piping plovers in the CPRV:

#### 1. Dispersal

Quantify dispersal of adults between units of nesting habitat on the Central Platte River among years.

#### 2. Colonization

Quantify colonization rate of newly constructed or managed nesting habitat by local vs. immigrant adults.

#### 3. Renesting

Quantify frequency and location of renesting attempts by adults with failed nests.

The research was jointly funded by the Program and the USGS-NPWRC. Details about findings of this research can be found in the Final Research Project Report that will be produced after the 2018 nesting season and will include banding and resigning data from continued efforts performed during 2009–2018.

*Adult and Chick Band Observations* – As part of Program-funded research implemented by USGS field crews, 152 adult and 685 juvenile least terns and 85 adult and 591 juvenile piping plovers were banded along the central Platte River between 2009 and 2016 (Table 11).

Year	Least Tern Adults	Least Tern Chicks	Piping Plover Adults	Piping Plover Chicks
2009	16	35	11	25
2010	7	74	13	64
2011	4	98	2	68
2012	9	103	15	86
2013	32	99	12	64
2014	28	114	11	106
2015	56	162	21	88
2016	39	107	28	90
Total	152	685	85	591

Table 11. Numbers of least tern and piping plover adults and chicks banded along the central Platte River, 2009–2016.

After nine years of band resighting efforts on the central Platte River, we have compiled valuable information regarding site and habitat (sandpit or riverine) fidelity and philopatry, wintering ground locations for central Platte River piping plovers, survival and recruitment, re-nesting events, and disturbance. We have observed several adult least terns and piping plovers return to

nest at the site where they were banded (and at other sites). We observed least tern and piping plover fledglings at nonnatal sites late in the nesting season on multiple occasions, which may be an indication that fledglings begin selecting nesting habitat for the subsequent year prior to departing for the winter grounds. 2017 band resighting season was a success as a total of 91 (71% of the birds observed) least terns and 48 (73% of the birds observed) piping plover bands were recorded (Table 12 and 13). Of the banded birds observed, 90 (99%) least terns and 39 (81%) piping plovers were banded within the AHR. A detailed summary of what has been observed and learned from banding efforts will be available in 2019.



Piping Plover that was banded as a chick on the central Platte and returned to nest at Broadfoot South in 2017.

Least Tern												
Sites Monitored	Nests Monitored	Banded Adults	Unbanded Adults	Banded Pairs	Unbanded Pairs	Adult 1 Banded, Adult 2 Unbanded	Adult 1 Banded, Adult 2 Not Observed	Adult 1 Unbanded, Adult 2 Not Observed	Neither Adult Observed			
Lexington	8	7	1	1	0	0	5	1	1			
Dyer	11	13	4	4	1	2	3	1	0			
Cottonwood Ranch OCSW	0	0	0	0	0	0	0	0	0			
Blue Hole	14	17	6	5	2	3	4	0	0			
Johnson	6	7	0	1	0	0	5	0	0			
Broadfoot South	30	28	14	8	1	9	3	3	6			
Newark West	13	8	9	1	2	2	4	3	1			
Newark East	8	9	3	3	0	2	1	1	1			
Leaman OCSW	2	2	1	0	0	1	1	0	0			
Trust Wild Rose - East	0	0	0	0	0	0	0	0	0			
Total	92	91	38	23	6	19	26	9	9			

Table 12. Totals for 2017 least tern band resignting efforts. Individual totals for each off-channel nesting site are pro-	ovided
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**Table 13.** Totals for 2017 piping plover band resignting efforts. Individual totals for each off-channel nesting site are provided.

