PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Monitoring the Abundance, Distribution, Reproductive Success, and Reproductive Habitat Parameters of Least Terns and Piping Plovers on the Central Platte River

I. INTRODUCTION

The States of Colorado, Nebraska, and Wyoming and the United States Department of the Interior (DOI) agreed to participate in the Platte River Recovery Implementation Program (Program), a basin-wide cooperative species-recovery program relating to four target species: interior least tern (*Sternula antillarum*), piping plover (*Charadrius melodus*), whooping crane (*Grus americana*), and pallid sturgeon (*Scaphirhynchus albus)* and their associated habitats in the central Platte River, Nebraska. One of the primary purposes of the Program is to secure "defined benefits for the target species and their associated habitats to assist in their conservation and recovery through a basin-wide cooperative approach agreed to by the three states and DOI (Final Program Document, 2006). The Program was initiated on January 1, 2007.

Program implementation will follow a process of adaptive management to address areas of scientific uncertainty. Targeted monitoring is an integral part of the adaptive management process. The adaptive management approach will allow for efficient modification of management actions in response to new and changing science learning and environmental conditions. The Program will monitor and document, relative to the habitat and species conditions that existed as of the effective date of the Program, habitat and species response to Program actions. The Program's Executive Director Office (ED Office or Program staff) and Technical Advisory Committee (TAC) will review monitoring results and make recommendations to the Program's Governance Committee (GC) regarding the effects of Program actions on the target species. The GC, using ED Office and TAC input, will evaluate projects and the overall Program to determine what, if any, changes are needed in management.

This monitoring protocol will be used to gather information on least tern and piping plover abundance, distribution, reproductive success, and reproductive habitat parameters in the study area. It is understood that regardless of survey method not all terns and plovers are certain of being detected and therefore full implementation of this or any other protocol will not represent complete use of the central Platte River valley. Information from this protocol will be used to help evaluate the biological response of terns and plovers and habitat to the land and water management activities of the Program.

II. PURPOSE

This document describes the design and survey methods for locating tern and plover nests and monitoring the reproductive success and reproductive habitat parameters at least tern and piping plover colonies in the central Platte River valley, Nebraska. The monitoring is designed to detect and relate trends in reproductive success to habitat conditions on the central Platte River during the time the protocol is implemented.

This information is designed for use in the annual and long-term planning for implementation of the Program's Adaptive Management Plan (AMP). Several priority hypotheses identified in the

AMP are directly linked to terns and plovers, and improving tern and plover productivity on the central Platte is one of the primary management objectives identified in the AMP. Data collected through this monitoring protocol will be utilized to determine effects and relationships that relate back to these priority hypotheses, the two management strategies identified in the AMP, and overall AMP implementation.

This protocol will also be used by Nebraska Public Power District (NPPD) and Central Nebraska Public Power and Irrigation District (Central), collectively "the Districts", as part of their compliance with Federal Energy Regulatory Commission (FERC) licensing.

III. DESIGN CONSIDERATIONS AND SPECIFICATIONS

III.A. Area of Interest

The area of interest for monitoring the reproductive success and reproductive habitat of least terns and piping plovers consists of the Platte River beginning at the junction of U.S. Highway 283 and Interstate 80 near Lexington, Nebraska, and extending eastward to Chapman, Nebraska. This includes approximately 90 miles of the Platte River and sandpits within 3.5 miles of the main channel or two miles of a side channel if the side channel extends beyond 3.5 miles of the main channel.

III.B. Sampling Design

The design consists of two main components: 1) survey of the Platte River between Lexington and Chapman, Nebraska and 2) survey of historic, existing, and potential sandpit nesting sites between Lexington and Chapman, Nebraska. Each sandpit and constructed, managed, or naturally existing river island will be searched seven times per breeding season (1 and 15 May, June, and July and 1 August) for tern and plover adults, nests, broods, and fledglings. Nests and broods located during these searches will be monitored as described in the Methods Section of this protocol. Data collected will be used to make informed judgments regarding trends in least tern and plover reproductive parameters associated with Program effects on habitat. Data collected during river surveys and sandpit surveys will be evaluated separately to monitor trends in least tern and piping plover use of the Platte River and sandpit sites. Observations of terns and plovers collected during the 3 mid-month surveys (15 May, June, and July) at river-island and sandpit sites monitored during the first 3 years of the Program will be evaluated separately to allow us to monitor trends in reproductive effort and success at these historic sites.

