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1997 Vegetation Monitoring for the 1100-EM-1, 1100-IU-1, and 100-IU-3 Operable Units

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EXECUTIVE SUMMARY

This report documents the results of revegetation monitoring conducted in late May and early June of 1997. Second year monitoring was conducted at the Horn Rapids Landfill, the Horseshoe Landfill, and the Nike Landfill while first year monitoring was conducted on the PSN 72/82, Bridge Overlook, PSN 12/14, and the North Slope Cheatgrass Area.

The Horn Rapids Landfill was revegetated with crested wheatgrass (*Agropyron cristatum*) and Siberian wheatgrass (*Agropyron sibericum).* The established wheatgrass component has maintained an equivalent canopy coverage from last year, while the stature of individual plants has increased. The percent canopy cover of the wheatgrasses on all six plots is very similar, ranging from 6.4% to 11.5%. The most abundant species are still Russian thistle *(Salsola kali),* Cheatgrass (*Bromus tectorum),* and the wheatgrasses. The health and vigor of wheatgrass plants on all plots appeared to be good at the time these measurements were taken and the development of the stand is progressing as expected.

The presence of the bunchgrasses and the increased sagebrush cover on the Horseshoe Landfill shows that a good diversity is developing. The Horseshoe Landfill was revegetated with transplanted bunchgrasses, and the Nike Landfill sites were revegetated with sagebrush tubelings and transplanted bunchgrasses. The canopy coverage of volunteer sagebrush plants *(Artemisia tridentata)* on Horseshoe Landfill has increased to 5.5% from last year's 2.8% and five species of bunchgrasses were recorded with a combined canopy cover of 3.7%. Cheatgrass is still the dominant species on Horseshoe Landfill with a canopy cover of 36.1%. The survival of the

transplanted bunchgrasses was good on all plots with survival counts of 68% for Horseshoe Landfill, 92% for plot 1, 83% for plot 2, and 86% for plot 3 on the Nike Landfill sites.

The vegetation recovery at the Bridge Overlook site is promising. The revegetation consisted of transplanting native bunchgrasses from the Environmental Restoration Disposal Facility. Four native species have already successfully recolonized the waste site, with canopy coverages equivalent to the control site. The survival of the transplanted bunchgrass species was 94%. The relatively small size of the site and the fact that it is bordered by well-developed native habitat improves the chances of these components establishing in the future.

Sagebrush tubelings and bunchgrasses from the Environmental Restoration Disposal Facility were planted at PSN 72/82. The canopy cover of the sagebrush is low compared to the control; however, the frequency of sagebrush (28% on the waste site versus 52% on the control) and the fact that green rabbitbrush *(Chrysothamnus viscidiflorus)* has invaded the waste site, should be adequate to develop the necessary canopy cover in the future. Five transplanted bunchgrass species were documented on the waste site.

Sagebrush tubelings and salvaged bunchgrasses from the Environmental Restoration Disposal Facility were planted on all seven PSN 12/14 plots while the access road into the PSN 12/14 was revegetated with a native seed mix. Sagebrush and bunchgrass survival was recorded for all seven plots, and ranged from 57.3% to 93.8% for sagebrush and 54% to 96.8% for the bunchgrasses. Plots 1, 2, 4, 5, and the access road were monitored for percent canopy cover and frequency of occurrence. The access road is comprised of early successional species, although

Sandberg's bluegrass *(Poa sandbergii)* and Carey's balsamroot *(Balsamorhiza careyana)* were noted outside of the monitoring plots. A shrub component is developing on plots 2 and 4. Plot 4 also has the highest species diversity and a cryptobiotic crust layer.

Sagebrush seedlings were transplanted in an old burn area on the Saddle Mountain Wildlife Refuge (SMWR) where fire had removed large tracts of sagebrush. Sagebrush were planted in August and October 1996. Survival of the August sagebrush was 5.5%, while the October sagebrush planting on the Small Plots and Road Transect was 92.7% and 85.7%, respectively.

The vegetation monitoring results for 1997 indicate that the sites are recovering. Native plant species are recolonizing the waste sites and for the sites that were monitored last year, improvements in canopy coverage and frequency of occurrence can be seen. The ultimate success of this effort, however, should not be judged until the native plants have had several years to become established.

1.0 INTRODUCTION

This report documents the results of revegetation monitoring conducted in late May and early June of 1997. The monitor sites included the Horn Rapids Landfill (HRL) near Richland; the Horseshoe Landfill and the Nike Landfill on Rattlesnake Mountain; and waste sites on the Hanford North Slope at location number PSN 72/82, Bridge Overlook, and location number PSN 12/14. One other area, referred to as the North Slope Cheatgrass Area, was also monitored for survival of sagebrush (*Artemisia tridentata)* that was planted in 1996. Figure 1 shows the locations of these sites. The extent of the revegetation effort conducted at each site varied depending on the surrounding habitat, the future use of the site, and the existing conditions at the site. The purpose of the vegetation monitoring on these revegetated sites is to measure the progress of plant succession and in most cases, compare it to the surrounding native community. Each site will be discussed separately along with a brief description of the revegetation effort conducted and the results of the 1997 monitoring.

This report will provide the second year measurements taken at the HRL, the Horseshoe Landfill, and the Nike Landfill. Results from the 1996 measurements were provided in a letter report dated September 17, 1996 (Henckel 1996) and are presented again in Appendix A. A comparison of the vegetation changes at the three sites is provided in this document. This is the first year measurements have been taken at the PSN 72/82, Bridge Overlook, PSN 12/14, and the North Slope Cheatgrass Area. Revegetation at all sites except the Cheatgrass Area began in the spring of 1995 with the salvage and transplanting of bunchgrasses from the Hanford Site. In 1996, supplemental planting using locally collected seed was conducted at the PSN 12/14 access road and at the PSN 72/82 sites. The Cheatgrass Area was planted with sagebrush seedlings in August and October 1996.

1.1 METHODS OF EVALUATING VEGETATION

The vegetation monitoring consisted of measuring the percent canopy cover of all plant species on the sites, the percent frequency of occurrence, and the percent survival of transplanted bunchgrasses and sagebrush. Canopy coverage and percent frequency measurements were conducted using the methods of Daubenmire (1970). Canopy coverage is defined as "the percentage of ground surface included in the vertical projection of a polygon drawn around the extremities of undisturbed foliage of a plant" (Daubenmire 1970) and provides a measure of the amount of ground covered by each species. Since it is possible, in dense stands of vegetation, to have species overlapping each other, total measured vegetative cover can exceed 100%. Within each location, a series of plot-frames were analyzed for canopy coverage of each species present. Frequency is the percentage of occurrences that a species is observed in the 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 x 100 = 40%.

