Burrowing Owl Conservation Report: 2020

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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P.O. Box 650
Richland, Washington 99352

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E. Norris, MSA
J. Nugent, MSA
J. Wilde, MSA

Mission Support Alliance
Richland, WA

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EXECUTIVE SUMMARY

The Western Burrowing Owl (*Athene cunicularia*) is a small migratory species of owl found throughout the Western United States. Burrowing Owls are found throughout a variety of habitats including shrub-steppe; and during the breeding season the Hanford Site is situated at the center of the predicted distribution of Burrowing Owls in Washington State (Smith et al. 1997). The Western Burrowing Owl is declining over much of its range, including on the Hanford Site and throughout the Columbia Basin (HNF-59375, Conway 2006). These declines have been attributed to habitat loss and a subsequent loss in burrowing mammals that the owls depend on for nesting habitat (Conway et al. 2006, Johnson et al. 2010). The Washington State Department of Fish and Wildlife lists Western Burrowing Owls as a Candidate Species, meaning the species is a candidate for listing as Sensitive, Threatened, or Endangered in Washington (WDFW 2020). Without intervention, continued declines may result in the extirpation of Burrowing Owls from the Hanford Site and the Columbia Basin.

The U.S. Department of Energy, Richland Operations Office conducts ecological monitoring on the Hanford Site to collect and track data needed to ensure compliance with environmental laws and policies, and prioritizes monitoring species that are rare or declining. The purpose of this report is to provide a comprehensive review of Burrowing Owl monitoring data and mitigation activities that have occurred on the Hanford Site since 2012. This report documents Burrowing Owl habitat monitoring, artificial burrow maintenance, owl banding activities with the U.S. Fish and Wildlife Service, and mitigation activities aimed at restoring Burrowing Owl habitat, specifically the installation of Artificial Burrow Systems (ABS) to replace lost nesting habitat. By consolidating Burrowing Owl data in a comprehensive report, biologists and decision-makers at the Hanford Site can easily access the most up-to-date Burrowing Owl abundance and distribution data to guide future species mitigation and management.

Burrowing Owl burrows were monitored on the Hanford Site biannually between 2012 and 2017, then annually from 2018 to 2020. The amount of burrows monitored differed in each year, depending on Burrowing Owl activity the previous year, newly installed ABS, and discoveries of new natural burrows. In 2013 and 2017, monitoring efforts focused on surveying for previously undocumented natural burrows. Burrowing Owl monitoring from 2012 to 2017 shows gradual declines in Burrowing Owl use of both natural and artificial burrows, suggesting Burrowing Owl populations were declining on the Hanford Site. Monitoring data from 2012 to 2017 showed a change in the most common type of active burrow from natural to artificial. This suggests that a lack of usable natural burrows has been a factor contributing to local Burrowing Owl population declines, elevating the importance of creating nesting habitat for Burrowing Owl population management on the Hanford Site.

Past mitigations of Burrowing Owl declines have focused on installing ABS in areas where owls historically nested in order to replace unusable burrows and return Burrowing Owls to the area. The ABS design has been changed and improved over the past decade, most recently in 2018. In 2018, Mission Support Alliance Ecological Monitoring staff began replacing old styles of ABS that were unusable or had been inactive for multiple years, along with installing ABS in areas identified as optimal Burrowing Owl habitat. A total of 51 ABS were installed in 2018 and will be maintained and monitored until deemed no longer usable. This effort was completed in 2020 when 2 ABS were installed in May and 11 ABS were installed in September (see Appendix A for maps).

The ABS will be maintained and monitored on an annual basis for occupancy. Occupied burrows will be returned to later in the nesting season and checked for young. The number of occupied new ABS doubled from 2019 to 2020 and ABS usage is expected to continue to increase at the Hazardous Materials Management and Emergency Response (HAMMER) Emergency Vehicle Operations Course (EVOC) complex burrows in the future. Despite this, the majority of new ABS clusters showed no signs of activity during 2019 and 2020 monitoring. As ABS are maintained, each year there is a chance they will be discovered and occupied by Burrowing Owls. If continually vacant, external factors potentially contributing to their vacancy should be analyzed.

By tracking Burrowing Owl populations and supporting those populations through habitat replacement, Hanford Site researchers are working to recover the local population of this declining species. Continued annual monitoring of Burrowing Owls is necessary to track the recovery of the species and determine if further recovery efforts are needed.

1.0 INTRODUCTION

The Western Burrowing Owl (*Athene cunicularia*) is a small migratory species of owl found throughout the Western United States. Burrowing Owls are found throughout a variety of habitats including shrub-steppe, grasslands, and plains; during the breeding season their range extends to include the Columbia Basin and the Hanford Site. The Hanford Site is situated at the center of the predicted distribution of Burrowing Owls in Washington State (Smith et al. 1997) and Burrowing Owls have historically used the Hanford Site as a breeding and nesting area. The majority of the owls from the Columbia Basin migrate south to California for the winter months and return to their northern territories to breed and raise young in the spring and summer (WDFW 2013).

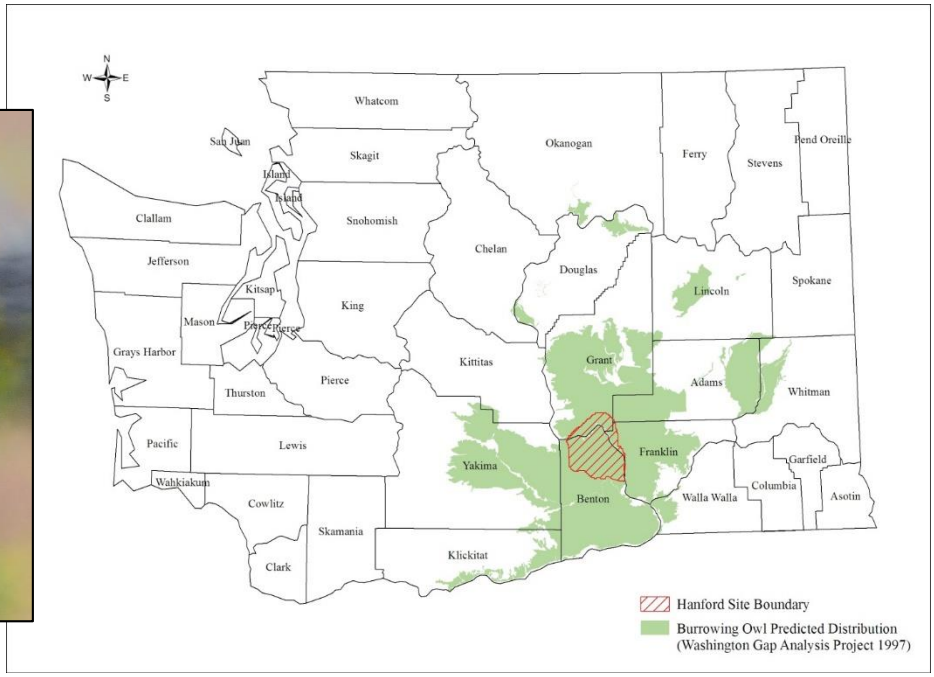

Figure 1. The Predicted Range of Burrowing Owls in Washington State, Showing Hanford (Washington Gap Analysis Project 1997).

As suggested by the name, Burrowing Owls are unique in that they nest in underground burrows made by fossorial (i.e., digging) mammals such as ground squirrels (*Urocitellus* spp.), yellow-bellied marmots (*Marmota flaviventris*), and American badgers (*Taxidea taxus*). Upon arriving back north in the spring, Burrowing Owls will search for deserted burrows in areas with low grass, shrub cover, and suitable perching areas (Green and Anthony 1989). Typically owls will select an area with multiple burrows near one another to provide escape routes from predators and multiple areas for food caches (Poulin et al. 2011). Burrowing Owls are known to nest in both mammal-excavated burrows and anthropogenic structures and have been known to nest in deserted irrigation pipes on the Hanford Site (HNF-56531). The Western Burrowing Owl is declining over much of its range, and declines have been recorded on the Hanford Site and throughout the Columbia Basin (HNF-59375, Conway et al. 2006). These declines have been attributed to habitat loss and a subsequent loss in burrowing mammals that the owls depend on for nesting habitat (Conway et al. 2006, Johnson et al. 2010). Ground squirrel populations have been

declining throughout the Columbia Basin and locally on the Hanford Site (Finger et al. 2007, HNF-59911). Ground squirrels are an important food source for badgers, another burrowing mammal (Finger et al. 2007). Increased stress on badger populations compounds the effect that ground squirrel population declines have on Burrowing Owls, as the owls depend on both species for nesting burrows. Additionally, the breeding range of Burrowing Owls is contracting in Washington State due to climate change and extirpation from former habitat (Macias-Duarte and Conway 2015). Multiple factors are causing Burrowing Owl populations to decline; without intervention continued declines may result in the extirpation of Burrowing Owls from the Hanford Site and the Columbia Basin.

1.1 PURPOSE AND NEED

The Washington State Department of Fish and Wildlife (WDFW) lists Western Burrowing Owls as a Candidate Species, meaning the species is a candidate for listing as Sensitive, Threatened, or Endangered in Washington (WDFW 2020). Because the owls reside on the Hanford Site and the Hanford Reach National Monument, the status of Burrowing Owl populations and the location of burrows are of concern locally to the U.S. Department of Energy, Richland Operations Office (DOE-RL) and the U.S. Fish and Wildlife Service (USFWS). Biennial Burrowing Owl monitoring over the past 8 years has shown dramatic decreases in active owl burrows on the Hanford Site (HNF-56531, HNF-59375, DOE/RL-2018-32). Without increased management and protection, the declining status of Burrowing Owl populations on the Hanford Site will likely continue.

The purpose of this report is to provide a comprehensive review of Burrowing Owl monitoring data and mitigation activities that have occurred on the Hanford Site since 2012. This report provides important trend data regarding Burrowing Owl population sizes at the Hanford Site over time. By consolidating Burrowing Owl data in a comprehensive report, biologists and decision-makers at Hanford can easily access the most up-to-date Burrowing Owl abundance and distribution data to guide future species mitigation and management.

1.2 REGULATORY DRIVERS

The DOE-RL conducts ecological monitoring on the Hanford Site to collect and track data needed to ensure compliance with environmental laws, regulations, and policies governing DOE activities. Ecological monitoring data provide baseline information about the plants, animals, and habitat under DOE-RL stewardship at Hanford required for decision-making under the *National Environmental Policy Act of 1969* (NEPA) and *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. The *Hanford Site Comprehensive Land Use Plan* (CLUP, DOE/EIS-0222-F), which is the Environmental Impact Statement for Hanford Site activities, helps ensure that DOE-RL, its contractors, and other entities conducting activities on the Hanford Site are in compliance with NEPA.

The Hanford Site Biological Resources Management Plan (BRMP, DOE/RL-96-32) is identified by the CLUP as the primary implementation control for managing and protecting natural resources on the Hanford Site. According to the CLUP

> *the BRMP provides a mechanism for ensuring compliance with laws protecting biological resources; provides a framework for ensuring that appropriate biological resource goals, objectives, and tools are in place to make DOE an effective steward of the Hanford*

biological resources; and implements an ecosystem management approach for biological resources on the Site. The BRMP provides a comprehensive direction that specifies DOE biological resource policies, goals, and objectives.

DOE-RL places priority on monitoring those plant and animal species or habitats with specific regulatory protections or requirements; that are rare and/or declining (federal or state listed endangered, threatened, or sensitive species); or of significant interest to federal, state, or tribal governments or the public. The BRMP ranks wildlife species and habitats (Levels 0 through 5), providing a graded approach to monitoring biological resources based on the level of concern for each resource. Burrowing Owls are ranked as Level 3 resources and considered important resources on the Hanford Site. Monitoring of Burrowing Owls is performed to meet the expectations of the BRMP and the Memorandum of Understanding between the U.S. Department of Energy (DOE) and USFWS Regarding the Implementation of Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds" (DOE and USFWS 2013).

Burrowing Owls and their nests are protected by the *Migratory Bird Treaty Act of 1918* (MBTA). Monitoring is essential to ensure the most current data is informing management decisions that can affect this species, and to ensure compliance with regulations such as the MBTA.