Monitoring all sandpits and chemically or mechanically managed, constructed, and naturally occurring river islands will allow unbiased estimation of trends in reproductive parameters at these areas. Because every accessible sandpit and river island will be surveyed, we will have a census of colonies and a sample of nests initiated at each colony. The nest is the sample unit for calculation of reproductive parameters and inference will be made to river islands and sandpits with areas of bare sand greater than one acre that we have access to. Only areas that were monitored before Program initiation will be used in analytical comparisons of data collected before and after Program implementation. Areas that were not monitored before Program initiation will not be used in the before-after analysis, but will be included in trend analyses.

Using similar methods to locate and monitor nests during surveys of sandpits and river islands will facilitate detection of trends in reproductive rates during the Program's First Increment.

III.B.1. River Surveys

Airboat surveys will be conducted on the entire 90-mile study area. Every channel with an active width (bare sand and/or water) greater than 250ft will be surveyed. The boat will be directed through the channels so observers can view all sand areas, making the total survey time dependent on the amount of sand present (i.e., more sand visible at low flows will require longer survey periods).

The entire river will be surveyed seven times per breeding season (1 and 15 May, June, and July and 1 August). Date frameworks are provided as guidelines to determine when to survey (survey date ±5 days), but the exact timing of the surveys will depend on flow and safety conditions. Before each survey, an aerial survey of habitat conditions will be conducted over the study area to determine the availability of bare sand, if its presence is in doubt. If there is no bare sand visible during the airboat survey framework, an airboat survey will not be conducted and will be recorded as survey=0 (number of nests unknown). If any bare sand is visible, regardless of size or condition, the airboat survey will be conducted when it is determined that flows have been at or below flight-day flows for three consecutive days.

III.B.2. Sandpit Surveys

All sandpits that have areas of bare sand (<20% vegetative cover) greater than one acre, and for which access can be gained, will be surveyed seven times for active tern and plover colonies each breeding season (1 and 15 May, June, and July and 1 August). All sandpit sites located and monitored before Program initiation will be surveyed under this component.

III.C. Timing

Surveys of river islands and sandpits to document adult, nest, chick, and fledgling presence will be conducted seven times annually (1 and 15 May, June, and July and 1 August). Least tern or piping plover nests or chicks observed during any survey will be monitored twice/week to evaluate their status. Information to be collected during each site visit is described in the Methods Section.

IV. METHODS

IV.A. Biological, Reproductive, and Habitat Definitions

Nest – Eggs in a bowl that are or were incubated by an adult. Excludes randomly deposited, non-incubated, individual eggs.

Nest Bowl – Nest cup (depression) including a 3-inch buffer area around the cup.

Nesting colony – Area encompassed by multiple nests within which disturbance to one nest results in a disturbance reaction by adults of other nests. In cases where only a single nest is present, the nest will serve as the "colony" for habitat measurements.

Colony Centroid – Average Northing and Easting GPS measure for all nests within a single colony.

Site – A group of river islands within close proximity of each other and managed as a group or sandpit island habitat surrounded by common water.

Nest Initiation – Nest is initiated when it is constructed and at least one egg is laid.

Nest Management – Management activities applied specifically to nests (i.e., exclosure).

Site Management – Management activities applied to the colony site (i.e. predator fencing, predator trapping, herbicide application, disking, mowing, etc.).

Nest Success – Nest is successful when at least one egg hatches.

Brood – 1 or more chicks hatched from a single nest.

Fledge – Least tern or piping plover chick has fledged when at least one of the 3 occur: 1) it is covered in unsheathed feathers, has a black eye stripe (least terns only), and has a short tail; 2) when sustained flight is observed; or 3) is at least 21 (least tern) or 28 (piping plover) days old. We will also record the number of chicks that survive to 15 days of age to allow comparisons to past data.

Total Nests Initiated – Total number of nests initiated whether successful or not. This total includes first nesting attempts as well as re-nesting attempts.

Apparent Nest-based Hatching Success – Number of eggs that hatched successfully divided by total number of eggs.

Apparent Nest Success – Total number of successful nests divided by total number of nests initiated (i.e., if there were 125 nests initiated and 100 nests were successful, nest success is 0.80 or 80%).

Apparent Nest-based Fledging Success – Number of fledged birds per initiated nest (i.e., if 60 chicks were fledged from 50 nests, the fledging success would be 1.2 fledged birds per nest).

Number of Pairs – Number of pairs will be estimated one of two ways: 1) the maximum number of nests and number of broods detected during any one survey; or 2) half of the maximum number of adults counted during any one survey. Data collection will allow the estimation of the number of pairs using either method.

