



Proposed Laser Interferometer Gravitational-Wave
Observatory STEM Exploration Center at Hanford near
Richland, Benton County, Washington

Ecological Survey Report

Final

Revised October 2, 2020

Prepared for:

National Science Foundation



Contents

Acronyms and Abbreviations iii

1. Introduction 1

 1.1 Project Details 1

 1.2 Location and Description 1

2. Methodology 4

 2.1 Background Review 4

 2.2 Fieldwork Methods 4

 2.2.1 Vegetation Assessment 4

 2.2.2 Significant or Rare Habitats 5

 2.2.3 Threatened and Endangered Species and Hanford Priority Species Assessment..... 5

3. Results 6

 3.1 Habitat Types 7

 3.1.1 Highly Altered Habitats 7

 3.1.2 Big Sagebrush Steppe 9

 3.2 Wildlife Observations 10

4. References 13

Appendixes

- A Plant List
- B Site Photographs

Tables

1 Species Used to Define Polygon Boundaries and Generate Mapping-Units Names 5

2 Threatened and Endangered Plant Species and Hanford Priority Species with Potential to Occur in Project Vicinity 6

3 Bird Species Observed Within 1 Mile of Project Area During Breeding Bird Surveys 11

Figures

1 Project Location 2

2 Project Area 3

3 Vegetation Types Observed in the Project Area 8

Acronyms and Abbreviations

Caltech	California Institute of Technology
DOE	U.S. Department of Energy
IPaC	Information for Planning and Consultation
LExC	LIGO STEM Exploration Center
LIGO	Laser Interferometer Gravitational-Wave Observatory
NRCS	Natural Resources Conservation Service
NSF	National Science Foundation
STEM	Science Technology, Engineering and Math
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WHNP	Washington Natural Heritage Program

1. Introduction

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is a national facility for gravitational-wave research and consists of two interferometers, one located in Livingston, Louisiana and the other at the Hanford Site near Richland, Washington. LIGO is funded by the National Science Foundation (NSF) and operated by the California Institute of Technology (Caltech) and the Massachusetts Institute of Technology. The interferometer at the Hanford Site (LIGO Hanford) is located on land owned by the United States (U.S.) and administered by the U.S. Department of Energy (DOE). Per its 1993 Memorandum of Understanding with DOE, NSF has a permit to use the site for LIGO. In 2019, Caltech received a grant for \$7.7 million from the State of Washington to construct a LIGO science, technology, engineering, and math (STEM) observatory adjacent to LIGO Hanford. Caltech has begun design work for this facility, calling it the LIGO STEM Exploration Center (LExC) and proposes to begin construction in October 2020.

LExC has the potential to complement and enhance the existing Education and Public Outreach component of NSF's award for the operations of LIGO Hanford. As the permit holder, NSF is considering whether to authorize Caltech to construct and operate LExC within the boundaries of the land described in the permit issued by DOE.

This survey was conducted in support of an environmental assessment being prepared by Jacobs Engineering Group Inc. (Jacobs). Habitat types within the study area were identified and mapped and the site was assessed for the potential for occurrence of federally listed threatened and endangered species.

1.1 Project Details

The proposed LExC would be constructed east of the existing parking lot along the current access road to LIGO Hanford. The visitor center would include construction of a new 13,000-square-foot building and associated infrastructure including water/sewer utilities, electrical service, and telecommunications connection. Utilities would be extended from existing services at LIGO Hanford. LExC construction activities would require excavation to support utilities installation and grading as needed for construction of a parking lot. The project area is approximately 25.5 acres, including approximately 4.9 acres of developed area consisting of buildings, landscaping, and roads and parking areas that were not surveyed for vegetation.

1.2 Location and Description

The LExC project area encompasses approximately 25.5 acres adjacent to LIGO Hanford along Hanford Route 10 in Benton County, Washington (46.454051°, -119.402360°, World Geodetic System 1984 Datum). The project is in Section 11 Township 11 North, Range 27 East (Figures 1 and 2).