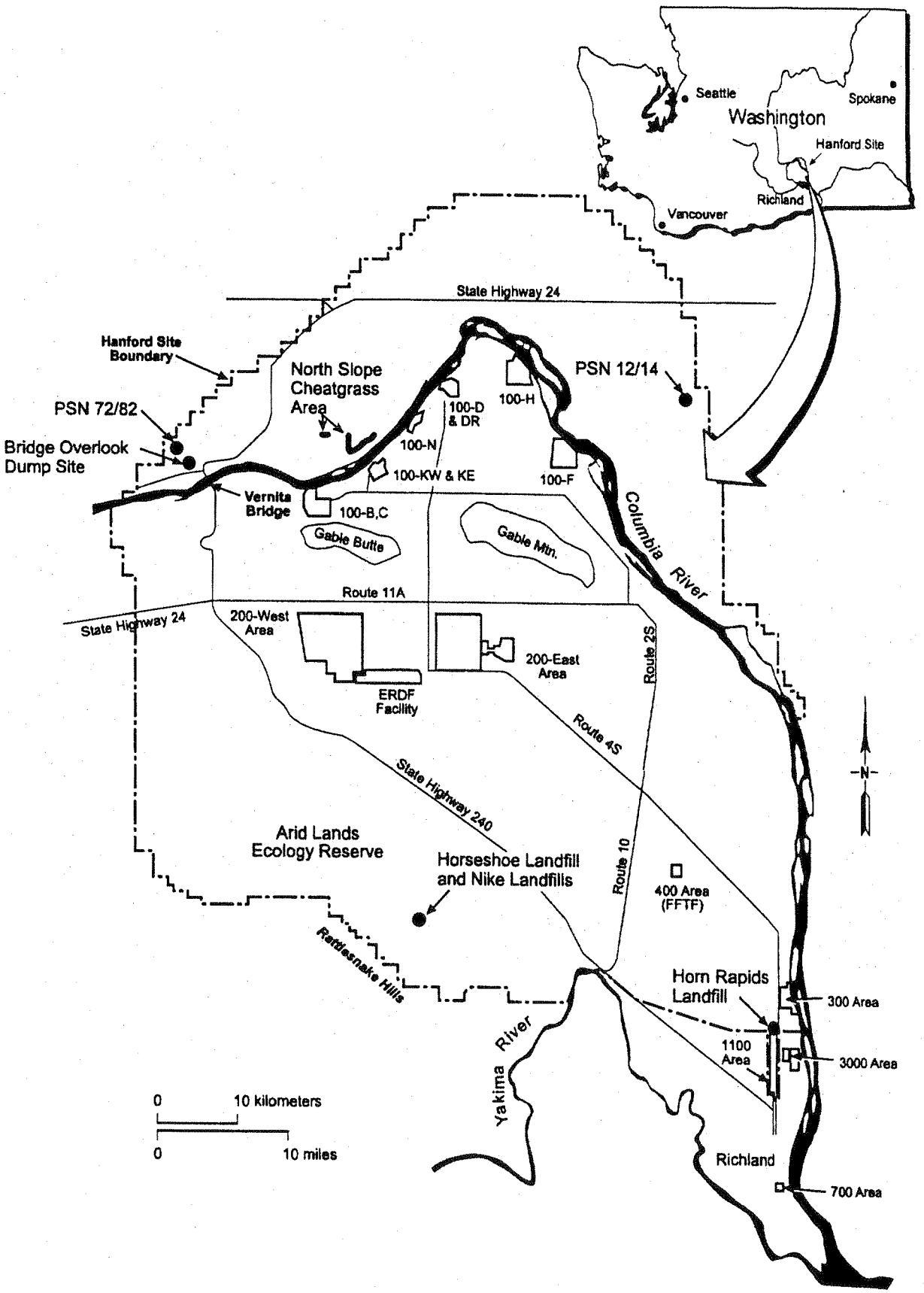
The relative magnitude of a frequency rating, when compared to a canopy coverage rating, provides an index of distribution of a species and its influence within a vegetative stand. At sites where bunchgrasses and/or sagebrush were transplanted, the percent survival was measured by

counting a representative number of plants at the site, determining if they were dead or alive, and calculating the percent alive. This report uses scientific nomenclature from Hitchcock and Cronquist (1973). Some plant names have been changed and new names can be found in Appendix B.

The objective of all revegetation efforts guides the type of restoration that is conducted, as well as the criteria that is used to assess the success of the effort. At HRL, the objective was to stabilize the topsoil and protect the landfill cap, while at the Horseshoe and Nike Site Landfills, the objective was to restore the areas with native bunchgrasses to suppress the growth of exotic plant species such as cheatgrass. All of the North Slope revegetation sites are surrounded by high quality habitat; thus, the objective was to restore those sites to reflect the nearby plant community. The objective of revegetating the North Slope Cheatgrass Area was to promote sagebrush re-establishment in an old burn area.

Control sites were established for the Horseshoe and Nike Landfills, and the sites on the North Slope. The control sites were chosen because they had similar physical and biological components to the pre-disturbance conditions of the waste site. For this monitoring effort, the control sites served to identify the plant composition of the surrounding area which was then used to compare against the plant establishment of the waste site. Success criteria are different for each waste site because of the different objectives; however, all sites will be evaluated based upon plant canopy cover, plant community composition, and the survival and growth of transplanted or woody plants. These criteria are detailed in the *Revegetation Manual for the Environmental Restoration Contractor* (McLendon and Redente 1997). The revegetation effort will be considered successful if the areas are stabilized to prevent erosion and dominated by recovering stands of native sagebrush and bunchgrasses.

Figure 1. Hanford Site Showing Locations of Revegetation Areas.



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2.0 HORN RAPIDS LANDFILL

The Horn Rapids Landfill (HRL) is a 20 hectare (50-acre) area located in the 1100-EM-1 Operable Unit immediately north of Richland, Washington. The landfill was used primarily to dispose of office and construction waste, asbestos, sewage sludge, and fly ash. The remedial investigation/feasibility study for this operable unit (DOE/RL 1992) identified about 230 m^3 (300 yd^3) of polychlorinated biphenyl (PCB) contaminated soil in the landfill. The remedial action, documented in the 1100 Area record of decision (EPA 1993) included excavation of the PCB-contaminated soil and capping 25 acres of the landfill. The landfill cap consisted of a 0.5-m (1.5-ft) layer of gravel covered with 15 cm (6 in.) of topsoil. The objective of this revegetation project was to stabilize the topsoil and protect the landfill cap. The site was revegetated with crested wheatgrass (*Agropyron cristatum*) and Siberian wheatgrass (*Agropyron sibericum)* in the fall of 1995 with guidance and concurrence from the Hanford Natural Resource Trustee Council.

A secondary goal of the revegetation effort was to compare planting techniques using a traditional rangeland seed drill and a planting device called an Imprinter. The Imprinter has been successfully used for planting in arid climates (St. John and Dixon 1995). A special imprinter was used at the HRL that had an added capability to inoculate the soil with mycorrhizal fungi. Mycorrhizal fungi form a beneficial symbiotic relationship with the roots of many late seral plants including bunchgrasses. The fungus absorbs nutrients from the soil and passes them to the plant in exchange for sugars from the plant. This relationship is not usually formed with the early seral stage weedy plant species.

2.1 REVEGETATION PLAN

Five different planting treatments were evaluated to determine the best technique and provide information that will be useful in planning future restoration projects. The area of the landfill that was revegetated was divided into six roughly equal plots for the purpose of establishing treatment areas (Figure 2). Two treatments using a rangeland seed drill were established. The first treatment included planting seed with a fertilizer application rate of 22.5 kg of nitrogen/hectare (20 lb/acre) and mulching the area with wheat straw (plots 1 and 6). This method has been used many times on the Hanford Site and has proven successful with this seed mix. The second treatment using the rangeland drill (plot 2) applied seed and straw mulch without fertilizer.

Three treatments were used to test the efficacy of the Imprinter under these conditions. The first was the application of seed, mycorrhizal fungi, and wheat straw mulch (plot 3). The second was the application of seed and mycorrhizal fungi with no mulch (plot 4) and the third was the application of seed alone (plot 5). The application of straw mulch was intended to reduce wind erosion and increase soil moisture retention. The mulch may also serve an added function to minimize available soil nitrogen which reduces competitiveness of early successional weedy species (Klein et al. 1996). Straw was spread over the appropriate treatment areas at a rate of two tons per acre.

The target seeding rate was 16.8 kg/hectare (15 lb/acre) pure live seed on all treatments with a 50% mix of both species. The actual seeding rate varied between the Imprinter and the range drill because of the difference in the metering systems on the two pieces of machinery. The three plots planted with the range drill (plots 1, 2, and 6) and plots 3 and 5 planted with the Imprinter received similar rates of seed. Plot 4, however, was the first to be planted and received a higher seeding rate because the metering system was not initially calibrated to the proper rate.

2.2 MONITORING RESULTS

The vegetation on the HRL was measured on May 20, 1997 by estimating canopy coverage and frequency of occurrence. Twenty-five plot frames measuring 20 by 50 cm were analyzed for each treatment. This year, 20 species were recorded on the HRL, an increase of 10 from 1996. The three most abundant species are wheatgrasses, Russian thistle (*Salsola kali*), and cheatgrass (*Bromus tectorum*). The other 17 species were generally much lower in both canopy cover and frequency (Tables 1 and 2). Most of these species are common early successional species that occur on disturbed soils. At this point, their presence does not appear to be adversely affecting the desired bunchgrass species. Overall, the canopy cover is dominated by the wheatgrasses in 1997, whereas in 1996, Russian thistle was the dominant species (Appendix A).