1.3 SCOPE OF REPORT

This report documents Burrowing Owl habitat monitoring, artificial burrow maintenance, owl banding activities with USFWS, and mitigation activities aimed at restoring Burrowing Owl habitat, specifically the installation of Artificial Burrow Systems (ABS) to replace lost nesting habitat. This report is structured so that it can be updated routinely to include the most recent Burrowing Owl monitoring data and the most current analysis of Burrowing Owl population recovery.
The remaining sections of this report cover the following topics:

- Section 2.0 summarizes previously reported Burrowing Owl monitoring data for calendar years 2012, 2013, 2015, 2017, and 2018.
- Section 3.0 details the installation of ABS throughout the Hanford Site in 2018.
- Section 4.0 describes the results of 2019 and 2020 Burrowing Owl ABS monitoring.
- Section 5.0 discusses trends in Burrowing Owl populations on the Hanford Site over time and future monitoring needs.
- Section 6.0 lists the literature cited throughout the report.
- Appendix A contains maps of the ABS installed on the Hanford Site as of March 1, 2020.

2.0 MONITORING DATA 2012 THROUGH 2018

Burrowing Owls were the subject of targeting monitoring in 2012, 2013, 2015, 2017, and 2018. Detailed monitoring data from 2012, 2013 and 2015 can be found in standalone reports HNF-54294, HNF-56531, and HNF-59375, respectively. Monitoring data from 2017 is reported in HNF-63012 and monitoring data from 2018 is first reported in this document. See Section 5.0 for an analysis of population trends over time.

Though the methods employed to monitor owls differed in some years, all of these monitoring efforts had the goal of identifying active Burrowing Owl burrows on the Hanford Site. The burrows were placed into one of two categories:

- Natural, meaning it was created by a burrowing animal or was an anthropogenic structure like old clay pipes
- Artificial, meaning the burrow was created specifically for the purpose of housing owls.

To determine if a burrow is active, researchers look in the burrow for owls and look for signs of occupation around the burrow entrance, also known as the porch. Signs of occupation include castings, feces, feathers, footprints, and animal or insect parts. If an owl is flushed from a burrow, the location where it lands is surveyed to determine if there are additional burrows in the vicinity of the known burrow. Prior to 2019, burrows were labeled as a nest burrow if they were highly used and in a centralized location, or if eggs or owl young were observed in the burrow. From 2019 on, the main burrow chamber of ABS could be accessed and burrows were labeled as a nest only if eggs or owl young were observed in the burrow. In all years, if burrows had signs of use but were not suspected to be a nest, they were labeled as a food cache. In addition to active, other historic burrow classifications include inactive, unusable, satellite, and potential for future use.

2.1 2012 MONITORING

Prior to 2012, there were 110 known active and inactive Burrowing Owl burrows on the DOE-managed portion of the Hanford Site. All of the known historic burrow locations were surveyed in May 2012 to determine occupancy. Table 1 displays the results of 2012 Burrowing Owl monitoring. Of the 110 known historic burrows, only 58 were usable. All 58 were categorized as natural and 16 of those 58 burrows were active in 2012. Thirteen additional natural burrows were discovered in 2012, 7 of which were active, bringing the total number of active burrows to 23. Of the 23 active natural burrows, 10 were anthropogenic and 13 were mammalian in origin.

As of 2012, there were 65 documented artificial burrows on the Hanford Site (including 10 artificial burrows east of the Rattlesnake Barricade along Army Loop Road maintained by Washington Closure Hanford [WCH]) and 16 of those were active. All 16 of the active artificial burrows were located near the Hazardous Materials Management and Emergency Response (HAMMER) Emergency Vehicle Operations Course (EVOC) within a cluster of 35 artificial burrows. Twenty-nine of the artificial burrows were scheduled for maintenance to remove built up vegetation and dirt.

For more detailed information regarding 2012 Burrowing Owl monitoring, refer to HNF-54294, *Burrowing Owl Monitoring Report for Calendar Year 2012*.

Table 1. Results of 2012 Burrowing Owl Burrow Surveys.

Burrow Type	Total Burrows Surveyed	Total Active Burrows	Proportion of Owls using Natural vs. Artificial Burrows
Natural	71	23	59%
Artificial	65	16	41%

2.2 2013 MONITORING

The goals of 2013 Burrowing Owl monitoring were to clean and maintain artificial burrows, to survey for new burrows, to determine the status of previously known burrows, and to assist USFWS with owl banding. With the exception of the 10 burrows maintained by WCH, all of the accessible artificial burrowing owl habitats on the Hanford Site were maintained in early 2013 prior to the spring arrival of Burrowing Owls. Six artificial burrows were still deemed "unusable" after maintenance. This was a change from 2012 monitoring, when no burrow maintenance was performed. Additionally, 2013 surveys for new burrows were more systematic and extensive than those employed in 2012. Surveys for previously undocumented burrows involved walking spiral transects around burrows that were active in 2012. The transect originated at the center of the active burrow or clusters of burrows and spiraled outward approximately 1,640 ft. (500 m).

Table 2 summarizes the results of 2013 Burrowing Owl monitoring. Fifteen of the 23 active burrows from 2012 were active in 2013 and the spiral transect surveys resulted in the discovery of 14 active natural burrows. A total of 29 active natural burrows were detected in 2013. Twenty-one artificial burrows were active in 2013 and, similar to 2012, all of those burrows were located within the HAMMER EVOC complex.

For more detailed information regarding 2013 Burrowing Owl monitoring, refer to HNF-56531, *Hanford Site Burrowing Owl Monitoring Report for Calendar Year 2013*.

Table 2. Results of 2013 Burrowing Owl Burrow Surveys.

Burrow Type	Total Burrows Surveyed	Total Active Burrows	Proportion of Owls using Natural vs. Artificial Burrows
Natural	37	29	58%
Artificial	65	21	42%

2.3 2015 MONITORING

Burrowing Owl monitoring goals in 2015 were similar to those in 2013 and included maintaining artificial burrows, surveying for active burrows, and banding owls with USFWS. All 29 active natural burrows from 2013 and all 65 artificial burrows were monitored for occupancy in 2015. When active burrows were located, the area surrounding the burrows was surveyed in an attempt to identify additional burrows. Areas surveyed for additional burrows were within a few hundred meters of the active burrow. Call broadcast surveys were performed at clusters of burrows that were active in 2013 but inactive in 2015 to verify that the burrows were inactive.

Accessible artificial burrowing owl habitats on the Hanford Site were maintained in early 2015 prior to the spring arrival of Burrowing Owls. As of February 2015, there were 65 artificial burrows on the DOE managed land on the Hanford Site. WCH performed maintenance on 10 burrows and Mission Support Alliance (MSA) performed maintenance on 52 burrows, the remaining 3 burrows had owls perched nearby and were not maintained. Despite maintenance actions, five artificial burrows were deemed unusable in 2015 due to being plugged with sandy soil.

Results of the 2015 Burrowing Owl surveys are summarized in Table 3. Of the 65 artificial burrows, 12 were active, all within the HAMMER EVOC complex. Within the HAMMER EVOC complex, two burrows changed status from inactive to active. The other 10 burrows had also been active in 2013. Of the 29 active natural burrows from 2013, only four remained active in 2015. Two additional natural burrows were discovered, bringing the total active natural burrows to six. Three of the six natural burrows were of mammalian origin and three were of anthropogenic origin.

For more detailed information regarding 2015 Burrowing Owl monitoring, refer to HNF-59375, *Hanford Site Burrowing Owl Monitoring Report for Calendar Year 2015*.

Table 3. Results of 2015 Burrowing Owl Burrow Surveys.

Burrow Type	Total Burrows Surveyed	Total Active Burrows	Proportion of Owls using Natural vs. Artificial Burrows
Natural	31	6	33%
Artificial	65	12	67%

2.4 2017 MONITORING

The goal of 2017 Burrowing Owl monitoring was to maintain artificial burrows and to detect active Burrowing Owl nests in both known nesting areas and new nesting areas within the DOE-managed portion of the Hanford Site. Burrow maintenance occurred in February 2017 at all artificial burrows on the DOE-managed portion of the Hanford Site, including the 10 burrows previously maintained by WCH. The majority of burrows along Army Loop Road were filled with sand to the point where they were determined to be unmaintainable.

In order to find previously undocumented burrows, a Geographic Information Systems (GIS) analysis was used to target potential nesting areas. GIS analysis included identifying areas with the combined features of minimal slope (0 to 6% incline), little to no shrub cover, and areas without sand dunes or rock outcrops. Areas that met these criteria were considered potential Burrowing Owl habitat and were subsequently surveyed.

Call broadcast surveys were performed between May 17 and June 28, 2017, at 305 points within potential Burrowing Owl habitat. Five Burrowing Owl individuals were detected in four different habitat areas, categorized as the Hanford Townsite area, the 100-D/100-H Area, the Gable Butte/Gable Mountain area, and in the Cold Creek Highway 240 area (Figure 2). Only one active burrow was found after detecting a Burrowing Owl individual using call broadcast surveys, that active burrow was in the Orchards Area. Though this survey only resulted in the discovery of one active burrow, it identified potential Burrowing Owl nesting locations in areas of the Hanford Site not previously known to have Burrowing Owls.

Burrowing Owl monitoring data from 2017 are summarized in Table 4. The six natural Burrowing Owl burrows that were active in 2015 were surveyed in 2017. All three of the active mammalian origin burrows active in 2015 were not active in 2017. A new active mammalian origin burrow was incidentally found in April but when this burrow was revisited during Burrowing Owl surveys it was abandoned. All three of the anthropogenic burrows remained active from 2015 to 2017. In addition to the natural burrows, the artificial burrows at the HAMMER EVOC complex were surveyed in 2017. Eight active burrows were identified in the HAMMER EVOC complex.

For additional information regarding 2017 Burrowing Owl monitoring, refer to DOE/RL-2018-32, *Hanford Site Environmental Report for Calendar Year 2017*.

Table 4. Results of 2017 Burrowing Owl Burrow Surveys.

Burrow Type	Total Burrows Surveyed	Total Active Burrows	Proportion of Owls using Natural vs. Artificial Burrows
Natural	6	3	27%
Artificial	33	8	73%

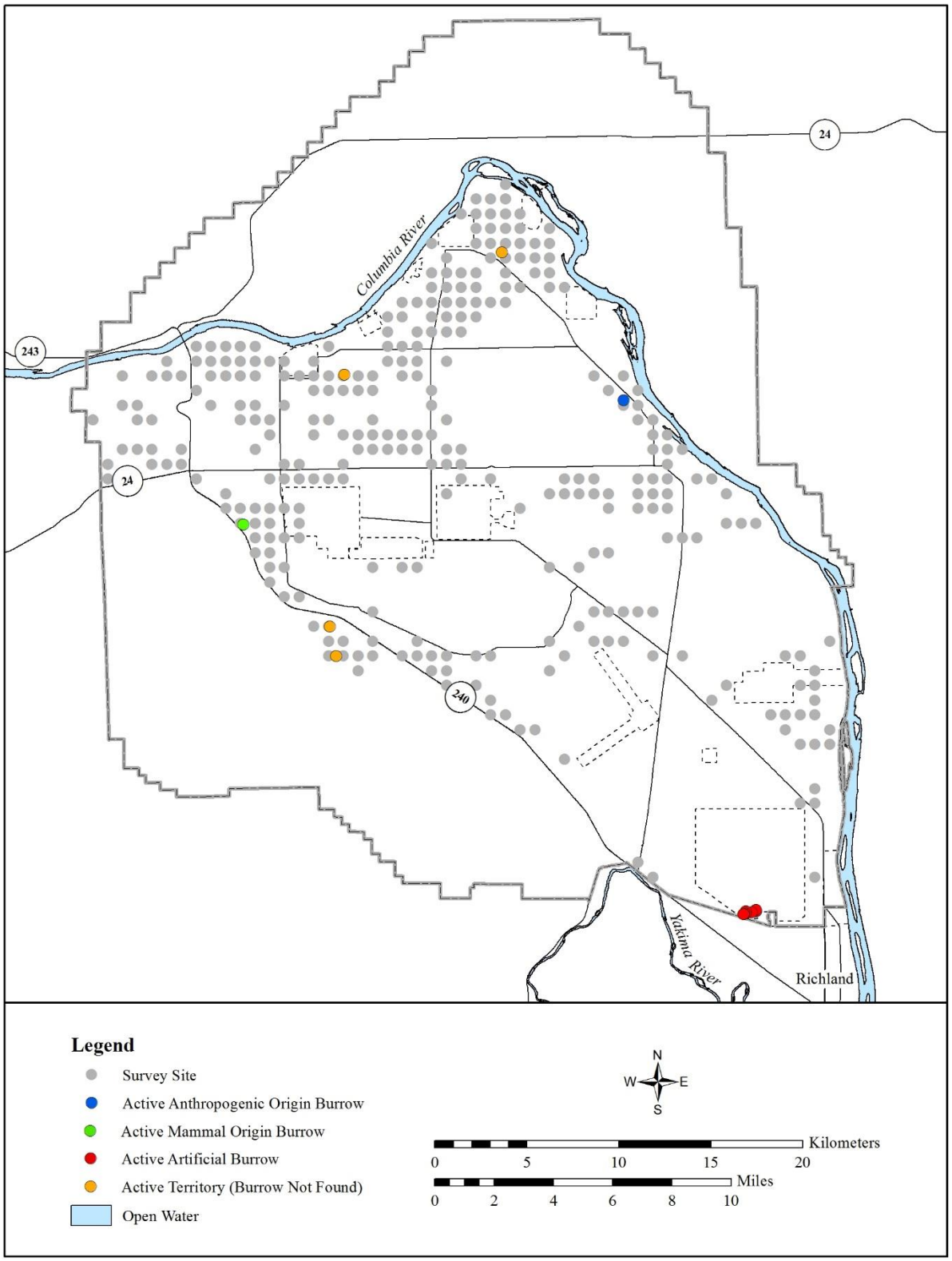

Figure 2. Active Burrowing Owl Burrows and Survey Areas from 2017 Burrowing Owl Monitoring.

