HNF-63012
Rev. 0

Hanford Site Ecological Monitoring Report for Calendar Year 2017

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

P.O. Box 650
Richland, Washington 99352

Approved for Public Release
Further Dissemination Unlimited

HNF-63012
Rev. 0

Hanford Site Ecological Monitoring Report for Calendar Year 2017

Date Published
December 2018

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

P.O. Box 650
Richland, Washington 99352

APPROVED
By Lynn M. Ayers at 7:03 am, Jun 26, 2019

Release Approval | Date

Printed in the United States of America

Page Intentionally Left Blank

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

The U.S. Department of Energy, Richland Operations Office (DOE-RL) conducts ecological monitoring on the Hanford Site to collect and track data needed to ensure compliance with an array of environmental laws, regulations, and policies governing the U.S. Department of Energy's (DOE) activities. Ecological monitoring data provide baseline information about the plants, animals, and habitats under DOE-RL stewardship at the Hanford Site required for decision making under the *National Environmental Policy Act* and *Comprehensive Environmental Response, Compensation, and Liability Act*. DOE/EIS-0222-FU, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement*, (CLUP) evaluates potential environmental impacts associated with implementing a comprehensive land use plan for the Hanford Site over the next 50 years.

The vision for the DOE-RL-managed portion of the Hanford Site focuses not only on the cleanup of nuclear facilities and waste sites but on the protection of groundwater, the Columbia River, and the restoration of the land for access and use. To reach these goals DOE-RL is working closely with partners, such as the U. S. Fish and Wildlife Service (FWS) and National Park Service, to enable use of the Hanford land consistent with the CLUP. As DOE-RL moves toward accomplishing this vision, monitoring the ecological resources present to determine whether there is a need for conservation and/or protection of any resources will be critical for making informed decisions for responsible site stewardship.

DOE-RL places priority on monitoring the following plant and animal species or habitats:

- Having specific regulatory protections or requirements
- Having rare and/or declining species (i.e., federally or state listed endangered, threatened, or sensitive)
- Having significant interest to federal, state, or Tribal governments or the public.

DOE/RL-96-32, *Hanford Site Biological Resources Management Plan* (BRMP) ranks plant and wildlife species and habitats (Levels 0 – 5) based on the level of concern for each resource.

Level 5 resources are the rarest and most sensitive species and habitats; they are considered irreplaceable or at risk of extirpation. These resources include species listed or formally proposed as threatened or endangered under the *Endangered Species Act of 1973* (ESA) and habitats designated as critical for these species to persist on the Hanford Site. Other Level 5 habitats are plant community element occurrences and rare habitats such as cliffs, lithosols, dune fields, ephemeral streams, and vernal pools, in addition to fall Chinook salmon and steelhead spawning areas.

Level 4 resources are considered essential to the biological diversity of the Hanford Site and the Columbia Basin Ecoregion. Level 4 resources include species listed by Washington State as endangered or threatened and species listed as candidate species by federal agencies. Habitats listed as Level 4 resources include habitats and protection buffers for federal candidates and Washington State threatened and endangered species; high-quality mature shrub-steppe, wetlands, swales, and riparian zones; and protection buffers for Bald Eagles. The management goal of Level 4 and 5 resources is preservation with a high level of status monitoring.

Level 3 resources are important resources such as Washington State sensitive, candidate, and review species; Washington State Department of Fish and Wildlife (WDFW) priority species; lower-quality mature shrub-steppe, high-quality grasslands, conservation corridors, and floodplains; and snake hibernacula, bat roosts, rookeries, Burrowing Owl buffer areas, and culturally important species not classified as a higher level resource. The management goal of Level 3 resources is conservation with a moderate level of status monitoring.

Level 2 resources are lower priority species and mid-successional communities. Level 2 resources include other plant and animal species of potential conservation concern such as migratory birds, state watch list plants, state monitor wildlife, and recreationally and commercially important species. Mid-successional habitats such as shrub-steppe or steppe communities where the herbaceous layer is dominated by non-native but show a high potential as restoration areas are considered Level 2 resources. The management goal of Level 2 resources is conservation with a low level of status monitoring.

Level 1 resources are common species and marginal habitat resources. Level 1 resources include relatively common native species and fragmented habitats too small, too degraded, and/or too isolated to be of conservation value.

Level 0 resources are non-native species, industrial sites, and other developed areas. Level 0 and 1 resources are not normally monitored.

The overarching goals of the BRMP are to:

- Foster preservation of important biological resources
- Minimize adverse impacts to biological resources from site development and other management activities
- Balance the site cleanup mission with resource stewardship obligations.

Specific DOE resource management objectives for the Hanford Site are to:

- Protect species and habitats of state and federal concern
- Maintain and preserve native biological diversity
- Reduce the spread of invasive species and provide integrated control of noxious weeds
- Improve degraded habitats in a strategic manner to increase landscape connectivity and native diversity, where and when feasible
- Reduce and minimize fragmentation of habitats
- Maintain landscapes that provide regional connectivity to habitats surrounding the Hanford Site.

The biological resource management primary elements for the Hanford Site include resource monitoring, mitigation, restoration, and impact assessment.

1.1 PURPOSE AND SCOPE

This report provides the details of the resource monitoring efforts conducted by DOE-RL in calendar year 2017. Resource monitoring work performed on fall Chinook salmon redds and Bald Eagles initiated in the fall 2016 and completed in 2017 is also included in this report.

1.2 REGULATORY BASIS

The BRMP is identified by the CLUP as the primary implementation document for managing and protecting natural resources on the Hanford Site.

> *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/EIS-0222-FU)

The BRMP was developed to support DOE compliance with applicable federal laws, regulations, Executive Orders, and DOE Orders. Key federal acts and Executive Orders that are relevant to biological resource management include the following:

- *Endangered Species Act of 1973*
- *National Environmental Policy Act of 1969*
- *Migratory Bird Treaty Act of 1918*
- *Bald and Golden Eagle Protection Act*
- *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
- *Resource Conservation and Recovery Act of 1976*
- *Clean Water Act of 1977*
- *Sikes Act*
- *Magnuson-Stevens Fishery Conservation and Management Act of 1976*
- Executive Order 13112, “Invasive Species”
- Executive Order 11990, “Protection of Wetlands”
- Executive Order 11988, “Floodplain Management”
- Presidential Memorandum of June 20, 2014, “Creating a Federal Strategy to Promote the Health of Honey Bees and other Pollinators”

- Presidential Proclamation 7319, "Establishment of the Hanford Reach National Monument" (65 FR 37253)
- DOE O 430.1C, *Real Property Asset Management*.

The BRMP also considers applicable Washington State regulations, especially those regarding fish and wildlife management and noxious weed control.

1.3 HANFORD SITE PHYSIOGRAPHY

The Hanford Site encompasses approximately 1,505 km^2 (581 mi^2) north of the confluence of the Columbia and Yakima Rivers within the Pasco Basin in south-central Washington State (Figure 1-1). In February 1943, the federal government, under the authority of the *War Powers Act*, acquired 1,689 km^2 (625 mi^2) of the Mid-Columbia Basin for the Hanford Site (known as the Hanford Engineer Works during the Manhattan Project) and offered resident compensation.

The Hanford Site stretches approximately 50 km (30 mi) north to south and about 40 km (24 mi) east to west, immediately north-northwest of the confluence of the Yakima and Columbia Rivers; the cities of Kennewick, Pasco, and Richland (the Tri-Cities); and the city of West Richland. The Columbia River flows 80 km (50 mi) through the northern part of the Hanford Site and, turning south, forms part of the Hanford Site's eastern boundary. Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge are on the southwestern and western boundaries of the Hanford Site; and Saddle Mountain is on the northern boundary.

The plateau of the central portion of the Hanford Site has two small east-west ridges: Gable Butte and Gable Mountain. Lands adjoining the Hanford Site to the west, north, and east are principally range and agricultural (WCH-520). With restricted public access, the diverse geographic features and land (Figure 1-2) provide a buffer for areas used for nuclear materials production, research, and ongoing waste storage and disposal. The Hanford Site is located within the Columbia Plateau Ecoregion, an area of dry, mid-latitude desert and mid-latitude steppe climates with hot, dry summers and cold winters. Vegetation is comprised of arid sagebrush steppe and grassland (Wiken et al. 2011) (Figure 1-2).

In 2000, portions of the Hanford Site were declared the Hanford Reach National Monument by Presidential Proclamation 7319 (65 FR 37253) for their ecological, cultural, and geological values. The FWS manages these portions of the Hanford Site as part of the Mid-Columbia River National Wildlife Refuge Complex through the *Hanford Reach National Monument Comprehensive Conservation Plan and Environmental Impact Statement* (FWS 2008). These areas cover 793 km^2 (306 mi^2) and include the north bank of the Columbia River Corridor, Saddle Mountain Unit, Rattlesnake Unit, Wahluke Unit, Ringold Unit, some federal owned islands in the Hanford Reach, and the sand dunes complex north of Energy Northwest. Resource monitoring efforts in this report occurred on portions of the Hanford Site managed by DOE-RL, mainly the central Hanford Site.

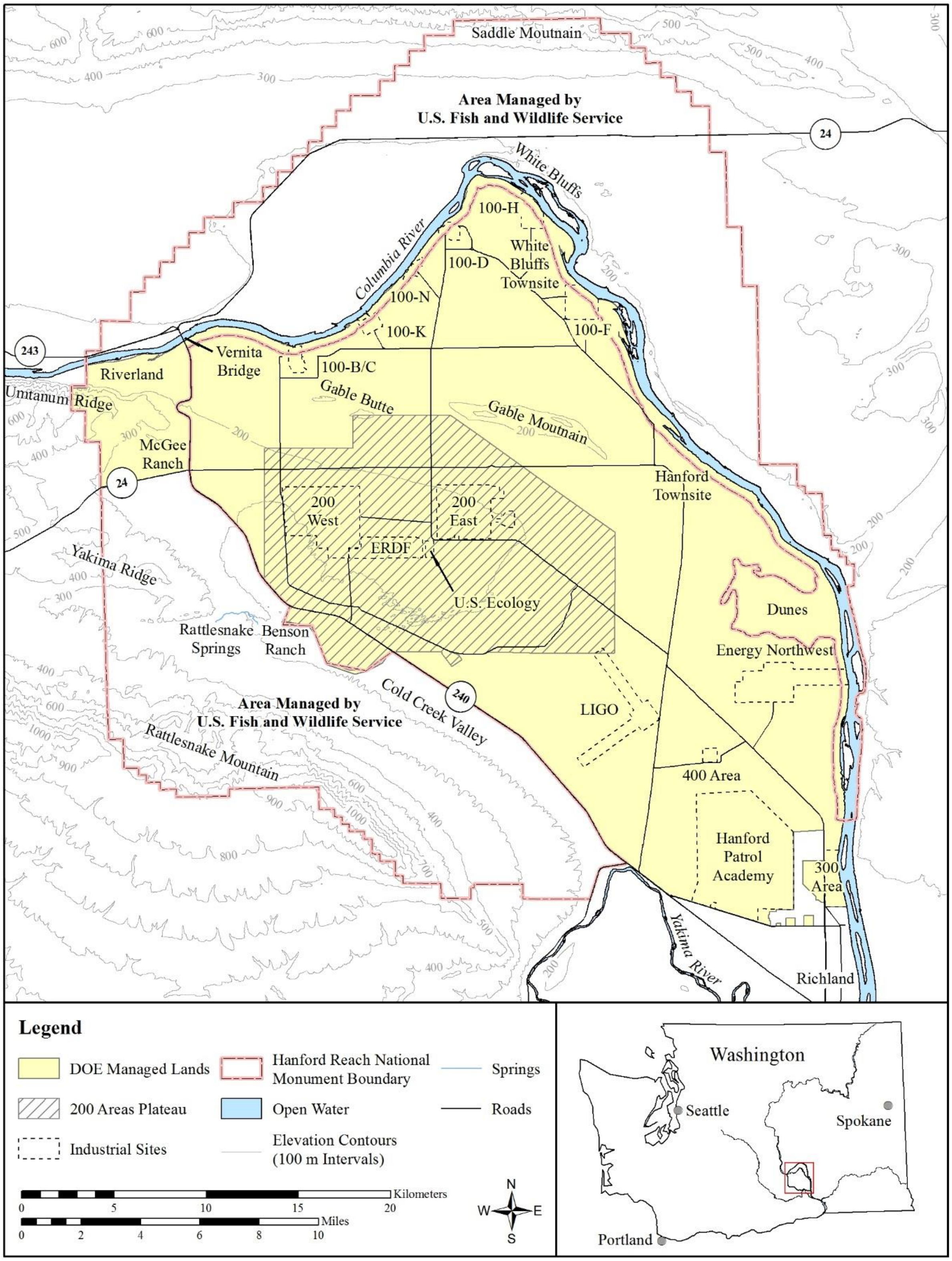


Figure 1-1. Map and General Features of the Hanford Site

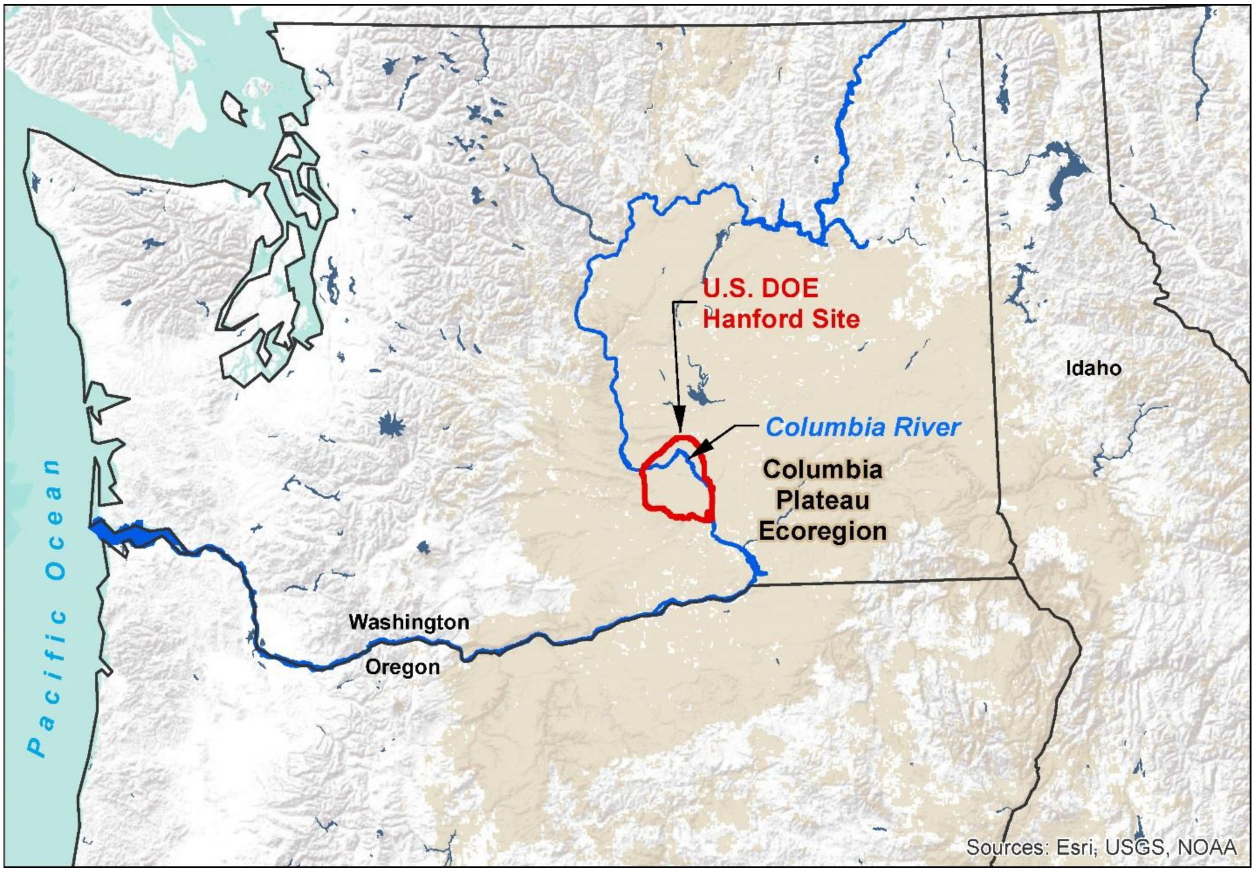


Figure 1-2. The Hanford Site within the Columbia Plateau Ecoregion

1.3.1 Climate

The Hanford Site climate is greatly affected by the moderating influences of the Pacific Ocean and buffering effects of surrounding mountain ranges. The Hanford Site is situated in the rain shadow of the Cascade Mountain Range to the west and buffered from more severe polar air masses and associated winter storms by the Rocky Mountains to the north and east (PNNL-15160, DOE/RL-96-32). The climate on the Hanford Site is semi-arid with hot, dry summers and cold winters. Normal (30-year averages from 1981 to 2010) monthly temperatures range from -5 °C (31.1 °F) in December to 25.1°C (77.1°F) in July. Normal precipitation is 18.14 cm (7.14 in.) annually; most precipitation occurs between October and June. During the period of this report the Hanford Site experienced a much colder, wetter winter and early spring (December 2016 through April 2017), and a hotter and drier spring to early fall (May 2017 through September 2017) (Table 1-1).

Table 1-1. Monthly Average Air Temperatures and Precipitation on the Hanford Site from October 2016 through December 2017.

Air Temperature (°C)															
	Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
2016	12.3	8.5	-2.6												
2017				-5.8	0.2	8.2	11.1	17.2	21.7	26.9	26.3	19.8	11.1	5.1	-0.8
Normal [30-Year Averages (1981-2010)]	11.7	4.7	-0.5	0.8	3.4	8.1	11.9	16.7	20.9	25.1	24.3	19.1	11.7	4.7	-0.5
Departure from Normal	+0.6	+3.8	-2.1	-6.6	-3.2	+0.2	-0.8	+0.5	+0.8	+1.8	+2.0	+0.7	-0.7	+0.4	-0.3
Precipitation (cm)															
	Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
2016	6.58	1.45	1.19												
2017				3.63	4.52	2.01	2.49	0.94	0.58	Trace	0.15	0.74	1.83	3.68	1.27
Normal [30-Year Averages (1981-2010)]	1.24	2.41	3.05	2.39	1.78	1.45	1.40	1.30	1.30	0.46	0.46	0.79	1.24	2.41	3.05
Departure from Normal	+5.33	-0.97	-1.85	+1.24	+2.74	+0.56	+1.09	-0.36	-0.71	-0.46	-0.30	-0.05	+0.58	+1.27	-1.78

Data from Hanford Meteorological Station (http://www.hanford.gov/page.cfm/HMS).

1.3.2 River Dynamics

The Hanford Reach is the only un-impounded, free flowing, non-tidal section of the Columbia River above Bonneville Dam. This section of the river is approximately 82 km (51 mi) and stretches from Priest Rapids Dam to just north of Richland, Washington. Priest Rapids Dam began generating power in 1959 and regulates flow discharges into the Hanford Reach. The Hanford Reach has no natural tributaries and, besides some irrigation runoff and groundwater discharge, Priest Rapids Dam is the main source of river dynamics on this section of the Columbia River (WDFW 2002). Daily average discharges range seasonally from 1,140 to 7,070 m^3/sec (40,000 to 250,000ft^3/sec) (Dauble and Watson 1997). The Federal Energy Commission (FERC) has set 1,019 m^3/sec (36,000 ft^3/sec) as the minimum flow from Priest Rapids Dam. Hanford Reach river flows were near the 50-year mean (1966-2015) for much of the time period of this report, with the exception of spring 2017 (March through June 2017) when river flows were well above the mean (Table 1-2).

1.3.3 Geology and Soils

The Hanford Site is located in the Columbia Plateau physiographic province and the Columbia River flood-basalt province. The Hanford Site lies within the Yakima Fold Belt, a region where the basalt has been deformed into a series of anticlinal ridges and synclinal valleys. River and stream sedimentation have filled the synclinal valleys between the anticlinal ridges. Cataclysmic flood during the Pleistocene created branching flood channels, giant current ripples, ice rafted erratics, giant flood bars, and other landforms visible on the Hanford Site. Subsequent to the Pleistocene, winds have reworked flood sediments creating sand dunes and windblown silt (PNNL-6415).

Soils on the Benton County portion of the Hanford Site were mapped and described in BNWL-243, *Soil Survey Hanford Project in Benton County Washington* (Figure 1-3). BNWL-243 described 15 different soils ranging from sand to silt and stony loams. The soils on the slopes of Rattlesnake Mountain, Yakima Ridge, Umtanum Ridge, Gable Mountain, and Gable Butte are comprised mostly of silt loams and stony silt loams while the soils of the Columbia River Plain are more sandy consisting mostly of sandy loams, loamy sand, sands, and dune sands.

1.3.4 Vegetation

The Hanford Site has some of the last remaining large tracts of shrub-steppe vegetation in Washington State. HNF-61417, *Upland Vegetation of the Central Hanford Site,* recently mapped and described the upland vegetation on the Central Hanford Site (Figure 1-4). At the coarsest scale, HNF-61417 identified 31 different vegetation mapping units on the Central Hanford Site. The five most abundant vegetation mapping units include Sandberg bluegrass (*Poa secunda*)-cheatgrass (*Bromus tectorum*), big sagebrush (*Atremisia tridentata*)/Sandberg bluegrass-cheatgrass, bitterbrush (*Purshia tridentate*)/bunchgrasses, bitterbrush/Sandberg bluegrass-cheatgrass, and bunchgrasses.

Table 1-2. Monthly Average River Flows on the Hanford Reach of the Columbia River from October 2016 through December 2017.

	River Flows (ft^3/sec)[a]														
	Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
2016	80.9	107.9	122.3												
2017				131.8	123.1	163.5	214.5	250.6	231.9	128.8	94.6	76.9	62.1	79.6	102.1
Mean (1966-2015)	79.8	91.9	106.0	112.0	111.0	111.0	121.0	159.0	186.0	147.0	110.0	78.9	79.8	91.9	106.0
Departure from Mean	+1.1	+16.0	+16.3	+19.8	+12.1	+52.5	+93.5	+91.6	+45.9	-18.2	-15.4	-2.0	-17.7	-12.3	-3.9

[a] Measurements are in thousands.
Data from United States Geological Service Gauging Station 12472800 Columbia River below Priest Rapids Dam, Washington (https://waterdata.usgs.gov/usa/nwis/uv?site_no=12472800).

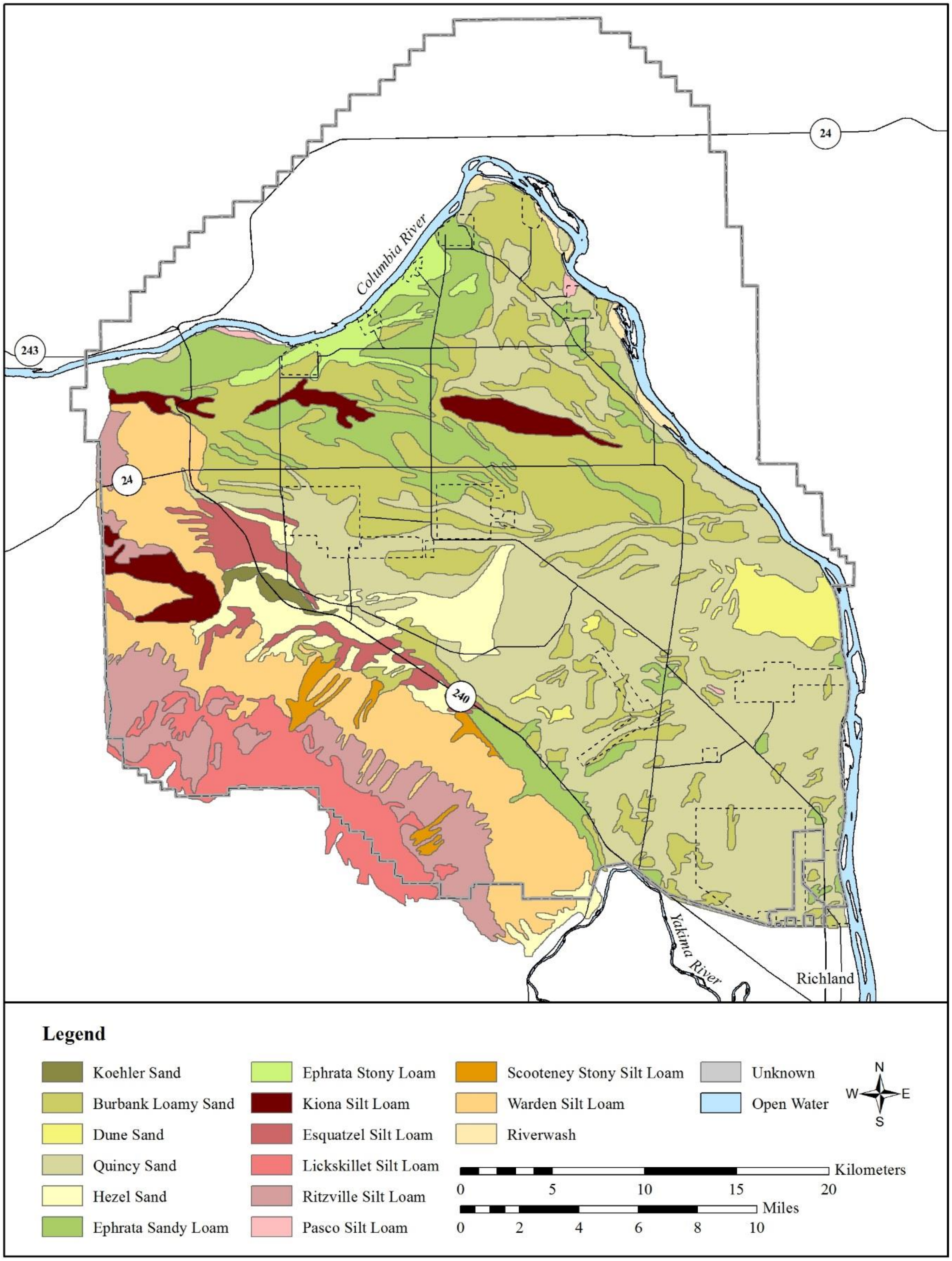


Figure 1-3. Soils on the Benton County Portion of the Hanford Site (BNWL-243)

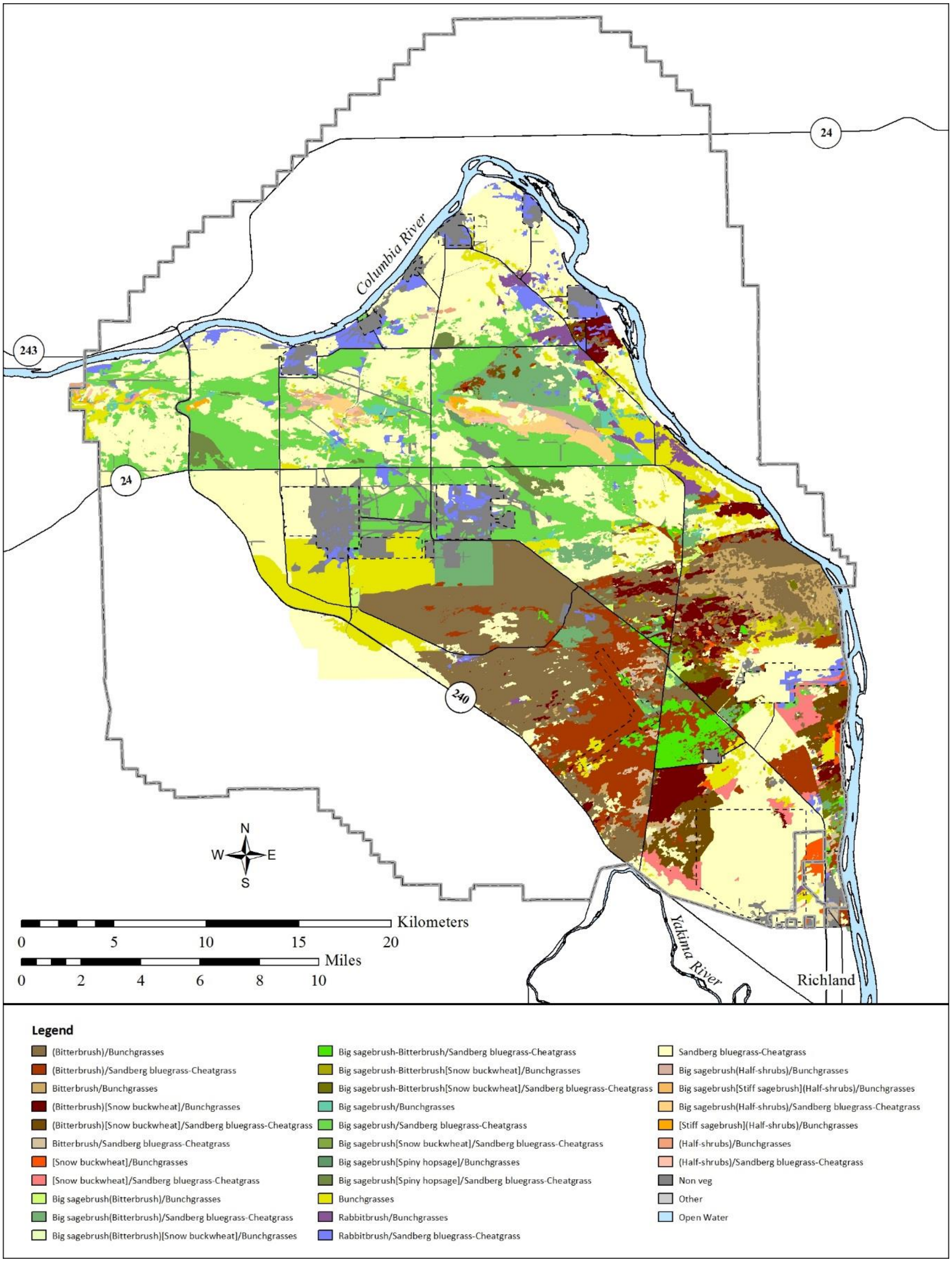


Figure 1-4. Upland Vegetation on Hanford Site DOE-Managed Lands (HNF-61417)

Page Intentionally Left Blank

2.0 RESOURCE MONITORING

DOE-RL planned and conducted 10 resource monitoring projects from October 2016 through December 2017. These projects included fall Chinook salmon (*Oncorhynchus tshawytscha*) redd counts (2016), steelhead (*Oncorhynchus mykiss*) redd counts, Bald Eagle (*Haliaeetus leucocephalus*) night roost and nest surveys (2016-2017), Burrowing Owl (*Athene cunicularia*) nest surveys, Ferruginous Hawk (*Buteo regalis*) nesting territory occupancy and productivity surveys, wading bird rookery surveys, roadside bird surveys, Townsend's ground squirrel (*Urocitellus townsendii*) colony surveys and habitat suitability model verification, bat monitoring for white-nose syndrome (WNS), and ephermeral vernal pool mapping and monitoring. The following section describes these efforts.

2.1 FALL CHINOOK SALMON REDD COUNTS 2016

2.1.1 Introduction

Fall Chinook salmon spawning areas are ranked as Level 5 resources, the highest ranking level in BRMP. According to the BRMP, "resources classified as Level 5 are the rarest and most sensitive habitats and species and are considered irreplaceable or at risk of extirpation or extinction." The management goal of Level 5 resources is preservation and requires a high level of status monitoring.

The population of fall Chinook salmon that spawns in the Columbia River Hanford Reach is the largest run remaining in the Pacific Northwest and has regional ecological and cultural significance, along with economic importance that reaches areas downstream on the Columbia River and up the Pacific Ocean as far as southeast Alaska (Dauble and Watson 1997). These fall Chinook salmon have been vital in efforts to preserve and restore other depleted Chinook salmon stocks in the Columbia Basin (Anglin et al. 2006). Fall Chinook salmon redds have been monitored annually at the Hanford Site, including aerial counts, since 1948 in order to provide an index of relative abundance among spawning areas and years (HNF-52190, HNF-54808, HNF-56707, HNF-58823, HNF-59813, DOE/RL-2016-33). The counts are also used to document the onset of spawning, locate spawning areas, and determine intervals of peak spawning activity. These data also allow for planning to avoid impacts such as disturbance or siltation to redds from Hanford Site activities. Understanding the location and abundance of spawning is a critical part of the management of this important population and facilitates protection of essential fish habitats safeguarded under the *Magnuson-Stevens Fishery Conservation and Management Act*.

The information collected during the aerial surveys is vitally important for the implementation of the Hanford Reach Fall Chinook Protection Program (HRFCPP, USACE 2006). The HRFCPP is an agreement among Public Utility District No. 2 of Grant County, Washington (Grant); Public Utility District No. I of Chelan County, Washington (Chelan); Public Utility District No. 1 of Douglas County, Washington (Douglas); DOE acting by and through the Bonneville Power Administration (BPA); National Oceanic and Atmospheric Administration Fisheries (NOAAF); WDFW; and the Confederated Tribes of the Colville Indian Reservation. The goal of this program is to protect Hanford Reach fall Chinook salmon during critical periods of their lifecycle through operational constraints imposed on the Priest Rapids Hydroelectric Project.

Commonly referred to as king salmon, Chinook are the largest of the Pacific salmon (Myers et al. 1998, Netboy 1958). The Columbia River supports three major runs (spring, summer, and fall) of Chinook salmon, generally based on the season during which the adults re-enter the estuary to begin their upstream migration to spawn. Chinook salmon that spawn in the Hanford Reach of the Columbia River are fall-run fish. Fall Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Myers et al. 1998, Fulton 1968, Healey 1991). Adult fall Chinook salmon destined for the Hanford Reach are upriver brights (fish retain their silver color during upstream migration) that enter the Columbia River in late summer and spawn in the fall. Spawning in the Hanford Reach typically begins in mid-October and lasts through November. Dauble and Waston (1997) found the first-observation of spawning ranged from September 28 to October 26 with a median date of October 16. Females fan out nests or “redds” in suitable gravel substrate and deposit eggs in a pocket while males simultaneously extrude milt to fertilize the eggs. Redds are readily identifiable at this time and appear as clean swept gravel patches amidst darker undisturbed substrate covered by algae (periphyton). “Redd life” is a term describing the period during which periphyton growth has not rendered the redd substrate indiscernible from the surroundings. Redd life is typically about 6 weeks on the Hanford Reach (PNL-7289); however, redds have been recorded to remain visible for over 16 weeks (HNF-53665, HNF-56705).

2.1.2 Methods

Aerial surveys of fall Chinook salmon redds were conducted in areas of the Hanford Reach consistent with past survey efforts and the historical data set (Figure 2-1). Eight additional sub-sections (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F, Dunes, and 300 Areas) were added beginning in 2011 to monitor the abundance and distribution of fall Chinook salmon redds in areas of the Columbia River adjacent to contaminated groundwater plumes of the Hanford Site (Figure 2-2) (DOE/RL-2016-33, DOE/RL-2014-52). These eight new sub-sections were divided so that redd counts and direct comparisons to historical records can still be made in the original areas.

The primary physical factors influencing the accuracy of aerial counts include depth of water over redds and water clarity. Wind action, available light, orientation of the river, and direction of the current can also affect redd counts. The accuracy of aerial counts also decreases with increasing numbers and density of redds within a large aggregate of redds (Visser et al. 2002). Flights are cancelled if weather conditions are not favorable (i.e., wind, fog, or low clouds). Field measurements suggest that the upper depth limit for detecting redds during aerial surveys conducted on the Hanford Reach was 3 to 4 m (10 to 13 ft) (PNL-7289) while other studies indicate that fall Chinook salmon spawn in water up to 9 m (30 ft) deep (Swan 1989); therefore, a proportion of redds located in deeper water may not be detected during aerial surveys (PNL-7289). Because it is seldom possible to view all redds from the air, these counts provide only an annual index of relative abundance and distribution of fall Chinook salmon spawning in the Hanford Reach of the Columbia River.

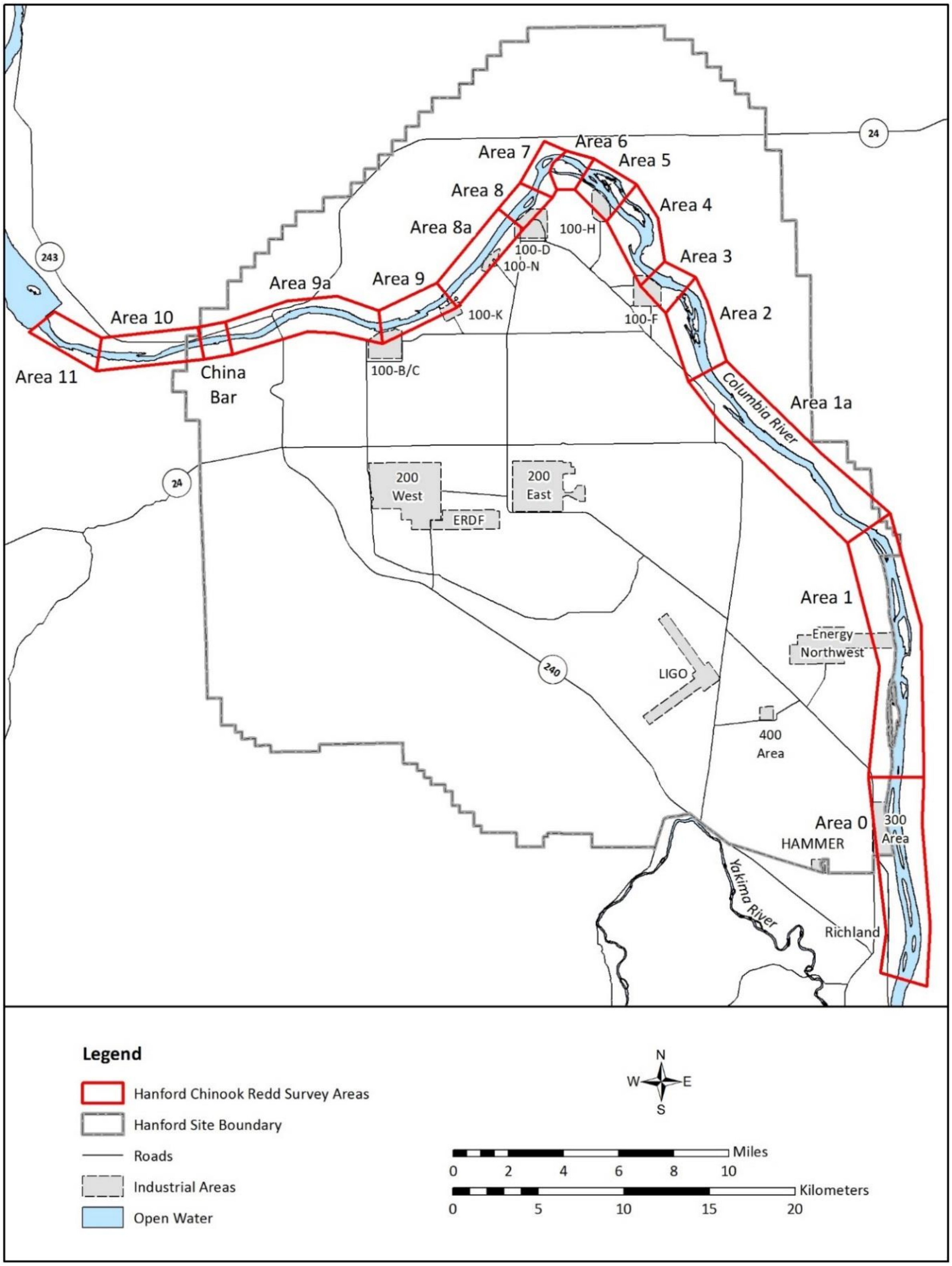


Figure 2-1. Aerial Survey Areas for Fall Chinook Redds Used Historically and in 2016

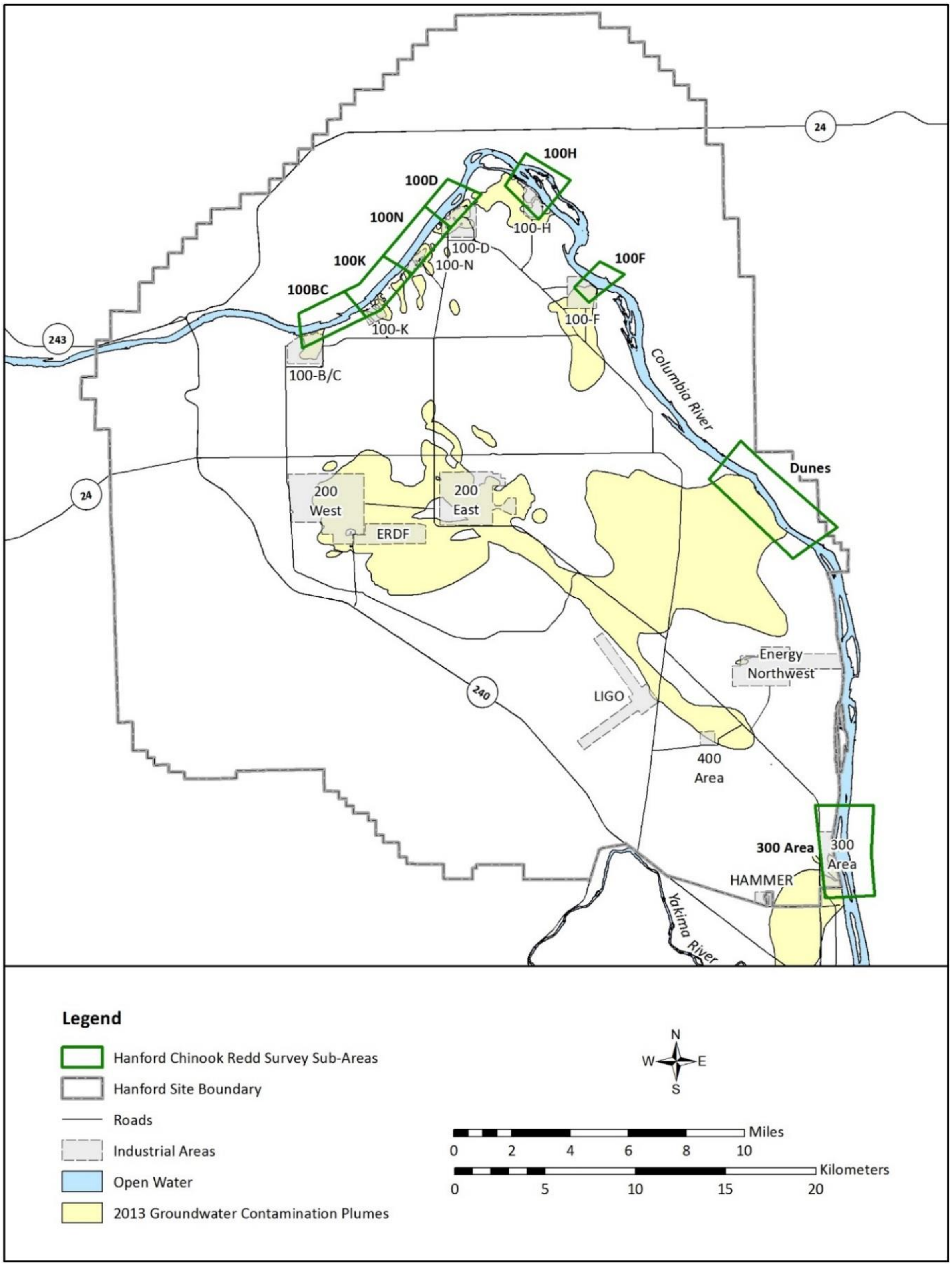


Figure 2-2. Fall Chinook Survey Sub-areas Adjacent to Groundwater Contamination Plumes

Beginning in mid-October under the terms of the HRFCPP, river flows are reduced in the morning every Sunday (the day of the week with the lowest power demand) to the Priest Rapids Dam minimum operating discharge of 1,019 m^3/sec (36,000 ft^3/sec).

This allows the Agency (NOAAF, WDFW, and Colville Indian Reservation) and Utility (Grant, Chelan, Douglas, and BPA) Party Monitoring Team to perform a ground survey of redd distribution at Vernita Bar just downstream of Priest Rapids Dam. These drawdowns occur every Sunday morning until the initiation of fall Chinook spawning has been set both above and below the 1,416-m^3/sec (50,000-ft^3/sec) flow elevations. A final drawdown is conducted on the Sunday prior to Thanksgiving to establish the minimum critical flow needed to protect pre-emergent fall Chinook salmon. Given the previously described limitations, this weekly reduction in river flow affords the best viewing conditions for aerial flights, which are then scheduled concurrent with the Sunday morning drawdowns, when possible.

Flights are scheduled to encompass the entire fall Chinook spawning period, usually mid-October (initiation of spawning) through the end of November (end of spawning). Three to four flights are typically conducted during this period. Early flights (October) are conducted to establish the initiation of spawning and later flights (November) occur during and just after the peak spawning period to establish the maximum redd count for the season by area and for the entire Hanford Reach. Multiple flights are necessary to minimize the effect of poor visibility or other sources of count variability that may occur during a single flight. Multiple flights also ensure comparability within the long-term database through consistency with past efforts. As a courtesy and consistent with past practices, aerial redd count information is shared with the HRFCPP parties to assist in the implementation of protective measures.

Survey flight altitudes range from 244 to 366 m (800 to 1,200 ft) with air speeds of 120 to 161 km/hr (75 to 100 mi/hr). Widely spaced fall Chinook redds are individually counted, while tightly grouped clusters of redds are estimated in groups of 10 or 50. Heavy spawning areas may require multiple aerial passes to collect complete counts. Observations begin in Richland at the Interstate 182 bridge and end at Priest Rapids Dam. Flights are conducted near noon to bracket the highest angle of the sun for optimum viewing conditions. Observers wear polarized glasses, as necessary, to reduce glare. All redds observed are documented by survey area on large format printed maps.

Because long-term trends in both redd abundance and distribution are important monitoring components, Mission Support Alliance (MSA) has taken several steps to ensure compatibility and consistency with past efforts, including the following:

- Thoroughly reviewing and adopting past monitoring protocols
- Coordinating/training with former redd count personnel
- Coordinating and exchanging of information with the WDFW and the Grant County Public Utility District to support the ongoing HRFCPP
- Using maps detailing the entire survey reach, as well as all historical sub-areas and spawning sites both as in-flight guidance documents and as field data recording forms
- Using the same air service, airplane, and pilots in 2016 that were used in previous years.

2.1.3 Results

Four surveys were completed along the Hanford Reach during 2016. All of the surveys were conducted on Sundays. Surveys were performed on October 23, November 6, November 13, and November 20. The counts for each flight are shown in Table 2-1. The maximum count describes the highest number of redds documented in a survey area within any single flight. The visual redd count total is calculated by summing the maximum redd count from each survey area, which equaled 13,268 in 2016. Table 2-2 shows the number of redds counted within the newer defined sub-areas coinciding with Hanford Site operational areas. Viewing conditions were very good on the first flight and fair to good on the remaining three flights. On the last three flights, a cloudy sediment plume stretched along the eastern shore from the White Bluffs down to Richland conceivably smothering newly formed redds or rendering the habitat unusable. The cloudy sediment plume is the product of slumping of the White Bluffs possibly exacerbated by rapid fluctuations in water levels.

Table 2-1. Summary of Fall Chinook Salmon Redd Counts by Areas for the 2016 Aerial Surveys in the Columbia River Hanford Reach.

Area	Description	10/23/2016	11/6/2016	11/13/2016	11/20/2016	Maximum Count
0	Islands 17-21 (Richland)	0	0	0	0	0
1	Islands 11-16	0	380	830	861	861
1a	Savage Island/Hanford Slough	0	0	0	0	0
2	Islands 8-10	35	1,020	1,685	1,735	1,735
3	Near Island 7	0	650	660	670	670
4	Island 6 (lower half)	54	1,135	1,805	1,807	1,807
5	Island 4, 5 and upper 6	68	2,140	2,262	2,270	2,270
6	Near Island 3	30	380	550	600	600
7	Near Island 2	40	810	1,120	1,140	1,140
8	Near Island 1	10	253	300	340	340
8a	Upstream of Island 1 to Coyote Rapids	0	0	0	0	0
9	Near Coyote Rapids	13	165	232	235	235
9a	Upstream of Coyote Rapids to China Bar	0	20	20	20	20
China Bar	China Bar/Midway	4	60	60	80	80
10	Near Vernita Bar	220	3,140	3,400	3,500	3,500
11	Upstream of Vernita Bar to Priest Rapids Dam	0	7	10	10	10
Total		474	10,160	12,934	13,268	13,268

Table 2-2. Summary of Fall Chinook Salmon Redd Counts by Sub-areas Adjacent to Hanford Site Operations for the 2016 Aerial Surveys in the Columbia River Hanford Reach.

