

Hanford Site Revegetation Monitoring Report for Fiscal Year 2016



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

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Introduction

This report describes the monitoring of areas revegetated by the River Corridor Closure Contractor (RCCC) and monitored by Mission Support Alliance in 2016. Site monitoring is a continuance of efforts performed by RCCC (2008 through 2015). The report contains data documenting the success status of revegetation areas associated with the *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* cleanup of National Priorities List waste sites at the Hanford Site in Richland, Washington. It contains vegetation monitoring data for seventeen sites selected to be representative sites for larger areas planted between the years of 2008 through 2015.

Monitoring efforts measure the structure and composition of native and non-native plant species within the revegetation areas. This provides a data timeline in which revegetation success can be based, as well as insight into which planting methods are most effective. A revegetation area will be considered successful if five years after planting, the native plant cover is at least 25% and the transplanted shrub survival is at least 50% as identified in the *Revegetation Manual for the Environmental Restoration Contractor* (McLendon et al. 1997). In order to achieve self-sustaining native vegetative populations within restoration sites, RCCC adjusted the extent of each revegetation effort depending on the surrounding habitat, existing conditions, and future land-use designation of the area (Phipps et. al. 2015). Each site monitored during 2016 is in section 3 of this report, and contains a brief discussion of the revegetation activities, when historical information was available, vegetation monitoring efforts, and tabulated 2016 data. Sites monitored in 2016 include 100-F-47 Site, 100-F-48 Site, 100-F Container Transfer Area, 118-F-6 Burial Ground, 118-F-6 Soil Staging Area, 1607-F-1 Site, 118-F-5 Burial Ground, 118-F-5 Soil Staging Area, 100-K Container Transfer Area, 118-K-1 Soil Staging Area, 118-K-1 Burial Ground, 128-K-2 Burn Pit 128-K-2 Soil Staging Area, 100-K-95 Tar Dump, 600-29 Site, 600-369 Site, and the 600-370 Site. The locations of the seventeen sites are depicted in Figure 1.

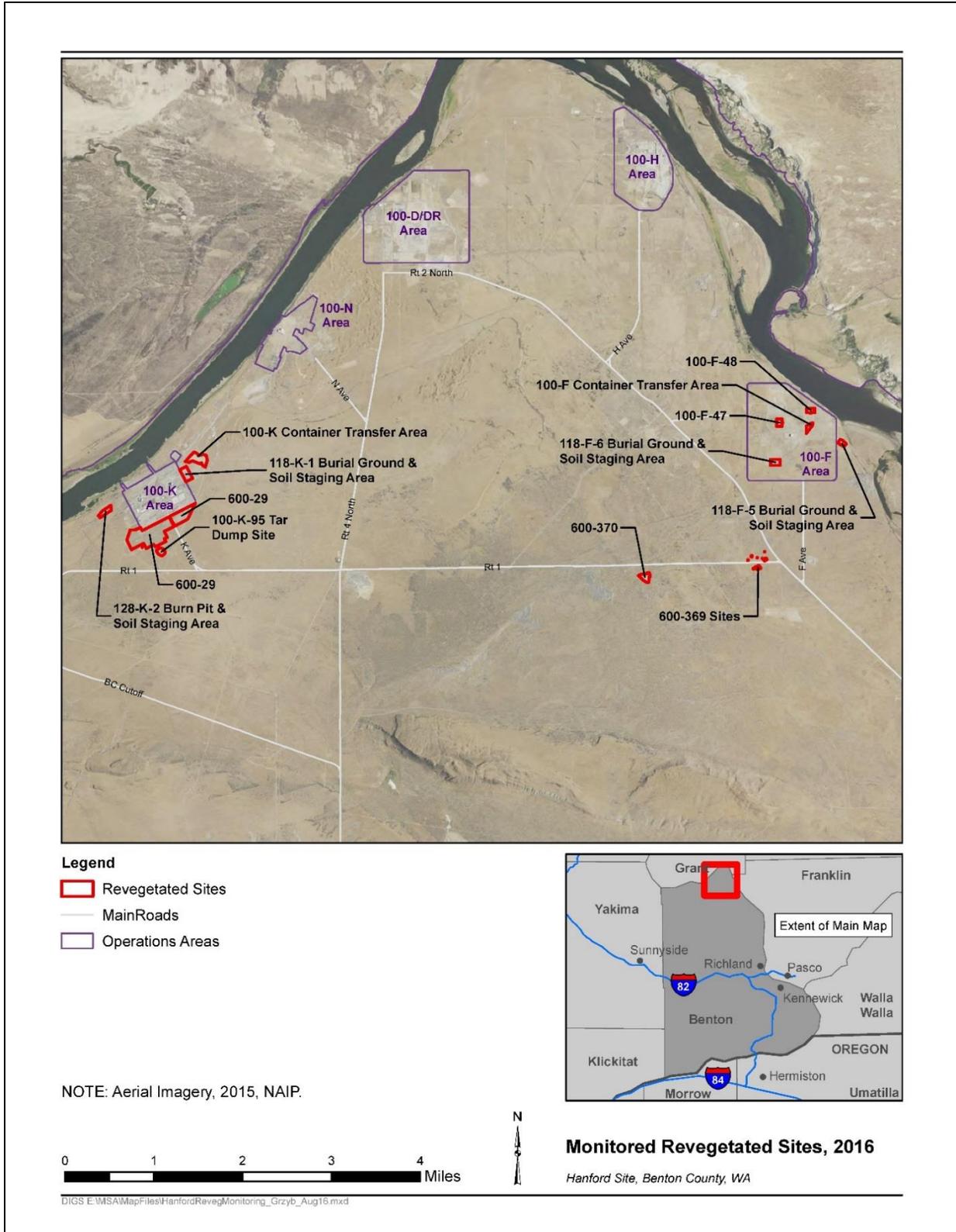


Figure 1. Map of Revegetation Sites Monitored in 2016

Methods

The 2016 revegetation monitoring consisted of a quantitative approach through repeated measurements to estimate canopy cover of all plant species observed within a plot frame; their frequency of occurrence; and percent survival of transplanted shrubs within an established transect. These shrubs include big sagebrush (*Artemisia tridentata*), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Analyzed data collected using these methods allow an estimate of relative seral stages and general site progression, levels of change, and provide a perspective for long-term achievement of management objectives.

Frequency of occurrence and canopy cover measurements were obtained using the methods described in *Steppe Vegetation of Washington* (Daubenmire 1970). Canopy coverage is defined in Daubenmire (1970) as “the percentage of ground surface included in the vertical projection of a polygon drawn around the extremities of undisturbed foliage of a plant.” By the use of this method, the measurement of the amount of ground covered by each species is obtained. The total vegetation can exceed 100% due to species overlapping when plot measurements are taken in densely vegetated areas. Depending on the size of the restoration site, the number of plot-frame measurements taken are analyzed to estimate canopy cover for each species present. Frequency is represented as the percentage of occurrences a species is observed within the given number of plot frames measured. For example, if a species was represented in 10 out of 25 plot frames, its frequency would be $10/25 \times 100 = 40\%$. The relative magnitude of a frequency rating in comparison to a canopy coverage rating provides an index of species distribution and its influence within a vegetation community. Species that were observed within a revegetated area but were not counted in a plot frame were recorded as occurrences and denoted as an “X” in the data tables. Washington State noxious species identified within the monitoring areas are delineated in the result tables along with their state class designation. Washington State noxious plant classes are defined as:

“Noxious weed is the traditional, legal term for invasive, non-native plants that are so aggressive they harm ecosystems or disrupt agricultural production. These plants crowd out the native species that fish and wildlife depend on. Washington State separates noxious weeds into three classifications. Class A noxious weeds are usually newcomers. They are often found in only a few places in the state, and state and local weed boards hope to completely eradicate them before they get a foothold in Washington. Class B noxious weeds are abundant in some areas of the state, but absent or rare in others. Class C Noxious weeds are already widespread in Washington” (Washington State Noxious Weed Board).