Apparent Pair-based Fledgling Success – Number of fledged birds per bird pair (i.e., if 60 chicks were fledged from 50 pairs, the fledging success would be 1.2 fledged birds per pair).

Nest Furniture – Any non-living object present within the diameter of the nest bowl such as driftwood, large cobble, boulder, bivalve, bone, etc.

Nest Elevation – Difference between the elevation of each nest and nearest water surface obtained via survey-grade GPS unit placed at the nest and waterline when first observed (record UTM coordinates and elevation). We will also conduct a Real Time Kinematic (RTK) Survey during the fall to improve the accuracy of our elevation measures.

Sandbar or Island Height – Elevation of the sandbar or island recorded from 3 evenly-spaced transects directed perpendicular to the flow of the water and centered on the centroid of the river colony. An RTK survey will be conducted after all terns and plovers leave the colony.

Vegetative Cover – Percent canopy cover within a 1-yd^2 area around the nest.

Vegetation Height – Maximum height of all vegetation within a 1-yd^2 area around the nest.

Bare Sand Area – % of the total area with <20% vegetative cover at each site.

Nearest Water – Distance from each nest to the nearest water line measured with a survey-grade GPS unit.

Nearest Bank (riverine) – Distance, across water at flows of 1,200cfs, from each nest to the nearest bank measured via laser rangefinder or off-site using a GIS.

Distance to Predator Perch – Distance to nearest predator perch ≥ 10 feet tall (i.e., tree, power-line pole, etc.) measured via laser rangefinder or off-site using a GIS.

Distance to Live Vegetation – Measured distance in inches from the center of a nest to living or current year vegetation within a 1-yd^2 area of the nest.

Pond Size (sandpits) – Size of pond adjacent to the colony's nesting substrate. This parameter can be measured using aerial photographs or GIS.

Wetted Channel Widths (riverine) – Wetted width of the channel on each side of the nesting area measured with a survey grade GPS unit or laser-range finder.

Channel Width (riverine) – Width of entire open-channel at flows of 1,200cfs, including sandbars, measured at the colony site. This measurement will be derived from a GIS.

Distance from Colony to River – Distance between centroid of the colony and closest active river channel. An active river channel is defined as channel carrying water when the entire river has a minimum flow of 1,200cfs. This parameter can be measured using aerial photographs, a GIS, LIDAR data, or the Program's hydraulic models.

IV.B. Field Techniques

Standard field methods will be used during each visit to a nesting area and information such as: date; time of day (arrival and departure); weather conditions; number of adults, nests, chicks, and fledglings present; and other species of wildlife present in area will be recorded. Attempts will be made to conduct independent, double-observer counts each time a site is visited; independent counts will allow us to address issues related to observer bias and biases associated with field techniques used. If we enter a site to collect data and observe additional adults, nests, chicks, or fledglings, we will update our counts on a new form that includes all documented observations during the site visit. Final counts reported will represent the maximum number of adults, nests, chicks, and fledglings counted by either observer during each site visit. Incidental observations (not including sandpit or river surveys conducted on the 1st or 15th of each month) of nests or broods obtained while traveling to or from a specific site to monitor nests or broods will be documented on the data sheets. Incidental observations of nests not observed to be 'active' during the subsequent scheduled 1st- or 15th-of the month survey, will not be included in survival estimates reported in Annual Reports; however, all incidental observations of nests will be reported in the total counts of nests observed. Visits within each colony will be conducted no more than twice during a seven-day period (unless further restricted by the Program's State or Federal permit); activity within the colony areas will be limited to less than 20 minutes in duration. All within-site nest visits will be conducted when the temperature is less than 90°F (32°C) to reduce stress and mortality to eggs and chicks. If predatory animals (e.g., hawks, raccoons) are visible or fresh sign of predatory animals is observed (e.g., fresh tracks) nests will not be approached.

IV.B.1. Nest location

River Surveys

River surveys to count adults, nests, chicks, and fledglings will be conducted seven times (1 and 15 May, June, and July and 1 August) during each breeding season on the central Platte River between Lexington and Chapman, Nebraska. An airboat will be used to access river habitat within each bridge segment. The operator of the boat and a minimum of one observer will survey active channels greater than 250 feet wide. The airboat will be operated such that observations of all bare sand areas can be made. Names of observers, time spent conducting the survey, date, weather, start location and time, and end location and time will be recorded on datasheets. GPS units will be used to accurately record the channels surveyed.

