FINAL WORK PLAN: Evaluation of the Impacts of Avian Predation on Salmonid Smolts from the Columbia and Snake Rivers, 2016

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PROJECT SUMMARY

As part of this Task Order (TO), we will: (1) implement components of the Inland Avian Predation Management Plan (IAPMP; USACE 2014), including adaptive management actions, in order to dissuade Caspian terns (*Hydroprogne caspia*) from nesting on Goose and Crescent islands; (2) monitor the efficacy of those management components and actions at both the colony- and system-level; (3) measure the inter-colony movements and dispersal of previously color-banded Caspian terns in the context of implemented management actions; (4) model the change in predation rates on juvenile salmonids (*Oncorhynchus* spp.) by Caspian terns in the Columbia Plateau region (*Figure 1*) concomitant with management actions implemented as part of the IAPMP; and (5) support the monitoring efforts at Don Edwards National Wildlife Refuge (NWR) by taking a single set of high-resolution aerial photography of the Corps-constructed tern islands in the Refuge that will be used to estimate Caspian tern colony size (number of breeding pairs) and area used (m^2) by nesting terns.

Figure 1: Study area in the Columbia Plateau region.

To address *Work Element 1* we will (a) dissuade all Caspian terns from nesting on Goose Island in Potholes Reservoir by using passive measures (i.e., stakes, rope, flagging, and owl decoys), and dissuade all terns from nesting on Crescent Island in McNary Reservoir by using a combination of silt fences, stakes, rope, flagging, woody debris, and willow plantings (passive dissuasion will be installed on both islands prior to the initiation of nesting activities by Caspian terns, ring-billed gulls [*Larus delawarensis*], and California gulls [*L. californicus*); (b) use active hazing (i.e., targeted use of human disturbance on land and from skiffs, green lasers, peregrine falcon kites) as an adaptive management technique to prevent Caspian terns, and other birds from nesting at Goose and Crescent islands, as necessary; (c)

collect any Caspian tern eggs laid on Goose Island or Crescent Island, under permit (i.e., egg take permits issued by the U.S. Fish and Wildlife Service [USFWS] under the Migratory Bird Treaty Act) and in accordance with Best Management Practices (BMPs; see *Appendix A*) developed by Oregon State University/Real Time Research and approved by the Corps and Reclamation; and (d) evaluate the effectiveness of willow plantings and Russian olive management on Crescent Island as a nesting deterrent for Caspian terns.

Action effectiveness monitoring (*Work Element 2*) will include both colony-level monitoring and system-level monitoring. Colony-level monitoring will be conducted in support of the IAPMP at both Goose Island and Crescent Island. Monitoring at both islands will be conducted daily by resident field crews throughout the breeding season (i.e., late February to late July) in conjunction with management tasks described above. Data collection at each island will be conducted according to established protocols (see Roby et al. 2014; Collis et al. 2015; BRNW 2015) and will include the following colony metrics: (a) temporal and spatial distribution of Caspian terns and gulls roosting or nesting on each island; (b) daily activities (behavior) of Caspian terns and gulls, including any nesting attempts by Caspian terns; (c) seasonal attendance (counts) of roosting and nesting Caspian terns and gulls; (d) types of habitat used by roosting and nesting Caspian terns and gulls; (e) the area (acreage) used by roosting and nesting Caspian terns and gulls; (f) formation of any incipient Caspian tern or gull colonies on or in the immediate vicinity of either island; (g) peak colony size (number of breeding pairs) for Caspian terns and gulls; (h) number of Caspian tern eggs laid and the disposition of those eggs; and (i) Caspian tern nesting success and nesting density, if applicable.

System-level monitoring will be conducted in support of both the IAPMP (USACE 2014) and the Caspian Tern Management Plan for the Columbia River Estuary (USFWS 2005, 2006). System-level monitoring of Caspian tern colonies will be carried out to determine the locations of all active or incipient Caspian tern breeding colonies in the Columbia Plateau region. At each Caspian tern colony that is larger than 30 breeding pairs, we will measure (a) seasonal colony attendance; (b) nesting chronology and behavior; (c) habitat types used for nesting; (d) nesting area occupied; (e) peak colony size (number of breeding pairs); and (f) number of nests initiated and young fledged (i.e., nesting success), if feasible (*Figure 2*). Monitoring will be by periodic aerial, ground-based, and/or boat-based surveys. High-resolution digital aerial photography will be taken at the peak of incubation at each colony to accurately measure the colony area by habitat type, the number of Caspian terns present, and the peak Caspian tern colony size. Additionally, we will remotely monitor water levels near the Blalock Islands complex in John Day Pool to determine how fluctuations in pool elevation affects the amount of Caspian tern nesting habitat available at that site. Finally, we will evaluate the feasibility of using Unmanned Aircraft Systems (UAS)

Figure 2: Monitoring of Caspian tern activity at the Blalock Islands in 2015.

as a reliable and cost-effective solution for aerial mapping projects (i.e., high-resolution photography for estimating colony size). Although we will continue to take high-resolution vertical imagery from a manned, traditional fixed-wing aircraft, we will also evaluate a multi-rotor UAS platform in 2016 as a proof-of-concept for implementing UAS in colony-level monitoring efforts. This feasibility study will be closely coordinated with all interested parties (i.e., the Corps, Reclamation, USFWS, and landowners) and, if approved, will be conducted at no cost to the Corps/Reclamation.

Work Element 3 will be addressed by systematically resighting previously color-banded Caspian terns during visits to the Goose Island, Crescent Island, and other nesting or roosting sites used by Caspian terns in the Columbia Plateau region during 2016. Using a comprehensive database containing banding and resighting records for Caspian terns dating back to 2005, we will assess (a) colony connectivity among sites in the Columbia Plateau region; (b) emigration rates of banded individuals from colony sites in the Columbia Plateau region to colony sites outside the region; and (c) immigration rates of banded individuals from colony sites outside the Columbia Plateau region to sites in the region. This information will help assess to what extent Caspian tern management actions implemented as part of the IAPMP (USACE 2014) and the Caspian Tern Management Plan for the Columbia River Estuary (USFWS 2005, 2006) are successful in relocating Caspian terns to sites outside the Columbia River basin.

The ultimate goal of the IAPMP is to reduce predation rates on juvenile salmonids by Caspian terns in the Columbia Plateau region to less than 2% of each Endangered Species Act (ESA)-listed salmonid population (hereafter ESU/DPS), per Caspian tern colony, per year (USACE 2014). As part of *Work Element 4*, we will estimate the number of Caspian terns residing at breeding colonies in the Columbia Plateau region during 2016. We will use this information and previously measured colony-specific per-capita predation rates to model predation rates by Caspian terns from each breeding colony where adequate historical data exists for managed (i.e. Goose and Crescent islands) and un-managed (i.e. Blalock and Twinning islands) tern colonies in the Columbia Plateau region during 2016. Per-capita predation rates will be estimated using smolt PIT tags recovered on Caspian tern colonies in the region during 2007-2015. This modeling approach will be used to evaluate to what extent the overriding management goal is being met, and where additional or modified management efforts might be implemented in future years to meet that goal.

Finally, to support on-the-ground efforts conducted by another contractor at the Corps-constructed tern islands at Don Edwards NWR in southern San Francisco Bay, we will coordinate and schedule an aerial photo census of the islands used by nesting Caspian terns (*Work Element 5*) so that an accurate measure of peak colony size and colony area can be estimated. Processed photography (i.e., a stitched mosaic of individual photos) will be provided to the COR and any other appointed POCs for analysis.

APPROACH & METHODOLOGY

Task 1. Project Planning, Technical Assistance, and In-season Reporting

As part of this task we will (1) carefully plan the work described herein prior to implementation; (2) provide technical assistance to the Corps by attending meetings and providing data upon request; and (3) create and disseminate regular (weekly and monthly) reports to (a) track project accomplishments, (b) notify resource managers of upcoming events in the project schedule, (c) identify unforeseen problems in implementation, and (d) allow for in-season adaptive management to maximize the probability of project success.

Task 1.1. – Develop Work Plan: This document is the Draft Work Plan. Following submittal of the Draft Work Plan, we will meet with the Corps and Reclamation staff for a pre-work coordination meeting, to include site visits to Goose and Crescent islands, to review the Draft Work Plan (26 February). We will coordinate the site visit and provide boat transportation to Goose and Crescent islands as part of this on-site, pre-season coordination meeting. Following regional review and NLT 30 days following receipt of comments, the Draft Work Plan will be revised and a Final Work Plan will be submitted to the Corps and Reclamation staff.

Task 1.2. – Provide technical assistance: We will provide technical assistance to the Corps and Reclamation staff in support of the implementation of the IAPMP. This support will include, but is not limited to: (1) providing requested project data and analysis specified in the PWS; (2) in-person attendance by senior staff at planning meetings and site visits; and (3) oral or written presentations of project information at designated meetings and workshops (see *Deliverables* section for a detailed description of the specific products and services provided to the Corps and Reclamation as part of this TO).

Task 1.3. – Provide weekly and monthly updates: During the field season (March to August 2016), weekly reports will be submitted to the COR and any other appointed POCs. In-season weekly reports will provide narrative outlining project accomplishments, upcoming schedule of events, unforeseen problems encountered, future assistance or services needed, and any other topics of discussion relative to the successful completion of the tasks listed in the PWS. In addition, weekly reports will include summary statistics in a tabular and/or graphical format providing an easy means to track important colony and project metrics throughout the 2016 breeding season. Because these weekly reports are for external distribution, we will revise each weekly report prior to its distribution, as directed by the COR. In all cases, project information and/or data will not be made available to the public without prior approval from the COR and POCs from the Corps and Reclamation.

We will submit monthly progress reports to the COR each month throughout the term of the TO (January 2016 to March 2017). Monthly progress reports will summarize monthly activities, project schedule, and other activities provided in weekly reports (e.g., colony and project metrics, problems encountered, and discussion topics). Monthly reports will also provide information to track progress toward project completion (i.e., percent completion of each task and sub-task by month and year-to-date).

Weekly and monthly progress reports will be delivered as attachments to emails sent to the COR and any other appointed POCs. Any issues identified by our team, the Corps, or Reclamation in these reports will be resolved during follow-up meetings or conference calls, as warranted.

Task 2. Passive nest dissuasion as part of the IAPMP

To deter Caspian terns from nesting on Goose Island and the surrounding islets in Potholes Reservoir (hereafter referred to as "Goose Island") and on Crescent Island in the mid-Columbia River during 2016, a network of passive nest dissuasion materials will be repaired, constructed, and maintained at both islands beginning before Caspian terns and gulls arrive at the colonies to breed (late February – early March) and lasting throughout the breeding season (late July). Following proven methods developed in the Columbia River estuary (BRNW 2013, BRNW 2014, BRNW 2015), and as previously described in the IAPMP (USACE 2014) and elsewhere (Roby et al. 2014; Collis et al. 2015), we will repair, erect, and maintain a matrix of vertical silt fences, stakes, polypropylene rope, and polyethylene flagging over historical Caspian tern nesting areas and other areas that are considered to be potentially suitable

nesting habitat for Caspian terns on both islands. Woody debris and owl effigies will also be used as additional passive nesting deterrents. The passive nest dissuasion materials and configurations will differ between islands and are described in detail below.

Task 2.1. – Repair, construct, and maintain passive nest dissuasion materials on Crescent Island: In 2015, a series of parallel fence rows spaced 15' apart were constructed across the former Caspian tern colony site and nearby sparsely vegetated areas, as well as in a second large, sparsely vegetated area in the southern part of the island. Additional fence rows were constructed along the perimeter of the island where continuous vegetation was not present at the island edge, and to bisect other large open areas. Fence rows were constructed by driving commercial-grade, painted steel, 6-foot fence posts into the ground to depths of at least two feet. Along each fence row, fence posts were spaced no more than six feet apart, and each fence row was securely anchored at both ends using specially designed angle brackets (Wedge-Loc®). Runs of taut, barbless wire were then secured to the fence posts at ground level, at 18 inches above ground level (AGL), and at 36 inches AGL. Commercial grade knitted material (PAK Unlimited Inc.; 90% privacy screen) was then zip tied to the top and bottom wire strands to create a visual barrier for any prospecting Caspian terns that might land on the ground. Fence rows were constructed across the entirety of the "Primary Dissuasion Area" and much of the "Secondary Dissuasion Areas" identified in the IAPMP. Additionally, twisted polypropylene rope (0.25-inch) was then attached to the fence posts at approximately 42 inches AGL using clove hitch knots. Ropes were fastened to alternating fence posts diagonally between two adjacent fence rows, and then 4-foot lengths of industrial barricade tape ("polyethylene flagging;" Mutual Industries; 3 mil) were inserted between strands of the rope at 3-foot intervals.

Also in 2015, passive nest dissuasion consisting of stakes, rope, and flagging or woody debris was used in the "Secondary Dissuasion Areas" to cover open areas where Caspian terns were less likely to prospect for nest sites due to the proximity of mature woody vegetation. Ropes and flagging were deployed in a 10-foot by 10-foot square array using 6-foot steel fence posts driven into the ground, and with diagonal strands of rope and flagging bisecting each square. Similar to the passive dissuasion installed on Goose Island (see *below*), a double layer of rope and flagging was deployed at or near the high waterline around the island's periphery, where fence rows could not be constructed. Woody debris was collected from downed dead trees and felled Russian olive trees (*Laeagnus angustifolia*; a non-native invasive) that did not contain heron or egret nest structures. This woody debris was placed primarily on the west side of Crescent Island, where nest prospecting was considered possible but unlikely, and in open areas below the high waterline. In total, approximately 2.2 acres of potential Caspian tern nesting habitat on Crescent Island was covered in passive nest dissuasion in 2015, consisting primarily of fence rows, rope, and flagging. Virtually all of the sparsely vegetated upland areas of Crescent Island were eliminated as potential Caspian tern nesting habitat through the deployment of passive nest dissuasion materials prior to the 2015 nesting season (Collis et al. 2015).

In 2016, a thorough inspection of the passive nest dissuasion materials installed on Crescent Island in 2015 (see *above*) will be conducted to determine the need for repairs and additional materials (*Figure 3*). Repair of existing materials will require replacement of flagging material as described above. Additionally, other passive nest dissuasion components (e.g., rope, zip ties, fence material) may need replacement. For all necessary repairs, we will procure and install materials identical in composition and deployment to those used in 2015, ensuring the structural integrity of all passive nest dissuasion measures. All repairs will be completed prior to the arrival of breeding gulls and terns, in concert with deployment of new passive dissuasion materials that may be needed (see *below*), and NLT 15 March. However, we will reserve sufficient quantities of all passive nest dissuasion materials in case any

Figure 3: Primary and secondary passive nest dissuasion areas on Crescent Island in 2016 (exact configuration of passive nest dissuasion materials may vary based on decisions made during pre-season site visit).

unexpected in-season maintenance was required and repairs could be accomplished without disturbance to non-target species, in adherence of established BMPs (*Appendix A*). Any reserve material will be stored on Crescent Island in an organized manner, with all excess material and debris removed from the island in a timely manner.