Sub-area	10/23/2016	11/6/2016	11/13/2016	11/20/2016	Maximum Count
300 Area	0	0	0	0	0
Dunes	0	0	0	0	0
100-F	0	640	660	670	670
100-H	68	2,140	2,262	2,270	2,270
100-D	10	53	300	340	340
100-N	0	0	0	0	0
100-K	0	0	0	0	0
100-BC	13	165	232	235	235
Total	91	2,998	3,454	3,515	3,515

2.1.4 Discussion

The peak annual redd count for 2016 (13,268) was the fourth highest count since 1948 and exceeds the average of the previous 10 years (10,092). The historical trend in redd counts since 1948 is shown in Figure 2-3. Fall Chinook salmon redd counts on the Hanford Reach in 2016 decreased by 35.8% from the highest count, which was recorded in 2015 (20,678). Although the redd count decreased in 2016, the recent annual redd counts generally far surpass counts for past decades. Harnish et al. (2014) attribute the increase in productivity of fall Chinook salmon in the Hanford Reach to operational changes at Priest Rapids Dam over the past 30-year period. These changes are now part of the HRFCPP. Using stock-recruit analyses to identify changes to the population's freshwater productivity that occurred over the 30-year period and corresponded with changes to dam operations, Harnish et al. (2014) observed a 217% increase in productivity that corresponded with constraints enacted to prevent redd dewatering and an additional 130% increase that coincided with constraints to limit stranding and entrapment of juveniles.

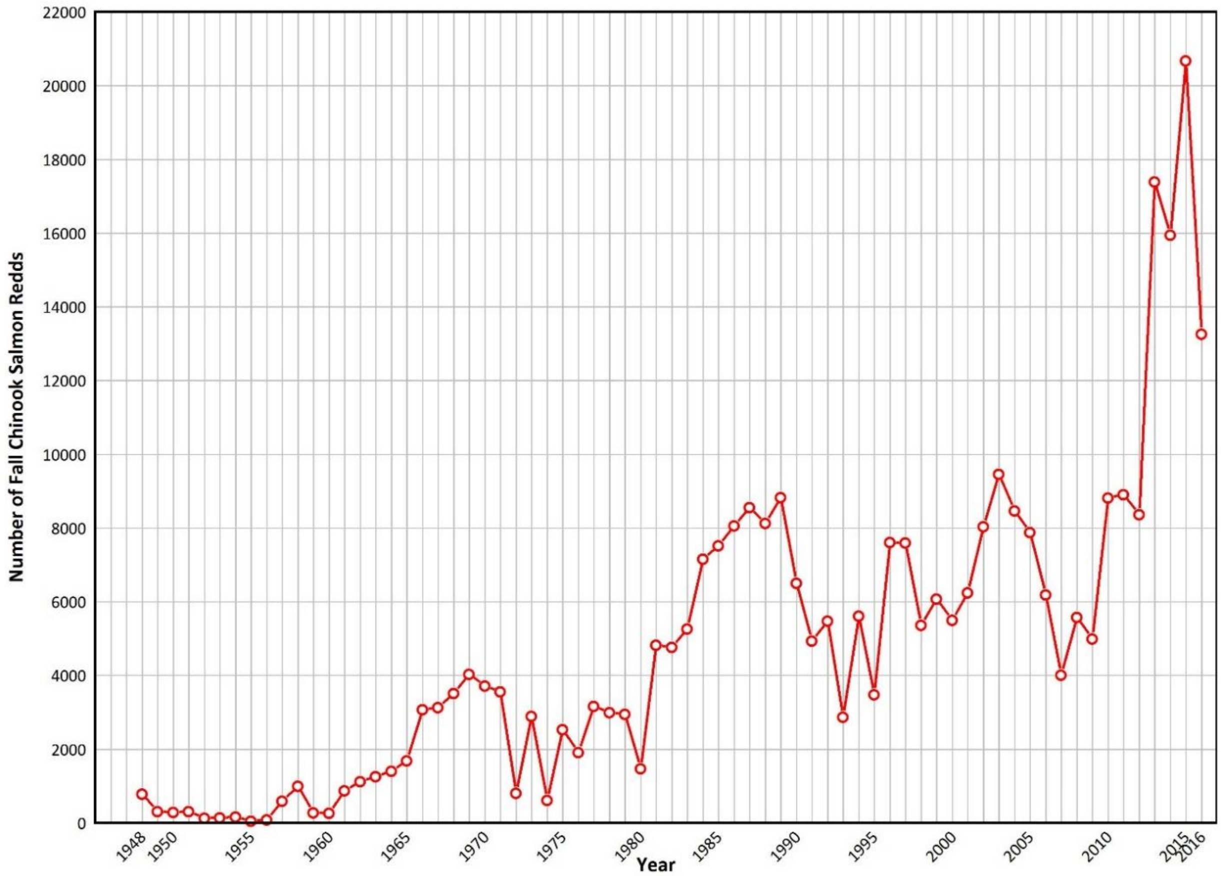


Figure 2-3. Visual Hanford Reach Fall Chinook Salmon Redd Counts 1948 to 2016

It is noteworthy that recent studies suggest that the entire early freshwater life phase is crucial for high population return (PNNL-23719). For example, 65% of cohorts from 1975 to 2004 that had high adult or spawner survival also experienced high survival during the egg-to-presmolt life phase. In addition, several factors could detract from high survival during the smolt phase, including the need to navigate past four dams and long slow-moving impoundments between dams, each of which are abundant in predators (mainly piscivorous fish).

One mitigating factor that could increase survival despite these hazards is high spring flows, which could effectively allow smolts to move more quickly through the dams and impoundments as well as limit their vulnerability to predators on their way downstream to the ocean. It appears that high spring flows are critical for the smolt phase. Thus, years in which the number of returning adult fall Chinook salmon is high should correspond to high spring flows during the corresponding early freshwater life phase for these individuals.

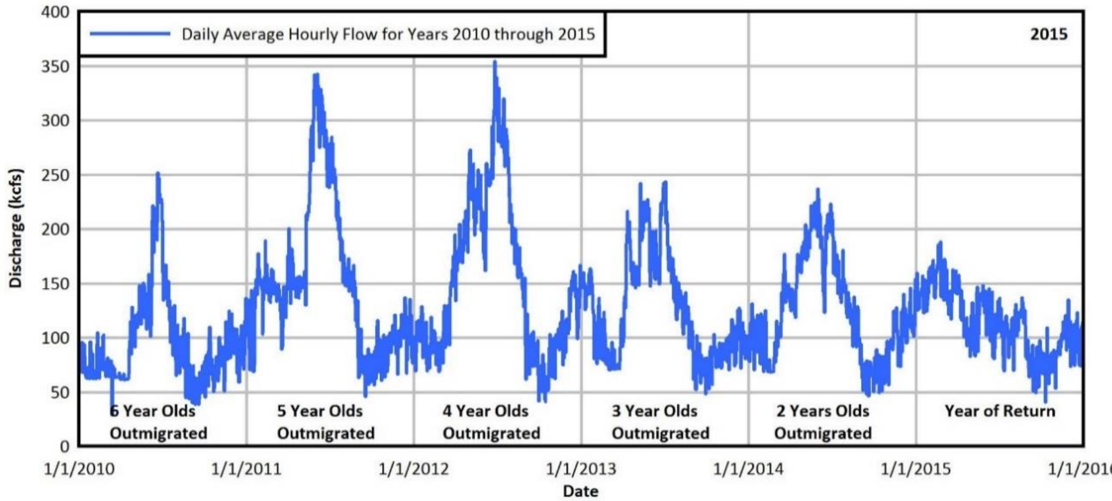
In 2015, ages 2-, 3-, 4- and 5-year olds returned at high numbers (32,401; 46,352; 108,908; and 78,572 individuals, respectively). These estimated returns were well above the median returns of ages 2- (8,394), 3- (46,352), 4- (23,180), and 5-year olds (15,487) returning to spawn during the 1996 to 2016 period (Table 2-3 was provided by P. Hoffarth, Washington State Department of Fish and Wildlife, in a personal communication on February 2, 2017). These fall Chinook salmon had their early freshwater phase during 2011, 2012, 2013, and 2014, which were all years during which peak spring flows were well over 5,663 m^3/sec (200,000 ft^3/sec) (Figure 2-4, top chart). By contrast, 2007 had low total numbers of ages 3-, 4- and 5-year olds returning (1,373; 7,636; and 4,620, respectively) (Table 2-3). These cohorts returning in 2007 had their early freshwater life phase in 2003, 2004, and 2005, all years during which peak spring flows were well below 5,663 m^3/sec (200,000 ft^3/sec) (Figure 2-4, middle chart). In 2016 there were good numbers of age 3-year olds (15,957) and high numbers of ages 4- (61,718), 5- (30,661), and 6-year olds (1,648) returning. These cohorts also had their early freshwater life phase during years with peak spring flows above 5,663 m^3/sec (200,000 ft^3/sec) (Figure 2-4, bottom chart). Based on these patterns we would predict that in 2017 there would be a low return of ages 2- and 3-year olds, a good return of ages 4- and 5-year olds, and a high return of age 6-year olds because peak spring flows were low during early freshwater life phase for ages 2- and 3-year olds, moderate for ages 4- and 5-year olds, and high for age 6-year olds.

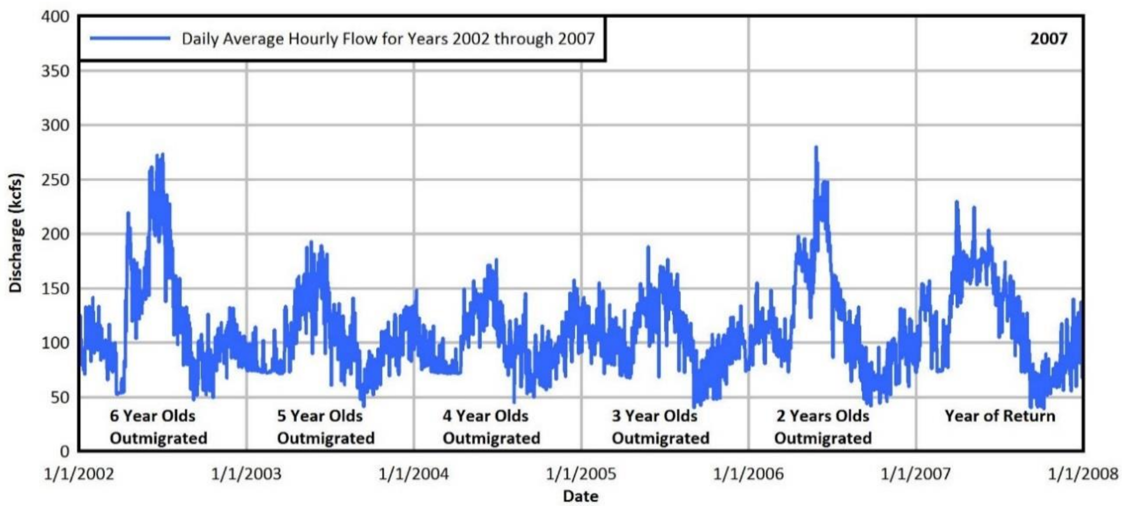
In summary, 2016 was a very good return year for fall Chinook salmon spawning in the Hanford Reach. The high return rate seen is likely due to optimized circumstances during the egg-to-presmolt phase as a result of changes made per HRFCPP. In addition, work by PNNL-23719 supports the idea that the entire early freshwater phase is important for salmon survival. It is tempting to speculate that high spring flows could further optimize survival during the smolt phase. Good correspondence between years in which there are high spring flows and high future productivity of fall Chinook suggest that the benefit of high spring flows warrant further study.

Table 2-3. Hanford Reach Fall Chinook Salmon Escapement[a] for 1996 to 2016.

Return Year	Age (Years)						Total
	2	3	4	5	6	7	
2016	6,437	15,957	61,718	30,661	1,648	0	116,421
2015	32,401	46,352	108,908	78,572	94	0	266,328
2014	31,290	12,308	132,051	8,110	48	0	183,807
2013	17,356	79,871	71,816	5,721	75	0	174,841
2012	5,897	14,182	21,274	16,362	0	0	57,715
2011	9,532	8,052	46,785	10,735	152	0	75,256
2010	6,608	21,958	32,902	25,446	68	34	87,016
2009	10,374	2,714	16,989	6,642	0	0	36,720
2008	5,697	4,533	8,662	10,121	45	0	29,058
2007	8,394	1,373	7,636	4,620	348	0	22,371
2006	4,606	3,725	17,206	25,543	532	0	51,700
2005	7,612	7,095	35,849	20,729	682	0	71,967
2004	8,231	10,968	16,739	49,951	1,806	0	87,695
2003	11,196	4,677	49,618	34,936	81	0	100,508
2002	15,167	11,367	42,439	15,487	50	0	84,510
2001	15,708	9,844	23,844	9,844	607	0	59,847
2000	11,993	2,765	13,416	19,847	0	0	48,021
1999	2,800	3,434	18,348	4,882	349	0	29,813
1998	5,983	5,560	3,919	19,625	306	0	35,393
1997	9,486	944	23,180	9,827	56	0	43,493
1996	5,701	9,001	21,249	7,040	257	0	43,248

[a] Escapement is the number of adult salmon that escape fisheries and return to a particular section of river to spawn.





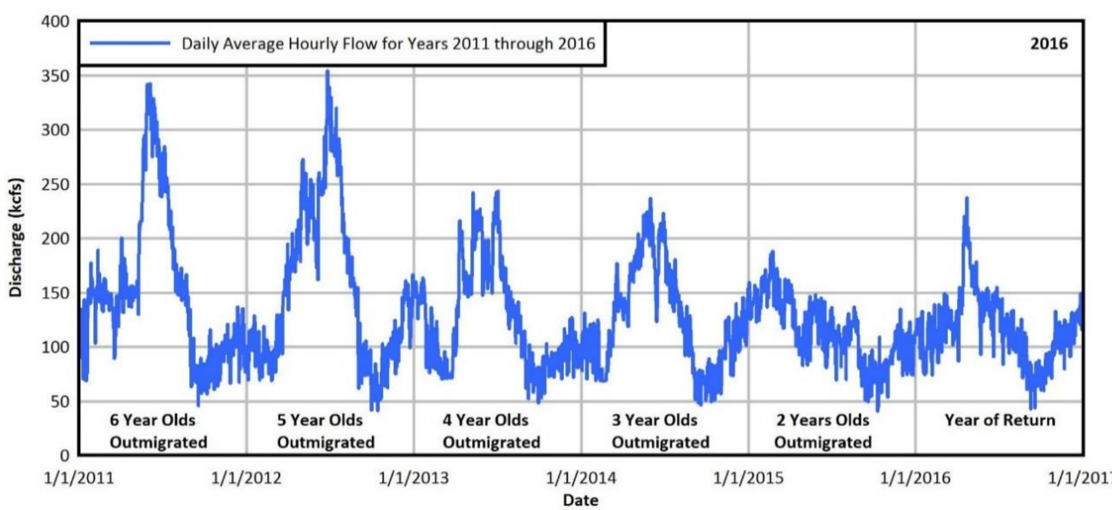


Figure 2-4. A Comparison of Five-Year Flow History in the Hanford Reach Prior to a Year of High (top panel) and Low (middle panel) Number of Returning Fall Chinook Salmon (bottom panel)

2.2 STEELHEAD REDD COUNTS 2017

Steelhead and their critical habitat are ranked as Level 5 resources, the highest ranking level in BRMP. According to BRMP, “resources classified as Level 5 are the rarest and most sensitive habitats and species and are considered irreplaceable or at risk of extirpation or extinction.” The management goal of Level 5 resources is preservation, and these resources require a high level of status monitoring. While the BRMP provides overall biological resource management policies, objectives, and goals, DOE/RL-2000-27, *Threatened and Endangered Species Management Plan: Salmon, Steelhead, and Bull Trout*, provides specific management activities for stocks of Upper Columbia River steelhead found within the Hanford Reach of the Columbia River.

Aerial and follow-up boat surveys for steelhead redds are conducted in the Hanford Reach during the spring of each year in order to identify potential spawning areas and timing, as well as to provide an annual index of relative abundance among spawning areas. These surveys serve to document any change in the status of steelhead spawning in the Hanford Reach and are used to help plan project activities to avoid redds, if any are identified.

A prized recreational fishery exists for steelhead throughout the Pacific Northwest; steelhead constitutes a primary component of Tribal fisheries in the Columbia Basin. Steelhead use the Hanford Reach for rearing as juveniles, as a migratory corridor as both juveniles and adults, and for spawning as adults. Upper Columbia River summer-run steelhead use the Hanford Reach and are currently listed as threatened under the ESA. Because of their ESA listing status and importance to recreational and Tribal fisheries, steelhead are monitored by DOE-RL.

On August 18, 1997, Upper Columbia River summer-run steelhead were listed as endangered under the ESA with an effective date of October 17, 1997 (62 FR 43937). This status was downgraded to threatened on January 5, 2006, reinstated to endangered status per U.S. District Court decision in June 2007; and downgraded to threatened again per U.S. District Court order in June 2009. The NOAAF issued results of a 5-year review on August 15, 2011, and concluded that this species should remain listed as threatened (76 FR 50447). Steelhead covered under this listing include all naturally-spawned anadromous steelhead populations and their progeny below natural and man-made impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the United States-Canada border. Also covered are artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop National Fish Hatchery, Omak Creek, and the Ringold steelhead hatchery programs. Critical habitat for this Evolutionarily Significant Unit within the Hanford Site includes the entire Hanford Reach (65 FR 7764, 70 FR 52630).

Steelhead are the anadromous (sea-run) form of the rainbow trout. Steelhead migrate from their natal streams to the ocean as juveniles and return to their natal streams as mature adults to spawn. They can survive spawning (iteroparity), whereas all pacific salmon die after spawning (semelparity). Although steelhead can survive spawning to spawn a second time, the repeat spawning rate in Washington State is low (4 to 15% [Wydoski and Whitney 1979]). In addition, adults encounter four mainstem Columbia River dams on their way to and from the Hanford Reach; therefore, repeat spawning in the Hanford Reach by a significant number of steelhead is unlikely.

Steelhead build nests, termed redds, in gravel or cobble substrate and spawn in the spring; the steelhead fry emerge from the gravel later that same spring. A typical steelhead redd covers approximately 4.4 to 5.4 m^2 (47.4 to 58.1 ft^2) (Bjornn and Reiser 1991). Adult steelhead generally utilize smaller tributary habitat and substrate than Chinook salmon but will spawn in larger mainstem rivers (e.g., Columbia River) where suitable habitat exists. In Idaho's Clearwater and Salmon Rivers, the preferred gravel size for nesting was 1.3 to 10.2 cm (0.5 to 4 in), water depth 0.2 to 1.5 m (0.75 to 5 ft), and water velocity 0.70 to 0.76 m/sec (2.3 to 2.5 ft/sec); these habitat conditions are available within the Hanford Reach (Orcutt 1968). In 2007, steelhead spawning habitat suitability surveys were conducted at multiple sites contained within three key contaminant plumes resulting from Hanford Site operations (Stables and Tiller 2007). Habitat suitability was assessed based upon depth, velocity, substrate size, and substrate embeddedness. Eleven of the 72 sites surveyed were found to be entirely suitable to support steelhead spawning at the flows present during the time of the surveys.

Steelhead occur in the Hanford Reach all year; however, most adults move into the Hanford Reach from August to November, peaking in September (Watson 1973, PNL-5371). Most steelhead that enter the Hanford Reach hold in the immediate vicinity for 6 to 8 months. A limited tagging study in 1967 found adults migrated near shorelines at depths less than 3 m (10 ft) (BNWL-1530).

Spawning within the Hanford Reach occurs between February and early June, with peak spawning in mid-May (Eldred 1970; Watson 1973; PNL-5371). Little is known about the quality and quantity of steelhead spawning, rearing, and adult holding habitat in the Hanford Reach. Watson (1973) estimated that from 1962 to 1971, an annual average of 35,000 steelhead that passed McNary Dam did not pass Priest Rapids Dam on the Columbia River or Ice Harbor Dam on the Snake River (DOE/RL-2000-27). After taking into account reductions due to migration into the Yakima and Walla Walla Rivers, sport catch, and natural mortality, Watson estimated that 10,000 of these fish were potential spawners in the Hanford Reach. Counts from 1977 to 1996 indicated an average of 20,000 steelhead that annually passed McNary Dam did not pass Priest Rapids or Ice Harbor Dams, and approximately 9,000 of these could potentially spawn in the Hanford Reach (DOE/RL-2000-27).

Gray and Dauble (1976) provide other evidence of steelhead spawning (DOE/RL-2000-27). They collected gravid and ripe females in late April and early May and collected spent males in August within the Hanford Reach. However, information on the quantity and location of steelhead spawning is difficult to assess because aerial surveys of steelhead spawning are often hampered by highly turbid spring runoff that obscures visibility. Prior to 2015, historical information on steelhead spawning primarily existed from the late 1960s and early 1970s during unusually low flow conditions. Low flow conditions at that time were 1,104 to 2,209 m^3/sec (39,000 to 78,000 ft^3/sec) when normal average flow is approximately 3,398 m^3/sec (120,000 ft^3/sec). Aerial surveys conducted in 1968 and 1970 showed key spawning areas at Vernita Bar, Coyote Rapids, Locke Island, 100-F islands, and Ringold (PNNL-13055). Redds counts totaled 220 in 1968 and 95 in 1970; Eldred (1970) estimated total steelhead spawning to be approximately 2,200 to 25,000 in 1968 and 950 to 7,800 in 1970. Fickeisen et al. (1980) indicated steelhead likely spawned at Vernita Bar, Coyote Rapids, Locke Island, and Ringold. An aerial survey conducted on April 30, 1998, identified up to 75 redds in the Hanford Reach, with the area from Wooded Island to Ringold having 14 redds and the 100-F Area islands having 61 (Dauble 1998, DOE/RL-2000-27).

Until 2015, few recent steelhead spawning events were documented in the Hanford Reach. A comprehensive study was conducted in spring 1999 to survey likely spawning areas near Locke Island but no steelhead redds were found (PNNL-13055). In spring 2005, the 100-N Area shoreline was investigated by aerial and boat surveys to search for spawning areas (PNNL-SA-75348). Results of these surveys showed only limited spawning near the Ringold Hatchery Creek (near United States Geological Survey [USGS] River Mile 355) in certain years. One verified steelhead redd was found near the 300 Area in spring 2003, and surveys in spring 2005 identified a single location where steelhead redds occurred downstream of Ringold at Island 15 (PNNL-SA-75348). Aerial steelhead redd counts were conducted during years 2007 through 2009 but only a single redd was observed in 2008, which was located near the upper portion of Locke Island. Aerial surveys conducted during 2012 along the entire length of the Hanford Reach detected no steelhead redds (HNF-53665). Four steelhead redds were located near the tip of Homestead Island (Island 13) during aerial surveys in 2013 (HNF-56705). No steelhead redds were observed during aerial surveys in 2014 (DOE/RL-2014-52). Forty-three steelhead redds were recorded in 2015 marking the first time in 17 years that a sizeable number of steelhead redds were observed in the Hanford Reach (HNF-59116).

Aerial surveys of steelhead redds are conducted using the same methods and in the same areas as the fall Chinook salmon redds described in the section above. However, excessively high river flows can cause flight cancellations. Excessively high flows resulting from spring run-off can flood areas typically characterized by terrestrial vegetation and lacking steelhead spawning habitat, and leave previously usable habitat with flows too swift for spawning and too deep to be observed from the air. Sustained flows in excess of 4,531 m^3/sec (160,000ft^3/sec) are considered too high to survey.

In spring 2017, river flows in the Hanford Reach rose above 4,531 m^3/sec (160,000 ft^3/sec) in mid-March and remained high until early July (Figure 2-5). These high river flows precluded any aerial surveys of steelhead redds from being performed in the Hanford Reach in 2017.

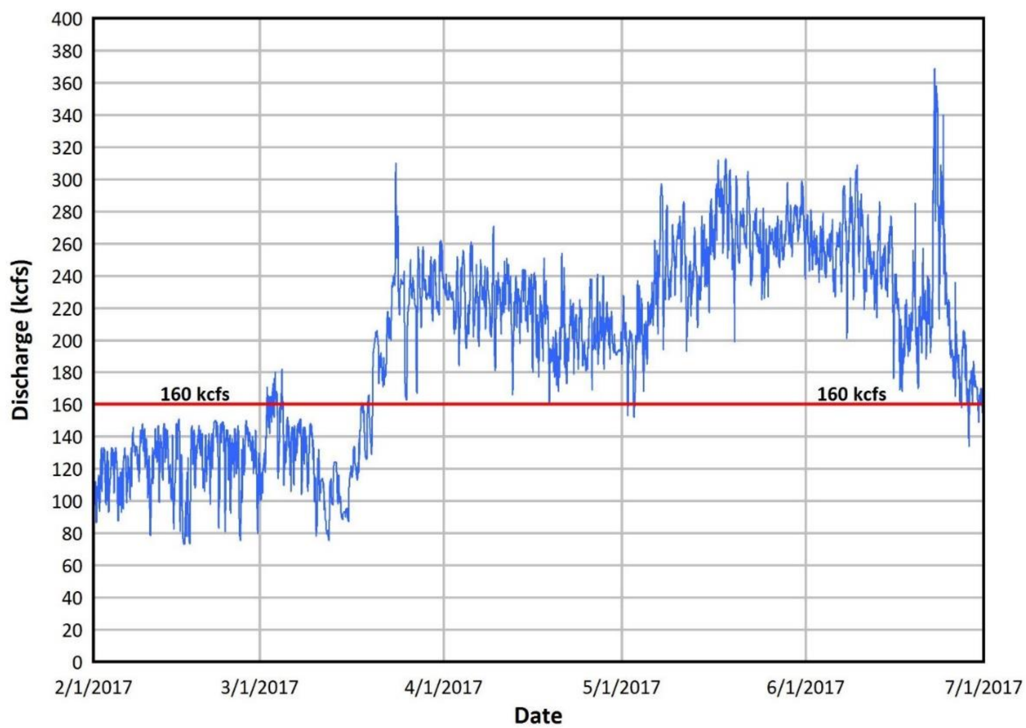


Figure 2-5. Columbia River Flows in the Hanford Reach in Spring 2017

2.3 BALD EAGLES

2.3.1 Introduction

A national symbol of the United States, the Bald Eagle plays an important role in the riverine ecosystem at the Hanford Site. Most Bald Eagles found on the Hanford Site occupy the site annually during winter and early spring. Monitoring Bald Eagles during this period is conducted to maintain current biological information about Bald Eagle abundance and distribution on the Hanford Site to ensure compliance with protection regulations and to inform future protection and management efforts. This section provides an overview of Bald Eagle activity on the Hanford Site between November 2016 and June 2017.

2.3.1.1 Bald Eagles on the Hanford Site. Bald Eagles primarily use the Hanford Reach of the Columbia River as a wintering area and are attracted to the spawning Chinook salmon and waterfowl found along the river. Bald Eagles arrive on the Hanford Site in mid-November to forage and are usually present until mid-March. Wintering Bald Eagles use different habitats for various activities such as perching, foraging, and roosting. Although Bald Eagles may be observed far from water, they typically occupy habitats within 400 m (0.25 mi) of the Columbia River and use trees growing along the shoreline for perching and roosting.

In Washington State, nest building may begin as early as December and young may fledge as late as August. In recent years, nest building on the Hanford Site has become an annual event. Historically, nests have been abandoned by mid-March as the Bald Eagles began to migrate to their summer territories, a successful nesting attempt was observed in 2013. Subsequently, Bald Eagles have occupied annually and successfully produced and fledged young at nests located on the Hanford Site.

2.3.1.2 Bald Eagle Protection and Management at Hanford. Bald Eagles are a success story for species protection under the ESA. In 2007, 40 years after the Bald Eagle was listed as endangered and given protection under the ESA, the FWS determined that the population of Bald Eagles in the lower 48 states had recovered sufficiently to be removed from the ESA endangered and threatened species list. Despite the significant recovery of Bald Eagle populations, federal laws including the *Bald and Golden Eagle Protection Act of 1940* and the *Migratory Bird Treaty Act of 1918* still provide protection for Bald Eagles, their nest trees, and communal night roosts. In addition, following delisting, the FWS developed the *National Bald Eagle Management Guidelines* (FWS 2007a), which provides monitoring and management guidance for Bald Eagles.

At the Hanford Site, DOE has developed DOE/RL-94-150, *Bald Eagle Management Plan for the Hanford Site, South-Central Washington*. This document provides an overview of Bald Eagle distribution, behavior, and ecology important to understanding the issues related to management and protection of this species on the Hanford Site and uses this information to define the actions that constitute the DOE policy regarding Bald Eagle protection and management on the Hanford Site. Key among these actions are protective measures for roost sites and nests, which are based on federal and state guidelines.

Roosting locations provide shelter from winter weather and serve a social function. The *Bald Eagle Management Plan for the Hanford Site, South-Central Washington* (DOE/RL-94-150) relies on a roost-site definition developed by the WDFW under its former management policies: a roost site is defined as a tree or a group of trees in which at least three Bald Eagles roost for at least 2 nights during a year. Administrative protection is initiated at a new roost site if monitoring determines the presence of three or more Bald Eagles on at least 2 nights during a year, or if continued monitoring over 2 or more years determines that the site is occupied at night by one or more Bald Eagles at least 30% of the time during wintering season and discontinued if these requirements are not met (DOE/RL-94-150). Bald Eagle night roost locations on the Hanford Site were protected from disturbance from November 15 through March 15 with 400-m (0.25-mi) buffers (Figure 2-6).

Eagle nesting activity is documented and potential nest sites are monitored to determine if new nest protection areas are necessary. A nest is considered occupied if a pair of Bald Eagles continue to use the nest after May 10, which is the latest first-egg date recorded for Bald Eagles in Washington State (Burke Museum 2013). When a new nest is identified, nesting exclusion buffers are enforced until the nest is abandoned or the young Bald Eagles have fledged. The FWS generally recognizes that a Bald Eagle nest is considered active for 5 years following occupation by a pair of Bald Eagles during the breeding season. Therefore, nest-site buffers are maintained throughout the roosting and nesting seasons for 5 years following occupation.

2.3.1.3 Hanford Site Bald Eagle Monitoring. Beginning in 2013, two levels of effort were established for annual Hanford Bald Eagle monitoring: comprehensive and limited. Comprehensive monitoring is performed triennially and limited monitoring occurs all other years. During limited monitoring, night roost surveys are performed bi-monthly (typically December to February) to document the continued usage of the currently protected communal night roosts. During comprehensive monitoring, the night roost monitoring frequency is increased to weekly or bi-weekly throughout the season to determine if administrative protections are justified at existing locations or if they need to be established at new roost sites. Boat surveys are performed during the season to document the abundance, age class, distribution, and activities of Bald Eagles using the Hanford Reach during both types of monitoring. A night roost survey is performed on the same date as each boat survey in order to compare diurnal and nocturnal abundance and distribution. This information is used during comprehensive monitoring to help determine whether or not there is a justification to search for new roost sites. An example of this process is as follows:

- Fiscal year 2015 monitoring results suggested that Bald Eagles were potentially roosting in locations susceptible to anthropogenic disturbance on the Hanford Reach (HNF-59488). Analysis of these results provided five potential night roost locations that were then monitored during FY 2016 in addition to the eight currently protected night roosts. These five sites were determined to not be night roosting sites and did not require additional buffer zone protection.

Nest surveys are performed following the same method during all years. The level of effort for any given year may be modified based on federal or state agency information requests, and/or if Hanford Site activities occur near or within Bald Eagle nest or night roost protection buffers.

Hanford Site Bald Eagle monitoring for FY 2017 followed the limited approach and included one initial boat survey and bi-monthly night roost surveys throughout the Bald Eagle wintering season, as well as one boat nest survey and intermittent terrestrial nest monitoring that continued through the nesting season.

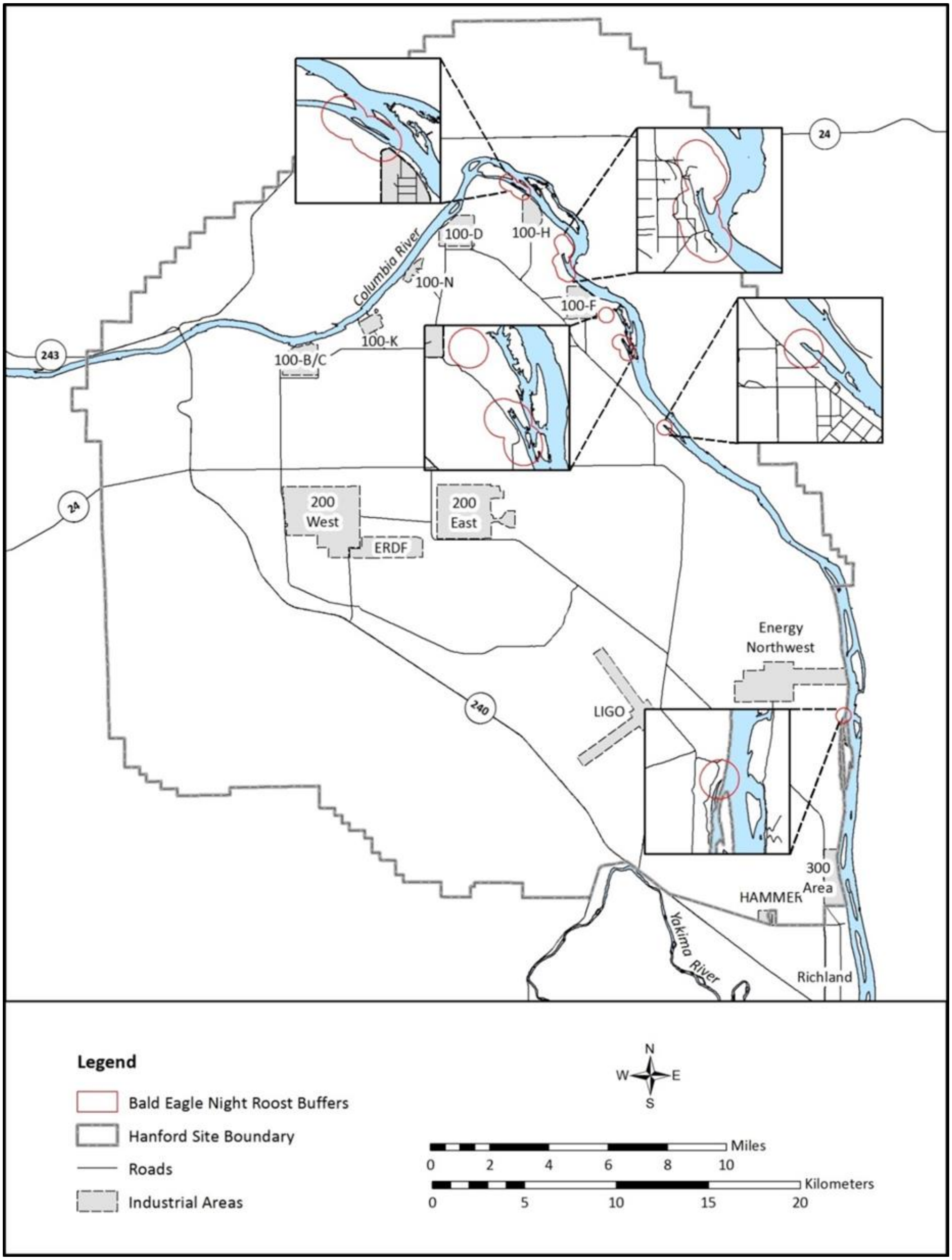


Figure 2-6. Protected Bald Eagle Night Roosts for Fiscal Year 2017

2.3.1.4 Objectives. The objectives of the FY 2017 monitoring effort was to document Bald Eagle use areas on the Hanford Site in accordance with DOE/RL-94-150, *Bald Eagle Management Plan for the Hanford Site, South Central Washington*, and to establish an understanding of sensible buffer distances for night roosts and nests in order to provide data for a future revision of this plan. Annual surveys of Bald Eagle night roosts and nest sites provide the information required to maintain and/or update administrative buffers to minimize disturbances to Bald Eagles and their habitats. Long-term trends of Bald Eagle distribution and abundance allow for the assessment of potential impacts from Hanford Site operations and the effectiveness of Bald Eagle management on the Hanford Site.

2.3.2 Methods

Fiscal year 2017 Bald Eagle monitoring followed the limited level of effort as described in Section 2.3.1.3 and consisted of buffer disturbance, night roost, boat, and nest surveys. Each of these survey methods is described in the sections below.

2.3.2.1 Buffer Disturbance Surveys. With the increasing Bald Eagle population and decreasing legal protection, Ecological Monitoring and Compliance (EMC) decided to evaluate how anthropogenic disturbance effected the proposed roost buffer distance when reduced from 400 to 200 m (0.25 to 0.12 mi). Outcomes from this study were used to redefine appropriate buffer distances that were implemented in the revised *Bald Eagle Management Plan for the Hanford Site* (DOE/RL-94-150, Rev. 3). At the time of monitoring, employees and vehicles were restricted from approaching within 400 m (0.25 mi) of the roost sites outside of the 10:00 AM to 2:00 PM time window annually from November 15 to March 15. In order to evaluate the effects of anthropogenic activity on roosting Bald Eagles, Ecological Monitoring and Environmental Surveillance (EM&ES) staff drove within 200 m (0.12 mi) (when accessible) of active roosts and simulated work activities. These work simulations included getting out of the vehicle, walking around, making work-related noises, and making their presence noticeable. Examples of work-related noises included shutting doors, tailgates, and tapping a mallet on rebar. All observations were recorded before, during, and after the test, as well as the distance from the roost from which the test was conducted. If any disturbance created issues with the birds, staff would vacate the area to the standard monitoring distance.

2.3.2.2 Night Roost Surveys. Night roost surveys were conducted at the eight protected night roost sites (Figure 2-7). These areas were monitored by three teams concurrently in a single evening. Surveys were conducted at dusk (15 minutes prior to sunset until there was insufficient light to see individual birds). Surveyors approached each location in a vehicle and remained outside of the designated 400-m (0.25-mi) buffer zones (DOE/RL-94-150) active in the FY 2017 monitoring season. Spotting scopes and binoculars were used to determine the number of Bald Eagles present, age class (adult vs. juvenile), and activity occurring at the roost. Surveyors then marked the specific location where the Bald Eagles were roosting on an aerial photo of the roost location. After recording the data from a roost location, surveyors quickly proceeded to the next location in order to maximize the number of surveys per night. At the conclusion of night roost monitoring for the season, all observations were digitized using geographic information system (GIS) software. The digitized points were then combined with all previously collected MSA EM&ES night roost observation points.

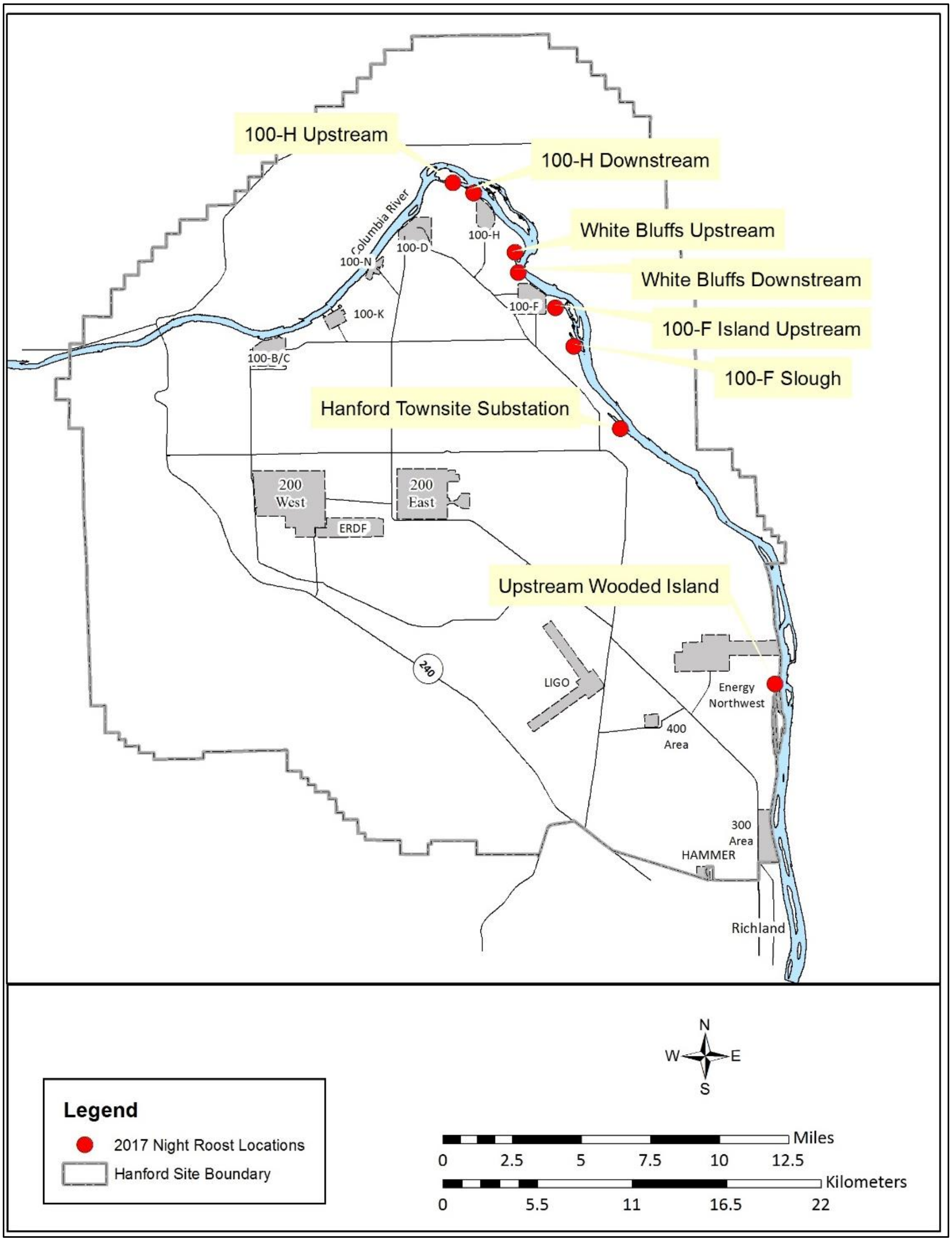


Figure 2-7. Locations Monitored for Bald Eagle Night Roosting During Fiscal Year 2017

2.3.2.3 Boat Surveys. Boat surveys of the entire Hanford Reach were performed two times during the season (mid-December and mid-March). Historically, mid-December has been the documented peak population season for new and returning Bald Eagles. On December 7, 2016, a boat survey was performed to determine the age class (i.e., adult or juvenile), distribution, and number of Bald Eagles on the Hanford Reach. Both shorelines of the Columbia River along the Hanford Site were surveyed beginning immediately upstream of Vernita Bridge and ending at the 300 Area (Figure 2-8). This survey via the river was accompanied with a night roost survey. The performance of boat and night roost surveys on the same day allows project staff to correlate day and night counts and distributions to identify potential night roost areas, nest sites, and important daytime perching areas. All spatial data collected during the surveys were transferred from hard copy maps into a GIS for analysis. A second boat survey was conducted using the same method on March 21, 2017, but for the purpose of closing out the roosting season and to identify new nests. Ancillary data collected during both boat surveys may help to confirm or establish the primary foraging areas along the Hanford Reach.

2.3.2.4 Nest Surveys. Nest surveys were performed at four potential nest locations in the vicinity of the 100-B/C Reactors, White Bluffs Peninsula, Hanford Townsite Substation, and Benton Substation (Figure 2-9). Nesting behaviors were also documented at the White Bluffs Peninsula and Benton Substation sites during night roost monitoring (November through February) due to the sites historically known as active nesting areas. The lack of foliage on trees during this time period allows surveyors to identify potential nest sites before they are obscured by leaves in late spring. Nest surveys were conducted on a monthly basis and consisted of 1-hour observations from at least 400 m (0.25 mi) at all four nest sites, documenting any signs of nesting activity (e.g., territory defense, nest tending, and pair bonding behaviors). Observations were recorded over the 1-hour survey every 10 minutes; any notable observations of importance were recoded between these intervals.

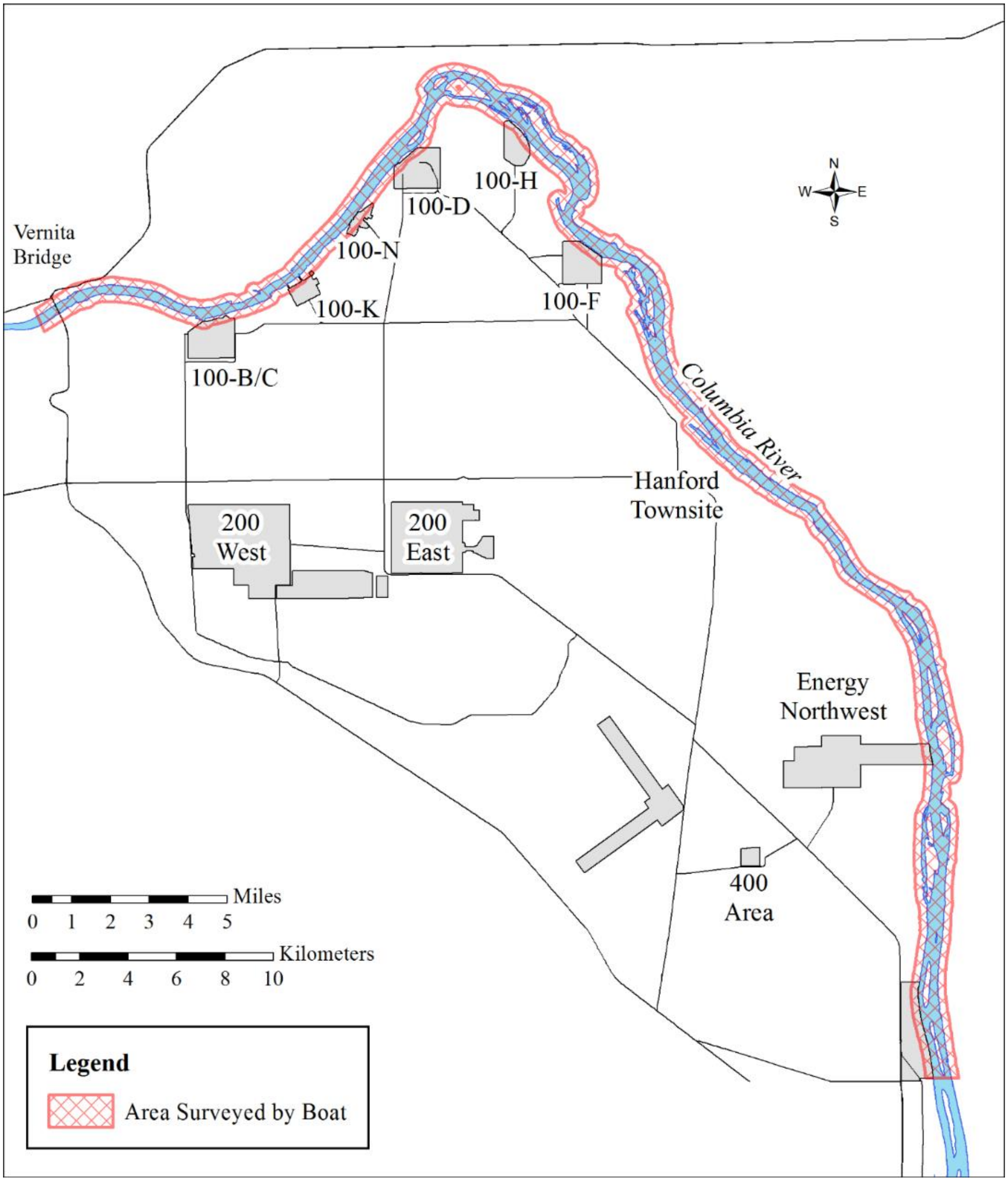


Figure 2-8. Area Surveyed by Boat

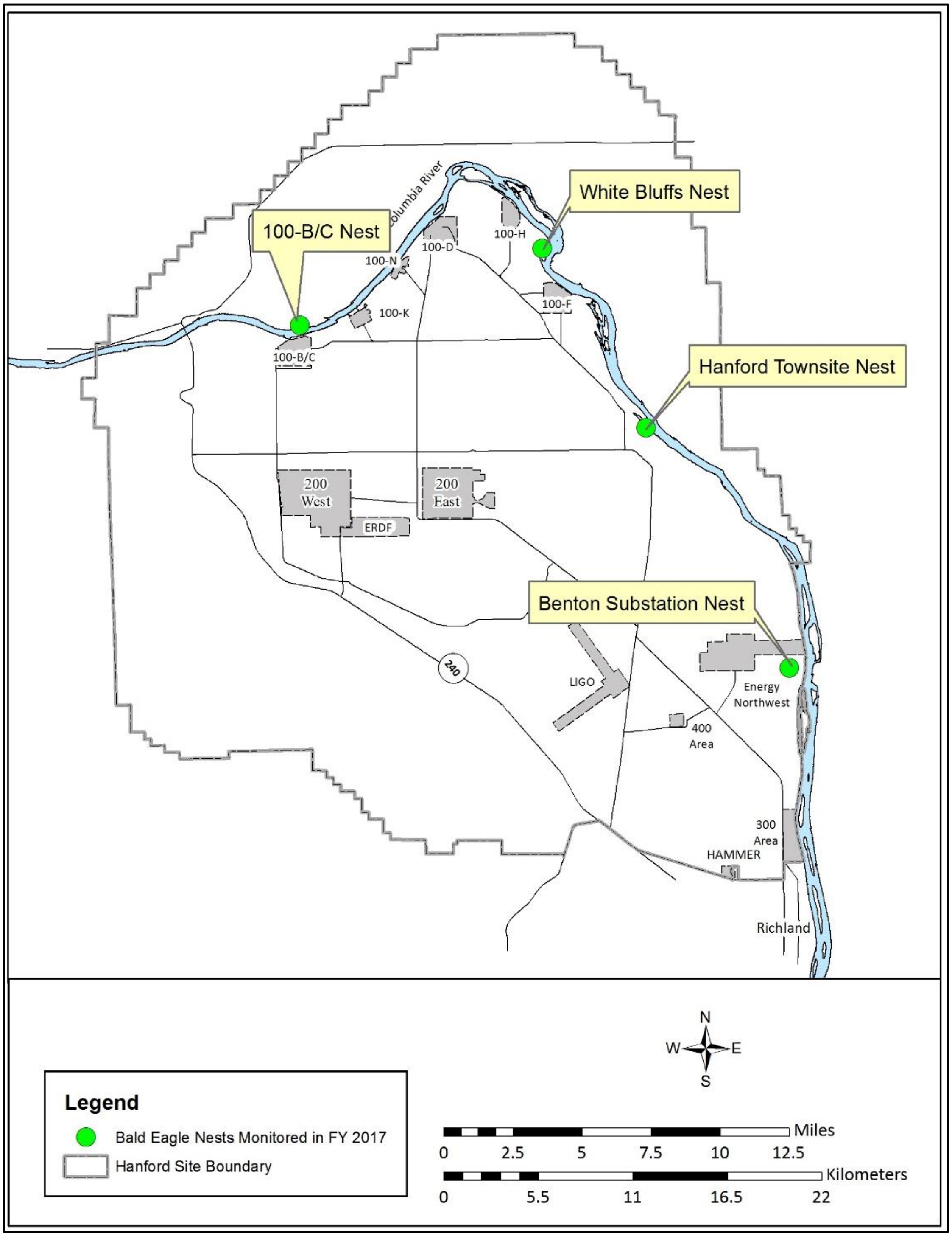


Figure 2-9. Bald Eagle Nests Monitored in Fiscal Year 2017

2.3.3 Results and Discussion

2.3.3.1 Buffer Disturbance Survey. Multiple disturbance surveys were conducted between December 12 and 21, 2016, coinciding with night roost surveys. Survey locations included the 100-H Upstream, 100-H Downstream, 100-F Slough, White Bluffs Upstream, White Bluffs Downstream, 100-F Island, and 100-F Slough night roosts. Anthropogenic disturbances consisted of slamming work truck doors and tailgates, yelling, clapping hands, and striking metal objects together. Distances from the occupied night roosts varied between 736 and 200 m (0.38 and 0.12 mi). Out of all of the surveys there was minimal reaction from the roosting Bald Eagles including no flushing. Disturbance surveys were conducted at six roost sites over 2 different days in December 2016. The results are as follows.