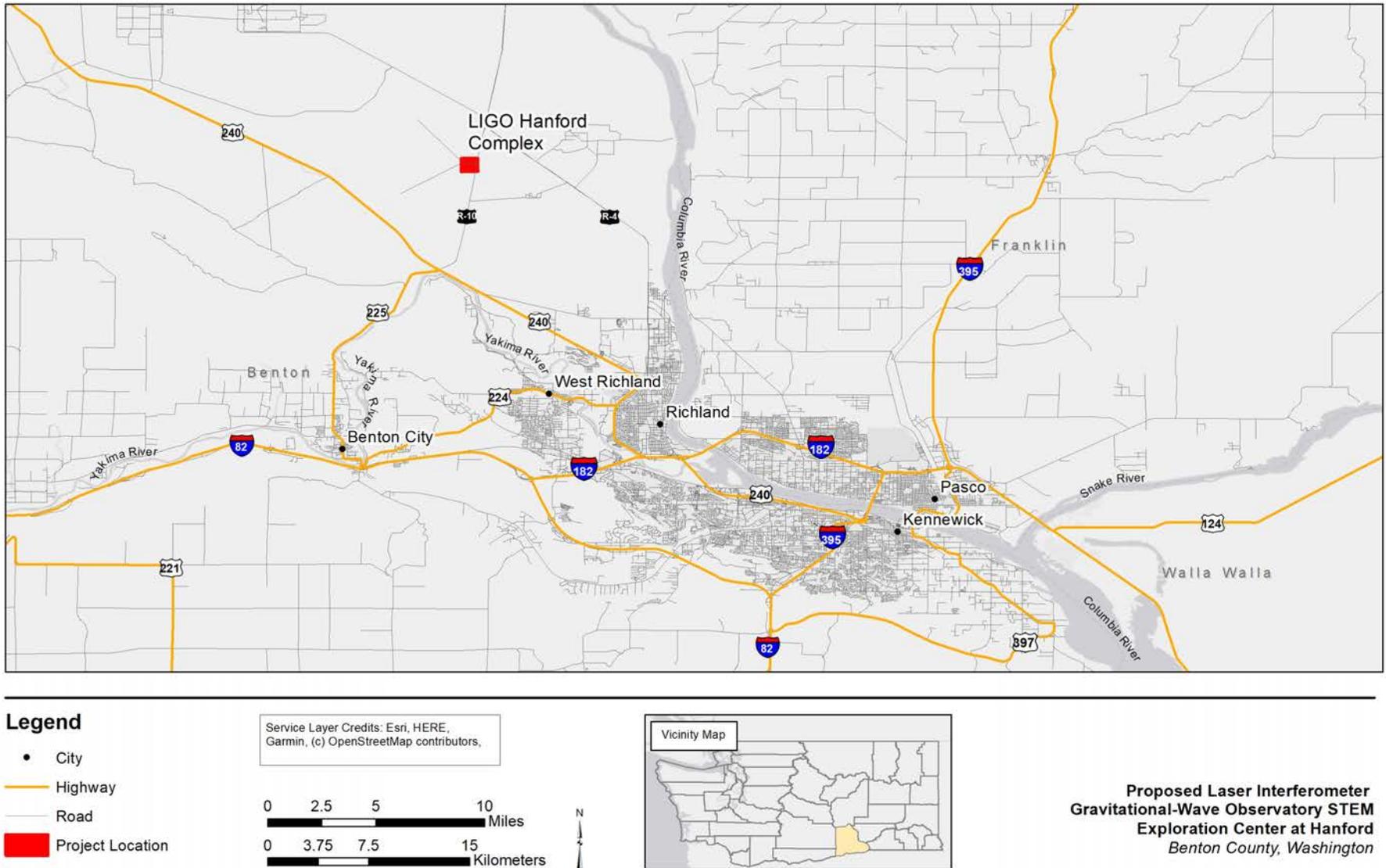
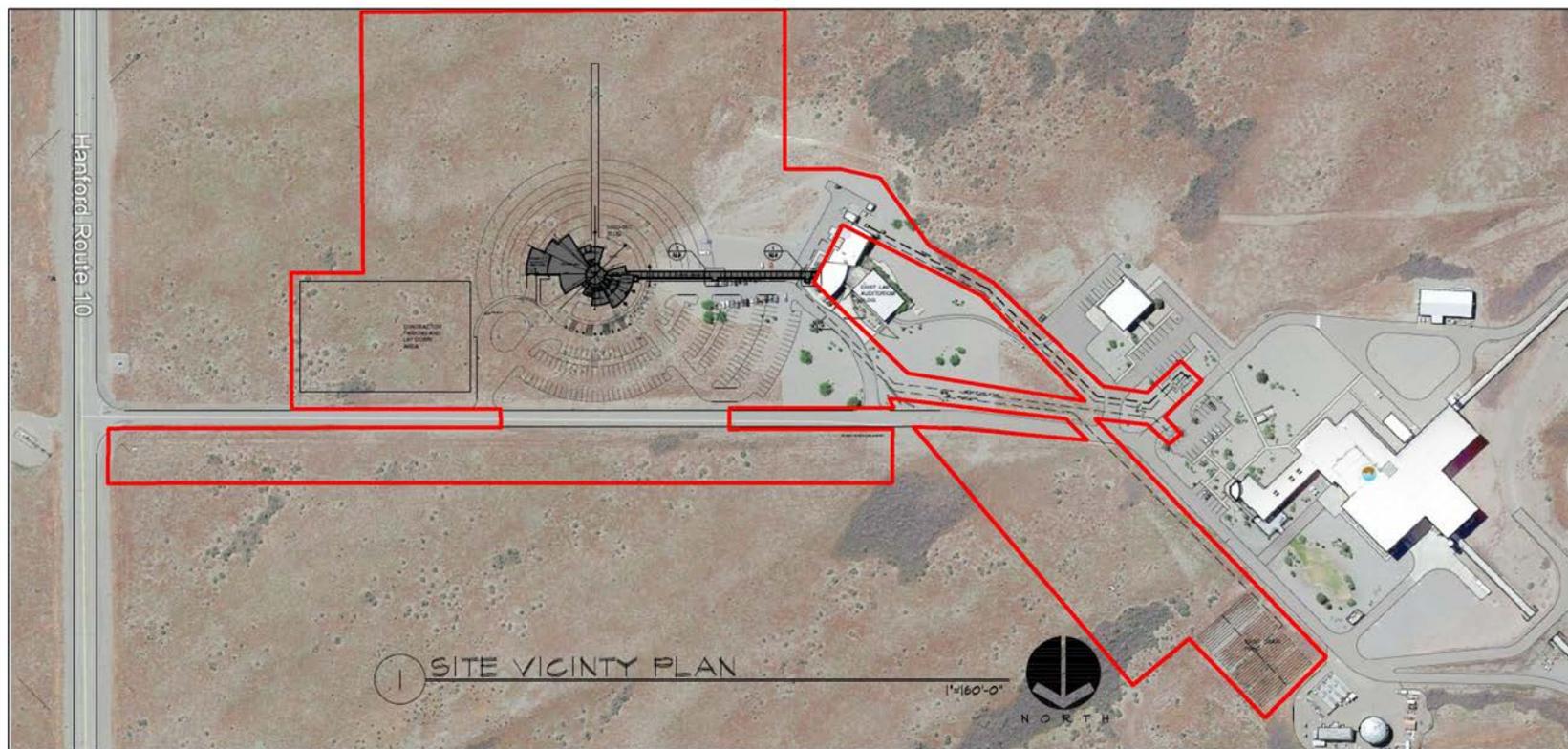


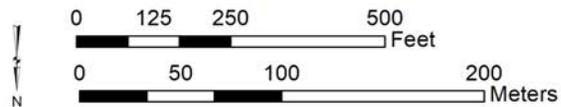
Figure 1. Project Location



Legend

 Project Boundary

Terence L Thornhill Architect, Site Plan,
Ligo-Sec Exploration Center, Richland WA



**Proposed Laser Interferometer
Gravitational-Wave Observatory STEM
Exploration Center at Hanford**
Benton County, Washington

Figure 2. Project Area

2. Methodology

To be consistent with recent vegetation mapping efforts at LIGO Hanford, Jacobs staff adapted the methodology outlined in the *Upland Vegetation of the Central Hanford Site* (Easterly et al. 2017) to document habitat types within and adjacent to the study area. This approach combined field observations, onsite photos, and the best available aerial imagery to delineate initial habitat polygons. A digital geographic information system map layer was created with polygons mapped in the field depicting the distribution of major species. Prior to field work, Jacobs staff used the best available satellite imagery for the Hanford Site to create a digital map of anticipated vegetation association polygon boundaries to aid field work.