In support of the willow planting and cutting of Russian olive trees performed by another contractor on Crescent Island during January – February 2016 (see *below*), we provided technical assistance on the final placement of Russian olive tree cuttings as supplemental passive nest dissuasion during a site visit conducted on 12 February. In select areas where removal of Russian olive trees on Crescent Island created new potential nesting habitat for terns, we will erect additional passive nest dissuasion materials (*Figure 3*). If the open habitat that is created is determined to be suitable tern nesting habitat (i.e., "Primary Dissuasion Areas"), additional fences will be constructed and connected with rope and flagging as described above. Likewise, if the open habitat that is created is determined to be marginal tern nesting habitat (i.e., "Secondary Dissuasion Areas"), additional posts, rope, and flagging will be installed on a 10' grid, connected to the existing dissuasion network described above.

All passive dissuasion, both repaired components and newly installed, will be completed prior to the arrival of breeding terns and gulls, and NLT 15 March. Once installed, at no time will any passive nest dissuasion materials be removed or altered for any reason without explicit permission from the Corps. Once installed, all dissuasion materials will become property of the Corps. However, disposable

material, specifically the barricade tape flagging, will be removed from the island following the Caspian tern breeding season, and NLT 30 September.

Task 2.2. – Repair, construct, and maintain passive nest dissuasion materials on Goose Island: During the 2014 and 2015 nesting seasons, a matrix of concrete pier blocks, rebar, PVC pipes, ropes, and flagging was used as the primary method of passive nest dissuasion on Goose Island. Concrete pier blocks (Mutual Materials; 12'' x 12'', 63 lbs. each) were placed in a 10' x 10' square grid in nearly all open areas on the island. The center of each concrete pier block was drilled out vertically to accommodate a 48-inch length of .5-inch (outside diameter) rebar and a 42-inch length of .5-inch (inside diameter) PVC pipe was slipped over the rebar. Twisted polypropylene rope (.25-inch) was then attached to the PVC at approximately 42" AGL using clove hitch knots, and the rope was further secured to the pipe using UV-resistant cable ties. Ropes were fastened to the vertical PVC pipes to form a 10' x 10' grid, with each grid square also bisected diagonally with a section of rope. Four-foot-long pieces of industrial barricade tape ("polyethylene flagging;" Mutual Industries; 3 mil) were inserted between the strands of the rope at approximately 3-foot intervals, and allowed to flutter in the wind as a visual deterrent to prospecting Caspian terns. A second layer of ropes and flagging was added below the initial layer forming a "double layer" in certain areas where Caspian terns were considered most likely to attempt nesting. In general, a 10 to 15 foot buffer of double layer passive nest dissuasion was installed around the perimeter of all contiguous areas of passive dissuasion in 2015.

Additionally, areas where nesting by Caspian terns had occurred in previous years, and areas identified in 2014 as suitable Caspian tern habitat, were again covered with a double layer of passive dissuasion. In total, more than 1,800 pier blocks, rebar stakes, and PVC sections were installed on Goose Island to support the rope and flagging matrix that covered 4.1 acres, more than 85% of the upland area of Goose Island in 2015. Virtually all of the previously used and potential Caspian tern nesting habitat that was above the waterline during mid-April 2015 was covered in passive nest dissuasion materials.

In 2016, after inspection of the passive nest dissuasion materials installed on Goose Island during 2014-2015 (see *above*) with Corps and Reclamation staff, we will determine the need for repairs and additional materials in 2016 (*Figure 4*). Repair of existing materials will require replacement flagging identical in composition and deployment to those used in 2015 (see *above*). Additionally, other passive nest dissuasion materials (e.g., rope, zip ties, PVC pipe) may need replacement. For all necessary repairs, we will procure and install materials identical in composition and deployment to those used in 2015, ensuring the structural integrity of all passive dissuasion measures. Upon complete refurbishment of materials deployed during 2014-2015, the preliminary 2016 passive nest dissuasion network will be identical to the final configuration in 2015, with a continuous single layer of rope and flagging covering all potential Caspian tern habitat. A second layer of rope and flagging will again be installed in areas where terns formerly nested, in other suitable tern nesting habitat, and as a perimeter surrounding all single layers of passive dissuasion. All repairs will be completed prior to the arrival of breeding gulls and terns, in concert with deployment of new passive nest dissuasion materials (see *below*), and NLT 15 March. However, we will reserve sufficient quantities of all passive nest dissuasion materials in case any unexpected in-season maintenance is required and repairs can be accomplished without disturbance to non-target species, in adherence of established BMPs (*Appendix A*). Any reserve material will be stored on Goose Island in an organized manner, with all excess material and debris removed from the island in a timely manner.

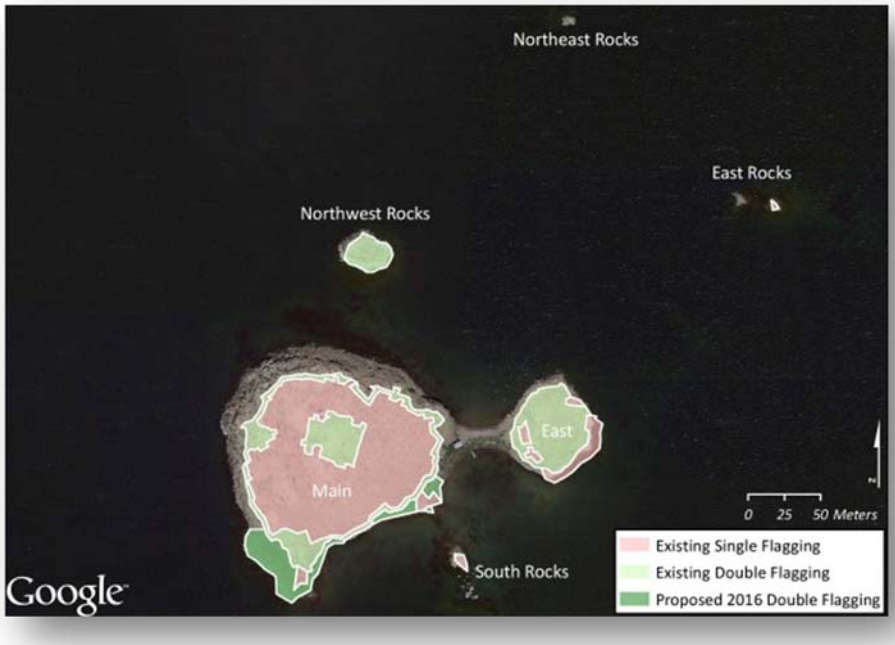

Figure 4: Single- and double-layers of rope and flagging on Goose Island in 2016 (exact configuration of passive nest dissuasion materials may vary based on decisions made during pre-season site visit).

Additional passive nest dissuasion will be constructed above the high water line in areas not covered in 2015, but where Caspian tern eggs were laid and/or significant use by prospecting Caspian terns was observed (Collis et al. 2015). Specifically, new dissuasion will be constructed on the southwest tip of Goose Island and areas along the southern shoreline (see *Figure 4*). Other areas for new dissuasion may be identified during preliminary site visits with POCs from the Corps and Reclamation. All newly constructed passive dissuasion will consist of two layers of rope and flagging identical in material and deployment to double-layer dissuasion deployed in 2015 (see *above*). In addition to the stakes, rope, and flagging, owl effigies (provided by Reclamation) will be redeployed on Goose Island as an additional passive dissuasion technique in 2016, and returned to Reclamation at the conclusion of the 2016 field season. We will also support Reclamation's efforts to deploy and test the efficacy of supplemental passive hazing techniques in 2016. We will provide technical assistance regarding the placement and operation schedule for dissuasion tests, and will notify Reclamation regarding any equipment malfunctions to maximize the efficacy of test actions.

All passive dissuasion, both repaired components and newly installed, will be completed prior to the arrival of breeding terns and gulls, and NLT 15 March. Once installed, at no time will any passive nest dissuasion materials be removed or altered for any reason without explicit permission from the Corps and Reclamation. Once installed, all dissuasion materials will become the property of Reclamation. However, disposable material, specifically the barricade tape flagging, will be removed from the island following the Caspian tern breeding season, and NLT 30 September. All passive dissuasion materials installed on Goose Island will be temporary and will not cause any permanent changes to the island.

Task 3. Active nest dissuasion as part of the IAPMP

In accordance with the IAPMP, active nest dissuasion methods will be used to supplement passive dissuasion measures to deter nesting attempts by Caspian terns, California gulls, ring-billed gulls, and

Canada geese (*Branta canadensis*) on Goose and Crescent islands in 2016. Active hazing will target Caspian terns, gulls, and geese (on Goose Island only; see *below*) in an attempt to prevent or delay colony formation. The purpose of active gull nest dissuasion will be to prevent or delay gull nesting because nesting gulls attract Caspian terns to nest. In addition, the initiation of gull and Canada goose nests over much of the island will limit or preclude researcher access needed to conduct the active Caspian tern nest dissuasion activities described below.

Active nest dissuasion methods will be conducted from late February through July, and will include: (1) forays into the colony by researchers to haze prospecting Caspian terns, gulls, and geese (hereafter referred to as "walk-throughs"; *Figure 5*); (2) approaching the shoreline of the island by boat or kayak to haze prospecting Caspian terns along the shore; (3) using a green laser during low light conditions to haze prospecting Caspian terns from a distance without disturbing gulls and geese attending nests with eggs; (4) waving a 10-foot PVC pole with caution tape tied to each end or flying a peregrine falcon kite to deter terns and gulls from landing or roosting on the island; and (5) destruction of all Caspian tern, gull, and goose nests that are found prior to egg-laying. Additionally, other active hazing methods may be tested, if allowed and approved by the COR. Active hazing will be conducted so as to both prevent Caspian tern nesting and maintain access to the island for walk-throughs for as long as is possible. Finally, in the event that Caspian tern eggs are laid on either Goose or Crescent islands, tern eggs will be collected under permit. A detailed description of active nest dissuasion activities that will be used at each island during the 2016 nesting season are provided below.

Figure 5: Active nest dissuasion, specifically island walk-throughs, conducted at Goose Island in 2015.

Task 3.1. – Conduct active nest dissuasion activities on Crescent Island: Active nest dissuasion will be conducted to disrupt nesting attempts by Caspian terns and gulls on Crescent Island by (1) island walk-throughs; (2) approaching the shoreline of the island by boat; (3) use of a green laser during low light conditions (*Figure 6*); (4) waving a 10-foot PVC pole with caution tape tied to each end; (5) flying a peregrine falcon kite on the island; and (6) destruction of all Caspian tern, gull, and Canada goose nests not containing eggs (collectively referred to as "active hazing"). Active hazing will target both prospecting Caspian terns and prospecting ring-billed and California gulls in an attempt to prevent or delay the onset of egg-laying by these colonial waterbird species. Active hazing of Canada geese on Crescent Island will not be conducted unless requested by the COR and the other designated POCs and allowed by the Conditional Use Permit issued to conduct this work.

Figure 6: Green laser used as an active nest dissuasion technique on Crescent Island in 2015.

To facilitate hazing and monitoring, a boat landing zone and access routes to potential dissuasion areas will be designated prior to the arrival of Caspian terns and gulls to Crescent Island. Birds will be passively and actively hazed from nesting within designated access areas throughout the nesting season, or until deemed no longer necessary for completion of the overall Caspian tern dissuasion efforts. The existing observation blind located adjacent to the former Caspian tern colony site on Crescent Island will be used to monitor Caspian tern and gull use of the surrounding area of the island. Because camping is not permitted on Crescent Island, a houseboat will be transported to Crescent Island and anchored in the cove prior to the arrival of Caspian terns and gulls to the island. The houseboat will allow the field crew to stay overnight near the island, facilitating early morning and late evening active hazing sessions of Caspian terns and gulls on Crescent Island. Evening hazing to prevent Caspian terns and gulls from remaining on Crescent Island overnight is considered especially important for deterring, or at least delaying, nest initiation. No structures that give the appearance of an established camp will be constructed or erected on Crescent Island in 2016.

Field crew members will be present at or near Crescent Island nearly continuously from late February through late July, if necessary. In accordance with BMPs (*Appendix A*) developed during the 2014 nesting season and revised in 2015, the frequency, duration, and methods of active hazing on Crescent Island will be altered over the course of the breeding season to enhance the efficacy of Caspian tern nest dissuasion and to avoid egg take of non-target species (e.g., gulls, Canada geese). Methods to dissuade prospecting Caspian terns and gulls during late February – early March will include incidental disturbance to Caspian terns and gulls caused by researchers repairing and installing passive nest dissuasion materials and intentional, but opportunistic, hazing of prospecting birds when observers walk across the island. Beginning with the arrival of Caspian terns and gulls intent on nesting on Crescent Island (early to mid-March), hazing activities will be conducted daily (7 days/week) and focused primarily during the dawn and dusk periods. Efforts will be made during this time to prevent terns and gulls from using Crescent Island as an overnight roost. Hazing frequency during mid-day will depend on bird activity at the island, but will not be less than two 1-hour walk-through sessions daily. In 2015, Caspian terns and gulls did not nest on Crescent Island and were rarely seen near the island after mid-May (Collis et al. 2015). We will monitor Crescent Island daily to ensure that Caspian terns and gulls do not return to nest in 2016. The methods, duration, and frequency of active hazing sessions, will be adjusted based on bird

numbers and breeding activities observed on Crescent Island. These seasonal adjustments in hazing activity on Crescent Island will be closely coordinated with the COR, and no reductions in hazing effort will be made without the COR's approval.

During island walk-throughs, flying a peregrine falcon kite and waving a 10-foot PVC pole with caution tape tied to each end (*Figure 7*) may be used to increase the effectiveness of our active hazing efforts on Crescent Island. These methods were used successfully in 2015 to (1) haze gulls that were observed rafting in the water near Crescent Island to positions further from the island; (2) prevent gulls hovering over Crescent Island from landing; and (3) flush gulls and terns off of Goose Island soon after they landed (Collis et al. 2015). Other active hazing methods may also be tested, if approved by the COR.

Figure 7: PVC pole with caution tape tied to each end used to prevent birds from landing on Crescent Island in 2015.

During each walk-through, any Caspian tern or gull nest observed will be recorded and all tern and gull nests not containing eggs will be destroyed. If Caspian tern eggs are laid despite our efforts to prevent egg-laying, a take permit issued to the Corps and Reclamation will allow researchers to collect tern eggane, as specified in the permit. The collection of Caspian tern eggs laid on Crescent Island is intended to enhance the prospects for successfully dissuading Caspian terns from forming a breeding colony on Crescent Island. BMPs (*Appendix A*) will be followed for all active hazing and egg collection efforts on Crescent Island, as well as for all necessary communication and reporting of these activities to the COR and other designated POC's. If any tern eggs are laid and subsequently collected under permit, we will report each event within 24 hours to representatives from the Corps and Reclamation to ensure compliance with MBTA permit regulations, and to facilitate accurate reporting to the USFWS by the Corps.

In the event that widespread establishment of gull nests precludes island walk-throughs on Crescent Island, the primary techniques used to actively dissuade prospecting Caspian terns will be the use of a green laser (Agrilaser®; LEM 50) during low-light conditions and motorboat or kayak-based approaches to the island to flush prospecting Caspian terns that are near the water's edge. During low light conditions, using the green laser will allow hazing of Caspian terns (from a distance) that are observed loafing or prospecting on Crescent Island, without disturbing nesting gulls that are attending eggs.