- **100-F Slough.** Roost was disturbed from three different distances (616, 350, and 235 m [0.38, 0.22, and 0.15 mi]) on December 13, 2016. At the time of disturbances there were two adult Bald Eagles present. There were no reactions to the increased anthropogenic noises observed.

- **100-H Upstream.** Roost was surveyed on December 21, 2016, from a distance of 400 and 200 m (0.25 and 0.12 mi). At the time of the first disturbance there were three adult and two juvenile Bald Eagles present; no behavioral changes to the anthropogenic disruption were shown. During the second disturbance (200 m [0.12 mi]) there were three adult and one juvenile Bald Eagles perched. They too did not show any behavioral changes during the survey.

- **100-H Downstream.** Roost was surveyed on December 13 and 21, 2016, from a distance of 400 and 235 m (0.25 and 0.15 mi). During both surveys dates there was one adult Bald Eagle present. During the first survey there was no reaction to the disturbance. The second survey resulted in an observed head turn but no other behavioral changes were observed.

- **100-F Island.** Roost was surveyed on December 21, 2016, from a distance of 400 and 204 m (0.25 and 0.13 mi). At the time of disturbances there were two adult Bald Eagles present. There were no reactions to the increased anthropogenic noises observed.

- **White Bluffs Upstream.** Roost was surveyed on December 21, 2016, from a distance of 400 and 350 m (0.25 and 0.22 mi). At the time of the first disturbance there were four adult and five juvenile Bald Eagles; there was no change in behavior observed. During the second disturbance (350 m [0.22 mi]) there were five adults and six juvenile Bald Eagles present. One juvenile arrived at the roost during the survey and Bald Eagle chatter was heard, which may have been unrelated to the disturbance and simply communication towards the arriving bird.

- **White Bluffs Downstream.** Roost was surveyed on December 21, 2016, from a distance of 736 and 424 m (0.46 and 0.26 mi). There was no reaction from the single perched Bald Eagle in the night roost during the disturbance survey. The bird was perched on the far northwest end of the night roost site, with a significant distance from the staff member, due to accessibility, during both disturbances.

2.3.3.2 Night Roost Surveys. Night roost surveys were performed over 8 nights during the FY 2017 season between November 21, 2016, and March 6, 2017. The majority of Bald Eagles present during the early season were juveniles who grouped in large numbers in areas where post-spawned fall Chinook salmon (*Oncorhynchus tshawytscha*) carcasses are known to accumulate. Both adult and juvenile numbers decreased between the first two night roost surveys, then remained relatively steady between the December 21 and February 21 surveys. The initial sharp decrease in juvenile Bald Eagle numbers was likely due to the depletion of their food source, Chinook salmon carcasses. Seasoned adult Bald Eagles continued to use the Hanford Reach, likely feeding on waterfowl and carrion as they are more experienced hunters.

2.3.3.3 Currently Protected Night Roosts. Based on the results of the FY 2017 night roost surveys, all eight of the currently protected night roosts qualified for continued protection under the communal night roost definition stated in Section 2.3.2.2. Results for the currently protected roosts are summarized in Table 2-4 and Figure 2-10, and observation summaries are described in the following.

- **White Bluffs Upstream.** White Bluffs Upstream was the most utilized roost with a total of 83 Bald Eagle observations. Seven of the eight surveys documented three or more Bald Eagles. A maximum count of 31 Bald Eagles was documented during the November 21 survey. Use of this roost remained consistent during the first seven surveys, charting the highest number of observations for a single roost five separate times in FY 2017.

- **100-H Upstream.** The 100-H Upstream night roost was the second most heavily used roost on the Hanford Site. During the FY 2017 season, a total of 40 Bald Eagle observations were documented. Three or more Bald Eagles were observed during five of the eight surveys. The roost was observed to be utilized during all eight surveys in FY 2017.

- **White Bluffs Downstream.** White Bluffs Downstream was utilized during the first six surveys but vacant the last two. A total of 16 Bald Eagle observations were documented at this roost; 2 survey nights were counts of 5, composing the majority of observations for the winter monitoring.

- **Upstream of Wooded Island.** Although this area is primarily a nest site with a pair of adult Bald Eagles documented during most surveys, four juvenile Bald Eagles were observed at the roost during the February 21 survey. A total of 15 observations were documented at the roost and nest area combined during the FY 2017 season. It can be strongly implied most observations were the same adult pair.

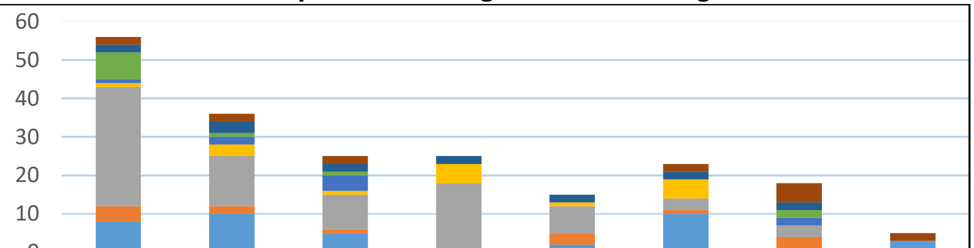
- **Hanford Townsite Substation.** This roost site was used consistently throughout the season primarily by a pair of adult Bald Eagles. Three Bald Eagles were documented during one of the surveys, thus continuing its status as a qualified communal night roost. A total of 15 observations were documented at this site during FY 2017 monitoring. The pair appeared to attempt nesting activities in a previously constructed rookery nest but were unsuccessful.

- **100-H Downstream.** 100-H Downstream was used equally during the first and second half of the season. In recent years this roost has been used very little, which may be associated to increased human presence remediation activity nearby but outside all buffer areas in the 100-H Area. With these remediation activities completed, Bald Eagles may begin to use this site with more regularity in the future. A total of 14 Bald Eagles were observed at this roost during the 2017 survey efforts. Despite having a lower total count than the 2016 season of 34, this roost continues to be occupied by more Bald Eagles than historically observed.

- **100-F Slough.** The 100-F Slough roost was utilized on and off during the season but usage dropped and remained vacant during the fourth, fifth, sixth, and final Bald Eagle surveys. The 100-F Slough roost had a total of 11 observations and only 1 survey documenting 3 or more Bald Eagles. While the number of observations observed in FY 2017 is drastically lower than those in FY 2016 (126), the totals should not be used as an overall use indicator because FY 2016 was an extensive survey year. What can be derived from the 2 years is they share the same pattern of use during the first third of the season, followed by a drastic drop by mid-late December. This can possibly be explained by a rapid depletion of Chinook carcasses in this particular area annually.

- **100-F Island Upstream.** 100-F Island Upstream was the least used roost with a total of nine observations. The maximum count at this roost site was four Bald Eagles, which were observed during the December 21 survey. No Bald Eagles were observed at the site during the following three surveys. Two Bald Eagles were seen on February 21, then the roost was again vacant.

Table 2-4. Survey Results for the Currently Protected Night Roosts During Fiscal Year 2017.



	Nov 21	Dec 7	Dec 21	Jan 4	Jan 16	Jan 30	Feb 21	Mar 6
Upstream of Wooded Island	2	2	2	0	0	2	5	2
Townsite Sub Station	2	3	2	2	2	2	2	0
100-F Slough	7	1	1	0	0	0	2	0
100-F Island Upstream	1	2	4	0	0	0	2	0
White Bluffs Downstream	1	3	1	5	1	5	0	0
White Bluffs Upstream	31	13	9	17	7	3	3	0
100-H Downstream	4	2	1	0	3	1	3	0
100-H Upstream	8	10	5	1	2	10	1	3

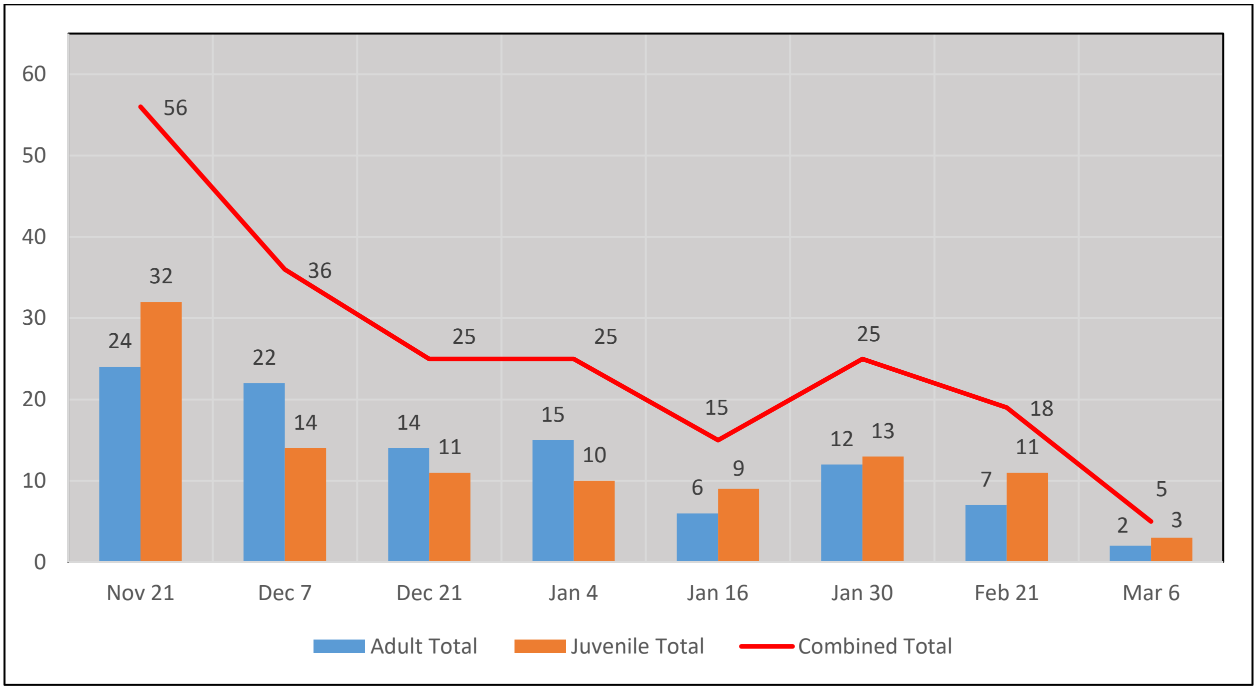


Figure 2-10. Fiscal Year 2017 Night Roost Totals

2.3.3.4 Boat Surveys. Boat surveys were performed on December 7, 2016, and March 21, 2017. The maximum boat count of 50 Bald Eagles documented during the December 7, 2016, survey was less than the previous all-time maximum count of 141 recorded during FY 2015 (December 9, 2014) but was still twice the average maximum count of 25 between 1961 and 2013.

Starting in 2013, the Hanford Reach has seen record numbers of returning Chinook salmon to spawn. The additional food source directly correlates with the increase of wintering Bald Eagles. The locations of the Bald Eagles counted on the Hanford Reach during the boat surveys for FY 2017 are shown in Figure 2-11. The stark difference in individuals observed between the two surveys is largely due to the depletion of salmon carcasses available as a reliable food source. It should be noted that the second boat survey was conducted to close out the roosting season and to identify new nesting locations, not for the purpose of counting wintering Bald Eagles.

For the second time in as many years, the maximum count of Bald Eagles on the Hanford Site was documented during night roost monitoring rather than a boat survey (56 total observations on the evening of November 21, 2016). Comparing corresponding boat and night roost surveys (performed on the December 7, 2016) shows that the night roost survey was 28% less than the daytime boat survey count. A better understanding of where the remaining Bald Eagles are roosting in the future could help ensure continued protection for this species.

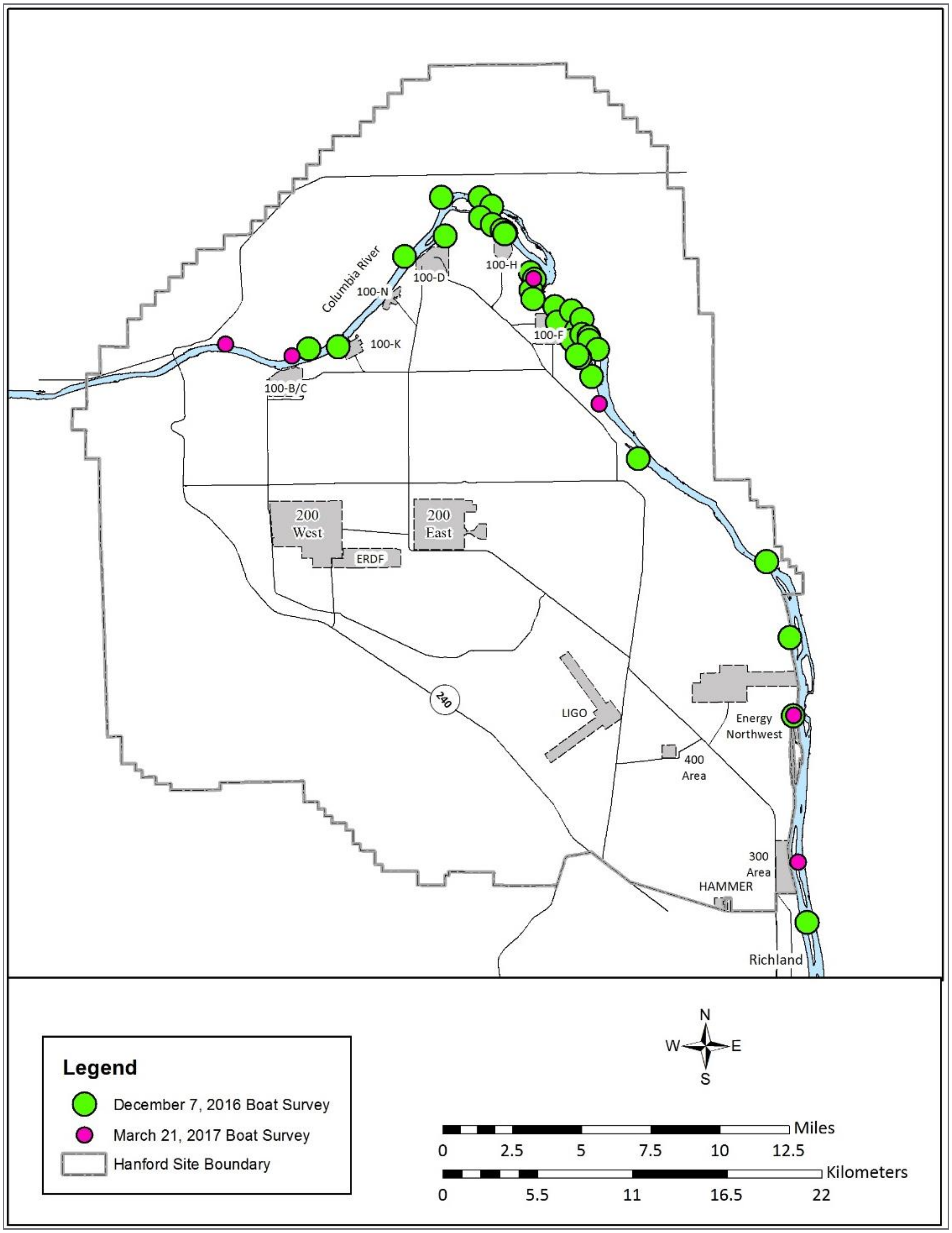


Figure 2-11. Locations of Eagle Sightings During Boat Surveys in FY 2017

2.3.3.5 Nest Surveys. Beginning in FY 2013 and again in FY 2014, monitoring staff documented a successful nest upstream of Wooded Island that produced a pair of fledglings. In FY 2015, the nest was successful for a third consecutive year with three fledglings observed near the nest in late spring. During FY 2016, monitoring staff performing deer surveys noted that a large stick nest was being constructed on a tower near the BPA's Benton substation; approximately 1,100 m (0.68 mi) northwest of the Upstream Wooded Island nest site. Monitoring staff later confirmed that the nest was active and that the Wooded Island nest was nearly gone, presumably from the Bald Eagles using the old nest materials to build the new nest. On April 27, 2016, monitoring staff confirmed that the nest was successful with the documentation of two Bald Eagle chicks in the nest. A pair of adult Bald Eagles was observed utilizing the nest during each night roost survey conducted in FY 2017; once again the nest was determined to be successful after two chicks were observed the following spring.

The nest located on the White Bluffs peninsula was occupied throughout the FY 2015 nesting season; however, because its location was obscured by foliage later in the nesting season, monitoring staff could not confirm that the nest was successful. On June 5, 2015, surveyors performing a roadside breeding bird survey (BBS) documented a juvenile Bald Eagle perched in the tree containing the nest, which could indicate a successful nest attempt. However, actual success could not be determined. During a nest survey on May 15, 2017, after 3 years, confirmation of success was finally made for this location when one chick was observed in the nest along with one adult.

While staff was conducting a rare plant survey on the east side of the Columbia River on May 5, 2017, an EM&ES staff member discovered an active nest on Savage Island with one adult in the nest and a second perched next to it. Follow-up surveys were not conducted by EM&ES as the land where the nest resides is managed by an agency other than DOE, resulting in an undetermined productivity status. Staff located a fourth nest across from the 100-B/C Reactor Area during the March 21, 2017, boat survey. One adult Bald Eagle was observed in the nest while a second perched nearby. The nest continued to be occupied on April 6, 2017, but was determined to be abandoned after no Bald Eagles were observed in or around the nest during all remaining nest surveys. A pair of Bald Eagles appeared to be attempting nesting activities in a previously constructed rookery nest at the Hanford Townsite substation night roost. During night roost surveys the pair was observed both in and around the nest. As the nesting season continued, nest monitoring proved the nest to be abandoned and the pair absent from the area. All nesting activities for FY 2017 are illustrated in Figure 2-12.

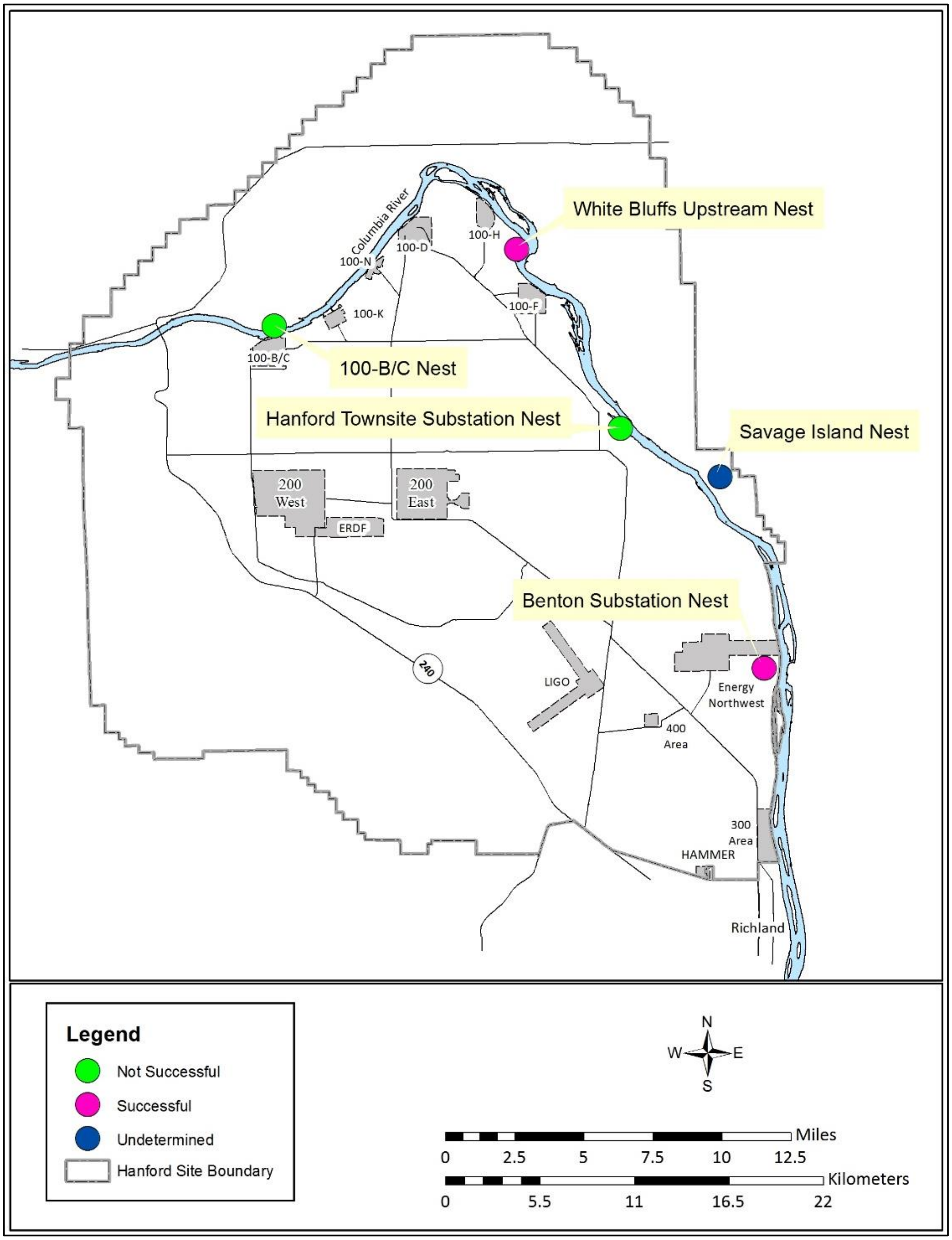


Figure 2-12. Nest Status in Fiscal Year 2017

2.3.4 Discussion

Long-term monitoring of the status and trends of Bald Eagle populations clearly show that national, state, and regional protections have been successful in reestablishing higher numbers of this species along the Hanford Reach. Although the Bald Eagle was removed from the federal endangered and threatened species list, the species is still protected under the *Bald and Golden Eagle Protection Act of 1940*. Understanding how Bald Eagles utilize the Hanford Reach is essential to ensure continued compliance with these laws.

Bald Eagles are sensitive to disturbance throughout all nest stages but are especially sensitive to human disturbance during the earlier stages of the nesting cycle. Disturbance during courtship, nest building, egg laying, and incubation can lead to abandonment of the nest. Continued protection of nest sites from human disturbance is necessary to minimize the impacts of ongoing Hanford Site operations. During the FY 2017 Bald Eagle survey season, staff conducted disturbance surveys in order to determine if the night roost buffer distance could be reduced from 400 to 200 m (0.25 to 0.12 mi) without impeding the Bald Eagles wintering activities. After multiple surveys consisting of anthropogenic disturbance, there was minimal to no reaction from the Bald Eagles. This data was used for decisions in the revision of DOE/RL-94-150, *Bald Eagle Management Plan for the Hanford Site, South-Central Washington.* This reduction in buffer distance will benefit human activities on the Hanford Site while still providing the protection of the sensitive night roost locations.

Nest sites are typically identified during boat surveys and night roost monitoring, with the occasional incidental discovery such as the Savage Island nest. The seasonal timing of these surveys allows monitoring staff to more easily detect nest building and nesting behavior. As the season progresses, nest monitoring is performed only on land and outside of a specified protection buffer zone. Nest monitoring becomes much more difficult as foliage begins to obscure the direct lines-of-sight to the nest. With two documented successful nests in 2017 and 5 consecutive years of nesting activity on the Hanford Site, future monitoring efforts could benefit from the addition of one or more boat surveys during the nesting season to provide an alternate viewpoint of the nests when land-based viewpoints are obscured by foliage. These additional boat surveys would also aid in the discovery of nests built later in the season, much like the 100-B/C Reactor and Savage Island nests in 2017.

A comparison of annual maximum counts of Bald Eagles and fall Chinook salmon redds for the Hanford Reach dating back to 1961 can be seen in Figure 2-13. Fitzner and Hanson (1979) compared 12 years of Bald Eagle survey data on the Hanford Reach with salmon redd and waterfowl densities and found that Bald Eagle numbers varied somewhat dependently with the salmon redd numbers but not with changing waterfowl numbers. Their study focused on winter Bald Eagle survey numbers collected between 1961 and 1977. During this timeframe Bald Eagle populations throughout the United States were at their lowest point due to habitat loss, declining prey availability, the widespread use of dichlorodiphenyltrichloroethane (DDT), and persecution from ranchers and fishermen. Since that time, a nationwide recovery of Bald Eagle populations has resulted in the delisting of Bald Eagles as an endangered species. The subsequent long-term Bald Eagle data collected on the Hanford Reach appears to adhere to their findings with a much increased response in Bald Eagle population to prey availability.

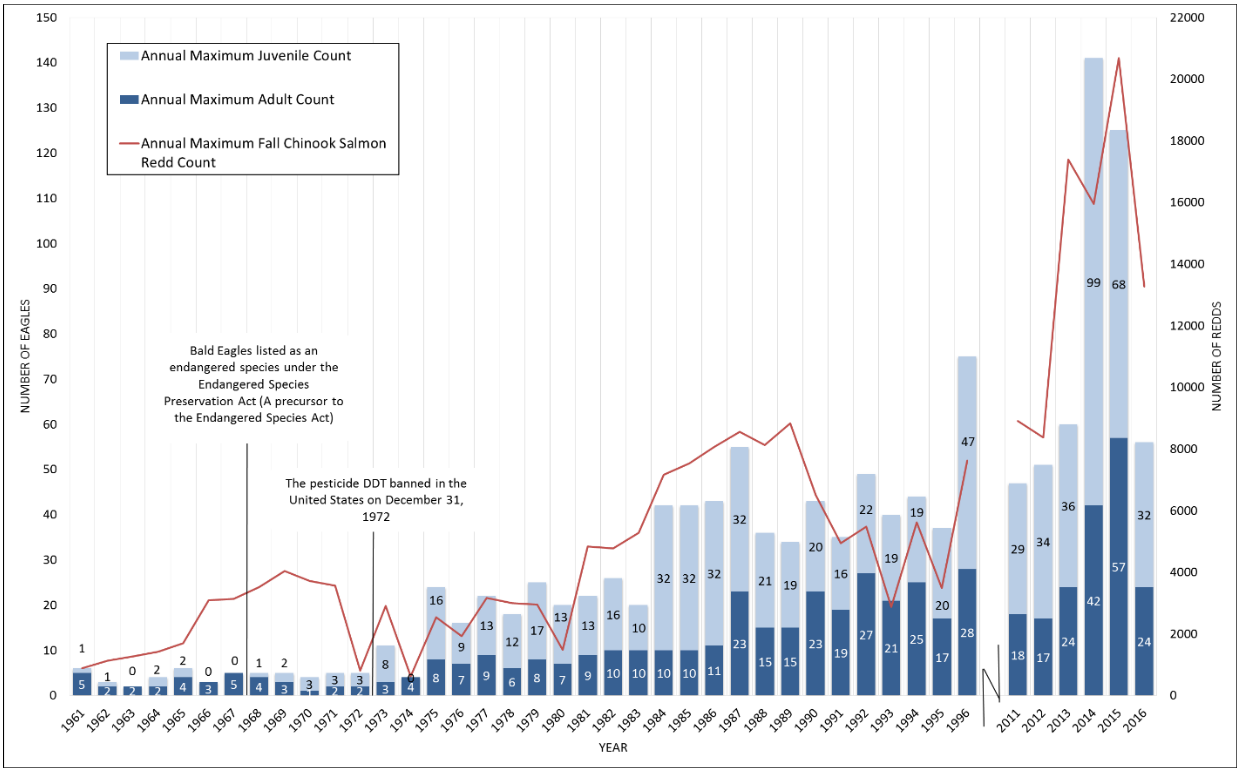


Figure 2-13. Annual Maximum Count Bald Eagles and Fall Chinook Redds from 1961 to Present

2.4 BURROWING OWLS

2.4.1 Introduction

The Burrowing Owl is a small owl species that inhabits dry open environments (e.g., deserts, grasslands, and shrub steppe) from south-central and southwestern Canada through the western United States and into Central and South America to southern Argentina. It is also found in Florida and on several Caribbean islands. As many as 15 to 25 subspecies of Burrowing Owls have been described; however, this presumption is based on morphology and geography and no systematic studies have been performed (Poulin et al. 2011). The subspecies of Burrowing Owl that occurs on the Hanford Site is the Western Burrowing Owl (*A. c. hypugaea*). The Western Burrowing Owl ranges from the southern portions of central and western Canada; through the western United States from the Dakotas to Texas and west to Washington, Oregon, and California; and south to central Mexico (Klute et al. 2003). In the northern portions of their range most Western Burrowing Owls are migratory, though some owls are known to overwinter in British Columbia, Idaho, and Washington (Belthoff and King 2002, Conway et al. 2006). Western Burrowing Owls winter in the southwest and south-central United States, throughout Mexico, and occasionally south to Panama (Klute et al. 2003).

The Western Burrowing Owl is declining over much of its range. Range contractions have occurred in southern Canada, the northeast Great Plains, and parts of California and the Pacific Northwest (Klute et al. 2003). The Burrowing Owl is listed as a National Bird of Conservation Concern in the United States (FWS 2002), as endangered in Canada (COSEWIC 2006), and as a species with Special Protection in Mexico (Diario Oficial de la Federación 2008). In the United States, Burrowing Owls are listed in 11 states (Poulin et al. 2011):

- Endangered in Minnesota
- Threatened in Colorado
- Species of Concern in Arizona, California, Florida, Montana, Oklahoma, Oregon, Utah, Washington, and Wyoming.

In eastern Washington, Conway and Pardieck (2006) analyzed data from North American BBSs and found numbers of breeding Burrowing Owls declined at a rate of 1.5% annually from 1968 to 2005. They theorize the Burrowing Owl decline in Washington State is probably due to loss of native grasslands and shrub steppe, along with the eradication of ground squirrels (*Spermophilus* spp.), yellow-bellied marmots (*Marmota flaviventris*), and American badgers (*Taxidea taxus*). Burrowing Owls rely on ground squirrel, marmot, and badger excavations, which they use for nesting burrows. On the Hanford Site, Larson (2009) found that 71% of Burrowing Owl nests located from 2006 to 2008 were in abandoned badger burrows.

The Hanford Site is one of a number of significant tracts of critical shrub-steppe habitat for the Columbia Basin Ecoregion, including the Yakima Training Center, Yakama Tribal lands, and Washington State Department of Fish and Wildlife areas. The Hanford Site is situated at the center of the predicted distribution of Burrowing Owls in Washington State (Washington Gap Analysis 1997) (Figure 2-14) and is an important area for the conservation of Burrowing Owls.

A Washington State candidate species and federal species of concern, the Burrowing Owl is ranked as a Level 3 resource in the BRMP. Level 3 resources are considered important resources on the Hanford Site and within the Columbia Basin Ecoregion. The management goal of Level 3 resources is conservation, with a moderate level of status monitoring. Burrowing Owl nesting surveys fulfill the obligations described in the *Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service Regarding the Implementation of* Executive Order 13186, "*Responsibilities of Federal Agencies to Protect Migratory Birds*" (DOE and FWS 2013) by conducting research and other activities for the preservation and enhancement of habitat for migratory birds, maintenance of bird populations, and minimization of human impacts on native species.

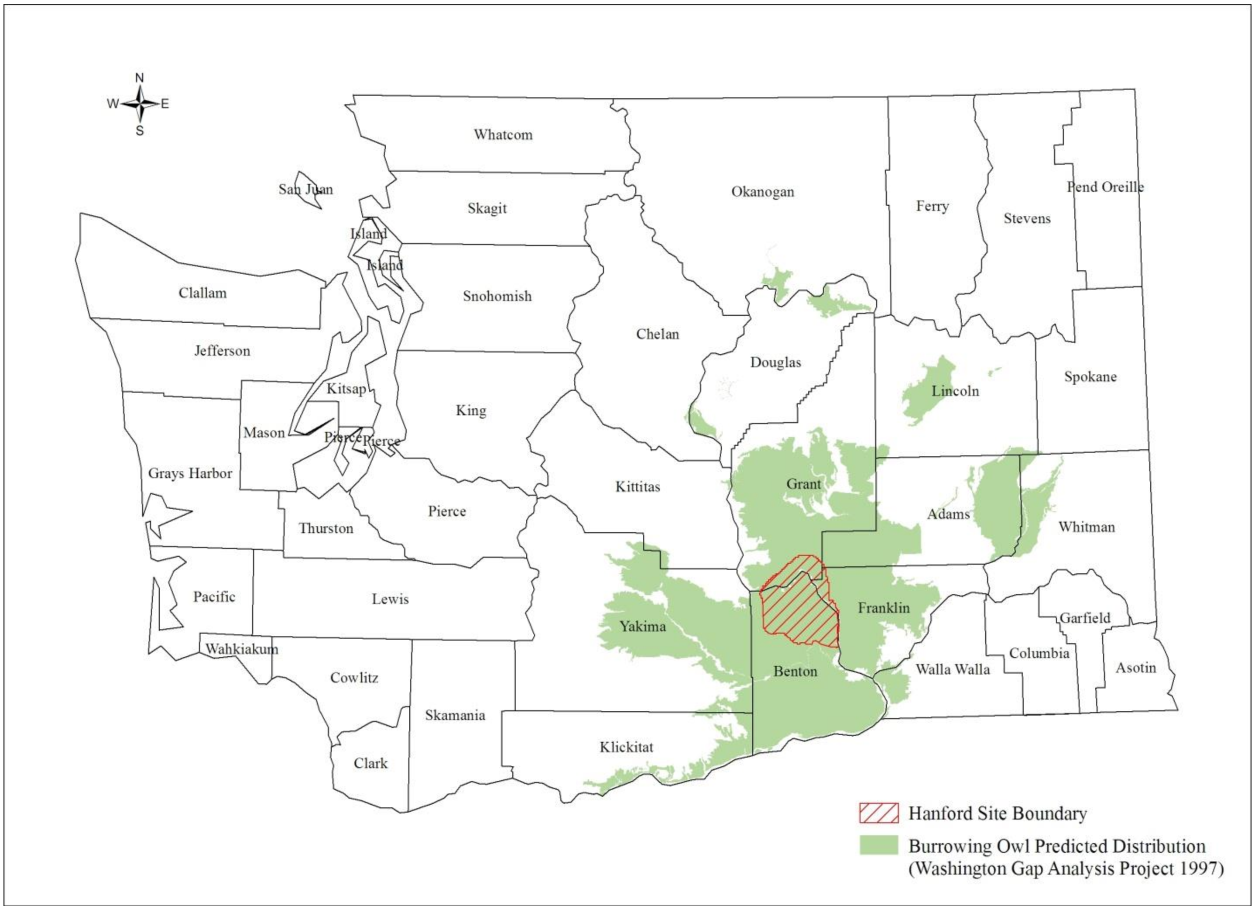


Figure 2-14. Predicted distribution of Burrowing Owls in Washington State (Washington Gap Analysis Project 1997)

Western Burrowing Owls nest in areas with sparse vegetation and gentle slopes, relying on fossorial mammals whose abandoned burrows are used for nesting and roosting (Knute et al. 2003). In southeastern Washington, Conway et al. (2006) found that the breeding season for Burrowing Owls extended from February 27 to September 5. They observed the mean date of arrival for migratory Burrowing Owls was March 27 for males and March 29 for females, with some owls arriving as early as February 20. Nest initiation (first egg laid) dates ranged from February 27 to July 4.

2.4.1.1 Objectives. The fundamental objective of the FY 2017 monitoring project was to document the distribution and abundance of Burrowing Owls on the DOE-RL managed portions of the Hanford Site. The primary goal was to design and implement an approach to detect new or previously undocumented nest burrows on the Hanford Site as well as formerly known sites. In addition, Owl Artificial Nest Burrow Systems (ABS) were surveyed and necessary maintenance was performed.

2.4.1.2 Scope. The scope of this project was to survey Burrowing Owls on the Hanford Site using a systematic call-broadcast survey. The geographic bounds of the survey is the DOE-RL managed portions of the Hanford Site (study area).

2.4.2 Methods

This project focused on areas that were mapped as potential nest habitats for Burrowing Owls. A GIS was used to perform a geometric intersection of map layers consisting of areas with characteristics likely to be suitable for Burrowing Owl nesting habitats. The selected map layers show areas with gentle slopes (0 to 6%), little to no shrubs, and that do not contain active or stabilized sand dunes or rock outcrops (Figure 2-15). Areas that met this criteria considered a potential Burrowing Owl nesting habitat.

Within the potential Burrowing Owl nesting habitat, ecologically similar zones (range: 378 to 4,078 ha [934 to 10,077 ac]) were delineated based on their soil, vegetation, and topographical relief (Figure 2-16). Each of the zones is comprised of a number of polygons of variable size. Polygons were grouped together into 12 discrete areas based on local physiographical features. For example, the Hanford Townsite area contains previously irrigated old fields with many anthropomorphic structures that Burrowing Owls might use for nesting (e.g., irrigation pipes and weir boxes). Table 2-5 describes the unique features of each area in more detail.

Survey sites across the Hanford Site were defined by creating a grid with 400- by 400-m (0.25- by 0.25-mi) cells over the entire study area. The center point of each cell that fell within 1 of the 12 areas was defined as a survey site for this monitoring project (Figure 2-17). A total of 314 survey sites were selected covering a total of approximately 50.25 ha (124.17 ac) of potential Burrowing Owl habitat. The number of survey sites within an area depends on the area’s size. The largest zone contains 65 survey sites, while the smallest zone contains 5 survey sites.

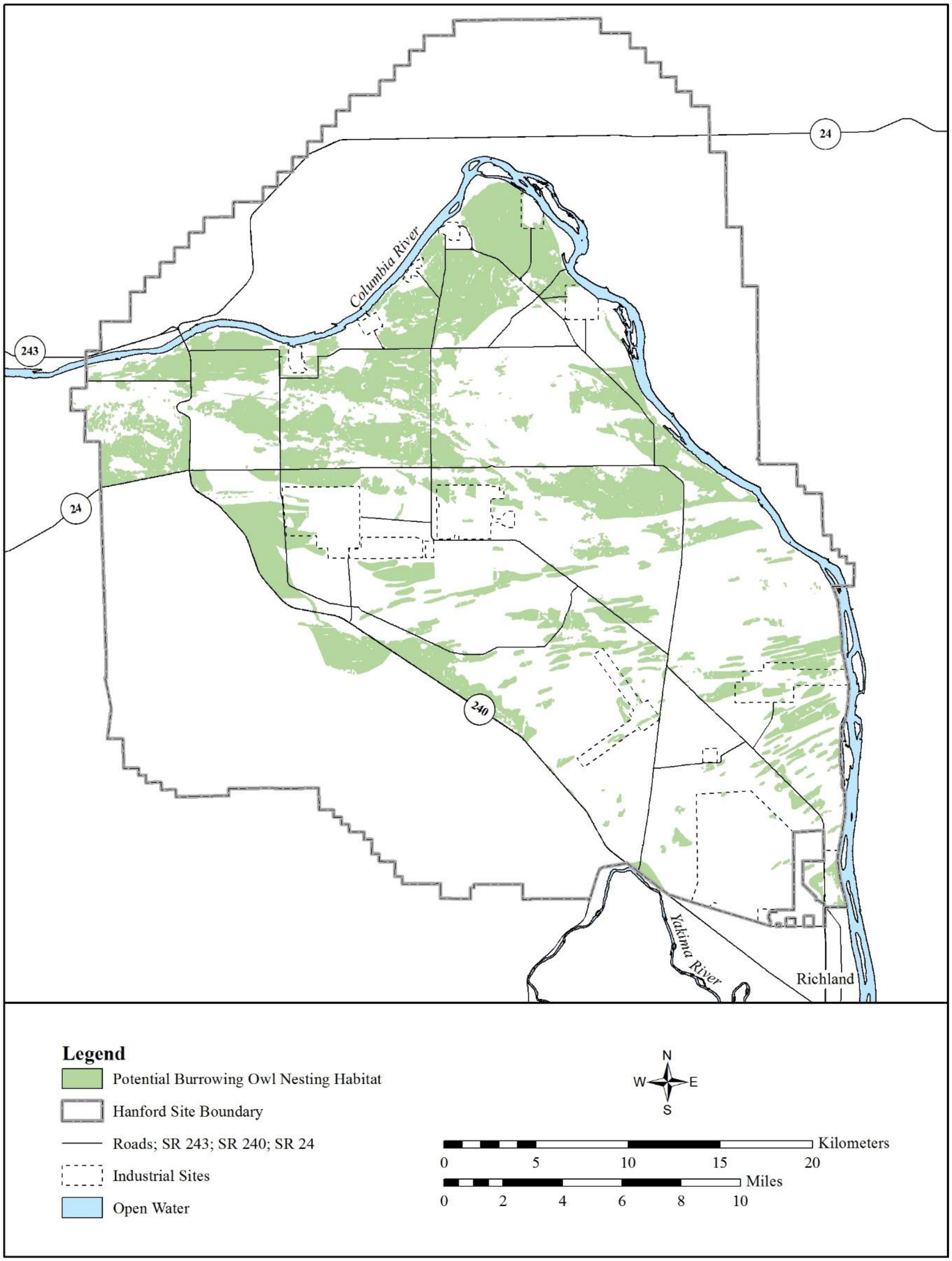


Figure 2-15. Potential Nest Habitats for Burrowing Owls on DOE-Managed Lands of the Hanford Site

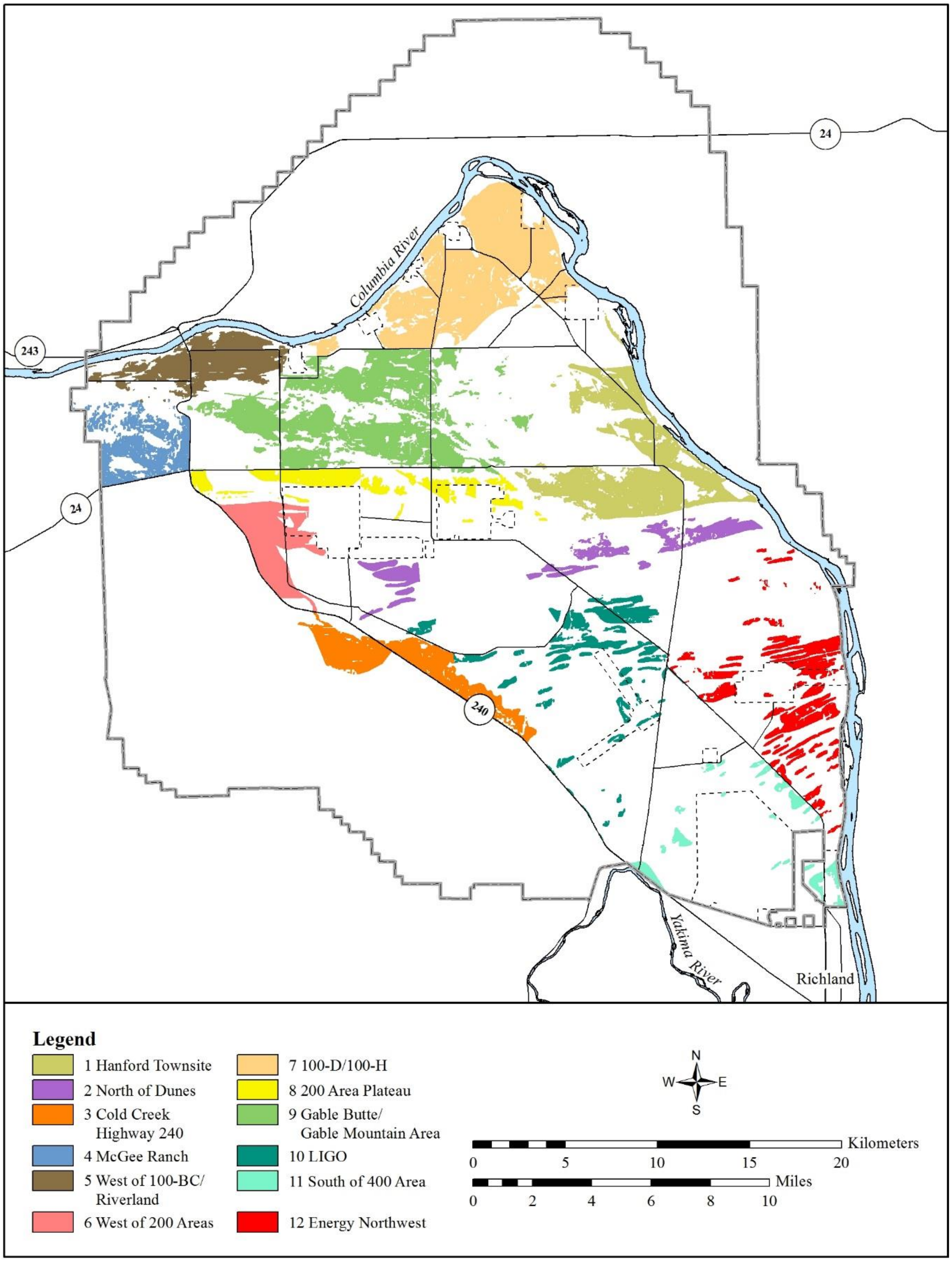


Figure 2-16. Potential Nest Habitat Areas for Burrowing Owls on DOE-Managed Lands of the Hanford Site

Table 2-5. Potential Habitat Areas for Burrowing Owls.