2.1 Background Review

Jacobs reviewed the following resources to gather information about environmental conditions and potential for federal- and state-listed species of concern, as identified in Section 4.2.5.6 of the *Hanford Site Biological Resources Management Plan* (DOE 2017) prior to the field visit.

- Hanford Site Biological Resources Management Plan (DOE 2017)
- Vascular Plants of the Hanford Site (Sackschewsky and Downs 2001)
- Upland Vegetation of the Central Hanford Site (Easterly et al. 2017)
- 2019 Washington Vascular Plant Species of Special Concern (WNHP 2019)
- U.S. Fish and Wildlife Service Information for Planning and Consultation (IPaC) Online (USFWS 2020a).
- Web Soil Survey interactive mapping application (NRCS 2020)
- National Wetland Inventory Wetlands Mapper (USFWS 2020b)
- National Hydrography (USGS 2020)
- Horn Rapids Dam WA 7.5-minute Topographic Quadrangle Map (USGS 1977)
- Historical Aerial Imagery, 1996 – 2017 (Google Earth 2020)
- Priority Habitats and Species: Maps (WDFW 2020)

2.2 Fieldwork Methods

2.2.1 Vegetation Assessment

Jacobs staff conducted fieldwork on March 18 and 19, 2020. Fieldwork consisted of delineating vegetation polygons based on the boundaries of dominant vegetation within the study area. An extensive on-foot meander survey method was used to document the composition of the vegetation, distribution of individual species, and boundaries of habitat types.

Vegetation associations were recorded using a Trimble Geo 7X set to submeter accuracy that was differentially corrected during post-processing. Species identified during the field survey were noted. Table 1 presents species that were used to define vegetation association polygon boundaries and generate mapping-unit names as defined by Easterly and others (2017).

Table 1. Species Used to Define Polygon Boundaries and Generate Mapping-Units Names

Scientific Name	Common Name	Priority for Mapping Polygon Boundary
Shrubs		
<i>Artemisia tridentata</i>	Big sagebrush	High
<i>Ericameria nauseosa</i>	Rubber rabbitbrush	Low
<i>Chrysothamnus viscidiflorus</i>	Yellow rabbitbrush	High
<i>Purshia tridentata</i>	Antelope bitterbrush	High
Grass		
<i>Achnatherum hymenoides</i>	Indian ricegrass	Low
<i>Agropyron cristatum/desortorium</i>	Crested wheatgrass	Low
<i>Bromus tectorum</i>	Cheatgrass	High
<i>Hesperostipa comata</i>	Needle-and-thread grass	High
<i>Poa secunda</i>	Sandberg bluegrass	High

During fieldwork, photographs were taken of each habitat type across the study area. The photograph points were recorded with a global positioning system point. Photographs of plant portraits of common species were taken.

2.2.2 Significant or Rare Habitats

No habitat types identified as significant or rare have been mapped in or adjacent to the project area. The nearest mapped habitat type is big sagebrush-needle-and-thread grass habitat more than 10,000 feet north of the project area, which is a community type tracked by the State of Washington.

2.2.3 Threatened and Endangered Species and Hanford Priority Species Assessment

Species with potential to occur on LIGO Hanford were identified from the *Hanford Biological Resources Management Plan* (DOE 2017). Species restricted to habitats that do not occur in the project vicinity or that have restricted ranges that do not overlap the project vicinity were removed from consideration. Biologists field-verified potential habitat for threatened and endangered species or federally and state-listed species of concern, as identified in Section 4.2.5.6 of the *Hanford Site Biological Resources Management Plan* (DOE 2017), during the habitat assessment.

Animal species listed as threatened and endangered species or Hanford priority species typically are restricted to specific habitats that do not occur in the project area. No mammal, reptile, or amphibian species listed as a threatened and endangered species or Hanford priority species would be expected to occur in the project area. The state candidate species and federal species of concern sagebrush lizard (*Sceloporus graciosus*) has been documented in the northern portion of the LIGO Hanford Site, but not near the project area, and this species would not be expected to occur in the project area. While the habitat is suitable for black-tailed jackrabbit (*Lepus californicus*), this species has not been observed within 2 miles of the project area.

Greater sage grouse (*Centrocercus urophasianus*) historically were common throughout the area, but are now considered extirpated from the site, as noted in the *Hanford Site Biological Resources Management Plan* (DOE 2017). Bird species protected under the Migratory Bird Treaty Act may nest or forage in the

project area or may use the project area as stopover habitat during migration. Bald eagles are known to nest on the Hanford Site, but not near the project area, and they would not use the project area. Other raptors, including the state-threatened ferruginous hawk (*Buteo regalis*), may forage in the project area, but these birds have not been documented nesting in the project area. Three ferruginous hawk nests are located within 8 miles of the project area, including one within 2 miles.

Federally and state-listed plant species known from the Hanford Site were evaluated to determine whether suitable habitats, as identified in the Rare Plant Field Guide (WDNR 2020), occur in or adjacent to the project site. Species limited to moist or specialized habitats that do not occur in the project area and species that occur as localized endemics outside the project area were eliminated from consideration. No federal threatened or endangered species and no state endangered plant species were identified with potential to occur in the project area. Sixteen plant species listed as state threatened or state sensitive were determined to have slight potential to occur the project area. These species were evaluated and are identified in Table 2.