Task 3.2. – Conduct active nest dissuasion activities on Goose Island: Active nest dissuasion will be conducted to disrupt nesting attempts by Caspian terns, gulls, and Canada geese on Goose Island by (1) island walk-throughs; (2) approaching the shoreline of the island by boat; (3) use of a green laser during low light conditions; (4) waving a 10-foot PVC pole with caution tape tied to each end; (5) flying a peregrine falcon kite on the island (*Figure 8*); and (6) destruction of all Caspian tern, gull, and Canada goose nests not containing eggs (collectively referred to as "active hazing"). Active hazing will target prospecting Caspian terns, gulls, and geese in an attempt to prevent or delay the onset of egg-laying by these colonial waterbird species.

Figure 8: Peregrine falcon kite used to flush terns and gulls from Goose Island in 2015.

To facilitate hazing and monitoring, a boat landing zone and access routes to potential dissuasion areas will be designated prior to the arrival of Caspian terns and gulls to Goose Island. Birds will be passively and actively hazed from nesting within designated access areas throughout the nesting season or until deemed no longer necessary for completion of Caspian tern dissuasion efforts. Prior to arrival of Caspian terns and gulls to the island (late February – early March), an observation blind and tunnel will be installed on the upper part of Goose Island, adjacent to the former Caspian tern colony site. The blind will be used to monitor Caspian tern, gull, and Canada goose use of the upper part of the island, which cannot be readily seen from a boat. Also, a portable building will be installed on Goose Island as a field camp to facilitate overnight stays on the island and to allow early morning and late evening hazing of Caspian terns, gulls, and geese from potential nesting areas. Evening hazing to prohibit Caspian terns, gulls, and geese from remaining on Goose Island overnight is considered essential for deterring, or at least delaying, nest initiation. Finally, a platform may be erected in shallow water off the shore of the island to facilitate hazing of prospecting Caspian terns with a green laser (see *below*) once gulls and geese are on nests with eggs.

Field crew members will be present at or near Goose Island nearly continuously from late February through late July, if necessary. In accordance with BMPs (*Appendix A*) developed during the 2014 nesting season and revised in 2015, the frequency, duration, and methods of active hazing on Goose Island will be altered over the course of the breeding season to enhance the efficacy of Caspian tern nest dissuasion and to avoid egg take of non-target species. Methods to dissuade prospecting Caspian terns, gulls, and geese during late February – early March will include incidental disturbance to Caspian terns, gulls, and geese caused by researchers repairing and installing passive nest dissuasion materials and intentional, but opportunistic, hazing of prospecting birds when observers walk across the island. Beginning with the arrival of Caspian terns and gulls intent on nesting on Goose Island (early to mid-March), hazing activities will be conducted daily (7 days/week) and focused primarily during the dawn and dusk periods. Efforts will be made during this time to prevent Caspian terns, gulls, and geese from using Goose Island as an overnight roost. Hazing frequency during mid-day will depend on bird activity on the island, but will not consist of less than two 1-hour walk-through sessions daily. In 2015, Caspian terns, gulls, and geese all nested on Goose Island and were continuously present on the island throughout the breeding season (Collis et al. 2015). Based on avian responses to dissuasion in 2015, we

anticipate that active hazing at Goose Island will need to be much more intensive than that at Crescent Island in 2016 in order to be successful at deterring nesting by Caspian terns. Continuous (daily) monitoring and active hazing at Goose Island will be carried out as necessary to delay the onset of gull and goose nesting and prevent Caspian terns from nesting on Goose Island in 2016. The methods, duration, and frequency of active hazing sessions will be adjusted based on the numbers and behaviors of birds using Goose Island. These seasonal adjustments in hazing activity on Goose Island will be closely coordinated with the COR, and no reductions in hazing effort will occur without the COR's approval.

During island walk-throughs, flying a peregrine falcon kite and waving a 10-foot PVC pole with caution tape tied to each end may be used to increase the effectiveness of our active hazing efforts on Goose Island. These methods were used successfully in 2015 to (1) haze gulls that were observed rafting on the water near Crescent Island and move them to locations further from the island, (2) prevent gulls that were hovering over Crescent Island from landing, and (3) flush gulls and Caspian terns off of Goose Island soon after they landed (Collis et al. 2015). Other active hazing methods may also be tested, if approved by the COR.

During each walk-through, any tern, gull, or goose nest observed will be recorded and all nests not containing eggs will be destroyed. If Caspian tern eggs are laid despite our efforts to prevent egg-laying, a take permit issued to the Corps and Reclamation will allow our researchers to collect tern eggs, as specified in the permit. The collection of any Caspian tern eggs laid on Goose Island is intended to enhance the prospects for successfully dissuading Caspian terns from forming a breeding colony on Goose Island. BMPs (*Appendix A*) will be followed for all active hazing and tern egg collection efforts on Goose Island, as well as for all necessary communication and reporting of these activities to the COR and other designated POC's. If any Caspian tern eggs are laid and subsequently collected under permit, we will report each event within 24 hours to representatives from the Corps and Reclamation to ensure MBTA permit regulations are met, and to facilitate accurate reporting to the USFWS by the Corps.

Once the widespread initiation of gull and/or goose nests curtails or precludes island walk-throughs on Goose Island, as was the case in 2014 and 2015, the primary techniques used to actively dissuade prospecting Caspian terns will be the use of a green laser (Agrilaser®; LEM 50) during low-light conditions and boat-based approaches to the island to flush prospecting Caspian terns that are near the water's edge. During low light conditions, using the green laser from the boat, observation blind, or platform located off the shore of the island will allow hazing (from a distance) of Caspian terns observed loafing or prospecting on Crescent Island, without disturbing gulls and geese attending nests with eggs.

Task 4. Colony- and system-level monitoring as part of the IAPMP

Action effectiveness monitoring will be conducted both at the colony-level and the system-level (region-wide). Colony-level monitoring will be accomplished by resident field crews stationed at both Goose Island and Crescent Island, and will be carried out in conjunction with management tasks described above. Colony-level monitoring is intended to evaluate the efficacy of nest dissuasion efforts on Goose and Crescent islands in preventing Caspian terns from nesting at these two former colony sites (see *below* for more details).

System-level monitoring will consist of periodic, carefully-timed aerial photography surveys in the Columbia Plateau region to (1) locate both active and incipient Caspian tern breeding colonies; (2) estimate tern colony size; and (3) evaluate nesting success at each tern colony (*Figure 9*). In addition, periodic ground- and boat-based surveys will be carried out by a mobile field crew (separate from the island-based field crews mentioned above) at all sizeable (> 30 breeding pairs) Caspian tern breeding

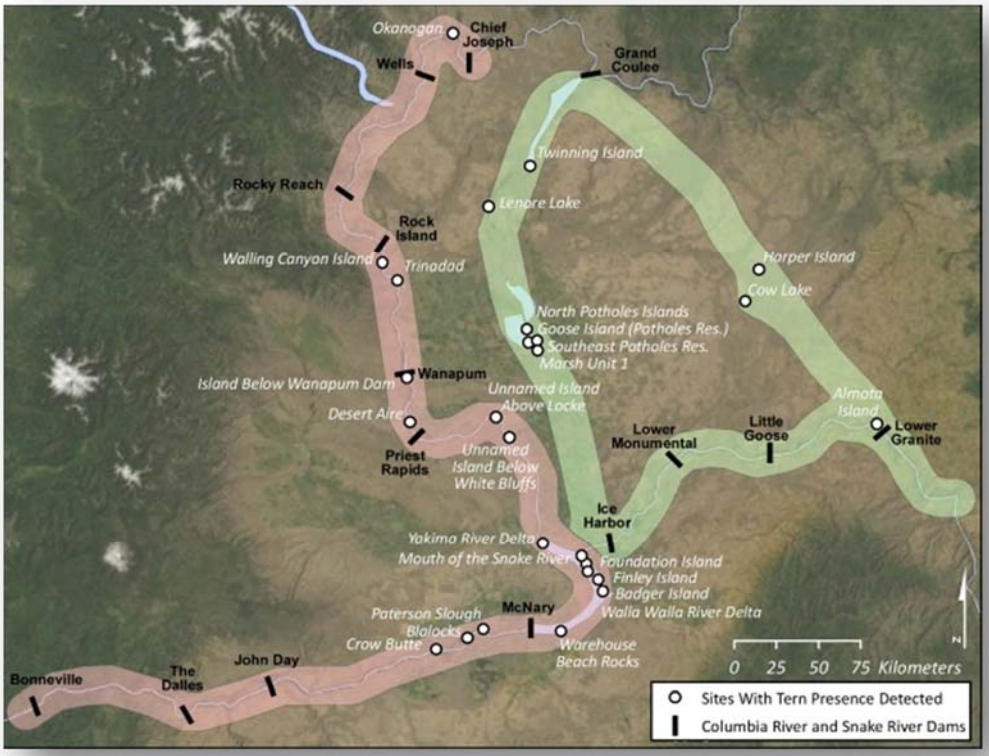

Figure 9: Aerial survey routes used in the Columbia Plateau region.

colonies that are identified during aerial surveys; these ground- or boat-based surveys are intended to accurately assess nesting chronology, colony attendance, and colony size, as well as to determine the outcome of any nesting attempts (i.e., nesting success). System-level monitoring will be accomplished with cost-sharing from the Grant County Public Utility District (GPUD)/Priest Rapids Coordinating Committee (PRCC).

Additionally, colony size estimates generated as part of the system-level monitoring, along with those generated as part of colony-level monitoring at Goose and Crescent islands, will be used to estimate the size of the breeding population of Caspian terns in the Columbia Plateau region during 2016. These data will help evaluate changes in size and distribution of nesting Caspian terns in the Columbia Plateau region associated with management.

Finally, to support on-the-ground efforts conducted by another contractor at the Corps-constructed tern islands at Don Edwards NWR in southern San Francisco Bay, we will coordinate and schedule an aerial photography survey of the islands used by nesting Caspian terns so that an accurate measure of peak colony size and colony area can be estimated.

Task 4.1. – Evaluate response of Caspian terns and gulls to nest dissuasion activities on Crescent Island (Colony-level monitoring): In conjunction with Task 3.1, we will monitor the daily activities of Caspian terns and gulls on Crescent Island from late February through July. With the installation of passive nest dissuasion materials on the former colony site and in most, but not all, of the sparsely vegetated habitat on Crescent Island, it is anticipated that some Caspian terns might attempt to roost or nest in areas just

outside, or perhaps within, the passive nest dissuasion on Crescent Island (as was the case on Goose Island in 2015; see Collis et al. 2015). As part of this task, we will evaluate the effectiveness of various methods used to prevent tern and gull nesting on Crescent Island (e.g., recently planted willows, silt fencing, stakes/rope/flagging, and woody debris).

To determine factors that may limit the efficacy of recently planted willows and scattered Russian olive debris in deterring nesting Caspian terns, weekly observations will be recorded to document use by various avian and mammalian species. Dissuasion zones established in 2015 will be used to characterize different habitat types that could potentially be used by wildlife at different rates. If any terns are observed within the willow planting or Russian olive cuttings, their location and behavior will be immediately recorded. Additionally, during each visit to Crescent Island researchers will search for signs of beaver activity within the exclusion fence, if detected researchers will note the area and number of willow stems affected. Researchers will repair any fence openings found that permit beaver access during daily walkthroughs. At least once per week (or until nesting geese and/or gulls prevent access) researchers will observe a portion of each dissuasion zone to characterize the presence of growth (e.g., new shoots, buds, leaves) water stress, herbivory, insect damage, and other vegetation. Observations will be largely qualitative, and be summarized in weekly reports and the annual report.

In the event that Caspian terns and/or gulls use Crescent Island as a roost or nest site, a combination of ground-, boat-, and blind-based monitoring, together with oblique and high-resolution vertical aerial photography, will be used to assess seasonal colony/island attendance by Caspian terns. If a Caspian tern or gull colony should form on Crescent Island, peak colony size, nesting success, nesting distribution, nesting area, and nesting density will be monitored. We will continuously (7 days/week) monitor the activities of Caspian terns and other waterbirds (i.e., gulls, geese, herons, and egrets) on Crescent Island from mid-March through July using a dedicated field crew. Monitoring of nesting and roosting terns and gulls will be conducted using daily counts of adults made by observers in a blind located near the edge of the former tern colony area, by boat, and on foot in areas with potential for minimal disturbance to actively nesting gulls, geese, or other protected migratory birds. Additional counts will be made while conducting active hazing efforts to assess action effectiveness of passive and active nest dissuasion measures. Seasonal attendance by adult Caspian terns and gulls on Crescent Island will be estimated based on the weekly average of the daily counts of adults on Crescent Island. Crescent Island will also be closely monitored for the formation of new Caspian tern satellite colonies and, once detected, incipient Caspian tern nest sites will be checked daily to count the numbers of adult terns, attended nests, tern eggs, and tern chicks at the site.

Estimates of Caspian tern colony size (i.e., number of breeding pairs) and nesting success (i.e., average number of young raised to fledging age per breeding pair) on Crescent Island will be based on ground counts of the peak number active nests (i.e., adult Caspian terns attending nests with eggs or nestlings) and peak counts of pre-fledged tern chicks (i.e., chicks in the black-capped stage of plumage development on or near the colony), respectively. These ground counts will be made by researchers from observation blinds or vantages at the periphery of the tern colony. Data collection methodologies used as part of this task will follow established protocols (Roby et al. 2002; Antolos et al. 2004; Roby et al. 2014; Adkins et al. 2014; BRNW 2015; Collis et al. 2015) such that the data collected in 2016 could be compared with analogous data collected in previous years and at other colonies.

High-resolution, vertical aerial photography will be taken of Crescent Island in late May and those geo-referenced images will be analyzed to estimate the total area (m^2) covered by passive nest dissuasion materials, the number of nesting and roosting gulls, the number of nesting and roosting Caspian terns,

and the estimated area (m^2) occupied by nesting Caspian terns and gulls on Crescent Island. Finally, these data will be used to estimate nesting density (number of nests/m^2) of Caspian terns and gulls on Crescent Island.

Task 4.2. – Evaluate response of Caspian terns and gulls to nest dissuasion activities on Goose Island (Colony-level monitoring): In conjunction with Task 3.2, we will monitor the daily activities of Caspian terns and gulls on Goose Island from late February through July. As was the case during 2014-2015, it is anticipated that some Caspian terns will attempt to nest in areas both within and outside the passive nest dissuasion on Goose Island. Consequently, a combination of ground-, boat-, and blind-based monitoring, together with oblique and high-resolution vertical aerial photography, will be used to assess seasonal colony/island attendance by Caspian terns, and if a colony should form, peak colony size, nesting success, nest distribution, nesting area, and nest density on Goose Island.