Survival of monitored shrubs was determined through the establishment of stationary transects over 5 years. In most cases, transects are 100 m (328 ft) in length; however, shorter (25 to 75 m [82 to 246 ft]) transects have been established at sites too small to support larger transects. Locational measurements for each shrub monitored are recorded along the transect, up to 5 m (16.4 ft) away from either side of the

measure tape, to identify individual survivorship (dead or alive) over the 5-year period, which is then converted into percent survival.

Plant identification in the 2016 monitoring efforts were conducted using the nomenclature in *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1973) and in *Vascular Plants of the Hanford Site* (Sackschewsky and Downs 2001). Appendix A of this report lists the updated species names provided by the United States Department of Agriculture's plant classification website ([USDA](#)). All frequency of occurrence and canopy cover measurements were taken between May 3rd and 5th of 2016, and all shrub transect monitoring occurred between June 17th and 21st of 2016.

Monitoring Results

100-F Sites

100-F-47 Site

Planting at the 100-F-47 site was completed on February 16, 2012. The site was planted with native bunch grasses and big sagebrush and spiny hopsage seedlings. Monitoring of the site began in 2016, four years after planting. The site was dominated by non-native cheatgrass (*Bromus tectorum*) and bulbous bluegrass (*Poa bulbosa*) with 43.0% and 10.5% cover respectively (Table 1). The most dominant native cover included bluebunch wheatgrass (*Agropyron spicatum*) with 4.3% cover and Sandberg's bluegrass (*Poa sandberii*) with 4.0% cover. The total native cover on the site was measured at 12.7%. Diffuse Knapweed (*Centaurea diffusa*), a Washington State Noxious Weed class B, was recorded on the site.

A 100 m tape was extended and 100 big sagebrush and two spiny hopsage shrubs were present within 5 m of either side of the measuring tape (Figure 2). The average height of the big sagebrush was 73 cm and the spiny hopsage was 25 cm.

Table 1. Percent Canopy Cover and Frequency of Occurrence at 100-F-47 in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	4.0	60.0
<i>Bromus tectorum</i> ^a (cheatgrass)	43.0	100.0
<i>Salsola kali</i> ^a (Russian thistle)	1.0	40.0
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	4.3	40.0
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	0.2	6.7
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	0.2	6.7
<i>Descurainia pinnata</i> (western tansymustard)	0.3	13.3
<i>Artemisia tridentata</i> (big sagebrush)	1.2	13.3
<i>Grayia spinosa</i> (spiny hopsage)	1.0	6.7
<i>Stipa comata</i> (needle-and-thread grass)	1.5	26.7
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	10.5	40.0
<i>Festuca microstachys</i> (small fescue)	0.3	13.3
<i>Medicago sativa</i> ^a (alfalfa)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Oryzopsis hymenoides</i> (Indian ricegrass)	X	X
<i>Sphaeralcea munroana</i> (Munro's globemallow)	X	X
Soil	45.8	100.0
Litter	49.2	100.0
Total canopy cover (litter not included)	67.5	
Total Invasive % Cover	54.8	
Total Native % Cover	12.7	

^a Invasive species

^b Washington State Classified Noxious Weed (class)

X = Present but not counted in plot frames



Figure 2. The 100-F-47 Site in 2016

100-F-48 Site

Plantings of native grasses and big sagebrush and spiny hopsage seedlings were completed at the 100-F-48 site on February 22, 2012. The site was monitored for the first time in 2016, four years after planting. Cheatgrass was the dominant species on the site with 47.3% of the total 53.8% vegetative cover. Native vegetation was measured at 4.2% cover (Table 2). Diffuse Knapweed, a Washington State Noxious Weed class B, was present on the site. A 100 m tape was extended and 46 big sagebrush plants were recorded within 5 m of either side of the measure tape. The big sagebrush averaged 68.9 cm tall (Figure 3).

Table 2. Percent Canopy Cover and Frequency of Occurrence at 100-F-48 in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	1.2	13.3
<i>Bromus tectorum</i> ^a (cheatgrass)	47.3	100.0
<i>Salsola kali</i> ^a (Russian thistle)	0.8	33.3
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	1.5	26.7
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	0.3	13.3
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	1.0	6.7
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	0.2	6.7
<i>Descurainia pinnata</i> (western tansymustard)	1.3	20.0
<i>Artemisia tridentata</i> (big sagebrush)	0.2	6.7
<i>Amsinckia lycopsoides</i> (fiddleneck)	X	X
<i>Oryzopsis hymenoides</i> (Indian ricegrass)	X	X
<i>Grayia spinosa</i> (spiny hopsage)	X	X
Soil	47.7	100.0
Litter	42.0	100.0
Total canopy cover (litter not included)	53.8	
Total Invasive % Cover	49.7	
Total Native % Cover	4.2	

^aInvasive species

^bWashington State Noxious Weed (class)

X = Present but not counted in plot frames



Figure 3. The 100-F-48 Site in 2016

100-F Container Transfer Area

The 100-F Container Transfer Area was revegetated in February 2012 with native grasses and big sagebrush and spiny hopsage seedlings. The site was monitored for the first time in 2016, four years after planting. The site has a total canopy cover of 46.0% dominated by Russian thistle (*Salsola kali*) at 22.5%, cheatgrass at 12.4%, and native Sandberg's bluegrass at 9.1% (Table 3). Diffuse Knapweed, a Washington State Noxious Weed class B, was observed on the site. Total native cover after 4 years of growth is 10.7%. A 100 m tape was extended and 54 sagebrush and 11 spiny hopsage plants were recorded (Figure 4). The average big sagebrush height was 44.1 cm, and average spiny hopsage was 22.7 cm tall.

Table 3. Percent Canopy Cover and Frequency of Occurrence at 100-F Area Container Transfer Area in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	9.1	58.1
<i>Bromus tectorum</i> ^a (cheatgrass)	12.4	90.3
<i>Salsola kali</i> ^a (Russian thistle)	22.5	100.0
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	0.1	3.2
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	0.1	6.5
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	0.1	3.2
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	0.1	3.2
<i>Descurainia pinnata</i> (western tansymustard)	1.3	38.7
<i>Stipa comata</i> (needle-and-thread grass)	0.1	3.2
<i>Ranunculus testiculatus</i> ^a (bur buttercup)	0.1	3.2
<i>Machaeranthera canescens</i> (hoary aster)	0.1	3.2
<i>Medicago sativa</i> ^a (alfalfa)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	X	X
<i>Grayia spinosa</i> (spiny hopsage)	X	X
<i>Sitanion hystrix</i> (bottlebrush squirreltail)	X	X
Soil	47.3	100.0
Litter	39.9	100.0
Total canopy cover (litter not included)	46.0	
Total Invasive % Cover	35.3	
Total Native % Cover	10.7	

^aInvasive species

^bWashington State Noxious Weed (class)

X = Present but not counted in plot frames



Figure 4. The 100-F Area Container Transfer Area in 2016

118-F-6 Burial Ground

The 118-F-6 Burial Ground was planted in November 2008. The site was seeded with Sandberg's bluegrass, Indian ricegrass (*Oryzopsis hymenoides*), bluebunch wheatgrass, prairie junegrass (*Koeleria cristata*), bottlebrush squirreltail (*Sitanion hystrix*), and needle-and-thread grass (*Stipa comata*). Triple-16 fertilizer was added at a rate of 134 kg/ha (120 lbs/ac) to the site along with 4,480 kg/ha (4,000 lbs/ac) of native grass straw mulch that was spread over the seeded area and crimped into the soil surface. Spiny hopsage, big sagebrush, and antelope bitterbrush plugs were planted into the seeded areas at approximately 1,200 plants/ha (500 plants/ac).