An observation that does not show up in the data is that the actual number of wheatgrass plants has declined dramatically, while the stature of the survivors has increased. This is an expected result and the trend is anticipated to continue as the plants mature. Also, the percent canopy cover on all plots is very similar this year ranging from 6.4% to 11.5%. After the first year, plot 4 (seed, mycorrhizal fungi, and no mulch) had 25.9% canopy cover for the wheatgrasses as a result of a noticeably higher seeding rate. This was twice as high as the next highest plot. However, this year plot 4 had the lowest canopy cover for wheatgrass at 6.4%. This was probably a result of competition for soil moisture during the first year, causing many of the seedling plants to die. This same competition of available soil moisture and self-thinning is seen in the growth of the Russian thistle. Both years of monitoring data indicate a high canopy cover and frequency for Russian thistle. However, very few plants survive to the size typical of Russian thistle (diameters of 50 to 150 cm [20 to 60 in.]) in late August. This lack of vigorous growth is typical of areas with strong competition for available soil moisture. The abundance of cheatgrass has increased on all plots. Cheatgrass is the dominant plant on plot 6 with 22.9% canopy cover, while the cover on the other plots ranges from 1.2 to 7.8%. Plot 6 is composed of a native sandy soil whereas plots 1 through 5 are an imported fine-grained loamy soil containing many rocks. Although cheatgrass cover is high on Plat 6, the canopy cover of wheatgrass on plot 6 is 11.1%; the second highest on the site. Therefore, the increase in cheatgrass cover does not appear to be impacting the development of the wheatgrass at this time.

For a comparison of the wheatgrass stand on the HRL to a mature community, the canopy coverage of a Siberian wheatgrass/thickspike wheatgrass (*Agropyron dasytachyum)* community planted on the 216-T-35 burial ground of the Hanford Site was measured at 18.3% after more than 10 years of growth (WHC 1994). The stature of the wheatgrass plants on the Horn Rapids

Burial Ground is still quite small (10 to 30 cm); however, the density is much higher than a mature stand would be. It is expected that as the stand develops, the density will drop and the strongest plants will survive to form larger bunchgrasses.

After 2 years of growth, there is very little difference in the vegetation measurements of the various treatments. The health and vigor of wheatgrass plants on all plots appeared to be good at the time these measurements were taken and the development of the stand is progressing as expected. The ultimate success of this effort, however, should not be judged until the wheatgrass stand has had several years (perhaps 3 to 5 years) to become established.

Table 1. Percent Canopy Cover on Horn Rapids Landfill for 1997.

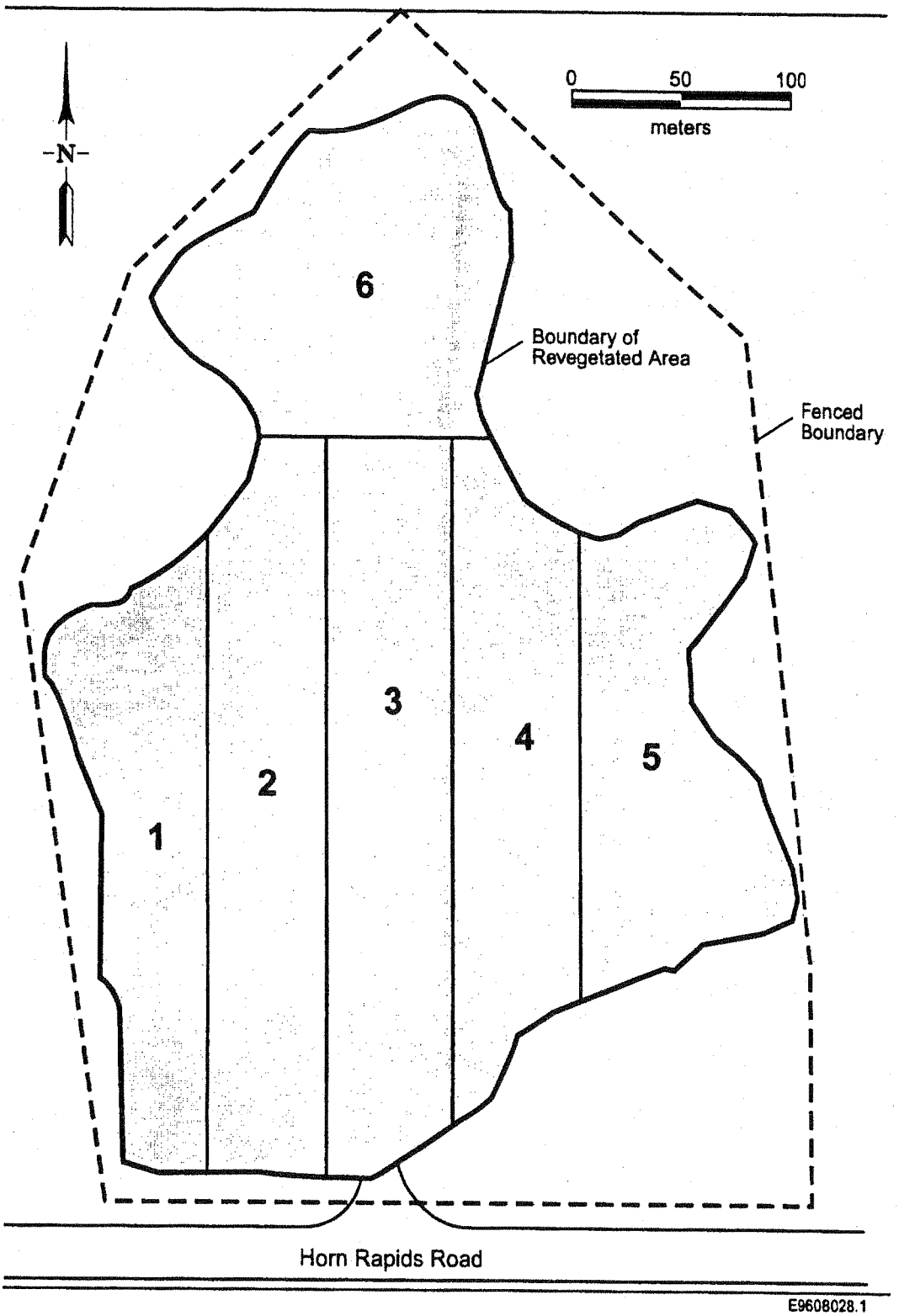
Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	7.5	9.5	10.1	6.4	11.5	11.1
Salsola kali (Russian thistle)	2.2	2.6	1.6	8.6	13.3	1.5
Bromus tectorum (cheatgrass)	6	7.8	5.5	1.6	1.2	22.9
Amsinckia lycopsoides (tarweed)	--	--	--	--	--	0.6
Sisymbrium altissimum (tumblemustard)	0.2	0.1	0.4	0.5	0.9	0.1
Ambrosia acanthicarpa (bur ragweed)	0.2	1.4		0.3	0.4	1.8
Chenopodium sp (lambsquarter)	0.2	0.1	0.3	1.0	1.1	--
Convolvulus arvensis (field bindweed)	--	--	--	0.2	--	--
Holosteum umbellatum (jagged chickweed)	4.0	4.8	2.3	0.9	0.3	0.4
Lactuca serriola (prickly lettuce)	0.2	0.3	0.3	--	--	--
Draba verna (spring whitlow)	0.2	2.9	2.1	0.6	1.1	0.2
Medicago sativa (alfalfa)	--	0.1	--	--	--	--
Descurainia pinnata (tansymustard)	0.1	0.3	0.2	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	0.2	0.2	--	--
Poa sandbergii (Sandberg's bluegrass)	--	--	0.1	--	--	--
Plantago patagonica (Indian wheat)	--	--	--	0.2	--	--
Erodium cicutarium (storksbill)	--	--	--	0.2	0.1	0.2
Agastache occidentalis (western horsemint)	--	--	--	0.2	--	--
Tragopogon dubius (yellow salsify)	0.8	0.1	--	--	--	--
Cardaria draba * (whitetop)	--	--	--	--	3 plants	--
Total	**21.6**	**30**	**23.1**	**20.9**	**29.9**	**38.8**

* Not counted in plot frames.