We will continuously (7 days/week) monitor the activities of Caspian terns and other waterbirds (i.e., gulls, Canada geese, Forster's terns) on Goose Island from mid-March through July using a dedicated field crew. Monitoring of nesting and roosting terns and gulls will be conducted using daily counts of adults made by observers in a blind located near the edge of the former colony area, by boat, and on foot in areas with potential for minimal disturbance to actively nesting gulls, geese, or other protected migratory birds. Additional counts will be made throughout the day while conducting active hazing efforts to assess action effectiveness of passive and active nest dissuasion measures. Seasonal attendance by adult terns and gulls on Goose Island will be estimated based on the weekly average of the daily counts of adults on Goose Island. Goose Island will also be closely monitored for the formation of new Caspian tern satellite colonies and, once detected, incipient Caspian tern nest sites will be checked daily to count the numbers of adult terns, attended nests, tern eggs, and tern chicks at the site.

Estimates of Caspian tern colony size (i.e., number of breeding pairs) and nesting success (i.e., average number of young raised to fledging age per breeding pair) on Goose Island will be based on ground counts of the peak number of active nests (i.e., adult Caspian terns attending nests with eggs or nestlings) and peak counts of pre-fledged tern chicks (i.e., chicks in the black-capped stage of plumage development on or near the colony), respectively. These ground counts will be made by researchers from observation blinds or vantage points at the periphery of the tern colony. Data collection methodologies used as part of this study will follow established protocols (Roby et al. 2002; Antolos et al. 2004; Roby et al. 2014; Adkins et al. 2014; BRNW 2015; Collis et al. 2015), such that the data collected in 2016 will be comparable with analogous data collected in previous years and at other colonies.

High-resolution, vertical aerial photography will be taken of Goose Island in late May and those geo-referenced images will be analyzed to estimate the total area (m^2) covered by passive nest dissuasion materials, the number of nesting and roosting gulls, the number of nesting and roosting Caspian terns, and the estimated area (m^2) occupied by nesting Caspian terns and gulls on Goose Island. Finally, these data will be used to estimate nesting density (number of nests/m^2) of Caspian terns and gulls on Goose Island.

Task 4.3. – Assess colony connectivity and dispersal patterns of Caspian terns via band resightings (System-level monitoring): To help assess the extent to which Caspian tern management actions implemented as part of the IAPMP (USACE 2014) and the Caspian Tern Management Plan for the Columbia River Estuary (USFWS 2005, 2006) are successful in relocating Caspian terns to sites outside

Figure 10: Caspian tern banded with field-readable leg bands.

the Columbia River basin, we will resight Caspian terns previously marked with field-readable leg bands (*Figure 10*) during visits to the Goose Island and Crescent Island colonies, as well as during visits to other nesting and roosting sites used by Caspian terns in the Columbia Plateau region during the 2016 nesting season. Using a comprehensive database containing banding and resighting records for Caspian terns dating back to 2005, we will assess (1) colony connectivity among sites in the Columbia Plateau region; (2) emigration rates of banded individuals from sites in the Columbia Plateau region to sites outside the region; and (3) immigration rates of banded individuals from sites outside the Columbia Plateau region to sites in the region. Some of the resighting effort in the Columbia Plateau region during 2016 will be funded by the GPUD/PRCC, as was the case during 2014-2015. Furthermore, all banding and resighting efforts performed outside the Columbia Plateau region will be conducted as part of related, but separately funded, studies. We will not conduct any Caspian tern banding activities that may conflict, or potentially appear to conflict, with implementation of the IAPMP in 2016.

Caspian terns that were banded with alphanumeric leg-bands in previous years (BRNW 2015), will be resighted using binoculars and spotting scopes up to 7 days per week at Goose and Crescent islands and up to 4 days/week at other colonies in the Columbia Plateau region during the 2016 breeding season. As part of related but separate studies, resighting of previously-banded Caspian terns will also be conducted at various sites in the Pacific Flyway region during 2016 to evaluate movements of Caspian terns from the Goose Island and Crescent Island to colony sites outside the Columbia Plateau region.

A data summary of all banded Caspian terns resighted in 2016 will be presented in the annual report. Also, movement probabilities of Caspian terns between colonies (or regions in some cases) will be estimated using multi-state analysis (Hestbeck et al. 1991, Brownie et al. 1993) in Program MARK (White and Burnham 1999). *A priori* models will be constructed to evaluate effects on movement probabilities, and Akaike's Information Criterion (AIC) will be used to select the best model (Burnham and Anderson 2002) to estimate inter-colony movements, given the data. Survival and resighting probabilities will be accounted for to estimate inter-colony movement probabilities (Suzuki 2012). Based on movement probabilities from 2015 to 2016 that are estimated from the analysis, plus the numbers of Caspian terns present at a colony in 2016, the numbers of terns (both banded and unbanded) that moved between

colonies inter-annually will be estimated. The resighting data summary and movement estimates from the this robust analysis will provide critical information, such as sites where Caspian terns dispersed to from managed colonies and net movements between managed colonies and other colony sites, to evaluate the effectiveness of management actions.

Finally, we will support on-the-ground efforts conducted by another contractor at the Corps-constructed tern islands at Don Edwards NWR in southern San Francisco Bay by providing banding and resighting information for all banded Caspian terns resighted at those colonies in 2016. These data will provide important information regarding where birds resighted at the Corps-constructed tern islands at Don Edwards NWR were reared and/or had nested in previous years.

Task 4.4. – Determine species and stock specific predation rates on juvenile salmonids from the Snake and Columbia rivers by Caspian terns nesting at colonies in the Columbia Plateau region (System-level monitoring): The goal of the IAPMP is to reduce Caspian tern predation rates on all ESA-listed salmonid ESUs/DPSs to less than 2% per tern breeding colony per year in the Columbia Plateau region (USACE 2014). Estimates of average per capita (per bird) predation rates by Caspian terns from previous years (2007-2015), coupled with information on the size of Caspian tern colonies (number of breeding pairs) in the Columbia Plateau region in 2016, will be used to predict predation rates by Caspian terns nesting at all colonies in the Columbia Plateau region in 2016 where adequate empirical data exists.

Colony-specific estimates of per capita predation rates on ESA-listed salmonids will be based on colony size estimates from 2016 and actual predation rate estimates from PIT tag recoveries from 2007-2015, where adequate historical data exists for managed (i.e. Goose and Crescent islands) and un-managed (i.e. Blalock and Twinning islands) tern colonies in the Columbia Plateau region. As part of this TO, PIT tags will not be recovered/detected on Caspian tern colonies in the Columbia Plateau region in 2016. With funding from GPUD/PRCC, PIT tags will be recovered/detected and actual predation rates will be calculated for all sizable (i.e. > 30 breeding pairs) tern colonies in the Columbia Plateau region in 2016. This funding will also support the sowing of test PIT tags at the Blalock Islands, Twinning Island, and Lenore Lake to estimate detection probabilities at each of these Caspian tern colony sites that were active in 2015 (see *below*).

Actual Predation Rates – Estimates of actual predation rates on ESUs/DPSs of salmonid smolts in 2007-2015 were based on methods previously developed by Evans et al. (2012) and Hostetter et al. (2015), and are presented in Bird Research Northwest (BRNW) (2013, 2014, 2015). In brief, the number of PIT-tagged smolts available to Caspian terns nesting at each colony was based on the number interrogated (detected alive) passing Lower Monumental Dam (Snake River), Rock Island Dam (Upper Columbia River), or McNary Dam (mid-Columbia River), whichever dam was the nearest upstream dam(s) with adequate PIT tag detection capabilities. PIT-tagged smolts were grouped by ESA-listed ESU/DPS, based on the species, run-type, rearing-type, and origin of each PIT-tagged fish. The proportion of available PIT-tagged smolts consumed by Caspian terns nesting at each colony is modeled dependently as a three-stage probabilistic process: (1) a PIT-tagged smolt was consumed by a Caspian tern (predation probability), (2) the PIT tag was egested on-colony (deposition probability), and (3) the PIT tag was detected by researchers after the nesting season (detection probability; *Figure 11*). These events were modeled for each year (2007-2015), at each Caspian tern colony (Goose, Crescent, Blalock, and Twinning islands), and for each ESA-listed salmonid ESU/DPS (Snake River steelhead, Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon, Upper Columbia River steelhead, Upper Columbia River spring Chinook salmon).

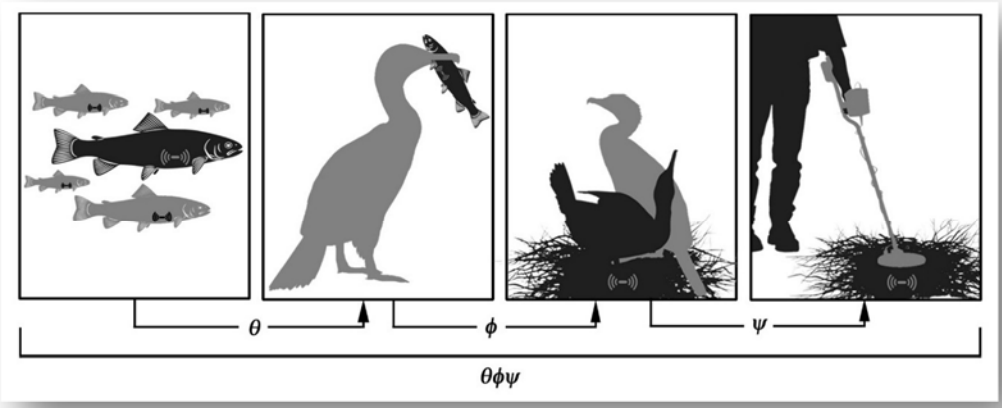

Figure 11: Conceptual model of the tag-recovery process in studies of avian predation. The probability of recovering a fish tag on a bird colony is the product of three probabilities: a tagged fish was consumed (predation probability, ϑ), the consumed tag was deposited on the nesting colony (deposition probability, ϕ), and the deposited tag was detected on the colony by researchers (detection probability, ψ).

We let θ_w represent the probability that a tagged fish is consumed by a Caspian tern in week *w*, ϕ represent the probability that a consumed fish tag is deposited back on the tern's breeding colony, and ψ_w represent the probability that a tag deposited on the tern colony in week *w* remains on the colony and is detected. The number of PIT tags recovered on a Caspian tern colony from a given week can therefore be modeled as a binomial process,

$$k_w \sim Binomial(n_w, \theta_w * \phi * \psi_w),$$

where k_w is the number of smolt PIT tags recovered from the number available during each week (n_w). Detection probability (ψ_w) was estimated directly using surveys of PIT tags known to have been deposited on-colony at specific times (i.e., before, during, and after the breeding season; see Evans et al. 2012). We modeled the change in detection probability over time as a logistic function of week,

$$logit(\psi_w) = \alpha + \beta * w,$$

where α is a logit scale regression intercept and β is the logit-scale estimate of change in detection probability for each week. Based on previous investigations of the tag deposition probability for nesting Caspian terns (BRNW 2015; Hostetter et al. 2015*),* we employed an informative prior – *Beta (*16.20, 6.55) – for ϕ.

We ascribed a hyper distribution for predation probabilities ($\vec{\theta}$),

$$logit(\theta_w) \sim Normal\left(\mu_\theta, \tau_\theta^2\right) \forall\, w$$

This enables the sharing of information among weeks, while also allowing predation probabilities (θ_w) among weeks to be unique. Noninformative priors are used in the specification of α, β, μ_θ, and τ_θ^2; $\alpha \sim Normal(0, 0.01)$, β$\sim Normal(0, 0.01)$, $logit^{-1}(\mu_\theta) \sim Uniform(0,1)$, and $\tau_\theta^2 \sim Uniform(0,20)$. Note that the Normal distribution is specified here by the mean and precision parameters.

Annual consumption totals for PIT-tagged smolts were defined to be the sum of the estimated number of PIT-tagged smolts consumed during each week:

$$Annual\ Consumption = \sum_w (\theta_w * n_w)$$

This estimate of consumption of PIT-tagged smolts was then divided by the total number of PIT-tagged smolts available during that migration year (based on interrogations of PIT-tagged smolts at dams) to estimate the annual predation probability:

$$Annual\ Predation\ Rate = {\textstyle\sum_w (\theta_w * n_w)} \Big/ {\textstyle\sum_w (n_w)}$$

All predation probability models were implemented using the software JAGS (Plummer 2003) accessed through R version 3.1.3 (R Core Team 2015). We ran three parallel chains for 50,000 iterations each and a burn-in of 5,000 iterations. Chains were thinned by 20 to reduce autocorrelation of successive Markov Chain Monte Carlo samples, resulting in 6,750 saved iterations. Chain convergence was tested using the Gelman-Rubin statistic ($\hat{R}$; Gelman et al. 2004). We report results as posterior medians, as well as 2.5 and 97.5 percentiles, which represent 95% Credibility Intervals (95 CI). Finally, to control for imprecise results that might arise from small sample sizes of interrogated PIT-tagged smolts, estimates of predation were only calculated for ESUs/DPSs when ≥ 500 PIT-tagged smolts were interrogated passing an upstream dam in 2015 (Evans et al. 2012). Predation probabilities ≤ 0.1% are presented without credibility intervals because the upper bounds of the credibility intervals are not greater than 0.1%.

Colony Size – Estimates of Caspian tern colony size (number of breeding pairs) in 2016 will be based on the methods of BRNW (2013, 2014, 2015) and are described above. In brief, colony sizes for Caspian terns nesting at all sizeable (> 30 breeding pairs) colonies in the Columbia Plateau region will be determined based on the largest number of incubating Caspian terns counted during aerial and ground surveys conducted near the end of the incubation period.

It is likely that Caspian tern colony size on Goose and Crescent islands in 2016 will be strongly influenced by passive and active nest dissuasion measures implemented as part of the IAPMP (see *above*). In 2015, no (zero) breeding pairs of Caspian terns laid or hatched eggs on Crescent Island and only two breeding pairs of Caspian terns hatched eggs on Goose Island (Collis et al. 2015). Caspian terns on Goose Island in 2015, however, made additional nesting attempts in which the eggs laid were either depredated by gulls or collected by researchers; in total, eggs were laid in 39 Caspian tern nests during the 2015 breeding season (Collis et al. 2015). Adult Caspian terns were also routinely observed on Goose Island in 2015 prior to and following hazing, with an average weekly count of 28 adult terns observed on the island during the smolt out-migration period for steelhead and yearling Chinook salmon from the Upper Columbia River (13 April to 14 June, 2015; Collis et al. 2015). Given the number and duration of Caspian tern nesting attempts and the daily presence of adult Caspian terns on Goose Island, it seems likely that the actual predation rates of Goose Island Caspian terns on salmonid smolts from the Upper Columbia River represented more than just that of the two breeding pairs that successfully hatched eggs on Goose

Island in 2015. Consequently, for the purpose of estimating predicted predation rates in 2015, Caspian tern colony size on Goose Island was considered to be between 14 and 39 breeding pairs in 2015 (Collis et al. 2015). For the purpose of this analysis, this same approach will be taken in estimating colony sizes for use in per capita predation rate estimates (see *below*) at Goose and Crescent islands in 2016.