2.5 2018 MONITORING

The goal of 2018 Burrowing Owl monitoring was to survey historically active natural burrows and to status the artificial burrows in the HAMMER EVOC complex prior to installation of new artificial burrow systems. In addition to status monitoring, annual maintenance of artificial burrows was performed on the burrows in the HAMMER EVOC complex in April 2018. Status monitoring occurred in late May 2018.

Historically active natural burrows were surveyed in areas categorized as the 400 Area, Borrow Area C, west of 200-West, West of 100-B/C, 100-B/C Cutoff, Holocek, Old Fields, and Orchards. In order to ensure Burrowing Owls were not going back to previously known natural burrow sites, 51 known natural burrows were surveyed. Only one was classified as active, confirming that monitoring methods were not missing potentially-active burrows. The active burrow was a mammalian-origin burrow in the west of 200-West Area. One new anthropogenic-origin burrow was discovered within the Old Fields area using a broadcast call. The new burrow was located within a deserted clay pipe and upon discovery chicks were heard vocalizing from the pipe. In order to establish clutch size, the active burrow at 100-D/100-H area was revisited in June and a wildlife camera was placed near the entrance to the burrow. Motion-triggered pictures were captured for two days and camera footage showed two adults and six young utilizing the burrow (Figure 3).

All artificial burrows within the HAMMER EVOC complex were surveyed in May 2018. Of the 33 artificial burrows, 10 showed signs of activity. Two of the burrows were completely filled with soil and debris and were unusable, and five burrows had filled in chambers.

An additional Burrowing Owl burrow within an abandoned pipe in the 200-East Area was documented during an Ecological Compliance Review in spring 2018 (MSA-1802433). This burrow was named the 1st Street Burrow and was monitored again in spring 2018 after the initial discovery. It was determined that there was likely an active nest within this burrow, but the nest was not accessible due to the location of the pipes.

Figure 3. Wildlife Camera Footage Showing One Adult and Six Young at the Old Fields Area Anthropogenic Burrow on June 7, 2018.

Table 5. Results of 2018 Burrowing Owl Burrow Surveys.

Burrow Type	Total Burrows Surveyed	Total Active Burrows	Proportion of Owls using Natural vs. Artificial Burrows
Natural	51	2	17%
Artificial	33	10	83%

3.0 ARTIFICIAL BURROW SYSTEM INSTALLATIONS 2018

The installation of ABS as a mitigation tactic to recover Burrowing Owl populations has been used throughout the Burrowing Owls' range over multiple decades (Johnson et al. 2013). As ground squirrel and badger populations decrease through the Columbia Basin, the number of natural burrows decreases and Burrowing Owls depend increasingly on artificial burrows to successfully breed. Burrowing Owls have been found to have a higher fidelity for ABS than for natural burrows excavated by badgers, likely due to the structural reliability of ABS compared to natural burrows (Rich 1984). Burrowing Owls can return to nest in the same burrow over multiple years, so burrow longevity and reliability play an important role in burrow selection (Belthoff and Smith 2003). Though ABS are not a preferred long-term solution to combating Burrowing Owl declines as they do not address the core causes of the population declines, they are a viable option for helping the recovery of the species (Johnson et al. 2013).

Burrowing Owl monitoring from 2012 to 2017 shows gradual declines in Burrowing Owl use of both natural and artificial burrows, suggesting Burrowing Owl populations are declining on the Hanford Site. Past mitigations of Burrowing Owl declines has focused on installing ABS in areas where owls historically nested. These mitigations proved successful in some areas while in others the burrows quickly filled with sand or were not spaced apart properly (according to current best practices). Specifications of the ABS design can greatly influence its chance of inhabitance (Johnson et al. 2013). Since the original installation of the artificial burrows along Army Loop Road and within the HAMMER EVOC complex, increased research has led to changes in ABS design recommendations. Additionally, some styles of ABS have a limited lifespan and eventually need replacing if they cannot be maintained, as seen by the burrows along Army Loop Road that became unusable. By 2017, all artificial burrows were over 10 years old and many were no longer usable due to the design preventing needed maintenance.

In 2018, MSA's Ecological Monitoring Program initiated an effort to expand Burrowing Owl nesting habitat and increase populations by installing a new design of ABS throughout the Hanford Site. The new design of ABS provides a larger nesting chamber and a more gradually curved entrance tunnel, allowing easier cleaning and maintenance and extending the longevity of the burrows. The new design also features an access port above the nesting chamber that allows for a higher level of maintenance and monitoring than was previously possible. This new design would both replace existing artificial burrows that were unusable or had been inactive for multiple years and would be installed in areas that were classified as potential Burrowing Owl habitat through GIS analysis. A total of 51 ABS were installed

in 2018 and will be maintained and monitored until deemed no longer usable. If this design proves successful, it will continue to be used in future Burrowing Owl conservation projects.

3.1 2018 ABS DESIGN

Design specifications for ABS installed in 2018 are described below and followed the recommendations of *User Guide to Installation of Artificial Burrows for Burrowing Owls* (Johnson et al. 2013). When compared to the 2018 design, the original design installed at the HAMMER EVOC complex and Army Loop Road used a smaller main burrow chamber (5-gal [18.93-L] bucket), a more extreme bend in the entrance tunnel (90-degree turn), and smaller tubing (4-in. [10.16-cm] tubing) (PNNL-15414). Burrowing Owls have been shown to prefer burrow chambers larger than what can be provided with a 5-gal (18.93-L) bucket (Smith and Belthoff 2001). Additionally, smaller burrows are more susceptible to being plugged by sand and are difficult to maintain, lowering their lifespan (Johnson et al. 2013). These flaws have been observed in artificial burrows previously installed at the Hanford Site. The 2018 design recommendations are based off dimensions of natural Burrowing Owl burrows and an integration of features from multiple ABS designs that have been proven successful (Johnson et al. 2013).

The main burrow chamber consists of a 55-gal (208-L) plastic drum that has been cut in half width-wise. The main burrow chamber is connected to a 10 ft (3.05 m) length of 6-in. (15.24-cm) corrugated plastic tubing that provides tunnel access to the chamber. The chamber is equipped with an access port, made up of a 3.5-gal (13.25-L) pail secured to the top of the main burrow chamber. This access port sits a few inches below the surface to allow for easy access and inspection of the main burrow chamber. Figure 4 shows an ABS prior to burial.

The main burrow chamber is installed no deeper than 3.3 ft (1 m) below grade on top of a wire mesh screen to protect the chamber from burrowing mammals. The inner chamber is then filled with 2 to 3 in. (5 to 7 cm) of rock-free dirt to cover the wire mesh. The plastic tubing is placed in a gently sloped (less than 17-degree) trench that extends up to the surface and acts as the entrance to the ABS. The tubing has an approximately 60-degree curve to keep the main chamber dark. The burrow area is backfilled after installation and cobble or rocks placed on top of the last 3 ft (0.9 m) of tubing to provide protection from digging predators like coyotes. Burrows are numbered and labeled using a wooden stake placed behind the main burrow chamber. Lastly, dirt or sand is pushed down the plastic tubing to provide a natural substrate for the owls to walk on. Figure 5 shows a burrow entrance.

Figure 4. An ABS, Showing the Main Burrow Chamber, Access Point, and Plastic Entrance Tunnel.

Figure 5. The Entrance to a Newly Installed ABS near Highway 240.

Burrowing Owl ABS are installed in clusters in order to provide multiple spaces for owls to nest, store food, and escape from predators. Clusters of two or three ABS spaced with the tunnel openings approximately 10 to 20 ft (3 to 6.1 m) apart provides sufficient space for nesting owls. A single perch post (less than 2 ft [0.6 m] tall) is placed in view of all the tunnel entrances to provide unobstructed views of approaching predators and easy access to the tunnels. Figures 6 and 7 show an ABS cluster with the associated perch post. Burrowing Owl ABS clusters are spaced at least 361 to 984 ft (110 to 300 m) apart to prevent competition between neighboring owl pairs. All ABS installed on the Hanford Site in 2018 followed these specifications.

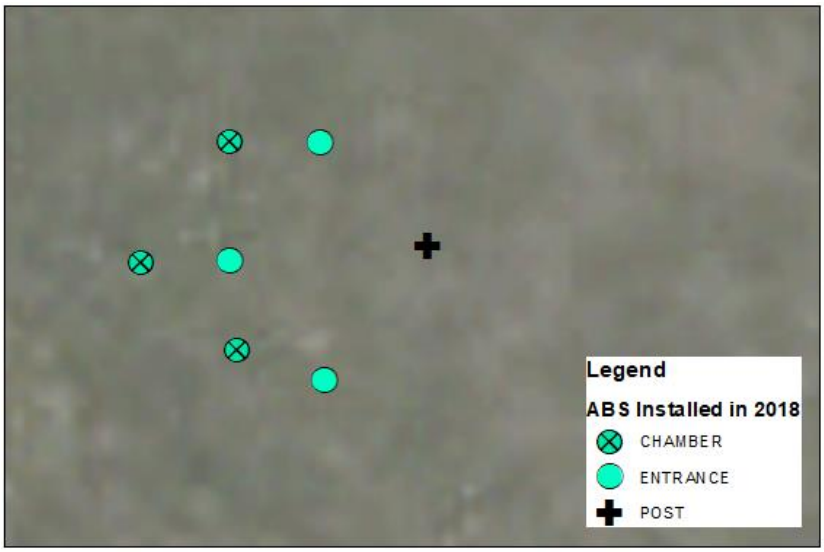

Figure 6. Diagram of a Three Burrow ABS Cluster as Seen From Above.

Figure 7. A Perching Post with a Cluster of Three ABS in the Holocek Area.

3.2 2018 ABS LOCATIONS

Between August and December 2018, a total of 51 newly designed ABS were installed throughout the DOE-managed portion of the Hanford Site. Of these 51 new burrows, 20 replaced unused artificial burrows and 31 were installed in areas identified as historic or potential Burrowing Owl habitat. Figures 8 and 9 show the distribution of ABS installed in 2018 across the Hanford Site.

The 20 replacement ABS were installed to replace selected artificial burrows within the HAMMER EVOC complex. The HAMMER EVOC complex burrows were targeted for replacement as they had been historically heavily used by Burrowing Owls (PNNL-15414) with that usage decreasing from 2012 to 2017. The specific burrows chosen within the HAMMER EVOC complex had past Burrowing Owl activity but recent inactivity. With the exception of one burrow (PNNL_5), all of the burrows that were replaced

were inactive during spring 2018 monitoring. The majority of the replaced burrows had been active at least once since 2012. MSA's Ecological Monitoring Program has the goal of replacing all of the artificial burrows within the HAMMER EVOC complex by end of 2020.