The 118-F-6 Burial Ground site was monitored in 2016 to verify if the revegetation effort met the minimum success criteria as defined in DOE/RL-96-17 and DOE/RL-2011-116. Prior to 2016, the 118-F-6 Burial Ground was last monitored in 2013. In 2016, after seven years of growth, the total native cover on the 118-F-6 Burial Ground was 13.3%, a decrease of 42.5% from 2013, and the total invasive cover was 47.8%, an increase of 22.3% (Table 4). Cheatgrass was the dominant species across the site with 32.8% cover, an increase of 19.6% from 2013 measurements. Sandberg's bluegrass was the dominant native species on the site with 7.6% cover, a decrease of 42.4% from 2013. Two Washington State Noxious Weeds, Diffuse

Knapweed, a class B species, and whitetop (*Cardaria draba*), a class C species, were also recorded on the site.

Shrub monitoring showed big sagebrush survival at 45.5% on the 118-F-6 Burial Ground in 2013 and at 34.1% in 2016. Total shrub (big sagebrush and spiny hopsage) survival on the 118-F-6 Burial Ground was at 36.4% in 2013 and at 27.3% in 2016, a 9.1% decrease. Monitoring results show that the 118-F-6 Burial Ground site does not meet the minimum success criteria of 25% native cover and 50% planted shrub survival five years after planting. A site specific revegetation plan will be developed to supplement this site.

Table 4. Percent Canopy Cover and Frequency of Occurrence at 118-F-6 Burial Ground in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	7.6	65.0
<i>Bromus tectorum</i> ^a (cheatgrass)	32.8	100.0
<i>Salsola kali</i> ^a (Russian thistle)	0.8	30.0
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	0.1	5.0
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	1.1	20.0
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	11.5	75.0
<i>Draba verna</i> ^a (spring whitlowgrass)	1.4	30.0
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	0.3	10.0
<i>Descurainia pinnata</i> (western tansymustard)	4.3	50.0
<i>Grayia spinosa</i> (spiny hopsage)	0.8	5.0
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	0.1	5.0
<i>Machaeranthera canescens</i> (hoary aster)	0.1	5.0
<i>Cardaria draba</i> ^b (whitetop) (C)	0.1	5.0
<i>Epilobium paniculatum</i> (tall willowherb)	0.1	5.0
<i>Chrysothamnus viscidiflorus</i> (green rabbitbrush)	X	X
<i>Lepidium perfoliatum</i> ^a (clasping pepperweed)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Oryzopsis hymenoides</i> (Indian ricegrass)	X	X
<i>Achillea millefolium</i> (yarrow)	X	X
<i>Sphaeralcea munroana</i> (Munro's globemallow)	X	X
<i>Stipa comata</i> (needle-and-thread grass)	X	X
<i>Sitanion hystrix</i> (bottlebrush squirreltail)	X	X
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	X	X
<i>Cryptantha circumscissa</i> (matted cryptantha)	X	X
<i>Erigeron pumilus</i> (shaggy fleabane)	X	X
Crust	11.5	75.0
Soil	41.8	100.0
Litter	18.8	100.0
Total canopy cover (litter not included)	61.0	

Total Invasive % Cover 2016	47.8
Total Native % Cover 2016	13.3
Change in Invasive % Cover from 2013	22.3
Change in Native % Cover from 2013	-42.5

^a Invasive species

^b Washington State Noxious Weed (class)

X = present but not counted in plot frames

118-F-6 Soil Staging Area

The 118-F-6 Soil Staging Area was planted in November 2008 at the same time as the 118-F-6 Burial Ground. The site was monitored for the first time in 2016, seven years after planting. The native cover on the site was 20.8% and the invasive cover was 28.7% for a total canopy cover of 49.7% (Table 5). The native cover was dominated by Sandberg’s bluegrass with 17.5% cover and the invasive cover was dominated by cheatgrass with 15.8% cover. There was an almost complete absence of shrubs present on the site (Figure 5). This site does not meet the minimum success requirements. A revegetation plan will be developed to improve this site.

Table 5. Percent Canopy Cover and Frequency of Occurrence at 118-F-6 Soil Staging Area in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	17.5	93.3
<i>Bromus tectorum</i> ^a (cheatgrass)	15.8	93.3
<i>Salsola kali</i> ^a (Russian thistle)	0.3	13.3
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	9.7	93.3
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	0.2	6.7
<i>Draba verna</i> ^a (spring whitlowgrass)	0.2	6.7
<i>Descurainia pinnata</i> (western tansymustard)	2.0	46.7
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	2.7	13.3
<i>Festuca microstachys</i> (small fescue)	0.2	6.7
<i>Agoseris heterophylla</i> (annual mountain dandelion)	1.0	6.7
<i>Psoralea lanceolata</i> (dune scurfpea)	0.2	6.7
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Achillea millefolium</i> (yarrow)	X	X
<i>Sitanion hystrix</i> (bottlebrush squirreltail)	X	X
<i>Sporobolus cryptandrus</i> (sand dropseed)	X	X
Crust	6.8	46.7
Soil	57.0	100.0

Litter	6.7	100.0
Total canopy cover (litter not included)	49.7	
Total Invasive % Cover	28.7	
Total Native % Cover	20.8	

‡ Invasive species

X = present but not counted in plot frames



Figure 5. 118-F-6 Soil Staging Area Site in 2016

1607-F-1 Site

The 1607-F-1 site was revegetated in November 2008. Similar to the 118-F-6 sites, the 1607-F-1 site was seeded with Sandberg’s bluegrass, Indian ricegrass, bluebunch wheatgrass, prairie junegrass, bottlebrush squirreltail, and needle-and-thread grass. Triple-16 fertilizer was applied at a rate of 134 kg/ha (120 lbs/ac) to the site along with 4,480 kg/ha (4,000 lbs/ac) of native grass straw mulch that was spread and crimped into the soil surface. Spiny hopsage, big sagebrush, and antelope bitterbrush plugs were planted into the seeded areas at approximately 1,200 plants/ha (500 plants/ac).

The 1607-F-1 site was monitored in 2016 to determine if the revegetation effort met the minimum success criteria as defined in DOE/RL-96-17 and DOE/RL-2011-116. The site was last monitored in 2013. In 2013,

total native canopy was 12.2% and the invasive cover was 107.2%. Cheatgrass was the dominant invasive species at this site with 57.2% cover followed by storkbill (*Erodium cicutarium*) with 37.8%. Sandberg’s bluegrass was the dominant native species with 7.5% cover. In 2016, the total native cover was 8.3%, a decrease of 3.9% from 2013, and the invasive cover was 101.8%, a decrease of 5.4% from 2013. Cheatgrass remained the dominant invasive species at the site with 64.8% followed by jagged chickweed (*Holosteum umbellatum*) with 22.5% (Table 6). Sandberg’s bluegrass remained the dominant native species with 6.3% canopy cover.

Big sagebrush monitoring at the site indicated a decrease of survival from 59.4% in 2013 to 46.9% survival in 2016 (Figure 6). None of the spiny hopsage recorded in 2013 have survived. The total shrub survival at 1607-F-1 was 57.6% in 2013 and 45.5% in 2016, a decrease of 12.1%. This site does not meet the minimum success requirements for native canopy, but is close to meeting success criteria for shrub survival. A revegetation plan will be developed to improve the site.

Table 6. Percent Canopy Cover and Frequency of Occurrence at 1607-F-1 in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	6.3	33.3
<i>Bromus tectorum</i> ^a (cheatgrass)	64.8	100.0
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	22.5	73.3
<i>Draba verna</i> ^a (spring whitlowgrass)	0.3	13.3
<i>Erodium cicutarium</i> ^a (storksbill)	1.3	20.0
<i>Descurainia pinnata</i> (western tansymustard)	0.3	13.3
<i>Sporobolus cryptandrus</i> (sand dropseed)	0.3	13.3
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	14.2	33.3
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Sphaeralcea munroana</i> (Munro's globemallow)	X	X
<i>Stipa comata</i> (needle-and-thread grass)	X	X
Crust	12.0	93.3
Soil	7.5	100.0
Litter	45.8	100.0
Total canopy cover (litter not included)	110.2	
Total Invasive % Cover 2016	101.8	
Total Native % Cover 2016	8.3	
Change in Invasive % Cover from 2013	-5.4	
Change in Native % Cover from 2013	-3.9	

^aInvasive species

X = present but not counted in plot frames



Figure 6. Shrub Transect at 1607-F-1 Site in 2016

118-F-5 Burial Ground

The 118-F-5 site was separated into two monitoring areas, the 118-F-5 Burial Ground and the 118-F-5 Soil Staging Area to allow for comparison between two contrasting soil types. The 118-F-5 Burial Ground was backfilled with coarse cobble from a local borrow area while the 118-F-5 substrate is a relatively fine-grained native topsoil. Planting of these sites was completed December 11, 2007. The same revegetation was performed at both sites which included broadcast seeding with a mixture of native grasses comprised of Sandberg's bluegrass, Indian ricegrass, bluebunch wheatgrass, prairie junegrass, bottlebrush squirreltail, needle-and-thread grass. Triple-16 fertilizer was added at a rate of 134 kg/ha (120 lbs/ac) to the site along with 4,480 kg/ha (4,000 lbs/ac) of native grass straw mulch that was spread and crimped into the soil surface. Big sagebrush and spiny hopsage plugs were planted into the seeded areas at approximately 1,200 plants/ha (500 plants/ac).