Area	Hectares	Number of Sites	Physical Description
1. Hanford Townsite	2,678.53	35	Old Fields, anthropomorphic burrows (irrigation pipes, weir boxes, etc.)
2. North of Dunes	870.50	14	Finer grained soils between sand dunes, natural burrows (badger)
3. Cold Creek/Highway 240	1,462.75	24	Finer grained soils along Cold Creek, natural burrows (badger, ground squirrel)
4. McGee Ranch	858.25	15	Old fields and natural areas, anthropomorphic and natural burrows (badger and ground squirrel)
5. West of 100-BC/Riverland	1,453.72	23	Old Fields, anthropomorphic burrows (irrigation pipes, weir boxes, etc.)
6. West of 200 Areas	1,214.70	21	Finer grained soils, natural burrows (badger)
7. 100-D/100-H Area	4,078.37	65	Old Fields, anthropomorphic burrows (irrigation pipes, weir boxes, etc.)
8. 200 Area Plateau	860.48	12	Finer grained soils, natural burrows (badger)
9. Gable Butte/Gable Mountain Area	3,334.12	57	Finer grained soils around Gable Butte and Gable Mountain, natural burrows (badger)
10. LIGO	989.51	21	Finer grained soils between sand dunes, natural burrows (badger)
11. South of 400 Area	378.21	5	Finer grained soils between sand dunes, natural burrows (badger)
12. Energy Northwest	1,212.73	22	Finer grained soils between sand dunes, natural burrows (badger)

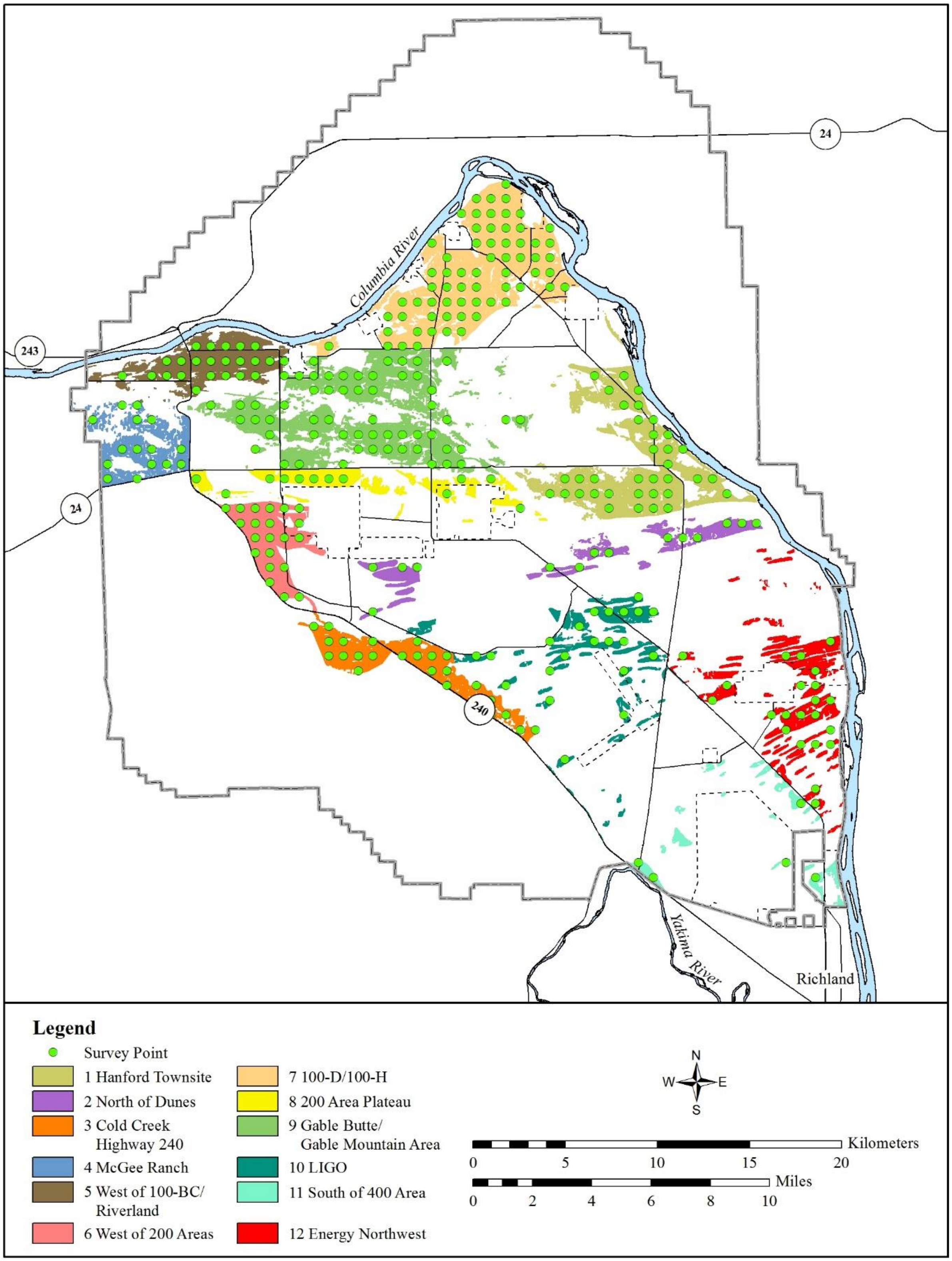


Figure 2-17. Call-Broadcast Survey Sites for Burrowing Owls on DOE-Managed Lands of the Hanford Site

2.4.2.1 Overview of call-broadcasts. Monitoring efforts consisted of a series of call-broadcast surveys performed across the study area. A minimum of one call-broadcast series was performed at each survey site.

2.4.2.2 Timing. The surveys were performed in early May through mid-June. Call-broadcasts were performed on days with little to no wind, warm temperatures, and lower cloud cover. Conway et al. (2008) found highest detection probability for Burrowing Owls is during the nestling period. The nestling period is from the day the first egg hatches until the first nestling reaches 44 days of age. In southeastern Washington, Conway et al. (2006) recorded 90% of first eggs hatched between May 1 and June 26. During this period surveys were performed in the morning or evening on days when the weather consisted of winds less than 12 km/hr (7.5 mi/hr), temperatures greater than 20 ^{o}C (68 ^{o}F), and cloud cover less than 75%. However, in northern latitudes Conway et al. (2008) determined that surveys can be conducted throughout the day.

2.4.2.3 Call-broadcasts. Field staff traveled to the center-point of each survey site by road or on foot. After field staff reached the center-point they began the call-broadcasts. Call-broadcasts consisted of a 3-minute passive segment followed by a 3-minute call-broadcast segment, followed by a 4-minute passive survey segment (10 minutes in all). The call-broadcasts were played using a handheld recorder and speaker at 80 decibels (when measured 1 m [3.28 ft] from the speaker). The 3-minute call segment consisted of 30 seconds of calls followed by 30 seconds of silence with this pattern repeated three times. The first two 30-second call periods consisted of the primary song of the male Burrowing Owl (coo-coo) and the third 30-second call period consisted of the alarm call (quick quick quick). If a Burrowing Owl is detected, the vicinity was searched for a nest burrow. Signs of a burrow being used may include an owl that retreats or flushes from the burrow, regurgitated pellets, feathers, nest lining, whitewash, or footprints.

2.4.3 Results

2.4.3.1 Broadcast-call Surveys. Broadcast surveys were conducted between May 17 and June 28, 2017. A total of 305 locations were surveyed including 304 directly on the designated survey points and one offset due to a contamination closure. Walking distances to each point varied greatly from just a few meters up to several kilometers. Six Burrowing Owls were detected at five locations on the Hanford Site during broadcast-call surveys. A seventh Burrowing Owl was discovered earlier in the spring while conducting Townsend ground squirrel surveys on April 11, 2017. This owl burrow was revisited during a broadcast-call survey on May 25, 2017, and was determined to be abandoned due to the absence of the owls and presence of spider webs and growing vegetation in the burrow entrance. Table 2-6 shows all of the Burrowing Owls discovered during the FY 2017 surveys, Figure 2-18 illustrates their location on the site. The five Burrowing Owl detections occurred in four different habitat areas. These were located in the Hanford Townsite Area, the 100-D/100-H Area, the Gable Butte/Gable Mountain area, and in the Cold Creek Highway 240 Area.

Table 2-6. Burrowing Owls Discovered in Fiscal Year 2017 Survey.

Date	Location	Number of Owls	Visual	Calling	Burrow Located
5/23/2017	Old Orchards	1	Yes	No	Yes
6/6/2017	On Fence near 100-F Railroad Bed	1	Yes	No	No
6/1/2017	Borrow Source C	1	No	Yes	No
6/1/2017	Borrow Source C	2	Yes	Yes	No
6/22/2017	Off B/C Cutoff Road	1	No	Yes	No

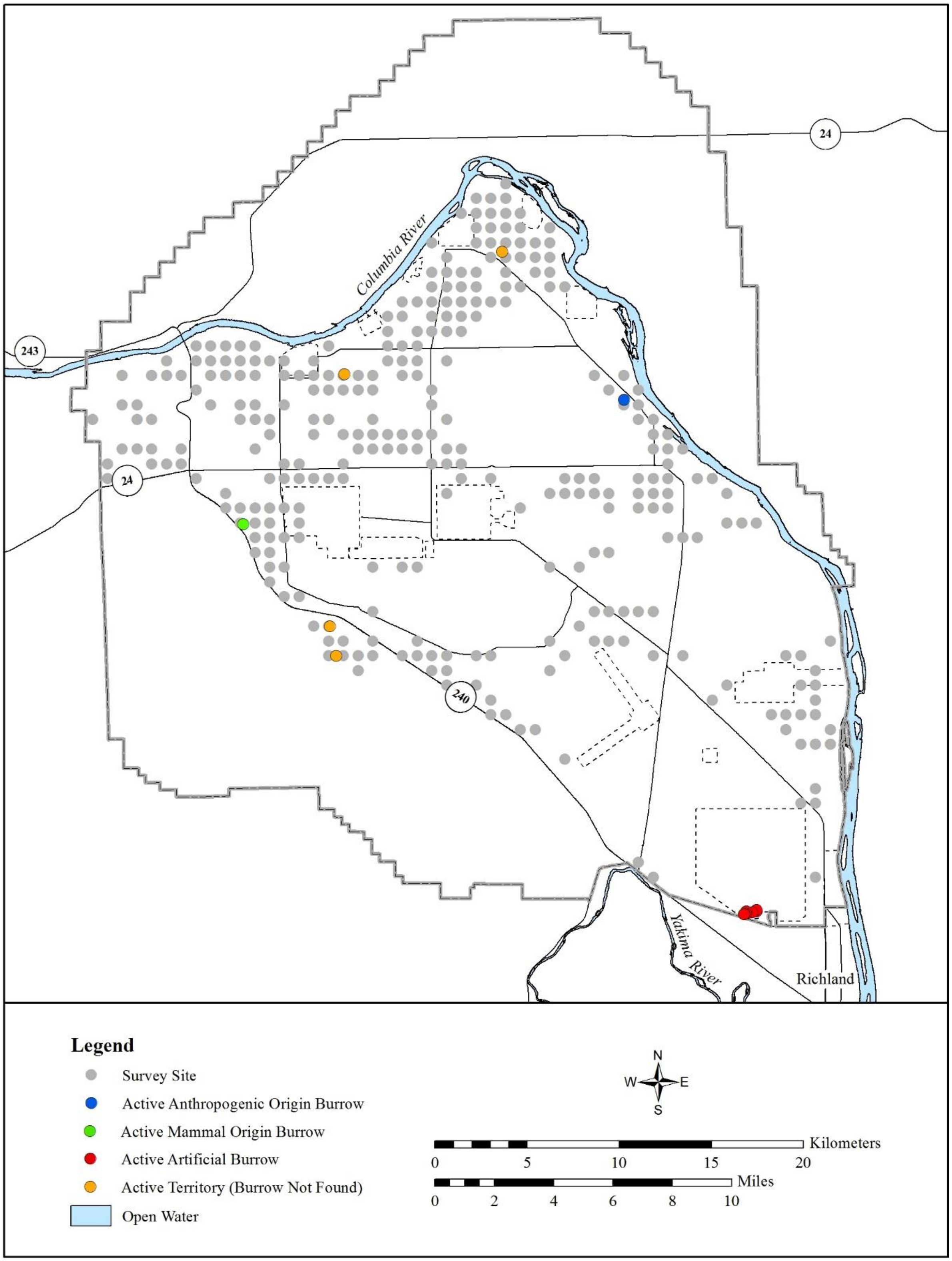


Figure 2-18. Burrowing Owl Locations on the Hanford Site (2017)

2.4.3.2 Artificial Burrows. On February 27, 2017, annual maintenance was performed on the artificial burrows at the Volpentest Hazardous Materials Management and Emergency Response (HAMMER) Federal Training Center. Annual maintenance includes cleaning out debris from the burrow entrances (typically vegetation and sand) and clearing vegetation that had grown in front of the entrances. The same maintenance duties were performed on the artificial burrows along Army Loop Road on February 28, 2017.

Most of the HAMMER burrows were in suitable condition after maintenance, while the majority of the Army Loop Road burrows had filled in with too much sand to be redeemed; thee burrows are not considered habitable. At both locations, there were no annual resident or early arriving owls observed during the burrow maintenance. On June 20, 2017, staff returned to the HAMMER facility and conducted owl surveys. Because the burrow locations are easily visible, the survey method used to find new burrows were not used. Instead, staff observed each burrow cluster from variable distances looking for signs of occupancy. Call-broadcasts were used to insight owls to exit the burrow. Each burrow was then inspected for signs of current use by checking for clear entrances free of debris and fresh pellets. In all, six Burrowing Owls were observed. One pair responded to the broadcast-call and exited their burrow, while the other four individuals responded to the broadcast-call but did not exit their burrow. These individuals were already perched on the perch post outside the burrows. The remains of one owl were found with a metal identification band still intact. The band (Figure 2-19) was investigated and determined to be from a female Burrowing Owl captured and banded at the facility on June 2, 2015. Figure 2-20 illustrates the findings of the artificial burrows at the HAMMER facility.

Figure 2-19. Identification Band found on Dead Burrowing Owl at the HAMMER Facility

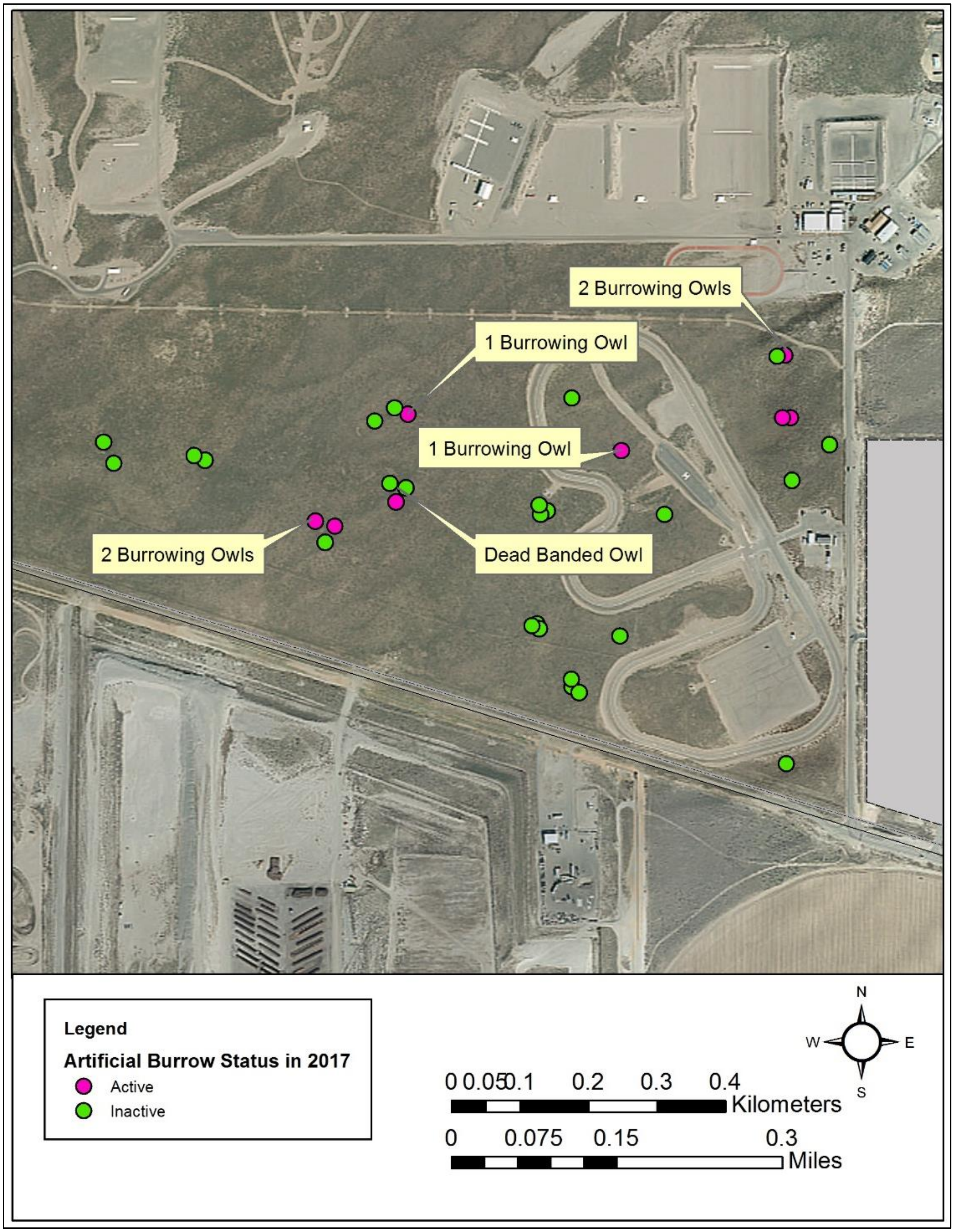


Figure 2-20. Status of the Artificial Burrows in 2017 at the HAMMER Facility

2.4.4 Conclusion

The objectives during the FY 2017 monitoring efforts were to survey locations that were determined to be suitable habitat in order to document the distribution and abundance of nesting Burrowing Owls on the DOE-RL-managed portions of the Hanford Site, and to provide maintenance and determine the status of the artificial burrows on site. Natural burrows on the Hanford Site are typically those created by badgers; despite the burrows life expectancy being much shorter than those of anthropogenic or artificial specific origin, numerous badger burrows that appear to be suitable for owl use have been observed in many locations on the Hanford Site. The data collected during the FY 2017 monitoring efforts suggest that the use of natural burrows continues to decline as illustrated in Figure 2-21.

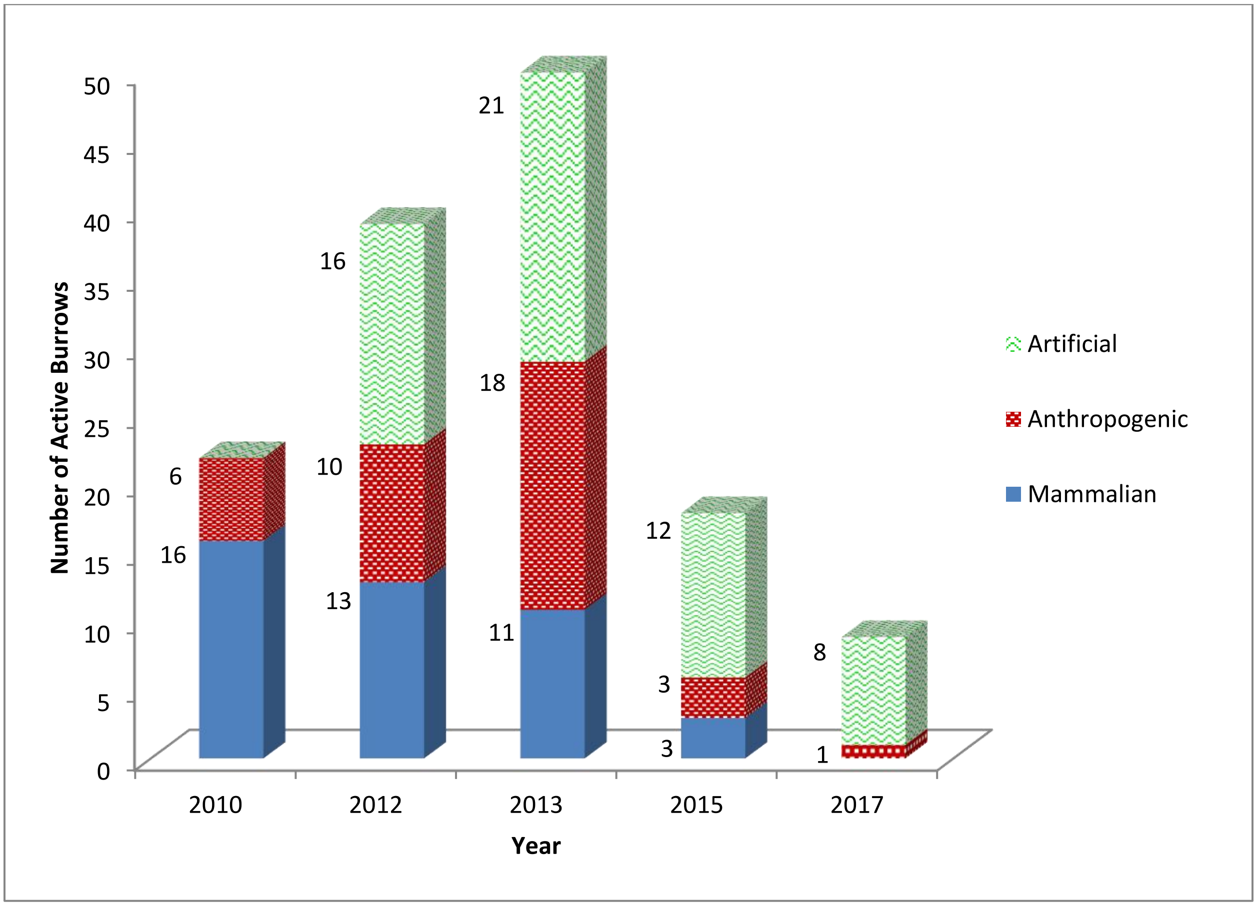


Figure 2-21. Number of Active Burrows per Year by Burrow Origin Type

All three of the natural burrows found to be active in 2015 have since been deemed inactive. During this year's rigorous efforts there were no natural active burrows located. This should not discount the possibility of natural and/or anthropogenic burrows being present based on the fact that there was both visual and acoustic confirmation of Burrowing Owls in areas previously unknown to be inhabited. It is probable that the four visual and/or callback observations hold true to this scenario, increasing the total burrow count to 14 during the 2017 efforts. One active natural burrow was incidentally discovered but was later determined to be abandoned. The area in which active anthropogenic burrows were observed in 2015 (Hanford Townsite's old orchard) was confirmed to still be active in 2017. The HAMMER facility had a total of 8 active artificial burrows in 2017 and 12 in 2015. This is a 33.3% decline in the number of active burrows at the HAMMER facility since it was last monitored. Although there was a decrease in owl numbers, the ABS at the HAMMER complex continues to be used, implying that owls are continuing to produce offspring in the colony. The success of this mitigation action suggests that additional onsite mitigation would be successful in preserving the remaining owl population on central Hanford. Relatively close geographically, the Umatilla Army Depot has made large efforts to install ABS when it was believed the breeding population of Burrowing Owls was down to four pairs. The efforts of the Global Owl Project and the Army, with use of ABS on that site, have brought the population back to estimates of over 58 breeding pairs as of the 2017 nesting season (communications with David Johnson of the Global Owl Project).

Based on the results of this review, this resource should be monitored again in 2019 (biennial). The focus should return to all potential habitat areas in which active burrows have been documented since 2010 and habitat areas similar to the historical sites. These efforts can be used to evaluate if family units have vacated active areas relocating to previously occupied areas. Future studies of active colonies should also consider documenting colony characteristics. Determining production from nest burrows and possible young mortality before fledging may provide explanation for population declines.

Due to the development and removal of infrastructure, natural disturbances, site cleanup activities, and other land use alterations, the landscape of the Hanford Site is continually changing. With the minimal use of natural burrows and continued loss of accompanying anthropogenic burrows, installation of ABS in active colony locations should be evaluated. Since the installation of the HAMMER complex burrows, updated designs and techniques have been developed for installation of Burrowing Owl burrows (Johnson et al. 2013). The new designs will not only provide adequate burrow locations for the existing populations to increase in number but provide a monitoring opportunity and easier maintenance for greater longevity. Additional ABS installed on the Hanford Site should provide meaningful contributions to slowing the rate of population decline and provide a direct link to conservation and recovery of the species throughout the Site.

2.5 FERRUGINOUS HAWK NESTING TERRITORY OCCUPANCY AND PRODUCTIVITY SURVEYS 2017

2.5.1 Introduction

A Washington State threatened species, the Ferruginous Hawk is ranked as a Level 4 resource in the BRMP. Level 4 resources are considered essential to the biological diversity of the Hanford Site and the Columbia Basin Ecoregion. The management goal of Level 4 resources is preservation with a high level of status monitoring.

The Ferruginous Hawk, the largest of the North American *Buteo* species, inhabits grassland, shrub-steppe, and desert habitats of western North America from southern Canada to central Mexico. The species nests in 17 U.S. states and 3 Canadian provinces (i.e., Washington, Oregon, Idaho, Nevada, California, Utah, Arizona, New Mexico, Texas, Oklahoma, Colorado, Kansas, Wyoming, Nebraska, South Dakota, North Dakota, Montana, Manitoba, Saskatchewan, and Alberta) and overwinter in the southwestern and south-central U.S. and Mexico (Ng et al. 2017). Generally, Ferruginous Hawks begin arriving in Washington State to nest in mid-February and begin laying eggs in mid-March. Most eggs hatch in May and most young fledge from late May through late July (WDFW 1996). Ferruginous Hawks build large stick nests. On the Hanford Site, Ferruginous Hawks have been found nesting on cliffs, rock outcrops, trees, and transmission towers.

Nesting Ferruginous Hawks were uncommon on the Hanford Site prior to 1987, with only 1 or 2 pairs nesting each year on basalt outcroppings on the side hills of Rattlesnake Mountain (Fitzner and Newell 1989). In 1987, four pairs of Ferruginous Hawks were observed nesting on the relatively new 230-kV transmission towers associated with the Washington Public Power Supply System reactors (now known as Energy Northwest). Construction of the transmission towers began in 1976 and lines were energized between December 1976 and July 1981. In 1988, seven Ferruginous Hawk nests were observed on 230-kV transmission towers, and one in a tree. In 1991, 1992, and 1993, 11 active Ferruginous Hawk nests were reported each year on the entire Hanford Site (8 to 10 active nests on the central Hanford Site) (WHC-EP-0513; Nugent 1995). The majority of these nests were located on the newly built transmission towers. A decrease in the number of nesting Ferruginous Hawks on the Hanford Site has occurred since the 1990s. PNNL-SA-46396, *Breeding Population Status and Nest Site Characterization of Hawks (Buteo spp.) and Common Ravens (Corvus corax) on the Hanford Site, Southcentral Washington,* reported four nesting pairs on transmission towers in 2005. The WDFW documented two nesting pairs on transmission towers in 2010 in a personal communication by Livingston in 2012. The number occupied Ferruginous Hawk nests have remained stable on the Hanford Site since 2010 with two to four nests occurring each year (all on transmission towers) from 2012 to 2016 (HNF-53073, HNF-56769, HNF-58717, HNF-59755, HNF-60469). In 2016, a productivity survey was conducted and a total of six young were produced on the Hanford Site at three nest sites (two young at each nest site) (HNF-60469).

Ferruginous Hawks are especially sensitive to human disturbance and incursion into their nesting areas. On the Hanford Site, nesting Ferruginous Hawks are protected using WDFW guidelines (WDFW 2004). Buffer zones of 1,000 m (3,281 ft) are established around active nests. Road closure signs are placed in the roads where they intersect with the 1,000-m (3,281-ft) buffers. Nest areas are protected from all human disturbance within 250 m (820 ft) between March 1 and May 31, and within 1,000 m (3,281 ft) for prolonged (greater than 0.5 hour) activities during the entire nesting and fledging season (March 1 to August 15). The identification of active nest sites during annual surveys allows for the protection of nesting Ferruginous Hawks.

2.5.2 Methods

Seventeen traditional Ferruginous Hawk nesting territories have been identified on the DOE-RL-managed lands of the Hanford Site (Figure 2-22). The definition of a nesting territory used for this survey "is an area that contains, or historically contained, one or more nests of a mated raptor pair and where no more than one pair is known to have bred at one time" (Steenhof and Newton 2007). Two surveys were conducted in 2017, one occupancy survey and one productivity survey. The occupancy survey took place May 18. All 17 traditional Ferruginous Hawk nesting territories were visited and assessed for occupancy. The occupancy survey included visiting historical nests, scoping all potential nest structures in the vicinity of historical nests, scanning ground and elevated perches for adult birds, and hiking through territories to elicit defensive behavior of adults that may otherwise not be detected. Occupancy of a territory by species other than Ferruginous Hawks (e.g., Red-tailed Hawks, Prairie Falcons, Common Ravens) was also recorded. The productivity survey was performed on June 21. Most young are 2 to 5 weeks old at this time. A surveyor visited the occupied territories, counted the young at each nest, and aged them based on plumage (Moritsch 1985).

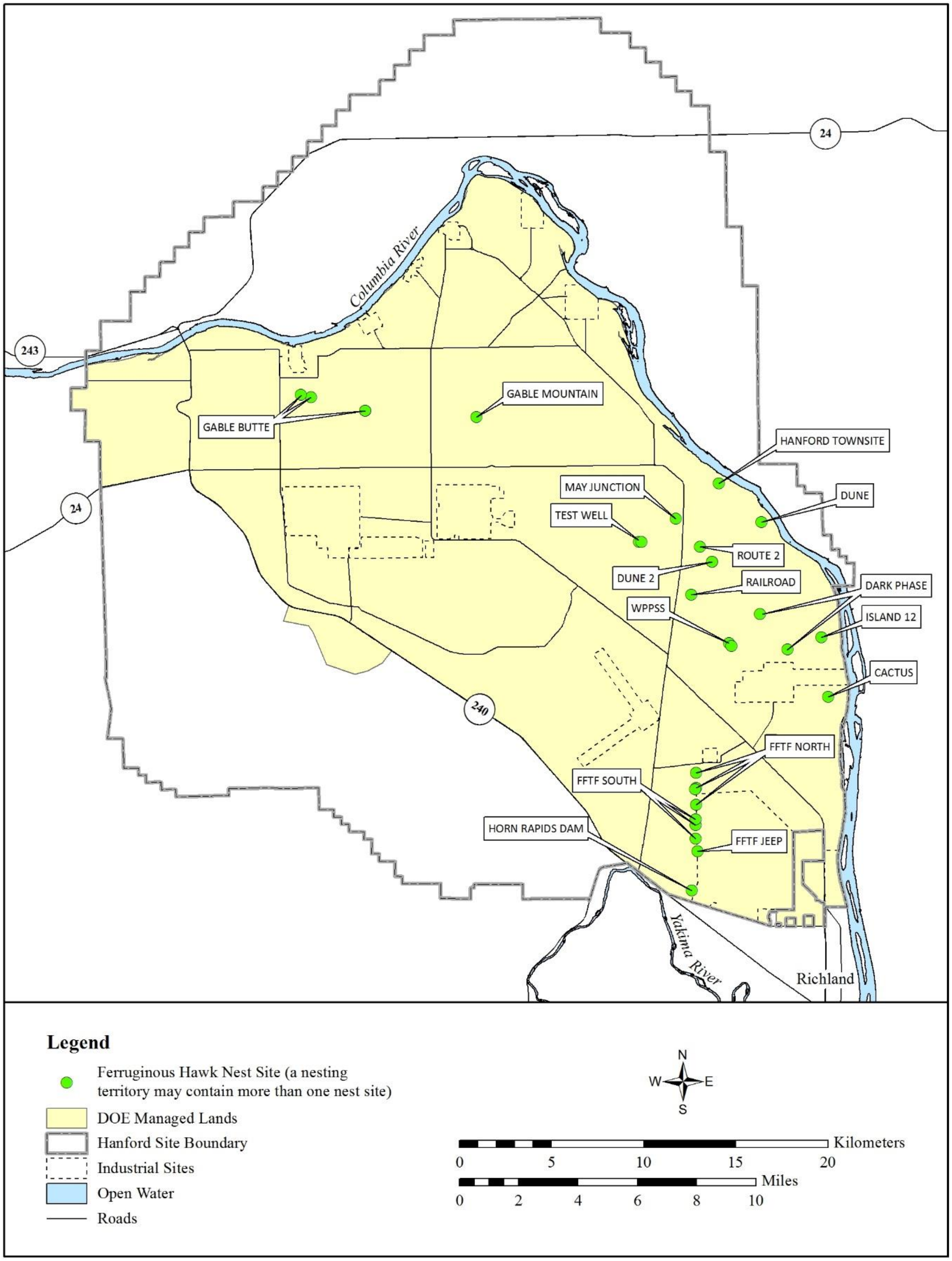


Figure 2-22. Traditional Ferruginous Hawk Nesting Territories on the DOE-RL-Managed Lands of the Hanford Site

2.5.3 Results

Three Ferruginous Hawk nesting territories (Dune 2, Dark Phase, and Fast Flux Test Facility Jeep) were occupied on DOE-RL managed-lands of the Hanford Site in 2017 (Figure 2-23) but only two territories were successful. One young each was produced at the Dunes 2 and Dark Phase nests. The nest in the FFTF Jeep territory that had been built on a transmission tower was found on the ground during the productivity survey.

2.5.4 Discussion

MSA has conducted 2 years (2016 and 2017) of occupancy and productivity surveys of Ferruginous Hawk nesting territories on the Hanford Site. Three nesting territories were occupied each year with three successful nests in 2016 and two successful nests in 2017. Six juveniles were fledged in 2016 for an average of two juveniles per successful nest and two juveniles were fledged in 2017 for an average of one juvenile per successful nest. No cause was detected for the decrease in Ferruginous Hawk productivity on the Hanford Site in 2017 but many studies have correlated nest success and productivity to the abundance of major prey (Ng et al. 2017). The severity (cold and wet) of the winter preceding the 2017 nesting season may have depressed small mammal populations or promoted heavy vegetation growth making hunting difficult.

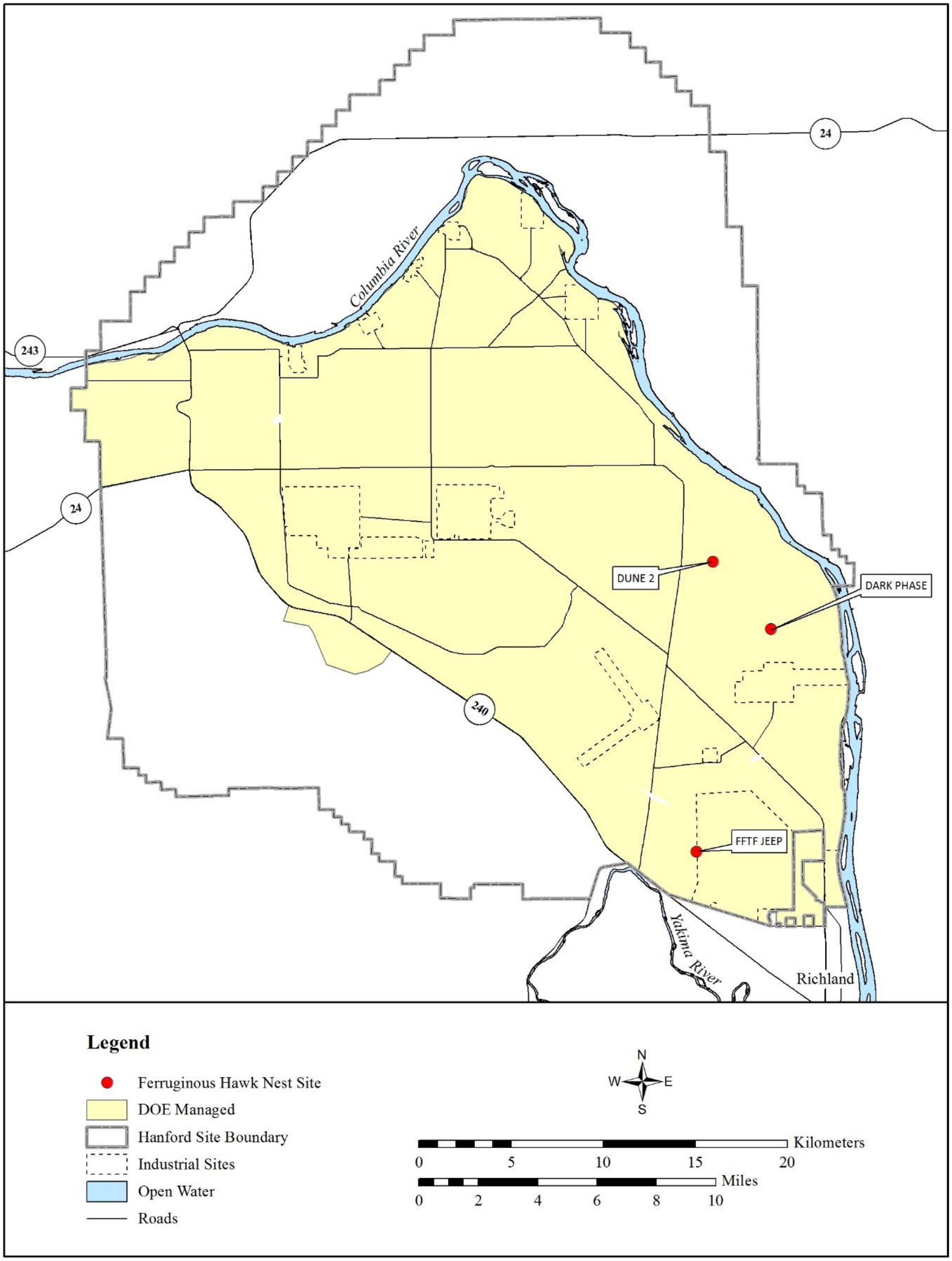


Figure 2-23. Active Ferruginous Hawk Nest Observed on the DOE-RL-Managed Lands of the Hanford Site in 2017

2.6 ROOKERIES

A Washington State monitored species (the Great Blue Heron [*Ardea Herodias*], Great Egret [*Ardea albais*], and the Black-crowned Night-heron [*Nycticorax nycticorax*]) are ranked as a Level 2 resource in the BRMP. Level 2 resources are considered essential to the biological diversity of the Hanford Site and the Columbia Basin Ecoregion. The management goal of Level 2 resources is conservation, with actions primarily to avoid and minimize disturbance. Wading bird rookeries as a whole are considered a Level 3 resource with a management goal of conservation and sustaining habitats present.

Great Blue Herons, Great Egrets, and Black-crowned Night-herons are highly vulnerable to human disturbance, predation, and competition for nesting habitat. Their habit of nesting in large groups makes them especially susceptible to these types of impacts. A single event involving human disturbance can lead an entire colony to terminate a nesting attempt. Because herons breed in colonies of up to 500 nests, early termination of even one nesting attempt can lead to a considerable loss of offspring (Burger 1978).

EMC has not conducted rookery-specific surveys prior to this effort, although incidental data has been recorded over time. Both the Great Blue Heron and the Black-crowned Night-heron are year-round residents of the Hanford Site, while the majority of the Great Egret nesting population arrive in March and migrate south to warmer climates in November. The scope of this survey was to locate all occupied and unoccupied rookeries on the Hanford Site bordering the Columbia River, from Riverlands downriver to the southern boundary of the 300 Area.

During the March 21, 2017, Bald Eagle boat survey, occupied and unoccupied rookeries visible from the boat were recorded and later digitized using ArcGIS. For all rookeries located, the number of nests were recorded. For those observed to be occupied, species and number of individuals was also recorded.

During the March 21, 2017, monitoring efforts, nine rookeries were located. Four were not currently occupied while five were. All occupants (31 birds in all) at this time were observed to be Great Blue Herons. The number of nests per rookery ranged from 2 up to 40 nests in a single location. The 9 rookeries totaled 109 nests. It needs to be taken into account that the monitoring efforts were conducted prior to nesting season and not all species and expected summer residents were present. The WDFW recommends a 300-m (984-ft) buffer around active rookeries for all human activities. Figure 2-24 illustrates where the nine rookeries are located along the Hanford Reach of the Columbia River. The information gathered from this monitoring effort will assist in the future protection of these colonial nesting birds during the critical breeding and rearing season.

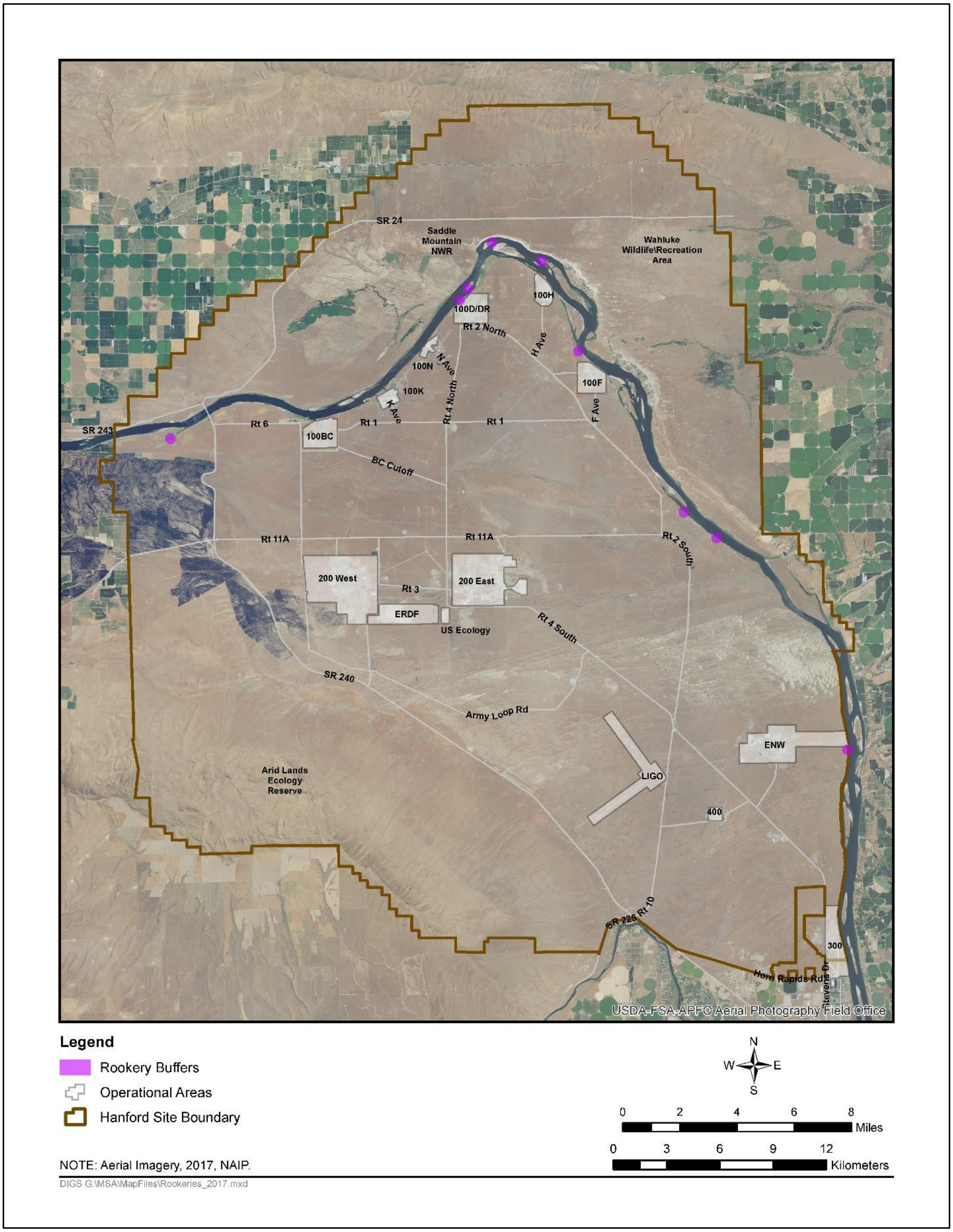


Figure 2-24. Colonial Nesting Bird Rookeries along the Hanford Reach of the Columbia River

2.7 ROADSIDE BIRD SURVEYS 2017

The Hanford Site contains a variety of bird habitats that include: basalt outcrops, riparian zones along streams and springs, shrub-steppe on slopes and plains, sand dunes and blowouts, and abandoned fields or disturbed areas (PNL-8942). The Hanford Site provides large expanses of habitat for shrub-steppe birds and other landbirds that depend on either mature stands of sagebrush or areas with at least some component of native grasses in the understory (TNC 1999). In some portions of land surrounding Hanford, human activities such as farming, urbanization, and industrial development have greatly decreased the amount of natural habitat that native landbirds require for survival. In turn, the riparian areas of the Hanford Site may have been improved by planting larger trees near homesteads and towns. These trees provide nesting locations, feeding areas, and roosting spots for many species.

The amount and quality of shrub-steppe habitat in the Columbia Plateau has been greatly reduced from historical levels due to urban development, agricultural conversion, wildfires, and fragmentation. These changes place additional stressors on shrub-steppe obligate species; some, such as the Greater Sage Grouse (*Centrocercus urophasianus*), have been locally extirpated. Federal laws, including the *Migratory Bird Treaty Act of 1918*, provide protection for these species. Monitoring is essential to not only maintain current biological information on the abundance and distribution of these species on the Hanford Site but also to ensure compliance with protection regulations and to inform future protection and management efforts.

Several sagebrush-steppe dependent species (such as the Sagebrush Sparrow [*Artemisiospiza nevadensis*], Sage Thrasher [*Oreoscoptes montanus*], and Loggerhead Shrike [*Lanius ludovicianus*]) are currently listed by the WDFW as “candidate species” and have the potential to be listed as threatened or endangered in the future (WDFW 2013). In addition, the Hanford Site and surrounding area provides refuge to potentially 17 state-listed species as well as numerous state-monitored species (WDFW 2017) that benefit from the large expanses of habitat. This list includes birds such as the Ferruginous Hawk, a state “threatened” species (WDFW 2013).

As resource managers of the Hanford Site, DOE-RL is responsible for conservation of wildlife and wildlife habitats (DOE/RL-94-150, Rev. 3). Avifauna have been documented and monitored on the Hanford Site for over 60 years (WHC-EP-0402), including over 20 years of roadside survey monitoring on four historical survey routes that were established by Pacific Northwest National Laboratory in 1988 (Figure 2-25). These routes were monitored in the spring months from 1988 through 1991, winter counts were added in 1992 and 1993. Each transect was monitored monthly between 1994 and 2001 (this information was provided by W. Rickard in a personal communication in 2011). The monitoring performed in 2017 provides continued data for documenting species occurrence and distribution on the Hanford Site and can be compared with the long-term data collected on the Hanford Site over multiple decades. The monitoring of birds that occur on the Hanford Site is a valuable tool for developing baseline information on the presence and distribution of biological resources across the Hanford Site, identifying trends in species or populations, and compiling biological information necessary to implement adaptive management (DOE/RL 96-32).

Bird Survey routes were modified in 2002 due to both the transfer of management responsibility of the Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE) from the DOE to the FWS and a large fire in 2000, which modified the habitat along the routes. In 2002, surveys along ALE were discontinued as part of the DOE routine program. A new route was established to monitor mature sagebrush communities on the north side of Gable Mountain and Gable Butte, previously burned areas, and successional grassland communities (HNF-55491). The four modified roadside bird survey routes that have been used from 2002 to present are shown in Figure 2-26.

In 2005, the Hanford Site became part of the North American BBS. The BBS is a unique collaborative counting effort designed to increase the understanding of North American bird populations and is now used as the primary data source for estimation of population change and modeling of the possible consequences of change in land use, climate, and many other possible stressors on bird populations (Sauer et al. 2011). Jointly developed and coordinated by the USGS, FWS, and the Canadian Wildlife Service, the BBS incorporates counting efforts across the Unites States and Canada. Comprehensive summaries of population change have been calculated for greater than 400 species of birds across North America (Sauer et al. 2003). In 2005, two of the current routes (Horn Rapids to Hanford Townsite and Old Fields) were surveyed in combination as the annual Horn Rapids BBS route. The Richland BBS route was created in 2006 from the previously discontinued ALE routes, including half of the current Army Loop Rd Route. Figure 2-27 shows the two USGS BBS survey routes performed at the Hanford Site.

To maintain consistency and allow the official BBS data to fit within the annual program results, MSA follows the methods of the BBS described in Section 2.0 when performing counts along survey routes.