Table 2. Percent Frequency of Occurrence on Horn Rapids Landfill for 1997.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	80	92	84	100	92	80
Salsola kali (Russian thistle)	68	84	64	96	96	40
Bromus tectorum (cheatgrass)	84	80	80	64	48	96
Amsinckia lycopsoides (tarweed)	--	--	--	--	--	4
Sisymbrium altissimum (tumblemustard)	8	4	16	20	36	4
Ambrosia acanthicarpa (bur ragweed)	8	36	--	12	16	52
Chenopodium sp (lambsquarter)	8	4	12	40	44	--
Convolvulus arvensis (field bindweed)	--	--	--	8	--	--
Holosteum umbellatum (jagged chickweed)	80	72	52	16	12	16
Lactuca serriola (prickly lettuce)	8	12	12	--	--	--
Draba verna (spring whitlow)	8	40	44	24	44	8
Medicago sativa (alfalfa)	--	4	--	--	--	--
Descurainia pinnata (tansymustard)	4	12	8	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	8	8	--	--
Poa sandbergii (Sandberg's bluegrass)	--	--	4	--	--	--
Plantago patagonica (Indian wheat)	--	--	--	8	--	--
Erodium cicutarium (storksbill)	--	--	--	8	4	8
Agastache occidentalis (western horsemint)	--	--	--	8	--	--
Tragopogon dubius (yellow salsify)	12	4	--	--	--	--

Figure 2. Horn Rapids Landfill Showing the Six Treatment Plots.



3.0 HORSESHOE LANDFILL

The Horseshoe and nearby Nike Base landfills are located on the Fitzner-Eberhardt Arid Lands Ecology Reserve and are included in the 1100-IU-1 Operable Unit (Figure 3). They were sampled and remediated as part of the remediation work outlined in the Record of Decision (ROD) for the 1100 Area National Priorities List site (EPA 1993). The completion of the remediation work was documented in the *Close-Out Report Fitzner-Eberhardt Arid Lands Ecology Reserve Remedial Action, Hanford, Washington* (DOE-RL 1996).

The revegetated area of the Horseshoe Landfill measures approximately 35 by 70 m (114 by 230 ft). The revegetated area on the Nike Base Landfill consists of three small sites measuring approximately 4 by 23 m (13 by 75 ft) (plot 1), 6 by 9 m (20 by 30 ft) (plot 2), and 4 by 9 m (13 by 30 ft) (plot 3). The disturbed soils on the surface of these sites were revegetated in the fall of 1995. Work began on November 29, 1995 and was completed on December 7, 1995.

The Horseshoe Landfill was revegetated with transplanted bunchgrasses and had a large number of sagebrush seedlings growing on it that were inadvertently planted during the backfilling, i.e., the seeds were already in the soil used to cover the surface. The exceptionally wet winter of 1994/1995 allowed the seeds to grow and become established. Therefore, the prospects for this site returning to a sagebrush/bunchgrass dominated community in the near future are very good. The three small Nike Landfill sites varied in vegetative cover from nearly bare to having some small sagebrush, cheatgrass, and Sandberg's bluegrass (*Poa sandbergii).* These sites were planted with bunchgrasses with the addition of 12 to 15 sagebrush seedlings each.

The vegetation growing on the Horseshoe Landfill and a relatively undisturbed site adjacent to the waste site was measured for percent canopy cover and percent frequency on May 20, 1997, using classical Daubenmire methods (1970). Within the Horseshoe Landfill and the control site, 25 plot-frames measuring 50 by 100 cm (20 by 40 in.) were analyzed for canopy coverage and frequency of occurrence of each species present.

Survival of the planted bunchgrasses was measured on the Horseshoe Landfill and the three small sites of the Nike Landfill by examining the bunchgrasses for green plant material in the crown area. If there were any green leaves present, the plant was recorded as alive. On the Horseshoe Landfill, three transects running the length of the revegetated area were counted. On the three small Nike Landfill sites, all bunchgrasses and sagebrush were counted.

3.1 MONITORING RESULTS

Twenty-one species of plants were recorded on the Horseshoe Landfill this year, 12 of which were native. The control site had 16 species recorded, 13 of which were native (Tables 3 and 4). Cheatgrass had the highest canopy cover on the waste site with 36.1%.

The next highest was sagebrush with 5.5%, an increase over last year from 2.8% cover (see Appendix A for 1996 measurements). There were five species of bunchgrasses recorded on the waste site that together had a combined canopy cover of 3.7%. Sandberg's bluegrass was the highest with 2.4%. Although the canopy cover of the bunchgrasses is still low, their presence on the site shows a good diversity is developing. The control site had nearly the same native species as the waste site; however, the dominance of the species mix was much different. The dominant species was Sandberg's bluegrass with 51.4% cover and 92% frequency. The sagebrush on this site are mature and provide a cover of 10.1%, which is within the typical cover range of a mature sagebrush community. Cheatgrass was also present at 25% cover, which is indicative of some level of prior disturbance, probably during the Army occupation of the site in the 1950's.

Cryptobiotic crust is an important component of a native shrub steppe community. It is made up of a mixture of lichens, mosses, and algae that bind the soil surface, thus helping to reduce erosion and facilitate percolation of water. A well-developed cryptobiotic crust is indicative of a mature native community, particularly in areas with fine soils. The percent of ground covered with biotic crust was measured at these sites. The amount of ground covered with biotic crust on the control site was 88.3%, while the waste sites still have not developed a crust layer.

The survival of the transplanted native bunchgrasses was good on all plots. On the Horseshoe Landfill, 239 plants were inspected and 162 were alive for a survival of 68% (Table 5). Survival is less than last year when it was 79%. On the three sites at Nike Landfill, the survival values for bunchgrasses were 92% for plot 1, 83% for plot 2, and 86% for plot 3. Not all of the transplanted sagebrush could be counted because the dead seedlings were extremely difficult to find among the cheatgrass and other vegetation on the sites. Therefore, no survival values could be calculated; however, live sagebrush were counted as follows: 13 on plot 1, 15 on plot 2, and 11 on plot 3. The difficulty in seeing dead bunchgrasses on these plots may also have contributed to the high survival rates recorded. The plants on these plots were not laid out in a grid pattern as accurately as on the Horseshoe Landfill, making it difficult to locate them in subsequent years.

Survival of the transplanted bunchgrasses is lower this year, but should still be high enough to ensure the establishment of the bunchgrass community in future years. The canopy cover and frequency for bluebunch wheatgrass (*Agropyron spicatum*) have remained about the same; however, the numbers for Sandberg's bluegrass have increased substantially from 0.3% in 1996 to 2.4% in 1997. Although it is still too early to judge success or failure of the revegetation effort on these sites, the development of the plant community is encouraging. The fact that the Horseshoe Landfill has about the same number of native species (most of which are the same) as the control site is evidence that the site is recovering.

Table 3. Percent Canopy Cover on the Horseshoe Landfill in 1997.

Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	36.1	25
Artemisia tridentata (big sagebrush)	5.5	10.1
Agropyron spicatum (bluebunch wheatgrass)	0.9	2.5
Poa sandbergii (Sandberg's bluegrass)	2.4	51.4
Sitanion hystrix (bottlebrush squirreltail)	1.1	--
Stipa comata (needle-and-thread grass)	--	0.1
*Poa bulbosa** (bulbous bluegrass)	0.1	--
Festuca octoflora (sixweeks fescue)	0.2	--
Oryzopsis hymenoides (Indian ricegrass)	0.1	0.1
*Sisymbrium altissimum** (tumblemustard)	2.2	0.1
*Melilotis officinalis** (sweet clover)	1.6	--
Epilobium paniculatum (tall willowherb)	1.6	0.1
*Lactuca serriola** (prickly lettuce)	1.8	--
Crepis atrabarba (slender hawksbeard)	0.7	4.7
*Kochia scoparia** (red belvedere)	0.1	--
*Salsola kali** (Russian thistle)	0.1	--
Descurainia sp (tansymustard)	0.2	--
Amsinckia lycopsoides (tarweed fiddleneck)	--	0.1
Chaenactis douglasii (hoary falseyarrow)	0.1	0.2
Erigeron filifolius (threadleaf fleabane)	0.8	1.2
Linum perenne (wild blueflax)	--	0.1
*Lepidium perfoliatum** (clasping pepperweed)	0.1	--
Lupinus sulphurous (sulfur lupine)	0.3	13.5
*Tragopogon dubius** (yellow salsify	--	0.5
Balsamorhiza careyana (Carey's balsamroot)	--	0.1
Machaeranthera canescens (hoary aster)	2.0	--
Biotic crust	--	88.3
Total (biotic crust not included)	**58**	**109.8**

* Introduced species.