Per Capita Predation Rates – Annual per capita predation probabilities during 2007-2015 were calculated using the methods of Evans et al. (2012) and are presented elsewhere (Roby et al. 2014; Collis et al. 2015). In brief, annual per capita predation probabilities for each Caspian tern colony and each salmonid ESU/DPS in year, *y*, were calculated by dividing the annual predation probability by the peak colony size from that year:

$$Annual\ Per\ Capita\ Predation\ Rate_y = \sum_w (\theta_{wy} * n_{wy}) / \sum_w (n_{wy}) \Big/ C_y$$

where C_y is the peak colony size in year, *y*, as previously defined.

We will calculate a per capita predation probability for each colony and each salmonid ESU/DPS in 2016 using the arithmetic average of the annual per capita predation rates in 2007-2015. We will build 95% CIs by averaging random samples of per capita predation rates generated from the posterior distributions calculated previously.

Predicted Predation Rates – In order to estimate predation probabilities in 2016 based on measures of colony size alone, we will use a Markov Chain Monte Carlo process to generate samples from a posterior predictive distribution based on random draws from the posterior distribution of the average annual per capita predation rate. Predicted per capita predation rate estimates for each salmonid ESU/DPS will then be generated for (1) all sizeable Caspian tern colonies in the Columbia Plateau region in 2016 and (2) various hypothetical Caspian tern colony sizes ranging from 0 to 700 terns at each of these three colony sites.

Task 4.5. – Detect the formation and estimate the size of Caspian tern colonies in the Columbia Plateau region (System-level monitoring): The geographic scope of the IAPMP includes the 10 "at-risk" sites identified in the IAPMP and other sites within the Columbia Plateau region where Caspian terns displaced from colonies on Goose and Crescent islands may relocate following management (USACE 2014). These colony sites (hereafter referred to as "prospective sites") include islands where Caspian terns have recently nested (i.e., within the last two years), including the Blalock Islands (John Day Reservoir; *Figure 12*), Twinning Island (Banks Lake), Harper Island (Sprague Lake), and Lenore Lake. Prospective colony sites also include sites where Caspian terns have previously, but

Figure 12: Caspian tern colony at the Blalock Islands in 2015.

not recently nested, including Miller Rocks (The Dalles Reservoir), Three Mile Canyon Island (John Day Reservoir), Badger Island (McNary Reservoir), Foundation Island (McNary Reservoir), Cabin Island (Priest Rapids Reservoir), and Solstice Island (Potholes Reservoir; Adkins et al. 2014). Other prospective colony sites that may have no history of Caspian tern nesting, but may be attractive as new colony sites because of the presence of other colonially nesting waterbirds include Island 20 and Island 18 in the Richland Islands complex on the mid-Columbia River (see *Figure 1 above*) and Goose Island in Banks Lake.

Periodic monitoring will be conducted at all of these prospective colony sites to help evaluate the consequences of management actions implemented on Goose and Crescent islands in 2016. We will assess whether reductions in colony size associated with the nest dissuasion actions at Goose and Crescent islands were compensated for by commensurate increases in Caspian tern colony size at prospective sites within the Columbia Plateau region, where Caspian terns may continue to consume significant numbers of ESA-listed salmonids.

Aerial photography surveys – Three aerial surveys will be conducted from a fixed-wing aircraft (Cessna 205; Gold Aero Flying Service) to determine the distribution of Caspian terns (both nesting and roosting) along the Columbia River from Bonneville Dam to Chief Joseph Dam, and on the lower Snake River from the mouth of the Clearwater River to the confluence with the Columbia River, as well as at sites off the mid-Columbia and lower Snake rivers that are within tern foraging range (~90 km) of the FCRPS (see *Figure 9 above*). The objective of aerial surveys is to identify all active Caspian tern nesting colonies and large roost sites within the region. The aerial surveys of the Columbia Plateau region will be conducted during the 2016 nesting season on the following schedule: (1) in late April, early in the incubation period, to check for the presence of newly formed colonies; (2) in mid-May, late in the incubation period, to determine numbers of breeding pairs, colony area, and habitat types occupied by nesting Caspian terns, as well as identify late-forming colonies; and (3) in late June, during the peak fledging period, to assess overall nesting success at active Caspian tern colonies. Aerial surveys will follow established methods, and will be conducted as described previously (Collis et al. 2015), including reconnaissance surveys to search for new Caspian tern colonies and photographic surveys of sites where nesting Caspian terns are present. When Caspian terns are observed on the ground on substrate that may be suitable for nesting, oblique aerial photography will be taken using a digital SLR camera with an image-stabilizing, zoom lens. When in-flight observations of Caspian terns or post-flight digital image inspection reveals a potential Caspian tern breeding colony, periodic ground- or boat-based surveys will be conducted to assess the breeding status and other colony metrics at the site (see *below*).

High-resolution (2-cm cell size at ground level), vertical aerial photography will be taken of all sizeable (> 30 breeding pairs) Caspian tern colonies in the Columbia Plateau region in 2016. Photography will be taken in late May and the geo-referenced images will be analyzed in a custom web-based GIS application to determine nesting distribution, colony size (number of active nests), and colony area (m^2) used by Caspian terns. Finally, these data will be used to estimate nest density (number of active nests/m^2) of Caspian terns at each site.

The emergence of Unmanned Aircraft Systems (UASs) as a reliable, cost-effective, rapidly deployable solution for aerial mapping projects, along with the advent of the Federal Aviation Administration (FAA) 333 Exemption process for the commercial application of UASs, has made it possible to use a UAS platform for collecting the high-resolution, geo-referenced imagery that we have traditionally acquired from a fixed-wing, manned aircraft. Although we will continue to fly high-resolution, vertical imagery surveys with a traditional fixed-wing, manned photogrammetry mapping system in 2016, we will also fly

one of the sites with a multi-rotor UAS platform in 2016 as a proof-of-concept for implementing UAS in future monitoring efforts.

The capabilities of UAS platforms coupled with high-resolution digital imaging sensors to acquire high-resolution imagery for mapping is well documented. The challenge in using UASs for monitoring bird colonies is primarily in relation to potential disturbance to nesting birds by the UAS. There is limited information regarding the use of UAS for surveying bird colonies. In 2010, RTR/OSU staff conducted a test UAS flight above a Columbia River gull colony, flown at approximately 175' AGL, and observed that the nesting birds displayed little or no apparent reaction to the presence of the UAS. In 2013 and 2014 the USFWS conducted test flights for surveying seabirds with a UAS and found that wildlife showed little to no reaction to the presence of the UAS from altitudes ranging from 70' to 225' AGL (Thomas 2014).

We will conduct a proof-of-concept UAS mapping flight at one of the colonies targeted by the traditional high-resolution, vertical imagery flights within three days of the manned flight. Our intent is to select a site that has multiple nesting species, including Caspian terns. We will work closely with the Corps to identify timing and location of this flight. The UAS mission will be conducted in accordance with all FAA requirements/regulations and will only be conducted if permitted by the landowner and the USFWS. An observer will be positioned with the UAS pilot and will maintain simultaneous communication with biologists who will monitor the bird colonies from an observation blind or nearby vantage. Colony monitors will alert the observer of any changes in the birds' behavior during the flight. If Caspian terns or other birds demonstrate wing lift or head bob behaviors, or movements off of nests, the pilot will immediately increase UAS altitude and direct the UAS away from the colony. Our intent is to demonstrate the ability to acquire high-resolution imagery (2-cm cells or better) without disturbing the target bird colonies. The Corps/Reclamation will not incur any additional costs related to the UAS feasibility study.

Land-based surveys – The frequency of ground-based and boat-based surveys of Caspian tern colony sites identified during aerial surveys will vary from several times a week to once a month, depending on the number of Caspian terns present and the type of bird activity observed at the site. Sizable Caspian tern colonies (> 30 breeding pairs) will be visited more often (weekly) to determine Caspian tern use of each island (i.e., roosting or nesting), seasonal colony/island attendance, nesting chronology, peak colony size, and the outcome of any nesting attempts (i.e., nesting success). Smaller colonies (< 30 breeding pairs) will be visited less frequently (monthly) to determine nesting status, change in colony size, peak colony size, and nesting success, if applicable. Land-based surveys of prospective Caspian tern colony sites will be conducted with cost sharing from GPUD/PRCC.

Task 4.6. – Evaluate Caspian tern nesting habitat within the Blalock Islands Complex (System-level monitoring): To assess how fluctuations in pool levels affects the amount of available Caspian tern nesting habitat at the Blalock Islands, we will install and maintain an autonomous, solar-powered water level monitoring system in the vicinity of the Blalock Islands. The system will be installed prior to arrival of birds at the Blalock Islands (early March – early April), and will operate until at least January 2017. Water level surface elevation readings will be recorded once every five minutes with a vertical accuracy of 1 cm. Water level surface elevations will be referenced to the following vertical datums: the North American Vertical Datum of 1988 (NAVD 88) and the National Geodetic Vertical Datum of 1929 (NGVD 29). Time stamped water levels will be delivered to the Corps in CSV format once per week, within 72 hours of the last water level reading in the weekly CSV file. Upon completion of data collection for this project all data will be compiled into a single CSV file and delivered to the Corps.

Water levels will be acquired with a Campbell Scientific CS451 Water-Level Recording Sensor (https://www.campbellsci.com/cs451), which is a vented, submersible pressure sensor that is designed for extended-duration deployment in river and lake settings. Data will be recorded by a Sutron CDMALink 2-Way Logging Transmitter (http://www.sutron.com/product/cdmalink/). The CDMALink Data Collection Platform (DCP) will be powered by a 5-Watt solar panel with a sealed lead acid battery backup that can power this system for up to a week in the event of solar power interruption. Water level readings, as well as sensor and DCP performance and health, will be transmitted from the DCP via a wireless cellular network. The DCP, solar panel, and pressure sensor will be mounted on a secure, stationary, in-river piling. We will use a Trimble R10 GNSS GPS to establish a temporary benchmark (TMB), in the vicinity of the water level sensor, and reference the sensor to the TMB. The Corps has also established a TMB (296.62', NAVD 88) in close proximity to the intended water level system installation site. We will record a position for the Corp's TMB to identify any vertical separation between the two benchmarks. During installation we will manually record water level observations with a Leica NA2 optical level for a minimum of one hour to verify sensor calibration and accuracy. Water level observations will be tied to the vertical datum of NAVD 88. Water level elevations will be reported to the Corps in both NAVD 88 and NGVD 29. Upon completion of the project all components of the water level monitoring system will be transferred to the Corps.

Finally, we will take photos from a fixed point (i.e., observation blind) that will document changes in available habitat at the Blalock Islands with changing water surface elevations. These photos will be taken during each visit to the Blalock Islands. All photos will have date and time stamps so that the photos can be related to the surface water elevations at the time the photos were taken. These photos will be provided to the Corps in weekly reports.

Task 4.7. – Conduct an aerial photo survey of Caspian tern colonies at the Don Edwards National Wildlife Refuge (System-level monitoring): We will conduct one aerial photography survey to collect high-resolution, vertical, geo-referenced aerial photography (2-cm cell size at ground level) to estimate peak colony size, colony area (m^2), nesting density (active nests/m^2), and type(s) of nesting habitat used by Caspian terns nesting at the five newly-constructed Caspian tern islands (i.e., islands #11 and #12 in Impoundment A16 and islands #12, #17, and #21 in Impoundment SF2) in Don Edwards NWR, southern San Francisco Bay during the 2016 breeding season.

This flight will be scheduled to occur during late incubation, likely in late May, based on previous observations of Caspian tern nesting chronology in the San Francisco Bay area (Collis et al. 2012). This timing is best for estimating peak colony size, total colony area (m^2), nesting density (active nests/m^2), and the type(s) of nesting habitat used by nesting Caspian terns. The actual timing of the flight will be adjusted, as necessary, based on close coordination with the USFWS and/or U.S. Geological Survey (USGS) personnel who will be monitoring the islands from the ground.

The aerial photography flight path will be determined by the flight operator to maximize travel efficiency and safety. The flight operator will be provided with discrete geographic coordinates for each target colony, as well as visual descriptions and size estimates of each target. Flight altitude, speed, and timing with respect to sun elevation will follow established protocols that have been used for vertical aerial photography capture for Caspian tern colony monitoring over the past five breeding seasons at other sites. Imagery will be re-sampled to 2-cm pixels, and geo-referenced to a projected coordinate system (UTM, NAD83). Distinguishing bird decoys from real birds based exclusively on aerial imagery interpretation is not always reliable. For the sites at Don Edwards NWR we will request that the

Government collect Real Time Kinematics (RTK) GPS coordinates for each decoy during the deployment process (or other method to identify decoy placement). USGS personnel associated with the Refuge have indicated that they are able to access an appropriate GPS system.

The close proximity of the Don Edwards NWR tern islands to structures that can be accurately discerned on existing geo-referenced imagery will make it feasible to remotely collect ground control coordinates that could be used to geo-reference the aerial photography during post-flight image processing. The processed photography (i.e., stitched mosaic of individual photographs) will then be provided to the Corps' COR, or to the designated POCs from the Corps, within 7 days of image capture for further analysis.

DELIVERABLES

E-verify

We will pre-screen candidates using the E-verify Program in order to meet the established employment eligibility requirements of the U.S. Government (see *Appendix B*). We will require each candidate to provide two valid forms of Government issued identification prior to entering their information into the E-verify system. A list of verified/eligible candidates will be provided to the COR NLT 5 business days following contract award and before commencement of work. This list will be updated throughout the life of the TO, as warranted.

Work Plan

We will prepare a detailed Draft Work Plan (this document) and deliver it electronically to the Corps and Reclamation for external distribution and review. This document includes details relating to the TO and tasks described in the PWS. Upon submittal of the Draft Work Plan we will meet with Corps and Reclamation staff for a pre-work coordination meeting to discuss the plan. Based on these discussions and comments received on the Draft Work Plan, the plan will be revised to address all comments received and a Final Work Plan submitted to the Corps and Reclamation NLT 30 days following receipt of comments on the Draft Work Plan.

Technical Meetings

We will attend, present, and otherwise actively participate in the following meetings:

Inland Avian Predation Work Group Meetings: One or two senior staff will be available to attend, in person, three Inland Avian Predation Work Group (or similar) meetings, as directed by the COR and other designated POCs. These meetings will be attended by Corps and Reclamation staff, as well as other stakeholders. Any presentation materials prepared for these meetings will be provided to the COR and other designated POCs for review and approval prior to each meeting.

Technical Level Work Meetings: One or two senior staff will be available to attend, in person, three technical meetings, as directed by the COR and other designated POCs. These meetings will be attended by Corps and Reclamation staff only. Any presentation materials prepared for these meetings will be provided to the COR and other designated POCs for review and approval prior to each meeting.

Avian Predation Workshop: No less that two senior staff will be available to attend, in person, the Avian Predation Workshop, tentatively scheduled for October 2016. As directed by the COR and other designated POCs, we will present project results at this workshop. All presentation materials, to include

an abstract and a PowerPoint presentation, will be provided to the COR and other designated POCs NLT 10 October or 7 days prior to the workshop. Any comments received from the COR and other designated POCs on these draft presentation materials will be addressed in the final versions.