If an adult piping plover(s) or least tern(s) is observed, the boat will be driven upstream of the location and the motor will be turned off. During double-observer counts, the observer who spotted the bird will not inform the other observer until the boat has past the location where the bird was observed; if all observers spot the bird, they will still drive by the location and the datasheets will be marked accordingly. As the boat drifts by the location where the bird was observed, both observers will independently attempt to locate any nesting or brood-rearing birds. After surveying the location where the bird was located, observers will compare datasheets and enter the final (maximum) count of adults, nests, chicks, and fledglings on a separate form. This method will enable us to locate nests and chicks without entering sites before permission is granted and to test for bias in observer counts. If a nest or brood is located, or if observers cannot confirm the absence of both, observers will enter the site to determine if a nest or brood is

present and collect data; if on privately owned land, a GPS point will be collected near the site and the point will be mapped on an aerial photograph or 7.5-minute quadrangle map and a hand-drawn map. The hand drawn map will include vegetative cover, distinguishing features of the area, estimated channel widths, and approximate topography. Subsequent site visits will use the UTM coordinates to navigate to the general location within the river and site maps or photos will be used to locate specific sites. After the site is searched for the presence of nest(s) or chick(s), the survey will begin again from where the bird was first observed. If least tern or piping plover nests or broods are observed on private property, the landowner will be contacted immediately after completing the survey in an attempt to gain access to the property to monitor the nest or brood as soon as possible. If landowner permission is not obtained and monitoring cannot occur from a distance, the nest(s) or chick(s) will be excluded from estimates of success; however, they will be included in counts of total nests and chicks observed. The surveyors will attempt to only count each bird once.

Sandpit Surveys

Similar to river surveys, semimonthly surveys for tern and plover adults, nests, chicks, and fledglings at sandpits will be conducted seven times during each breeding season (1 and 15 May, June, and July and 1 August). Independent double-observer counts will be made using binoculars and/or spotting scopes at a distance great enough to not cause disturbance of nesting birds (usually > 165 ft, but closer or farther as terrain dictates) and for at least 1/2 hour. Observations will be done from multiple locations to provide complete coverage of the site. Following the survey, observers will compare counts and will enter final counts on a separate data sheet; final counts will be recorded as the maximum number of adults, nests, chicks, and fledglings observed by either observer.

Once nests are located, they will be mapped on aerial photographs and data will be collected according to methods outlined in the Nest and Brood Monitoring Section of this protocol. Nests may be marked with visible markers to allow subsequent observers to know within-site data had been collected at the nest; relocations of unmarked nests for monitoring purposes will be based on hand-drawn maps, written descriptions, and GPS coordinates collected during the initial observation. Subsequent monitoring for hatching success and fledging success is described in the Nest and Brood Monitoring Section of this protocol. The UTM coordinates of each colony location will be estimated using GPS locations of nests.

If a sandpit has active nests that are being monitored every three days, it will not be necessary to do additional semimonthly surveys of the site; data obtained on the visit to the colony nearest the semimonthly-survey date will be used. The surveyor will mark the nearest survey date on the datasheet and record the number of adults, active nests, chicks, and fledglings observed at the site. Data obtained at river-island and sandpit sites during semimonthly surveys will be combined to provide a census of the number tern and plover adults, nests, chicks, and fledglings present at these sites.

IV.B.2. Nest and Brood Monitoring

Monitoring active nests will begin immediately after the first nests are initiated and will be conducted for all nests located on chemically or mechanically managed, constructed, or naturally occurring river islands and sandpit sites. The observers will spend a minimum of 1/2 hour at each colony location and will scan the area using binoculars and/or a spotting scope at least five times. During each scan, each observer will record: the number of adults, nests, chicks, and fledglings present; estimated time until fledging for each chick; and any other pertinent information for each site on data sheets (attached). Independent, double-observer counts will be recorded during all visual scans to allow us to determine and address issues related to imperfect detection rates, observer bias, and biases related to survey techniques. Following visual scans and prior to entering colony sites, observers will compare counts and will enter final counts on a separate data sheet; final counts will be recorded as the maximum number of adults, nests, chicks, and fledglings observed by both observers. If observers enter a site and observe additional (or fewer) adults, nests, chicks, or fledglings, they will note the discrepancies on the final data form that includes all documented observations during the site visit.