The 118-F-5 Burial Ground was monitored in 2016 to verify if the revegetation effort met the minimum success criteria as defined in DOE/RL-96-17 and DOE/RL-2011-116. The 118-F-5 Burial Ground site was last monitored in 2012. In 2012, the native cover was 7.0% and the invasive cover was 71.3%. Bluebunch wheatgrass was the dominant native species at only 2.3% while cheatgrass was the dominant invasive

species at 67.2%. In 2016, the native cover was 5.5%, a decrease of 1.5% and the invasive cover was 26.8%, a decrease of 44.5% (Table 7). Sandberg's bluegrass was the dominant native species at only 3.2%. Cheatgrass was still the dominant invasive species at 11.8% followed by bulbous bluegrass at 4.7%. Diffuse Knapweed, a Washington State Noxious Weed class B, was observed on the site.

Shrub monitoring at the 118-F-5 Burial Ground revealed big sagebrush survival was at 27.6% in 2012 and at 22.4% in 2016, a 5.2% decrease (Figure 7). Monitoring results confirmed that the 118-F-5 Burial Ground does not meet the minimum success criteria of 25% native cover and 50% planted shrub survival five years after planting. A site specific revegetation plan will be developed to improve this site.

Table 7. Percent Canopy Cover and Frequency of Occurrence at 118-F-5 Burial Ground Site in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	3.2	33.3
<i>Bromus tectorum</i> ^a (cheatgrass)	11.8	93.3
<i>Salsola kali</i> ^a (Russian thistle)	1.0	40.0
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	0.2	6.7
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	8.7	93.3
<i>Draba verna</i> ^a (spring whitlowgrass)	0.7	26.7
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	0.8	33.3
<i>Descurainia pinnata</i> (western tansymustard)	0.3	13.3
<i>Artemisia tridentata</i> (big sagebrush)	1.0	6.7
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	4.7	53.3
<i>Oryzopsis hymenoides</i> (Indian ricegrass)	X	X
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	X	X
<i>Sporobolus cryptandrus</i> (sand dropseed)	X	X
<i>Machaeranthera canescens</i> (hoary aster)	X	X
Crust	1.5	26.7
Soil	70.0	100.0
Litter	13.0	100.0
Total canopy cover (litter not included)	32.3%	
Total Invasive % Cover 2016	26.8%	
Total Native % Cover 2016	5.5%	
Change in Invasive % Cover from 2012	-44.5%	
Change in Native % Cover from 2012	-1.5%	

^a Invasive species

^b Washington State Noxious Weed (class)

X = present but not counted in plot frames



Figure 7. Shrub Transect at 118-F-5 Burial Ground Site in 2016

118-F-5 Soil Staging Area

Planting at the 118-F-5 Soil Staging Area was completed on December 11, 2007. Soil at the 118-F-5 Soil Staging Area is a relatively fine-grained native topsoil. The planting of 118-F-5 Soil Staging Area was identical to the adjacent 118-F-5 Burial Ground.

The 118-F-5 Soil Staging Area was monitored in 2016 to determine if the revegetation effort met the minimum success criteria as defined in DOE/RL-96-17 and DOE/RL-2011-116. The 118-F-5 Soil Staging Area was last monitored in 2012. In 2012, the native cover was 10.7% and the invasive cover was 80.2%. Several native species were recorded including Sandberg's bluegrass at 1.7%, fiddleneck (*Amsinckia lycopsoides*) at 1.8%, big sagebrush at 1.5%, and gray rabbitbrush (*Chrysothamnus nauseosus*). Cheatgrass was the dominant invasive species at 65.5%. In 2016, the native cover was 14.7%, an increase of 4.0% and the invasive cover was 74.9%, a decrease of 5.3% (Table 8). Several other native species were recorded including fiddleneck at 2.6%, needle-and-thread grass at 2.3%, Indian wheat (*Plantago patagonica*) at 2.0%, and sand dropseed (*Sporobolus cryptandrus*) at 1.6%. Cheatgrass was the dominant invasive species at 45.1% followed by jagged chickweed at 19.2%.

Shrub survival was unchanged from 2012 to 2016. Big sagebrush survival was at 17% and total shrub survival was 15.4% (Figure 8). Only one of eleven spiny hopsage plants was alive along the transect in 2012

and that one plant was still alive in 2016. The 118-F-5 Soil Staging Area does not meet the minimum success criteria of 25% native cover and 50% planted shrub survival five years after planting. A site specific revegetation plan will be developed for this site.

Table 8. Percent Canopy Cover and Frequency of Occurrence at 118-F-5 Soil Staging Area in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	3.0	37.5
<i>Bromus tectorum</i> ^a (cheatgrass)	45.1	100.0
<i>Salsola kali</i> ^a (Russian thistle)	0.3	12.5
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	4.0	37.5
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	19.2	95.8
<i>Draba verna</i> ^a (spring whitlowgrass)	4.9	16.7
<i>Achillea millefolium</i> (yarrow)	0.1	4.2
<i>Descurainia pinnata</i> (western tansymustard)	0.3	12.5
<i>Amsinckia lycopsoides</i> (fiddleneck)	2.6	25.0
<i>Artemisia tridentata</i> (big sagebrush)	0.7	8.3
<i>Sporobolus cryptandrus</i> (sand dropseed)	1.6	4.2
<i>Oryzopsis hymenoides</i> (Indian ricegrass)	0.6	4.2
<i>Stipa comata</i> (needle-and-thread grass)	2.3	12.5
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	1.5	16.7
<i>Machaeranthera canescens</i> (hoary aster)	0.4	16.7
<i>Plantago patagonica</i> (Indian wheat)	2.0	20.8
<i>Ambrosia acanthicarpa</i> (bur ragweed)	0.3	12.5
<i>Oenothera pallida</i> (evening primrose)	0.1	4.2
<i>Cryptantha circumscissa</i> (matted cryptantha)	0.6	4.2
<i>Phlox longifolia</i> (longleaf phlox)	X	X
<i>Opuntia polyacantha</i> (starvation pricklypear)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Achillea millefolium</i> (yarrow)	X	X
<i>Grayia spinosa</i> (spiny hopsage)	X	X
<i>Astragalus caricinus</i> (buckwheat milkvetch)	X	X
<i>Astragalus sclerocarpus</i> (stalked-pod milkvetch)	X	X
Crust	2.8	70.8
Soil	42.5	100.0
Litter	31.3	100.0
Total canopy cover (litter not included)	89.6%	
Total Invasive % Cover 2016	74.9%	
Total Native % Cover 2016	14.7%	
Change in Invasive % Cover from 2012	4.0%	
Change in Native % Cover from 2012	-5.3%	

^aInvasive species

X=present but not counted in plot frames



Figure 8. Shrub Transect at 118-F-5 Soil Staging Area in 2016

100-K Sites

100-K Container Transfer Area

The 100-K Container Transfer Area was planted in December 2015. The site was seeded with sand dropseed, Sandberg's bluegrass, Indian ricegrass, bluebunch wheatgrass, prairie junegrass, bottlebrush squirreltail, and needle-and-thread grass. Big sagebrush, antelope bitterbrush, and spiny hopsage seedlings were planted into the seeded areas at approximately 1,600 plants/ha (650 plants/ac). Ratios of shrubs were 75% big sagebrush, 15% antelope bitterbrush, and 10% spiny hopsage.