Table 4. Percent Frequency of Occurrence on the Horseshoe Landfill in 1997.

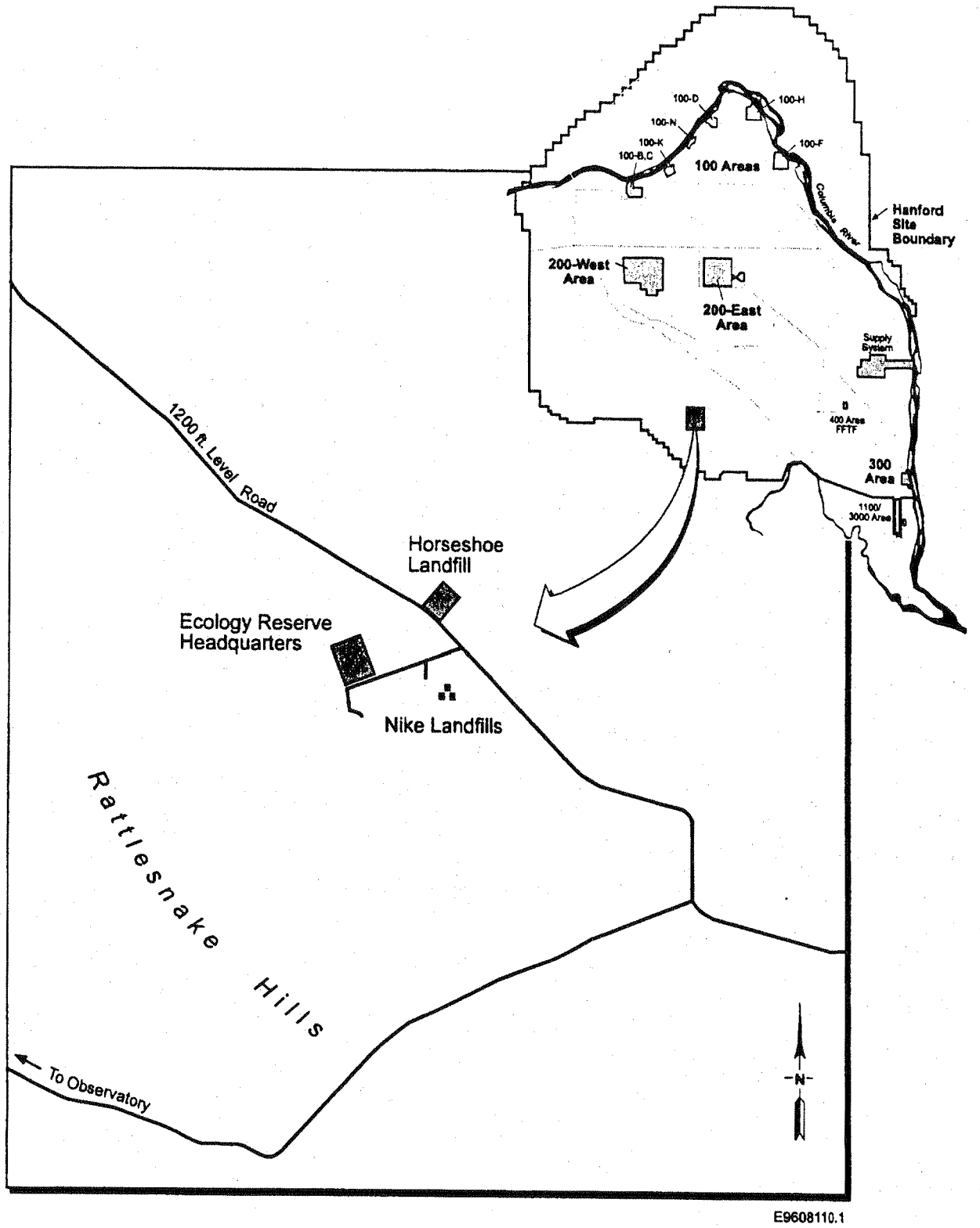
Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	88	84
Artemisia tridentata (big sagebrush)	64	60
Agropyron spicatum (bluebunch wheatgrass)	36	4
Poa sandbergii (Sandberg's bluegrass)	56	92
Sitanion hystrix (bottlebrush squirreltail)	24	--
Stipa comata (needle-and-thread grass)	--	4
*Poa bulbosa** (bulbous bluegrass)	4	--
Festuca octoflora (sixweeks fescue)	8	--
Oryzopsis hymenoides (Indian ricegrass)	4	4
*Sisymbrium altissimum** (tumblemustard)	48	4
*Melilotis officinalis** (sweet clover)	64	--
Epilobium paniculatum (tall willowherb)	64	4
*Lactuca serriola** (prickly lettuce)	52	--
Crepis atrabarba (slender hawksbeard)	8	68
*Kochia scoparia** (red belvedere)	4	--
*Salsola kali** (Russian thistle)	4	--
Descurainia sp (tansymustard)	8	--
Amsinckia lycopsoides (tarweed fiddleneck)	--	4
Chaenactis douglasii (hoary falseyarrow)	4	8
Erigeron filifolius (threadleaf fleabane)	12	28
Linum perenne (wild blueflax)	--	4
*Lepidium perfoliatum** (clasping pepperweed)	4	--
Lupinus sulphurous (sulfur lupine)	12	76
*Tragopogon dubius** (yellow salsify	--	20
Balsamorhiza careyana (Carey's balsamroot)	--	4
Machaeranthera canescens (hoary aster)	40	--
Biotic crust	--	96

* Introduced species.

Table 5. Percent Survival of Transplanted Bunchgrasses and Sagebrush Plants in 1997.

Site Name	Sagebrush	Bunchgrass
Horseshoe Landfill	N/A	68
Nike Landfill		
Plot 1	N/A	83
Plot 2	N/A	92
Plot 3	N/A	86
Bridge Overlook	N/A	94
PSN 12/14		
Plot 1	91.3	54
Plot 2	75	96.8
Plot 3	76.5	62.5
Plot 4	93.8	66.7
Plot 5	58.1	72
Plot 6	57.8	74.4
Plot 7	57.3	81.3
North Slope Cheatgrass Area		
Small Plots (Aug)	5.5	N/A
Small Plots (Oct)	92.7	N/A
Road Transect	85.7	N/A

Figure 3. Horseshoe and Nike Landfills.



4.0 NORTH SLOPE SITES

There were 39 distinct waste sites identified within the 100-IU-3 Operable Unit of the 100 Area National Priority List site. The 100-IU-3 Operable Unit is located on the North Slope of the Hanford Site. The cleanup of these waste sites was documented in the *Close-Out Report North Slope (Wahluke Slope) Expedited Response Action, Hanford Washington* (DOE/RL 1994a) to satisfy milestone No. M-16-82 of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). The sites were remediated and cleanup activities took place in 1994. A detailed description of the remediation activities is provided in *A Compendium of Field Reports for the North Slope (Wahluke Slope) Expedited Response Action* (DOE/RL 1994b). The determination that no further remedial action is necessary was made in the *Declaration of the Record of Decision for the 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units* (EPA 1996).

Most of the remediation efforts involved the removal of physical hazards associated with the military and homesteading activities, such as abandoned water wells and debris removal, excavation of landfills, and backfilling of open cisterns. Landfill excavation resulted in the most soil disturbance and involved using a bulldozer and an excavator to remove the overburden and excavate areas suspected of having hazardous waste. Hazardous materials were removed for proper disposal while nonhazardous materials were left in the trench and backfilled with the excavated soil.