When permission is obtained to enter a nest or colony location, the nest will be approached to collect a GPS location, mark the nest (if so desired), record habitat measurements, count eggs in the nest bowl, and float an egg (see Appendix for guidelines) during the initial visit and will only be re-visited to determine cause of loss (predation, weather, other). The number of eggs in each nest determined to be incomplete during the initial visit (<3 eggs) will be counted during subsequent visits using binoculars or a spotting scope from a distance and will be confirmed if the colony is entered to investigate predation or to GPS another nest. Numbered nest markers (e.g., tongue depressor, paint stir-stick, or similar object), when used, will be place 10 feet north of the nest at a height of 6 inches or less to allow observers to easily locate and identify nests during subsequent visits. A site-specific numbering system such as LT-01, LT-02, PP-01, PP-02, etc. will be used on nest markers to identify the first and second least tern and piping plover nest observed at each site, respectively. To confirm nest status, active nests will be viewed twice a week from a distance great enough not to disturb the birds. Monitoring will continue until the nest becomes inactive either through nest success or nest failure. Colonies will not be entered more than twice in a seven-day period unless further restricted by the Program's State or Federal permit.

When a nest is no longer active (as observed by using binoculars or spotting scope from a distance), the observer will determine if the nest hatched, was abandoned, or was depredated. If the observer suspects nest failure, he/she will enter the colony to check the nest for evidence of the outcome. Indications that the nest was abandoned include no disturbance to the nest, eggs intact in the nest, and intact eggs not at incubation temperature. Evidence that the nest was depredated includes broken eggs, disturbed nest site, and predator tracks. All evidence (type of tracks, condition of egg fragments, scat, and any other sign) relating to potential nest predators will be recorded on data sheets. If the nest was successful, there may be small eggshell fragments in the bottom of the nest but the adult will have removed the larger pieces from the nest. Another indication that the nest was successful is that there will be a chick(s) in the area

with the adults and fecal material in the immediate vicinity of the nest. The outcome of each nest, including an estimate of the number of hatched eggs, will be documented on data sheets. Fledging status of least terns and piping plovers will be determined by observation of the natal area from a distance great enough to minimize disturbance to adults or chicks (usually > 165 ft). An estimate of the number of successfully fledged chicks will be based on age and date chicks were last observed or directly counted if chicks are observed flying from natal areas. Each site will be monitored twice a week until chicks are no longer observed at the natal area.

IV.B.3. Habitat Measurements

For each nest in the study area, 10 on-site habitat parameters will be measured at the time each nest is located: 1) the distance between the nest and the nearest water, including the type of water, 2) the elevation of the nest above the water level, 3) nest specific management activities, 4) bare sand area at the colony site, 5) distance to nearest predator perch ≥ 10 feet tall, 6) wetted channel widths on each side of the nesting area (riverine), 7) percent canopy cover within a 1-yd^2 area centered on the nest, 8) height of living vegetation within a 1-yd^2 area centered on the nest, 9) distance to nearest living vegetation > 6 inches tall and within a 1-yd^2 area centered on the nest, and 10) presence of nest furniture within the nest bowl (nest cup plus a 3-inch buffer area around the cup). We will estimate the percent canopy cover and maximum height of living vegetation within a 1-yd^2 area centered on each nest and percent bare sand area at the nesting site from a distance during subsequent site visits. Additional off-site information will be collected for each colony or nest including: 1) site management, 2) nearest bank (at 1,200cfs), 3) channel width (riverine) or pond size (sandpit), and 4) distance to active river channel (from the centroid of nests in each colony).

IV.C. Analysis Methods

Estimates of reproductive parameters will be summarized separately, as well as combined, for the river and sandpit surveys. In both cases, the nest will be the sample unit for the calculation of reproductive parameters by colony, river segment, habitat type (river island or sandpit), or all Program associated habitats. Associations between reproductive parameters and habitat variables will use the nest or the colony as the experimental unit depending on the habitat variable. Inference for these analyses will be to the sandpits within the study area or colonies on the Platte River within the study area. For the trend analysis of data collected at sandpits and historic river islands, the experimental unit will be the colonies because the location of the sites will be the same every year. For the trend analysis on the river, the experimental unit will be the river segment because colonies will not be in the same location of the river every year.

Apparent Hatching Success

The total number of eggs present and hatched at each site will be calculated. We will calculate apparent hatching success for naturally occurring river islands, chemically or mechanically managed or constructed river islands, and sandpit sites separately and combined. Apparent hatching success will be calculated two ways: nest-based estimates will be calculated as the total number of hatched eggs divided by the total number of nests initiated; egg-based estimates will be calculated as the total number of hatched eggs divided by the total number of eggs observed.

Apparent Nest Success

The total number of initiated nests and successful nests will be summed for each colony. We will calculate apparent nest success for naturally occurring river islands, mechanically managed or constructed river islands, and sandpit sites separately and combined. The estimate of nest success will be calculated as the total number of successful nests divided by the total number of nests initiated.