	Piping Plover												
Sites Monitored	Nests Monitored	Banded Adults	Unbanded Adults	Banded Pairs	Unbanded Pairs	Adult 1 Banded, Adult 2 Unbanded	Adult 1 Banded, Adult 2 Not Observed	Adult 1 Unbanded, Adult 2 Not Observed	Neither Adult Observed				
Lexington	3	4	2	1	0	2	0	0	0				
Dyer	4	3	2	0	0	2	1	0	1				
Cottonwood Ranch OCSW	1	2	0	1	0	0	0	0	0				
Blue Hole	6	7	3	1	0	3	2	0	0				
Johnson	1	2	0	1	0	0	0	0	0				
Broadfoot South	9	11	6	3	1	4	1	0	0				
Newark West	8	11	3	4	1	1	2	0	0				
Newark East	1	1	0	0	0	0	1	0	0				
Leaman OCSW	4	6	1	2	0	1	1	0	0				
Trust Wild Rose - East	1	1	1	0	0	1	0	0	0				
Total	38	48	18	13	2	14	8	0	1				

#### NEST DATA

Over the past eleven years we have collected habitat measures believed to influence nest placement and productivity. We used a GIS and LiDAR to determine elevation of each nest above the waterline and to determine distances to predator perch and nearest waterline for all nests. Summaries of the habitat metrics found to influence nest-site selection by least terns and piping plovers are presented in Tables 12 & 13.

**Table 12.** Average off-channel least tern nest elevations above water, distances to edge of water, and distances to predator perch by site during 2017. These covariates were found to influence nest site selection by least terns on off-channel sites along the central Platte River (Baasch et al. 2017).

Interior Least Terns									
Site Name	Average Elevation Above Water (in)	Average Distance to Edge of Water (yds)	Average Distance to Predator Perch (yds)						
Lexington Sandpit	135	48	152						
Dyer Sandpit	94	51	252						
Blue Hole	88	34	188						
Johnson Sandpit	61	19	303						
Broadfoot - Kearney South	84	28	306						
Broadfoot South - Non-Access Islands	81	15	117						
Newark West	96	31	221						
Broadfoot Newark East	75	25	455						
Leaman East OCSW	84	48	246						

**Table 13.** Average off-channel piping plover nest elevations above water, distances to edge of water, and distances to predator perch by site during 2017. These covariates were found to influence nest site selection by piping plovers on off-channel sites along the central Platte River (Baasch et al. 2017).

	<b>Piping Plover</b>		
Site Name	Average Elevation Above Water (in)	Average Distance to Edge of Water (yds)	Average Distance to Predator Perch (yds)
Lexington Sandpit	143	59	164
Dyer Sandpit	100	39	284
Cottonwood Ranch Sandpit	233	50	237
Blue Hole	90	36	188
Johnson Sandpit	91	17	179
Broadfoot - Kearney South	83	39	298
Broadfoot South - Non-Access Islands	77	41	234
Newark West	105	43	170
Broadfoot Newark East	145	50	327
Leaman East OCSW	79	54	232
Trust Wildrose East	71	31	232

#### HABITAT SELECTION STUDY

The EDO used resource selection functions and 15 years of data to assess the influence physical site attributes and inter- and intra-specific interactions have on nest site selection by least terns and piping plovers on off-channel nesting sites (Baasch et al. 2017). We found nest site selection by least terns and piping plovers was influenced by factors the Program can manage such as distance to predator perch and elevation above waterline as well as factors that cannot be managed. The relative probability of use for both species was maximized when distance to the nearest predator perch was  $\geq 150$  m and elevation above the waterline was  $\geq 3$  m. Probability of use for nesting by least terns increased as distance to water increased whereas the probability of use by piping plovers was maximized when distance to water was ~50 m. In addition, we found piping plovers avoided nesting near each other, whereas colonial least terns selected nest sites near those of conspecifics. Our results suggest that important features of constructed, off-channel nesting sites for both species should include no potential predator perches within 150 m of nesting habitat and nesting areas at least 3 m above the waterline. Efficient site designs for least terns would be circular, maximizing the area of nesting habitat away from the shoreline whereas an effective site design for piping plovers would be more linear, maximizing the area of nesting habitat near the waterline. An efficient site design for both species would be lobate, incorporating centralized nesting habitat for least terns and increased access to foraging areas for nesting and brood-rearing piping plovers.