The restoration plan for the North Slope sites was based on the quality of the sites and the quality of the surrounding vegetation. The vegetation on and surrounding many of the sites prior to cleanup consisted mostly of cheatgrass, Russian thistle, tumblemustard (*Sisymbrium altissimum*), and other introduced weed species with some recolonization of big sagebrush and Sandberg's bluegrass. The soils at the revegetation areas are easily eroded by wind when exposed and are well drained and generally sandy-fine loam, loamy-fine sand, or sand.

Three sites (Bridge Overlook, PSN 72/82, and PSN 12/14) were selected for revegetation because of the surrounding high quality habitat, project timing, and available resources (Hughes 1995). It was also felt that these sites would benefit the most from revegetation. An additional area on the North Slope was selected for restoring the sagebrush component to a cheatgrass/Sandberg's bluegrass community that had previously burned. This area was called the North Slope Cheatgrass Area and is located just north of the 100-K Area on the Saddle Mountain National Wildlife Refuge (Figure 1). The planting of sagebrush at this site was conducted to compensate for not restoring the remaining small, poor quality waste sites on the North Slope. Agreements were reached with the Natural Resource Trustees not to restore the remaining sites because they were either surrounded by poor quality habitat, were so small that it was not cost effective to restore them, or because the area might possibly be farmed in the future after the land is excessed by the U.S. Department of Energy.

4.1 REVEGETATION PLAN

Native bunchgrass species were salvaged from the Environmental Restoration Disposal Facility (ERDF) and were used for the initial planting on PSN 72/82, Bridge Overlook, and PSN 12/14. An estimated 9,000 (maximum) plants were salvaged from the ERDF site in early February 1995. The estimated makeup of these plants was 90% needle-and-thread grass (*Stipa comata*), with the remaining 10% Indian ricegrass (*Oryzopsis hymeniodes*) and Sandberg's bluegrass (Hughes 1995). The 1997 monitoring noted prairie junegrass (*Koeleria cristata*) as an additional bunchgrass species that was transplanted.

As part of the site preparation, soil samples were taken from each of the three revegetation sites and sent to a local laboratory for percent organic matter, nitrogen, phosphorus, and potassium analysis. The results of the analysis indicated that the soils were deficient in phosphorus; therefore, an 11-52-0 granular fertilizer was recommended to correct the deficiency (Hughes 1995). Hughes (1995) stated that all plants at PSN 72/82 and Bridge Overlook and about 4,000 plants at three of the PSN 12/14 plots received fertilizer. Volunteer revegetation crews were directed to add 15 ml (1 tablespoon) of fertilizer for the 3.8 L (1 gallon) sized plants and 30 ml (2 tablespoons) for the larger plants. In addition, 30 grass plants at both the Bridge Overlook (with fertilizer) and PSN 12/14 (without fertilizer) were planted in areas of undisturbed soil adjacent to the landfill areas ("control" areas) (Hughes 1995). These control areas were not well marked and could not be found during the monitoring effort.

Hughes (1995) also stated that maintenance watering will be applied to selected areas of the PSN 72/82 and PSN 12/14 throughout the growing season while the Bridge Overlook transplants and 886 plants at PSN 12/14 were not to receive maintenance water. The different watering regimes were being done to test the effect of watering on transplant establishment. However, during the revegetation process, the selected areas and plants that were to receive maintenance water were not identified either in the field or on paper. Therefore, the monitoring effort could not compare the different watering treatments on transplant growth and survival.

5.0 BRIDGE OVERLOOK

The Bridge Overlook site is located approximately 1 mile northwest of the Vernita Bridge (Figures 1 and 4). The restoration on this site consisted of transplanting bunchgrasses from the ERDF site in the spring of 1995. The vegetation on the Bridge Overlook site was measured on May 21, 1997. A total of 11 species were identified on the waste site, 9 of which were native. The two non-native species, cheatgrass and Russian thistle, were also the most abundant (Tables 6 and 7). A relatively undisturbed site just west of the waste site served as the control. The control site had 18 species, 16 of which were native. The control site had a cryptobiotic crust component (21.8% cover) and a diverse shrub layer composed of sagebrush, bitterbrush (*Purshia tridentata)*, spiny hopsage (*Grayia spinosa)*, green rabbitbrush (*Chrysothamnus viscidiflorus*), and snow buckwheat (*Eriogonum niveum).* The waste site had not developed a crust layer, and only had a few spiny hopsage shrubs existing outside of the sampling plots. The control site also had a greater percent cover of non-native species than the waste site.

Prairie junegrass and needle-and-thread grass were the two species of transplanted bunchgrasses at the waste site. The total survivorship of the bunchgrass transplants was 94% (Table 5). These two species were not found in the control site; however, they are common to sandy areas on the Hanford Site (Sackshewsky et al. 1992) and the region. Native species have already successfully recolonized the waste site as can be seen by the presence of dune scurfpea (*Psoralea lanceolata*), whitestem stickleaf (*Mentzelia albicaulis*), Great Basin gilia (*Gilia leptomeria*), and pale eveningprimrose (*Oenothera pallida*). These species are typical of early to mid-seral dune communities.

The vegetation recovery at the bridge overlook site is promising because of its relatively small size, it is bordered by well-developed native habitat, and is sparsely invaded by cheatgrass and Russian thistle. The presence of dune scurfpea is also encouraging because it is a rhizomatous legume, which helps to stabilize sandy soils, thereby reducing erosion and enhancing the establishment of other plant species. Being a legume, dune scurfpea fixes nitrogen and incorporates it into the surrounding soil column. These factors increase the potential for successful recolonization of native species on the site.

5.1 PSN 72/82

The PSN 72/82 site is located near the Bridge Overlook site (Figure 4). The areas that were revegetated included the PSN 72/82 Well Mound and a small staging area adjacent to it. Sagebrush tublings and bunchgrasses salvaged from the ERDF were planted on the Well Mound in March 1995 and fertilizer was added to the planting hole for each. Small plants (1-gallon) received 1 tablespoon (15 ml) and larger plants (2-gallon) received 2 tablespoons (30 ml). The small staging area was planted in the fall of 1996 with a seed mix of sagebrush, snow buckwheat, spring turpentine parsley (*Cymopterus terebinthinus*), Carey's balsamroot (*Balsamorhiza careyana*), and Sandberg's bluegrass. No monitoring was conducted on this site in 1997; however, it will be added to the monitoring program in future years.

A total of 16 species were recorded on the waste site, 14 of which were native. A relatively undisturbed area to the east of the waste site served as the control site. The control site had 15 species, 12 of which were native (Table 8). Cheatgrass was the most abundant species on both the waste site and the control site. Sagebrush was the next abundant species on the control site.

Green rabbitbrush has also invaded the waste site, enhancing the shrub component of the site. Although the canopy cover of the shrubs is low, the frequency of sagebrush (28% on the waste site versus 52% on the control site) and rabbitbrush (4% versus 4%) occurrence on the waste site compared to the control site should be adequate to develop the necessary canopy cover in the future (Table 9). The effect of the fertilizer addition is two-fold. Some of the transplanted sagebrush were flowering the year after they were transplanted. Given that sagebrush is a perennial plant, induction of flowering is typically not caused by stress, but by adequate plant energy levels to support flower and seed development (Larcher 1995). Cheatgrass also responded to the fertilizer addition. A ring of cheatgrass now surrounds each sagebrush plant on the waste site, competing with the sagebrush for the additional nutrient and water input. Therefore, the addition of fertilizer into the soil enhanced the growth of both desirable and undesirable species, and should be carefully considered for future revegetation efforts.

Five bunchgrass species were transplanted onto PSN 72/82. These species are prairie junegrass, Indian ricegrass, Sandberg's bluegrass, bottlebrush squirreltail (*Sitanion hystrix*), and needle-and-thread grass. No bunchgrasses were recorded in the control plot-frames; however, Sandberg's bluegrass was noted as being present on the control site. The control site is a typical sagebrush/spiny hopsage shrub association with a dominant cheatgrass understory. Depending upon the history of the site and the type(s) of disturbance(s), this shrub association can have a wide range of understory species. Aside from the bunchgrasses, the species composition of the waste site and the control site is fairly similar.