Seven areas of the Hanford Site were identified as preferred areas for the installation of ABS based on the presence of historic Burrowing Owl habitat (Figure 8). With the exception of the 400 Area location, all of these areas were also selected by the 2017 GIS analysis for having high suitability for Burrowing Owl habitat due to the presence of preferred habitat features. Of the seven areas, four were selected for ABS installation in 2018. The four areas are categorized as Highway 240, Orchards, Old Fields, and Holocek.

The HAMMER EVOC complex, Old Fields, Holocek, and Orchards ABS were installed in August and September 2018, and the Highway 240 ABS were installed in December 2018. Each cluster of ABS was installed with a new wooden perching post in view of all the burrow entrances. Clusters were installed at least 656 ft (200 m) apart in their respective areas to prevent competition between neighboring burrows. The ABS at Old Fields and Orchards were installed in two clusters of two ABS and two clusters of three ABS for a total of 10 ABS in each area. The ABS at Holocek were installed in one cluster of three ABS and one cluster of two ABS for a total of five ABS in that area. The ABS at Highway 240 were installed in three clusters of two ABS for a total of six ABS in that area. Each ABS was given a unique number from 1 to 51, which was written on a stake above the burrow chamber and labeled on each ABS via a metal tag. See Appendix A for ABS locations and corresponding numbering.

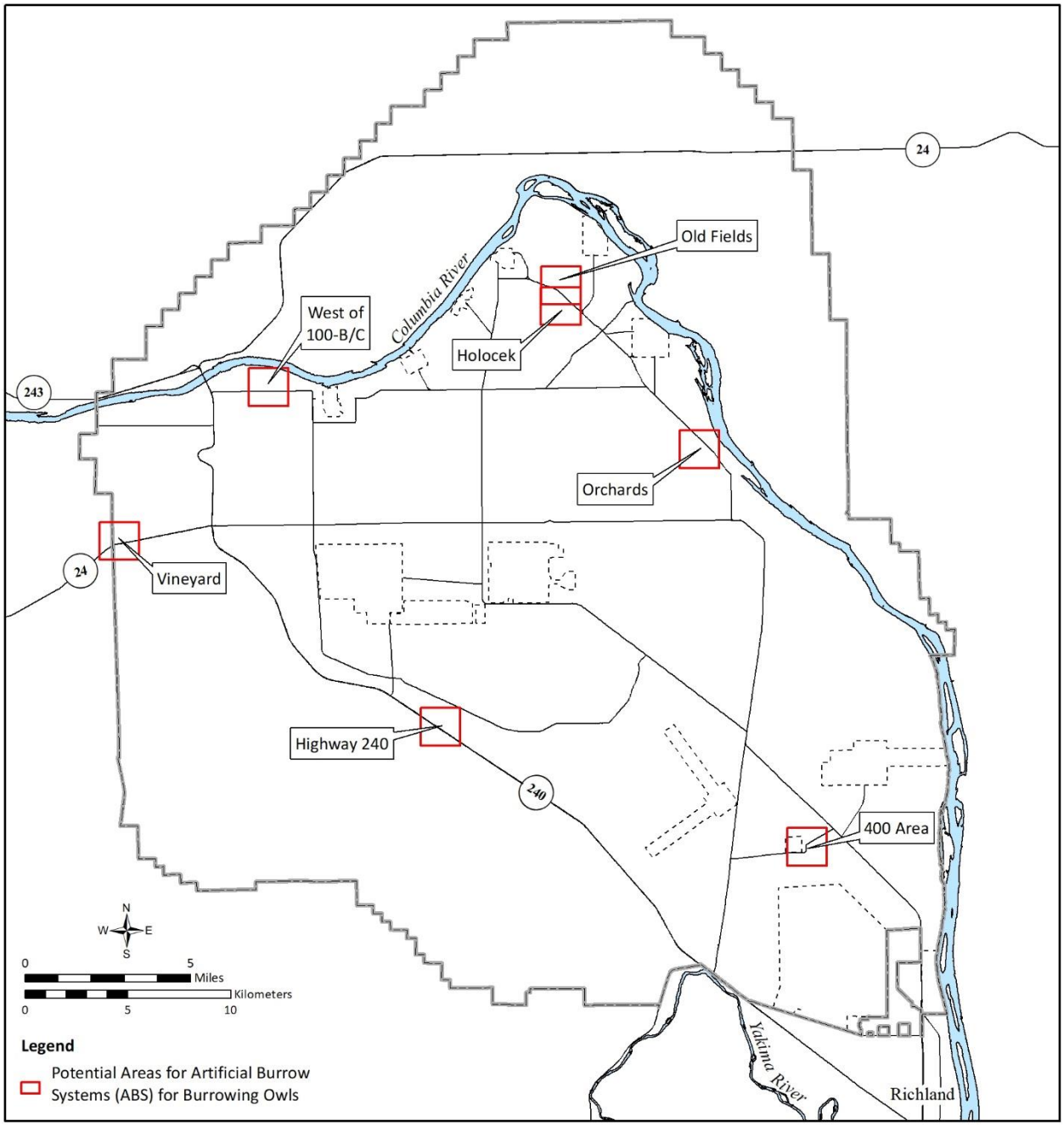

Figure 8. Pre-determined Preferred Locations for New ABS Installations.

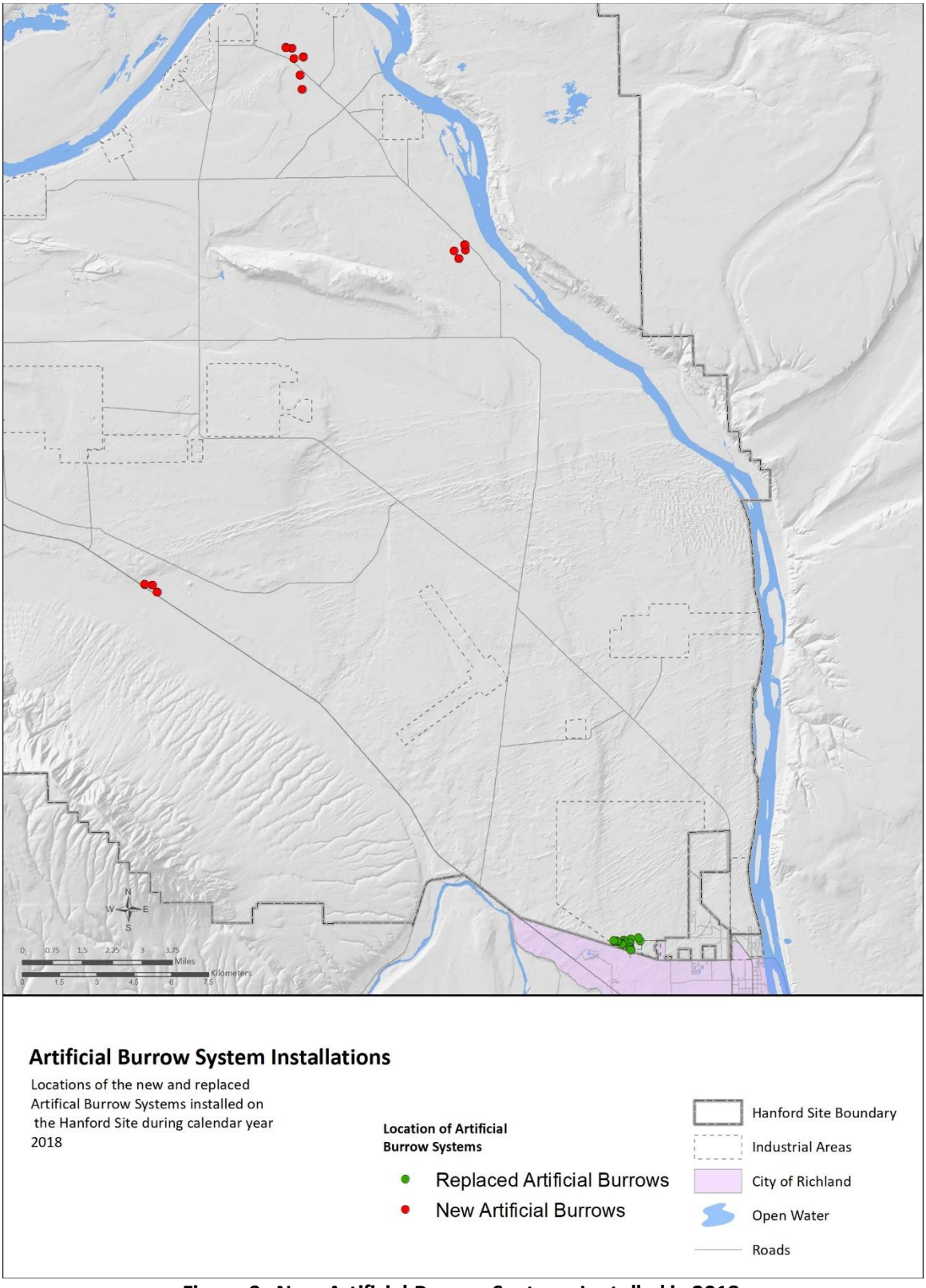

Figure 9. New Artificial Burrow Systems Installed in 2018.

4.0 ARTIFICIAL BURROW SYSTEM MONITORING

The artificial burrow systems installed in 2018 are monitored on an annual basis to determine owl usage and maintenance requirements. This section describes annual ABS monitoring that occurred in 2019 and 2020. In addition to annual monitoring, maintenance was performed in the early spring both years and Burrowing Owl banding occurred in conjunction with USFWS in June 2019.

Monitoring in 2019 and 2020 followed the same methodology. ABS monitoring occurred in late May to early June. The ABS are approached quietly on foot and are observed for owl activity. If an owl is flushed from a burrow while approaching, the location where it landed is noted and searched for additional burrows. The tunnel entrance is then blocked with a plunger and the chamber openings are located, unearthed, and opened. If no nest is present in the main chamber, the entrance tunnels and the main chamber are plunged and cleaned of debris. In addition to observations, monitoring included checking the porch and main chamber for footprints, bones, pellets, feathers, and other signs of owl use. ABS where Burrowing Owl use was evident were listed as active, ABS with no signs of Burrowing Owl use were listed as inactive. Burrows with evidence of Burrowing Owl use but no detectable food cache or nest were listed as potentially active. Active burrows are classified as nests, food caches, or unknown, depending on the contents of the burrow and status of the surrounding burrows.

4.1 2019 MONITORING

Annual ABS maintenance was performed in March and April 2019, prior to the arrival of migrating owls. As part of maintenance activities, the burrow entrance tunnels were plunged to remove debris and dirt and vegetation was cleared from the porch. Areas where the tunnel or burrow chamber were exposed from elk or predator digs were covered with dirt and re-buried. Rocks were replaced over the entrance to the tunnel if they had been removed. The majority of the new ABS were usable at the time of March/April maintenance, though a few appeared to have been moved by elk or other large mammals so that the burrow entrance was no longer flush with the ground. Remaining old-style ABS were not maintained.

ABS monitoring occurred in late May 2019 and all ABS installed in 2018 were visited and evaluated for Burrowing Owl activity. Additional burrows surveyed included the anthropogenic burrow at the Old Fields area found in 2018 and a burrow near the 200-East Area found in an Ecological Compliance Review (referred to as the 1st Street Burrow). Artificial burrows along Army Loop Road were not monitored.

ABS monitoring surveyed a total of 58 burrows, 51 of which were the new ABS installed in 2018. Five were older artificial burrows at the HAMMER EVOC complex that were in clusters with the new ABS, one was an anthropogenic burrow found in the Old Fields area in 2018, and one was the 1st Street Burrow. The anthropogenic burrow in the Old Fields area was not active in 2019. Of the 51 new ABS, four were active during 2019 monitoring (ABS# 39, 47, 48, 49). One of the five older artificial burrows were active, this burrow was in the same cluster as a 2018 ABS (EVOC_5; in same cluster as ABS# 39). One of the

new ABS showed some signs of owl activity but its active status could not be determined and it was listed as inactive (ABS# 50).