Table 2. Threatened and Endangered Plant Species and Hanford Priority Species with Potential to Occur in Project Vicinity

Scientific Name	Common Name	Status
<i>Aliciella leptomeria</i>	Great basin gilia	State Threatened
<i>Astragalus columbianus</i>	Columbia milkvetch	State Sensitive
<i>Astragalus geyeri</i> var. <i>geyeri</i>	Geyer's milkvetch	State Threatened
<i>Cistanthe rosea</i>	Rosy pussypaws	State Threatened
<i>Corispermum villosum</i>	Hairy bugseed	State Sensitive
<i>Cryptantha leocophaea</i>	Gray cryptantha	State Threatened
<i>Cryptantha scoparia</i>	Miner's candle	State Threatened
<i>Cryptantha spiculifera</i>	Snake River cryptantha	State Sensitive
<i>Cuscuta denticulata</i>	Desert dodder	State Threatened
<i>Eatonella nivea</i>	White eatonella	State Threatened
<i>Eremothera minor</i>	Small-flower evening primrose	State Sensitive
<i>Minuartia pusilla</i>	Annual sandwort	State Threatened
<i>Nicotiana attenuata</i>	Coyote tobacco	State Sensitive
<i>Oenothera caespitosa</i>	Tufted evening primrose	State Sensitive
<i>Oenothera pygmaea</i>	Dwarf evening primrose	State Sensitive
<i>Pediocactus nigrispinus</i>	Snowball cactus	State Sensitive

3. Results

The results provided are limited by the season of the field survey. Only those species expressed at the time of survey or with persistent identifiable remains from the previous year could be identified. The active growing season was just beginning at the time of survey and several emerging plants were not yet identifiable at the time of survey.

3.1 Habitat Types

This section provides descriptions of the habitat types identified during survey. A map of the vegetation types in the project area is provided as Figure 2. A vegetation list is provided as Appendix A, which identifies the species observed and the habitat types they occurred in. Due to rounding errors, the sum of individual habitat types may not sum to the total acreage of the project area.

3.1.1 Highly Altered Habitats

3.1.1.1 Non-vegetated/Highly Disturbed Areas

These areas include the drainfield area at the northern end of the project area and other areas in proximity to developed areas or roads where off-road vehicle use had removed most vegetation. Non-vegetated/highly disturbed areas cover 2.32 acres (8.98 percent of the project area).

The drainfield area is at the northwestern end of the project area (Figure 3) and was highly disturbed from historic installation of subsurface infrastructure and routine access for maintenance. The area is surrounded by a berm and the surface of the drainfield has been excavated to some extent below original grade. The drainfield area provides no intact native vegetation communities and is dominated by non-native species, particularly cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola tragus*).

There are non-vegetated/highly disturbed areas around the LIGO Hanford Lab Support Building and its parking area and between the road and the drainfield area where vehicles are regularly driven (Figure 3). Vegetation has been substantially altered in these areas and exposed sand is prevalent. Shrub species have been eliminated and grasses and forbs are absent from much of the area where vehicular traffic is the highest. Cheatgrass is the predominant vegetation and other non-native species occur including spring draba (*Draba verna*), Russian thistle, tall tumbled mustard (*Sisymbrium altissimum*), and crossflower (*Chorispora tenella*).

Along the LIGO Hanford Access Road, crested wheatgrass (*Agropyron cristatum/desortorium*) has been planted and is locally abundant. Tapertip onion (*Allium acuminatum*)¹ was a minor component near the edges of this habitat type north of LIGO Hanford Access Road.

3.1.1.2 Developed Areas

Developed areas include buildings, landscaping, roads and parking areas, and gravel lots. These areas cover 4.06 acres (16.02 percent of the project area). Developed areas lacked vegetation, except for xeriscaping around buildings. These areas were not assessed for vegetation but are mapped on Figure 3.

3.1.1.3 Russian Thistle

Non-native species, including invasive species were found in all habitat types. However, certain areas accumulated Russian thistle to the exclusion of all other vegetation except for occasional big sagebrush that had not yet succumbed. These areas were clearly evident on aerial photography and were mostly outside of the project area, although inclusions were mapped as a distinct habitat type (Figure 3). The three areas mapped as Russian thistle encompassed 0.47 acre (1.95 percent) of the project area.

The field survey noted that Russian thistle areas were always in depressions. The buildup of masses of dead Russian thistle is very slow to decompose and precludes other species from growing. This was the only habitat type that did not have cheatgrass because of the dense mat of Russian thistle.

¹ The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) botanist has submitted that this species has not been previously recorded in the lower elevations of the Hanford Site and the observed specimen is likely a member of the *Liliaceae* family (Link, 2020)