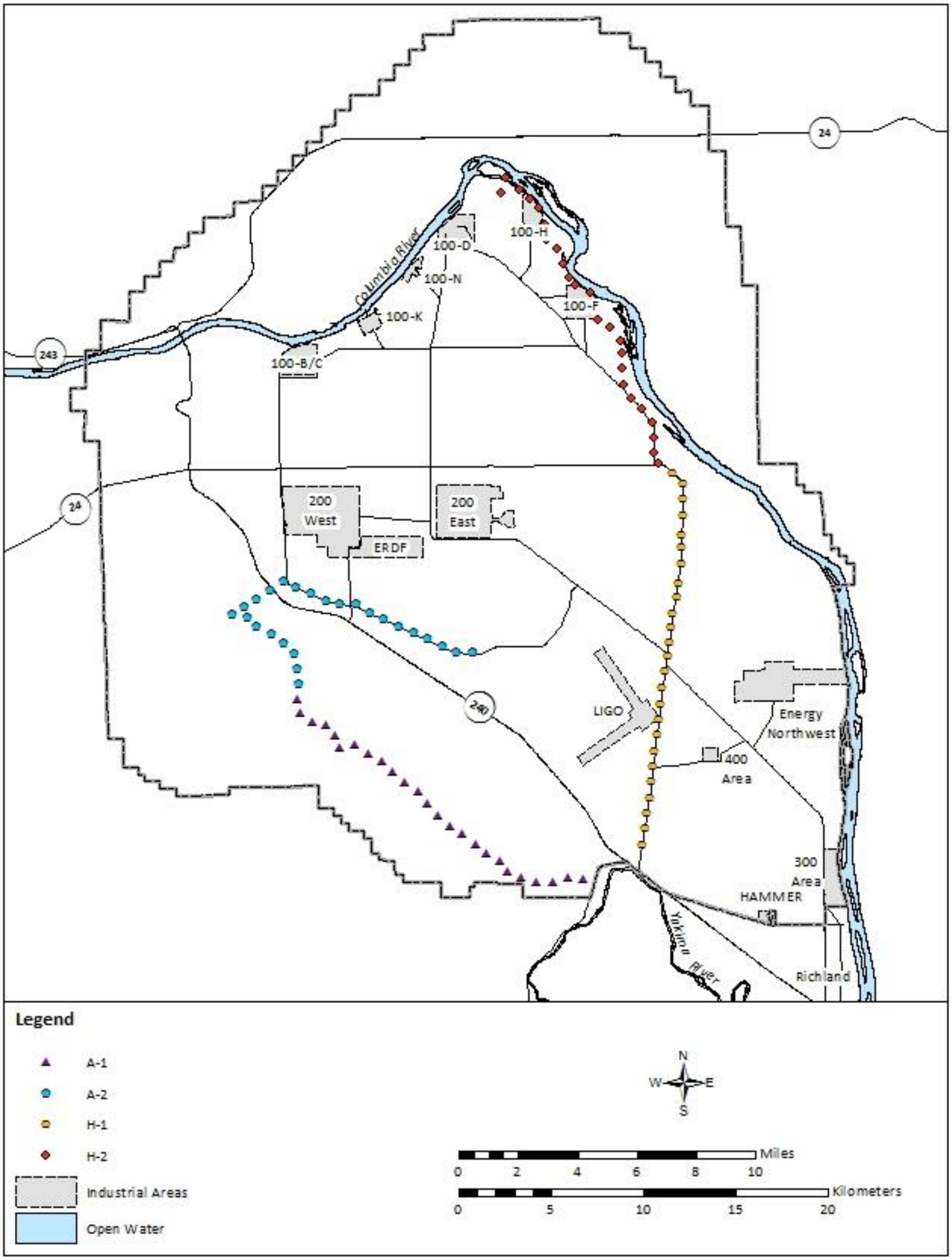


Figure 2-25. Roadside Bird Survey Routes Performed on the Hanford Site from 1988-2001

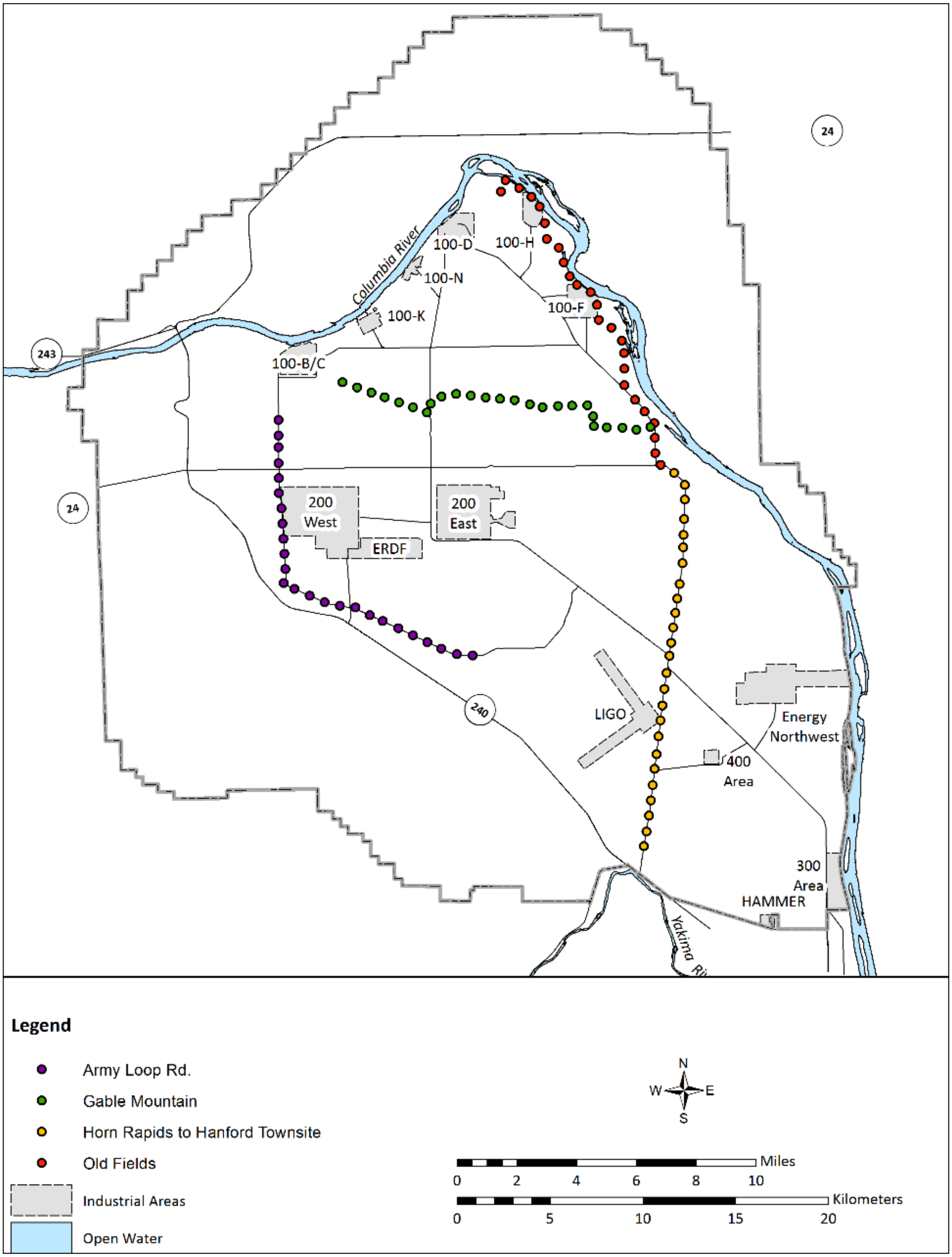


Figure 2-26. Roadside Bird Survey Routes and Point Locations Used on the Hanford Site Since 2002

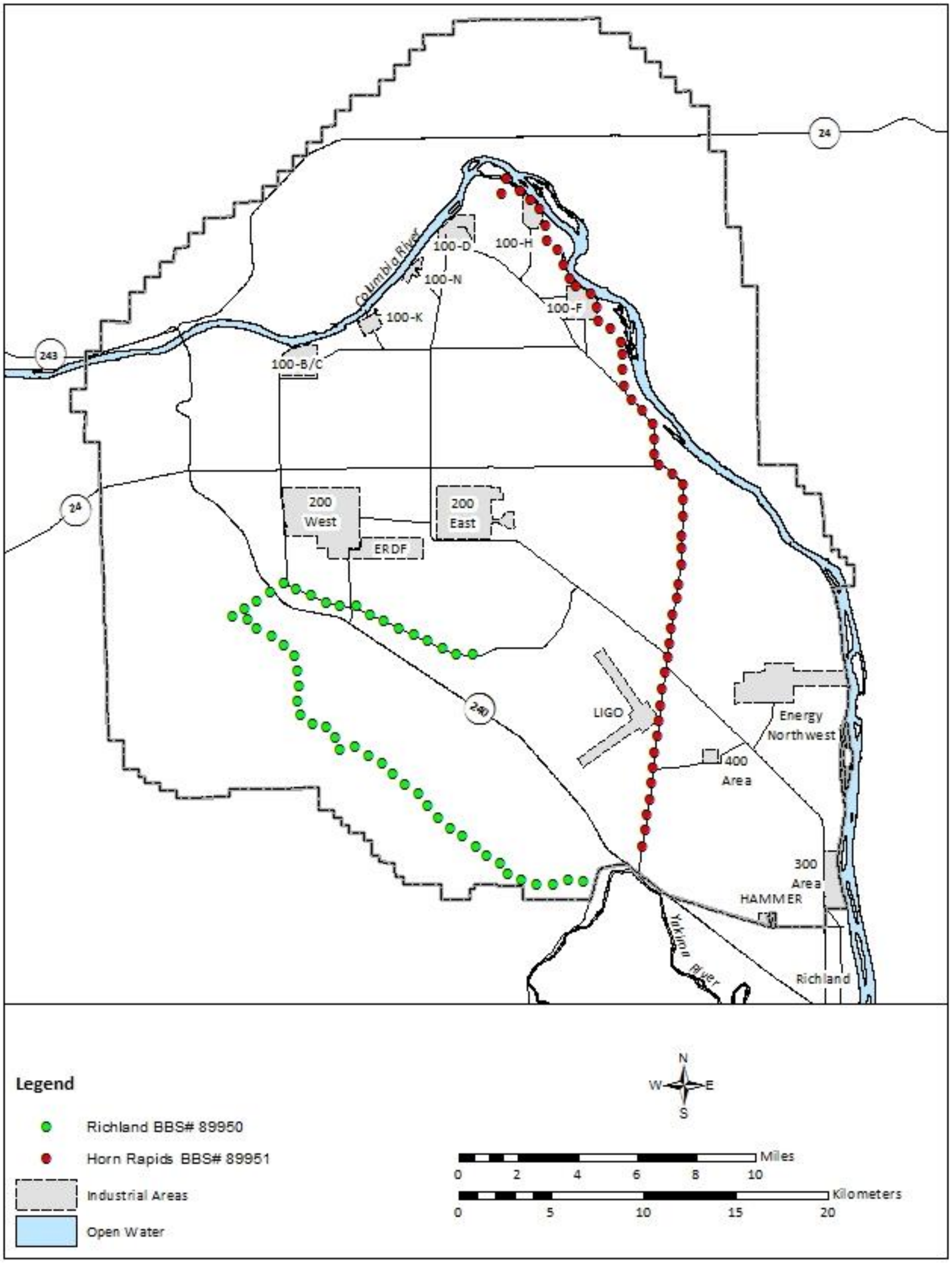


Figure 2-27. The U.S. Geological Survey Breeding Bird Survey Routes Performed Annually on the Hanford Site

2.7.1 Objectives and Scope

Part of the Executive Order 13186 included directions to federal agencies to take actions in implementation of the *Migratory Bird Treaty Act of 1918* and promote the conservation of migratory bird populations. MSA coordinates with site contractors and outside agencies to collect valuable data on avian species. In the 2017 season, annual roadside survey counts (including the USGS BBS) were performed.

Migratory bird and BBSs were performed on four historical survey routes in 2017 (Figure 2-26). Road surveys are a practical way to monitor changes in species richness, the number of species represented in the community, and relative abundance; how common or rare a species is relative to other species in the community; and of shrub-steppe birds over time and in response to various types of land-use changes. Monitoring of avian populations on the Hanford Site strengthens migratory bird conservation through data collaboration between DOE-RL and other agencies including federal, state, Tribal, and local governments.

This report does not provide an inventory of all birds that inhabited any portion of the Hanford Site in 2017 but rather documents the status of birds identified through a transect survey. The scope of this work is to document the numbers of birds using areas by documenting bird presence. All data collected during these activities is used by the Hanford Ecological Monitoring and Compliance program. The USGS BBS data is used by the USGS in their national analysis and state of the birds reporting.

2.7.2 Methods

In 2017 the survey protocols included roadside survey counts. Roadside survey counts are widely used in avian monitoring programs across the country. By performing these protocols, data is obtained over a large geographic coverage.

2.7.2.1 Roadside Survey Counts. Roadside survey counts follow the protocols used for the BBS coordinated by the USGS annually throughout North America (Bystrack 1981, Sauer et al. 2011). Four survey routes (Figure 2-26) or portions of routes were surveyed a single time during the 2016 breeding season in coordination with BBS.

The Hanford Site routine roadside routes are 20 km (12.43 mi) compared to the 40-km (24.85-mi) routes used in the BBS (Figures 2-26 and 2-27). The 40-km (24.85-mi) Horn Rapids 89951 BBS route surveys both the Horn Rapids to Hanford Townsite (20 km [12.43 mi]) and Old Fields (20 km [12.43 mi]) Hanford survey routes. All roadside routes contain point counts at 0.8-km (0.5-mi) intervals marked with steel fence posts, rebar posts, pin flags, or by global positioning system (GPS) coordinates only. There are 25 survey points per Hanford route and 50 survey points per BBS route. Birds within 400 m (0.25 mi) of each survey point were identified by sight or sound during a 3-minute observation at each marker post. Surveyors drove to each survey location and observed the area for 3 minutes, recording their observations, then continued to the next location. The number of vehicles passing by during the survey time was recorded on the field sheet for each point. Observers remained at a survey point for more than the 3 minutes only if additional time was needed to confirm identification or to count birds that were noted during the 3-minute observation period. Observations of any nesting activities within 400 m (0.25 mi) of the survey point were also noted. It is acknowledged that a roadside monitoring program is not without bias; however, the benefits are considered to outweigh most disadvantages (USDA 1993). Attempts were made to start all Hanford surveys in the early morning hours, starting no earlier than 30 minutes before sunrise and no later than 30 minutes following sunrise. The BBS survey routes were started as near as possible to 0438 hours, as required by the USGS for BBS surveys performed from May 25 through July 7. Surveys were halted if adverse weather conditions (such as high winds, heavy rain, or snowfall) developed during the route survey. Each route was surveyed once during pre-breeding, breeding, and fall survey period.

2.7.2.2 Trending and Evaluation of Roadside Data from 5 years of Data Collection. There is a wide range of indices for evaluating species diversity. Species diversity is highly correlated with species richness and provides insight into the makeup of a community. An extreme example to the value of diversity indexes would be to look at two communities, each with 5 species and 100 total individuals. Community A contains 96 of species 1 and only a single individual of the other 4 species; community B contains 20 individuals each of 5 species. The question becomes which community is more diverse? If the researchers belief is that both communities are equally diverse than species richness suffices as the only needed indices. If the belief of the researchers are that the communities are vastly different in diversity due to the imbalance of individuals, than species diversity indexes provide additional insight (FWS 1999).

The most widely used diversity index is referred to as Shannon's index. Shannon's index reflects both species richness and evenness of distribution among species present. An equation for the Shannon index using natural logarithms (ln) is:

$$H' = \sum_{i=1}^{i=S} (p_i)(\ln p), i = 1,2, \dots S$$

Where S = number of species in the sample and p_i is the proportion of all individuals belonging to the species. Additionally, for this report we transform H' with natural logarithms given by $e^{h'}$ and is labeled as N_1. This transformation expresses the diversity in terms of species instead of the original base 2 term of bits. When species diversity is close to species richness the communities are considered to have an evenness. That is the species distribution is maximally even when $S = N_1$. More information on Shannon's index and reasoning for its use in avian monitoring programs can be found in the *Statistical Guide to Data Analysis of Avian Monitoring Programs* (FWS 1999).

2.7.3 Roadside Bird Survey Results

All surveys were completed successfully during the breeding season and resulted in data collection of four Hanford route surveys (Table 2-7). The Horn Rapids BBS route includes both the Horn Rapids to Townsite and Old Fields routes in a single run. The second half of the Army Loop Rd route (points 12 through 25) were surveyed in 2017 as part of the Richland BBS route completion and then points 1 through 11 completed following the Richland BBS. The breeding season surveys are the most consistently surveyed period and most often used for trending. For the 2017 breeding season surveys, a total of 1,223 individual birds were documented (Table 2-8), similar to the 1,219 individuals counted during breeding period surveys in 2016 and 1,227 individuals from same period in 2015. Forty-Four bird species were documented in the 2017 breeding season survey (Table 2-9), which was down slightly from the 50 and 51 species seen in breeding period surveys during 2016 and 2015, respectively.

Table 2-7. 2017 Survey Dates and Location.

Route Name	Breeding Survey Date
Army Loop Rd	06/22/2017[a]
Gable Mountain	06/14/2017
Horn Rapids to Hanford Townsite	06/11/2017 [b]
Old Fields	06/11/2017[b]

[a] Surveyed during Richland BBS
[b] Surveyed during Horn Rapids BBS

The Cliff Swallow (*Petrochelidon pyrrhonota*) was the most abundant species documented. The surveys documented 296 individuals on 2 survey routes, nearly 25% of the total number of individuals seen. This was due to a very high number of breeding swallows present around the reactor areas during the morning of the survey. The usual most abundant species were present in high numbers once again: the Horned Lark (*Eremophila alpestris*) had 223 individuals, 18.29% of surveyed individuals, and the Western Meadowlark (*Sturnella neglecta*) had 218 individuals, 13.95% of all individuals counted (Table 2-8). The Horned Lark was counted on 79 survey points (79 %) while the Western Meadowlark was documented on 70 survey points (70%). While the Cliff Swallow had the highest number of individuals counted it was only seen on 14 points during the surveys, 14% of survey points. These three species accounted for over half of the individuals counted during the 2017 surveys (56.52%).

During the breeding season the Old Fields route had the highest species diversity and the highest abundance of individuals (Table 2-9). The “Old Fields” route has historically been the route with the highest species richness and abundance. The route runs along the northeastern edge of the central Hanford Site, often directly adjacent to the Columbia River, providing the largest variety of habitat of any route.

Table 2-8. Species, Sorted by Abundance, During Breeding Season Roadside Surveys Performed on the Central Hanford Site in 2017. (3 Pages)

Common Name	Scientific Name	Routes[a]	Individuals	% Counts	Stops[b]	% Stops
Cliff Swallow	*Petrochelidon pyrrhonota*	2	296	24.28	14	14.00
Horned Lark	*Eremophila alpestris*	4	223	18.29	79	79.00
Western Meadowlark	*Sturnella neglecta*	4	170	13.95	70	70.00
Bank Swallow	*Riparia riparia*	1	69	5.66	4	4.00
European Starling	*Sturnus vulgaris*	4	63	5.17	12	12.00
Ring-billed Gull	*Larus delawarensis*	1	61	5.00	9	9.00
Lark Sparrow	*Chondestes grammacus*	4	40	3.28	26	26.00
Common Raven	*Corvus corax*	4	28	2.30	16	16.00
Sagebrush Sparrow	*Artemisiospiza nevadensis*	3	27	2.21	14	14.00
Brewer's Blackbird	*Euphagus cyanocephalus*	2	24	1.97	6	6.00

Table 2-8. Species, Sorted by Abundance, During Breeding Season Roadside Surveys Performed on the Central Hanford Site in 2017. (3 Pages)

Common Name	Scientific Name	Routes[a]	Individuals	% Counts	Stops[b]	% Stops
Common Nighthawk	*Chordeiles minor*	4	22	1.80	6	6.00
Great Egret	*Ardea alba*	1	21	1.72	3	3.00
Western Kingbird	*Tyrannus verticalis*	4	18	1.48	9	9.00
Eastern Kingbird	*Tyrannus tyrannus*	1	16	1.31	7	7.00
California Quail	*Callipepla californica*	2	14	1.15	6	6.00
Loggerhead Shrike	*Lanius ludovicianus*	3	12	0.98	8	8.00
Red-winged Blackbird	*Agelaius phoeniceus*	1	11	0.90	4	4.00
Mourning Dove	*Zenaida macroura*	4	10	0.82	8	8.00
Canada Goose	*Branta canadensis*	1	10	0.82	2	2.00
American White Pelican	*Pelecanus erythrorhynchos*	1	10	0.82	4	4.00
Great Blue Heron	*Ardea herodias*	1	10	0.82	2	2.00
American Robin	*Turdus migratorius*	1	9	0.74	2	2.00
Bullock's Oriole	*Icterus bullockii*	1	8	0.66	4	4.00
Rock Wren	*Salpinctes obsoletus*	1	7	0.57	5	5.00
Tree Swallow	*Tachycineta bicolor*	1	5	0.41	2	2.00
Long-billed Curlew	*Numenius americanus*	2	5	0.41	3	3.00
Black-billed Magpie	*Pica hudsonia*	1	5	0.41	3	3.00
Double-brested Cormorant	*Phalacrocorax auritus*	1	3	0.25	2	2.00
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	1	3	0.25	2	2.00
Red-tailed Hawk	*Buteo jamaicensis*	3	3	0.25	3	3.00
House Finch	*Haemorhous mexicanus*	1	3	0.25	1	1.00
Swainson's Hawk	*Buteo swainsoni*	1	2	0.16	2	2.00
Brown-headed Cowbird	*Molothrus ater*	1	2	0.16	1	1.00
Common Merganser	*Mergus merganser*	1	2	0.16	2	2.00
Savannah Sparrow	*Passerculus sandwichensis*	2	2	0.16	2	2.00
Western Wood-pewee	*Contopus sordidulus*	1	1	0.08	1	1.00
Osprey	*Pandion haliaetus*	1	1	0.08	1	1.00
Greater Yellowlegs	*Tringa melanoleuca*	1	1	0.08	1	1.00
Sage Thrasher	*Oreoscoptes montanus*	1	1	0.08	1	1.00
Prairie Falcon	*Falco mexicanus*	1	1	0.08	1	1.00

Table 2-8. Species, Sorted by Abundance, During Breeding Season Roadside Surveys Performed on the Central Hanford Site in 2017. (3 Pages)

Common Name	Scientific Name	Routes[a]	Individuals	% Counts	Stops[b]	% Stops
Ring-necked Pheasant	*Phasianus colchicus*	1	1	0.08	1	1.00
Ferruginous Hawk	*Buteo regalis*	1	1	0.08	1	1.00
Lazuli Bunting	*Passerina amoena*	1	1	0.08	1	1.00
Bald Eagle	*Haliaeetus leucocephalus*	1	1	0.08	1	1.00

[a] Count of how many of the four unique Hanford Roadside routes was species identified (four max)
[b] Number of survey points the species was identified

Table 2-9. Species Richness and Abundance Counted During the 2017 Breeding Season Roadside Bird Survey Routes on the Hanford Site Sorted by Route.

Route Name	Surveys Performed	Species Richness	Abundance
Army Loop Road	1	12	79
Gable Mountain	1	16	180
Horn Rapids to Hanford Townsite	1	15	196
Old Fields	1	36	768
Total	4	44 [a]	1223

[a] Unique species identified

2.7.3.1 Diversity Index. A survey from the breeding season during the most recent 5 years (2012 through 2016) was compiled and the average number of individuals, total number of species seen, and Shannon's Diversity index calculations were calculated (Table 2-10) and compared to the data seen in 2017.

Table 2-10. 2017 Survey Data Compared to the Past Five Year Cumulative Data and Shannon's Diversity Index and Evenness on the Four Hanford Routes (2012-2016).

Route Name	5-year Average	2017 Counts (+/- to Average)	5-Year Ecological Species Diversity[a]	2017 Ecological Species Diversity[a]	5-Year Evenness	2017 Evenness
Army Loop Road	133.6	79 (-54.6)	4.97	5.28	0.498	0.669
Gable Mountain	188.4	180 (-8.4)	7.9	7.14	0.634	0.709
Horn Rapids to Hanford Townsite	245.8	196 (-49.8)	5.7	4.81	0.534	0.580
Old Fields	674	768 (+94)	18.4	11.8	0.706	0.688
Average	310.45	305.75 (-4.7)	9.24	7.26	0.593	0.662
Cumulative	1241.8	1223 (-18.8)	17.1	13.8	0.664	0.694

[a] Shannon's index expressed as N_1

2.7.4 Discussion

For over 25 years the roadside bird survey monitoring program has provided the Hanford Site with valuable avian community data needed for population and habitat evaluation. As designed, the surveys are intended to be an indicator of abundance, species distribution, and potential habitat quality. Performing surveys using BBS methods is an efficient way of collecting species data over large portions of the Hanford Site and provide data that are comparable with the historical data set. All Hanford BBS route data are also displayed on the USGS BBS database for download and viewing.

The species documented and the number of individuals documented was found to be similar to past years and the points most often saw Western Meadowlark and Horned Lark counts. The standout in 2017 was the high number of cliff swallows that were within view and range to be counted as the most abundant species. Species richness on the Old Fields route (36) was the highest of all routes and had nearly four times the amount of individuals as any other route. This is to be expected as there is the largest diversity of habitats along the route including the species-rich areas near the Columbia River. However, when we look at Table 2-10 we see that the diversity index of this route, while still higher than other routes, dropped this year when compared to the last 5 years. One way this can be explained is although a high number of species are seen, many of the sightings are of a single individual or small number of individuals while the more common birds of the route maintain high count numbers including cliff swallows in 2017. All survey routes have a much lower diversity index than species richness number. If the identical number of individuals is counted for all species than the diversity index should be equal to the species richness. This skew is explained by the high number of Western Meadowlarks and Horned Larks that are counted during surveys and the large communities of Cliff Swallows seen on reactor structures along the river. These three species accounted for 56.52% of all individuals. If over half of the individuals counted are limited to just 6.8% of species, we end up with the low diversity index numbers documented in Table 2-10. Over the past 5 years (Table 2-10) the Gable Mountain route had a higher diversity index and higher evenness than Army Loop Road and Horn Rapids to Townsite even though it has a lower species richness. In 2017, it had the second highest species diversity (Table 2-9) and the second highest diversity index (Table 2-10). Much of this route passes through high quality shrub habitat on the north side of Gable Mountain. While the number of species is lower, there are less areas for meadowlark and lark to dominate the survey numbers; species like Loggerhead Shrike and Sagebrush Sparrows are more prevalent leading to more evenness in individuals across species. This data should be taken to understand the value of the remaining high quality habitats on the Hanford Site to the avian community and disturbance avoidance that should be taken to conserve these areas. Additionally, year after year the Old Fields route documents the highest species diversity and diversity index. Many species of birds are able to use and breed in these areas along the river that now have reduced Hanford activities. Consideration for the breeding birds and other avian usage should be done prior to any land use changes for these habitats.

Bird surveys on the Hanford Site should continue to document species diversity, population trending, and other environmental changes in the area. DOE should continue to protect what small portions of the site remains in shrub habitats and continue with quality restoration and revegetation projects across the site to increase the amount of shrub habitat. This data suggests that quality shrub habitats produce a more diverse and even population in the avian communities that inhabit these areas. Measuring effectiveness of habitat conservation, restoration, or mitigation through bird surveys can be an efficient method. During breeding season birds are often vocal and in view as to attract mates. This makes documenting individuals consistent with a high degree of accuracy. This documentation can be used for evaluation of diversity and trends of populations over time as done in this report. The Hanford Site continues to be an excellent reserve for avian species and their continued success.

2.8 TOWNSEND'S GROUND SQUIRREL MONITORING

2.8.1 Introduction

The Townsend's ground squirrel is listed as a State Candidate species by the WDFW (WDFW 2016) and is ranked as a Level 3 resource in the BRMP. The management goal for Level 3 resources is conservation and requires a moderate level of status monitoring.

Ground squirrels are important to the shrub-steppe ecosystem for many reasons. They serve as a food source for mammals (e.g., badgers and coyotes) and fall prey to predatory birds (e.g., hawks, falcons, and owls). Ground squirrels are an important food item for Ferruginous Hawks, a Washington State threatened species, in many portions of their range (Fitzner et al. 1977). The ground squirrel diet consists of a variety of foods including seeds, which contributes to native plant seed dispersal. The burrows that ground squirrels dig help to aerate the soil and provide burrows for other species including Burrowing Owls, which are a federal species of concern (Sato 2012). The decline of ground squirrel populations is in part due to the loss of suitable habitat and isolation of communities through fragmentation, as well as control programs aimed to eradicate ground squirrels through poisoning and shooting that were widely practiced in the past (WDFW 2013).

Ground squirrels are underground for much of the year for hibernation and estivation, making it crucial to monitor during the correct time frame. The ground squirrels' lifecycle consists of several seasonal components. During mid- to late January, ground squirrels emerge from their burrows after hibernation. They spend the next month breeding, followed by gestation and rearing of young. The young become active outside the burrow by mid-April. Ground squirrels become dormant again starting in late May to late June, entering a type of torpor called estivation that is used to avoid the hot and dry portion of the year (WDFW 2013). After estivation, ground squirrels emerge and spend late September and October foraging in preparation for hibernation.

The crucial window to observe and monitor ground squirrels begins in late January after hibernation and ends in late May when estivation begins. These months are the longest active period for ground squirrels and thus are the best time for monitoring. Ground squirrels breed and rear young during this time; age determination is easier because the juveniles are significantly smaller than the adults. Protective maternal alarm calls are also used at this time, maximizing the likelihood of detecting occupied colonies.

2.8.2 Ground Squirrels on the Hanford Site

The range of Townsend's ground squirrels are limited to the Columbia Basin of Washington State where they are found west of the Columbia River. Two subspecies of Townsend's ground squirrels are known to occur: *U. townsendii nancyae* and *U. townsendii townsendii*. *U. townsendii nancyae* is found north and east of the Yakima River, which includes the Hanford Site, and *U. townsendii townsendii* occurs south and west of the Yakima River (Yensen and Sherman 2003). Using the WDFW's Washington Gap Analysis Program, Figure 2-28 shows that the Hanford Site falls within the predicted distribution area of the Townsend's ground squirrel. Ground squirrels on the Hanford Site are known to consume mostly Sandberg's bluegrass (*Poa secunda*) followed by a variety of forbs, (e.g., western tansymustard [*Descurainia pinnata*], lupine [*Lupinus* spp.], and long-leaf phlox [*Phlox longifolia*]) (Rogers and Gano 1980).

Prior to 2012, six Townsend's ground squirrel colonies were documented on the Hanford Site. During 2012 and 2013, MSA surveyed 45 diamond transects totaling 173 km (108 mi) (covering 1,038 ha [2,565 ac]) and documented the status of the previously known colonies (HNF-53075; HNF-56374). No new colonies were detected during the transect surveys; one of the six colonies documented prior to 2012 (300 Area colony) was found to still be occupied. An additional seven previously undocumented colonies were identified during surveys focused on areas where ground squirrels were incidentally encountered during compliance reviews and other surveys. The historically active colony and the seven newly found active colonies were re-surveyed in 2015. In 2015, the 300 Area colony and four others were observed to be active. Locations of all known Townsend's ground squirrel colonies (active and inactive) on the DOE-managed portion of the Hanford Site are shown in Figure 2-29.

2.8.3 Habitat Suitability Modeling of Townsend's Ground Squirrels

In 2015, a habitat suitability model for Townsend's ground squirrels was developed for the Hanford Site. The model was based on a habitat connectivity study conducted by the Washington Wildlife Habitat Connectivity Working Group (WHCWG). The Washington WHCWG is a partnership composed of federal and state agencies, Tribes, and universities co-led by the WDFW and Washington State Department of Transportation. Townsend's ground squirrels within the Columbia Plateau Ecoregion were chosen as a focal species in the Washington WHCWG Connected Landscapes Project analysis (WHCWG 2012). The habitat connectivity study consisted of analyzing distribution, habitat associations, and sensitivity to several anthropogenic factors together in a GIS. The study modeled habitat concentration areas, habitat resistance, cost-weighted distance, and connectivity linkages. The data used to develop the model were regional, state, and national datasets. The output of the model is a valuable tool for assessing connectivity of the Hanford Site with surrounding habitats; however, a finer scale model using Hanford Site-specific data layers was needed to provide more meaningful data on a sitewide scale.

GIS raster data layers were developed for the Hanford Site-specific Townsend's ground squirrel habitat suitability model by using vegetation and soil characterizations at ground squirrel colonies occupied on the Hanford Site in 2015, as well as information derived from a literature review. Habitat suitability models assess the quality of habitat for a species within a study area based on known and assumed habitat associations for several different factors. For this model, the factors considered were soil, land cover, slope, and distance to roads; railroads; and power transmission lines. Classifications of each factor were ranked and assigned a suitability value from 0.00 (unsuitable habitat) to 1.00 (optimal habitat). The rankings were based primarily on the model developed for the Washington Connected Landscapes Project's analysis for the Columbia Plateau Ecoregion (WHCWG 2012), with the exception of soil and land cover. The Hanford Site data layers for these factors are of a much finer resolution and contain many more classifications; therefore, these factors were ranked using a literature review and the results of the soil and vegetation characterization performed at each of the occupied sites. ArcGIS software was used to combine raster layers for each factor and produce a final suitability map resulting in a suitability score for each pixel. All raster layers used or developed were 5- by 5-m (16.4- by 16.4-ft) resolution. The extent of the model encompasses the central Hanford Site and ALE Reserve to assess connectivity with the surrounding areas. Rankings for each factor are described in the following sections.

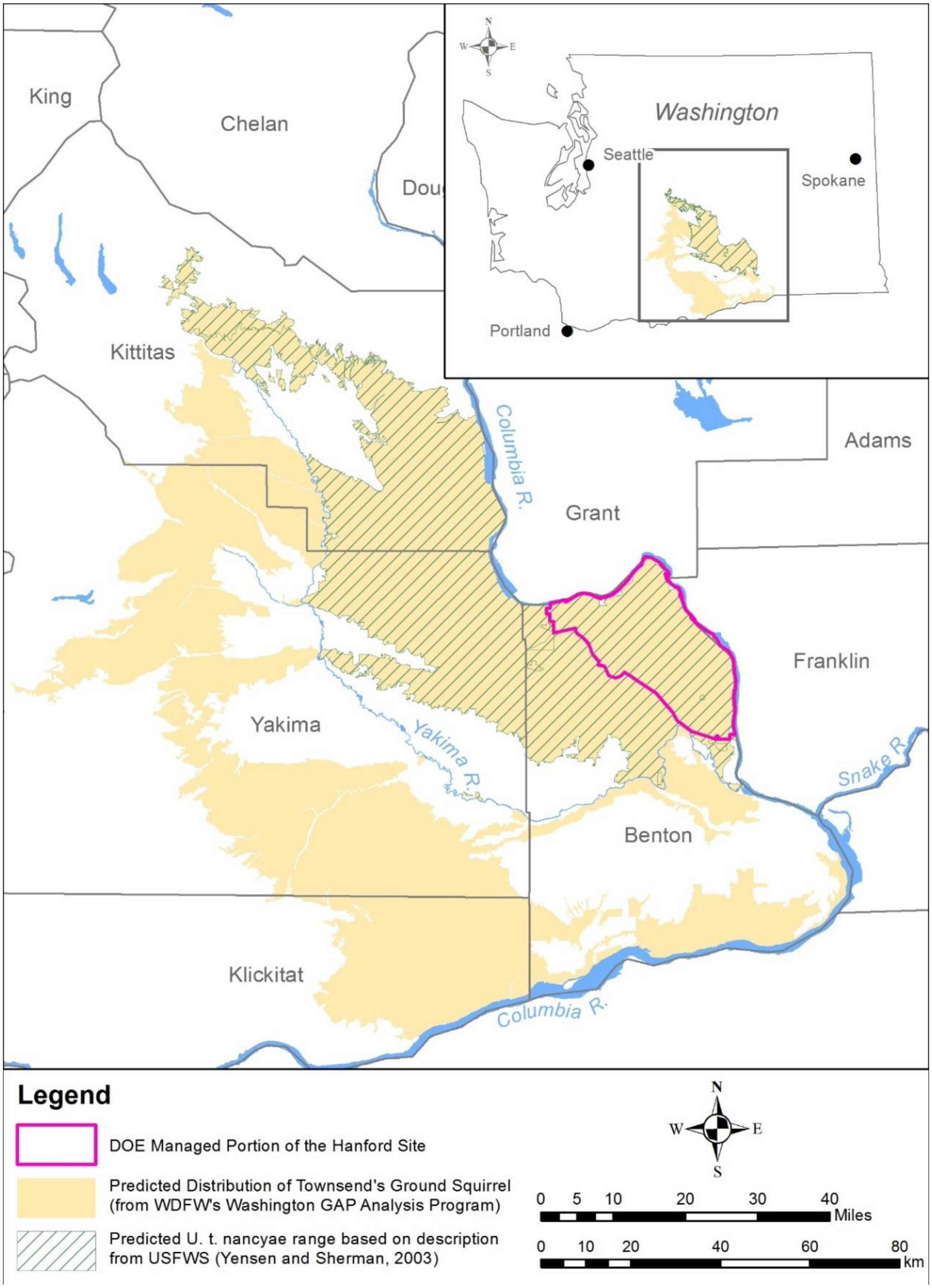


Figure 2-28. Predicted Townsend's Ground Squirrel Distribution with Overlay of the Subspecies *U. Townsendii Nancyae*'s Predicted Range in Relation to the DOE-Managed Portion of the Hanford Site

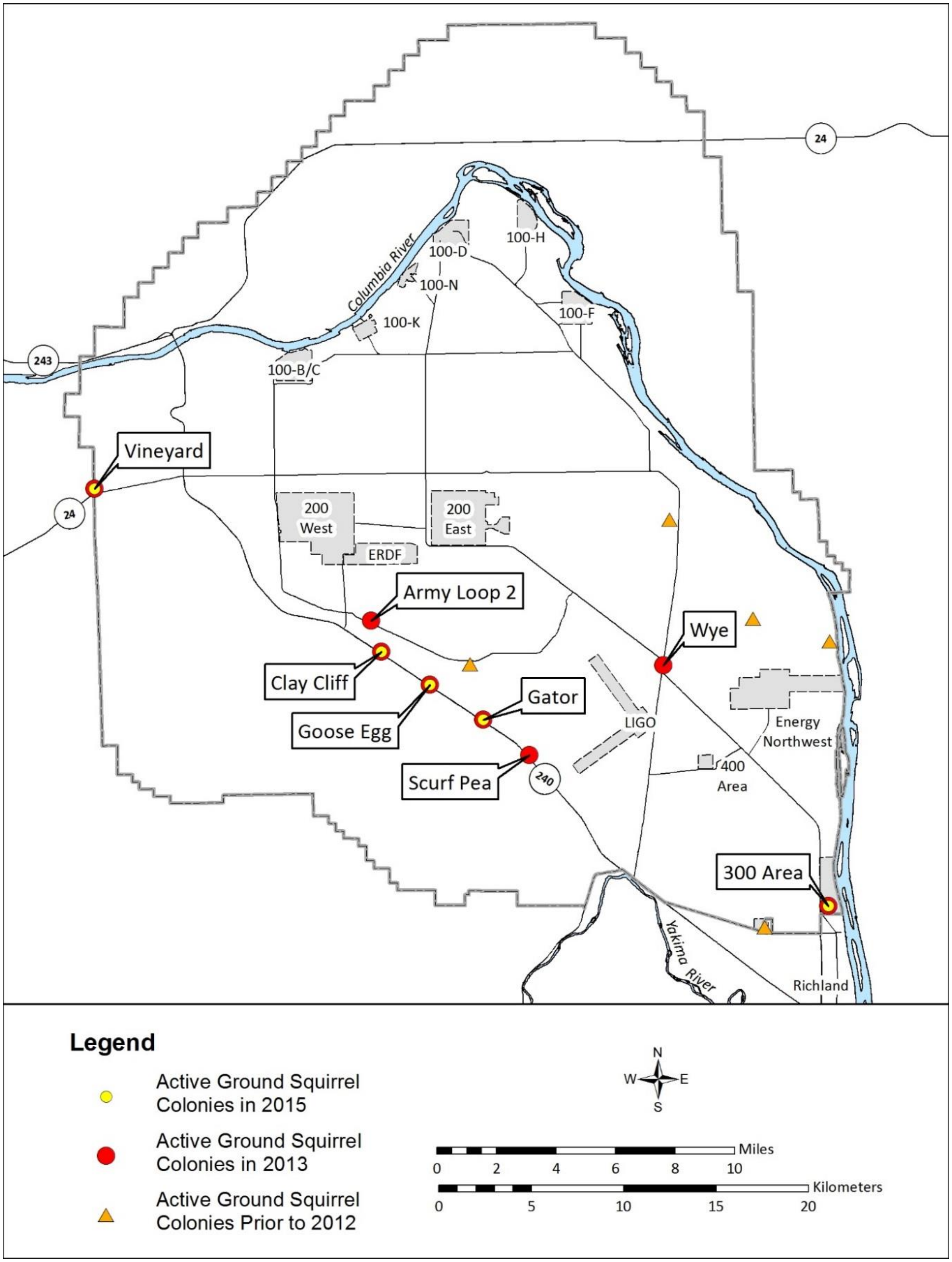


Figure 2-29. Locations of all Known Townsend's Ground Squirrel Colonies (active and inactive) on the DOE-Managed Portion of the Hanford Site

2.8.3.1 Soil Type. Ground squirrels require soils that are easily excavated yet provide stability for their burrow networks. Soil texture strongly influences the ability of a burrow to remain stable, as well as the nutrient-holding ability of a soil, the amount of water the soil can store, the amount of this water that is available to plants, how fast water moves through the soil, and many other properties. Soil depth is also important for ground squirrels as deeper burrow networks can provide insulation from extreme temperatures. Regional studies have shown that ground squirrels may select sites based on soil characteristics more than other variables and have a preference for deep silt loam soils (Greene 1999). The soil types found on the Hanford Site were ranked for both texture and depth class, and assigned a habitat value rating as shown in Table 2-11.

Table 2-11. Soil Type Ranking.

Soil Name	Habitat Value
Riverwash	0.00
Burbank loamy sand	0.60
Quincy sand	0.60
Ephrata sandy loam	0.80
Ephrata stoney loam	0.80
Pasco silt loam	1.00
Kiona silt loam	0.70
Warden silt loam	1.00
Ritzville silt loam	1.00
Esquatzel silt loam	1.00
Hezel sand	0.60
Dunesand	0.00
Koehler sand	0.30
Scooteney stoney silt loam	0.60
Lickskillet silt loam	0.30

2.8.3.2 Land Cover/Vegetation. Townsend's ground squirrels consume green vegetation during their active period from early winter into late spring, then shift their focus to the seeds of grasses and forbs to prepare for estivation (Yensen et al. 1992). A study on the diets of Townsend's ground squirrels on the ALE Reserve showed that their intake was primarily Sandberg's bluegrass followed by a variety of forbs (western tansymustard, lupine, and long-leaf phlox) (Rogers and Gano 1980). In areas where fire destroyed the native shrub and bunchgrasses, cheatgrass (Bromus tectorum) can be an important food source; however, wild fluctuations in productivity due to year-to-year changes in precipitation can cause populations in these areas to be much less stable (Yensen et al. 1992). While shrubs could potentially offer cover and some level of burrow stability, ground squirrels can detect predators at a greater distance in areas with little-to-no shrub canopy; it is believed that line-of-sight availability prevails in site selection (Sharpe and Van Horne 1998). The rankings of habitat value for the vegetation classifications on the Hanford Site are listed in Table 2-12.

Table 2-12. Land Cover/Vegetation Type Ranking.

Vegetation Class	Habitat Value
Native bunchgrasses	1.00
Native bunchgrasses/Cheatgrass	1.00
Sparse and/or Half- shrub/Native bunchgrasses	0.70
Sparse and/or Half- Shrub/Native bunchgrasses/Cheatgrass	0.70
Dense shrub/Native Bunchgrasses	0.50
Dense shrub/Native bunchgrasses/Cheatgrass	0.50
Non-vegetated sand - bluffs - talus	0.00
Gravel/Industrial/Non-vegetated/Agricultural/Exotic weed	0.00

2.8.3.3 Slope. The rankings for slope were based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion (Sato 2012) and are listed in Table 2-13.

Table 2-13. Slope Ranking.

Slope (degrees)	**Habitat Value**
0 to 20	1.00
20 to 40	0.70
Greater than 40	0.00

2.8.3.4 Roads and Traffic. The ranking of the roads was based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion (Sato 2012; Table 2-14). All known ground squirrel colonies on the Hanford Site are found adjacent to main roads. While it is obvious that detection of colonies near main roads is much more likely, it is also believed that the proximity to human activity provides some level of protection for the ground squirrel from predators such as badgers and raptors.

Table 2-14. Road Ranking.

Roads	**Buffer Distance (m)**	**Habitat Value**
Highway centerline	0–5	0.00
Highway inner	5–500	1.00
Highway outer	> 500	1.00
Local roads centerline	0–5	0.00
Local roads inner	5–500	1.00
Local roads outer	> 500	1.00

2.8.3.5 Railroads. The ranking of the railroads layer was based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion

(Sato 2012; Table 2-15). All railroads on the Hanford Site are now inactive and ground squirrels could potentially use these rights-of-way as corridors for movement.

Table 2-15. Railroad Ranking.

Railroads (inactive)	Buffer Distance (m)	Habitat Value
Railroad centerline	0–5	0.00
Railroad inner	5–500	1.00
Railroad outer	> 500	1.00

2.8.3.6 Transmission Lines. The ranking of the transmission lines layer was based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion (Sato 2012; Table 2-16); however, with the minimal availability of natural structures in the study area, it is assumed that the availability for raptors to perch and nest on the towers has a stronger negative influence on ground squirrels than suggested. Therefore, rankings were downgraded for the regions closer to the transmission lines for the Hanford Site model.

Table 2-16. Transmission Line Ranking.

Transmission Lines	Buffer Distance (m)	Habitat Value
One line inner	0–200	0.30
One line middle	200–500	0.60
One line outer	> 500	1.00
Two or more lines inner	0–200	0.30
Two or more lines middle	200–500	0.60
Two or more lines outer	> 500	1.00

2.8.3.7 Factor Weights. Each of the six factors was assigned a weight that reflects the assumed relative influence each have on the distribution of Townsend's ground squirrels in this region (Table 2-17). Weights were chosen using literature review and expert opinion.

Table 2-17. Factor Weights.

Factor	Weight (%)
Soil type	30
Land cover/Vegetation type	20
Slope	20
Transmission lines	15
Roads and traffic	7.5
Railroads	7.5

Thus, the habitat suitability score for each pixel in the model was based on the following equation:

Habitat Suitability Score =(0.30 x Soil Type Value) + (0.20 x Land Cover/Vegetation Type Value) + (0.20 x Slope Value) + (0.15 x Transmission Line Value) + (0.075 x Roads Value)+ (0.075 x Railroads Value)

2.8.3.8 Model Output. Suitable habitat areas for the Townsend's ground squirrel were modeled using habitat values of greater than or equal to 0.85, 0.90, and 0.95 (Figure 2-30). We consider the model output with areas having a habitat suitability score of greater than or equal to 0.90 as the best representation of ground squirrel habitat present on site. The map showing a habitat suitability score of greater than or equal to 0.90 has 90 polygons within the DOE-managed portion of the Hanford Site, mostly found near Highway 240 adjacent to the ALE Reserve, as well as some areas in the northern portion of the site, and ranges from less than 1 to 1,858 ha (2.47 to to 4,591 ac). Four out of the five currently occupied sites also fall within these areas. Mean size was 90.8 ha (224.4 ac) and the total area for all 90 polygons was 8,175 ha (20,201 ac) (10% of the total area of the Central Hanford Site).

2.8.4 Objectives

The two objectives of the 2017 ground squirrel monitoring effort was to assess the status and size of the 2015 active ground squirrel colonies and apply the Hanford Site Townsend's ground squirrel habitat suitability model to locate new colonies. Systematic searches for new colonies within the areas of high habitat suitability (greater than or equal to 0.90) were performed.

2.8.5 Methods

2.8.5.1 Status and Size of the 2017 Active Townsend's Ground Squirrel Colonies. Surveyors used a GPS to navigate to the previously identified Townsend's ground squirrel colony locations. Active ground squirrel burrows were identified as holes approximately 7 cm (2.8 in.) in diameter, absent of vegetation covering the entrances, lacking spider webs at the opening, and with tracks and/or signs of herbivore foraging near the opening. Surveyors also documented visible individuals and audible alarm calls. Each colony was determined to be inactive or active based on these criteria. Any burrows identified outside of the previously defined polygons that were generated by connecting the coordinates of the outermost burrows in the colony were flagged and the polygons extended to include those new burrows.

2.8.5.2 Application of Habitat Suitability Model. The model was used to search for previously unknown populations of ground squirrels. A habitat suitability score of greater than or equal to 0.90 was selected as the best representation of ground squirrel habitat present on site. The model produced 90 polygons with habitat suitability scores of greater than or equal to 0.90. All polygons larger than 40 ha (98.8 ac) with a habitat suitability score of greater than or equal to 0.90 (Figure 2-31) were elected to be surveyed. These polygons were superimposed by a grid with a 20-ha (49.4-ac) cell size. In order to adequately search each polygon, the centroid of every 20-ha (49.4-ac) cell that fell within that polygon was calculated and transects were mapped to pass through each centroid. Examples of these transects are provided in Figure 2-32. Due to time constrains, polygons with a habitat suitability score of greater than or equal to 0.95 were made priority areas. Polygons that were not searched in 2017 can be searched in future years.