5.2 PSN 12/14

The PSN 12/14 site is located approximately 4 miles east of the White Bluffs Landing in the northeast corner of the Hanford Site (Figures 1 and 5). Both sagebrush tubelings and salvaged bunchgrasses from ERDF were planted on all seven PSN 12/14 plots from March 27 through April 1, 1995. Sagebrush and bunchgrass survival was recorded for all seven plots; however, only plots 1, 2, 4, 5, and the access road were monitored for percent canopy cover and frequency of occurrence. The access road into the PSN 12/14 waste sites was revegetated with a seed mix consisting of sagebrush, bitterbrush, snow buckwheat, spring turpentine parsley, Carey's balsamroot, and Sandberg's bluegrass.

Canopy cover and frequency of occurrence on all PSN 12/14 plots was dominated by cheatgrass (Tables 10 and 11). The control site was a relatively undisturbed area adjacent to the seven waste sites (Figure 5). A total of 12 species were recorded, 10 of which were native. The shrub layer consisted of sagebrush and bitterbrush with an understory dominated by cheatgrass and Sandberg's bluegrass. The other sites all had a high number of native species; however, most of them are early successional.

The access road is comprised of early successional species. The total cover is low compared to the control, with most of the cover coming from cheatgrass. Seedlings of Sandberg's bluegrass and Carey's balsamroot were observed on the access road, but were not found within the sampling plot-frames. Plot 4 had the greatest species diversity of the five plots with 13 species, 9 of which were native. Plot 4 also had a fairly high cover of cryptobiotic crust that aids in site stabilization. The cryptobiotic crust layer had not yet developed in the other plots except for plot 1. In highly disturbed sandy areas such as plots 5, 6, and 7, a crust layer is very slow to develop, and even in late seral communities is often very limited. For example, the control sites at Bridge Overlook and PSN 72/82 had crust coverage of 21.8% and 29.4%, respectively. Therefore, a crust layer may or may not develop on these areas within the monitoring time frame. In plot 2, the presence of winged dock (*Rumex venosus*) was recorded, which is a rhizomatous native species that should help stabilize the site.

The sagebrush and bunchgrass survival counts for all seven plots are listed in Table 5. Sagebrush survival ranged from 57.3% to 93.8%, while bunchgrass survival ranged from 54% to 96.8%. The bunchgrass species that were planted varied by plot, but overall they consisted of Sandberg's bluegrass, needle-and-thread grass, and prairie junegrass. Indian ricegrass was also planted, but did not occur in the monitoring plot-frames. All of the bunchgrass species are typical of sandy areas.

Table 6. Percent Canopy Cover on Bridge Overlook Sites in 1997.

Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	5.8	32.4
*Salsola kali** (Russian thistle)	1.4	0.2
Ambrosia acanthicarpa (bur ragweed)	1.8	0.6
Psoralea lanceolata (dune scurfpea)	1.4	1.2
Koeleria cristatum (prairie junegrass)	0.1	--
Stipa comata (needle-and-thread grass)	0.7	--
Gilia leptomeria (great basin gilia)	0.2	0.2
Mentzelia albicaulis (whitestem stickleaf)	0.2	--
Oenothera pallida (pale eveningprimrose)	0.1	0.1
Descurainia sp. (tansymustard)	1.7	--
Cryptantha circumscissa (matted cryptantha)	0.1	0.2
Eriogonum niveum (snow buckwheat)	--	12.1
Artemisia tridentata (big sagebrush)	--	4.2
Purshia tridentata (antelope bitterbrush)	--	6.5
Chrysothamnus viscidiflorus (gray rabbitbrush)	--	1.5
Grayia spinosa (spiny hopsage)	X	3.5
Oryzopsis hymenoides (Indian ricegrass)	X	1.5
Festuca octoflora (six-weeks fescue)	--	0.1
Cymopterus terebinthinus (spring turpentine parsley)	X	0.6
Layia glandulosa (white-daisy tidytips)	--	0.1
Comandra umbellata (bastard toadflax)	--	0.9
Amsinckia lycopsoides (tarweed fiddleneck)	X	0.1
Biotic crust	--	21.8
Total (biotic crust not included)	**13.5**	**66**

* Introduced species.
X = Present but not counted in plot frames.

Table 7. Percent Frequency of Occurrence on Bridge Overlook Sites in 1997.

Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	60	84
*Salsola kali** (Russian thistle)	36	8
Ambrosia acanthicarpa (bur ragweed)	32	24
Psoralea lanceolata (dune scurfpea)	16	8
Koeleria cristatum (prairie junegrass)	4	--
Stipa comata (needle-and-thread grass)	8	--
Gilia leptomeria (great basin gilia)	8	8
Mentzelia albicaulis (whitestem stickleaf)	8	--
Oenothera pallida (pale eveningprimrose)	4	4
Descurainia sp. (tansymustard)	12	--
Cryptantha circumscissa (matted cryptantha)	4	8
Eriogonum niveum (snow buckwheat)	--	28
Artemisia tridentata (big sagebrush)	--	16
Purshia tridentata (antelope bitterbrush)	--	12
Chrysothamnus viscidiflorus (gray rabbitbrush)	--	4
Grayia spinosa (spiny hopsage)	--	8
Oryzopsis hymenoides (Indian ricegrass)	--	4
Festuca octoflora (six-weeks fescue)	--	4
Cymopterus terebinthinus (spring turpentine parsley)	--	4
Layia glandulosa (white-daisy tidytips)	--	4
Comandra umbellata (bastard toadflax)	--	16
Amsinckia lycopsoides (tarweed fiddleneck)	--	4
Biotic crust	--	56

* Introduced species.

Table 8. Percent Canopy Cover at PSN 72/82 Well Mound Sites in 1997.

Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	23.1	40.8
*Salsola kali** (Russian thistle)	2.5	6.4
Ambrosia acanthicarpa (bur ragweed)	2.0	0.1
Oenothera pallida (pale eveningprimrose)	0.5	0.1
Artemisia tridentata (big sagebrush)	3.6	16
Chrysothamnus nauseosus (gray rabbitbrush)	0.1	0.6
Grayia spinosa (spiny hopsage)	--	1.5
Koeleria cristata (prairie junegrass)	0.1	--
Oryzopsis hymenoides (Indian ricegrass)	0.3	--
Poa sandbergii (Sandberg's bluegrass)	0.2	--
Sitanion hystrix (bottlebrush squirreltail)	0.1	--
Stipa comata (needle-and-thread grass)	0.5	--
Amsinckia tessellata (devil's lettuce)	0.2	0.1
*Sisymbrium altissimum** (tumblemustard)	0.5	0.1
Descurainia pinnata (tansymustard)	0.3	1.4
Fritillaria pudica (yellowbell)	0.1	0.8
Erodium cicutarium (storksbill)	0.1	0.2
Balsamorhiza careyana (Carey's balsamroot)	--	0.8
Comandra umbellata (bastard toadflax)	--	0.6
Machaeranthera canescens (hoary aster)	--	0.1
Biotic crust	0.1	29.4
Total cover (biotic crust not included)	**34.2**	**69.6**

* Introduced species.

Table 9. Percent Frequency of Occurrence at PSN 72/82 Well Mound Sites in 1997.

Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	88	96
*Salsola kali** (Russian thistle)	80	28
Ambrosia acanthicarpa (bur ragweed)	80	4
Oenothera pallida (pale eveningprimrose)	20	4
Artemisia tridentata (big sagebrush)	28	52
Chrysothamnus nauseosus (gray rabbitbrush)	4	4
Grayia spinosa (spiny hopsage)	--	4
Koeleria cristata (prairie junegrass)	4	--
Oryzopsis hymenoides (Indian ricegrass)	12	--
Poa sandbergii (Sandberg's bluegrass)	8	--
Sitanion hystrix (bottlebrush squirreltail)	4	--
Stipa comata (needle-and-thread grass)	20	--
Amsinckia tessellata (devil's lettuce)	8	4
*Sisymbrium altissimum** (tumblemustard)	20	4
Descurainia pinnata (tansymustard)	12	36
Fritillaria pudica (yellowbell)	4	32
Erodium cicutarium (storksbill)	4	8
Balsamorhiza careyana (Carey's balsamroot)	--	12
Comandra umbellata (bastard toadflax)	--	4
Machaeranthera canescens (hoary aster)	--	4
Biotic crust	4	72

* Introduced species.