First year monitoring occurred at the 100-K Container Transfer Area in 2016. The native cover on the site was 3.8% and the invasive cover was 48.4% (Table 9). The dominant native species was Sandberg's bluegrass at 2.0% and the dominant invasive species included cheatgrass at 28.1% and Russian thistle at 17.5%. Diffuse Knapweed, a Washington State Noxious Weed class B, was documented on the site. The site was nearly absent of shrubs therefore, no shrub transect was established. A site specific revegetation plan will be developed to supplement shrub planting on this site.

Table 9. Percent Canopy Cover and Frequency of Occurrence at 100-K Container Transfer Area Site in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	2.0	30.0
<i>Bromus tectorum</i> ^a (cheatgrass)	28.1	100.0
<i>Salsola kali</i> ^a (Russian thistle)	17.5	80.0
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	2.3	40.0
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	0.3	10.0
<i>Draba verna</i> ^a (spring whitlowgrass)	0.1	5.0
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	0.1	5.0
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	0.1	5.0
<i>Descurainia pinnata</i> (western tansymustard)	0.9	35.0
<i>Artemisia tridentata</i> (big sagebrush)	0.8	5.0
<i>Lactuca serriola</i> ^a (prickly lettuce)	X	X
<i>Chaenactis douglasii</i> (hoary falseyarrow)	X	X
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	X	X
<i>Ulmus pumila</i> (Siberian elm)	X	X
Crust	0.0	0.0
Soil	39.3	100.0
Litter	26.3	100.0
Total canopy cover (litter not included)	52.1%	
Total Invasive % Cover	48.4%	
Total Native % Cover	3.8%	

^a Invasive species

^b Washington State Noxious Weed (class)

X = present but not counted in plot frames

118-K-1 Burial Ground Site

The revegetation of the 118-K-1 Burial Ground was completed on March 23, 2013. Information on what was planted at the 118-K-1 Burial Ground was not available but it is assumed that planting was similar to other sites at the 100-K Area with seeding of sand dropseed, Sandberg's bluegrass, Indian ricegrass, bluebunch wheatgrass, prairie junegrass, bottlebrush squirreltail, and needle-and-thread grass and planting of big sagebrush, antelope bitterbrush, and spiny hopsage plugs at approximately 1,600 plants/ha (650 plants/ac). Ratios of shrubs were 75% big sagebrush, 15% antelope bitterbrush, and 10% spiny hopsage.

The first monitoring of the site occurred in 2016, three years after planting. No frequency of occurrence and canopy cover measurements were taken in May 2016 due to radiological posting of the site. However, two transects were established in June, both 100 m long, and plants were counted and measured within

5 m of either side (Figure 9). On the first transect, 66 big sagebrush plants were counted with an average height of 48.0 cm. The second transect contained 80 big sagebrush plants with an average height of 61.4 cm. Future monitoring efforts will include plot measurements on this site.



Figure 9. One of Two Shrub Transects at 118-K-1 Burial Ground in 2016

118-K-1 Soil Staging Area

The planting of 118-K-1 Soil Staging Area was completed on March 23, 2013. Information on what was planted at the 118-K-1 Soil Staging Area was not available but is assumed to be similar to the 118-K-1 Burial Ground. The site was first monitored in 2016 and, three years following planting, the native cover was 4.4% and the invasive cover was 58.5% (Table 10). The dominant native species was western tansymustard (*Descurainia pinnata*) at 3.5% and the dominant invasive species consist of Russian thistle at 43.0% and cheatgrass at 11.9%. Diffuse Knapweed, a Washington State Noxious Weed class B, occurred on the site.

Two shrub transects were established in 2016, both 100 m long, with shrubs counted and measured 5 m on either side of the tape measure. The first transect contained 45 big sagebrush plants with an average height of 90 cm (Figure 10), and the second transect contained 31 big sagebrush plants with an average height of 73 cm (Figure 11).

Table 10. Percent Canopy Cover and Frequency of Occurrence at 118-K-1 Soil Staging Area in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	0.1	5.0
<i>Bromus tectorum</i> ^a (cheatgrass)	11.9	100.0
<i>Salsola kali</i> ^a (Russian thistle)	43.0	100.0
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	3.4	35.0
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	0.1	5.0
<i>Descurainia pinnata</i> (western tansymustard)	3.5	65.0
<i>Lactuca serriola</i> ^a (prickly lettuce)	0.1	5.0
<i>Stipa comata</i> (needle-and-thread grass)	0.8	30.0
<i>Amsinckia lycopsoides</i> (fiddleneck)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Sphaeralcea munroana</i> (Munro's globemallow)	X	X
<i>Chenopodium leptophyllum</i> (slimleaf goosefoot)	X	X
Crust	0.0	0.0
Soil	26.3	90.0
Litter	54.8	100.0
Total canopy cover (litter not included)	62.9%	
Total Invasive % Cover	58.5%	
Total Native % Cover	4.4%	

^a Invasive species

^b Washington State Noxious Weed (class)

X = present but not counted in plot frames



Figure 10. Shrub Transect #1 at 118-K-1 Soil Staging Area in 2016



Figure 11. Shrub Transect #2 at 118-K-1 Soil Staging Area in 2016

128-K-2 Burn Pit

The revegetation of the 128-K-2 Burn Pit site was finished on December 8, 2012 and first monitored in 2016, four years after planting. Planting at 128-K-2 Burn Pit site is assumed to be similar to other 100-K Area sites. The native cover after four years was 19.8% and the invasive cover was 33.8%. Sandberg's bluegrass was the dominant native species at 12% while cheatgrass the dominant invasive species at 23.3% (Table 11). Diffuse Knapweed, a Washington State Noxious Weed class B, was recorded on the site.

A 100 m shrub monitoring transect was established, and plants were counted and measured 5 m on either side of the measuring tape (Figure 12). During the shrub transect monitoring, 83 big sagebrush plants were counted, with an average height of 65.4 cm.

Table 11. Percent Canopy Cover and Frequency of Occurrence at 128-K-2 Burn Pit in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	12.0	78.9
<i>Bromus tectorum</i> ^a (cheatgrass)	23.3	100.0
<i>Salsola kali</i> ^a (Russian thistle)	4.3	68.4
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	3.0	21.1
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	0.7	21.1
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	3.8	26.3
<i>Draba verna</i> ^a (spring whitlowgrass)	1.5	31.6
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	0.2	5.3
<i>Descurainia pinnata</i> (western tansymustard)	2.5	47.4
<i>Artemisia tridentata</i> (big sagebrush)	1.0	5.3
<i>Stipa comata</i> (needle-and-thread grass)	0.2	5.3
<i>Epilobium paniculatum</i> (tall willowherb)	0.2	5.3
<i>Sphaeralcea munroana</i> (Munro's globemallow)	1.0	5.3
<i>Tragopogon dubius</i> ^a (yellow salsify)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
Crust	0.0	0.0
Soil	49.2	100.0
Litter	38.7	94.7
Total canopy cover (litter not included)	53.7%	
Total Invasive % Cover	33.8%	
Total Native % Cover	19.8%	

^a Invasive species

^b Washington State Noxious Weed (class)

X = present but not counted in plot frames



Figure 12. Shrub Transect at 128-K-2 Burn Pit in 2016

128-K-2 Soil Staging Area

The planting of the 128-K-2 Soil Staging Area was completed on December 8, 2012. Substrate at this site varies from primarily cobble with varying amounts of sandy loam to sandy loam with few cobbles. Planting at 128-K-2 Burn Pit site is assumed to have been planted similar to other 100-K Area sites.