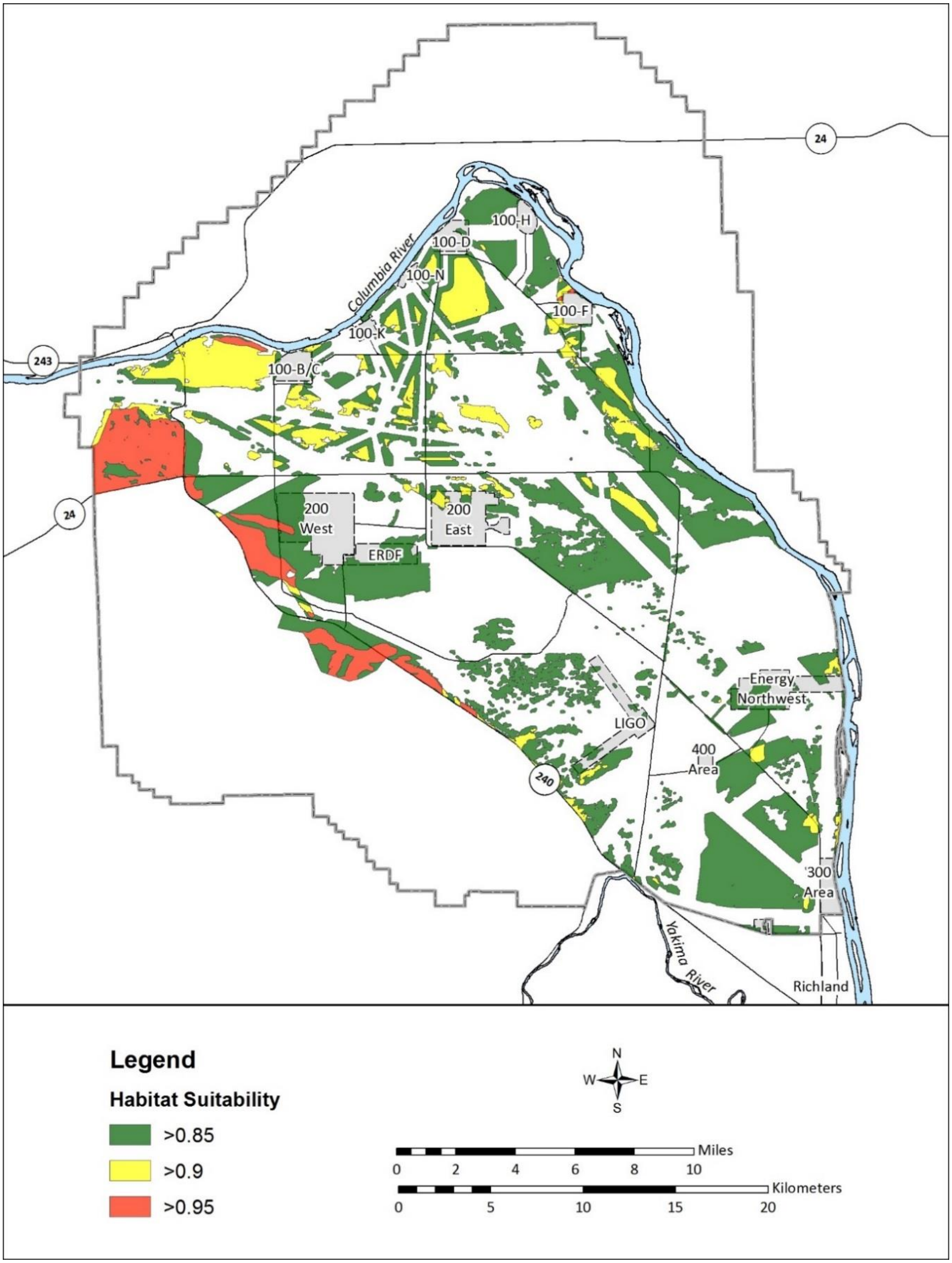


Figure 2-30. Habitat Suitability Map of the DOE-Managed Portion of the Hanford Site and ALE Reserve with a Habitat Suitability Scores of 0.85 and Greater

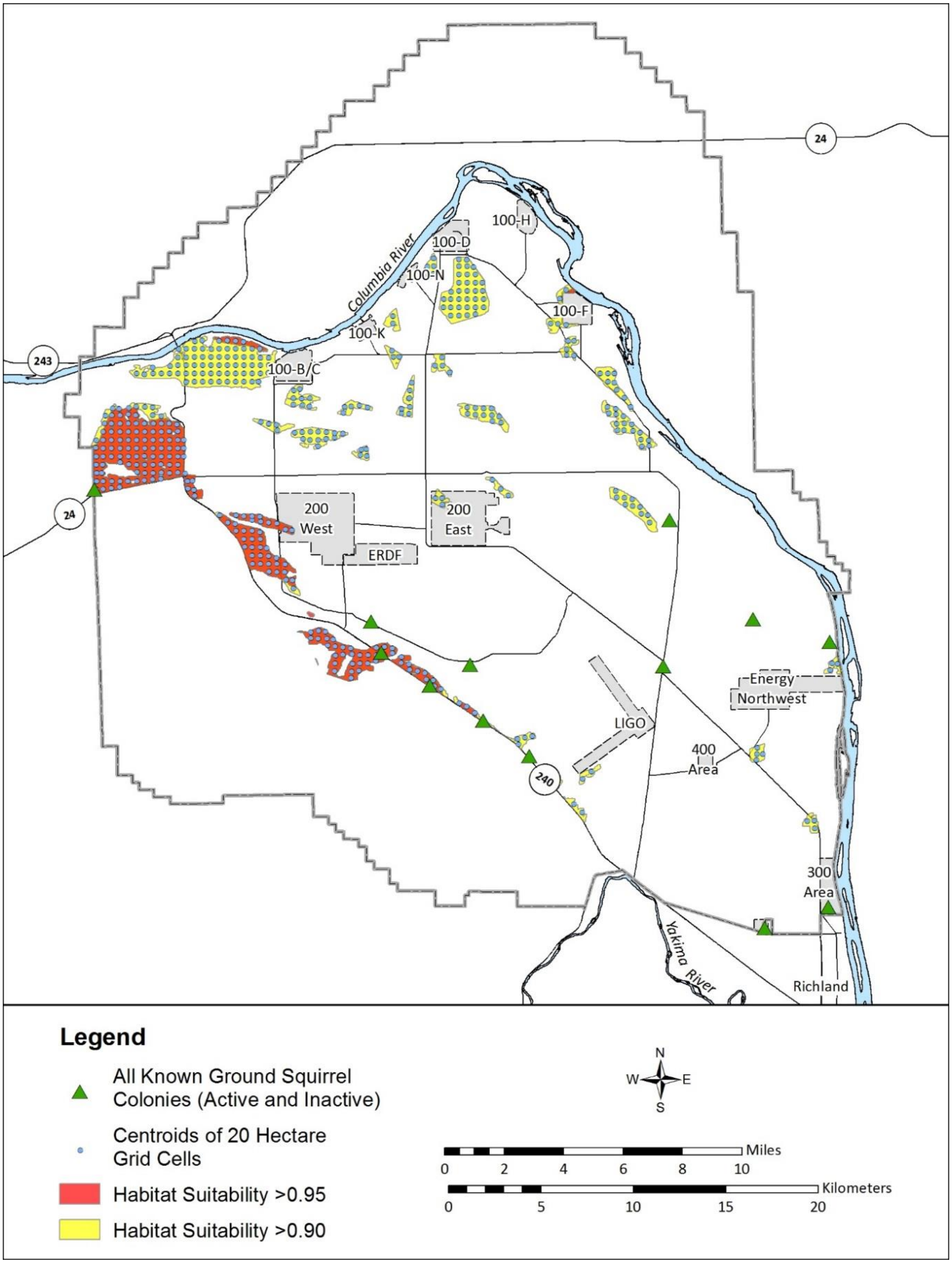


Figure 2-31. All Polygons Larger than 40 ha (98.8 ac) with Habitat Suitability Scores of Greater than or Equal to 0.90 that will be Searched for Ground Squirrel Colonies

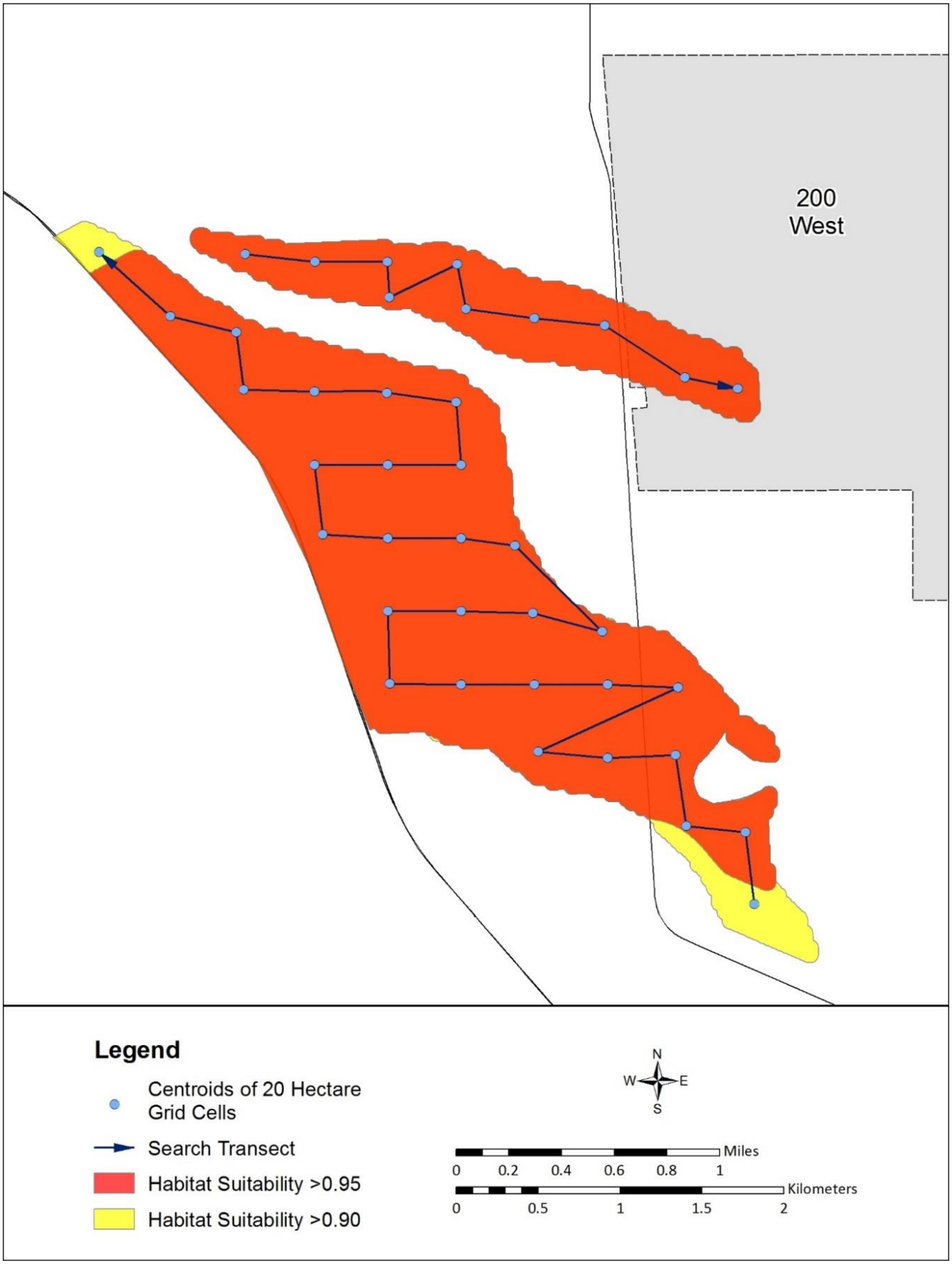


Figure 2-32. Examples of Ground Squirrel Search Transects Passing Through Each of the Centroids of Each of the 20-ha (49.4-ac) Grid Cells

The transects were completed by two surveyors with each surveyor covering a 30-m (98-ft)-wide swath, for a total of 60-m (197-ft) wide along the length of the transects. One surveyor carried the GPS while the second surveyor paralleled, keeping a 30-m (98-ft) distance. Surveyors searched for active ground squirrel burrows along each transect. When burrows were found they were flagged and the surrounding area out to 60 m (197 ft) was surveyed. Using this method, the outermost burrows were identified and the extent of the colony was to be captured as a polygon with the GPS.

2.8.6 Results

2.8.6.1 Status of 2017 Ground Squirrel Colonies. The five Townsend's ground squirrel colonies that were known to be active in 2015 were resurveyed on April 4, 2017. These colonies surveyed included the Vineyard, Clay Cliff, Goose Egg, Gator, and 300 Area. Of these five colonies, Vineyard, Gator, and Goose Egg were found to be active. The perimeter of colony holes were mapped and compared to the size recorded in 2015. The Vineyard colony slightly increased in size from 0.5 to 0.6 ha (1.24 to 1.5 ac). This colony is actually larger than the recorded measurements due to extending off of the Hanford Site onto adjacent land. The Gator colony decreased from 5.1 to 1.8 ha (12.6 to 4.45 ac); one ground squirrel was observed crossing Route 240 and entering a colony burrow. The size of the Goose Egg colony remained unchanged from 2015. The other two colonies appeared to be inactive with no ground squirrels or evidence of activity observed. Colony activity for each survey year conducted (2012, 2013, 2015, and 2017) is referenced below in Figure 2-33.

2.8.6.2 Habitat Suitability Transects. Ten Townsend's ground squirrel survey transects were completed between April 5 and May 1, 2017. Transects varied in length ranging from 1.8 to 13.3 km (1.1 to 8.3 mi) (Figure 2-34). Five transects were located along Route 240, four in the McGee Ranch/Umtanum Ridge area and one near the 100-B/C Reactors. Longer transects were completed in multiple days, while multiple shorter ones were completed in 1 day. While much of the area surveyed proved to be quality ground squirrel habitat, there were no new colonies, individual holes, or ground squirrels observed.

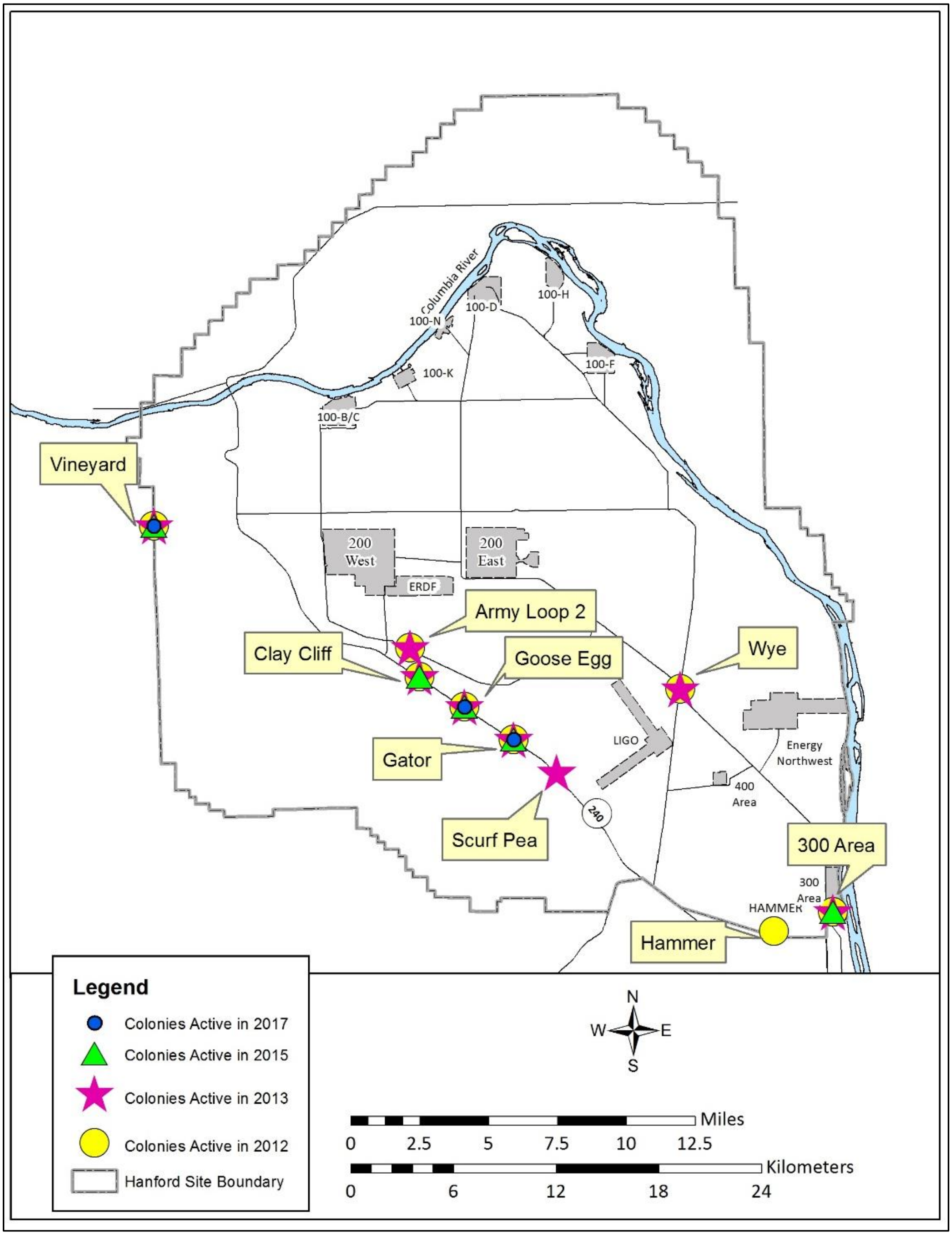


Figure 2-33. Locations of all Known Townsend's Ground Squirrel Colonies on the DOE-Managed Portion of the Hanford Site Active during each Survey Year.

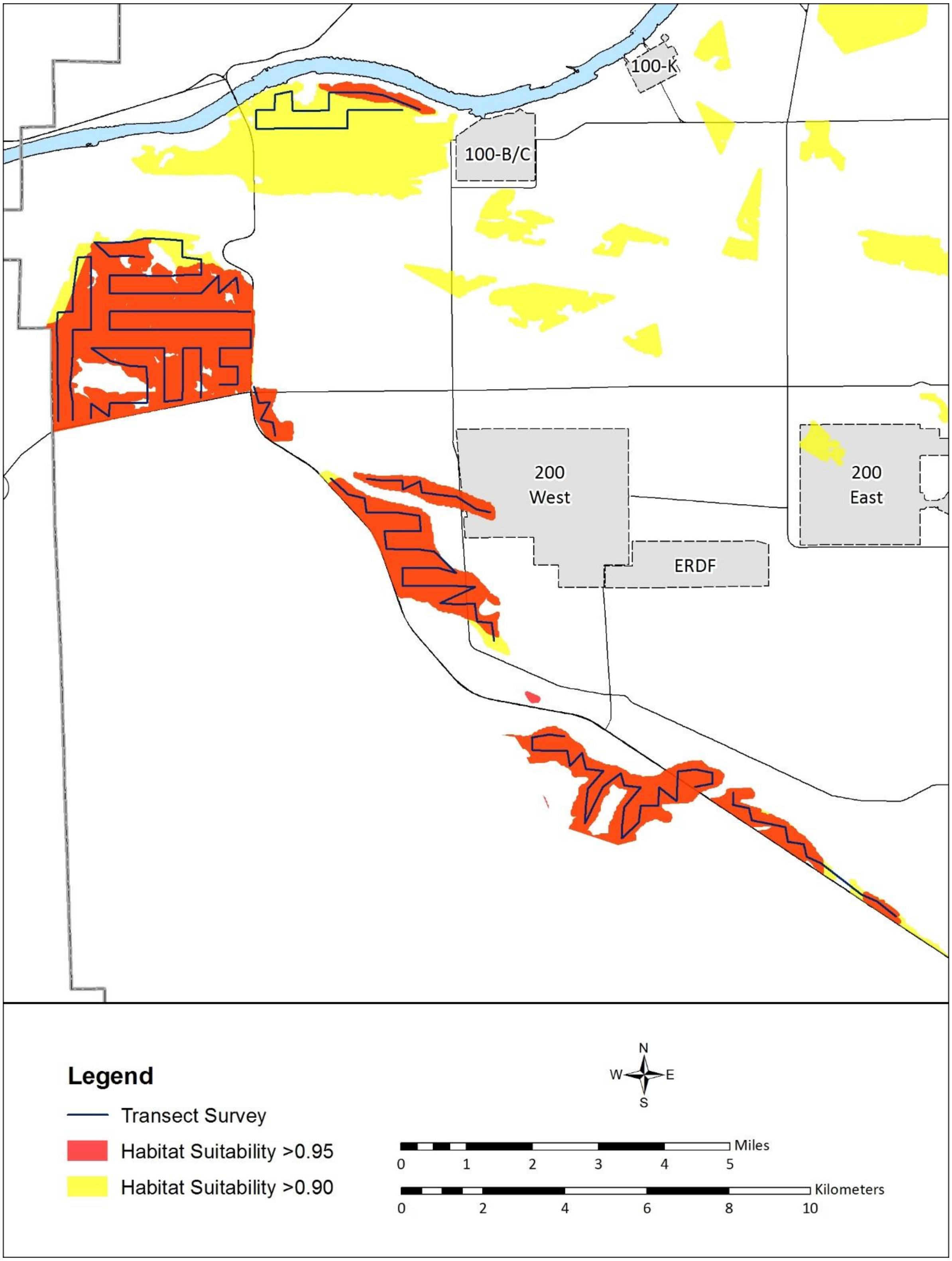


Figure 2-34. Transects Surveyed for Townsend's Ground Squirrel Colonies on the DOE-Managed Portion of the Hanford Site

2.8.7 Conclusion

Townsend's ground squirrel numbers continue to decline on the Hanford Site. There are a few probable reasons for this occurrence including the high number of resident raptors, presence of coyotes and badgers, and climate change. The Hanford Site has a dense population of raptors; the populations are bolstered by the prevalence of artificial nesting structures (e.g., transmission towers, planted trees) on which 90% of the raptor nests were found in 2016 (HNF-60469). It has been proposed that the high density of raptors on the Hanford Site may be negatively impacting prey species, including Townsend's ground squirrels (HNF-58717). In a study of the diet of raptors on the Hanford Site, the *Buteos* (including the Ferruginous Hawks, Red-tailed Hawks [*Buteo jamaicensis*], and Swainson's Hawks [*Buteo swainsoni*]) were the primary predators of Townsend's ground squirrels (PNL-3212).

The model presented in this section is based on the habitat associations of the previously occupied sites for Townsend's ground squirrels on the Hanford Site, a literature review of several regional studies of ground squirrels, and an existing model of the Townsend's ground squirrel for the Columbia Plateau Ecoregion (WHCWG 2012). Habitat suitability models are inherently limited by the quality and type of datasets available for the study area, the over-or-under-estimation of the importance of the variables used in the model, and the omission of important habitat associations that are not accounted for. Therefore, this model is a prediction of species-habitat relationships that can be used to identify potential impacts on Townsend's ground squirrel habitat and management actions that may mitigate losses in habitat quality and/or quantity. All three active ground squirrel colonies were located within the region designated by a habitat suitability score of greater than or equal to 0.90. Human activity was not accounted for in this model and, in retrospect, likely provides protection by deterring predators such as hawks, badgers, and coyotes. While modifications to the model could be made to capture this variable, the likelihood of detection – and thus the protection of colonies in habitats in close proximity to human activity on the Hanford Site – is very high. Roads and traffic may have a similar protective factor that is not necessarily accounted for in the model. Not enough data exist to place a higher value to areas near roadways; however, all currently active colonies do occur adjacent to major roads or high traffic areas.

As seen in Figure 2-35, there has been a drop in known active colonies. Although there appears to be a bell-shaped increase and decrease over the last 5 years, it must be taken into account that thorough surveys had not been conducted until until 2012. Because each previously known colony that was found to be active the prior monitoring year was resurveyed, along with vast new territory, it can be established that new colonies are not developing while active ones are dying off.

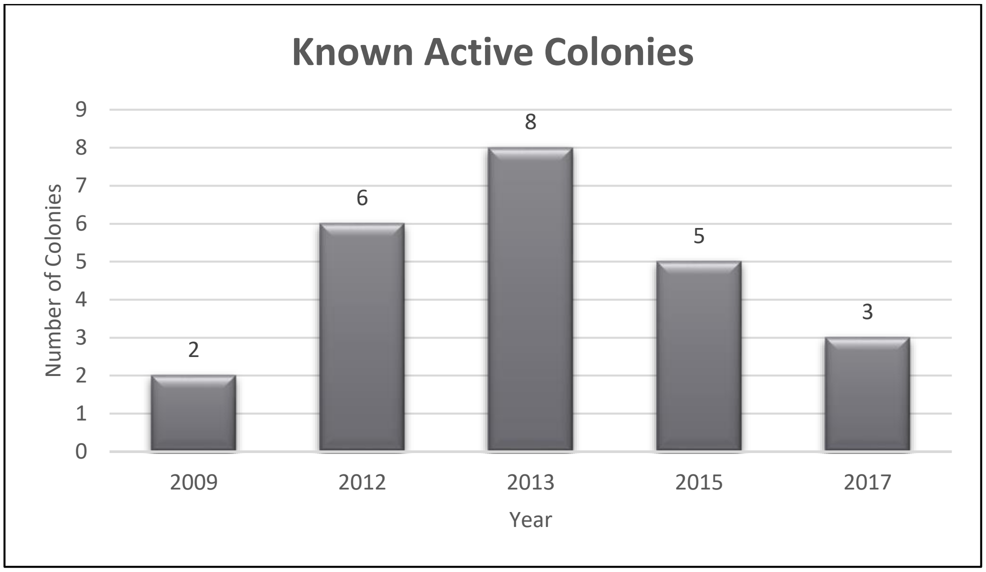


Figure 2-35. Known Active Colonies by Year

It is highly recommended that conservation efforts be put into place to ensure the future of the Townsend's ground squirrel on the Hanford Site. Reintroduction of ground squirrels with the cooperation of state and federal agencies is the suggested route to reinstate a viable population. Currently, the decline in population numbers may have plagued chances of a natural comeback, strongly relying now on the aid of conservation efforts and translocation from surrounding communities.

2.9 HANFORD SITE BAT MONITORING

Several species of bats have been documented on the Hanford Site with nine species identified during The Nature Conservancy (TNC) surveys in 1997 and 1998 and an additional eight species listed as potentially present (Soll et al. 1999). The survey conducted by MSA during the summer of 2012 also documented nine species (HNF-53759). Roosting concentrations of big-brown bats (*Eptesicus fuscus*), pallid bats (*Antrozous pallidus*), and all roosts for bats in the genus *Myotis* are considered Priority Habitats by the WDFW (WDFW 2013). Roosting congregations can be maternity colonies, winter roosts, or night roosts. Males typically day-roost alone or in small groups and do not have the same strict roosting habitat requirements as maternity colonies. Maternity colonies are specialized locations where groups of female bats roost together to give birth and raise their young. Individuals show strong fidelity to these roosting locations; the same roosts are used year-after-year. These locations are selected for proximity to food and water resources, as well as appropriate temperature, humidity, and light conditions. The bats congregate to share body heat in order to conserve energy. These maternity locations are vital to successful reproduction. Night roosts are located close to feeding areas and are used by bats for resting and digestion between feeding bouts. Bats are known to habitually use night roosts from night-to-night and from year-to-year (Ormsbee et al. 2007). Although some species that occur on the Hanford Site are migratory (silver-haired bat, hoary bat), most bats remain in the region during the winter. Due to cold temperatures and lack of available food (insects), bats must hibernate in winter roosts to survive. Winter roosts are selected for cold and constant temperatures so bats can down-regulate their body temperature, slowing their metabolism and conserving energy to survive through the winter. Bats select all communal roost types for very specific conditions that may not be otherwise available in the same areas.

Monitoring and protection of roosting locations is becoming increasingly important with the outbreak of the fungal infection referred to as WNS. White-nose syndrome is affecting bats in the eastern United States and Canada and is rapidly expanding westward. Bats save energy during the winter by reducing their body temperature and entering a state of hibernation called torpor. They break these torpor bouts by warming their body temperature back up at regular intervals through the winter; these events are termed arousals. Bats are thought to use these arousals for depuration, defecation, grooming, breeding, and possibly drinking. Although these arousals represent a relatively small portion of the time the bats spend winter roosting, a large amount (up to 80%) of their energy stores for the season are burned during arousals (Thomas et al. 1990). Bats are thought to increase the number of arousals due to WNS, likely for additional grooming. Although other factors may be contributing, the excessive arousals cause bats to exhaust their energy stores prior to the end of the winter, resulting in starvation. This disease spreads quickly through roosting colonies and causes fatality rates up to 100% at infected winter roosts (more information available at whitenosesyndrome.org). The expansion of this disease occurred westward in 2016 when a little brown myotis (*Myotis lucifigus*) was found in Western Washington. With the disease now present in the state, it is extremely important to monitor and characterize roosts to provide a baseline in case the disease reaches this area. Bat researchers must follow strict WNS protocols established by the FWS and other agencies when working with bats (WNS 2016).

2.9.1 Objectives and Scope

The WDFW began monitoring winter roosts or known summer roosts early in the spring as part of a statewide effort for tracking WNS in Washington State. The Hanford Site was contacted by WDFW to request access and assistance in the collection of bats on site to test for the WNS. During planning for this scope, it was determined that early collection of the Yuma myotis (*Myotis yumanenis*) from the 183-F clearwell or the 183-D clearwell would yield highest capture potential. The Hanford Site maternity roost in the 183-F clearwell is believed to be the largest known *Myotis yumanensis* in Washington State. During June 2016, a count of bats emerging from the roost documented between 3,300 and 3,600 using the 183-F clearwell. The clearwell had seen a population estimate as high as 6,600 in July 2012. Population counts have been performed five times on the 183-F clearwell since 2009 (2009, 2011 twice, 2012, 2016). While 2012 saw record numbers, the average population from those five counts is 4,111 bats and a median of 3,777 bats.

2.9.2 Methods and Results

Mist netting activities took place on April 26, 2017, with the support of Hanford Site biologists and radiological control technicians, as well as WDFW biologists. Two single high-mist nests (9 m [30 ft] and 12 m [40 ft]) were located immediately south of the 183-F clearwell entrance with a triple high 12-m (40-ft) net located to the east end of the clearwell (Figure 2-36) Following sundown, a total of 37 bats were captured in the mist nets as they emerged from the structure.

Figure 2-36. Location of Mist Nets around 183F Clearwell

Seven bats were immediately released from the net, 30 were bagged for additional measurements (Table 2-18). All 30 bats were surveyed both for radiological contamination and ultra violet (UV) for detection of *Pseudogymnoascus destructans* (*Pd*), the fungus that causes WNS. All bats returned negative for both contamination and UV detection of any fungus. All bats appeared healthy and of normal expected weight, only 2 of 30 bats had any signs of wing damage.

Table 2-18. Data from the WDFW Bat Capture Data Form. (2 Pages)

Bat No.	Time (24hr)	Net No.	Species	FA (mm)	Tragus Shape (P/B)[a]	Keeled Calcar (Y/N)	Sex (F/M)	Age (A/SA)[b]	WDI (0-3, P)	Weight (g)	UV (-, +)	NWHC Sample #
1	2042	1	MYYU	32	P	N	F	A	0	5.5	-	366
2	2042	1	MYYU	35	P	N	F	A	0	5	-	364
3	2042	1	MYYU	35	P	N	F	A	0	5	-	369
4	2042	2	MYYU	34	P	N	F	A	0	4.5	-	354
5	2042	2	MYYU	35	P	N	F	A	0	4.5	-	368
6	2042	3	MYYU	31.5	P	N	F	A	0	4.5	-	351
7	2042	3	MYYU	34	P	N	F	A	0	4.5	-	354
8	2055	2	MYYU	3	P	N	F	A	1	4.5	-	357
9	2055	2	MYYU	31	P	N	F	A	0	5	-	N/A
10	2055	2	MYYU	31	P	N	F	A	0	6	-	356
11	2055	1	MYYU	36	P	N	F	A	0	6	-	363
12	2057	1	MYYU	35	P	N	F	A	0	4.5	-	N/A
13	2057	1	MYYU	35	P	N	F	A	0	6	-	348
14	2057	1	MYYU	32	P	N	F	A	0	5.5	-	353
15	2057	1	MYYU	31	P	N	F	A	0	6	-	N/A
16	2057	1	MYYU	36	P	N	F	A	0	5.5	-	347
17	2057	1	MYYU	36.5	P	N	F	A	0	6.5	-	N/A
18	2057	1	MYYU	31	P	N	F	A	0	6	-	360
19	2057	1	MYYU	31	P	N	F	A	0	4.75	-	365
20	2057	1	MYYU	33	P	N	F	A	0	6	-	350
21	2100	1	MYYU	35	P	N	F	A	0	6	-	370
22	2100	1	MYYU	35	P	N	F	A	1	5	-	359
23	2100	1	MYYU	35	P	N	F	A	0	5	-	358
24	2100	1	MYYU	34	P	N	F	A	0	4.5	-	N/A

Table 2-18. Data from the WDFW Bat Capture Data Form. (2 Pages)

Bat No.	Time (24hr)	Net No.	Species	FA (mm)	Tragus Shape (P/B)[a]	Keeled Calcar (Y/N)	Sex (F/M)	Age (A/SA)[b]	WDI (0-3, P)	Weight (g)	UV (-, +)	NWHC Sample #
25	2100	1	MYYU	35	P	N	F	A	0	5	-	352
26	2100	1	MYYU	31	P	N	F	A	0	5	-	346
27	2100	1	MYYU	36	P	N	F	A	0	5	-	349
28	2100	1	MYYU	33	P	N	F	A	0	6	-	362
29	2100	1	MYYU	36	P	N	F	A	0	4.5	-	361
30	2100	1	MYYU	35	P	N	F	A	0	4.5	-	355
31	2100	1	MYYU	32	P	N	F	A	0	6	-	367
32	2100	1	MYYU	N/A	P	N	F	A	N/A	N/A	N/A	N/A
33	2100	1	MYYU	N/A	P	N	F	A	N/A	N/A	N/A	N/A
34	2100	1	MYYU	N/A	P	N	F	A	N/A	N/A	N/A	N/A
35	2100	1	MYYU	N/A	P	N	F	A	N/A	N/A	N/A	N/A
36	2100	1	MYYU	N/A	P	N	F	A	N/A	N/A	N/A	N/A
37	2100	1	MYYU	N/A	P	N	F	A	N/A	N/A	N/A	N/A

[a] P and B stand for Point and Blunt
[b] A and S stand for Adult and Subadult
FA = length of forearm including wrist
N/A = not available
NWHC = National Wildlife Health Center
MYYU = Yuma myotis (*Myotis ymanensis*)
WDI = wing damage index
UV = ultraviolet

Both bats that had slight wind damage (Wing Damage Index of 1) were due to a few minor pin-sized holes or tears seen in the wing. Of the 30 bats, 25 had both muzzle (nose) and wing swabs; these swabs were sent to the USGS National Wildlife Health Center for analysis for the *Pd* fungus that causes the WNS (Figure 2-37). No physical signs of WNS were present on any of the bats collected and all bats were determined to be females and appeared healthy. Concluding measuring and swabbing, all bats were released back to the environment in good health. With the success of netting at this single location, no additional netting was required of the 183-D clearwell. Results were received on June 2, 2017, from the USGS National Wildlife Health Center laboratory confirming that *Pd* was not present on bats collected from the 183-F clearwell maternity colony on the Hanford Site. The coordination and teamwork between DOE contractors and the WDFW was efficient, safe, and well executed. Depending on future results of the rest of Washington State and any changes to Hanford Site populations, this sampling effort may be repeated in out years.

Figure 2-37. Yuma Myotis Bat Being Handled for Measurements and Muzzle/Wing Swabs

2.10 VERNAL POOLS

2.10.1 Introduction

Shallow ephemeral wetlands, or vernal pools, in very small to rarely large depressions occur throughout the exposed, volcanic scablands on the Columbia Plateau. These pools are characterized by fresh water inundation for much of the winter and spring followed by dramatic lowering of the water table at the approach of summer. On the Columbia Plateau, vernal pools are geographically limited but can be locally common (Rocchio and Crawford, 2015b). In Washington State, the Columbia Plateau Vernal Pool ecosystem is considered to be Imperiled, that is with a high to moderate risk of extirpation (Rocchio and Crawford 2015a).

In 1997, during surveys conducted on the Hanford Site for the DOE, TNC located three previously undocumented clusters of approximately 20 vernal pools. The Hanford Site pools were located on the east end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain (DOE 1998). The fall and winter of 1996/1997 was unusually wet; 25 cm (9.7 in.) of precipitation fell from October 1996 through March 1997 compared with a normal (30-year average) precipitation of 12.3 cm (4.85 in.) (MSA 2018).

The fall and winter 2016/2017 seasons were also an unusually wet period with 17.4 cm (6.86 in.) of precipitation, which included 71 cm (28 in.) of snow falling between October and the end of February. During the late winter of 2017, the vernal pools documented in 1996/1997 were rediscovered and found to contain significant amounts of water. This section documents the study of roughly 25 vernal pools found on Umtanum Ridge, Gable Butte, and Gable Mountain during 2017 (Figure 2-38).

Figure 2-38. One of the Largest of the Vernal Pools Located on Gable Butte (March 2017)

2.10.1.1 Purpose and Need. Because vernal pools have not been regularly tracked or well-studied on the Hanford Site, and because they represent an imperiled ecosystem in Washington State, monitoring of these pools was initiated during the 2017 season. The purpose of this monitoring was to:

- Locate and map the vernal pools located on the central Hanford Site
- Provide a seasonal timeline for the pools
- Describe the vegetation present in the vernal pools
- Document wildlife use of the pools through the use of trail cameras
- Look for evidence of the use of the pools as a breeding area for anurans
- Document pool use by aquatic crustaceans, insects, and/or other macroinvertebrates
- Identify occurrences of any federal or Washington State-listed species in the pools, including any endemic species or state-listed species of concern.

2.10.1.2 Vernal Pool Status and Management on the Hanford Site. The following section describes the Columbia Plateau Vernal Pool Ecological System in Washington State and its current conservation rankings and status. In addition, the management status of this ecological system on the Hanford Site is discussed.

<u>Columbia Plateau Vernal Pool Ecological System in Washington State</u>
Vernal pools occur throughout the exposed volcanic scablands on the Columbia Plateau in Washington, Oregon, and northern Nevada. Washington occurrences are concentrated in the Channeled Scablands and glaciated areas in Adams, Douglas, Grant, Lincoln, southern Okanogan, and Spokane Counties (Rocchio and Crawford 2015b).

The Washington State Natural Heritage Program (WNHP) ranks ecological systems known to occur in Washington State. The 2016 Ecological Systems List ranks the Columbia Plateau Vernal Pool ecosystem as S2/S3, which indicates an imperiled ecosystem with a high to moderate risk of extirpation in Washington State (WNHP 2016). The primary threat facing this ecosystem at the Hanford Site is invasive non-native species.

Washington Wetlands Ratings

Vernal pools are precipitation-based, seasonal wetlands. In eastern Washington, they are defined to include only scabrock and rainpool vernal wetlands (Ecology 2014). To be classified as a vernal pool, the wetland should be less than 372 m^2 (4,000 ft^2) and meet at least two of the following criteria:

- *Its only source of water is rainfall or snowmelt from a small contributing basin and the basin has no groundwater input.* The wetland will typically lay in areas where the basalt has been exposed by the ice age floods and where basalts have small depressions that collect rainwater or snowmelt.

- *Wetland plants are typically present only in spring; the summer vegetation is typically upland annuals.* The water is present in the wetland for only short periods of time, usually less than 120 days. Wetland plants will be found only during the time of standing water or immediately afterwards.

- *The soils in the wetland are shallow (less than 30 cm or 1 ft deep) and are underlain by an impermeable layer such as basalt or clay.*

- *Surface water is present for less than 120 days during the wet season*. (Ecology 2014)

Relatively undisturbed vernal pools are either a Category II or III wetlands, depending on their location in the landscape (Ecology 2014). Vernal pools that are located in a landscape with other wetlands and relatively undisturbed during the early spring are rated Category II; isolated, undisturbed vernal pools are Category III. Category II wetlands are considered difficult, if not impossible to replace, and provide high levels of some functions, while Category III wetlands are generally less diverse or more isolated from other natural resources in the landscape.

The intent of rating categories is to provide a basis for developing standards for protecting and managing wetlands. Some decisions that can be made based on the rating include the width of buffers needed to protect the wetland from adjacent development and uses in, and around, the wetland. Washington State provides general guidance for protecting and managing Washington wetlands in *Wetlands in Washington State – Volume 2: Guidance for Protecting and Managing Wetlands* (Ecology 2005).

Hanford Site Management Guidance

The BRMP is identified by the CLUP as the primary implementation control for managing and protecting natural resources on the Hanford Site (DOE/RL-96-32). 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 (e.g., federal or state listed endangered, threatened, or sensitive species); or are 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.

Resources classified as Level 5 are the rarest and most sensitive habitats and species and are considered irreplaceable or at risk of extirpation or extinction. Per BRMP, the vernal pools on the Hanford Site are considered to be Level 5 resources. The primary management goal for Level 5 resources is preservation. There is no practical way to replace or restore a Level 5 habitat resource if it is lost; therefore, avoidance is the preferred mitigation for this habitat.

Regular inventory and monitoring is a critical component of DOE-RL's strategy to manage Level 5 resources effectively. Monitoring provides the information needed to determine population trends, distribution of species or habitat, and whether the habitat is declining. This information can then be used to determine if management actions are effective or if additional access restricted or other protective measures are required.

2.10.1.3 Scope. This section of the 2017 comprehensive ecological monitoring report:

- Describes the vernal pools on the Hanford Site and provides an overview of the historical monitoring that occurred in the mid-1990s
- Describes the methods used to monitor vernal pools on the Hanford Site during the FY 2017 season
- Provides a review of the data collected in FY 2017 and the conclusions reached
- Outlines future management actions and proposed monitoring to be taken in response to the results of the 2017 study.

A more detailed report that includes observations and discussion of the data collected at each of the vernal pools can be found in HNF-62115, *Ecological Monitoring Report: Vernal Pools on the Hanford Site*.

2.10.2 Historical Overview of the Vernal Pools on the Hanford Site

The number, size, and extent of vernal pools on the Hanford Site appears to be closely linked to the amount and type of precipitation received in the fall and winter months. In 1996 through 1997, above average amounts of snow that lingered for a longer than average amount of time resulted in three well-defined clusters of vernal pools on the Hanford Site. The information below is based on the observations made in spring 1997 (DOE 1998).

2.10.2.1 General Description. The Hanford Site pools are located on the eastern end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain. Each cluster of pools is situated on top of an impermeable basalt layer that enables water to pond in shallow depressions during wetter winter seasons. The pools are sometimes characterized by a distinct zonation of species from the bottom of the pool (which might be barren throughout the growing season) to the upper pool edge (which is generally occupied by various annual plant species). Vernal pools show wide variation in their degree of development (i.e., some appear to be pools that fill intermittently and are invaded by sagebrush during extended dry periods years).

2.10.2.2 Historical Monitoring at Hanford (1996 and 1997). The 1997 survey found that the vernal pools on the Hanford Site showed wide variation with regard to a number of traits including pool size, species composition, dominant species, degree of invasion by weedy (mostly non-native) species, and presence of rare plant species (DOE 1998). Pools averaged 18 by 18 m (60 by 60 ft) in size but ranged from 6 by 6 m (20 by 20 ft) to 46 by 30 m (150 by 100 ft). Dominant species were typically annuals. Some vernal pools had a high cover of moss and lichen species. In addition to their botanical resources, there was ample evidence of avian and other wildlife use of these vernal pools as they often provide water during dry times of the year.

The cluster of 10 to 11 vernal pools on the eastern end of Umtanum Ridge were of relatively high quality and appeared to be the most undisturbed (pristine) pools on the Hanford Site. Large and vigorous subpopulations of Suksdorf's monkeyflower (*Erythranthe suksdorfii,* formerly *Mimulus suksdorfii*) were found in almost all of these pools. Mousetail (*Myosurus calvicauli*) was located in one of the vernal pools. The pools were spread out over an area of about 305 by 915 m (100 by 3,500 ft).

The low, middle portion of Gable Butte supported a cluster of six or seven vernal pools. These pools supported healthy populations of several thousand *Erythranthe suksdorfii* and spreading pygmyleaf (*Loeflingia squarrosa* var *squarrosa*) plants. The area was far from current development; however, an old road did cross through the largest vernal pool.

The cluster of three pools on the eastern side of Gable Mountain was least pristine of the three sets of vernal pools. These weedy, intermittently filled pools supported a population of several hundred *Erythranthe suksdorfii* plants. The aggressive weed, yellow starthistle (*Centaurea solstitialis*), posed a serious threat to native plants at these pools.

An alkaline spring and marshy area was found in a large shallow basin at the east end of Umtanum Ridge in the same area as the vernal pools. This previously unknown spring did not appear to have been significantly damaged by past grazing. It is perhaps the only spring of its kind on the Hanford Site. This spring supported a population of seep paintbrush (*Castlleja minor* var. *exilis*) and other alkali-tolerant plant species. There also were a number of weedy species present that could threaten the persistence of native plant species at the spring.

2.10.3 2017 Monitoring Methods

Late winter 2017 was unusually wet and snowy, and vernal pools were again noted at the east end of Umtanum Ridge in late February. This section documents the monitoring done during the 2017 season that focused on relocating pools that were documented in the 1997 survey, locating additional pools that had been overlooked, and establishing a baseline for future studies of this unique ecological system.

2.10.3.1 Locations and Descriptions of Vernal Pools on the Hanford Site. The first goal of the 2017 monitoring effort was to document the location of vernal pools on the Hanford Site. Locations documented in 1997 by TNC were revisited. All pools found were photographed and their location documented using GPS information collected with a hand-held Trimble. Larger pools were mapped by taking a series of GPS readings at the perimeter of the pool. A single GPS point was made for smaller pools (generally considered those with diameters roughly less than 9 m [10 yd]).

On March 16, 2017, an aerial survey was conducted from a single-engine fixed-wing aircraft at an altitude of 300 to 1,070 m (1,000 to 3,500 ft). As shown in Figure 2-39, the flight took two passes east-west over the central portion of the Hanford Site above Gable Mountain, Gable Butte, and the eastern portion of Umtanum Ridge. In addition, the flight flew over another potential site of a vernal pool near the Laser Interferometer Gravitational-Wave Observatory.

Vernal pools were located at all three previously documented locations (i.e., Umtanum Ridge, Gable Butte, and Gable Mountain). Figure 2-40 provides a map showing the general locations of the vernal pool clusters on the Hanford Site. In all three areas, the underlying substrate was a rocky lithosol. Each location is discussed in more detail in the sections below.

2.10.3.2 Seasonal Timeline. All vernal pools were revisited on a roughly monthly basis to assess the condition. Photographs of each pool were taken and the perimeters of larger pools were mapped using GPS to determine changes in pool size. In addition, one or more pools were photographed daily at mid-day using a trail camera. Visits continued until the pools dried out and vegetation had become established.

2.10.3.3 Vegetation Monitoring. Surveys of the vegetation present in the vernal pools occurred in mid-summer after all of the pools had dried out. These surveys documented the species present and noted obvious visual patterns in plant distribution within the pools. Previous researchers have noted zonal vegetation patterns of more or less concentric zones of different species groupings in vernal pools (Crowe et al. 1994).

Of particular interest was the presence or absence of species endemic to vernal pools. A list of core native taxa that are found almost exclusively in vernal pools in Washington State can be found in Bjork and Dunwiddie (2004). In addition to endemic species, three state-listed species of conservation concern were found to inhabit some of the Hanford Site’s vernal pools in 1997 (DOE 1998):

- Suksdorf’s monkeyflower (Erythranthe suksdorfii [formerly Mimulus suksdorfii])
- Mousetail (Myosurus clavicaulis)
- Spreading pygmyleaf (Loeflingia squarrosa var squarrosa).

Any species of conservation concern encountered in Washington State (WNHP 2017) were documented for submission to the Washington Natural Heritage Program Rare plant database.

Populations of non-native invasive weeds in or around the pools were also noted as these species pose the greatest threat to vernal pool ecosystems on the Hanford Site.

In addition to documenting the vascular plants present, any area with a noticeable amount of cryptogamic species (e.g., mosses and lichens) was documented.