#### PREDATOR CAMERA STUDIES

2017 was the first year that predator identification research was conducted at off-channel nesting sites. Prevention of predation by terrestrial predators is an important objective for increasing productivity of least tern and piping plover. As such, permanent electrified fences are in place on the entrance of each off-channel nesting site. Non-electrified panel wings are positioned on the ends of the permanent fence and extend 2–3 meters into the water. However, predation



is still a factor for reducing productivity at off-channel nesting sites. Predation events and predator species type are truly unknown factors because it is difficult to determine those specifics when the event was not seen firsthand. The purpose of the study is to investigate predator presence and possible predation events at off-channel nesting sites and the effectiveness of panel wings. Both of these tasks will be executed using remote cameras. Results from the study will help to identify possible actions that can be implemented to help prevent future predation. Results from 2017 field season are still being analyzed, but from the data available the cameras were successful at capturing predators on the off-channel nesting sites.



#### TRAPPING DATA

2017 marked the 6<sup>th</sup> year of predator trapping on the 6 Program-owned off-channel nesting sites. Though the number of Program-owned off-channel nesting sites has increased during this time, the average number of predators caught at each site increased substantially in 2017 as compared to previous years (Figure 15). Predators include bull snake, raccoon, weasel, opossum, skunk, fox, coyote, and bobcat.



Figure 15. Numbers of predators trapped at Program-owned off-channel nesting sites, 2012–2017.

\* Predators include bull snake, raccoon, weasel, opossum, skunk, fox, coyote, and bobcat. \*\*Trapping did not occur at Broadfoot South during 2012

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#### ACKNOWLEDGEMENTS

<sup>\*\*\*</sup>Trapping did not occur at Follmer-Alda during 2012–2014

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We would also like to acknowledge the privately-owned sand and gravel mining companies who allowed us access to their property to monitor and collect data on interior least tern and piping plover activities. These companies included Broadfoot Sand and Gravel Corporation and Hooker Brothers Sand and Gravel.





## Appendices

#### **Program Mark Survival Estimates**

**Appendix 1.** Daily and incubation-period survival rates for least tern nests monitored on sandpit sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{21}$ .

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival	Daily Nest Survival	Daily Survival I C	v Nest Rate 95% XI	Incubation Period Survival	Incubation Nest Surv 95%	on Period vival Rate 6 CI
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	17	6	275	0.9767	0.0094	0.9491	0.9895	0.6240	0.3783	0.8191
Johnson	7	1	134	0.9921	0.0079	0.9461	0.9989	0.8532	0.4111	0.9798
Lexington	11	3	192	0.9830	0.0097	0.9487	0.9945	0.7103	0.3919	0.9032
Dyer	11	0	222	0.9673	0.0083	0.9465	0.9802	1.0000	1.0000	1.0000
Broadfoot South	31	15	507	0.9682	0.0128	0.9310	0.9856	0.5145	0.3464	0.6793
Broadfoot South Non-access	13	6	202	1.0000	0.0000	1.0000	1.0000	0.5236	0.2705	0.7652
Newark West	15	9	252	0.9606	0.0129	0.9260	0.9794	0.4476	0.2384	0.6771
Newark East	10	5	198	0.9713	0.0127	0.9328	0.9880	0.5581	0.2843	0.8007
Leaman OCSW	3	1	47	0.9773	0.0225	0.8555	0.9968	0.6314	0.1293	0.9518
All Sites	118	46	2,008	0.9753	0.0036	0.9672	0.9815	0.6070	0.5169	0.6903

**Appendix 2.** Daily and brooding-period survival rates for observed least tern broods (1 or more chicks) monitored on sandpit sites during 2017. Brooding-period brood survival rate =  $(\text{daily brood survival rate})^{21}$ .

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival	Daily Brood Survival	Daily Survival I C	Brood Rate 95% I	Brooding Period Survival	Broodin Survival I C	g Period Rate 95% ZI
		Lost		Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	9	1	119	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000
Johnson	6	6	39	0.7935	0.0757	0.6084	0.9048	0.0098	0.0002	0.3021
Lexington	4	1	80	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000
Dyer	11	0	224	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadfoot South	16	11	190	0.9350	0.0189	0.8865	0.9637	0.2610	0.1076	0.5085
Broadfoot South Non-access	4	4	18	0.6723	0.1363	0.3789	0.8734	0.0004	0.0000	0.5027
Newark West	6	1	105	0.9898	0.0101	0.9315	0.9986	0.8154	0.3359	0.9747
Newark East	5	0	105	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Leaman OCSW	2	2	26	0.9167	0.0564	0.7212	0.9791	0.1755	0.0113	0.7988
All Sites	63	26	906	0.9712	0.0058	0.9574	0.9806	0.5572	0.4259	0.6810