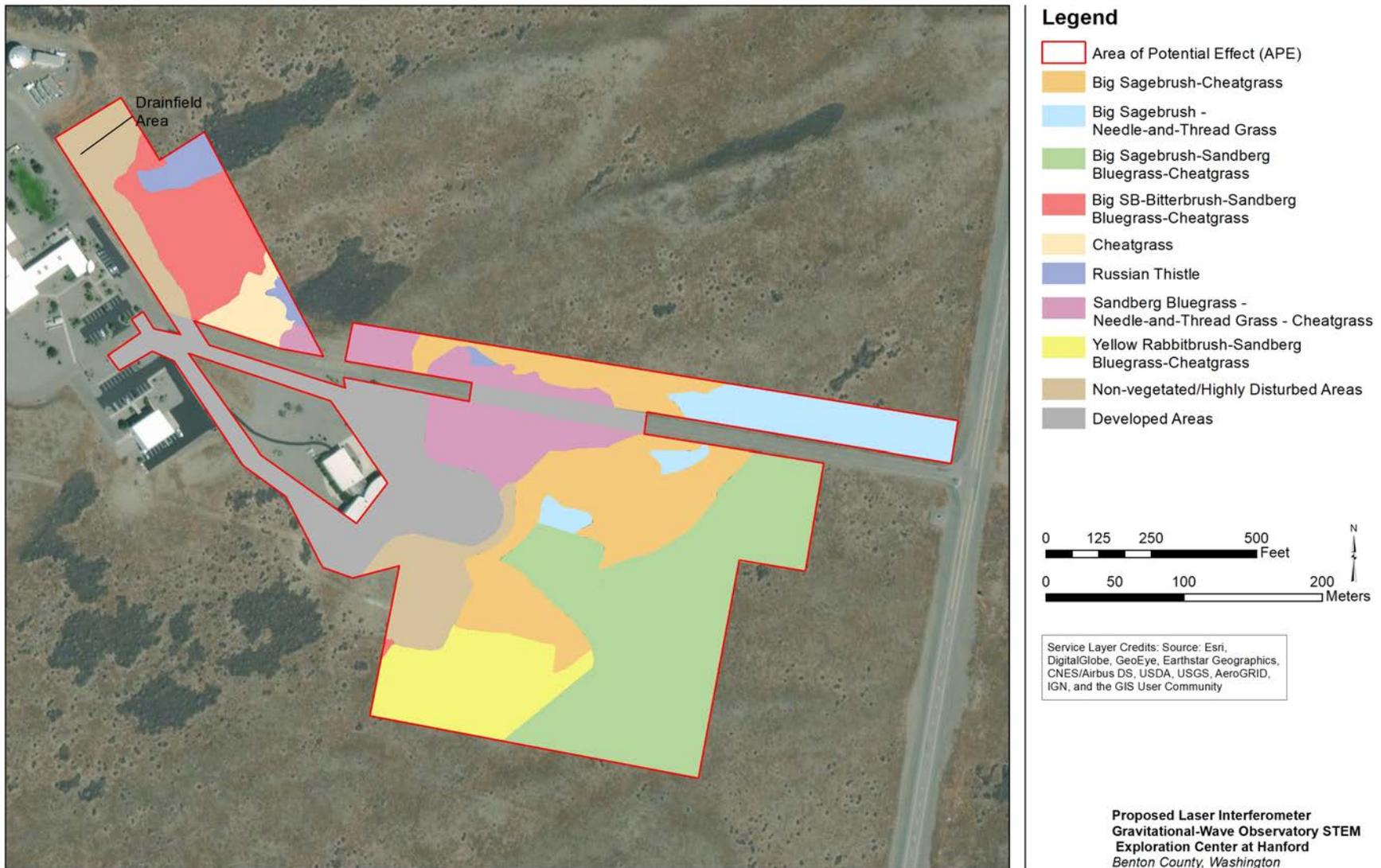


Figure 3. Vegetation Types Observed in the Project Area

Review of historical aerial photographs indicated that these areas are not permanent landscape features, and could be absent from a particular area for a number of years. However, the aerial photographs indicated the mapped areas had been stable since 2015.

3.1.2 Big Sagebrush Steppe

In the absence of disturbance and non-native species, it is likely that the entire project area would consist of Big Sagebrush-Sandberg bluegrass habitat. However, because of the presence of non-native species and reduction in cover of big sagebrush following recent fires, several distinct vegetation communities were identified and mapped. All of these habitat areas displayed evidence of additional anthropomorphic disturbance, such as presence of active or abandoned groundwater wells and limited rutting from vehicle traffic, but that disturbance was not sufficient to substantially alter the vegetation as for areas discussed previously as non-vegetated/highly disturbed areas.

3.1.2.1 Big Sagebrush-Sandberg Bluegrass-Cheatgrass

This habitat type covered the largest amount of the project area, 6.03 acres (24.61 percent of the project acre). The big sagebrush-Sandberg bluegrass-cheatgrass habitat type was limited to the eastern side of the project area and occurred on both sides of the LIGO Hanford Access Road (Figure 3). The three dominant species provided most of the overwintering persistent vegetative cover. Indian ricegrass (*Achnatherum hymenoides*) and needle-and-thread grass (*Hesperostipa comata*) occurred within this habitat type, but plants were widely scattered and never in sufficient numbers to be locally dominant. There were scattered occurrences of small patches of Carey's balsamroot (*Balsamorhiza careyana*) and western yarrow (*Achillea millefolium*). Rosettes of smoothstem blazingstar (*Mentzelia laevicaulis*) were common. Russian thistle and tall tumbled mustard occurred throughout this habitat type, but scattered and in low numbers. The non-native ephemeral spring draba carpeted much of the ground and it could be considered a co-dominant species during early spring. Other spring ephemerals, including the native slender phlox (*Microsteris gracilis* var. *humilior*) and non-native jagged chickweed (*Holosteum umbellatum*), also were common, but not in numbers comparable to spring draba.

Where the big sagebrush-Sandberg bluegrass-cheatgrass habitat type approached the LIGO Hanford Access Road, Sandberg bluegrass would be replaced by crested wheatgrass, which was apparently expanding outward from where it likely was planted. Near the interface with the Yellow Rabbitbrush-Sandberg Bluegrass-Cheatgrass habitat type, a few yellow rabbitbrush (*Chrysothamnus viscidiflorus*) occurred and in the southernmost portions of this habitat type, rubber rabbitbrush (*Ericameria nauseosa*) occurred in small numbers. Rubber rabbitbrush was not observed in any other portions of the project area.

Along the LIGO Hanford Access Road, crested wheatgrass has been planted and is locally abundant. On the north side of the LIGO Hanford Access Road, tapertip onion occurred locally in large patches in areas where grass cover was reduced. This species was not observed south of LIGO Hanford Access Road.