Third year monitoring of the 128-K-2 Soil Staging Area was completed in 2015. The total native cover on the site was 12% and the total invasive cover was 23.5%. The dominant native species in 2015 included Sandberg's bluegrass at 5.6%, big sagebrush at 3.1%, bluebunch wheatgrass at 1.7%, and Munro's globemallow (*Sphaeralcea munroana*) at 1.5%. The dominant invasive species on the site in 2015 consisted of Russian thistle at 12.6%, cheatgrass at 7.09%, and tumble mustard (*Sisymbrium altissimum*) at 2.9%. In 2016, the fourth year of monitoring, native cover increased by 5.5% to 17.5% but invasive cover also increased by 26.3% to 49.8% (Table 12). The dominant native species on the site in 2016 were Sandberg's bluegrass at 14.7% and bluebunch wheatgrass at 2.2%. The dominant invasive species occurring on the site in 2016 included cheatgrass at 46.0% and Russian thistle at 1.3%.

Shrub survival on the 128-K-2 Soil Staging Area decreased by 6.3% from the 2015 monitoring results (figure 13). Shrub survival in 2015 was at 63.3% and at 57.0% in 2016. This site is not anticipated to achieve the minimum required native cover following the fifth year of monitoring that will be completed next year, however, shrub survival is on target to be above the required 50% but will be confirmed in 2017.

Table 12. Percent Canopy Cover and Frequency of Occurrence at 128-K-2 Soil Staging Area in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	14.7	80.0
<i>Bromus tectorum</i> ^a (cheatgrass)	46.0	100.0
<i>Salsola kali</i> ^a (Russian thistle)	1.3	53.3
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	2.2	20.0
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	0.7	26.7
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	1.0	6.7
<i>Draba verna</i> ^a (spring whitlowgrass)	0.8	33.3
<i>Descurainia pinnata</i> (western tansymustard)	0.7	26.7
<i>Tragopogon dubius</i> ^a (yellow salsify)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Sphaeralcea munroana</i> (Munro's globemallow)	X	X
Crust	0.0	0.0
Soil	30.2	93.3
Litter	48.5	100.0
Total canopy cover (litter not included)	67.3%	
Total Invasive % Cover	49.8%	
Total Native % Cover	17.5%	
Change in Invasive % cover from 2015	26.3%	
Change in Native % Cover from 2015	5.5%	

^aInvasive species

X = present but not counted in plot frames



Figure 13. Shrub Transect at 128-K-2 Soil Staging Area in 2016

100-K-95 Tar Dump

The revegetation of the 100-K-95 Tar Dump was completed on February 13, 2014. Substrate at the site is composed of loamy sand and sandy loam with varying amounts of scattered boulders. Planting at 100-K-95 Tar Dump is assumed to be similar to other 100-K sites with one exception. Due to the boulders on site, the revegetation crew was unable to distribute straw mulch over a portion of the site. For monitoring purposes, the site was divided into two areas, Area 1 (nonstrawed) and Area 2 (strawed).

The 100-K-95 Tar Dump was last monitored in 2015, the second year of monitoring. In 2015, the native and invasive cover were similar in Area 1 and Area 2. Native cover in Area 1 was 0.6% and 2.6% in Area 2 while invasive cover was 62.1% in Area 1 and 64.4% in Area 2. Canopy covers by individual species were also similar between the two areas. Native cover for the entire 100-K-95 Tar Dump site in 2015 was 1.6% and the invasive cover was 63.3%. No native species was above 1% cover in 2015. The dominant invasive species on the 100-K-95 Tar Dump site in 2015 were composed of cheatgrass at 38.0%, Russian thistle at 12.3%, and tumble mustard at 10.1%. In 2016, the third year of monitoring of the 100-K-95 Tar Dump site, the native cover for the entire site was 0.9%, essentially unchanged from 2015, while the invasive cover was 86.5%, an increase of 23.2% from 2015 (Table 13).

Two Shrub monitoring transects were established in 2014, one in both Area 1 and Area 2. In 2015, the shrub survival rate was 32.0% in Area 1 (nonstrawed) and 3.5% in Area 2 (strawed), resulting 17.7% for the entire site. In 2014, there were both antelope bitterbrush and big sagebrush plants surviving on the site but in 2015, only sagebrush plants remained. In 2016, the shrub survival rate was 23.0% in Area 1 and 3.5% in Area 2; the shrub survival rate for the entire site was 13.6%. Currently, both native cover and shrub survival on this site are well below the requirements to be considered successful.

Table 13. Percent Canopy Cover and Frequency of Occurrence at 100-K-95 in 2016

Species	% Cover	% Freq of Occ
<i>Bromus tectorum</i> ^a (cheatgrass)	52.5	100.0
<i>Salsola kali</i> ^a (Russian thistle)	1.0	36.7
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	13.5	80.0
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	15.1	73.3
<i>Draba verna</i> ^a (spring whitlowgrass)	4.3	33.3
<i>Oryzopsis hymenoides</i> (Indian ricegrass)	0.9	20.0
<i>Poa bulbosa</i> (bulbous bluegrass)	0.1	3.3
<i>Tragopogon dubius</i> (yellow salsify)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Lomatium sp.</i>	X	X
<i>Erigeron sp.</i>	X	X
Crust	0.0	0.0
Soil	35.2	96.7
Litter	32.0	100.0
Total canopy cover (litter not included)	87.4%	
Total Invasive % Cover 2016	86.5%	
Total Native % Cover 2016	0.9%	
Change in Invasive % Cover from 2015	23.2%	
Change in Native % Cover from 2015	-0.7%	

^a Invasive species

X = present but not counted in plot frames



Figure 14. Shrub Transect #1 at 100-K-95 Tar Dump Site in 2016



Figure 15. Shrub Transect #2 at 100-K-95 Tar Dump Site in 2016

600 Area Sites

600-29 Site

Planting at the 600-29 site was completed on December 12, 2012. The site was first monitored in 2016, four years after planting. It is not documented which species were planted at this site but it is assumed the site was planted similar to other sites in the 600 Area. Many sites in the 600 Area were broadcast seeded with a mixture of native grasses including Sandberg’s bluegrass, Indian ricegrass, bluebunch wheatgrass, prairie junegrass, bottlebrush squirreltail, and needle-and-thread grass. In addition, 134 kg/ha (120 lbs/ac) of triple-16 fertilizer was added to the sites along with 4,480 kg/ha (4000 lbs/ac) of straw mulch that was spread over the seeded area and crimped into the soil surface. Big sagebrush and bitterbrush plugs were planted into the seeded areas at approximately 1,235 plants/ha (500 plants/ac).

In 2016, the native cover on the 600-29 site was 23.4% and the invasive cover was 22.6% (Table 14). The dominant native species on the site include Sandberg’s bluegrass at 11.4% cover and bluebunch wheatgrass at 6.1% cover. The dominant invasive species on the site consist of cheatgrass at 17.5% cover and diffuse knapweed, a Washington State Noxious Weed class B, at 4.3% cover.

A 100 m shrub monitoring transect was established, and plants were counted and measured 5 m off both sides of the tape measure. Sixty-four big sagebrush plants were counted with an average height of 60.2 cm.