Apparent Fledging Success

The total number of fledglings will be calculated for each site. We will calculate apparent fledging success for naturally occurring river islands, chemically or mechanically managed or constructed river islands, and sandpit sites separately and combined. Estimates of fledging success will be calculated three ways: nest-based fledgling success will be calculated as the total number of fledglings divided by the total number of nests initiated; hatch-based fledging success will be calculated as the total number of fledglings divided by the total number of successful nests; chick-based fledgling success will be calculated as the total number of fledglings divided by the total number of chicks that successfully hatched. We will also determine fledging success when chicks are 15 days of age (original fledging age) to allow us to monitor long-term trends in fledging rates

Incubation-period Survival

The incubation period for interior least tern and piping plover nests will be considered to be 21 and 28 days, respectively. Nests that hatch ≥1 chick will be considered successful. When the fate of a nest is unknown, we will assign a failed status to the nest if the date of determination is <21 days (interior least tern) or <28 days (piping plover) since initiation. For example, if a site with no nests present is surveyed on 8 May; surveyed again on 15 May when a piping plover nest is first observed; is monitored again on 18 and 21 May and we find the nest to be active and intact; but on 24 May we observed no eggs in or adults on the nest, a "failed" status will be assigned to the nest as the nest likely did not hatch. If, however, this nest, with an unknown fate, is known to be active on 10 June (26 days after initial observation) and is observed on 14 June (30 days after initial observation), the nest will be censored at 26 days and assigned a "success" status. Our assumption is that, on average, successful and failed nests will be discarded in the same proportion that they existed in the data.

Logistic Exposure models developed in Program R, or a similar program, will be used to estimate daily and incubation-period survival rates for least tern and piping plover nests. Data will be grouped by habitat type (sandpit, naturally occurring river island, and chemically or mechanically managed or constructed river island) and a null model and 'habitat' or group model will be analyzed to determine: 1) overall survival rate for all nests (estimated from null model); 2) if survival rates differ between habitat type (based on AICc); and 3) habitat-specific survival rates (estimated from 'habitat' model if AICc rank is higher than null model). Estimates of incubation-period survival rates will be determined by raising daily-survival rates to the 21^{st} or 28^{th} power for least terns and piping plovers, respectively (Mayfield, 1961). We will also develop models to determine if factors such as initiation date, exposure days, habitat type (sandpit, naturally occurring river island, and mechanically managed or constructed river island),

vegetative cover, nest elevation above the waterline, distance to water, and distance to bank influence nest survival. We will also compute Mayfield estimates of daily and incubation survival rates to allow us to observe trends in survival over time.

Brooding-period Survival

The brood-rearing period for least terns and piping plovers will be considered to be 21 and 28 days, respectively. Any brood with at least 1 chick that fledges will be considered successful. Similar to nests, when the fate of a brood is unknown, we will assign a failed status to least tern broods if the date of determination is <21 days post-hatch and will censor the data to the last known date the brood was active if the date of determination is ≥21 days. Estimates of daily survival will be determined using methods outlined in the Incubation-period Survival Section. Estimates of brooding-period survival rates will be determined by raising daily-survival rates to the 21^{st} (least tern) or 28^{th} (piping plover) power (Mayfield, 1961). Additional models will be developed to determine the influence of factors such as hatching date, exposure days, and habitat type (sandpit, naturally occurring river island, and mechanically managed or constructed river island) on brood survival. As not all adults and chicks will be marked, we will not be able to estimate nest-specific survival rates from initiation through fledging; however, when possible we will.

Associations with Reproductive Parameters

Physical habitat measurements made at the colony level can be used in regression equations to predict reproductive parameters (hatching success, nesting success, fledgling success). One scale of this analysis will be a regression of the habitat covariates measured on each site to the mean parameters calculated by site. The sample unit for this analysis will be the site (sandpit, naturally occurring river island, and chemically or mechanically managed or constructed river island). Possible covariates include the size of the site (bare-sand area), elevation, and the distance to the water. This analysis will be conducted within and across years using site averages.

A second scale of analysis would be to use regression to relate habitat covariates measured at a nest to the reproductive response parameters for the corresponding nest. The sample unit for this analysis would be the nest. We can estimate the association of changes in habitat variables with changes in response variables. These regressions will include a site indicator variable to detect site influences on the reproductive parameters. The number of chicks hatched from a nest can be related to habitat using normal linear regression, while success of a nest (yes or no) can be related to habitat using logistic regression. Analysis will be conducted within and across years.