3.1.2.2 Big Sagebrush-Needle-and-thread Grass

There were three areas mapped where needle-and-thread grass occurred as a co-dominant herbaceous species with big sagebrush. This habitat type covers 1.7 acres (6.64 percent) within the project area. Big sagebrush and needle-and-thread grass were the dominant species. Sandberg bluegrass exhibited reduced density and was not a dominant species and cheatgrass also was present. Other species included Indian ricegrass, smoothstem blazingstar, Carey's balsamroot, Russian thistle, tall tumbled mustard, spring draba, slender phlox, and jagged chickweed.

This habitat type would be included in the *Artemisia tridentata* ssp. *wyomingensis*/*Hesperostipa comata* Group that is considered rare in the State of Washington and is tracked by the state. These small areas are disjunct from the nearest mapped element occurrence, which is in the northern part of LIGO Hanford.

3.1.2.3 Big Sagebrush-Cheatgrass

This habitat type was similar to the big sagebrush-Sandberg bluegrass-cheatgrass habitat type and occurred adjacent to that habitat type (Figure 3). Big sagebrush-cheatgrass was the second most abundant habitat type, covering 4.24 acres (16.41 percent of the project area). Bunchgrasses were not present except as a minor component of the vegetation. Western yarrow, smoothstem blazingstar, Russian thistle and tall tumbledustard occurred throughout this habitat type. Spring draba was very common and other spring ephemerals included slender phlox and jagged chickweed. Carey's balsamroot was not observed in this habitat type. Along the LIGO Hanford Access Road, crested wheatgrass has been planted and is locally abundant.

3.1.2.4 Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass

This habitat type was similar to the big sagebrush-Sandberg bluegrass-cheatgrass habitat type. Bitterbrush (*Purshia tridentata*) was added as a co-dominant shrub. Western yarrow, spring draba, Russian thistle, and tall tumbledustard were common and jagged chickweed also occurred. Indian ricegrass, Carey's balsamroot, the two rabbitbrush species, and slender phlox were not observed in this habitat type. The two areas mapped for this habitat type (Figure 3) cover 1.71 acres within the project area (6.64 percent). The two areas consist of a small portion of a larger area extending into the project area south the LIGO Hanford Access Road and a large area north of LIGO Hanford Access Road. Bitterbrush was not observed in any other habitat type in the project area.

3.1.2.5 Yellow Rabbitbrush-Sandberg Bluegrass-Cheatgrass

A fairly large area in the south-central portion of the project site, covering 2.09 acres (8.20 percent) of the project area, lacked sagebrush or bitterbrush (Figure 3). Yellow rabbitbrush was the shrub component of this area, with Sandberg bluegrass and cheatgrass, along with spring draba, providing most of the ground cover. Other herbaceous species included western yarrow, smoothstem blazingstar, Russian thistle, tall tumbledustard, spring draba, and jagged chickweed. Small amounts of rubber rabbitbrush (*Ericameria nauseosa*) occurred near the southern end of the project area. Rubber rabbitbrush was visibly more abundant to the south of the project area.

3.1.2.6 Sandberg Bluegrass-Needle-and-Thread Grass-Cheatgrass

The areas mapped for this habitat type were in the central portion of the project area, both north and south of the LIGO Hanford Access Road (Figure 3). This habitat type covered 2.21 acres (8.59 percent of the project area). This community lacked shrub species, with the three grass species being the dominant vegetation. Other herbaceous species included smoothstem blazingstar, Russian thistle, tall tumbledustard, spring draba, slender phlox, and jagged chickweed.

Along the LIGO Hanford Access Road, crested wheatgrass has been planted and is locally abundant.

3.1.2.7 Cheatgrass

One small portion of the project area covering 0.5 acre (1.95 percent of the project area) was dominated entirely by cheatgrass (Figure 3). While a few other species co-occurred, no other species occurred in sufficient numbers to be considered a co-dominant, although the ephemeral spring draba was abundant. Minor amounts of Russian thistle and tall tumbledustard were present, but no bunchgrasses were observed. Most other herbaceous species were absent or occurred only in very low numbers.

3.2 Wildlife Observations

During the field survey, Jacobs staff noted observations of wildlife or signs of wildlife. Three coyotes (*Canis latrans*) were observed moving through the project area and numerous tracks of coyote were observed. A burrow, likely belonging to an American badger (*Taxidea taxus*), was observed at the base of an electrical utility pole at the eastern edge of the project area. Small mammal burrows were observed

throughout the project area, but tracks in the vicinity of the burrows were unidentifiable due to distortion from the gusty wind of both days. No other mammals or mammal signs were observed.

No reptiles were observed during the field survey.

Western meadowlark (*Sturnella neglecta*) were heard singing from shrubbery through both days of field work and occasionally sighted. Singing birds were widely spaced on the landscape. Because of the constant singing at this time of year and the spacing, it is likely that meadowlark nest in the project area and that males were establishing breeding territories at the time of survey. Common raven (*Corvus corax*) were observed flying overhead. No other avian species or signs were observed. However, other bird species will utilize the project area during other times of the year. Observations of 24 avian species have been made within 1 mile of the project area during breeding bird surveys (Table 3). These species may occur in the project area, and some of them could nest there. It also is possible that other species may nest or forage in the project area.

Wolf spiders (family Gnaphosidae) and darkling beetles (family Tenebrionidae) were observed throughout the site. No other invertebrates or signs of invertebrates were observed.