AFEP Annual Review: No less that two senior staff will be available to attend, in person, the AFEP Annual Review, tentatively scheduled for late November – early December 2016. As directed by the COR and other designated POCs, we will present project results at this meeting. All presentation materials, to include an abstract and a PowerPoint presentation, will be provided to the COR and other designated POCs for review and approval prior to the meeting. The draft abstract will be submitted NLT 1 November 2016 and the PowerPoint presentation will be submitted NLT 20 November 2016 or 14 days prior to the meeting. Any comments received from the COR and other designated POCs on these draft presentation materials will be addressed in the final versions.

Progress Reports

We will prepare weekly and monthly updates and provide them electronically to the COR and the other designated POCs. Weekly updates will be provided during the field season (March – August) for the purposes of communicating/coordinating:(1) project accomplishments; (2) daily and weekly activities, including summary statistics; (3) upcoming project schedule/activities; (4) requests for assistance; (5) all take activities, including permit status; (6) problems encountered; and (7) issues that need to be discussed/resolved with the COR and the other designated POCs. Monthly reports will be provided from contract award throughout the life of the TO for the purposes of communicating/coordinating: (1) summary of project accomplishments; (2) summary of monthly activities, including summarization of reporting metrics provided in the weekly reports; (3) upcoming project schedule/activities; (4) take permit compliance; (5) coordination requests; (6) problems encountered; (7) monthly and YTD estimates of percent completion for each task and subtask; and (8) any other proposed discussion topics with the Corps and Reclamation POCs. All written reports will be revised prior to distribution and internal processing as requested by the COR and the designated POCs. In addition to these weekly and monthly updates, the COR will be notified on a daily basis regarding any issues related to take or potential take. Finally, we will be available for any meeting/conference calls to resolve issues identified in weekly/monthly updates.

Draft Preliminary Report

We will prepare a stand-alone 2016 Draft Preliminary Report summarizing study results, submitted electronically to the COR NLT 30 September 2016. The Draft Preliminary Report will include material content for each study task and sub-task for the purpose of planning future IAPMP activities by Corps and Reclamation staff. The Draft Preliminary Report will include the following sections: (1) Executive Summary, (2) Project Objectives and Tasks, (3) Methods and Analysis, (4) Results, and (5) Discussion, including potential biases and discussions of related projects and literature. Efforts will be made to use previous field and analytical methods such that data collected in 2016 are directly comparable to data collected in previous years. Any deviation from previously used protocols will be communicated with the Corps prior to implementation and will be carefully documented in the Draft Preliminary Report.

Final Report

The Final Report will address all comments received by the COR and other reviewers to the maximum extent practicable, and be submitted electronically to the COR NLT 15 March 2017.

Raw and Processed Data

All data collected as part of this study are the property of the U.S. Government and will be provided to the Corps upon completion of this work (*Table 1*). Finalized databases and spreadsheets, including all raw and processed data collected as part of this and other related work, will be provided to the COR. This will include, but may not be limited to, GIS layers (e.g., shape files), banding and band resighting data, PIT tag data, and all data pertaining to the execution of the work (e.g., daily active hazing effort)

Table 1. List of raw and processed data by task that will be delivered to the Corps upon completion of work.

Data Source	Data Type	Time Period
Task 2		
Mapped location of passive dissuasion at Crescent and Goose islands	ArcGIS Data	2016
Task 3		
Dissuasion data from Crescent and Goose islands	MS Excel or Access File	2016
Task 4		
Egg collection log from Crescent and Goose islands (if applicable)	MS Excel or Access File	2016
Locations of tern eggs laid at Crescent and Goose islands (if applicable)	ArcGIS Data	2016
Colony monitoring data from Crescent and Goose islands (if applicable)	MS Excel or Access File	2016
List of terns banded at Crescent and Goose islands	MS Excel or Access File	2000 - 2016
List of CATEs resighted at Columbia Plateau locations (with their original banding location)	MS Excel or Access File	2016
PIT tag detection efficiency data for Crescent, Goose, Twinning, and Blalock islands tern colonies	MS Excel or Access File	2007 - 2016
PIT tag deposition data for Crescent Island tern colony	MS Excel or Access File	2004 - 2006
List of PIT tags detected on Crescent, Goose, Twinning, and Blalock islands tern colonies	MS Excel or Access File	2007 - 2016
Aerial survey data from flights to detect tern colonies	MS Excel or Access File	2016
High resolution vertical imagery of tern colonies (Columbia Plateau)	ArcGIS Data	2016
Count data used to estimate tern colony size	ArcGIS Data	2016
Colony monitoring data from incipient tern colonies (if applicable)	MS Excel or Access File	2016
Blalock islands water level monitoring data	MS Excel or Access File	2016
High resolution vertical imagery of tern colonies (DENWR)	ArcGIS Data	2016

and calculation of colony metrics (e.g., colony counts, productivity). We will work with the COR and other designated POCs to determine the most appropriate data format prior to data delivery. The historical Caspian tern PIT tag data supporting PIT tag analyses associated with Task 4.4 shall be provided via updates to an existing database being furnished to the Corps under a different contract (i.e., PIT tag data from East Sand Island in the Columbia River estuary). The update to this database shall include all historical Caspian tern PIT tag data, including deposition rate and detection efficiency data, collected in the Columbia Plateau region regardless of the original funding agency, assuming we receive permission from that funding agency to include those data.

Technical Memorandum

A Technical Memorandum will be prepared and submitted to the Corps documenting the data processing and analytical methods used in this study. This document will be prepared in such a way as to allow independent peer review of the data processing and analysis methods. All methodologies, assumptions, constraints, data gaps, etc. will be clearly described.

PIT Tags

Upon completion of this work, all tags (PIT, acoustic, etc.) physically removed via magnets from Corps or Reclamation property will be provided to the COR or other designated POCs, regardless of funding entity supporting the collection of the tags. These tags will be provided to the Corps once all data, including metadata, have been uploaded to PTAGIS. At a minimum, the metadata provided will include the location (i.e., bird species/colony) and date of tag recovery. If any recovered tags have identifiable contact information (e.g., floy tags, acoustic tags) they will be returned to the respective owner and/or reported to the respective owner with all pertinent metadata also being transmitted to the COR.

Photographic Material

All photos and photographic data collected as part of this study are the property of the U.S. Government will be provided to the COR or the other designated POCs within one week of capture. We will provide these materials using the most appropriate electronic transfer means, depending on the size of the files and as directed by the COR.

Water Level Sensor Data

We will provide all water level data collected at the Blalock Islands on a weekly basis, within 72 hours of data download.

Water Level Sensor

Upon completion of this work, the water level sensor and associated mounting hardware will be provided to the Corps in good working order. We will also provide all pertinent manuals, specs, and operating procedures.

SCHEDULE

A detailed schedule of research activities by task and sub-task, including deliverables and key project milestones, are provided below in *Table 2*.

Table 2. Schedule of research activities, deliverables, and key project milestones by task and sub-task during the study period.

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
Task 1						
1.1	E-verify	NLT 5 business days following award	Electronically to COR	List of eligible/verified candidates, update as needed.	Jan 2016	Mar 2017
1.1	Draft Work Plan	Prior to initiation of on-site activities	Electronically to COR & POCs	Complete project schedule; data collection and analysis methods; necessary permits; BMPs; project services required; equipment description, use and deployment schedule; QA/QC Plan; description of related work.	Late Jan 2016	Mid Feb 2016
1.1	Pre-work "Site visit" Meeting	Prior to initiation of on-site activities	Provide transportation and meet with COR and POCs on site	Discuss project details and Draft Work Plan.	Late Feb 2016	Late Feb 2016
1.1	Final Work Plan	NLT 30 days following receipt of comments from Corps and Reclamation on Draft Work Plan	Electronically to COR & POCs	Incorporate all comments on Draft Work Plan in Final Work Plan.	Late Feb 2016	Late Mar 2016

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
1.2	Work Group Meetings	During field work (February – August)	In-person attendance (staff and senior staff); Presentation materials submitted electronically to COR & POCs	3 meetings to present project results to Corps, Reclamation, and stakeholders.	Late Feb 2016	Aug 2016
1.2	Technical Meetings	Throughout term of TO	In-person attendance (staff and senior staff); Presentation materials submitted electronically to COR & POCs	3 planning meetings with Corps and Reclamation staff.	Late Feb 2016	Mar 2017
1.2	Avian Predation Workshop Abstracts and Presentation Materials Review	NLT 10 October or 7 days prior to the event	Electronically to COR & POCs	Review abstracts and presentation materials with Corps prior to workshop.	Oct 2016	Oct 2016
1.2	Avian Predation Workshop	October	In-person attendance (staff and senior staff); Abstract and PowerPoint submitted electronically to COR & POCs	Annual meeting to present results from various avian predation-related studies.	Early Oct 2016	Late Oct 2016
1.2	AFEP Abstract and Presentation Review	20 November 2016 or 14 days prior to the scheduled meeting	Electronically to COR & POCs	Review presentation with Corps prior to AFEP Annual Review.	Nov 2016	Nov 2016

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
1.2	AFEP Annual Review	Late November – early December	In-person attendance (staff and senior staff); Abstract and PowerPoint submitted electronically to COR & POCs	Annual meeting to present results Corps-funded studies.	Early Nov 2016	Dec 2016
1.3	Monthly Updates	Monthly throughout term of TO	Electronically to COR & POCs	Describe monthly project progress and plans (to include hazing efforts).	Jan 2016	Mar 2017
1.3	Weekly Updates	Weekly during field season (February – August)	Electronically to COR & POCs	Describe weekly project progress and plans (to include hazing efforts).	Feb 2016	Aug 2016
Task 2						
2.1	Repair of passive dissuasion on Crescent Is.	Prior to arrival of birds at the island	NA	Assess condition of existing dissuasion; repair fences, stakes, and rope; install flagging.	Feb 2016	Early Mar 2016
2.1	Install new passive dissuasion on Crescent Is.	Prior to arrival of birds at the island, as needed	NA	Install new fences, stakes, rope, and flagging, as needed	Feb 2016	Early Mar 2016

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
2.1	Provide input on Russian olive tree placement	Early January or as directed by the COR	NA	Provide input to the Corps COR on the final dispersal of cut Russian olive trees across the island for the purposes of creating effective passive dissuasion and to ensure repair and maintenance of existing passive dissuasion materials can be effectively performed.	Early Jan 2016	Early Feb 2016
2.1	Maintain passive dissuasion on Crescent Is.	As needed	NA	Maintain fences, stakes, rope, flagging, and woody debris, as needed.	Early Mar 2016	Late July 2016
2.1	Remove passive dissuasion on Crescent Is.	NLT 31 September 2016	NA	Remove all flagging and project equipment from island.	Aug 2016	Sept 2016
2.2	Repair of passive dissuasion on Goose Is.	Prior to arrival of birds at the island	NA	Assess condition of existing dissuasion; repair stakes and rope; install flagging.	Feb 2016	Early Mar 2016
2.2	Install new passive dissuasion on Goose Is.	Prior to arrival of birds at the island, as needed	NA	Install additional stakes, rope, and flagging, as needed; install owl effigies.	Feb 2016	Early Mar 2016
2.2	Maintain passive dissuasion on Goose Is.	As needed	NA	Maintain stakes, rope, and flagging, as needed.	Early Mar 2016	Late July 2016
2.2	Remove passive dissuasion on Goose Is.	NLT 31 September 2016	NA	Remove all flagging and project equipment from island.	Aug 2016	Sept 2016

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
Task 3						
3.1	Anchor houseboat in cove near Crescent Is.	Early March	NA	Allows crew to stay near island to facilitate dawn and dusk hazing efforts.	Early Mar 2016	Late Jul 2016
3.1	Conduct active hazing on Crescent Is.	When birds present on island	NA	Adaptive management strategy to prevent nesting.	Late Feb 2016	Late Jul 2016
3.2	Construct field camp on Goose Is.	Early March	NA	Allows crew to stay on island to facilitate dawn and dusk hazing efforts.	Early Mar 2016	Late Jul 2016
3.2	Conduct active hazing on Goose Is.	When birds present on island	NA	Adaptive management strategy to prevent nesting.	Late Feb 2016	Late Jul 2016
Task 4						
4.1	Colony monitoring on Crescent Is.	Late February - July	NA	Assess management effectiveness on Crescent Is.	Late Feb 2016	Late Jul 2016
4.2	Colony monitoring on Goose Is.	Late February - July	NA	Assess management effectiveness on Goose Is.	Late Feb 2016	Late Jul 2016

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
4.3	Resighting of color-banded Caspian terns	Late February - July	NA	Method to determine colony connectivity and dispersal of managed Caspian terns.	Late Feb 2016	Late Jul 2016
4.4	Determine species and stock specific predation rates on salmonids	Following breeding season	NA	Evaluate Caspian tern impacts to salmonids based on past PIT tag recoveries.	Aug 2016	Sept 2016
4.5	System-level monitoring in the Columbia Plateau region: aerial photo surveys	Early incubation; Late incubation; Peak fledging	NA	3 photo surveys to determine Caspian tern colony locations, colony size, and colony area.	Late Apr 2016	Late Jun 2016
4.5	System-level monitoring in the Columbia Plateau region: high resolution aerial photo survey	Late incubation	NA	High resolution, vertical imagery used to estimate colony size and area	Late May 2016	Late May 2016
4.5	System-level monitoring in the Columbia Plateau region: land-based surveys	April – July	NA	Assess colony metrics at all Caspian tern colonies in the Columbia Plateau region.	Apr 2016	Jul 2016

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
4.6	System-level monitoring in the Columbia Plateau region: water level monitoring at Blalock Islands	NLT 60 days following award – late January 2017	NA	Assess fluctuations in water levels at the Blalock Islands and how that affects the availability of tern nesting habitat.	Jan 2016	Jan 2017
4.7	System-level monitoring at Don Edwards NWR: high resolution aerial photo survey	Late incubation	NA	One set of high resolution photos to estimate tern colony size and colony area.	Late Feb 2016	Late Jul 2016
4.7	Don Edwards NWR materials	By 16 February 2016	NA	Provide any materials necessary to be placed at Don Edwards NWR	Late Feb 2016	Late Jul 2016
ALL						
All	Draft Preliminary Report	NLT 30 September 2016	Electronically to COR & POCs	Draft report including Executive Summary, Project Objectives and Tasks, Methods and Analysis, Results, and Discussion. Report shall also include at minimum, a discussion of biases and other related projects.	Aug 2016	Late Sept 2016
All	Final Report	NLT 15 March 2016	Electronically to COR & POCs	Incorporation of all comments received on Draft Preliminary Reports. Substantive and detailed response to all Corps comments.	Oct 2016	Mid Mar 2017

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
All	Raw and Processed Data	NLT 15 March 2016	Electronically to COR	Raw and processed data files to the Corps to include, GIS layers (e.g., shape files), banding and band resighting data, PIT tag data, and all data pertaining to the execution of the work.	Jan 2017	Mid Mar 2017
All	Technical Memorandum	NLT 15 March 2016	Electronically to COR	Documentation of data processing and analytical methods, pertinent metadata, and programmatic code necessary for the Corps to conduct independent peer-review of analyses.	Jan 2017	Mid Mar 2017
All	Physically Recovered Tags	NLT 15 March 2016	Transferred to Corps	Physically recovered PIT tags shall be returned to the Corps upon their inclusion in PTAGIS. Other identifiable tag types shall be transferred to the respective owner with receipt of delivery also sent to the Corps.	Jan 2017	Mid Mar 2017
All	Photographic Material (4.7)	Within one week (7 days) of creation	Electronically to COR & POCs	All photographs taken during the contract period will be provided to the Corps with one week of creation.	Late Feb 2016	Mid Mar 2017

Task	Deliverable/ Required Service	Date Required	Delivery Method	Description	Anticipated Start Date	Anticipated End Date
All	Water Level Sensor Data (4.6)	Weekly, within 72 hours of download	Electronically (single CSV formatted file) to COR & POCs	Water level sensor data at the Blalock Island Complex.	Jan 2016	Jan 2017
All	Project equipment	NLT 15 March 2016	Transferred to Corps	Water level sensor	Mid Mar 2017	Mid Mar 2017

QUALITY ASSURANCE/QUALITY CONTROL PLAN

Key Personnel (see *above*) will ensure that all nest dissuasion materials adhere to the specifications described above and that all nest dissuasion activities are conducted as described above and in accordance with the BMPs (see *Appendix A*). Key Personnel will also make sure that field protocols and permit requirements are being followed and that data are collected, analyzed, and reported so as to ensure accuracy and consistency with previously reported results. An internal schedule for each task and deliverable identified in the TO will be created to ensure fulfillment of project deadlines and deliverables (see *above*). All acquired information (raw data, summary data, output from queries/analyses, etc.) will be organized, validated, and automatically archived (backed up) on both local and remote (online) servers for redundancy.