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival	Daily Nest Survival	Daily Survival I C	/ Nest Rate 95% CI	Incubation Period Survival	Incubation Nest Surv 95%	on Period vival Rate 6 CI
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	12	3	188	0.9830	0.0098	0.9485	0.9945	0.6286	0.2915	0.8745
Johnson	1	1	16	0.9309	0.0667	0.6385	0.9904	0.1449	0.0020	0.9344
Lexington	4	0	108	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Dyer	4	2	113	0.9799	0.0141	0.9232	0.9950	0.5779	0.1845	0.8923
Broadfoot South	10	4	244	0.9826	0.0086	0.9547	0.9935	0.6233	0.3261	0.8499
Broadfoot South Non-access	3	3	53	0.9387	0.0343	0.8265	0.9801	0.1814	0.0205	0.7014
Newark West	8	2	211	0.9901	0.0070	0.9613	0.9975	0.7644	0.4005	0.9403
Newark East	1	0	28	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Leaman OCSW	5	4	95	0.9521	0.0234	0.8791	0.9819	0.2655	0.0580	0.6797
Cottonwood Ranch OCSW	1	0	28	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000
Trust Wild Rose East	1	0	21	0.9830	0.0098	0.9485	0.9945	0.6286	0.2915	0.8745
All Sites	50	19	1,105	0.9816	0.0042	0.9713	0.9882	0.6058	0.4645	0.7313

Appendix 3. Daily and incubation-period survival rates for piping plover nests monitored on sandpit sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{28}$ .

Appendix 4. Daily and brooding-period survival rates for observed piping plover broods (1 or more chicks)	monitored on sandpit sites during
2017. Brooding-period survival rate = $(daily brood survival rate)^{28}$ .	

Site	# Broods	# Broods	Exposure Days	Daily Brood Survival	Daily Brood Survival	Daily Survival I C	Brood Rate 95% M	Brooding Period Survival	Broodin Survival	g Period Rate 95% CI
		LOSI		Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	9	1	142	0.9923	0.0077	0.9474	0.9989	0.8118	0.3296	0.9743
Lexington	3	0	75	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Dyer	2	0	56	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadfoot South	6	5	83	0.9337	0.0286	0.8504	0.9722	0.1570	0.0264	0.5611
Newark West	6	2	120	0.9823	0.0124	0.9320	0.9956	0.6174	0.2196	0.9025
Newark East	1	0	26	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Leaman OCSW	1	1	16	0.9333	0.0644	0.6480	0.9907	0.1552	0.0024	0.9327
Cottonwood Ranch OCSW	1	0	25	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000
Trust Wild Rose East	1	0	26	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000
All Sites	30	9	569	0.9831	0.0056	0.9679	0.9912	0.6316	0.4315	0.7948

**Appendix 5.** Daily and incubation-period survival rates for least tern nests monitored on Program and non-Program sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{21}$ .

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival	Daily Nest Survival	Daily Brood Survival Rate 95% CI		Incubation Period Survival	Brooding Period Survival Rate 95% CI	
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Non-Program	35	10	601	0.9822	0.0056	0.9672	0.9904	0.6978	0.5247	0.8285
Program	83	36	1,428	0.9724	0.0045	0.9620	0.9800	0.5715	0.4654	0.6714
All Sites	118	46	2,008	0.9753	0.0036	0.9672	0.9815	0.6070	0.5169	0.6903

*Program sites:* Dyer, Broadfoot South, Broadfoot South Non-access, Newark West, Newark East, & Leaman OCSW. *Non-Program sites:* Lexington, Blue Hole, & Johnson Sandpit

**Appendix 6.** Daily and brooding-period survival rates for least tern broods (1 or more chicks) monitored on Program and non-Program sites during 2017. Brooding-period brood survival rate =  $(\text{daily brood survival rate})^{21}$ .