Table 3. Bird Species Observed Within 1 Mile of Project Area During Breeding Bird Surveys

Scientific Name	Common Name	Scientific Name	Common Name
<i>Artemisiospiza nevadensis</i>	Sagebrush sparrow	<i>Haemorhous mexicanus</i>	house finch
<i>Buteo jamaicensis</i>	Red-tailed hawk	<i>Hirundo rustic</i>	Barn swallow
<i>Buteo swainsoni</i>	Swainson's hawk	<i>Icterus bullockii</i>	Bullock's oriole
<i>Buteo regalis</i>	Ferruginous hawk	<i>Lanius ludovicianus</i>	Loggerhead shrike
<i>Callipepla californica</i>	California quail	<i>Numenius americanus</i>	Long-billed curlew
<i>Charadrius vociferus</i>	killdeer	<i>Oreoscoptes montanus</i>	Sage thrasher
<i>Chondestes grammacus</i>	Lark sparrow	<i>Pica hudsonia</i>	Black-billed magpie
<i>Chordeiles minor</i>	Common nighthawk	<i>Sturnella neglecta</i>	Western meadowlark
<i>Corvus corvax</i>	common raven	<i>Sturnus vulgaris</i>	European starling
<i>Eremophila alpestris</i>	Horned lark	<i>Tyrannus verticalis</i>	Western kingbird
<i>Euphagus cyanocephalus</i>	Brewer's blackbird	<i>Zenaida macroura</i>	Mourning dove
<i>Falco sparverius</i>	American kestrel	<i>Zonotrichia leucophrys</i>	White-crowned sparrow

Threatened and Endangered Species and Hanford Priority Species

No threatened and endangered species or Hanford priority plant species were observed during field survey because the surveys occurred prior to expression of these species. No threatened and endangered species or Hanford priority animal species were observed during field survey.

The western meadowlark, which is protected under the Migratory Bird Treaty Act, occurred throughout the project area and adjacent lands. This species was exhibiting territorial breeding behavior, with individual birds in shrubs singing almost continuously. The birds appeared to be trying to establish breeding territories or defend territories from rival males.

The suitability of observed habitats was assessed for species with potential to occur in the project area.

No federally or state endangered, threatened, sensitive, or candidate avian species were observed during the field survey. The state-threatened ferruginous hawk and three state candidate species (loggerhead shrike, sagebrush sparrow, and sage thrasher) have been observed within 1 mile of the project area during breeding bird surveys. Raptors likely would not nest in the project area, but foraging is likely. Other avian species may forage or nest in the project area.

The burrowing owl (*Athene cunicularia*) could use the project area. However, there was no evidence of burrowing owl use at any of the small mammal burrows observed during the field survey and the species has not been observed in the project vicinity during historical surveys of breeding bird. This species is not expected to occur in the project area.

While no endangered species or Hanford priority invertebrate species were observed during the field survey, non-aquatic invertebrates, particularly lepidopterans (butterflies and moths), may occur in the project area during periods when nectar-providing plants are in bloom.

Sixteen plant species were identified with potential to occur in the project area. The likelihood of occurrence in the project area is discussed for each species.

Annual Sandwort: The field survey was too early in the season to observe plants in vegetative growth. This species typically occurs in undisturbed open rocky ground with sandy soils. There are no areas of open rocky ground within the project area. Annual sandwort is not expected to occur in the project area due to lack of habitat.

Columbia Milkvetch: The field survey was too early in the season to observe plants in vegetative growth. The site is approximately 20 miles from the nearest recorded location. All known populations are in proximity to the Columbia River and the species would not be expected in the project area, which is much farther from the Columbia River than any known populations.

Coyote Tobacco: The field survey was too early in the season to observe plants in vegetative growth. While the species typically expresses after fire, other landscape disturbance also may trigger growth. No fire has been recorded in the project area within the past two years, so fire would not have triggered expression. The anthropogenic disturbance near the LIGO Hanford facility and LIGO Hanford Access Road has resulted in reduced vegetative cover and may provide conditions suitable for this species. Overwintering stalks were not observed and would be very unlikely to make it through the winter in a condition that could be identified. While unlikely due to the lack of regular fire through the area, occurrence of this species in the project area cannot be ruled out.

Desert Dodder: Host species for this parasitic plant occur in the project area. However, there was no evidence of dodder vines from the previous year in any sagebrush or rabbitbrush within the project area. While persistence of dodder vines through the winter is poor, it is likely that the interior of some of the shrubs would have provided sufficient protection for the remnant vines to be observed. Desert dodder is not expected to occur in the project area.

Dwarf Evening Primrose: The field survey was too early in the season to observe plants in vegetative growth. This species typically occurs in open rocky ground with sandy soils. There are no areas of open rocky ground within the project area. Dwarf Evening Primrose is not expected to occur in the project area due to lack of habitat.

Geyer's Milkvetch: The field survey was too early in the season to observe plants in vegetative growth. This species occurs along the Columbia River or drainages. The nearest known population is 18 miles north of LIGO. Because the habitat is atypical for the species and the distance to the nearest population makes dispersal improbable, Geyer's milkvetch is not expected to occur in the project area.

Gray Cryptantha: The field survey was too early in the season to observe plants in vegetative growth. This species does not tolerate disturbance and occurs in destabilized sand dunes, which do not occur in the project area. Gray cryptantha would not be expected in the project area due to lack of habitat.

Great Basin Gilia: The field survey was too early in the season to observe plants in vegetative growth. This species typically occurs in open rocky ground with sandy soils. There are no areas of open rocky ground within the project area. Great Basin gilia is not expected to occur in the project area due to lack of habitat.

Hairy Bugseed: The field survey was too early in the season to observe plants in vegetative growth. The species typically occurs in open sandy areas including dunes, but it also occurs in waste places. The anthropogenic disturbance near the LIGO facility and LIGO Hanford Access Road has resulted in reduced vegetative cover and may provide conditions suitable for this species. Overwintering stalks were not observed but recent disturbance from vehicle operation could have eliminated remnant stalks. While unlikely, occurrence of this species in the project area cannot be ruled out.

Miner's Candle: The field survey was too early in the season to observe plants in vegetative growth. This species typically occurs in open rocky ground with sandy soils. There are no areas of open rocky ground within the project area. Miner's candle is not expected to occur in the project area due to lack of habitat.

Rosy Pussypaws: Commonly associated species occur in the project area and the habitat is suitable for this species. The survey was conducted before this species would typically begin growth. The nearest known population is 13 miles north of LIGO and the distance to the nearest population makes dispersal improbable. While unlikely, occurrence of this species in the project area cannot be ruled out.