The active ABS burrows were spread between three clusters, one at the HAMMER EVOC complex (ABS# 39) and two clusters in the Highway 240 area (ABS# 48) (Figure 10). Three caches and two nests were documented within the five active burrows. Six chicks were found in ABS# 39 and eight eggs and three chicks were found in ABS# 48.

4.2 2020 MONITORING

Annual ABS maintenance was performed in February and March 2020, prior to the arrival of migrating owls. As part of maintenance activities the burrow entrance tunnels were plunged to remove debris and dirt, and vegetation was cleared from the porch. Areas where the tunnel or burrow chamber were exposed by elk or predator digs were covered with dirt and re-buried. Rocks were replaced over the entrance to the tunnel if they had been removed.

In March 2020, two additional ABS were installed in the HAMMER EVOC complex, replacing older artificial burrows. These ABS (ABS# 52 and 53) each replaced older artificial burrows that were not in a cluster. The associated perch was also replaced. An additional 11 ABS were planned to be replaced in March 2020 but safety restrictions prevented the installations.

With the exception of the ABS in the Orchards area, all of the ABS installed in 2018 and 2020 were revisited on June 1 and 2, 2020. The ABS in the Orchards area (ABS# 8 through 10 and 20 through 26) could not be accessed in early June due to a recent wildfire that burned the area on May 30 and 31, 2020. The Orchards burrows were monitored on June 16, 2020. The burrows appeared to be undamaged by the wildfire and the associated perches showed minimal scorching (Figure 11). Only the exteriors of the burrows were surveyed and no Burrowing Owl activity was noted.

ABS monitoring surveyed a total of 58 artificial burrows and 1 anthropogenic burrow. Fifty-three of the monitored artificial burrows were the new design and five were the old design. Thirteen ABS were found to be active during 2020 monitoring. Five of those ABS were the old design and eight were the new design. The active burrows were found in the Highway 240 area and HAMMER EVOC complex, similar to where they were found in 2019. The anthropogenic 1st Street Burrow was the same burrow monitored in 2019 in the 200-East Area and was again active in 2020, bringing the total to 14 active burrows on the Hanford Site in 2020. Figure 12 shows all active burrows found in 2020 Burrowing Owl monitoring.

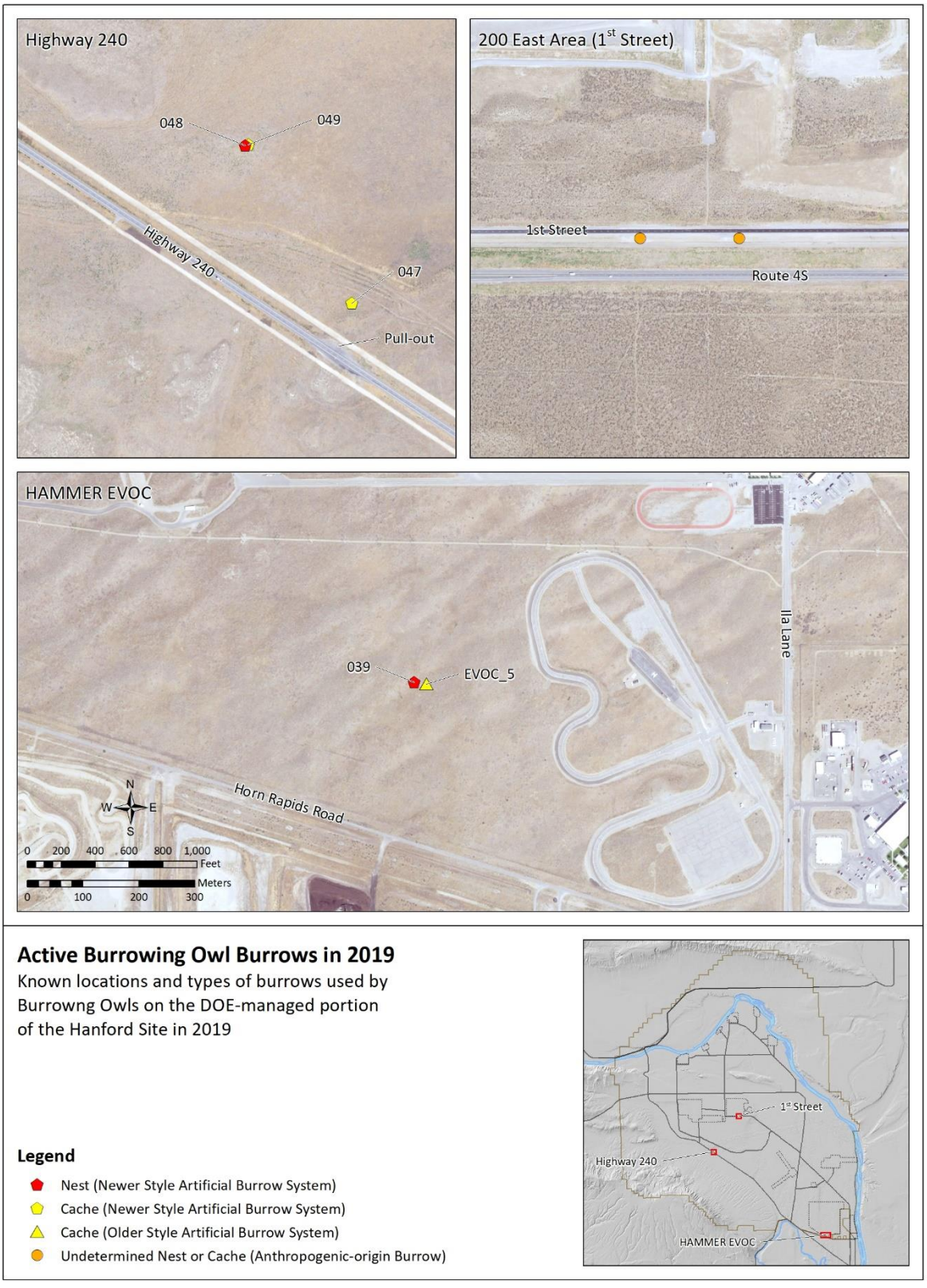

Figure 10. Active Burrowing Owl Burrows in 2019.

Figure 11. A Cluster of ABS in the Burned Orchards Area (ABS# 24 through 26).

Figure 12. Active Burrowing Owl Burrows in 2020.

All six of the burrows located in three clusters in the Highway 240 area were active (ABS# 46 through 51). There was one nest (ABS# 46), the other five burrows were food caches. Though these burrow clusters are spaced relatively far apart (1,050 ft [320 m] at the least), one nesting pair may be using all of them. The nest in ABS# 46 contained nine eggs and no young.

Four clusters in the HAMMER EVOC complex contained active burrows (Figure 13). Two nests were found, one in a new ABS (ABS# 44) and one in an older style ABS in the same cluster as ABS# 38. It is hypothesized that there in an additional nest in an older style ABS in the same cluster as ABS# 39, but the burrow could not be accessed to confirm this. The nest in ABS# 44 contained 2 eggs and 5 young. An adult female Burrowing Owl with a banded left leg was in the main chamber of ABS# 44.

The contents of the nest in the older style of ABS were not assessed as the main chamber was not accessible; however, it was determined to be a nest due to the presence of feathers and likely young during an observation with a borescope camera. Three of the four active clusters in the HAMMER EVOC complex contained both old and new ABS and had Burrowing Owl activity in the old style of ABS but not the new style. It was found that in two of those three clusters, the new style ABS were not usable due to the entrance being too far off the ground or the tunnel being clogged with sand. Some of the new ABS in those clusters showed older signs of activity, suggesting they had been used by Burrowing Owls before being disturbed or clogged. These tunnels were unclogged and the entrances were fixed. A permanent solution of securing the entrance with rebar is recommended for all tunnels so that they cannot be moved out of place by mammals. Neither the Holocek, Old Fields, nor the Orchards ABS had burrowing owl activity. Six of those 25 ABS were unusable at the time of June monitoring due to being too far off the ground or being clogged.

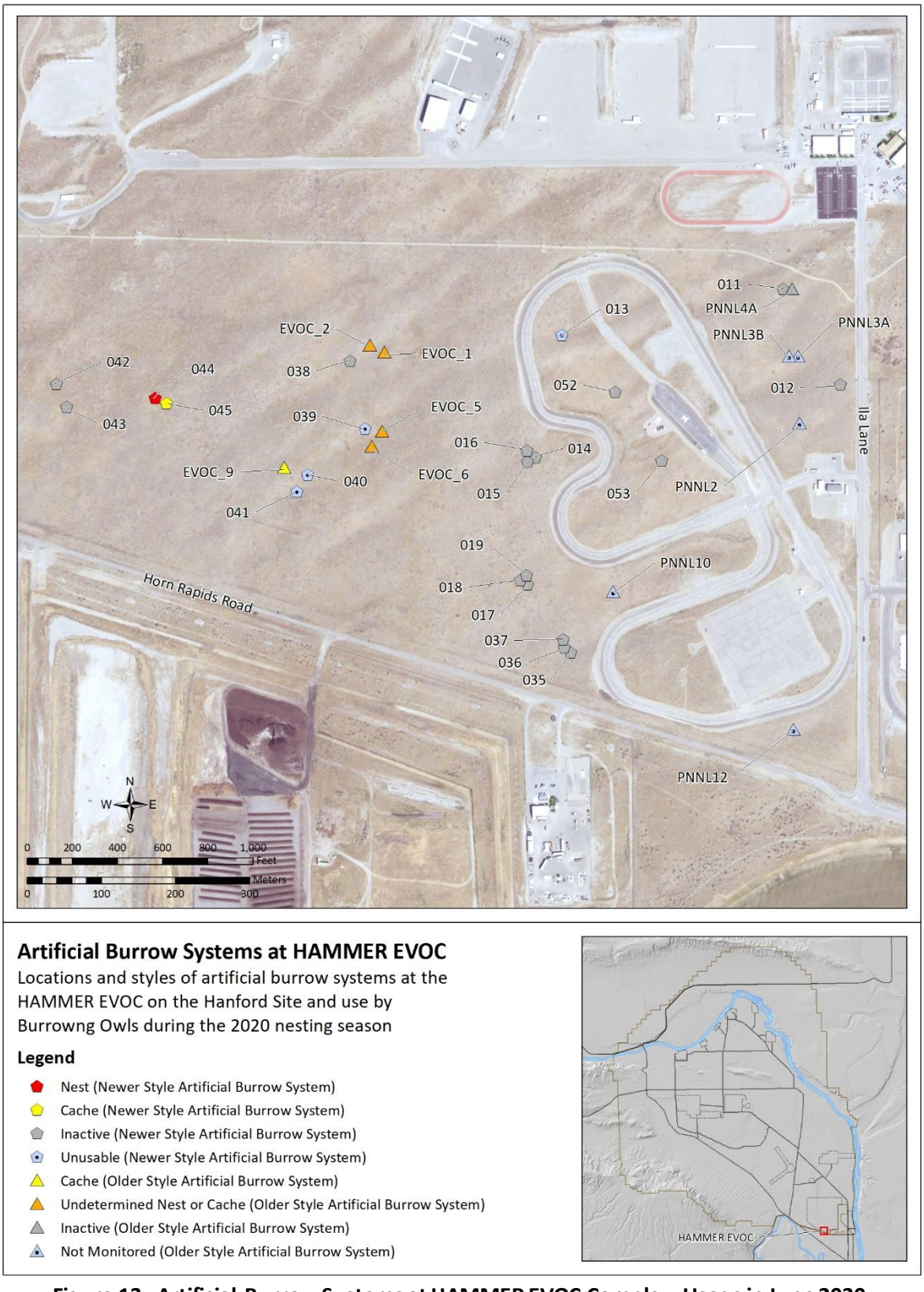

Figure 13. Artificial Burrow Systems at HAMMER EVOC Complex, Usage in June 2020.

Burrowing Owl banding was performed on July 6, 2020. All known active clusters with artificial burrows were revisited. Throughout banding, multiple adult Burrowing Owls were flushed from burrows and were not banded. Twelve Burrowing Owls were banded, consisting of 1 adult and 11 young. One young owl was found in ABS# 38, two young owls were found in ABS# 44, and eight young owls were found in ABS# 47. The adult owl was captured in a Burrowing Owl trap placed on the entrance to an old style ABS labeled HAMMER 1. Each owl was banded, weighed, and had both its wings and tail measured. Figure 14 shows a young owl banded in 2020. The young owls banded in the HAMMER EVOC complex were estimated to be over 30 days old and expected to be from the nests identified during ABS monitoring on June 1 and 2. The eight young owls found in ABS# 47 are expected to be less than or equal to 30 days old and are from the eggs discovered on June 1, 2020. There were nine eggs originally found in ABS# 46, showing a high survival rate for that clutch.