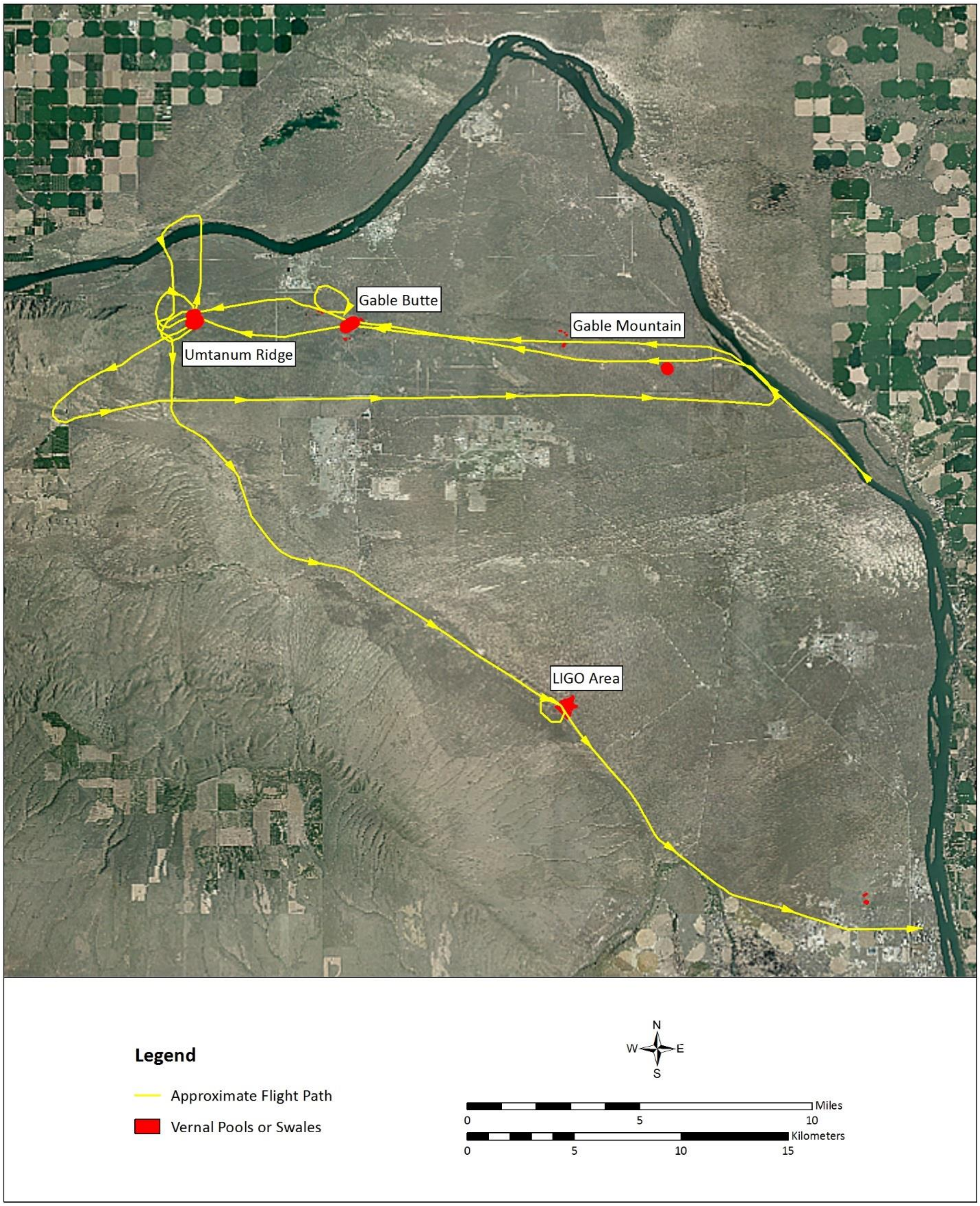


Figure 2-39. Path of the Aerial Survey of Vernal Pool Areas on the Hanford Site

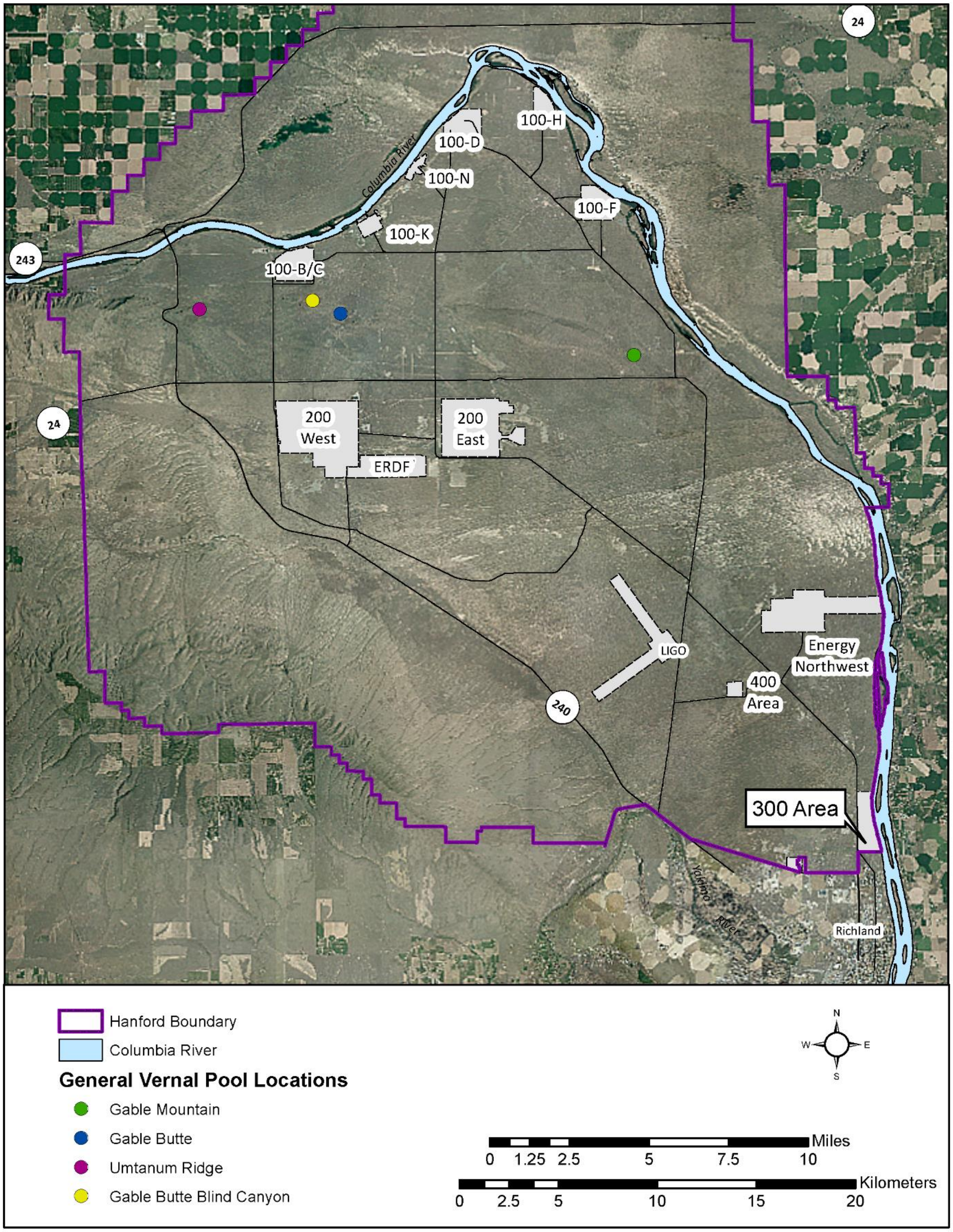


Figure 2-40. General Locations of the Vernal Pool Areas on the Hanford Site

2.10.3.4 Wildlife Usage. Wildlife and wildlife signs were noted during visits to the vernal pools throughout the season. In addition to these incidental data, trail cameras were set up at some pools to capture wildlife present at the pool throughout the day. Specific sampling efforts focused on the presence or absence of breeding anurans; macroinvertebrates were also sampled throughout the season in the pools that still contained water.

<u>Trail Cameras</u>
Trail cameras were used at four different pools during the March/April timeframe in order to document wildlife and determine when they are used as a local water source. Hanford Site Security was notified of trail camera locations.

<u>Anurans</u>
Two species of native anurans (frogs and toads), the Woodhouse's toad (*Anaxyrus woodhousii*) and the Great Basin spadefoot toad (*Spea intermontana*), inhabit the Hanford Site. These anurans are known to breed in the ephemeral pools and sloughs adjacent to the Columbia River; however, there are no data indicating whether they also use the vernal pools for this purpose. Visual surveys were used to locate breeding habitats and identify which anurans were present.

<u>Macroinvertebrates</u>
The goal of the macroinvertebrate sampling was to determine whether or not the vernal pools support an active population of macroinvertebrates, not to prepare a definitive list of taxa or to quantify the number of macroinvertebrates in a given pool. A second goal was to look specifically for the presence or absence of fairy shrimp. Samples were collected from March through May (if pools were still filled). A D-frame mesh net was used to collect the sample from the pool by walking in or around the pool and forcing pool water through the net. All macroinvertebrates collected with the net were dumped into a wide plastic tub for observation and categorized according to type.

2.10.4 Summary and Conclusions

The vernal pools on the Hanford Site in 2017 exhibited a wide range of characteristics ranging from their size and persistence to the species present. This section provides an overall summary of the observations made and data collected for the Hanford Site's vernal pools in 2017, as well as the trends noted and conclusions reached.

2.10.4.1 Location and Sizes. In 2017, pools were documented in all three of the locations that pools were observed in 1997 (DOE 1998). In addition, an additional pool situated along the northern ridge in a blind canyon further west on Gable Butte was recorded (Figure 2-40). The aerial flight over the northern portion of the Hanford Site allowed the identification of several pools not seen during the ground survey, including the pool in the blind canyon and a second pool just to the east of that pool.

All of the pools were located in rocky areas with exposed basalt and very shallow soils. The underlying impermeable basalt layer allows water to pool in lower lying areas following fall-winter rainfall and snowmelt. The size of the pools vary based on the size of the local depressions and the amount of precipitation received. In 2017, pools ranged in area from 7,015 m^2 (1.73 ac) to puddle-sized; the median size of the pools large enough to measure (larger than roughly 10 m^2 [107 ft^2]) was 360 m^2

(0.09 ac). Many of the pools appeared as though they are filled with water most years; however, to date that has not been documented[1].

The vegetation surrounding the majority of the vernal pool locations is typical of local lithosolic communities. Big sagebrush (*Artemisia tridentata*), stiff sagebrush (*Artemisia rigida*), and buckwheats (*Eriogonum* spp.) were the most common shrubs surrounding the pools; Sandberg bluegrass (*Poa secunda*) and bluebunch wheatgrass (*Psuedoregnaria spicata*) were the most commonly represented bunchgrasses in the understory.

<u>Umtanum Ridge Vernal Pools</u>

A group of roughly 10 vernal pools and a likely spring are clustered together at the eastern end of Umtanum Ridge. As shown in Figure 2-40, Pools 1 and 2 are located fairly close to the ridgeline while the remaining pools are further south. One area, marked as a possible spring on the map below, remained wet well into the summer and appears to have a more continuous source of water than the surrounding pools, which are dependent on precipitation for fill. The TNC also noted an alkaline spring and marshy area in the same area as the vernal pools on Umtanum Ridge (DOE 1998).

The first two pools in the Umtanum Ridge cluster, Pools U-1 and U-2, were incidentally observed on February 28, 2017, while doing other ecological monitoring work. A return visit made to this area on March 13 to check for additional pools and document their location and size found eight more pools. Subsequent visits were made on March 30, April 6, May 8 and 12, June 5, and July 18.

Table 2-19 documents the size of the 10 identified Umtanum Ridge pools on March 13, 2017. All of the pools were larger on this date than on any subsequent observation dates; it was noted that U-1 and U-2 appeared to have dried out a bit since February 28.

<u>Gable Butte Saddle Area Vernal Pools</u>

Vernal pools on Gable Butte are found in two distinct areas. The largest set, a cluster of 10 or more pools found in the saddle to the west of the railroad cut, is the subject of this section. The pools in this area of Gable Butte were the largest seen on the Hanford Site in 2017. The second area on the butte is further to the west and contains the blind canyon pool, which is covered separately in the next section of this document.

On March 6, 2017, a preliminary survey to locate pools on Gable Butte was performed. GPS data were collected for the perimeters of the three largest pools (GB-1, GB-2, and GB-4). Other smaller pools were noted as discrete points. Figure 2-42 shows the locations of the pools in the Gable Butte saddle area, the pool boundaries were measured on March 6, 2017, and subsequent outlines were measured in early April.

Table 2-20 provides the areas of the pool measured on March 6 and/or April 6, 2017. At about 0.7 ha (1.75 ac), Gable Butte Pool 4 was by far the largest vernal pool seen in 2017. As this pool began to dry out it separated into three distinct pools, which were subsequently labeled GB-4A, -4B, and -4C (from south to north).

---

[1] In early March 2018, as this report was being written, all the vernal pools discussed in this report were revisited. The fall/winter rainfall in the 2017/2018 time period was below average; therefore, no vernal pools were present on the Hanford Site.

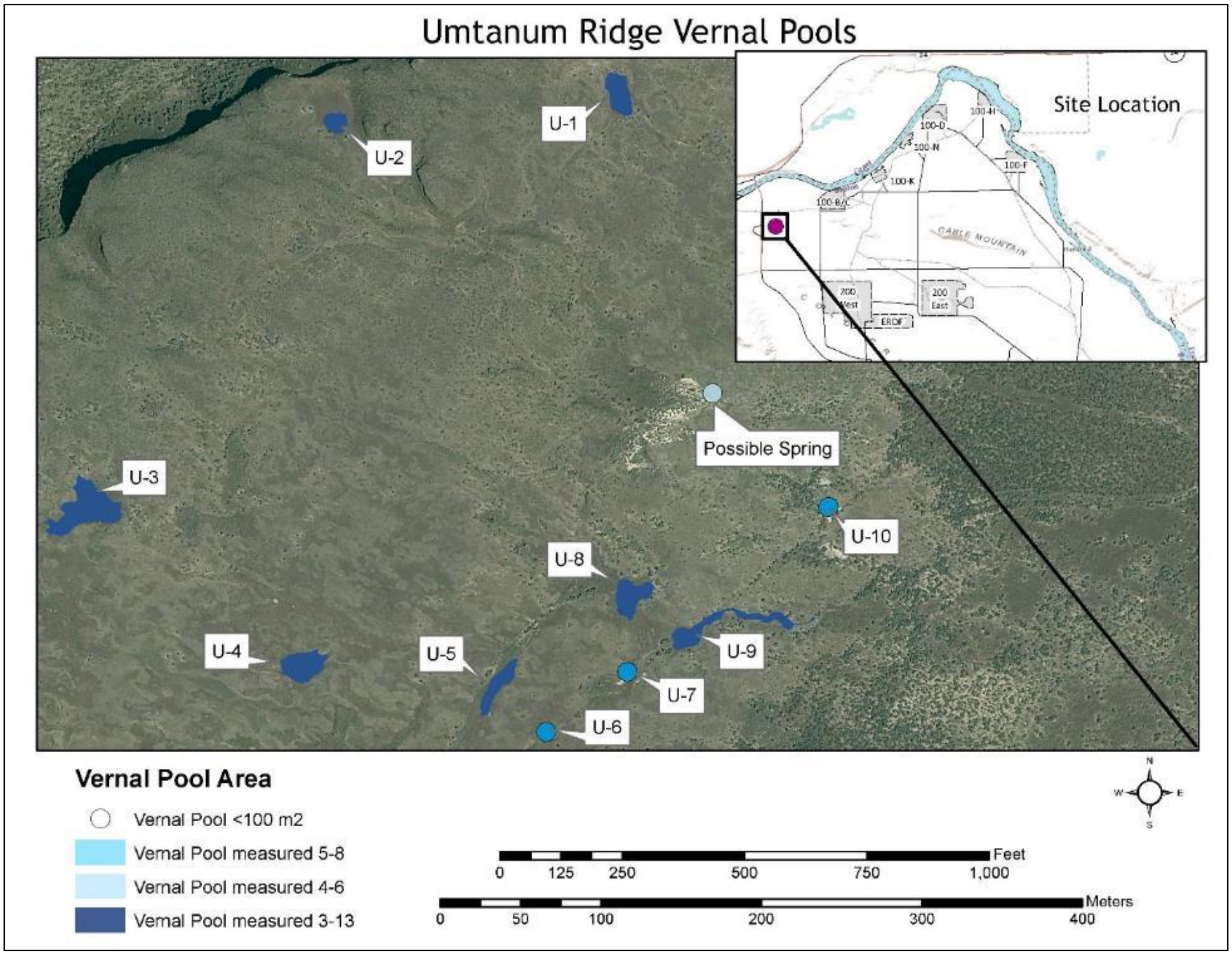


Figure 2-41. Cluster of Vernal Pools on Umtanum Ridge

Table 2-19. Sizes of the Vernal Pools on Umtanum Ridge. (March 13, 2017).

Vernal Pool Identifier	Area (m^2)	Area (acres)
U-1	323.9	0.080
U-2	155.1	0.038
U-3	831.0	0.205
U-4	406.6	0.100
U-5	280.4	0.069
U-6	Very small	Very small
U-7	Very small	Very small
U-8	359.5	0.089
U-9	485.2	0.120
U-10	Very small	Very small

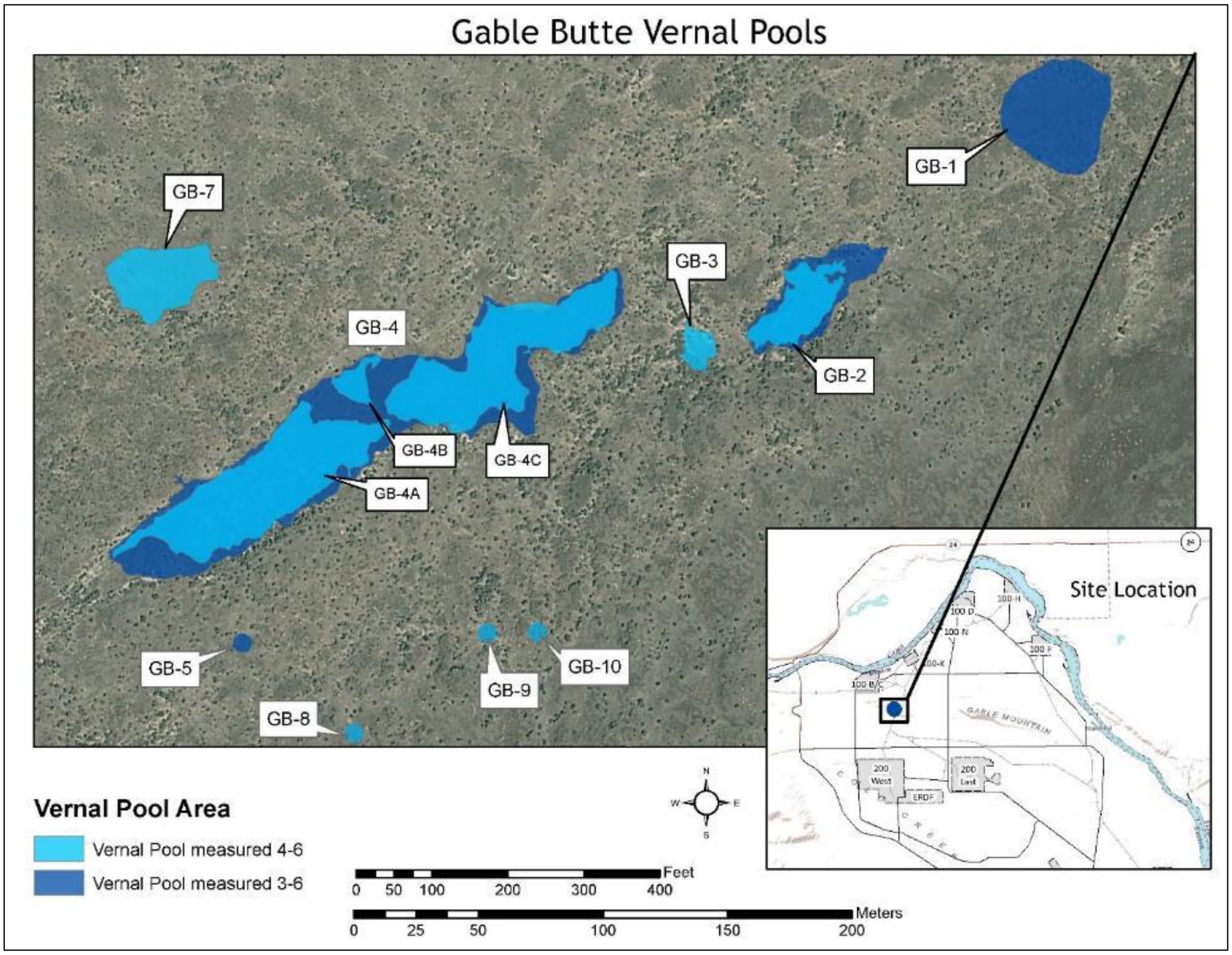


Figure 2-42. Cluster of Vernal Pools in the Saddle on Gable Butte

Table 2-20. Gable Butte Vernal Pool Sizes.

Vernal Pool Identifier	Date	Pool Area (m²)	Pool Area (acres)
GB-1	3-6	1542.18	0.381
GB-2	3-6	1202.34	0.297
	4-6	699.38	0.173
GB-3	4-6	182.04	0.045
GB-4 [a]	3-6	1.733	7014.71
GB-4A	4-6	2312.82	0.572
GB-4B	4-6	181.93	0.045
GB-4C	4-6	2521.14	0.623
GB-7	4-6	938.98	0.232

[a] Pool GB-4 broke into three pools (GB-4A, -4B, and -4C) as it began to dry out.

Gable Butte Blind Canyon Vernal Pool

The blind canyon pool on Gable Butte was identified during the aerial flight on March 16 and was first visited on March 30, 2017. This pool is located in a small area bordered by steep basalt formations on both sides and by a ridge with a steep drop off at the northeast edge. The blind canyon pool covered an area of 465.9 m^2 (0.115 acre) on March 30. Although this pool is on Gable Butte, it is separated from the larger cluster of pools to the east. Late in the season, a second pool near the ridge was located to the east of the blind canyon pool; however, the second pool was not monitored in 2017. Figure 2-43 is an aerial photograph of the area showing where these two pools occured.

Figure 2-43. Aerial Photograph of the Blind Canyon Pool on Gable Butte (March 16, 2017)

Gable Mountain Vernal Pools

The Nature Conservancy descriptions of the pools found in the mid-1990s included a cluster of pools on the southeast lower elevations of Gable Mountain. This area was revisited in 2017 and the three pools were located and mapped (Figure 2-44). This area is quite rocky and the surrounding vegetation was dominated by cheatgrass and Sandberg bluegrass. The biological crust was very well developed on the lithosols around the pools.

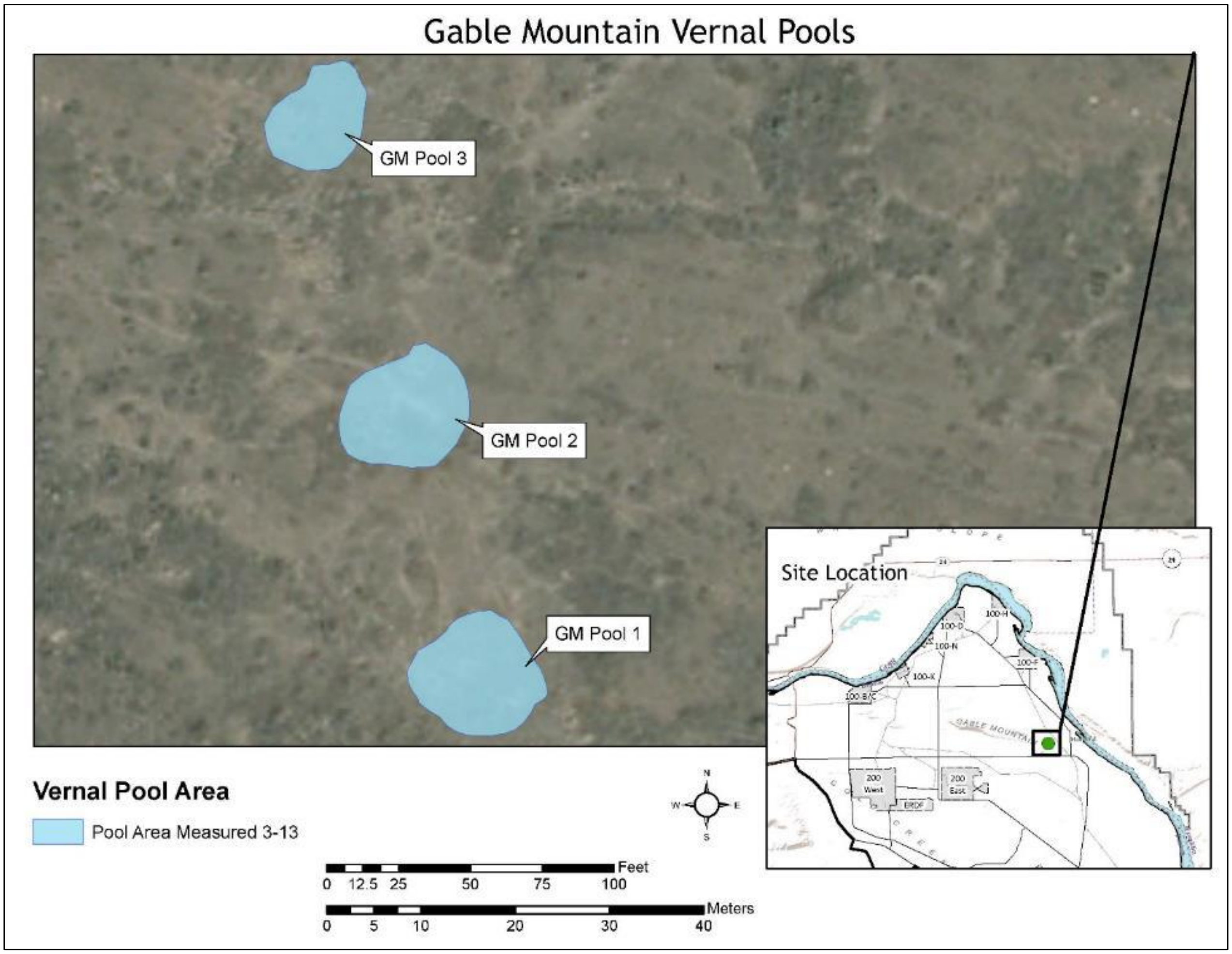


Figure 2-44. Vernal Pools on Lower Elevation of Gable Butte

The areas of the Gable Mountain pools in mid-March 2017 are shown in Table 2-21.

Table 2-21. Size of Vernal Pools on Gable Mountain (March 13, 2017).

Pool Number	Pool Area (m²)	Pool Area (acres)
GM-1	137.60	0.034
GM-2	137.36	0.034
GM-3	90.41	0.022

2.10.4.2 Seasonal Timelines. The presence and duration of vernal pools on the Hanford Site appears to vary drastically from year to year. The sections below discuss the relationship between yearly patterns in snowfall, total precipitation, and the presence of vernal pools in the spring, as well as the season patterns of pool dry out seen in 2017.

Yearly Patterns

Timelines for the vernal pools are highly dependent on the weather patterns for that particular season. Because the water in the pools comes from precipitation, rainfall and snow cover during the previous fall and winter may determine if the vernal pools are seen at all, as well as how short the period of inundation is at each site.

As a comparison with other years, the period from September 2016 to February 2017 ranks as the third wettest season since the fall-winter of 1995/1996. Note that the wettest fall/winter periods prior to 2016/2017 occurred in the back-to-back seasons of 1995/1996 and 1996/1997.

Snowfall during the winter months may also be tied to the formation of vernal pools, since thaw may release a significant amount of water in a relatively short timeframe. In the fall/winter of 2016/2017, 71 cm (28 in.) of snow fell. This snowfall amount was tied in the fall/winter season of 1995/1996 and exceeded only two times in the past 22 years. The normal snowfall (the 30-year average from 1981 through 2010) is 38.9 cm (15.3 in.) per year (MSA 2018).

On March 5, 2018, all vernal pools documented in 2017 were revisited; however, no water was found in any of the pool locations. As of early March, the fall/winter rainfall for the 2017/2018 was 11 cm (4.4 in.) of precipitation including 17 cm (6.8 in.) of snow (MSA 2018). Figure 2-45 shows Gable Butte Pool 4 as of March 5, 2018. This pool had water covering 7,015 m^2 (1.73 ac) on March 6, 2017.

Figure 2-45. Large Vernal Pool on Gable Butte on March 5, 2018 (looking south)

<u>2017 Vernal Pool Seasonality</u>
Vernal pools were revisited periodically during 2017 until the pools dried out and vegetation had become established. The following patterns of pool dry out were seen for each of the pool locations.

- On Umtanum Ridge, pools were beginning to dry out by mid-March and trail cameras captured the dry out of pool U-2, which appeared to be empty on March 18. By early April only the two largest pools on Umtanum Ridge (pools U-3 and U-4) still contained any water. Pool U-3 had shrunk by 63% and pool U-4 by 62% between March 13 and April 6. Exact dryout dates for these pools are not known; however, trail camera photographs show that pool U-4 still contained water on April 14.

- The pools located on the saddle of Gable Butte all contained water on March 6. All of the smaller pools had dried out by April 4. The five largest pools (GB-1, GB-2, GB-3, GB-4, and GB-7) still contained water in early April, although the largest pool (GB-4) had broken into three smaller pools. By April 28, 2017, all of these pools, with the exception of pool GB-1, still had not dried out. All pools were dry by the final visit on July 31.

- The vernal pool located in the blind canyon on Gable Butte still had water in it on May 8 but had dried before the final visit on August 17.

- The Gable Mountain pools all held water through the end of March but only pool GM-1 contained any water on May 8. By June 5, pool GM-1 has also dried out.

Overall, in 2017, the smaller vernal pools lasted only a few weeks and were dry by mid-March. The larger pools, however, still contained water well into the spring. Although the exact dates of dry out are unknown, it is clear that at least five or six pools were still present in mid-May.

2.10.4.3 Vegetation. Surveys of the vegetation present in the vernal pools occurred in mid-summer after all of the pools had dried out.

<u>Species Found in the Vernal Pools.</u>
As listed in Table 2-22, a total of 47 species of vascular plants were observed in the Hanford Site's vernal pool basins in 2017. Overall, approximately 62% of the species found in the pools were native while the rest were introduced. About 72% of the species in the pools were annuals.

The wetland status of the species observed is also noted in Table 2-22. The wetland status assigned was based on the *National Wetland Plant List* for the arid west (Lichvar et al. 2016). The indicator codes used in the table are explained in Table 2-23.

As is typical of seasonal wetlands, many of the plants found in the vernal pool basins after they dried up are non-hydrophytes; 43% are strictly upland species while an additional 30% are facultative upland plants. Of the remaining species, only *Erythranthe floribunda* is considered an obligate wetland species. Four species (*Gnaphalium palustre, Grindelia hitsuta, Juncus bufonius,* and *Polypogon monspeliensis*) are generally found in wetlands, while the remaining seven species are facultative species, occurring in both wetland and non-wetlands.

As noted in Table 2-22, there were differences among the vegetation at the three pool locations; however, 18 species were found at all three pool locations (Figures 2-46 and 2-47).

Table 2-22. Vegetation Present in the Vernal Pool Basins after Dry-Out. (2 Pages)

Scientific Name	Common Name	Native or Introduced	Special Status	Wetland Status	Vernal Pool Locations		
					Umtanum Ridge	Gable Butte	Gable Mtn.
Achillea millefolium	yarrow	native		FACU		X	
Amaranthus albus	white pigweed	introduced		FACU	X	X	X
Ambrosia acanthicarpa	bur ragweed	native		UPL			X
Amsinckia lycopsoides	fiddleneck tarweed	native		UPL			X
Artemisia tridentata (recruits)	big sagebrush	native		UPL	X		
Bromus tectorum	cheat grass	introduced		UPL	X	X	X
Chaenactis douglasii	hoary false yarrow	native		UPL	X		
Chenopodium leptophyllum	slimleaf goosefoot	native		FACU		X	X
Convolvulus arvensis	field bindweed	introduced	WA - Class C weed	UPL			X
Conyza canadensis	horseweed	native		FACU	X	X	X
Cryptantha circumscissa	matted cryptantha	native		UPL	X	X	
Descurainia sophia	flixweed	introduced		UPL		X	
Distichlis spicata	alkali saltgrass	native		FAC		X	
Draba verna	spring whitlowgrass	introduced		UPL	X	X	X
Epilobium brachycarpum	tall willowherb	native		UPL		X	
Erigeron pumilus	shaggy fleabane	native		UPL	X	X	X
Erodium cicutarium	storksbill	introduced		UPL	X	X	
Erythranthe floribunda	purplestem monkeyflower	native		OBL	X	X	X
Erythanthre suksdorfii	Suksdorf's monkeyflower	native	WA - Sensitive	FACU	X	X	X
Euphorbia serpyllifolia	thymeleaf spurge	native		UPL		X	X
Gnaphalium palustre	lowland cudweed	native		FACW	X	X	X
Grindelia hirsutula	hairy gumweed	native		FACW			X
Heliotriopium curassavicum	salt heliotrope	native		FACU		X	
Holosteum umbellatum	jagged chickweed	introduced		UPL	X	X	

Table 2-22. Vegetation Present in the Vernal Pool Basins after Dry-Out. (2 Pages)

Scientific Name	Common Name	Native or Introduced	Special Status	Wetland Status	Vernal Pool Locations		
					Umtanum Ridge	Gable Butte	Gable Mtn.
Hornungia procumbens	ovalpurse	introduced		FAC	X	X	X
Juncus bufonius	toad rush	native		FACW	X	X	X
Kochia scoparia	summer cypress	introduced	WA - Class B weed	FAC	X	X	
Lactuca serriola	prickly lettuce	introduced		FACU	X	X	X
Lepidium latifolium	broadleaf pepperweed	introduced	WA - Class B weed	FAC	X	X	X
Lepidium perfoliatum	clasping pepperweed	introduced		FACU		X	
Leymus cinereus	giant ryegrass	native		FAC	X	X	X
Microsteris gracilis	pink microsteris	native		FACU	X		X
Neoholmgrenia andina	obscure suncup	native		UPL	X	X	X
Peritoma lutea	yellow bee-plant	native		FACU		X	
Plantago patagonica	woolly plantain	native		UPL		X	
Plectritis macrocera	white cupseed	native		FACU	X		
Poa secunda	Sandberg bluegrass	native		FACU	X	X	X
Polypogon monspeliensis	rabbitsfoot grass	introduced		FACW		X	X
Psuedoregneria spicata	bluebunch wheatgrass	native		UPL	X		
Rhaponticum repens	Russian knapweed	introduced	WA - Class B weed	UPL		X	
Salsola tragus	Russian thistle	introduced		FACU	X	X	X
Sisymbrium altissimum	Jim Hill tumble mustard	introduced		FACU	X	X	X
Sphaeralcea munroana	Munro's globemallow	native		UPL		X	X
Tragopogon dubius	salsify	introduced		UPL	X	X	
Verbena bracteata	carpet verbena	native		FAC	X	X	X
Veronica peregrina	purslane speedwell	native		FAC			X
Vulpia spp.	vulpia	introduced		N/A	X	X	X

FAC = facultative
FACU = facultative upland
FACW = facultative wetland
N/A = not available
OBL = obligate wetland
UPL = obligate upland
WA = Washington State

Table 2-23. Indicator Codes for Vernal Pools.

Indicator Code	Indicator Status	Designation	Comment
OBL	Obligate Wetland	Hydrophyte	Almost always occur in wetlands
FACW	Facultative Wetland	Hydrophyte	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Hydrophyte	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Non-hydrophyte	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Non-hydrophyte	Almost never occur in wetlands

FAC = facultative
FACU = facultative upland
FACW = facultative wetland
OBL = obligate wetland
UPL = obligate upland

Conyza canadensis
horseweed

Erigeron pumilis
shaggy fleabane

Erythranthe floribunda
purple-stemmed monkeyflower

Erythranthe suksdorfii
Suksdorf's monkeyflower

Gnaphalium palustre
lowland cudweed

Juncus bufonius
toad rush

Leymus cinereus
giant wildrye

Neoholmgrenia andina
obscure suncup

Poa secunda
Sandberg bluegrass

Verbena bracteata
bracted verbena

Figure 2-46. Native Plants Found in Vernal Pools at All Three Locations (3 Pages)

Amaranthus albus
white pigweed

Draba verna
spring whitlow grass

Hornugia procumbens
ovalpurse

Lepidium latifolium
broad-leaved pepperweed

Polypogon monspielensis
annual rabbitfoot grass

Sisymbrium altissimum
Jim Hill tumblemustard

Figure 2-47. Distinctive Introduced Plants Found in Vernal Pools at all Three Locations (2 Pages)

<u>Vegetation Patterns in the Dried Vernal Pool Basins</u>

In addition to documenting the species present, obvious visual patterns in plant distribution within the pools were noted during late summer vegetation surveys. Previous researchers have noted zonal vegetation patterns of more or less concentric zones of different species groupings in vernal pools (Crowe et al. 1994); however, these concentric zones were not found in the majority of vernal pool basins at the Hanford Site in 2017.

Although distinct zones were not commonly observed in the majority of Hanford Site pools in 2017, individual species often did have areas within the dried pool basins where they did tend to be found more frequently. Distribution notes for each of the species observed in the Hanford Site pools in 2017 can be found in Table 2-24.

In addition to 2017 observation for the Hanford Site pools, notes from a study done by Bjork and Dunwiddie (2004) are included for comparison in Table 2-24. During their 1997 and 1998 studies of the vernal pools in eastern Washington, Bjork and Dunwiddie looked at the floristics of 342 vernal pools located in Spokane, Adams, Lincoln, Grant, and Okanogan Counties. Although all of these pools are located in areas that receive marginally more annual precipitation than the Hanford Site (ranging from an average of 23 cm [9 in.] at Coulee City in the west to 36 cm [18 in.] in Spokane) and 1997 was an unusually wet year[2], it is interesting to note species trends.

Table 2-24. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Achillea millefolium	yarrow	On margins – Gable Mountain pools only	Common on margins, occasional on basins; local form flood tolerant
Amaranthus albus	white pigweed	in pool basin, germinated after desiccation – all locations	Occasional summer annual on pool basins, germinating post desiccation
Ambrosia acanthicarpa	bur ragweed	On margins – Gable Mountain	(*Ambrosia* sp.) a single occurrence on margins of an alkaline pool; non-core
Amsinckia lycopsoides	fiddleneck tarweed	On margins – Gable Mountain	Common at margins, growing at higher densities on pool margins than surrounding grasslands (
Artemisia tridentata (recruits)	big sagebrush	Middle of early drying shallow pools - Umtanum Ridge	Common around pools; flood intolerant; germinates occasionally in pools post-desiccation but is later killed in high water
Bromus tectorum	cheat grass	Common in margins and areas of the pools that dried earlier in the season – all locations	Uncommon on margins; apparently flood intolerant
Chaenactis douglasii	hoary false yarrow	Uncommon – found on basin that dried out by end of March on Umtanum Ridge	Not listed in Bjork and Dunwiddie 2004.
Chenopodium leptophyllum	slimleaf goosefoot	On margins and basin - Gable Butte and Gable Mountain	(*Chenopodium alba* complex) Occasional on margins; non-core
Convolvulus arvensis	field bindweed	On margin – uncommon on Gable Mountain	Locally common on basins and margins
Conyza canadensis	horseweed	On margins and in basin – all locations	Common on margins and basin, germinating post-desiccation
Cryptantha circumscissa	matted cryptantha	In basin – common to sandier basin areas on Gable Butte and Umtanum Ridge	Not listed in Bjork and Dunwiddie 2004.

[2] In 1998, nearly all pools were fully desiccated by the middle of April. Water levels in 1997 were extremely high; most pools began to dry at the end of May, though very large pools retained standing water through June. (Bjork and Dunwiddie 2004)

Table 2-24. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Descurainia sophia	flixweed	On margins - Gable Butte	Occasional on margins, mostly where disturbed; non-core
Distichlis spicata	alkali saltgrass	On margin – Gable Butte	Common on basins and margins of alkaline/salty pools
Draba verna	spring whitlowgrass	On margin, sometimes underwater at edges of pools – all locations	Occasional on margins; flood intolerant; very common beyond high water mark on both lithosol and deeper soils surrounding vernal pools
Epilobium brachycarpum	tall willowherb	On margins - Gable Butte	Very common on margins
Erigeron pumilus	shaggy fleabane	In early desiccated pools – all locations	Rare on margins; flood intolerant; noncore
Erodium cicutarium	storksbill	On margins – Umtanum and Gable Butte	Not listed in Bjork and Dunwiddie 2004.
Erythranthe floribunda	purplestem monkeyflower	On margins and in basins – all locations	(*Mimulus floribundus*) Occasional on margins, grows extremely robustly around alkaline/salty pools
Erythanthre suksdorfii	Suksdorf's monkeyflower	On margins and in basins – all locations	(*Mimulus suksdorfii*) Rare on margins
Euphorbia serpyllifolia	thymeleaf spurge	In basin – Gable Butte and Gable Mountain	(*Chamaesyce serpyllifolia*) Common on pool basin, germinating post-desiccation
Gnaphalium palustre	lowland cudweed	Common - on margins and in basins – all locations	Very common on basins, occasional on margins
Grindelia hirsutula	gumweed	Uncommon , on margins - Gable Mountain	(listed as *G. columbiana* and *G. nana*) Common in central and west sub-regions, on basins and margins, equally common in pools and surrounding grasslands
Heliotriopium curassavicum	salt heliotrope	Where found, formed large mats within pool – Gable Butte	Not listed in Bjork and Dunwiddie 2004.
Holosteum umbellatum	jagged chickweed	On margins – Gable Butte and Umtanum Ridge	Rare on margins, locally very common in surrounding grasslands, non-core
Hornungia procumbens	ovalpurse	In basin – all locations	Not listed in Bjork and Dunwiddie 2004.
Juncus bufonius	toad rush	In basin – all locations	Very common
Kochia scoparia	summer cypress	On margins – Gable Butte and Umtanum Ridge	Not listed in Bjork and Dunwiddie 2004.
Lactuca serriola	prickly lettuce	On margins – all locations	Common on margins and basins, mostly germinating post desiccation; highly drought tolerant, flowering well into autumn
Lepidium latifolium	broadleaf pepperweed	On margins and in basin with deeper soils – all locations	Occasional on margins, most common where alkaline/salty (
Lepidium perfoliatum	clasping pepperweed	Common on margins and in basin – Gable Butte	(*Lepidium* spp.?) Rare on margins, non-core

Table 2-24. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Leymus cinereus	giant ryegrass	On margins, occasionally in basin in pools that desiccated earlier in season –all locations	Very common margins
Microsteris gracilis	pink microsteris	On margins – Gable Mountain and Umtanum Ridge	Very common on margins, especially in east sub-region; sometimes forming dense populations of tall robust plants having relatively large, fragrant flowers
Neoholmgrenia andina	obscure suncup	Common in basins and on margins – all locations	(*Camissonia andina*) Occasional on basins and margins
Peritoma lutea	yellow bee-plant	On margins and in basin – common on Gable Butte	Not listed in Bjork and Dunwiddie 2004.
Plantago patagonica	woolly plantain	In basin – Gable Butte	Very common, mostly on margins
Plectritis macrocera	white cupseed	On margins – Umtanum Ridge	Occasional on margins
Poa secunda	Sandberg bluegrass	On margins (underwater early in season) and occasionally in basin of shallower pools – all locations	Not listed in Bjork and Dunwiddie 2004.
Polypogon monspeliensis	Annual rabbitsfoot grass	On margins – Gable Butte	Common on margins and basins of alkaline/salty margins
Psuedoregneria spicata	bluebunch wheatgrass	On margins – shallow early drying pools – Umtanum Ridge	Flood intolerant, occasional along pool margins, non-core
Rhaponticum repens	Russian knapweed	Uncommon – Gable Butte	Not listed in Bjork and Dunwiddie 2004.
Salsola tragus	Russian thistle	Common – germinated after desiccation in basin and on margins – all locations	Not listed in Bjork and Dunwiddie 2004.
Sisymbrium altissimum	Jim Hill tumble-mustard	On margins - all locations	Common on margins, particularly where disturbed; flood intolerant; germinating post-desiccation; very common in surrounding grassland, non-core
Sphaeralcea munroana	Munro's globemallow	Uncommon – on margins – Gable Butte and Gable Mountain	Not listed in Bjork and Dunwiddie 2004.
Tragopogon dubius	salsify	On margins – Umtanum Ridge and Gable Butte	Occasional on margins; non-core
Verbena bracteata	carpet verbena	Very common, more common on margins, but sometimes in basin –all locations	Rare on margins or basins; germinating post-desiccation; flood intolerant, non-core

Table 2-24. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Veronica peregrina	purslane speedwell	Uncommon – Gable Mountain	Very common, mostly on basins
Vulpia spp.	vulpia	Small annual grass; on margins - all locations	(*Vulpia octoflora*) Rare on margins, non-core

[a] In some cases, scientific names for species have changed since Bjorn and Dunwiddie (2004) completed their study. In those cases, the species listed in their work has been included in parentheses for clarity.

Special Status Species

One species, *Erythranthe suksdorfii* (Suksdorf's monkeyflower), found in the vernal pools in all three Hanford Site locations is listed as a Washington State Sensitive species (WNHP 2017). Suksdorf's monkeyflower is a small plant, which is generally only 3 to 10 cm (1 to 4 in.) tall. Most of the plants seen in the vernal pool basins were at the larger end of that range and seemed to be quite robust. At the state level, this species is ranked as an S3, meaning that it is considered to be vulnerable at a moderate risk of extirpation in the state.

Two additional state-listed species were observed in the vernal pools by the TNC in 1997: mousetail (*Myosurus clavicaulis*) and spreading pygmyleaf (*Loeflingia squarrosa* var *squarrosa*). Mousetail was observed in a pool on Umtanum Ridge while spreading pygmyleaf was observed on Gable Butte. Neither species was observed in the 2017 vernal pool surveys.

Weedy Species

As noted above, 38% of the species documented in the vernal pools were non-native species, many of which are somewhat weedy or invasive in habit. Many of the native annual species found are also considered to be weeds. Overall, almost half of the species noted in the vernal pools are listed as invasive in *Weeds of the West* (Whitson et al. 2012). In the absence of other pressures on the vernal pools at the Hanford Site (e.g., heavy grazing and agricultural use), these species may pose the greatest threat to vernal pool ecosystems on the Hanford Site. Previous studies have noted flixweed (*Descurainia sophia*), knapweed species (*Centaura*), and Jim Hill tumble-mustard (*Sisymbrium altissimum*) as particularly invasive in vernal pools (Bjork and Dunwiddie 2004). Native species, such as toad rush (*Juncus bufonius*), also appears to increase with greater disturbance in the pools (Brown 2001).

Among the non-natives found in the pools, four species are listed as noxious weeds by the Washington State Noxious Weed Control Board (2017).

- *Kochia scoparia* (kochia), *Lepidium latifolium* (broad-leaved pepperweed), and *Rhaponticum repens* (Russian knapweed) are categorized as Class B noxious weeds, which are nonnative species whose distribution is limited to portions of Washington State. The goal with Class B weeds is to prevent them from spreading into new areas and to contain or reduce their population in already infested areas. None of these weeds are designated for control in Benton County because these species are already abundant; however, these species are controlled on the Hanford Site.

- *Convolvulus arvensis* (field bindweed) is a Class C noxious weed. Class C weeds are widespread in Washington State or are of special interest to the agricultural industry.

In the mid-1990s during the TNC survey, a heavy infestation of the aggressive weed *Centaurea solstitialis* (yellow starthistle) was noted in the vernal pools on Gable Mountain (DOE 1998). This species appears to have been controlled and was not seen during the 2017 surveys.

<u>Biological Soil Crusts</u>
As the vernal pools began to dry out, the coverage of the basin area by nonvascular plants became apparent in a number of the pools. A variety of mosses and liverworts were observed, although no attempt was made to quantify the coverage or the species composition of these species in the biological soil crust in the 2017 study. Figure 2-48 depicts two areas within recently dried vernal pools where mosses and liverworts were especially prevalent.

Figure 2-48. Mosses and Liverworts Growing in Recently Dried Vernal Pool Basins

2.10.4.4 Wildlife Use. Wildlife and wildlife signs were noted during visits to the vernal pools throughout the season. In addition to this incidental data, trail cameras were set up at some pools to capture wildlife present at the pool throughout the day. In April and May, specific sampling efforts focused on the presence or absence of breeding anurans and macroinvertebrates in the pools that still contained water.