Small-flower Evening Primrose: The field survey was too early in the season to observe plants in vegetative growth. This species typically occurs in open rocky ground with sandy soils. There are no areas of open rocky ground within the project area. Small-flower evening primrose is not expected to occur in the project area due to lack of habitat.

Snake River Cryptantha: Commonly associated species occur in the project area. The survey was conducted before this species would typically begin growth. However, Snake River cryptantha typically occurs in stony soils and soils in the project area are not stony. Because the habitat is not suitable, the species is not expected to occur.

Snowball Cactus: This species does not occur in the project area. While the habitat is marginally suitable for the species, no cacti of any type, including ball cacti, were observed during survey.

Tufted Evening Primrose: The field survey was too early in the season to observe plants in vegetative growth. This species typically occurs in open rocky ground with sandy soils. There are no areas of open rocky ground within the project area. Tufted evening primrose is not expected to occur in the project area due to lack of habitat.

White Eatonella: The field survey was too early in the season to observe plants in vegetative growth. This species typically occurs in open rocky ground with sandy soils. There are no areas of open rocky ground within the project area. White eatonella is not expected to occur in the project area due to lack of habitat.

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Appendix A Plant List

Scientific Name	Common Name	Habitat Associations
<i>Achillea millefolium</i>	Western yarrow	Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Yellow Rabbitbrush-Sandberg Bluegrass-Cheatgrass
<i>Achnatherum hymenoides</i>	Indian ricegrass	Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass
<i>Agropyron cristatum/desortorium</i>	Crested wheatgrass *	Off-Road Vehicle Traffic Areas, Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Sandberg Bluegrass-Cheatgrass
<i>Allium acuminatum</i>	Tapertip onion	Limited to north side of the LIGO Hanford Access Road in Off-Road Vehicle Traffic Areas, Big Sagebrush-Sandberg Bluegrass-Cheatgrass
<i>Artemisia tridentata</i>	Big sagebrush	Drainfield Area, Off-Road Vehicle Traffic Areas, Russian Thistle, Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass
<i>Balsamorhiza careyana</i>	Carey's balsamroot	Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass
<i>Bromus tectorum</i>	Cheatgrass *	Drainfield Area, Off-Road Vehicle Traffic Areas, Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass, Sandberg Bluegrass-Needle-and-thread Grass-, Cheatgrass
<i>Chorispora tenella</i>	crossflower	Drainfield Area, Off-Road Vehicle Traffic Areas,
<i>Chrysothamnus viscidiflorus</i>	Yellow rabbitbrush	Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Yellow Rabbitbrush-Sandberg Bluegrass-Cheatgrass
<i>Draba verna</i>	Spring draba *	Drainfield Area, Off-Road Vehicle Traffic Areas, Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass, Sandberg Bluegrass-Needle-and-thread Grass-Cheatgrass, Cheatgrass
<i>Ericameria nauseosa</i>	Rubber rabbitbrush	Yellow Rabbitbrush-Sandberg Bluegrass-Cheatgrass
<i>Hesperostipa comata</i>	Needle-and-thread grass	Big Sagebrush-Needle-and-thread Grass, Sandberg Bluegrass-Needle-and-thread Grass-Big Sagebrush-Sandberg Bluegrass-Cheatgrass,

Scientific Name	Common Name	Habitat Associations
<i>Holosteum umbellatum</i>	Jagged chickweed *	Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass, Sandberg Bluegrass-Needle-and-thread Grass-, Cheatgrass
<i>Mentzelia laevicaulis</i> ²	Smoothstem blazingstar	Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass, Sandberg Bluegrass-Needle-and-thread Grass-, Cheatgrass
<i>Microsteris gracilis var. humilior</i>	Slender phlox	Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass, Sandberg Bluegrass-Needle-and-thread Grass-
<i>Poa secunda</i>	Sandberg bluegrass	Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass, Sandberg Bluegrass-Needle-and-thread Grass-, Cheatgrass
<i>Purshia tridentata</i>	Bitterbrush	Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass
<i>Salsola tragus</i>	Russian thistle *	all
<i>Sisymbrium altissimum</i>	Tall tumbled mustard *	Drainfield Area, Off-Road Vehicle Traffic Areas, Big Sagebrush-Needle-and-thread Grass, Big Sagebrush-Sandberg Bluegrass-Cheatgrass, Big Sagebrush-Cheatgrass, Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass, Sandberg Bluegrass-Needle-and-thread Grass-, Cheatgrass

* Non-native species

² Note that the CTUIR botanist has submitted that *M. laevicaulis* does not occur in the stabilized dunes at the Hanford Site and that the observed specimen is likely *Mentzelia albicaulis*, a common annual in the dunes (Link, 2020).

Appendix B Site Photographs



Achillea millefolium



Achnatherum hymenoides



Allium acuminatum



Artemisia tridentata



Balsamorhiza careyana



Bromus tectorum



Chorispora tenella



Chrysothamnus viscidiflorus



Draba verna



Hesperostipa comata



Holosteum umbellatum



Mentzelia laevicaulis



Microsteris gracilis var. *humilior*



Purshia tridentata



Salsola tragus



Sisymbrium altissimum



Typical Russian Thistle Habitat Type



Transition from Big Sagebrush-Cheatgrass to Yellow Rabbitbrush-Sandberg Bluegrass-Cheatgrass



Cheatgrass Habitat Type



Typical Unpaved Disturbed Area



Typical Off Road Vehicle Traffic Area



Drainfield Area



Transition from Crested wheatgrass dominated area adjacent to LIGO Access Road to Big Sagebrush-Sandberg Bluegrass-Cheatgrass



Disturbed Area Adjacent to LIGO Access Road



Sandberg Bluegrass-Needle-and-thread Grass-Cheatgrass



Big Sagebrush-Sandber Bluegrass-Cheatgrass



Big Sagebrush-Needle-and-thread Grass



Transition from Off Road Vehicle Traffic Area to Big Sagebrush-Bitterbrush-Sandberg Bluegrass-Cheatgrass



Typical minor disturbance – includes off road vehicle access