Table 14. Percent Canopy Cover and Frequency of Occurrence at 600-29 in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg’s bluegrass)	11.4	75.0
<i>Bromus tectorum</i> ^a (cheatgrass)	17.5	100.0
<i>Salsola kali</i> ^a (Russian thistle)	0.8	30.0
<i>Agropyron spicatum</i> (bluebunch wheatgrass)	6.1	50.0
<i>Draba verna</i> ^a (spring whitlowgrass)	0.1	5.0
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	0.8	5.0
<i>Centaurea diffusa</i> ^b (diffuse knapweed) (B)	4.3	30.0
<i>Descurainia pinnata</i> (western tansymustard)	0.4	15.0
<i>Stipa comata</i> (needle-and-thread grass)	1.4	30.0
<i>Machaeranthera canescens</i> (hoary aster)	1.3	25.0
<i>Epilobium paniculatum</i> (tall willowherb)	0.3	10.0
<i>Astragalus succumbens</i> (crouching milkvetch)	1.9	5.0
<i>Medicago sativa</i> ^a (alfalfa)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Achillea millefolium</i> (yarrow)	X	X
<i>Sphaeralcea munroana</i> (Munro’s globemallow)	X	X

<i>Amsinckia lycopsoides</i> (fiddleneck)	X	X
<i>Penstemon</i> sp.	X	X
<i>Ambrosia acanthicarpa</i> (bur ragweed)	X	X
Crust	0.0	0.0
Soil	48.3	100.0
Litter	31.8	100.0
Total canopy cover (litter not included)	46.0%	
Total Invasive % Cover	22.6%	
Total Native % Cover	23.4%	

^a Invasive species

^b Washington State Noxious Weed (class)

X = present but not counted in plot frames

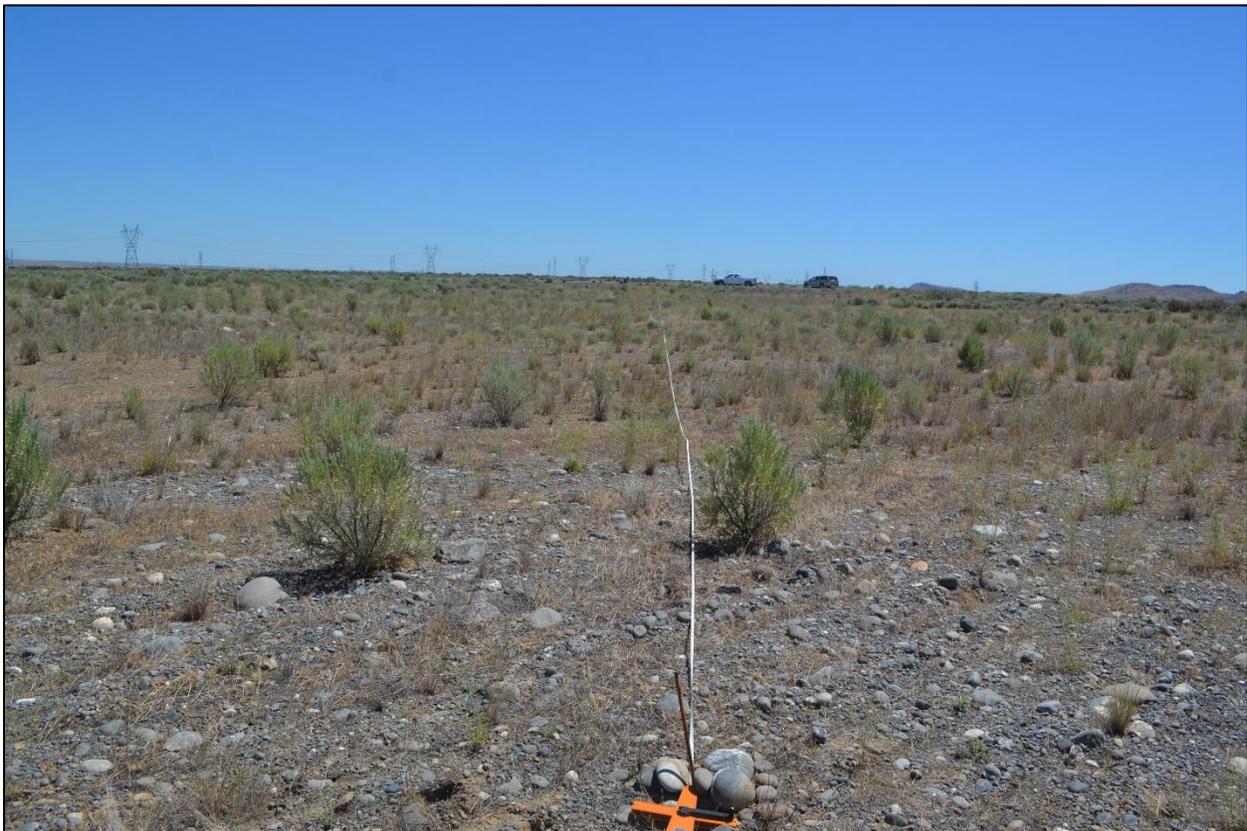


Figure 16. Shrub Transect at 600-29 Site in 2016

600-369 Site

The 600-369 site is comprised of eight small areas, the largest of which is approximately 0.4 ha (1 ac). Revegetation work at the 600-369 site was completed on January 16, 2014. It is assumed that planting

was similar to other sites in the 600 Area. The largest area, 600-369:3 site, was monitored and will be considered representative of the smaller areas of the 600-369 site. Two distinct substrate types are present on the 600-369:3 site, an inner area composed primarily of backfill cobbles with smaller amounts of loamy sand soils and an outer area consisting primarily of sandy loam soils with few cobbles. In the first two monitoring years, the 600-369:3 site was divided into two areas, Area 1 to represent the innermost cobble area and Area 2 to represent outermost sandy loam area. In the two years of monitoring, it appears that the two substrates have similar capacities to support native vegetation although the sandy loam has a greater capacity to support invasive species as well.

In 2015, the native cover on the entire 600-369:3 site was 21.8% and the invasive cover was 31.2%. The dominant native species on the 600-369:3 site in 2015 were bunchgrasses (including sand dropseed, bottlebrush squirreltail, needle-and-thread grass, and prairie junegrass) at 17.8% cover and Sandberg's bluegrass at 4.1% cover. The dominant invasive species were Russian thistle at 21.3% cover followed by tumble mustard at 5.9% cover and cheatgrass at 3.2% cover. In 2016, the native cover on the 600-369:3 site was 1.3%, a decrease of 20.5% from 2015, and the invasive cover was 30.9%, essentially unchanged from 2015 (Table 15). No native species were measured above 1% cover on the 600-369:3 site in 2016. The dominant invasive species on the 600-369:3 site in 2016 included cheatgrass at 27.2% cover and jagged chickweed at 3.3% cover. Rush skeltonwed (*Chondrilla juncea*) a Washington State class B noxious weed was also found one the site. Currently, native cover on this site is well below the requirements to be considered successful.

In 2015, big sagebush survival was at 62.3% and overall shrub survival was at 55.0%. None of the 15 antelope bitterbrush plants recorded in 2014 survived into 2015. In 2016, big sagebrush survival was at 60.5% and overall shrub survival was at 53.5% (Figure 17).

Table 15. Percent Canopy Cover and Frequency of Occurrence at 600-369 in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	0.8	33.3
<i>Bromus tectorum</i> ^a (cheatgrass)	27.2	100.0
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	3.3	66.7
<i>Draba verna</i> ^a (spring whitlowgrass)	0.2	6.7
<i>Descurainia pinnata</i> (western tansymustard)	0.5	20.0
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	0.2	6.7
<i>Tragopogon dubius</i> ^a (yellow salsify)	X	X
<i>Chondrilla juncea</i> ^b (rush skeletonweed) (B)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Stipa comata</i> (needle-and-thread grass)	X	X

Crust	0.0	0.0
Soil	37.2	100.0
Litter	50.0	100.0
Total canopy cover (litter not included)	32.2%	
Total Invasive % Cover	30.9%	
Total Native % Cover	1.3%	
Change in Invasive % Cover from 2015	0.3%	
Change in Native % Cover from 2015	20.5%	

^a Invasive species

^b Washington State Noxious Weed (class)

X = present but not counted in plot frames



Figure 17. Shrub Transect at 600-369:3 Site in 2016

600-370 Site

The planting of the 600-370 site were finished on January 16, 2014. It is assumed that the planting at this site was equivalent to other sites in the 600 Area. Substrates at this site are primarily sandy soils with varying amounts of large cobbles. In 2015, the second year of monitoring, the native cover was at 7.1%

and the invasive cover was at 34.4%. The dominant native species on the site in 2015 consisted of Sandberg’s bluegrass at 3.9% cover, big sagebrush at 1.8% cover, and dune scurfpea (*Psoralea lanceolata*) at 1.2% cover. In 2016, the native cover on the 600-370 site was at 3.4% and the invasive cover was at 32.4%. The dominant native species on the site in 2016 included Sandberg’s bluegrass at 1.3% cover and western tansymustard (*Descurainia pinnata*) at 1.4% cover. The dominant invasive species on the site in 2016 were composed of cheatgrass at 28.3%, jagged chickweed at 2.6% cover, and Russian thistle at 1.3% cover. Currently, native cover on this site is far below the requirements to be considered successful.