<u>Large Mammal Use</u>
Evidence of the use of vernal pools by the larger mammals on the Hanford Site was found in every vernal pool studied during spring 2017. The trail cameras placed at selected vernal pools also recorded the use of pools at all three locations by mule deer, elk, and coyotes (Figure 2-49). The trail cameras usually operated for a few days at a time because curious elk generally knocked them down.

Figure 2-49. Trail Camera Photos of Elk on Umtanum Ridge and Mule Deer at Gable Mountain Pools

(The pictures above have been lightened for better viewing.)

Footprints made by Rocky Mountain elk (*Cervus elaphus nelso*ni), mule deer (*Odocoileus hermionus*), and coyote (*Canis latrans*) were sometimes so numerous that the basin of the vernal pools and the surrounding area were pockmarked by the numerous indentations. The microhabitat afforded by these footprints were often the sites for the germination of the annuals colonizing the pools after dryout.

Scat left by elk, mule deer, coyote, and Nuttall's cottontail rabbit (*Sylvilagus nuttallii*) was also common in and adjacent to the pools (Figure 2-50). Other signs of wildlife use include elk antler sheds and coyote dig sites (Figure 2-51).

Figure 2-50. Typical Scat Found In or Adjacent to the Vernal Pools

Figure 2-51. Signs of Vernal pool Use by Large Mammals

<u>Avian Use</u>

A review of avian uses of vernal pools in California documented over 65 taxa that were found in or adjacent to pools. The diversity of bird species found was attributed to the distinct habitat features of the pools such as water surface areas, water depth, inundation period, soil moisture gradient, vegetation zones and condition, invertebrate biota compositions of and proximity to wetland complexes, tradition, and disturbance. Zones within the vernal pools that vary throughout the season as the pools fill and dry out contain an array of micro- and macro-habitats from open water to mudflats and dry pool beds (Silveira 1998).

Although there were no formal surveys of bird use at the Hanford Site vernal pools in 2017, incidental observations included sightings of waterfowl, wading birds, and sagebrush dwelling passerines at the pools.

Waterfowl observed included four Bufflehead ducks (*Bucephela albeola*) seen in the large pool (GB-4) on the saddle of Gable Butte on April 6, a pair of Mallards (*Anas platyrhynchos*) captured by a trail camera in the vernal pool in the Gable Butte Blind Canyon on April 13 (Figure 2-52), and another Mallard pair seen in large pool on Gable Butte (pool GB-4) on April 28. Both the Mallards and the Buffleheads were on the surface of the pools feeding when observed, and all of the birds remained feeding through the site visits. Silveira (1998) noted that the shallow vernal pools resulted in optimal foraging depths for a number of waterfowl species, including Mallards, which prefers water depths of less than 25.4 cm

(10 in.). This was consistent with the depths of the two pools in which they were observed in 2017. The diversity of aquatic invertebrates in the pools was credited with providing high protein foods for dabbling ducks.

Shorebirds seen included a Greater Yellowlegs (*Tringa melanoleuca*) feeding along the margin of the GB-4 pool on April 6, and Least Sandpipers (*Calidris minutilla*) feeding in the mud along the margins of the GB-7 pool on April 28 (Figure 2-52). Greater Yellowlegs, aquatic gleaners, generally prefer areas with a water depth of less than 15.2 cm (6 in.), while sandpipers are aquatic gleaners that generally feed along shorelines and in mudflats (Silveira 1998).

An empty Horned Lark (*Eremophila alpestris*) nest was noticed on May 8 in the basin of pool U-2 on Umtanum Ridge; this pool had dried out in mid-March (Figure 2-52). Silveira (1998) noted that Horned Larks were generally observed using the dry pool beds.

A Western Meadowlark (*Sturnella neglecta*) was captured by a trail camera at pool U-4 on Umtanum on April 4 (Figure 2-52). Silveira (1998) observed Meadowlarks feeding on the mudflats and dried vernal pool beds. It is interesting to note that Horned Larks and Western Meadowlarks were two of three most commonly observed passerines in a study of avian use of vernal pools on the Santa Rosa plateau as well (Baker et al. 1992).

Three Common Nighthawks (*Chordeiles minor*) were observed circling over the vernal pools on the saddle of Gable Mountain during the visit in mid-July. Although no direct interaction with the dried vernal pools was seen during the visit, it is interesting to note that Silveira (1998) comments on Nighthawks nesting in dry vernal pool beds.

Because vernal pools often are found at a distance from more permanent water sources and some pools may not fill each year, waterfowl and shorebirds are considered to be an important dispersal agent for propagules among vernal pool groups. This dispersal may have important consequences for populations and species diversity of vernal pool plants and invertebrates (Silveira 1998, Baker et al. 1992).

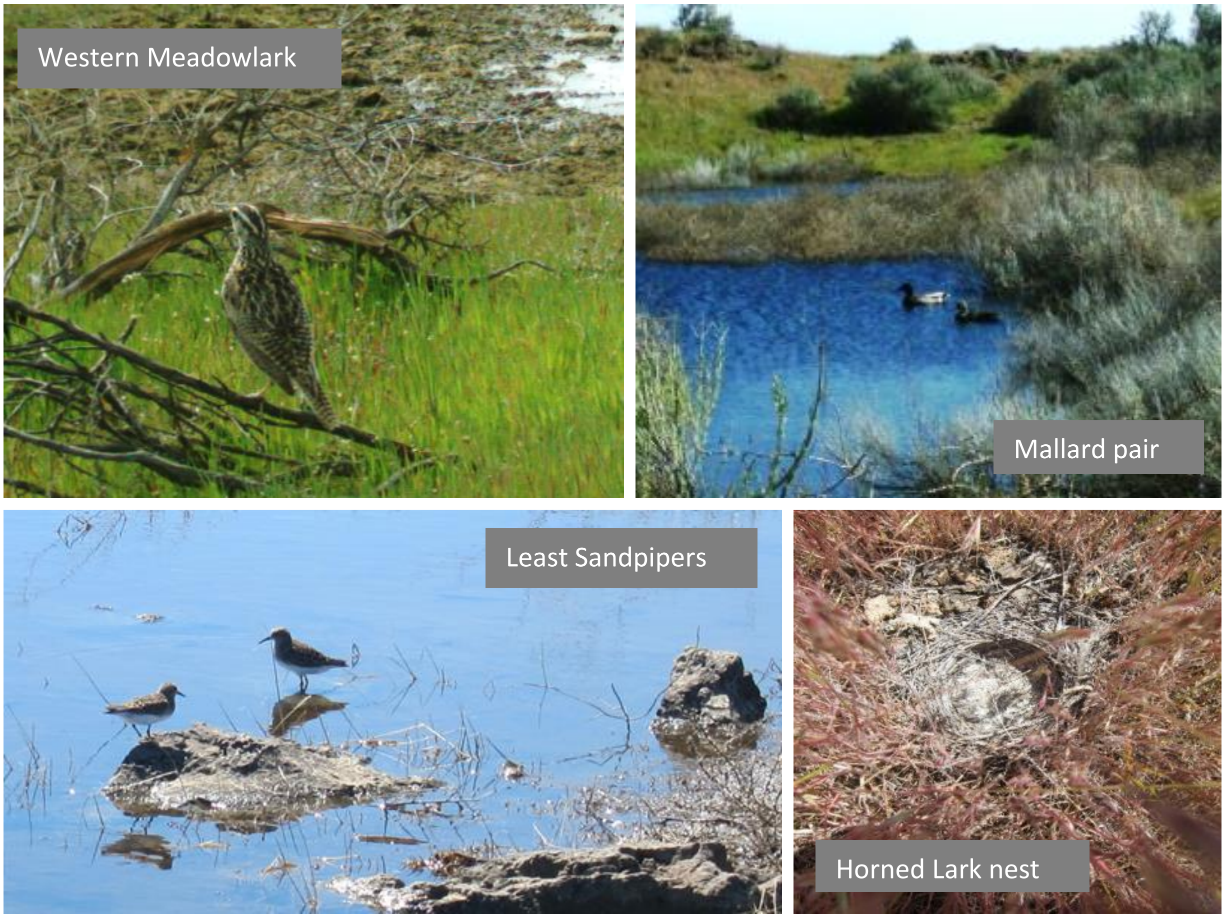


Figure 2-52. Avian Use of the Vernal Pools

Anurans

In late April 2017, a large number of spadefoot toad tadpoles were seen in the largest vernal pool (GB-4) on Gable Butte. Although the duration of this vernal pool in 2017 is not certain, significant water was still present when the tadpoles were observed. Figure 2-53 shows one of the largest tadpoles observed.

A study done on the vernal pool duration and metamorphosis of the western spadefoot toad (*Spea hammondii*) in California concluded that pools need to persist 5 weeks after breeding to support successful metamorphosis (Morey 1998). The key conclusions of this work were:

- The size and somatic condition of the adult toads are positively correlated with pool duration.
- The risk of mortality sharply increases in pools that dry sooner than about 35 days after breeding.

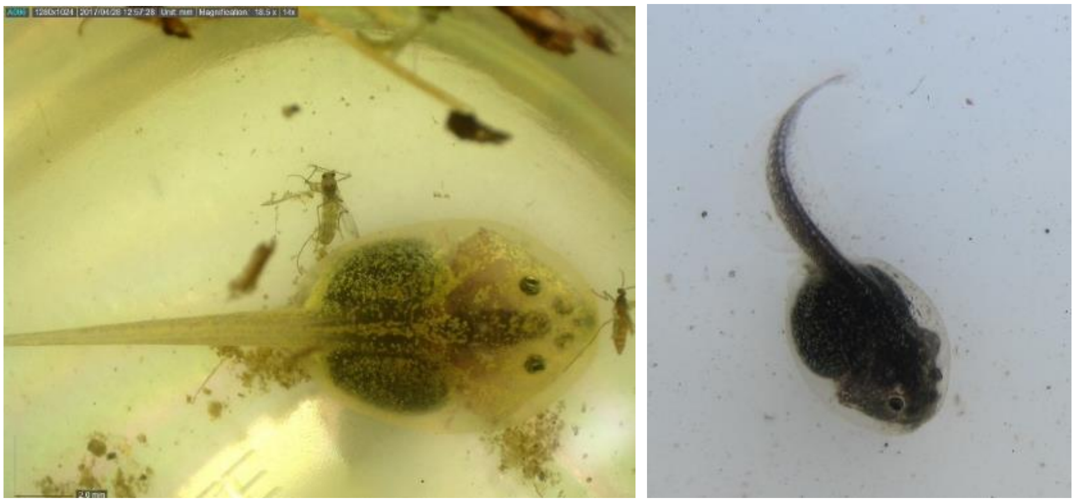


Figure 2-53. Great Basin Spadefoot Toad Tadpoles in Vernal Pool on Gable Butte (4/28/2017)

Macroinvertebrates

The goals for sampling within active vernal pools were first to determine whether or not the pools supported an active population of macroinvertebrates and, second, to look specifically for the presence or absence of fairy shrimp. Fairy shrimp are of particular interest because these crustaceans can survive prolonged periods (sometimes decades) of heat and desiccation by forming a cyst in a late stage of embryonic development, allowing them to persist through the sometimes lengthy dry periods in the vernal pool environment. Because the cyst contains a well-developed embryo, fairy shrimp can quickly develop into mature adults when conditions are right, reproducing before the vernal pool dries out. In addition, not all the dormant cysts appear to hatch in a single season. Three species of fairy shrimp known from the vernal pools of California[3] (conservancy fairy shrimp [*Branchinecta conservation*], longhorn fairy shrimp [*Branchinecta longiantenna*], and vernal pool fairy shrimp [*Branchinecta lynchi*]) are currently listed as Endangered (conservancy and longhorn fairy shrimp) or Threatened (vernal pool fairy shrimp) under the ESA.

Macroinvertebrates were collected in all of the pools assessed and the basic organisms observed appeared to be common to all of the pools. As the season progressed the size of the populations increased dramatically, and a net was not needed to ascertain the presence of the many aquatic insects inhabiting the pools. Because the initial goal of the monitoring was to ascertain whether free-swimming macroinvertebrate populations could be found in the pools on the Hanford Site, no attempt was made to identify these organisms below the family classification level. The major types of macoinvertebrates found during 2017 consisted of the following (Figure 2-54):

- **Water boatmen** (Family Corixidae, Order Hemiptera - true bugs) were the first insect seen in the late winter. They increased in numbers as the season progressed and persisted throughout the time the pools were full.

- **Mosquitoes** (Family Culicidae, Order Diptera - flies) were found with increasing regularity as the season progressed. All stages of the mosquito life cycle were observed.

[3] Vernal pool fairy shrimp have also been documented in vernal pools in southern Oregon.

- **Midges** (Family Chironomidae, Order Diptera - flies) are sometimes known as Blind Mosquitoes because they resemble mosquitoes; however, male midges tend to have feathery antennae, something not seen on mosquitoes. Larvae are worm-like and are sometimes called blood worms. Larvae were commonly seen in the pools.

- **Predaceous diving beetle** (Family Dytiscidae,Order Coleoptera - beetles) first became noticeable later in the season. Both the larvae, commonly known as water tigers, and adults were seen in the pools.

- **Water Striders** (Family Gerridae, Order Hemiptera – true bugs) were not seen as commonly as the insects above but could be seen skating across the surface of the pools, particularly the larger pool on Gable Butte.

A smaller net was used to look for fairy shrimp (Order Anostraca). Despite a focused search throughout the later part of the season, none were seen in any of the pools in 2017.

A previous study of free-swimming invertebrate communities in eastern Washington vernal pools found eight species of crustaceans (four species of copepods [Copepoda]; one species each of seed shrimps [Ostracoda], water fleas [Cladocera], clam shrimps [Conchostrac], and fairy shrimps [Anostraca]) and seven species of swimming insects (two species of mosquitos [Culicidae], four species of diving beetles [Dytiscidae], and one species of water strider [Gerridae]). In addition, rotifers (Rotifera) and water mites (Acarina) were collected (Kulp and Rabe 1984). The vernal pools surveyed were in areas with much higher rainfall than the Hanford Site. Activity traps and a Wilding sampler were used to collect samples, which may account for the greater number of taxa seen.

Figure 2-54. Macroinvertebrates found in Hanford Vernal Pools

2.10.5 Management Actions and Proposed Future Monitoring

The results of the monitoring of vernal pools on the Hanford Site initiated the following management actions:

- All pool location will be used to update the Hanford Site map of Level 5 resources, which is generally published in the BRMP (DOE/RL-96-32).

- The locations of populations of noxious weeds (Washington Noxious Weed Control Board 2017) found in or encroaching upon the vernal pools will be referred to Mission Support Alliance's Biological Controls group for control of those plants.

- The vernal pools will be evaluated as potential plant community element occurrences. Proper documentation will be submitted to the Washington Natural Heritage Program if the criteria for an element occurrence are met.

Based on the 2017 monitoring, the future monitoring tasks are recommended.

- While the vernal pool areas are fairly well defined in the field, these pools probably do not fill with water every year. Even if the pools do contain water, the size likely varies significantly from year to year. In order to better understand the vernal pools on the Hanford Site, an annual survey should be done in the mid-February to March timeframe (after any surface snow has melted). This survey should include GIS mapping of the perimeters of any pools present.

- Vegetation monitoring should be for a series of years, including both wet and dry years, so that the ecological impact of the intermittent flooding in the species coverage and diversity can be better understood. Transects that traverse the center of the pool would be useful to further delineate any zonation that may be occurring in the pools.

- Rare plant monitoring should occur in years when the vernal pools are present because the three Washington State-listed species previously identified (Suksdorf's monkeyflower, mousetail, and spreading pygmyleaf) as residing in the pools are small annual plants that may not be present in the drier years. Periodic monitoring may allow a better understanding of the conditions needed for germination and survival of these rare species.

- More complete and specific monitoring of the pools for macroinvertebrates should be done when pools are present. The 2017 monitoring was completed to assess whether or not the pools supported these organisms, and because the 2017 survey indicated that, indeed, a large diverse population is present; therefore, a more focused survey should be completed. Survey methods should be chosen to make sure all potential macroinvertebrate taxa are likely to be found and a more detailed identification of the organisms present should be made (i.e., to genus level or below if practical). Sampling for fairy shrimp needs to begin earlier in the season since these organisms generally are found in cool-water pools. Some vernal pool species require temperatures of 50 °F (10 °C) or less to hatch (FWS 2007b).

- The largest pool on Gable Butte supported numerous spadefoot toad tadpoles in 2017; although the tadpoles were noted, it is not known if they were able to complete full metamorphosis before the pool dried out. A more focused study of the timing for egg laying, tadpole development, as well as pool conditions would add much to the understanding of this species onsite. In addition, call surveys for Woodhouse's toads (*Anaxyrus woodhousii*), a Washington State Monitor species restricted to shrub-steppe habitat in the Columbia Plateau Ecoregion (WDFW 2015), should be done to see if they also use the vernal pools for egg laying.

- The information on bird use of the pools was collected incidentally in 2017. Focused bird surveys of the pools would provide additional information about their importance to a range of birds from waterfowl and shorebirds to upland species during the spring nesting season. These birds may be quite important in the spread of vegetation and macroinvertebrates within and among the pools onsite.

- A more focused study of the use of the pools by mammals is also recommended. Trail cameras were useful but limited by the ease with which elk, in particular, knocked them over and rendered them useless. Small mammal use of the pools was not specifically studied or observed in 2017. More focus on the identification of tracks and scat found in the mud within the pool area or live traps may provide additional data.

3.0 REFERENCES

62 FR 43937. National Marine Fisheries Service. "Endangered and Threatened Species: Listing of Several Evolutionarily Significant Units of West Coast Steelhead." August 18, 1997. *Federal Register*. Online at: http://www.westcoast.fisheries.noaa.gov/publications/frn/1997/62fr43937.pdf.

65 FR 7764. National Marine Fisheries Service. "Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California." Final Rule. February 16, 2000. *Federal Register*. Online at: http://www.westcoast.fisheries.noaa.gov/publications/frn/2000/65fr7764.pdf.

65 FR 37253. 2000. "Establishment of the Hanford Reach National Monument." *Federal Register,* Washington, D.C. Online at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2000_register&docid=00-15111-filed.pdf.

70 FR 46924 – 46995. "Endangered and Threatened Wildlife and Plants; Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon." August 11, 2005.

70 FR 52630. National Marine Fisheries Service. "Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho." September 2, 2005. *Federal Register*. Online at: http://www.westcoast.fisheries.noaa.gov/publications/frn/2005/70fr52630pre.pdf.

76 FR 50447. National Marine Fisheries Service. "Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead In California." Notice of availability of 5-year reviews. August 15, 2011. *Federal Register*. Online at: http://www.westcoast.fisheries.noaa.gov/publications/frn/2011/76fr50447.pdf.

ACE. 2006. *Hanford Reach Fall Chinook Protection Program, Hanford Reach Fall Chinook Protection Program Executed Agreement*. U.S. Army Corps of Engineers, Richland, Washington. Online at: http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/2006/draft/app7.pdf.

Anglin, D. R., S. L. Haeseker, J. J. Skalicky, H. Schaller, K. F. Tiffan, J. R. Hatten, P. Hoffarth, J. Nugent, D. Benner, and M. Yoshinaka. 2006. *Effects of Hydropower Operations on Spawning Habitat, Rearing Habitat, and Stranding/Entrapment Mortality of Fall Chinook Salmon in the Hanford Reach of the Columbia River*. Final Report. Columbia River Fisheries Program Office, U.S. Fish and Wildlife Service, Vancouver, Washington.

Baker, W. S., F. E. Hayes, and E. W. Lathrop. 1992. "Avian Use of Vernal Pools at the Santa Rosa Plateau Preserve, Santa Ana Mountains, California." *The Southwestern Naturalist* 37(4):392-403.

Bald and Golden Eagle Protection Act of 1940, 16 U.S.C. 668-668d, et seq. Online at https://www.fws.gov/birds/policies-and-regulations/laws-legislations/bald-and-golden-eagle-protection-act.php.

Belthoff, J. R. and R. A. King. 2002. "Nest-site characteristics of Burrowing Owls (*Athene cunicularia*) in the Snake River Birds of Prey National Conservation Area, Idaho, and Applications to Artificial Burrow Installation." *Western North American Naturalist* 62 (1):112-119.

Bjork, C. R. and P. W. Dunwiddie, 2004, "Floristics and Distribution of Vernal Pools on the Columbia Plateau of Eastern Washington." *Rhodora* 106(928):327-347.

Bjornn, T. C. and D. W. Reiser. 1991. "Habitat requirements of salmonids in streams." *Influences of forest and rangeland management on salmonid fishes and their habitats*. American Fisheries Society Special Publication 19: 83-138. Online at: https://www.for.gov.bc.ca/hfd/library/ffip/Bjornn_TC1991.pdf.

BNWL-243. 1966. *Soil Survey Hanford Project in Benton County, Washington*, Pacific Northwest Laboratory, Richland, Washington. Online at: https://www.osti.gov/servlets/purl/6152345.

BNWL-1530. 1973. *Behavior of Ultrasonic Tagged Chinook Salmon and Steelhead Trout Migrating Past Hanford Thermal Discharges (1967)*. Battelle Pacific Northwest Laboratories, Richland, Washington.

Brown, W. L. 2001. "Eastern Washington Vernal Pools: Ecology and Conservation." *Conservation of Washington's Rare Plants and Ecosystems*, pp. 144-150, Washington Native Plant Society, Seattle, Washington.

Burger, J. 1978. "Pattern and mechanism of nesting in mixed-species heronries." *Wading birds*. Natl. Audubon Soc. Res. Rep. 7: 45-58

Bystrak, D. 1981. *The North American Breeding Bird Survey.* Cooper Ornithological Society, Allen Press, Lawrence, Kansas. Online at: http://pubs.er.usgs.gov/publication/5210285.

Clean Water Act of 1977. 33 USC 1251, et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601-9675, et seq.

Conway, C. J. and K. L. Pardieck. 2006. "Population trajectory of burrowing owls in eastern Washington." *Northwest Science* 80:292-297.

Conway, C. J., V. Garcia, M. D. Smith, L. A. Ellis, and J. Whitney. 2006. "Comparative demography of burrowing owls within agricultural and urban landscapes in southeastern Washington." *Journal of Field Ornithology* 77:280-290.

Conway, C. J., V. Garcia, M. D. Smith, and K. Hughes. 2008. "Factors affecting detection of burrowing owl nests during standardized surveys." *Journal of Wildlife Management* 72:688-696.

COSEWIC. 2006. COSEWIC assessment and update status report on the Burrowing Owl *Athene cunicularia* in Canada. Ottawa: Committee on the Status of Endangered Wildlife in Canada.

Crowe, E. A., A. J. Busacca, J. P. Reganold, and B. A. Zamora. 1994. "Vegetation Zones and Soil Characteristics in Vernal Pools in the Channeled Scabland of Eastern Washington," *Great Basin Naturalist* 54(3): 234-247.

Dauble, D. D. 1998. Letter Report to Keith Wolf, Washington Department of Fish and Wildlife, October 22.

Dauble, D. D. and D. G. Watson. 1997. "Status of Fall Chinook Salmon Populations in the Mid-Columbia River, 1948–1992." *North American Journal of Fisheries Management* 17 (2): 283–300. Online at: http://dx.doi.org/10.1577/1548-8675(1997)017<0283:sofcsp>2.3.co;2.

DOE O 430.1C. 2016. *Real Property Asset Management*. U.S. Department of Energy, Washington, D.C.

DOE. 1998. *Biodiversity Inventory and Analysis of the Hanford Site, 1997 Annual Report.* U.S. Department of Energy, Richland, Washington.

DOE and FWS. 2013. *Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service Regarding Implementation of Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds."* U.S. Department of Energy and U.S. Fish and Wildlife Service, Washington, D.C. Online at: http://energy.gov/sites/prod/files/2013/10/f3/Final%20DOE-FWS%20Migratory%20Bird%20MOU.pdf.

DOE/EIS-0222-FU. 1999. *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. U.S. Department of Energy, Washington, D.C. Online at: http://energy.gov/nepa/downloads/eis-0222-final-environmental-impact-statement-0.

DOE/RL-94-150. 2013. *Bald Eagle Management Plan for the Hanford Site, South-Central Washington*. Rev. 2. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/Hanford%20Bald%20Eagle%20Management%20Plan%20Rev.%202%20-%20FINAL.PDF.

DOE/RL-94-150. 2017. *Bald Eagle Management Plan for the Hanford Site, South-Central Washington*., Rev. 3. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: https://www.hanford.gov/files.cfm/DOE-RL-94-150_Rev3.pdf.

DOE/RL-96-32. 2017. *Hanford Site Biological Resources Management Plan*. Rev. 2. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/DOE-RL-96-32-01.pdf.

DOE/RL-2000-27. 2015. *Threatened and Endangered Species Management Plan: Salmon, Steelhead, and Bull Trout*. Rev. 2. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/DOE-RL-2000-27_Rev_02.pdf.

DOE/RL-2014-52. 2015. *Hanford Site Environmental Report for Calendar Year 2014*. Rev 0. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: http://msa.hanford.gov/files.cfm/DOE-RL-2014-52.pdf.

DOE/RL-2016-33. 2016. *Hanford Site Annual Environmental Report for Calendar Year 2015*. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: http://msa.hanford.gov/page.cfm/enviroreports.

Ecology. 2005. *Wetlands in Washington State – Volume 2: Guidance for Protecting and Managing Wetlands*, Publication #05-06-008. https://fortress.wa.gov/ecy/publications/SummaryPages/0506008.html

Ecology. 2014. *Washington State Wetland Rating System for Eastern Washington*, 2014 Update, Publication # 14-06-030. https://fortress.wa.gov/ecy/publications/documents/1406030.pdf

Eldred, D. 1970. Steelhead Spawning in the Columbia River, Ringold to Priest Rapids Dam, September 1970 Progress Report. Washington Department of Game, Ephrata, Washington. 4 pp.

Endangered Species Act of 1973. 16 U.S.C. 1531-1544, et seq., Public Law 93-205, as amended.

Executive Order 11988. May 24, 1977. "Floodplain Management." *Federal Register*, Office of the President, 32 CFR 644.320. Online at http://www.archives.gov/federal-register/codification/executive-order/11988.html.

Executive Order 11990. May 24, 1977. "Protection of Wetlands." *Federal Register*, Office of the President, 32 CFR 644.319. Online at http://www.archives.gov/federal-register/codification/executive-order/11990.html.

Executive Order 13112, February 3, 1999. "Invasive Species." *Federal Register*, Office of the President, 64 FR 6183. Online at https://www.gpo.gov/fdsys/pkg/FR-1999-02-08/pdf/99-3184.pdf.

Executive Order 13186. January 10, 2001. "Responsibilities of Federal Agencies to Protect Migratory Birds." *Federal Register*, Office of the President, 66 FR 3853 Online at: http://energy.gov/nepa/downloads/executive-order-13186-responsibilities-federal-agencies-protect-migratory-birds.

Federación, Diario Oficial de la. 2008. Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio Lista de especies en riesgo.

Fickeisen, D. H., D. D. Dauble, D. A. Neitzel, W. H. Rickard, R. L. Skaggs, and J. L. Warren. 1980. *Aquatic and Riparian Resource Study of the Hanford Reach, Columbia River, Washington*. Battelle Pacific Northwest Laboratories, Richland, Washington.

Fitzner, R. E. and R. L. Newell. 1989. Ferruginous hawk nesting on the U.S. DOE Hanford Site: case history of a recent invasion caused by transmission lines. In *Proceedings IV: Issues and technology in the management of impacted wildlife*. Pp. 125-132. Thorne Ecological Institute, Boulder, Colorado. Online at: http://www.fs.fed.us/rm/pubs_other/rmrs_1989_davis_p001.pdf.

Fitzner, R. E., D. Berry, L. L. Boyd, and C. A. Rieck. 1977. “Nesting of Ferruginous Hawks (Buteo regalis) in Washington 1974-75.” *The Condor* 79:245-249. Online at: https://sora.unm.edu/sites/default/files/journals/condor/v079n02/p0245-p0249.pdf

Fulton, L. A. 1968. *Spawning Areas and Abundance of Chinook Salmon (*Oncorhynchus tshawytscha*) in the Columbia River Basin--Past and Present*. U.S. Fish and Wildlife Service Special Scientific Report--Fisheries No. 571. 26 pp. Online at: http://www.nwfsc.noaa.gov/assets/26/6638_08042010_145107_Fulton.1968-rev.pdf.

FWS. 1999. *Statistical Guide to Data Analysis of Avian Monitoring Programs*. BTP-R6001-1999. U.S. Fish and Wildlife Service, Washington, D.C

FWS. 2002. *Birds of Conservation Concern*. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia.

FWS. 2007a. *National Bald Eagle Management Guidelines,* U.S. Fish and Wildlife Service, Washington, D.C.

FWS. 2007b. *Vernal Pool Fairy Shrimp (Branchinecta lynchi) – 5-Year Review: Summary and Evaluation*, Sacramento Fish and Wildlife Office, Sacramento, California.

FWS. 2008. *Hanford Reach National Monument Comprehensive Conservation Plan.* U.S. Fish and Wildlife Service, Richland, Washington.

Gray, R. H. and D. D. Dauble. 1976. “Synecology of the Fish Community Near Hanford Generating Project and Assessment of Plant Operational Impacts,” pp. 5.1 to 5.55. In: *Final Report on Aquatic Ecological Studies Conducted at the Hanford Generating Project, 1973-1974*. WPPSS Columbia River Ecology Studies Vol. 1. Washington Public Power Supply System, Richland, Washington.

Greene, E. 1999. *Abundance and habitat associations of Washington ground squirrels in north-central Oregon*, Master’s thesis, Oregon State University, Corvallis, Oregon.

Harnish, R. A., R. Sharma, G. A. McMichael, R. B. Langshaw, and T. N. Pearsons. 2014. “Effect of Hydroelectric Dam Operations on the Freshwater Productivity of a Columbia River Fall Chinook Salmon Population.” *Canadian Journal of Fisheries and Aquatic Sciences* 71 (4): 602–615. Online at: http://www.nrcresearchpress.com/doi/abs/10.1139/cjfas-2013-0276#.WJoXl2czXAU.

Healey, M. C. 1991. “The Life History of Chinook Salmon (Oncorhynchus tshawytscha).” *Life History of Pacific Salmon*, Eds. C. Groot and L. Margolis. pp. 311–393. University of British Columbia Press, Vancouver, British Columbia, Canada.

HNF-52190. 2012. *Fall Chinook Redd Monitoring Report Calendar Year 2011*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/hnf-52190_-_rev_00%20public%20relesed.pdf.

HNF-53073. 2013. *Raptor Nest Monitoring Report for Calendar Year 2012*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-53073_-_rev_00_No_Coversheets.pdf.

HNF-53075. 2012. *Ground Squirrel Monitoring Report for Calendar Year 2012*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-53075_-_Rev_00.pdf

HNF-53665. 2012. *Steelhead Redd Monitoring Report for Calendar Year 2012*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/hnf-53665_-_rev_00.pdf.

HNF-53759. 2012. *Summer Bat Monitoring Report for Calendar Year 2012.* Rev. 0. Mission Support Alliance, Richland, Washington. Online at: https://www.hanford.gov/files.cfm/HNF-53759_-_Rev_00_no_coversheets.pdf.

HNF-54808. 2013. *Hanford Reach Fall Chinook Redd Monitoring Report for Calendar Year 2012*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/hnf-54808_-_rev_00_nc.pdf.

HNF-55491. 2013. *Hanford Roadside Bird Surveys Report for Calendar Year 2012*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: https://www.hanford.gov/files.cfm/hnf-55491_rev_0_release.pdf.

HNF-56374. 2013. *Ground Squirrel Monitoring Report for Calendar Year 2013*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-56374_-_Rev_00.pdf

HNF-56705. 2014. *Hanford Site Steelhead Redd Monitoring Report for Calendar Year 2013*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-56705_-_Rev_00.pdf.

HNF-56707. 2014. *Hanford Reach Fall Chinook Redd Monitoring Report for Calendar Year 2013*. HNF-56707. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-56707_-_Rev_00.pdf.

HNF-56769. 2014. *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2013*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-56769_-_Rev_00.pdf.

HNF-58717. 2015. *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2014*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-58717_-_Rev_00.pdf.

HNF-58823. 2015. *Hanford Reach Fall Chinook Redd Monitoring Report for Calendar Year 2014*., Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-58823_-_Rev_00.pdf.

HNF-59116. 2015. *Hanford Site Steelhead Redd Monitoring Report for Calendar Year 2015.* Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-59116_-_Rev_00.pdf.

HNF-59755. 2016. *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2015*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-59755_-_Rev_00.pdf.

HNF-59813. 2016. *Hanford Reach Fall Chinook Redd Monitoring Report for Calendar Year 2015*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-59813_-_Rev_00.pdf.

HNF-60469. 2016. *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2016*. Rev 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF_60469-00_Cleared_without_forms.pdf.

HNF-61417. 2017. *Upland Vegetation of the Central Hanford Site*. Rev. 0. Mission Support Alliance, Richland, Washington. Online at: https://www.hanford.gov/files.cfm/HNF-61417-00_WO_Cover.pdf

HNF-62115. 2018. *Ecological Monitoring Report: Vernal Pools on the Hanford Site.* Rev. 0. Mission Support Alliance, Richland, Washington.

PNNL-15160. 2005. *Hanford Site Climatological Summary 2004 with Historical Data*. Pacific Northwest National Laboratory, Richland, Washington. Online at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-15160.pdf

Johnson, D. H, M. A. Gillis, J. L. Rebholz, J. L. Lincer and J. R. Belthoff. 2013. *Users Guide to Installation of Artificial Burrows for Burrowing Owls Version 2.0.* Tree Top Inc., Selah, Washington.

Klute, D. S., L. W. Ayers, M. T. Green, W. H. Howe, S. L. Jones, J. A. Shaffer, S. R. Sheffield, and T. S. Zimmerman. 2003. *Status assessment and conservation plan for the Western Burrowing Owl in the United States*. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C.

Kulp, R. L. and F. W. Rabe. 1984. "Free-Swimming Invertebrate Communities of Vernal Pools in Eastern Washington." In *Northwest Science* 58(3):177-186. http://www.fsl.orst.edu/rna/Documents/publications/Free-swimming%20invertebrate%20communities%20of%20vernal%20pools%20in%20Eastern%20Washington%201984.PDF

Larson, K. B. 2009. *Nest Habitat Selection of Burrowing Owls in Relation to Soils, Burrow Availability, and Burrow Temperature*. MS Thesis. Washington State University, Pullman, Washington.

Lichvar, R. W., D. L. Banks, W. N. Kirchner, and N. C. Melvin. 2016. "The National Wetland Plant List: 2016 Wetland Ratings for the Arid West." In *Phytoneuron* 2016-30: 1-17. Online at: http://wetland-plants.usace.army.mil/.

Magnuson-Stevens Fisheries Conservation and Management Act. 16 USC 1801-1884.

Migratory Bird Treaty Act of 1918, 16 U.S.C. 703, et seq.

Morey, S. R. 1998. "Pool Duration Influences Age and Body Mass at Metamorphosis in the Western Spadefoot Toad: Implications for Vernal Pool Conservation," In *Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference*, California Native Plant Society, Sacramento, California.

Moritsch, M. Q. 1985. *Photographic Guide for Aging Nestling Ferruginous Hawks*. U.S. Department of the Interior, Bureau of Land Management, Snake River Birds of Prey Project, Boise, Idaho. Online at: https://archive.org/details/photographicguid26mori.

MSA. 2018. *Hanford Meteorological Station - Monthly and Annual Precipitation*, Richland, Washington. Website accessed in February and March 2018. Online at: https://www.hanford.gov/page.cfm/MetandClimateDataSummary.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. *NOAA Technical Memorandum NMFS-NWFSC-35 Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, Washington. Online at: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/chinook/sr1998-chinook1.pdf.

National Environmental Policy Act of 1969, 42 U.S.C. 4321, et seq.

Netboy, A. 1958. *Salmon of the Pacific Northwest: Fish vs. Dams*. Binfords & Mort, Portland, Oregon.

Ng, J., M. D. Giovanni, M. J. Bechard, J. K. Schmutz, and P. Pyle. 2017. "Ferruginous Hawk (Buteo regalis)." Version 2.0. In *The Birds of North America*. Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/bna.ferhaw.02.

Nugent, J. J. 1995. *Nest-Site and Habitat Selection of Buteo Species in Southeastern Washington and the Use of Geographic Information Systems to Model Nest Habitat Quality*. MS Thesis. University of Montana, Missoula, Montana. Online at: http://scholarworks.umt.edu/cgi/viewcontent.cgi?article=7568&context=etd.

Orcutt, D. R., B. R. Pulliam, and A. Arp. 1968. "Characteristics of Steelhead Trout Redds in Idaho Streams." *Transactions of the American Fisheries Society* 97: 42-45.

Ormsbee, P. C., J. D. Kiser, and S. I. Perimeter. 2007. *Importance of Night Roosts to the Ecology of Bats.* Chapter 5 – Bats in Forests, Conservation and Management. The John Hopkins University Press, Baltimore, Maryland.

PNL-3212. 1981. *Raptors of the Hanford Site and Nearby Areas of Southcentral Washington*. Pacific Northwest National Laboratory, Richland, Washington.

PNL-5371. 1985. *Anadromous Salmonids of the Hanford Reach, Columbia River: 1984 Status*. Pacific Northwest Laboratory, Richland, Washington. Online at: http://www.osti.gov/energycitations/product.biblio.jsp?query_id=5&page=0&osti_id=5222130.

PNL-7289. 1990. *Spawning and Abundance of Fall Chinook Salmon (*Oncorhynchus tshawytscha*) in the Hanford Reach of the Columbia River, 1948–1988*. Pacific Northwest Laboratory, Richland, Washington. Online at: http://pdw.hanford.gov/arpir/index.cfm/docDetail?accession=D196110653.

PNL-8942. 1993. *Habitat Types on the Hanford Site: Wildlife and Plant Species of Concern*. Pacific Northwest Laboratory, Richland, Washington. Online at: https://www.osti.gov/scitech/servlets/purl/10110777.

PNNL-6415. 2007. *Hanford Site National Environmental Policy Act (NEPA) Characterization*. Rev 18. Pacific Northwest National Laboratory, Richland, Washington. Online at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-6415Rev18.pdf

PNNL-13055. 1999. *Steelhead Spawning Surveys Near Locke Island, Hanford Reach of the Columbia River*. Pacific Northwest National Laboratory, Richland, Washington. Online at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13055.pdf.

PNNL-23719. 2014. *Survival of Wild Hanford Reach and Priest Rapids Hatchery Fall Chinook Salmon Juveniles in the Columbia River: Predation Implications*. Pacific Northwest National Laboratory, Richland, Washington.

PNNL-SA-46396. 2005. *Breeding Population Status and Nest Site Characterization of Hawks (Buteo spp.) and Common Ravens (Corvus corax) on the Hanford Site, Southcentral Washington.* Pacific Northwest National Laboratory, Richland, Washington.

PNNL-SA-75348. 2010. *Assessment of Apatite Injection at 100-NR-2 for Potential Impact on Threatened and Endangered Species*. Pacific Northwest National Laboratory Richland, Washington. Online at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084235.

Poulin, R. G., L. D. Todd, E. A. Haug, B. A. Millsap, and M. S. Martell. 2011. "Burrowing Owl (Athene cunicularia), version 2.0." *The Birds of North America*. Cornell Lab of Ornithology, Ithica, New York. Online at: https://doi.org/10.2173/bna.61.

Presidential Memorandum. 2014. "Presidential Memorandum—Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators." *Federal Register,* Office of the President, 79 FR 35903-35907. Online at: https://obamawhitehouse.archives.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Rocchio, F. J. and R. C. Crawford. 2015a. *Conservation Status Ranks of Washington's Ecological Systems*, Natural Heritage Report 2015-03, Washington Natural Heritage Program, Washington State Department of Natural Resources, Olympia, Washington. http://file.dnr.wa.gov/publications/amp_nh_conservation_status.pdf

Rocchio, F. J. and R. C. Crawford, 2015b, *Ecological Systems of Washington State. A Guide to Identification*, Natural Heritage Report 2015-04, Washington Natural Heritage Program, Washington State Department of Natural Resources, Olympia, Washington. http://file.dnr.wa.gov/publications/amp_nh_ecosystems_guide.pdf.

Rogers, L. E. and K. A. Gano. 1980. "Townsend Ground Squirrel Diets in the Shrub-Steppe of Southcentral Washington." *Journal of Range Management* 33 (6): 463–465.

Sharpe, P. B. and B. Van Horne. 1998. "Influence of habitat on behavior of Townsend's ground squirrels (*Spermophilus townsendii*)." *Journal of Mammalogy* 79 (3): 906–918.

Sato, C. 2012. "Appendix A.5: Habitat Connectivity for Townsend's Ground Squirrel (*Urocitellus townsendii*) in the Columbia Plateau Ecoregion." *Washington Connected Landscapes Project: Analysis of the Columbia Plateau Ecoregion*. Washington Wildlife Habitat Connectivity Working Group. Washington's Department of Fish and Wildlife and Department of Transportation, Olympia, Washington. Online at: http://www.waconnected.org/wp-content/themes/whcwg/docs/A5_TownsendsGroundSq_ColumbiaPlateau_2012.pdf.

Sauer, J. R., J. E. Fallon, and R. Johnson. 2003. *Use of North American Breeding Bird Survey Data to estimate population change for bird conservation regions*. J. Wildlife Management 67:372-389.

Sauer, J. R, J.E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. *The North American Breeding Bird Survey 1966-2009 Summary Analysis and Species Accounts.* USGS Patuxent Wildlife Research Center, Laurel, Maryland. Online at: https://www.mbr-pwrc.usgs.gov/bbs/bbs2009.html.

Sharpe, P. B. and B. Van Horne. 1998. "Influence of habitat on behavior of Townsend's ground squirrels (*Spermophilus townsendii*)." *Journal of Mammalogy* 79 (3): 906–918.

Sikes Act, 16 USC 670a-670o, PL 86-797, as modified by PL 93-452.

Silveira, J. G. 1998. "Avian Uses of Vernal Pools and Implications for Conservation Practice," *Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1966 Conference*, California Native Plant Society, Sacramento, California.

Stables, T. B. and B. L. Tiller. 2007. *Suitability of Aquatic Habitat for Steelhead Spawning at Selected Sites in the Hanford Reach of the Columbia River, Measured February 21-25, 2007*. Environmental Assessment Services, Richland, Washington.

Steenhof, K. and I. Newton. 2007. “Assessing Nesting Success and Productivity.” *Raptor Research and Management Techniques*, Hancock House Publishers, Blaine, Washington. Online at: http://www.raptorresearchfoundation.org/files/2015/10/Raptor_Research_all.pdf.

Swan, G. A. 1989. “Chinook Salmon Spawning Surveys in Deep Waters of a Large, Regulated River.” *Regulated Rivers: Research & Management* 4 (4): 355–370. Online at: http://www.nwfsc.noaa.gov/assets/2/7293_07122012_094837_Swan.1989.pdf.

Thomas, D. W., M. Dorais, and J. Bergeron. 1990. “Winter Energy Budgets and Cost of Arousals for Hibernating Little Brown Bats, Myotis lucifugus.” *Journal of Mammalogy* 71(3):475-479.

TNC. 1999. *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999.* The Nature Conservancy, Seattle, Washington.

USDA. 1993. *Handbook of Field Methods for Monitoring Landbirds.* U. S. Department of Agriculture, Pacific Southwest Research Station, Albany, California. Online at: http://www.fs.fed.us/psw/publications/documents/psw_gtr144/psw_gtr144.pdf.

Visser, R., D. D. Dauble, and D. R. Geist. 2002. “Use of Aerial Photography to Monitor Fall Chinook Salmon Spawning in the Columbia River.” *Transactions of the American Fisheries Society* 131 (6): 1173–1179. Online at: http://dx.doi.org/10.1577/1548-8659(2002)131<1173:uoaptm>2.0.co;2.

WAC 232-12-297. “Endangered Threatened, and Sensitive Wildlife Species Classification.” *Washington Administrative Code*, Olympia, Washington. Online at: http://apps.leg.wa.gov/wac/default.aspx?cite=232-12-297.

Washington Gap Analysis Project. 1997. Gap Analysis Predicted Distribution Map for Burrowing Owls. Online at: http://naturemappingfoundation.org/natmap/maps/wa/birds/WA_burrowing_owl.html.

Watson, D. G. 1973. *Estimate of Steelhead Trout Spawning in the Hanford Reach of the Columbia River*. Battelle Pacific Northwest Laboratories, Richland, Washington.

WDFW. 1996. *Washington State Recovery Plan for the Ferruginous Hawk*. Washington Department of Fish and Wildlife, Olympia, Washington. Online at: https://wdfw.wa.gov/publications/01336/wdfw01336.pdf.

WDFW. 2002. *2001 Evaluation of Juvenile Fall Chinook Salmon Stranding on the Hanford Reach of the Columbia River*. Bonneville Power Administration and the Public Utility District Number 2 of Grant County, Washington State Department of Fish and Wildlife, Olympia, Washington. Online at: https://wdfw.wa.gov/publications/00189/

WDFW. 2004. *Management Recommendations for Washington's Priority Species – Volume IV: Birds*. Washington Department of Fish and Wildlife, Olympia, Washington. Online at: http://wdfw.wa.gov/publications/00026/wdfw00026.pdf.

WDFW. 2013. *Threatened and Endangered Wildlife in Washington: 2011 Annual Report Management Recommendations for Washington's Priority Species – Volume IV: Birds*. Washington Department of Fish and Wildlife, Olympia, Washington. Online at: http://wdfw.wa.gov/publications/01385/wdfw01385.pdf.

WDFW. 2015. *State Wildlife Action Plan Update, Appendix A-3, Species of Greatest Conservation Need, Fact Sheets, Amphibians and Reptiles*. Washington Department of Fish and Wildlife, Olympia, Washington. Online at: http://wdfw.wa.gov/publications/01742/12_A3_Reptiles_and_Amphibians.pdf

WDFW. 2017. *Species of Concern in Washington. Washington Department of Fish and Wildlife*. Washington Department of Fish and Wildlife, Olympia, Washington. Online at: http://wdfw.wa.gov/conservation/endangered/.

WHC-EP-0402. 1992. *Status of Birds at the Hanford Site in Southeastern Washington*. Rev. 1. Westinghouse Hanford Company, Richland, Washington. Online at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196103569.

WHC-EP-0513. 1994. *Threatened and Endangered Wildlife Species of the Hanford Site Related to CERCLA Characterization Activities*. Westinghouse Hanford Company, Richland, Washington. Online at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D196075970.

WHCWG. 2012. W*ashington Connected Landscapes Project: Analysis of the Columbia Plateau Ecoregion*. Washington's Department of Fish and Wildlife and Department of Transportation, Wildlife Habitat Connectivity Working Group, Olympia, Washington. Online at: http://waconnected.org/columbia-plateau-ecoregion/.

WNHP. 2016. *Washington Natural Heritage Program 2016 Ecological Systems List*. Washington State Department of Natural Resources, Washington Natural Heritage Program, Olympia, Washington. http://file.dnr.wa.gov/publications/amp_nh_eco_sys_list.pdf

WNHP. 2017. *Rare Species Lists*. Washington State Department of Natural Resources, Washington Natural Heritage Program, Olympia, Washington. http://www.dnr.wa.gov/NHPlists

Washington State Noxious Weed Control Board. 2017. *2017 Washington State Noxious Weed List,* http://www.nwcb.wa.gov/printable-noxious-weed-list

Watson, D. G. 1973. *Estimate of Steelhead Trout Spawning in the Hanford Reach of the Columbia River*. Battelle Pacific Northwest Laboratories, Richland, Washington.

Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, and R. Parker. 2012. *Weeds of the West*. 11th Edition. The Western Society of Weed Science, Western Land Grant Universities Cooperative Extension Services, and the University of Wyoming. Color World Printers, Jackson, Wyoming.

Wiken, E., F. J. Nava, and G. Griffith. 2011. *North American Terrestrial Ecoregions—Level III*. Commission for Environmental Cooperation, Montreal, Canada. Online at: http://www3.cec.org/islandora/en/item/10415-north-american-terrestrial-ecoregionslevel-iii-en.pdf.

WNS. 2016. National White-Nose Syndrome Decontamination Protocol – Version 04.12.2016. U.S. Fish and Wildlife Service, White-Nose Syndrome Response Team, Washington, D.C.

Wydoski, R. S., and R. R. Whitney. 1979. *Inland Fishes of Washington*. University of Washington Press, Seattle, Washington.

Yensen, E. and P.W. Sherman. 2003. *Field Guide to the Ground-Dwelling Squirrels of the Pacific Northwest*. U.S. Fish and Wildlife Service, Boise, Idaho.

Yensen, E., D.L. Quinney, K. Johnson, K. Timmerman, and K. Steenhof. 1992. “Fire, vegetation changes, and population fluctuations of Townsend’s ground squirrels.” *American Midland Naturalist* 128: 299–312.

Page Intentionally Left Blank