In the process of Burrowing Owl banding, four ABS (ABS# 38, 39, 40, 41) that were determined to be inactive in June were found to have clear signs of owl activity and use. Three of those four ABS were unusable in June due to clogging with sand or the tunnel entrance being inaccessible. The switch from inactive to active is likely due to the ABS becoming usable and an increased number of Burrowing Owls in the area as the young hatched. July monitoring efforts resulted in an increase from 14 active burrows on the Hanford Site to 18.

During ABS installs in September 2020, one Burrowing Owl was observed using PNNL_3A, PNNL_3B, and ABS# 11. Each burrow had signs of Burrowing Owl activity, including feathers, castings, and scat. Burrows PNNL_3A and PNNL_3B had not been monitored during the June monitoring effort. This Burrowing Owl was presumed to be a male due to occupying burrows late in the season; there is a chance the owl overwinters on the Hanford Site.

Figure 14. A Young Burrowing Owl with a Recently Banded Left Leg.

5.0 DISCUSSION

Burrowing Owls are becoming increasingly scarce throughout their range and similar patterns in decline have been seen on the DOE-managed portion of the Hanford Site. Efforts to track Burrowing Owl populations and nesting and the subsequent discovery of population declines on the Hanford Site have led to the installation of artificial burrow systems as a mitigating measure to help support owl populations. The following section discusses the results of past Burrowing Owl monitoring, the effects of 2018 ABS installations, and future actions that should be taken to continue supporting Burrowing Owl recovery.

Monitoring results have shown a decline in Burrowing Owls nesting on the Hanford Site. Natural burrows of mammalian-origin have a limited lifespan and revisiting the same natural burrows annually will show declines in activity as the burrows degrade. Burrowing Owls tend to return to the same burrow year after year, but if that burrow is no longer usable, they may seek out burrows in the surrounding areas. When analyzing Burrowing Owl declines at the Hanford Site, it can be hypothesized that only monitoring known active mammalian-origin burrows will always show a pattern of population decline as those burrows become unusable and the owls find new, not-surveyed burrows. In 2013 and 2017, attempts were made to reduce this bias by surveying potential Burrowing Owl habitat in addition to the known burrows.

In 2013, methods included spiral transects designed to detect additional natural burrows in areas surrounding previously active burrows, which proved successful and identified a number of new active burrows. Most of these new burrows were no longer active when surveyed again in 2015. In 2017, a GIS analysis of potential Burrowing Owl habitat indicated there was a large amount of potential Burrowing Owl habitat at the Hanford Site but only one active burrow was found when those habitats were surveyed. Monitoring methods in 2013 and 2017 decreased the likelihood that Burrowing Owls were not being detected on the Hanford Site due to a lack of monitoring potential habitat. During this same time, numbers of Burrowing Owls using artificial burrows were also gradually declining. Observed declines of Burrowing Owl populations at the Hanford Site are most likely due to an environmental cause rather than monitoring bias.

From 2012 to 2017 there was a change in the most common type of active burrow from natural to artificial, as shown in Figure 15. This graph should not be interpreted as absolute, as the number of each type of burrow monitored varied from year to year but shows an important pattern. As Burrowing Owls were declining on the Hanford Site, their reliance on artificial burrows appears to have been increasing. This supports monitoring data collected in 2013 and 2017, where the Hanford Site was surveyed for additional active natural burrows and very few were found. This suggests that a lack of usable natural burrows has been a factor contributing to local Burrowing Owl population declines. This also elevates the importance of installing ABS for Burrowing Owl population management on the Hanford Site. Monitoring data from 2019 and 2020 were not included in this graph because monitoring did not target burrows of natural origin.

Patterns of Burrowing Owl use of natural and artificial burrows from 2010 to 2020 are illustrated in Figure 16. As described in this report, monitoring methods differed from year-to-year; however, the areas where Burrowing Owls were most likely to be found were consistently targeted. The number of usable ABS has also varied throughout the monitoring years, as demonstrated by the Army Loop Road

burrows that have completely filled with sand and become unusable. Accessing the main chamber of the old style of ABS is not possible, so the true number of usable ABS year-to-year cannot be determined. The cause of the most notable decline from 2013 to 2015 has not been determined.

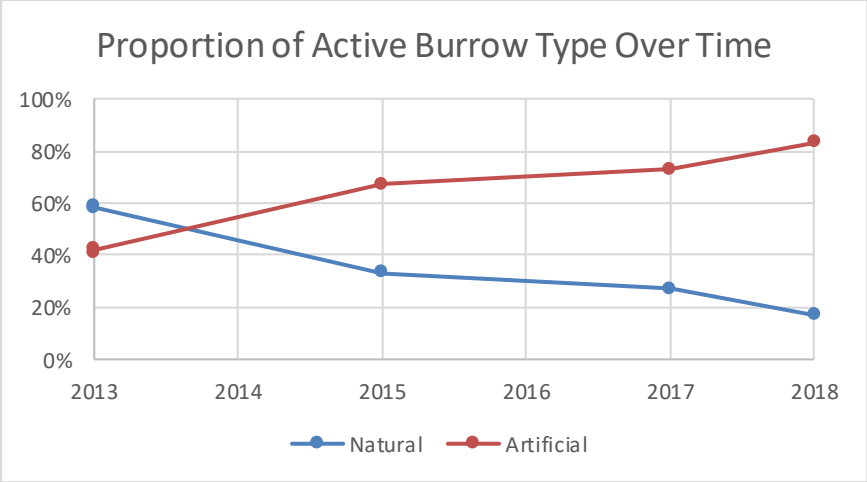

Figure 15. Changes in Proportion of Active Burrow Type.

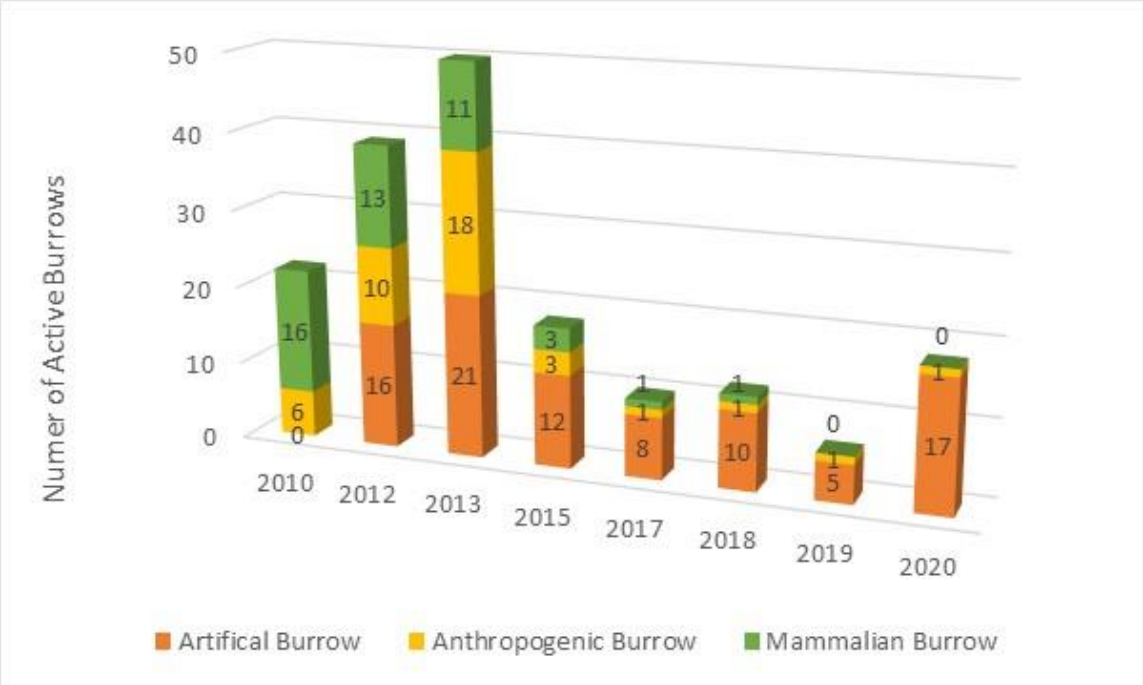

Figure 16. Number of Active Burrows per Year by Origin Type Detected During Monitoring[1].

[1] Note that different numbers of burrows were surveyed each year but the burrows targeted each year were those that were most likely to be active.

As discussed in the introduction, the cause of Burrowing Owl declines has been attributed to habitat loss and a subsequent loss in burrowing mammals that the owls depend on for nesting habitat (Conway et al. 2006, Johnson et al. 2013). This suggests that availability of nesting areas may be a limiting factor in Burrowing Owl populations. Artificial burrows have been used in attempts to replace Burrowing Owl nesting habitat at the HAMMER EVOC complex in 2003 and along Army Loop Road in 2007 (PNNL-15414, PNNL-16976). Only the HAMMER EVOC complex burrows showed signs of use; however, by 2015 use was declining and those burrows were degrading and becoming harder to maintain.

After seeing substantial declines in Burrowing Owl active burrows from 2013 to 2017, 51 newly designed artificial burrow systems were installed throughout the Hanford Site in the late summer and winter of 2018. These burrows were designed to provide desirable nesting areas for Burrowing Owls and to allow easy cleanup and access for researchers. The burrows were first monitored in 2019 and four of the 51 new ABS were in use. Three of those ABS were in the Highway 240 area and one was in the HAMMER EVOC complex. In 2020, two additional ABS were installed in the HAMMER EVOC complex. Of the 53 ABS using the updated design, 8 were active, 6 in the Highway 240 area and 2 in the HAMMER EVOC complex. The increase in Burrowing Owl use of ABS on the Hanford Site suggests ABS are successfully replacing lost habitat.

Burrowing Owls have been detected in the Highway 240 area in natural burrows since 2010 monitoring. Owl nests in the Highway 240 area gradually declined between 2010 and 2013 until reaching zero active burrows in 2015 (Figure 17). A Townsend's ground squirrel colony (identified as the Clay Cliffs colony) had been declining in this same area until 2017 when it was determined to be extirpated (Figure 18) (J. Wilde, personal communication, May 28, 2020). The decline and eventual disappearance of ground squirrels from the Highway 240 area would result in less natural nest burrows for Burrowing Owls as the original ground squirrel burrows and related badger digs degrade. This deterioration in burrows correlates with the decrease in Burrowing Owl nesting in the Highway 240 area, suggesting a lack of nesting resources was the cause of decline. Burrowing Owls returned to the Highway 240 area after nesting resources were restored in the form of ABS. In 2020, all six ABS installed in the Highway 240 area were active and at least eight Burrowing Owl young were produced at this site. In this area, ABS successfully replaced a portion of the lost nesting habitat for Burrowing Owls. This suggests that future ABS could be installed near deserted ground squirrel colonies to replace lost nesting habitat.

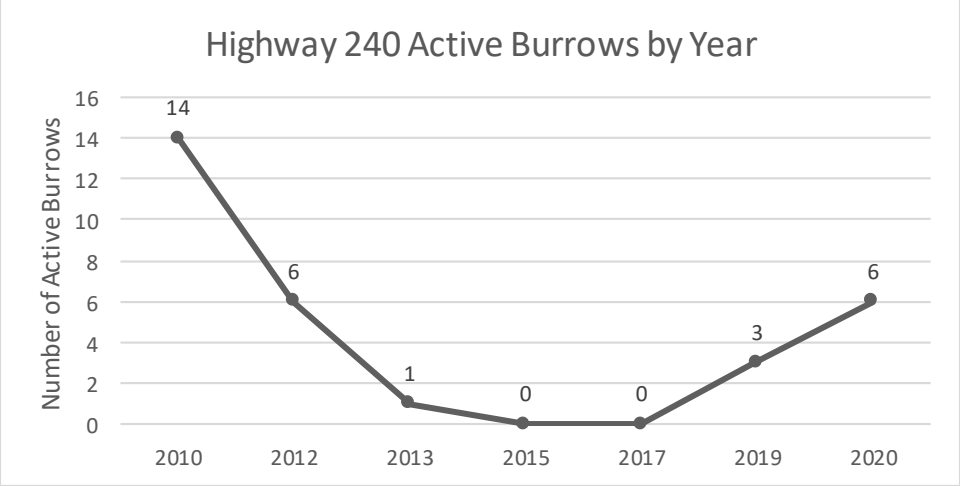

Figure 17. Burrowing Owl Active Burrows in the Highway 240 Area.