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival SE	Daily Brood Survival Rate 95% CI		Brooding Period Survival	Brooding Period Survival Rate 95% CI	
		Lost				Lower	Upper	Rate	Lower	Upper
Non-Program	19	7	238	0.9722	0.0112	0.9394	0.9874	0.5684	0.3160	0.7897
Program	44	18	668	0.9708	0.0068	0.9542	0.9816	0.5534	0.4018	0.6956
All Sites	63	26	906	0.9712	0.0058	0.9574	0.9806	0.5572	0.4259	0.6810

*Program sites:* Dyer, Broadfoot South, Broadfoot South Non-access, Newark West, Newark East, & Leaman OCSW *Non-Program sites:* Lexington, Blue Hole, & Johnson Sandpit

Appendix 7. Daily and incubation-period survival rates for piping plover nests monitored on Program and non-Program sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{28}$ .

Site	# Nests	# Nests Lost	# Nests Exposure Lost Days		Daily Nest Survival	Daily Brood Survival Rate 95% CI		Incubation Period Survival	Brooding Period Survival Rate 95% CI	
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Non-Program	18	4	333	0.9873	0.0063	0.9666	0.9952	0.7078	0.4318	0.8853
Program	32	15	772	0.9791	0.0053	0.9657	0.9874	0.5657	0.4014	0.7167
All Sites	50	19	1,105	0.9816	0.0042	0.9713	0.9882	0.6058	0.4645	0.7313

*Program sites:* Dyer, Broadfoot South, Broadfoot South Non-access, Newark West, Newark East, Cottonwood Ranch OCSW, & Leaman OCSW.

Non-Program sites: Lexington, Blue Hole, Johnson, & Trust Wild Rose East Sandpit

**Appendix 8.** Daily and brooding-period survival rates for piping plover broods (1 or more chicks) monitored on Program and non-Program sites during 2017. Brooding-period brood survival rate =  $(\text{daily brood survival rate})^{28}$ .

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival SE	Daily Brood Survival Rate 95% CI		Brooding Period Survival	Brooding Period Survival Rate 95% CI	
		1050				Lower	Upper	Rate	Lower	Upper
Non-Program	13	1	243	0.9956	0.0044	0.9694	0.9994	0.8876	0.4969	0.9844
Program	17	8	326	0.9739	0.0091	0.9487	0.9869	0.4896	0.2667	0.7167
All Sites	30	9	569	0.9831	0.0056	0.9679	0.9912	0.6316	0.4315	0.7948

*Program sites:* Dyer, Broadfoot South, Newark West, Newark East, Cottonwood Ranch OCSW, & Leaman OCSW. *Non-Program sites:* Lexington, Blue Hole, & Trust Wild Rose East Sandpit

#### **Mayfield Survival Estimates**

**Appendix 9.** Daily and incubation-period survival rates for least tern nests monitored on sandpit sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{21}$ .

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival	Daily Nest Survival	Daily Daily Nest Nest Survival Rate 959 urvival CI		Incubation Period Survival	Incubation Period Nest Survival Rate 95% CI	
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	17	6	275	0.9782	0.0088	0.9609	0.9954	0.6292	0.4329	0.9086
Johnson	7	1	134	0.9925	0.0074	0.9780	1.0071	0.8544	0.6263	1.1604
Lexington	11	3	192	0.9844	0.0090	0.9668	1.0019	0.7184	0.4925	1.0411
Dyer	11	0	222	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadfoot South	31	15	507	0.9704	0.0075	0.9557	0.9852	0.5322	0.3858	0.7306
Broadfoot South Non-access	13	6	202	0.9703	0.0119	0.9469	0.9937	0.5309	0.3179	0.8759
Newark West	15	9	252	0.9643	0.0117	0.9414	0.9872	0.4659	0.2812	0.7629
Newark East	10	5	198	0.9747	0.0111	0.9529	0.9966	0.5844	0.3630	0.9310
Leaman OCSW	3	1	47	0.9787	0.0210	0.9375	1.0200	0.6366	0.2577	1.5150
All Sites	118	46	2,008	0.9771	0.0033	0.9705	0.9836	0.6147	0.5338	0.7072

**Appendix 10.** Daily and brooding-period survival rates for observed least tern broods (1 or more chicks) monitored on sandpit sites during 2017. Brooding-period brood survival rate =  $(\text{daily brood survival rate})^{21}$ .