Trend Detection

Using both the historic data from monitored colony sites and data collected under this protocol, the slope of the least squares regression line against time will be estimated for each colony. The average and standard error of the slope statistic across colonies will provide an estimate and confidence interval of average trend.

Note that without a reference area there will be a tendency for the effects of the increased flows and habitat management to be confounded with trends in the reproductive parameters due to

other factors not measured. For example, the reproductive success may increase immediately after Program initiation because the weather was more conducive to the birds successfully fledging young for those years. With data collected over time, the effects of other factors will diminish and the inferences regarding the effects of the Program will get stronger.

Before-After Analyses

Data from sites (colonies) that were monitored before Program initiation can be compared to data collected under this protocol in the same areas and timeframes. Because the Program influences all colonies in the study area, cause and effect relationships cannot be established by this analysis. Reproductive parameters will be calculated without adjustments for comparison with pre-Program survey data.

Before-after analyses will be conducted by averaging the values of the reproductive parameters before and after Program implementation for each sandpit. The slope between these two numbers will be calculated and the average slope (over sandpits) will be an estimate of the before to after change in the parameter. Inferences are to the sandpits involved in this analysis.

Nest Habitat Characteristics

Habitat measurements made at the nests will be summarized using means across nests and normal based confidence intervals (Zar 1984). Colony level habitat measurements will also be summarized using means across colonies and normal based confidence intervals (Zar 1984).

V. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

QA/QC measures will be implemented at all stages of the study, including field data collection, data entry, data analysis, and report preparation. Observers will be trained in the methods used and tested on their ability to locate and identify nests. At the end of each survey day, each observer will be responsible for inspecting his or her data forms for completeness, accuracy, and legibility. The study team leader will review data forms to insure completeness and legibility, and any problems detected will be corrected. Any changes made to the data forms will be initialized by the person making the change.

Data will be entered into electronic files at a centralized database by qualified technicians. These files will be compared to the raw data forms and any errors detected will be corrected. Any irregular codes or any unclear or ambiguous data will be discussed with the observer and study team leader. All changes made to the raw data must be documented for future reference.

After the data have been keyed and verified, the study team leader or QA/QC technician will check a five percent sample of data forms against the final computer file. Any problems identified in later stages of analysis will be traced back to the raw data forms, and appropriate changes in all steps will be made.

VI. DATA COMPILATION AND STORAGE

A centralized database will be established to store, retrieve and organize field observations. Data from field forms will be keyed into electronic data files using a pre-defined format that will make

subsequent data analysis straightforward. All field data forms, field notebooks, and electronic data files will be retained for ready reference.

VII. REPORT FORMAT

A draft and final annual report will be produced each year describing the methods employed; observations obtained during mid-month river surveys, mid-month sandpit-island surveys, and all semi-monthly surveys; any conclusions that can be drawn from monitoring efforts; and any findings obtained through research specific to least terns and piping plovers. The report will have both written and graphical components. Graphs will show trends from year to year in such things as number of nests initiated, nesting success, and fledging success. The report will also contain maps showing areas searched for nests and areas that contained nests.

VIII. ADMINISTRATION

The Program will be responsible for protocol implementation and permit acquisition.

IX. DATA SHEET

(Excel spreadsheet attached)

X. BIBLIOGRAPHY

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Appendix: Information copied from the 2009, U.S. Army Corps of Engineers: Least Tern and Piping Plover Monitoring Handbook.

Appendix F— Egg Floating Guide

Determining the egg incubation stage provides valuable data both short term and long term for least tern and piping plover recovery. In the short term, knowing the egg incubation stage provides a probable nest hatch date. For example, a piping plover nest is found and the incubation stage of the eggs is determined to be eighteen days. Knowing that it takes around 28 days for a plover egg to hatch, it can be calculated that in about ten days the eggs will be close to hatching. The egg incubation stage, when combined with the clutch size, can be used to calculate a nest initiation date (the date the female laid the first egg of the clutch). This data is important in determining long-term nesting trends.

When to Float an Egg

Upon nest discovery, one egg from the clutch should be floated to determine incubation stage. There is one exception to this rule - an egg will not be floated if any of the eggs in the clutch are pipping. A pipping egg is an egg that is close to hatching. The chick is attempting to break through the egg shell and the outside of the shell will have a distinctive fracture pattern. This pattern can best be described as a series of fracture lines radiating out from the point of impact. Do not touch a pipping egg as the egg shell has fractured and could easily break if handled. If a pipping egg is picked up and immersed in water, there is a possibility the chick could drown from water getting into the egg. It is not necessary to determine incubation stage for a pipping egg because it is hatching. If a clutch does not contain a pipping egg, an egg will be floated.