In 2015, big sagebush survival was at 46.4% and overall shrub survival was at 45.2%. None of the 4 antelope bitterbrush plants recorded in 2014 survived into 2015. In 2016, big sagebrush survival was at 43.3% and overall shrub survival was at 44.4%, which is close to meeting the criteria for success (Figure 18).

Table 16. Percent Canopy Cover and Frequency of Occurrence at 600-370 in 2016

Species	% Cover	% Freq of Occ
<i>Poa sandbergii</i> (Sandberg's bluegrass)	1.3	25.0
<i>Bromus tectorum</i> ^a (cheatgrass)	28.3	100.0
<i>Salsola kali</i> ^a (Russian thistle)	1.3	50.0
<i>Holosteum umbellatum</i> ^a (jagged chickweed)	2.6	80.0
<i>Draba verna</i> ^a (spring whitlowgrass)	0.1	5.0
<i>Descurainia pinnata</i> (western tansymustard)	1.4	55.0
<i>Amsinckia lycopsoides</i> (fiddleneck)	0.1	5.0
<i>Stipa comata</i> (needle-and-thread grass)	0.4	15.0
<i>Mentzelia albicaulis</i> (white-stemmed stick-leaf)	0.1	5.0
<i>Poa bulbosa</i> ^a (bulbous bluegrass)	0.1	5.0
<i>Psoralea lanceolata</i> (dune scurfpea)	0.1	5.0
<i>Phlox longifolia</i> (longleaf phlox)	X	X
<i>Tragopogon dubius</i> ^a (yellow salsify)	X	X
<i>Chrysothamnus viscidiflorus</i> (green rabbitbrush)	X	X
<i>Eriogonum niveum</i> (snow buckwheat)	X	X
<i>Oenothera pallida</i> (evening primrose)	X	X
<i>Artemisia tridentata</i> (big sagebrush)	X	X
<i>Sisymbrium altissimum</i> ^a (tumble mustard)	X	X
<i>Chrysothamnus nauseosus</i> (gray rabbitbrush)	X	X
<i>Achillea millefolium</i> (yarrow)	X	X
<i>Sphaeralcea munroana</i> (Munro’s globemallow)	X	X
Crust	0.0	0.0
Soil	44.6	100.0
Litter	37.4	100.0
Total canopy cover (litter not included)	35.8%	

Total Invasive % Cover	32.4%
Total Native % Cover	3.4%
Change in Invasive % Cover from 2015	-2.0%
Change in Native % Cover from 2015	-3.7%

‡ Invasive species

X = present but not counted in plot frames



Figure 18. Shrub Transect at 600-370 Site in 2016

1.0 Summary

Mission Support Alliance conducted vegetation monitoring at seventeen sites on the Hanford Site revegetated by River Corridor Contractor between the years 2008 and 2015. None of the sites that were revegetated at least 5 years ago met the minimum criteria to be considered successful (Table 17). A site is considered successful if five years after planting, the native cover is at least 25% and the transplanted shrub survival is at least 50%. This criteria for success comes from the *Revegetation Manual for the Environmental Restoration Contractor* (McLendon et al. 1997), which was implemented by WCH for these monitoring efforts. Five of the seventeen sites have been determined to be unsuccessful five years after

planting. These sites include the 118-F-6 Burial Ground, the 118-F-6 Soil Staging Area, the 1607-F-1 site, the 118-F-5 Burial Ground, and the 118-F-5 Soil Staging Area. All five sites failed to meet minimum native cover and shrub survival conditions. Seven other sites planted in 2012 and 2013 had no shrub transects established immediately after planting resulting in the inability to determine shrub survival. In these cases, a different metric will be initiated to determine success of the shrub plantings. None of the remaining sites less than 5 years post planting currently have native cover and/or shrub survival standards that meet the minimum thresholds needed to be considered successful. As table 17 below illustrates, there are a handful of sites which have not surpassed the five year mark, and are either meeting or forecasted to meet at least one of the success criteria.

Table 17. Summary of Revegetation Sites Monitored in 2016

Site	Date of Planting	Number of Years after Planting	Years of Monitoring										Results of Monitoring in 2016	
			2008	2009	2010	2011	2012	2013	2014	2015	2016	Percent Native Cover (success criteria 25%)	Percent Shrub Survival (success criteria 50%)	
100-F Sites														
100-F-47 Site	02/16/2012	4					-	-	-	-	-	1	12.7%	No previous monitoring
100-F-48 Site	02/22/2012	4					-	-	-	-	-	1	4.2%	No previous monitoring
100-F Container Transfer Area Site	02/2012	4					-	-	-	-	-	1	10.7%	No previous monitoring
118-F-6 Burial Ground Site	11/2008	7		1	2	3	4	5	-	-	-	6	13.3%*	34.1%*
118-F-6 Soil Staging Area Site	11/2008	7		-	-	-	-	-	-	-	-	1	20.8%*	~0.0%*
1607-F-1 Site	11/2008	7		1	2	3	4	5	-	-	-	6	8.3%*	45.5%*
118-F-5 Burial Ground Site	12/11/2007	8		1	2	3	4	5	-	-	-	6	5.5%*	22.4%*
118-F-5 Soil Staging Area Site	12/11/2007	8		1	2	3	4	5	-	-	-	6	14.7%*	15.4%*
100-K Sites														
100-K Container Transfer Area Site	12/2015	<1										1	3.8%	Very Few Shrubs
118-K-1 Burial Ground Site	03/23/2013	3						-	-	-	-	1	Not surveyed	No previous monitoring
118-K-1 Soil Staging Area Site	03/23/2013	3						-	-	-	-	1	4.4%	No previous monitoring
128-K-2 Burn Pit Site	12/08/2012	3						-	-	-	-	1	19.8%	No previous monitoring
128-K-2 Soil Staging Area Site	12/08/2012	3						1	2	3	4		17.5%	57.0%
100-K-95 Tar Dump Site	02/13/2014	2							1	2	3		0.9%	13.6%
600 Area Sites														
600-29 Site	12/12/2012	3						-	-	-	-	1	23.4%	No previous monitoring
600-369 Site	01/16/2014	2							1	2	3		1.3%	53.5%
600-370 Site	01/16/2014	2							1	2	3		3.4%	44.4%

*Revegetation site did not meet minimum criteria five years after planting for native canopy and/or shrub survival.

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Washington State Noxious Weed Board
<http://www.nwcb.wa.gov/>

3.0 Appendix A

NAME CHANGES INCLUDED IN INTEGRATED TAXONOMIC INFORMATION SYSTEM

The following list includes recent name changes for species mentioned in this report. The first name is that used in Flora in the Pacific Northwest (Hitchcock and Cronquist 1973) and the second is the more recent version provided by the United States Department of Agriculture's plant classification website ([USDA](http://www.usda.gov)).

Agropyron spicatum = *Pseudoroegneria spicata* ssp. *spicata*
Atriplex spinosa = *Grayia spinosa*
Chrysothamnus nauseosus = *Ericameria nauseosa* var. *nauseosa*
Epilobium paniculatum = *Epilobium brachycarpum*
Festuca microstachys = *Vulpia microstachys*
Koeleria cristata = *Koeleria macrantha*
Oryzopsis hymenoides = *Achnatherum hymenoides*
Poa sandbergii = *Poa secunda*
Psoralea lanceolata = *Psoralidium lanceolatum*
Ranunculus testiculatus = *Ceratocephala testiculata*
Salsola kali = *Salsola tragus*
Sitanion hystrix = *Elymus elymoides* ssp. *elymoides*
Stipa comata = *Hesperostipa comata* ssp. *Comate*

(Hitchcock, C. L., and A. Cronquist, 1973, Flora of the Pacific Northwest, University of Washington Press, Seattle, Washington.)