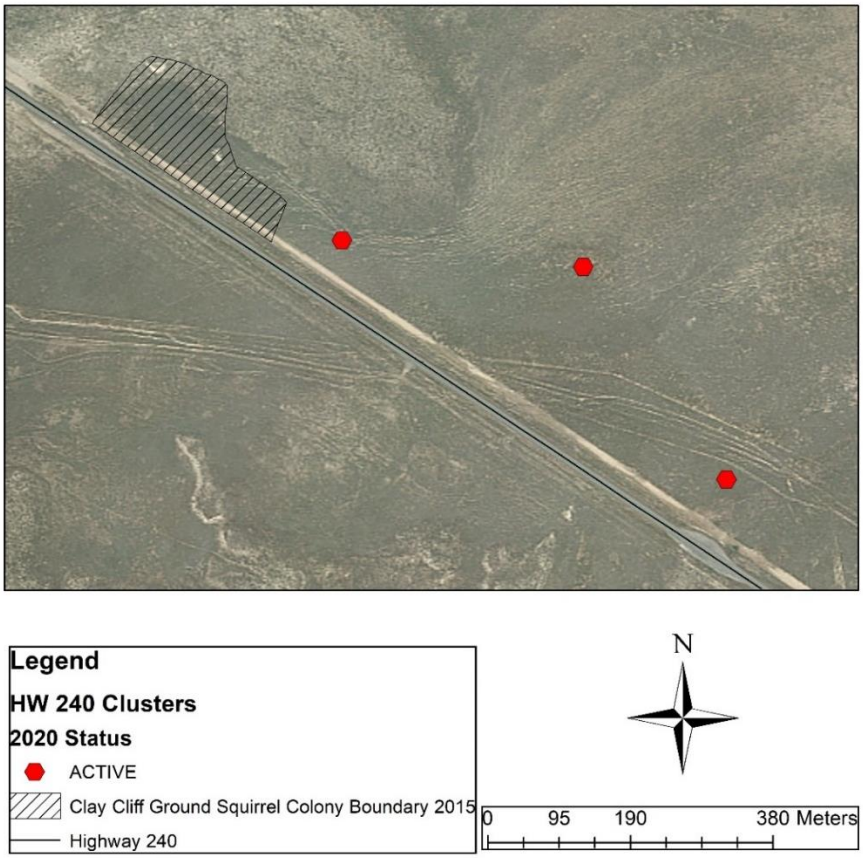

Figure 18. Clay Cliffs Ground Squirrel Historic Colony Boundary Compared to the Location of Highway 240 ABS.

Though the Highway 240 area can be considered a success, the majority of new ABS clusters showed no signs of activity during 2019 and 2020 monitoring. Burrowing Owls show fidelity to nesting areas, especially nesting areas where the owls were reproductively successful (Dechant et al. 2002). There were two nests found on the Hanford Site in 2019, one in the Highway 240 area (ABS# 48) and one in the HAMMER EVOC complex (ABS# 39). In 2020, the Highway 240 area and HAMMER EVOC complex both saw increased usage by Burrowing Owls with active burrows increasing from three to six at Highway 240 and from two to seven at the HAMMER EVOC complex. If this pattern continues, an increase in Burrowing Owl use of those ABS clusters would be expected in coming years. Three areas, Old Fields, Holocek, and Orchards, had no Burrowing Owl activity after ABS installation. As ABS are maintained, each year there is a chance they will be discovered and occupied by Burrowing Owls. If continually vacant, external factors potentially contributing to their vacancy should be analyzed. Examples of such factors are vegetation height, density, prey availability, or predation pressure.

In 2018, monitoring occurred before ABS installation and though there was a slight increase in the number of artificial burrows used, numbers were still significantly less than 2012 and 2013. Additionally, weather patterns in the late winter of 2018 resulted in freezes and long-term snowpack that lasted well into March, which may have affected 2018 Burrowing Owl nesting. A similar harsh winter occurred in 2019, potentially affecting 2019 Burrowing Owl nesting. Use of artificial burrows decreased from 2018

to 2019, after the installation of new ABS. This may seem to suggest that Burrowing Owls preferred the old style of ABS but four of the five occupied ABS in 2019 were the new design.

Use of artificial burrows increased from 2019 to 2020, active burrows in the new design increased from four to eight, and active burrows in the old design increased from one to five. If this increasing trend continues it suggests that Burrowing Owls are nesting successfully and returning to the artificial burrows year after year. Some natural variation in the number of Burrowing Owls nesting on the Hanford Site is to be expected but decreasing patterns over time is cause for concern. If Burrowing Owl occupation of burrows decreases in the coming years, the decreases may be due to factors other than available nesting space.

ABS should be maintained annually in order to increase their chance of occupancy by Burrowing Owls. Monitoring in June 2020 found multiple ABS with unusable tunnel entrances, some in clusters with active ABS. Once the entrances were fixed, Burrowing Owls started using the burrows again, as evidenced in July 2020 monitoring. Long-term solutions for stabilizing the tunnel entrances must be considered to ensure continued use of the ABS. This is especially important considering the potential for male owls that overwinter on the Hanford Site to use ABS throughout the entire year.

Along with routine maintenance, ABS should be monitored annually to detect changes in Burrowing Owl populations. As ABS continue to be used, there is a chance the young will return to the Hanford Site to breed and raise their own young. Monitoring ABS at Hanford will continue to provide insight to both Burrowing Owl populations at the Hanford Site and within the greater Columbia Basin.

Continued banding and tracking of owls will provide evidence to confirm that Burrowing Owls are returning to the same nesting areas on the Hanford Site. Banding allows a deeper understanding of the demographics of the species on the Hanford Site and on a larger regional scale. Burrowing Owls banded on the Hanford Site may return and nest in new chambers or be captured at other regional locations (such as the Umatilla Chemical Depot ABS, USFWS or WDFW ABS installations) and beyond. Capture of banded owls will allow researchers such as the Global Owl Project to better understand breeding site selection, migration patterns, or interactions between regional populations.

Prior to the installation of the new ABS, researchers could not easily access the burrow chamber and assess clutch size or hatchling age. Continued monitoring of ABS will allow researchers to track Burrowing Owl reproductive success and gain insight into factors contributing to that success. This will allow researchers to better manage and recover Burrowing Owl populations at the Hanford Site.

Though ABS do not directly address the cause of Burrowing Owl decline, they are an effective management tool in recovering lost Burrowing Owl habitat. A lasting Burrowing Owl population recovery must focus on the root cause of population decline. At Hanford, this appears to be the extirpation of burrowing mammals, specifically ground squirrel colonies. Targeted efforts to recover ground squirrel populations will recover the natural habitat that Burrowing Owls rely on and provide a more permanent solution to recovering Burrowing Owl populations at the Hanford Site. Burrowing Owls are an important component of the ecosystem at Hanford and are declining on the Hanford Site and through most of their range. By tracking Burrowing Owl populations and supporting those populations through habitat replacement, Hanford Site researchers are working to recover the local population of this sensitive species. Continued monitoring of Burrowing Owls is necessary to track the recovery of the species and determine if further recovery efforts are needed.

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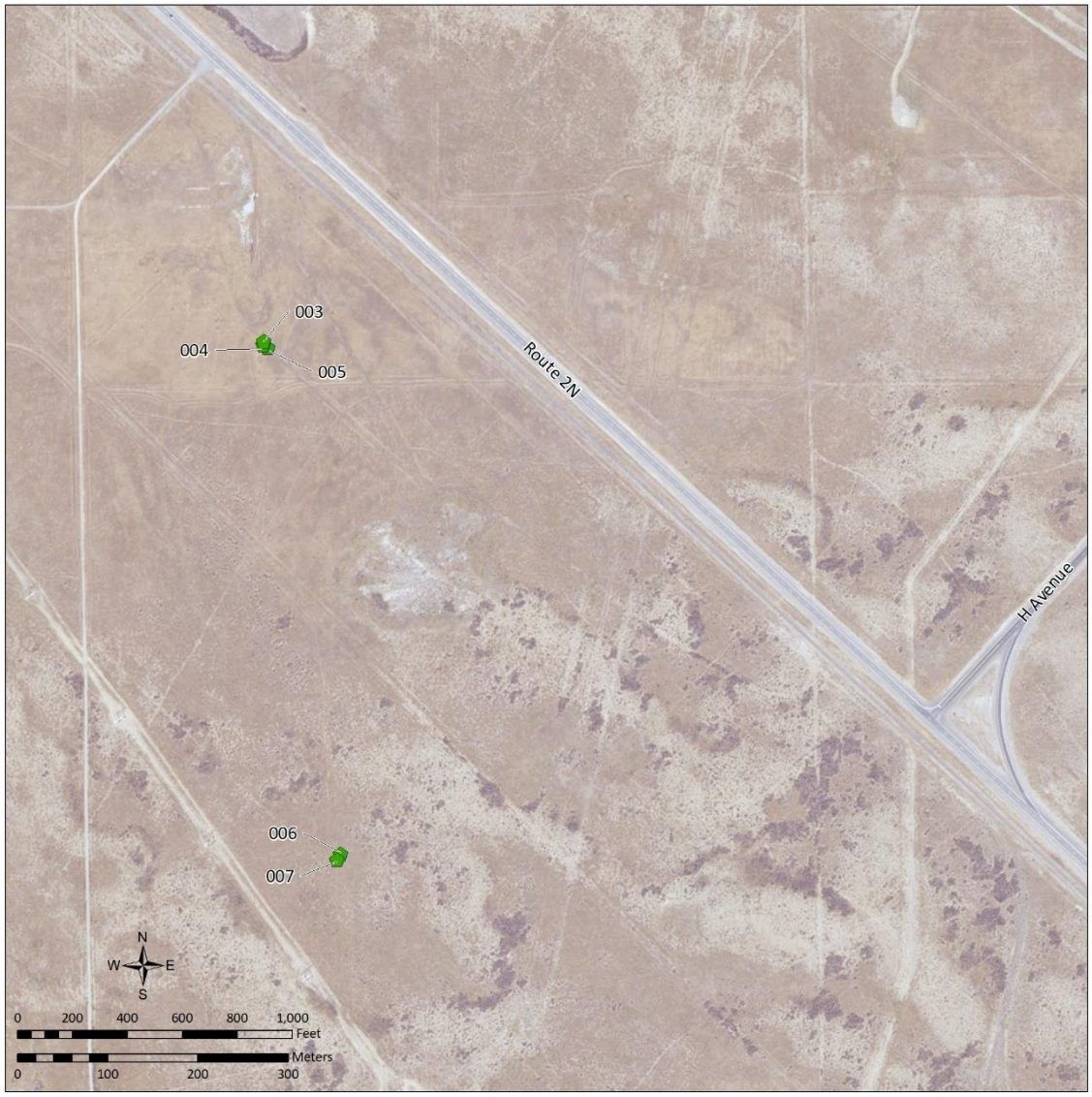
APPENDIX A

MAPS OF ABS INSTALLED BETWEEN JUNE 2018 AND SEPTEMBER 2020

A-1. Artificial Burrow Systems at the HAMMER EVOC Complex.