Four primary phases of the work include: (1) passive nest dissuasion deployment, (2) active nest dissuasion actions, (3) data collection and analysis, and (4) reporting. Our approach to Quality Control/Quality Assurance for each phase is described below.

Passive nest dissuasion: To ensure that expected areas of passive dissuasion at Crescent and Goose islands are met, and that accurate estimates of needed materials are available for procurement, approximate areas and configurations needed to be covered in 2016 will be delineated using ESRI ArcMap software and 2015 georeferenced aerial imagery. Fence features at Crescent Island will be drawn as lines with 15-ft. spacing. The total length of fencing required will be calculated in linear feet for each dissuasion layout. Areas of posts, rope, and flagging at both Crescent and Goose islands will be drawn as polygons that will then be populated with 10 ft. x 10 ft. matrices of points (representing posts). The number of posts in each dissuasion area will be quantified in order to calculate quantities of posts, rope, and flagging.

Material selection/testing **–** All materials sourced to execute the installation of passive dissuasion at Crescent and Goose islands were and will be extensively researched to ensure: (1) materials are of commercial/industrial quality to withstand adverse environmental conditions, (2) materials can be purchased from qualified vendors able to provide bulk quantities with short lead times, and (3) materials were previously used in similar applications. Whenever possible, identical materials and vendors will be selected based on prior successful applications (i.e. Goose Island in 2014-2015 and Crescent Island in 2015). Samples of potential dissuasion materials will be procured whenever possible, and inspected by experienced personnel (Brad Cramer) to determine their likelihood of effectiveness.

Material installation – To ensure installation of passive dissuasion materials at Crescent and Goose islands is in accordance with the IAPMP, PWS, and accepted Work Plan, multiple levels of QA/QC will be employed. Georeferenced image-based schematics of each island will be created to ensure minimum areas of passive dissuasion are met. Thorough site planning will occur at each site before any installation begins to ensure consistent distances between fence rows, pier blocks, and posts. When possible, jigs will be constructed to both automate site layout and the cutting of bulk materials to accepted installation lengths. Experienced personnel with prior experience installing passive dissuasion (Brad Cramer) will be on site to ensure that consistent and quality work occurs. All staff participating in the installation will receive detailed instructions and training on proper installation techniques and be provided with adequate tools and safety equipment. Senior project personnel will receive photographs and site maps each week throughout the installation process, and receive daily progress reports via phone and email to

ensure satisfactory and timely installation occurs at both Crescent and Goose islands. Once all passive dissuasion is installed at each site (NLT 15 March), we will provide the USACE and Reclamation with schematics (to-scale) depicting the final configuration of passive dissuasion at each site, in addition to a series of high-quality photographs to document specifications and workmanship.

Active nest dissuasion: Our team is committed to conducting the project described herein with the highest possible degree of scientific and professional integrity. We have extensive experience conducting avian predation research and monitoring in the Columbia River and Snake River systems, and have directly contributed to the Corps and Reclamation efforts to develop, implement, and monitor management activities focused on reducing Caspian tern predation of juvenile salmonids in the Columbia Basin.

In 2014, a Best Management Practices (BMPs; see *Appendix A*) document was prepared by OSU/RTR and approved by the Corps and Reclamation. This document was developed to guide all field activities associated with the implementation of the IAPMP. This working document has been revised to cover work to be conducted at Goose and Crescent islands in 2015-2016, and will continue to be developed by the PIs as needed, with input from senior staff in the field, and changes/additions approved by the COR and other designated POCs prior to implementation.

Senior staff (Pete Loschl or Brad Cramer) will visit field sites where active nest dissuasion activities are being conducted no less than twice each month during the field season (i.e. February - August) to ensure that all procedures outlined in the Work Plan are being successfully implemented, along with all stipulations and conditions in the associated management documents and issued permits. Additionally, experienced crew leaders (e.g., John Mulligan) will be on site throughout the field season to oversee daily activities.

All activities associated with active dissuasion at each site will be recorded in detail by project staff in field notebooks. Wherever possible, standardized data collected to assess the effectiveness of active dissuasion will be gathered electronically in the field to eliminate transcription errors. These data will be regularly archived in a secure web portal accessible to senior staff. At least once per week senior staff will review field data to ensure accurate, complete, and standardized data are being collected. In addition, weekly maps will be drafted by each site crew lead to document notable use of Goose and Crescent islands by Caspian terns, gulls, Canada geese, and other waterbirds of potential interest. The maps will include locations of active nests (all species, as feasible), nest prospecting locations (Caspian terns), and loafing/roosting locations (Caspian terns). All maps will be reviewed by senior project staff and shared with action agencies in weekly reports.

Data collection, analysis, and reporting: To ensure quality, accurate, and standardized data collection occurs for the tasks described above, all project staff will receive a detailed data collection protocol developed by senior project staff, and undergo formal training by senior staff in the field (Kirsten Bixler and Yasuko Suzuki). Additionally, electronic data collection systems will be developed and employed whenever possible. At a minimum, a suite of electronic data collection applications will be used to document active dissuasion, record Caspian tern breeding chronology, collect resight observations, and quantify waterbirds at sites of interest from ground, boat, and aerial surveys. Electronic data collection will reduce transcription errors and ensure standardized information is being gathered across the project by all staff. All data are regularly archived in a secure project web portal that is monitored by senior project staff at least once per week. A hierarchical access system ensures only senior project staff are able to make changes to and download data. All data derived from these systems undergoes

additional review prior to analysis. In addition a series of unique validation rules has been built into each application to prevent erroneous data collection. All data systems have undergone field testing to ensure accurate and efficient data collection.

The Key Personnel will internally review all project deliverables (i.e. work plan, progress reports, annual report, presentation materials, and technical memorandum; see *above*) for content, formatting, and accuracy. Following internal review, Corps and Reclamation staff will have the opportunity to review results. Any comments, questions or concerns by the Corps and Reclamation will be addressed as they arise and fully resolved and incorporated into the final deliverables. The Program Manager (Ken Collis) will ensure adherence to PWS requirements, government standards, and secure distribution. See *Figure 13* for work flow diagram for data collection analysis, and reporting.

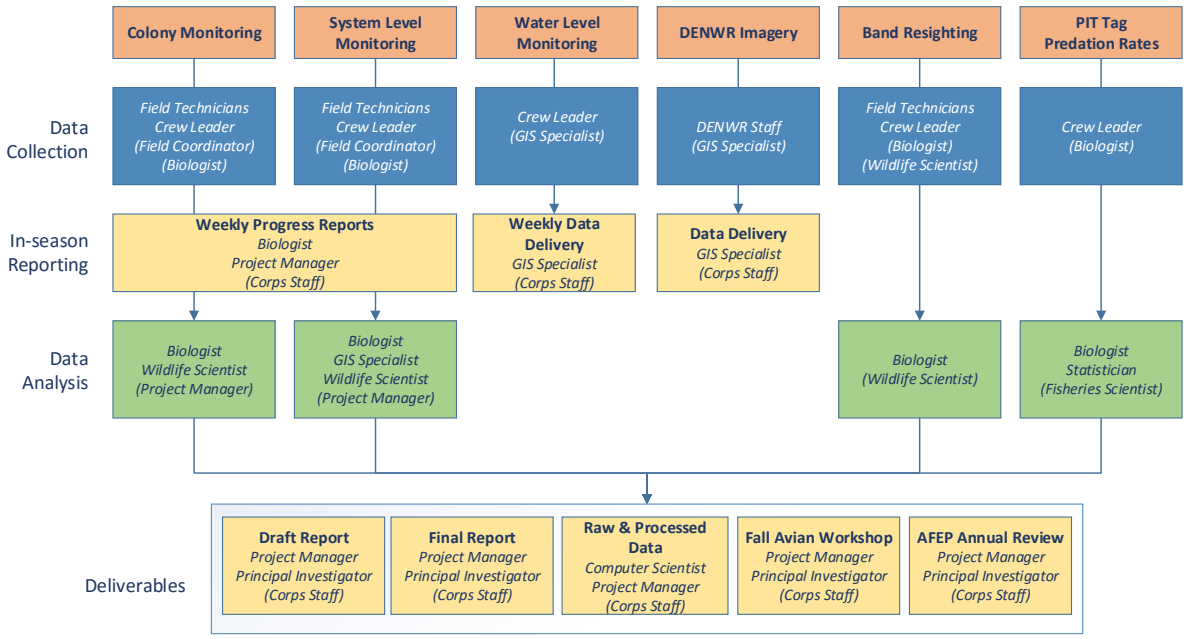

Figure 13: Flow chart illustrating project workflow, primary contributors, and personnel involved in Quality Control and Quality Assurance (identified in parentheses).

GOVERNMENT FURNISHED EQUIPMENT

Aside from the existing passive nest dissuasion materials on Goose Island and Crescent Island, the observation blind on Crescent Island, owl decoys and propane cannons on Goose Island, and 12-mm PIT tags for detection efficiency studies, there is no Corps or Reclamation furnished, loaned, or directly procured equipment/materials identified in this work. We will purchase equipment as part of this contract (i.e. water monitoring equipment deployed in the field from March 2016 – January 2017) that will become Corps property at the completion of the work. The water monitoring equipment and owl decoys will be tagged to identify the property owner (Corps/Reclamation), study dates, and expected removal date. All equipment will be returned to the Corps (water monitoring equipment) and Reclamation (owl decoys) as specified above.

CONTRACTOR EQUIPMENT

We have all the equipment (boats, tunnels, field camps, temporary observation blinds, optics, etc.) required to conduct this work safely and as proposed. We will be responsible for the setup, use, and removal of all contractor-owned equipment used during the duration of this work (February – July) in accordance with landowner and permitted conditions. All equipment will be tagged to identify the property owner (Real Time Research/OSU), study dates, and expected removal date. All equipment will be removed from Goose Island and Crescent Island as described above, or as coordinated with the COR.

PERMITS

All permits needed to conduct this work will be acquired prior to initiating any work in the field (i.e. Conditional Use Permit for island access and the Migratory Bird Treaty Act Take Permit for Caspian tern egg collection), the former will be obtained by our research team and the latter will be obtained by the Corps and provided to our team. All project staff will strictly adhere to the terms and conditions of these permits.

There will be no ground disturbing activities as part of this work. If archaeological remains are found during any activities, all work in the immediate area will cease and efforts will be made to protect the find and notify the COR immediately.

SAFETY

We will conform to all safety standards of the most recent edition of the Corps' Safety and Health Requirements Manual EM-385-1-1. A Job Safety Analysis, also known as an Activity Hazard Analysis (AHA), will be prepared as required in Section 1 of EM-385-1-1 prior to initiation of the work tasks. The Job Safety Analysis will be updated and resubmitted to the designated POCs and COR, as warranted.

Our research team has been working in the Columbia Plateau region for well over a decade and this knowledge is paramount to crew safety and the overall success of the project. All employees hired to do work outlined in the TO will be required to complete approved boat safety training, First Aid, CPR, and animal care and use training. A Health and Safety Plan, which details potential risks and ways to avoid these risks while working in the field, will be provided to all employees (contractors and subcontractors) prior to the initiation of field work. Regular visits into the field by senior staff will assure that all work is being conducted in accordance with all safety protocols.

We will coordinate with the COR when accessing Goose Island and Crescent Island. Only employees/staff having security clearance will be allowed to access the study site.

RELATED STUDIES

Work conducted as part of this Task Order is part of a comprehensive program to manage piscivorous waterbirds to reduce their impacts on ESA-listed juvenile salmonids from the Columbia River Basin. Funding for this comprehensive program comes from many sources, including the U.S. Army Corps of Engineers (USACE) – Walla Walla District and the U.S. Bureau of Reclamation (this study) as well as the

Bonneville Power Administration (BPA; funding obligated), Grant County Public Utility District/Priest Rapids Coordinating Committee (GPUD/PRCC; funding obligated), and the USACE – Portland District (funding and contractor still pending); see below for the program funding support provided by each agency, by location and task (*Table 3*). In general, funding for avian predation work conducted in the Columbia River estuary will be from a grant from BPA and a contract from USACE – Portland District; funding for work conducted outside the Columbia River Basin will be from a contract from USACE – Portland District; funding for avian predation work conducted in the Columbia Plateau region will be from contracts with the USACE - Walla Walla District, BOR, and the GPUD/PRCC.

Although there is cost sharing from GPUD/PRCC to conduct work in the Columbia Plateau region in 2016 (to increase sampling effort), there are no activities proposed or planned that will impinge on the work or study objectives outlined herein.

Table 3: Agency funding to implement, monitor, and evaluate plans to reduce avian predation on ESA-listed salmonids in the Columbia Basin.

	Funding Contribution by Agency				
	BPA	USACE Portland	USACE Walla Walla	BOR	GPUD/PRCC
Caspian Terns					
Columbia River Estuary					
Implementation of management actions	x	x			
Colony and system-level monitoring	x	x			
Band resightings	x				
PIT tag recoveries and analysis (salmonids)	x				
Columbia Plateau Region					
Implementation of management actions			x	x	
Colony and system-level monitoring			x	x	x
Band resightings			x	x	x
Tracking of previously satellite-tagged terns					x
PIT tagging of salmonids at Rock Island Dam					x
PIT tag recoveries and analysis (salmonids)			x	x	x
Interior OR and Northeastern CA					
Implementation of management actions		x			
Colony and system-level monitoring		x			
PIT tag recoveries and analysis (sucker and redband trout)		x			
Don Edwards NWR, San Francisco Bay					
Implementation of management actions		x	x	x	
Colony and system-level monitoring		x	x	x	
Band resightings		x	x	x	
Double-crested cormorants					
Columbia River Estuary					
Implementation of management actions		x			
Colony and system-level monitoring		x			
Band resightings		x			
PIT tag recoveries and analysis (salmonids)		x			
Gulls and Pelicans					
Columbia River Estuary					
Colony and system-level monitoring	x				
Columbia Plateau					
Colony and system-level monitoring					x
PIT tag recoveries and analysis (salmonids)					x

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APPENDIX A: BEST MANAGEMENT PRACTICES

The goal of management on Goose Island and Crescent Island (hereafter referred to collectively as the "managed islands") is to prevent any more than 40 pairs of Caspian terns from nesting on either island. In order to achieve this goal, the objective in 2016 is to dissuade all Caspian terns from nesting on the two managed islands. Caspian tern nesting is defined as terns laying one or more eggs in a nest scrape.