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival	Daily Brood Survival	Daily Brood Survival Rate 95% CI		Brooding Period Survival	Brooding Period Survival Rate 95% CI	
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	9	1	119	0.9916	0.0084	0.9752	1.0080	0.8376	0.5901	1.1821
Johnson	6	6	39	0.8462	0.0578	0.7329	0.9594	0.0300	0.0015	0.4187
Lexington	4	1	80	0.9875	0.0124	0.9632	1.0118	0.7679	0.4546	1.2806
Dyer	11	0	224	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadfoot South	16	11	190	0.9421	0.0169	0.9089	0.9753	0.2858	0.1345	0.5916
Broadfoot South Non-access	4	4	18	0.7778	0.0980	0.5857	0.9698	0.0051	0.0000	0.5257
Newark West	6	1	105	0.9905	0.0095	0.9719	1.0091	0.8179	0.5496	1.2084
Newark East	5	0	105	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Leaman OCSW	2	2	26	0.9231	0.0523	0.8206	1.0255	0.1862	0.0158	1.6970
All Sites	63	26	906	0.9713	0.0055	0.9604	0.9822	0.5426	0.4283	0.6854

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival	Daily Nest Survival	Daily Survival F C	Nest Rate 95% I	Incubation Period Survival	Incubation Nest Surv 95%	on Period ival Rate CI
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	12	3	188	0.9840	0.0091	0.9661	1.0020	0.7133	0.4850	1.0419
Johnson	1	1	16	0.9375	0.0605	0.8189	1.0561	0.2579	0.0151	3.1470
Lexington	4	0	108	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Dyer	4	2	113	0.9823	0.0124	0.9580	1.0066	0.6873	0.4060	1.1484
Broadfoot South	10	4	244	0.9836	0.0081	0.9677	0.9995	0.7067	0.5015	0.9904
Broadfoot South Non-access	3	3	53	0.9434	0.0317	0.8812	1.0056	0.2942	0.0702	1.1247
Newark West	8	2	211	0.9905	0.0067	0.9774	1.0036	0.8187	0.6194	1.0783
Newark East	1	0	28	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Leaman OCSW	5	4	95	0.9579	0.0206	0.9175	0.9983	0.4052	0.1640	0.9645
Cottonwood Ranch OCSW	1	0	28	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Trust Wild Rose East	1	0	21	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
All Sites	50	19	1,105	0.9828	0.0039	0.9751	0.9905	0.6947	0.5894	0.8178

Appendix 11. Daily and incubation-period survival rates for piping plover nests monitored on sandpit sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{28}$ .

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival	Daily Brood Survival	Daily Survival	Brood Rate 95% CI	Brooding Period Survival	Broodin Survival	g Period Rate 95% CI
		Lost		Rate	SE	Lower	Upper	Rate	Lower	Upper
Blue Hole	9	1	142	0.9930	0.0070	0.9792	1.0067	0.8621	0.6432	1.1508
Lexington	3	0	75	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Dyer	2	0	56	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadfoot South	6	5	83	0.9398	0.0261	0.8886	0.9909	0.2712	0.0837	0.8262
Newark West	6	2	120	0.9833	0.0117	0.9604	1.0062	0.7026	0.4283	1.1395
Newark East	1	0	26	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Leaman OCSW	1	1	16	0.9375	0.0605	0.8189	1.0561	0.2579	0.0151	3.1470
Cottonwood Ranch OCSW	1	0	25	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Trust Wild Rose East	1	0	26	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
All Sites	30	9	569	0.9842	0.0052	0.9739	0.9944	0.7155	0.5742	0.8894

**Appendix 12.** Daily and brooding-period survival rates for observed piping plover broods (1 or more chicks) monitored on sandpit sites during 2017. Brooding-period survival rate =  $(\text{daily brood survival rate})^{28}$ .