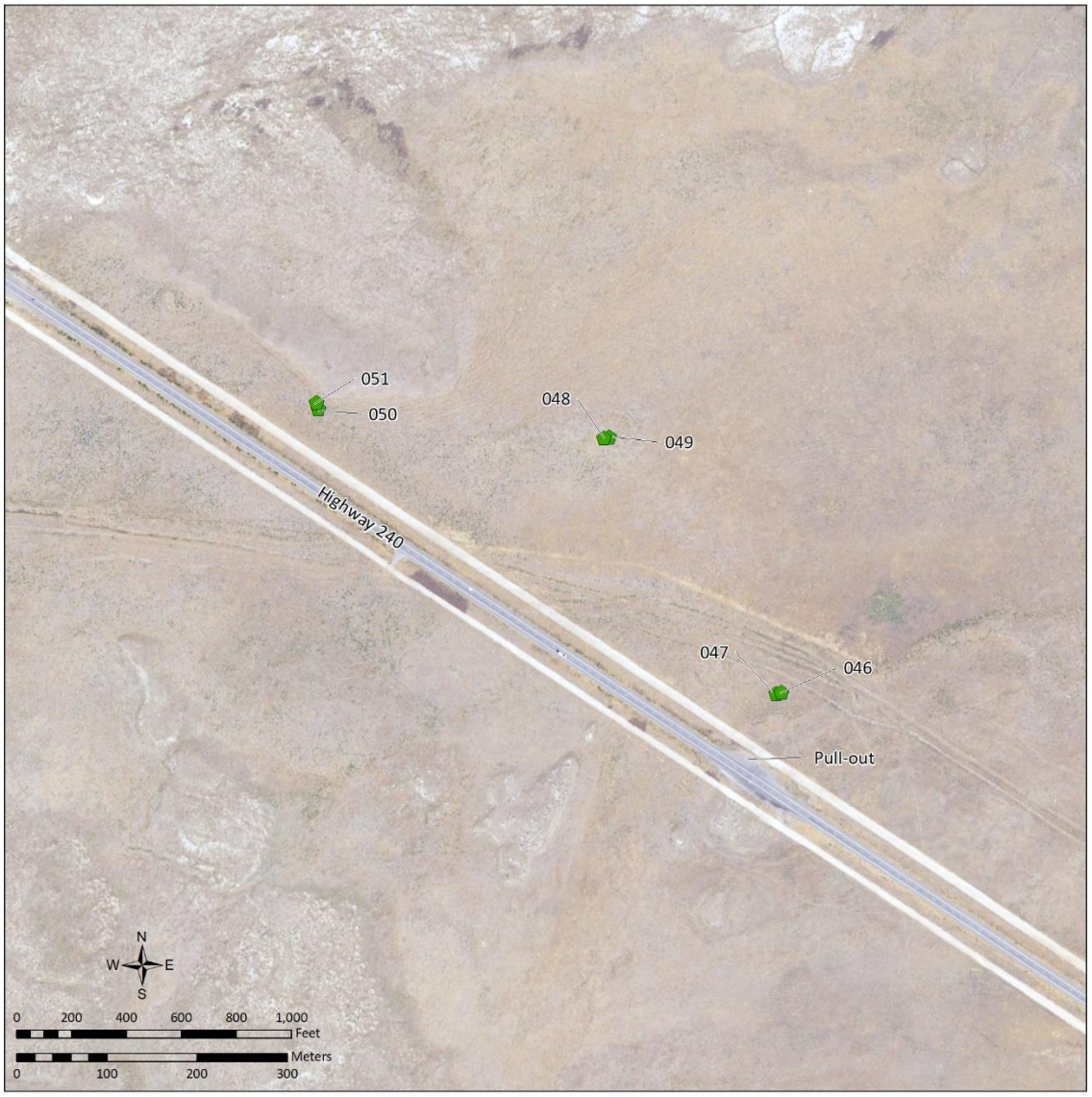
Artificial Burrow Systems at the Holocek Area

Locations and styles of artificial burrow systems at the Holocek Area on the Hanford Site as of 03/01/2020

Legend

Newer Style Artificial Burrow Systems (Installed as of 03/01/2020)

A-2. Artificial Burrow Systems at the Holocek Area.



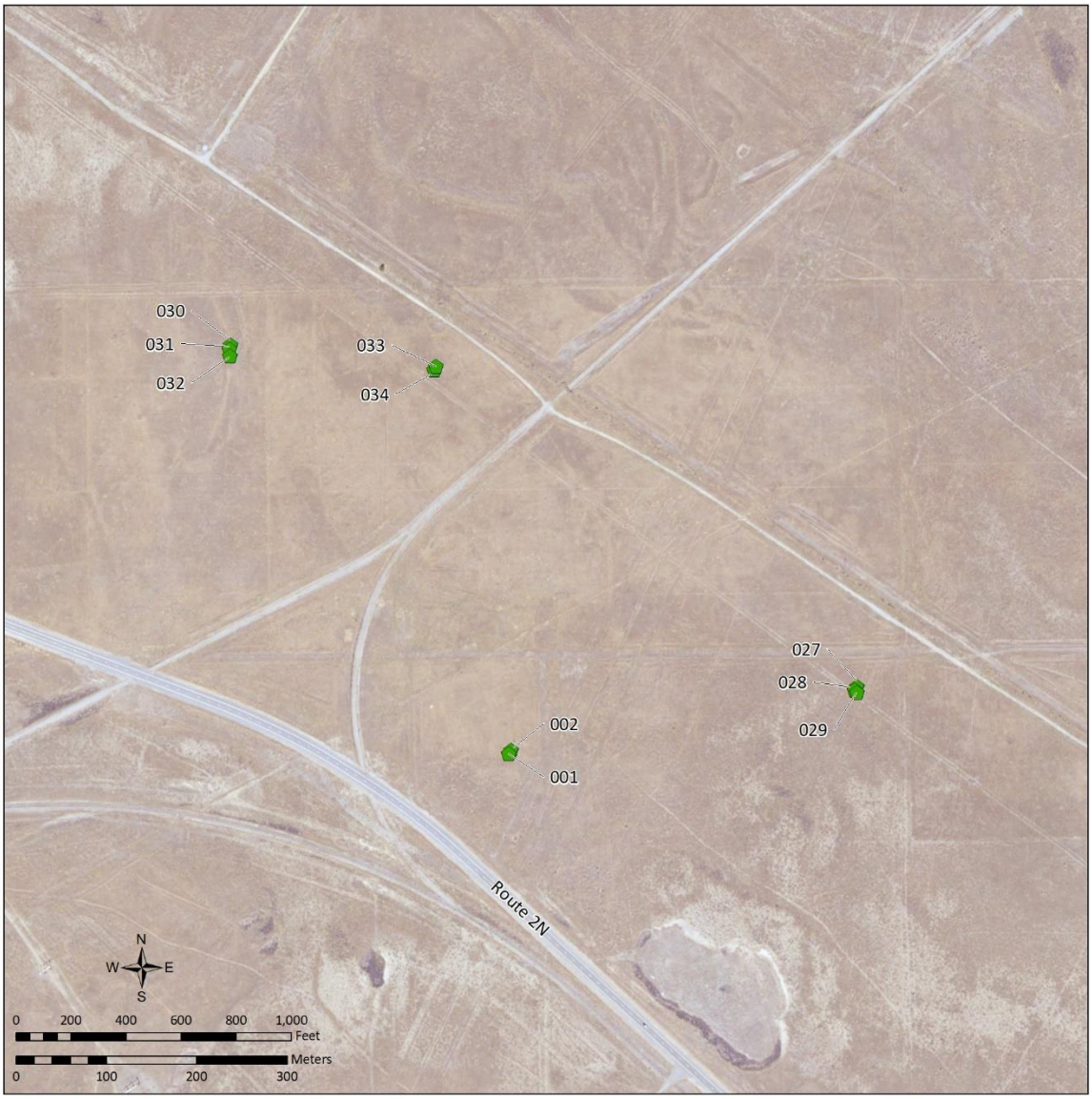
Artificial Burrow Systems at the Highway 240 Area

Locations and styles of artificial burrow systems at the Highway 240 Area on the Hanford Site as of 03/01/2020

Legend

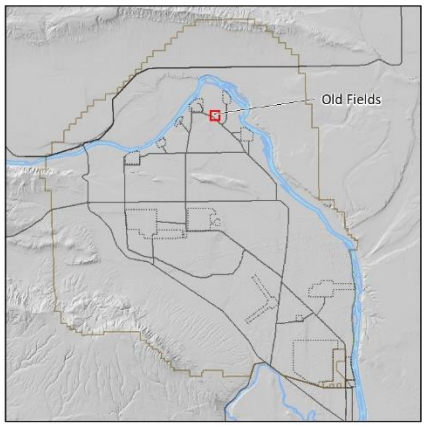
Newer Style Artificial Burrow Systems (Installed as of 03/01/2020)

A-3. Artificial Burrow Systems at the Highway 240 Area.



Artificial Burrow Systems at the Old Fields Area

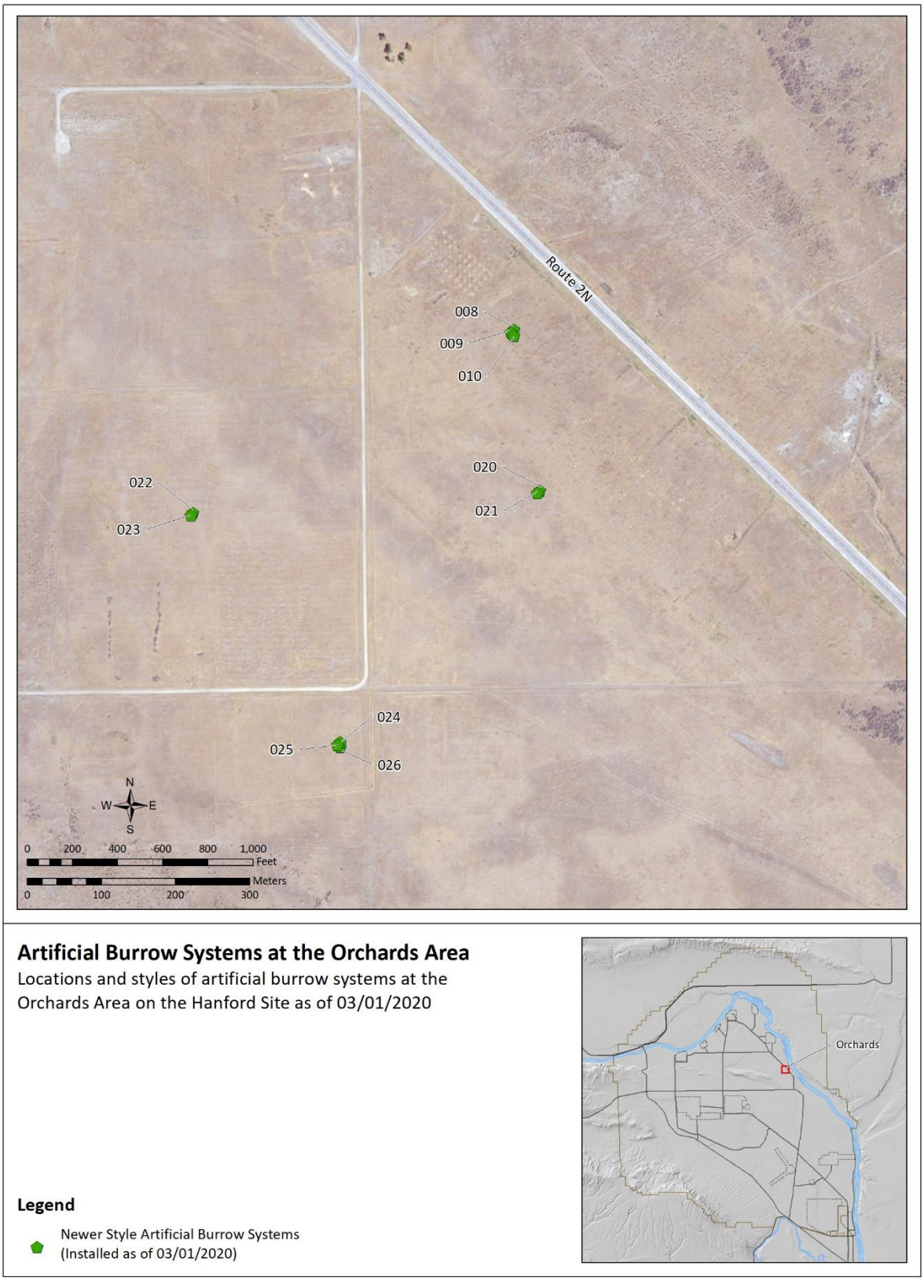
Locations and styles of artificial burrow systems at the Old Fields Area on the Hanford Site as of 03/01/2020



Legend

Newer Style Artificial Burrow Systems (Installed as of 03/01/2020)

A-4. Artificial Burrow Systems at the Old Fields Area.



A-5. Artificial Burrow Systems at the Orchards Area.