A strategy that the federal management agencies (Corps of Engineers, Bureau of Reclamation, and U.S. Fish and Wildlife Service) have adopted for achieving the above objective is to try to prevent or delay all gulls from nesting on the managed islands. This strategy is based on the supposition that once gulls lay eggs on the managed islands, Caspian terns will be attracted to nest near active gull nests, and terns that attempt to nest near active gull nests cannot be hazed without causing gull nests to fail. This is because nests of gulls that are flushed during tern hazing will be at risk of having their eggs depredated by other gulls. The U.S. Fish and Wildlife Service has stated that, while it is prepared to issue a permit to take a limited number of Caspian tern eggs on the managed islands (≤ 200 eggs total), in the event that Caspian terns successfully lay eggs, the agency cannot issue a permit for incidental take of other migratory bird species, including incidental take of gull eggs during tern hazing activities. Therefore, by preventing or delaying gull nesting on the managed islands, the potential for active gull nests (those with eggs) to shield Caspian tern nests from hazing would be reduced. Similarly, Canada geese, herons, and egrets have nested on one or both of the managed islands in previous years, and BMPs have been developed for these species as well.

The difficulty in dissuading all gulls from nesting on the managed islands using passive dissuasion (landscape fabric fences; stakes, ropes, and flagging; woody debris; owl decoys) and human hazing techniques has been communicated to the federal management agencies. Prior to the waterbird breeding season, large areas of passive dissuasion will be installed on each island at the direction of the management agencies to make the islands less attractive to nesting Caspian terns. Observations on Goose Island during 2014-2015 indicated that, unlike Caspian terns, ring-billed gulls and California gulls did not avoid passive dissuasion; the two gull species readily entered areas of passive dissuasion and initiated nests. In addition, gulls tended to acclimate more readily than Caspian terns to repeated human hazing, and quickly returned to their nest sites after flushing due to human hazing.

The Bureau of Reclamation (owner of Goose Island) is planning to test additional management actions for precluding gulls and terns from nesting on Goose Island in 2016, including propane cannons, water cannons, predator decoys, bird distress call systems, and windsocks. These test actions are limited in their use to the period before gulls begin laying eggs on the island, and these actions will be managed directly by Reclamation. Crepuscular and nocturnal hazing using bright lights and lasers to enhance the efficacy of passive dissuasion and daytime human hazing have been authorized for use again in 2016 under Reclamation's NEPA Categorical Exclusion for test actions noted above. These techniques showed some promise for delaying the initiation of gull nests on Goose Island during 2014-2015 by causing island abandonment by gulls each night during the early stages of the breeding season (before egg-laying commenced). However, once gull nests with eggs are confirmed on either managed island, crepuscular or night-time hazing that may lead to overnight island abandonment will be discontinued to avoid egg loss during the nocturnal absence of nesting adults. Weather-permitting, personnel will stay overnight in a portable building on Goose Island, or in a houseboat anchored just off-shore of Crescent Island, so they can haze any gulls that attempt to spend the night on the islands during the pre-egg-

laying period, and to use bright lights and lasers to dissuade gulls that attempt to return to the island at first light.

Passive dissuasion (stakes, ropes, and flagging at both islands, plus fabric fencing on Crescent Island) will be installed to cover essentially all of the suitable and marginally suitable Caspian tern nesting habitat on the managed islands, and the area where passive dissuasion has been deployed will be the primary focus of gull hazing. Fixed and portable observation blinds may also be used to dissuade gull nesting using lasers, especially gulls that attempt to nest in any interior areas of either managed island.

Results of passive and active nest dissuasion at Goose Island during 2014-2015 indicated that even with intensive human hazing, gulls are likely to ultimately establish nests and lay eggs on Goose Island, both within and outside the passive dissuasion areas. In 2015 for the first time, two pairs of Caspian terns were decoyed into areas of passive dissuasion by nesting gulls and ultimately nested successfully. Also, Caspian terns initiated nests on marginal nesting habitat on Goose Island that lies just outside areas covered by passive dissuasion; therefore, more passive dissuasion will be added to Goose Island in 2016 (as determined during the pre-season site visit). Careful monitoring and active hazing of prospecting Caspian terns will likely be necessary in 2016 to prevent Caspian terns from nesting on Goose Island.

We have also developed BMPs for minimizing disturbance to other nesting migratory birds during hazing of gulls and Caspian terns on the two managed islands. Canada geese are known to nest on both managed islands, and great blue herons, black-crowned night-herons, and great egrets are known to nest on Crescent Island. Flushing any of these non-target species from their nests has the potential to result in egg loss due to egg predators. Canada geese generally nest on the ground, whereas herons and egrets generally build stick nests in trees and tall shrubs. The areas where herons and egrets have nested previously on Crescent Island are in the densely-vegetated interior of the island; these areas are not used by nesting gulls or Caspian terns and are unsuitable as nesting habitat for either gulls or terns. Consequently, these areas of the island will not be hazed to prevent or delay gull nesting, and will be avoided to minimize disturbance to non-target nesting herons and egrets.

Using the same techniques described for Caspian terns and gulls, geese, herons, and egrets will be dissuaded from establishing new nests on the portions of the managed islands where gull and tern hazing will be conducted. For any goose, heron, or egret nests with eggs, or nests of other non-target migratory birds that may be discovered during the process of hazing Caspian terns or gulls, practices to reduce the chances of egg loss are described in detail below.

Early in the pre-breeding period, before behaviors associated with imminent egg-laying are widespread (e.g., nest-building, copulation), human hazing of gulls will consist of walk-throughs of the island to flush any and all gulls and Caspian terns that are present. Twice each day, a 2-person crew will conduct a walk-through of each managed island. These walk-throughs will occur early in the day (before 10:00 am) and late in the day (after 3:00 pm), weather permitting. During each walk-through, the locations of any gull and tern aggregations will be mapped on a diagram of the island. Once per week, the locations of gulls by species (ring-billed gulls or California gulls) and terns will be mapped. Any areas where gulls or terns are holding territories or engaged in pre-laying behaviors (i.e. courtship, territorial display, copulation, and nest-building) will also be marked on the map. If possible, the species of gull (California or ring-billed) that is engaged in pre-laying behaviors will be recorded. All gulls on the island will be flushed at least once during each walk-through event, unless gulls are known or suspected of attending eggs. All gull and tern nests not containing eggs that are discovered during island walk-throughs will be dismantled or filled in.

Prior to each of the early-day walk-throughs, the crew will boat around each managed island and estimate the numbers of all gulls and Caspian terns on the island, as well as the numbers of gulls and Caspian terns roosting on any emergent rocks nearby. Counts will be completed relatively quickly (< 30 min). When large numbers of gulls are present (thousands), it will be acceptable to estimate the number of gulls present by counting in 100s of individuals, and there will be no attempt to distinguish between the two gull species in the numbers of gulls present. Gull counts/estimates will be entered into the waterbird survey mobile data collection application and reported in the weekly report to the Corps and Reclamation. An estimate of the proportion of each gull species on each managed island and how gull numbers were estimated (e.g., counted by 100s) will be included. Counts of Caspian terns observed on each island will be entered into the Caspian tern mobile data collection application and reported in the weekly report to the Corps and Reclamation. If Caspian terns are likely present in areas difficult to survey from the boat, follow-up counts of Caspian terns will be conducted from blinds adjacent to the former colony areas, or other suitable vantage. For extended observations of Caspian terns from a blind, we will include counts upon arrival and before departure, and will include the maximum number of Caspian terns observed in the "notes" section of the tern mobile data collection application. We will update or replace boat-based counts/estimates of gulls and Caspian terns with blind-based counts when blind-based counts are more accurate or complete. In addition to counts of gulls present on the managed islands, we will use the waterbird survey mobile data collection application to record the numbers of Canada geese, herons, and egrets that are observed during waterbird surveys and during hazing activities. For each species, we will record data on the number of individuals, nesting status (if known), and number of eggs for any active goose nests located (clutch size for heron and egret nests will not be determined because they generally nest only in trees or tall shrubs). As for gulls and Caspian terns, we will include counts/estimates of individuals, nesting status, and any observed pre-laying behaviors in the weekly report to the Corps and Reclamation.

Once large numbers of gulls have initiated pre-laying behaviors on the managed islands, island walk-throughs will be increased in frequency in an effort to increase the deterrence for gulls and Caspian terns to lay eggs on the islands. At least two morning walk-throughs starting in the hour before dawn and conducted over the subsequent 3-hour period, and two afternoon walk-throughs conducted over a 3-hour period and ending after dark will be conducted; during each walk-through all gulls and/or Caspian terns will be flushed, with the exception of those gulls known or suspected to be attending eggs. During the period leading up to egg-laying by gulls, colony monitors will stay over-night on or near the island (with landowner authorization and weather permitting) so that all gulls can be cleared off the island over-night by hazing after dark, and so that hazing can be initiated as soon as gulls attempt to return to the island in the pre-dawn hours.

If gulls are suspected of having laid eggs in a nest, either outside or inside the passive dissuasion area, the attending adult gull will be approached slowly and cautiously in order to induce the gull to stand-up, but not flush from its nest. This may require carefully approaching the gull nest to within a few meters. Once the gull has stood up and if the observer determines that eggs are present, the observer will gradually back away from the nest in order to avoid flushing the adult gull and exposing the egg(s) to potential predation by other gulls. The number of gull nests with eggs and the number of eggs per nest will be recorded. Each gull egg detected on a managed island will be reported to Pete Loschl and/or Dan Roby as soon as practical (during the same day, at the latest) so that they can forward the information to the Corps and Reclamation. If loss of a gull egg due to gull depredation is observed, this will also be reported the same day to Pete Loschl and/or Dan Roby. Potential new gull nests will be checked for eggs only if the nest is more than 15 m from the nearest gull nest already confirmed to contain eggs.

If a Caspian tern nest with eggs is suspected anywhere on a managed island, the verification procedure will depend on the context of the suspected Caspian tern nest. If no active gull nests are verified or suspected within 15 m of the suspected Caspian tern nest, then the tern nest will be approached close enough to cause the tern to flush from the nest scrape. If there are known or suspected gull nests within 15 m of the suspected tern nest, then the approach of the suspected tern nest will be slow and cautious so as to preclude gulls from flushing from their nests and exposing their eggs to gull predation. If the Caspian tern on the suspected nest is flushed and reveals one or more tern eggs, those eggs will be collected (under permit) and transported whole in egg containers back to the field house. Collected Caspian tern eggs can be stored temporarily in a refrigerator, for eventual transport to Oregon State University for further analyses.

If a suspected Caspian tern nest is located within 15 m of a known or suspected gull nest containing eggs, the tern nest will not be approached to verify the presence of tern eggs UNLESS previous experience with the nesting gulls in question indicates that they are unlikely to flush from their nests as a result of an observer approaching the suspected tern nest. If a recently laid Caspian tern egg can be collected without causing nesting gulls to flush and expose their own eggs to gull predation, then it will be collected; if the Caspian tern egg cannot be collected without flushing gulls from nearby nests with eggs, than the tern egg will not be collected. Any Caspian tern eggs that are laid on either of the managed islands, whether or not they are collected, will be reported to Pete Loschl and/or Dan Roby as soon as practical so that they can forward the information to the Corps and Reclamation, and for subsequent reporting to the USFWS. Reporting to the Corps and Reclamation will occur during the same day that any Caspian tern eggs are detected or collected for reporting to the USFWS Migratory Bird office in Portland.

If a Canada goose nest with eggs is suspected anywhere on a managed island, the verification procedure will depend on the context of the suspected goose nest, as for suspected Caspian tern nests. If no active gull nests are verified or suspected within 15 m of the suspected goose nest, then the goose nest should be inspected to confirm the nest contents. If eggs are confirmed, they should be counted quickly and the goose down lining the nest should be pulled over the eggs to shield them from the view of predators. This should occur very quickly and researchers should then move away from the nest.

If a heron or egret nest is being built on either of the managed islands in an area that is suitable for gull or Caspian tern nesting (i.e., sparsely vegetated or unvegetated ground), then these pre-laying herons and egrets will be hazed in the process of hazing pre-laying gulls and terns. If a heron or egret nest is suspected of containing one or more eggs (based on the behavior of parent birds at the nest, the verification procedure will again depend on the context of the suspected nest, as for suspected Caspian tern nests. Field technicians will use professional judgment to decide whether a heron or egret nest suspected of containing eggs is in potential gull or Caspian tern nesting habitat. If the suspected heron or egret nest is in densely-vegetated habitat completely unsuitable for gull or tern nesting habitat, it will be avoided. Because field technicians will likely be unable to see into heron and egret nests in trees or tall shrubs, field personnel should observe suspected heron and egret nests in potential tern or gull nesting habitat from a vantage that does not cause the heron or egret to leave the nest. Herons or egrets that hold tight to well-built stick nests when an observer moves slowly to within 15 m will be considered to contain eggs. Heron and egret nests will be recorded as “active” for nests deemed likely to contain eggs or “inactive” for herons/egrets that appear to be pre-breeding or nest building. Researchers will promptly move away from heron and egret nests that likely contain eggs.

Continued gull or Caspian tern nest dissuasion in any area around a known or suspected active goose, heron, or egret nest (i.e., containing eggs) will be carried out using techniques to minimize the possibility of egg loss by these non-target species. These include (1) a slow, indirect approach to the area where a nest is known to be present, (2) averting eyes to avoid direct eye contact with the attending bird, (3) when possible, traveling along the island perimeter to avoid pressuring the attending bird into a preferred escape route in the direction of water, (4) moving relatively quickly away from the area where a nest with eggs is located (the general 30-m vicinity), and, (5) when the possibility of gull nest initiation (egg-laying) appears low, the frequency of gull dissuasion will be temporarily reduced in areas with newly discovered goose nests with eggs and/or goose nests with recently-laid eggs (as suggested by small, likely incomplete clutches [e.g., < 4 eggs]). If feasible, gull dissuasion near incipient goose nest will be reduced for 4-7 days until the nesting geese further invest in their nesting effort and there is less risk of nest abandonment. Gull dissuasion will be reduced locally in a similar manner around newly discovered heron and egret nests that likely contain eggs to reduce the likelihood of nest abandonment during the early incubation phase. If there is a potential risk of egg predation during any short term displacement of a goose from a nest (e.g., by common ravens), (6) the goose down lining the nest will be used to cover the eggs to obscure them from view. Other best management practices to minimize nest abandonment and egg loss by migratory bird species other than Caspian terns will be employed as identified.