Pipping Egg—Fracture Pattern in Red Circle

How to Float an Egg

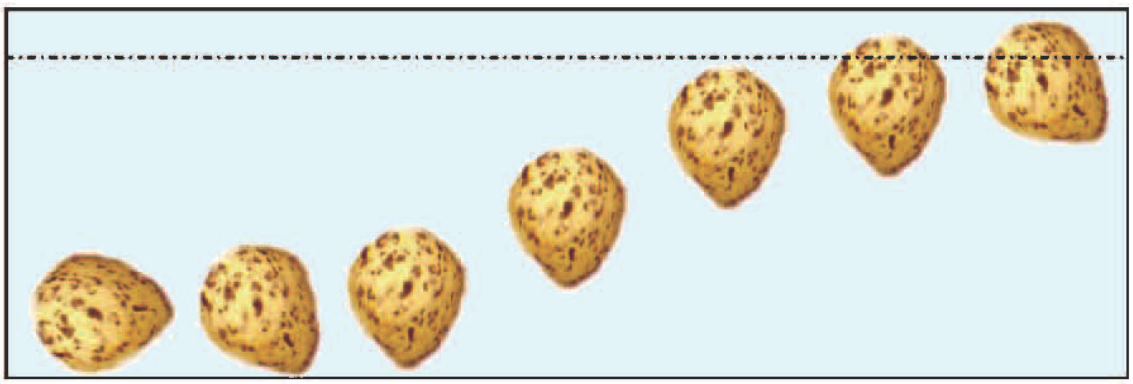
Prior to handling an egg, hands must be washed with no scent soap to ensure human scent is not left on the egg. This is done to protect the clutch from predators. Predators such as raccoons and mink have a powerfully developed sense of smell, and human scent, imparted by touching the egg, could lead predators to the nest. The preferred method is to use a no-scent towelette that can be carried during the survey and used to wipe hands prior to egg handling. A second method is to wash hands with no-scent soap where water is available. A problem with this method is that if something with human scent is touched during the survey hand washing will need to occur again prior to egg handling. This could be time consuming if a water source is not nearby.

As mentioned in the equipment section, the float cup should be made of transparent plastic; a glass cup is never to be used. The cup should be filled three-quarters full with water taken from the river or reservoir. It is a good idea to let the water warm up for a few minutes after the cup is filled as the water taken from the river or reservoir can be quite cold. The cup of water should be good for all the nests on the site; it does not have to be refilled for each new egg.

Picking up Egg

Egg floating in Plastic Cup

Select an egg that is free of fecal or any other foreign material. When transferring the egg to the cup, have the cup a short distance above and to the side of the nest. If the egg is accidentally dropped the distance to the ground will be minimized and increase the chance the egg may survive the drop. Place the egg at the bottom of the cup and let it float. **Do not drop the egg into the cup.** Dropping the egg into the water increases the chance that the egg could be damaged. After the egg stabilizes, compare its position to that of the egg float chart (see below). Determine the incubation stage by looking at the number below the position selected on the float chart. After the incubation stage has been determined, gently remove the egg from the cup and place it back in its original position in the nest. It is not necessary to dry the egg before returning it to the nest. Do not ever shake the egg to remove excess water.



Plover	1	5	9	12	17	23	28
Tern	1	4	7	10	13	15	19

564

Generally, only **one** egg is floated from a nest. There are circumstances however where it may be necessary to float more than one egg.

If the egg selected for floating floats to the top of the water with the pointed end up rather then down, this indicates an addled egg (an egg where the embryo has died). This egg should be placed back in the nest and another egg should be floated. If this occurs mark one in the un-hatched egg category of the nest record and include this in the nest comment.

The maximum clutch size for least terns is usually three eggs and for piping plovers, four eggs. If a tern nest is found with four eggs or a plover nest with five or more eggs, the additional egg or eggs may have been laid by a different bird and could have a different incubation stage from the rest of the clutch. In the case of oversized clutches at least two eggs and possibly three should be floated. If, after floating two eggs, the eggs have the same incubation stage; record that as the incubation stage for the clutch. If the two eggs have different incubation stages, float a third egg and if its incubation stage agrees with one of the two previous eggs, record that as the incubation stage for the clutch.

Four Egg Tern Nest

After the incubation stage has been determined it is not necessary to re-float an egg on subsequent nest visits. Nor is it necessary to enter the incubation stage on subsequent visits as that is automatically calculated through the TPDMS. The TPDMS will also calculate the nest initiation date and the probable hatch date.

Five Egg Plover Nest