**Appendix 13.** Daily and incubation-period survival rates for least tern nests monitored on Program and non-Program sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{21}$ .

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival	Daily Nest Survival	Daily Brood Survival Rate 95% CI		Incubation Period Survival	Brooding Period Survival Rate 95% CI	
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Non-Program	35	10	601	0.9834	0.0052	0.9731	0.9936	0.7030	0.5645	0.8736
Program	83	36	1,428	0.9748	0.0041	0.9667	0.9829	0.5850	0.4906	0.6964
All Sites	118	46	2,008	0.9771	0.0033	0.9705	0.9836	0.6147	0.5338	0.7072

*Program sites:* Dyer, Broadfoot South, Broadfoot South Non-access, Newark West, Newark East, & Leaman OCSW. *Non-Program sites:* Lexington, Blue Hole, & Johnson Sandpit

**Appendix 14.** Daily and brooding-period survival rates for least tern broods (1 or more chicks) monitored on Program and non-Program sites during 2017. Brooding-period brood survival rate =  $(\text{daily brood survival rate})^{21}$ .

Site	# Broods	# Broods Lost	Exposure Days	Daily Daily Brood Brood Survival Survival		Daily Brood Survival Rate 95% CI		Brooding Period Survival	Brooding Period Survival Rate 95% CI	
		2050		Rate	SE	Lower	Upper	Rate	Lower	Upper
Non-Program	19	7	238	0.9706	0.0110	0.9491	0.9921	0.5342	0.3340	0.8457
Program	44	18	668	0.9731	0.0063	0.9608	0.9853	0.5635	0.4316	0.7332
All Sites	63	26	906	0.9713	0.0055	0.9604	0.9822	0.5426	0.4283	0.6854

*Program sites:* Dyer, Broadfoot South, Broadfoot South Non-access, Newark West, Newark East, & Leaman OCSW *Non-Program sites:* Lexington, Blue Hole, & Johnson Sandpit

**Appendix 15.** Daily and incubation-period survival rates for piping plover nests monitored on Program and non-Program sites during 2017. Incubation-period nest survival rate =  $(\text{daily nest survival rate})^{28}$ .

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival	Daily Nest Survival	Daily Brood Survival Rate 95% CI		Incubation Period Survival	Brooding Period Survival Rate 95% CI	
				Rate	SE	Lower	Upper	Rate	Lower	Upper
Non-Program	18	4	333	0.9880	0.0060	0.9763	0.9997	0.7759	0.6041	0.9935
Program	32	15	772	0.9806	0.0050	0.9708	0.9903	0.6623	0.5371	0.8150
All Sites	50	19	1,105	0.9828	0.0039	0.9751	0.9905	0.6947	0.5894	0.8178

*Program sites:* Dyer, Broadfoot South, Broadfoot South Non-access, Newark West, Newark East, Cottonwood Ranch OCSW, & Leaman OCSW.

Non-Program sites: Lexington, Blue Hole, Johnson, & Trust Wild Rose East Sandpit

**Appendix 16.** Daily and brooding-period survival rates for piping plover broods (1 or more chicks) monitored on Program and non-Program sites during 2017. Brooding-period brood survival rate =  $(\text{daily brood survival rate})^{28}$ .

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival	Daily Brood Survival	Daily Brood Survival Rate 95% CI		Brooding Period Survival	Survival Rate 95%	
		1050		Rate	SE	Lower	Upper	Rate	Lower	Upper
Non-Program	13	1	243	0.9959	0.0041	0.9878	1.0039	0.9170	0.7734	1.0859
Program	17	8	326	0.9755	0.0086	0.9587	0.9923	0.5935	0.4121	0.8494
All Sites	30	9	569	0.9842	0.0052	0.9739	0.9944	0.7155	0.5742	0.8894

*Program sites:* Dyer, Broadfoot South, Newark West, Newark East, Cottonwood Ranch OCSW, & Leaman OCSW. *Non-Program sites:* Lexington, Blue Hole, & Trust Wild Rose East Sandpit