Table 10. Percent Canopy Cover for PSN 12/14 in 1997.

Species	Control	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	52.3	13.7	42.9	14.5	56.5	32.3
Ambrosia acanthicarpa (bur ragweed)	0.4	3.2	6.0	4.5	0.5	3.4
*Sisymbrium altissimum** (tumblemustard)	0.4	--	16	1.0	1.5	1.1
*Salsola kali** (Russian thistle)	--	0.9	4.0	1.5	2.0	0.7
Artemisia tridentata (big sagebrush)	15.6	--	1.5	0.5	--	--
Purshia tridentata (antelope bitterbrush)	2.1	--	--	--	--	--
Poa sandbergii (Sandberg's bluegrass)	14.6	0.1	0.3	--	--	--
Stipa comata (needle-and-thread grass)	--	6.8	3.0	3.5	3.0	--
Koeleria cristata (prairie junegrass)	--	0.1	--	--	--	--
Amsinckia tessellata (devil's lettuce)	--	--	0.1	--	--	--
Cymopterus terebinthinus (turpentine parsley)	0.7	--	--	--	--	--
Descurainia pinnata (tansymustard)	0.1	0.9	--	--	--	--
Draba verna (spring whitlow)	2.5	--	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	0.3	0.5	1.5	0.1
Eriogonum niveum (snow buckwheat)	--	0.6	--	--	--	--
Festuca octoflora (six weeks fescue)	--	--	--	--	--	0.5
Holosteum umbellatum (jagged chickweed)	0.8	--	--	--	--	0.3
*Lactuca serriola** (prickly lettuce)	--	--	0.8	--	1.0	0.2
Machaeranthera canescens (hoary aster)	--	--	0.3	--	--	--
Microsteris gracilis (annual phlox)	1.1	--	--	--	--	0.3
Oenothera pallida (pale eveningprimrose)	--	0.2	0.3	3.5	--	--
Phlox longifolia (longleaf phlox)	0.1	--	0.1	--	--	--
Rumex venosus (winged dock)	--	--	--	0.5	--	--
Biotic crust	52.5	--	38.5	--	0.5	--
Bare soil	20.2	86.3	20.9	80.5	30	--
Total cover (not including crust or bare soil)	**90.7**	**26.5**	**75.6**	**30**	**66**	**38.9**

* Introduced species.

Table 11. Percent Frequency of Occurrence on PSN 12/14 Sites in 1997.

Species	Control	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	100	96	95	100	80	96
Ambrosia acanthicarpa (bur ragweed)	16	88	45	80	20	56
*Sisymbrium altissimum** (tumblemustard)	16	--	70	40	60	24
*Salsola kali** (Russian thistle)	--	36	65	60	80	28
Artemisia tridentata (big sagebrush)	32	--	10	20	--	--
Purshia tridentata (antelope bitterbrush)	8	--	--	--	--	--
Poa sandbergii (Sandberg's bluegrass)	48	4	10	--	--	--
Stipa comata (needle-and-thread grass)	--	56	20	40	20	--
Koeleria cristata (prairie junegrass)	--	4	--	--	--	--
Amsinckia tessellata (devil's lettuce)	--	--	5	--	--	--
Cymopterus terebinthinus (turpentine parsley)	8	--	--	--	--	--
Descurainia pinnata (tansymustard)	4	36	--	--	--	--
Draba verna (spring whitlow)	60	--	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	10	20	60	4
Eriogonum niveum (snow buckwheat)	--	4	--	--	--	--
Festuca octoflora (six weeks fescue)	--	--	--	--	--	20
Holosteum umbellatum (jagged chickweed)	12	--	--	--	--	12
*Lactuca serriola** (prickly lettuce)	--	--	30	--	40	8
Machaeranthera canescens (hoary aster)	--	--	10	--	--	--
Microsteris gracilis (annual phlox)	44	--	--	--	--	12
Oenothera pallida (pale eveningprimrose)	--	8	10	40	--	--
Phlox longifolia (longleaf phlox)	4	--	5	--	--	--
Rumex venosus (winged dock)	--	--	--	20	--	--
Biotic crust	72	--	70	--	20	--
Bare soil	64	100	70	100	60	--

* Introduced species.

Figure 4. PSN 72/82 and Bridge Overlook Revegetation Sites.

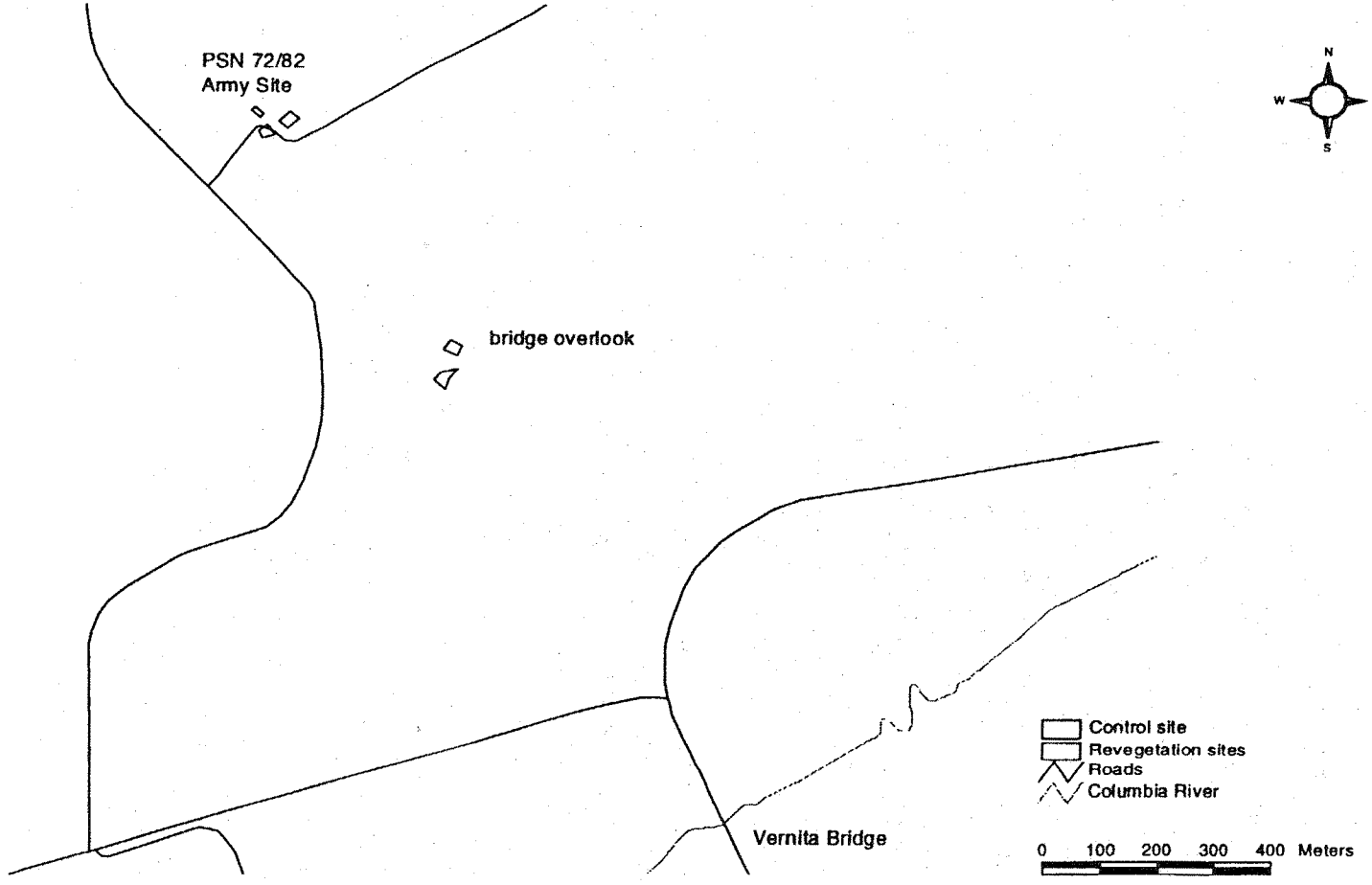
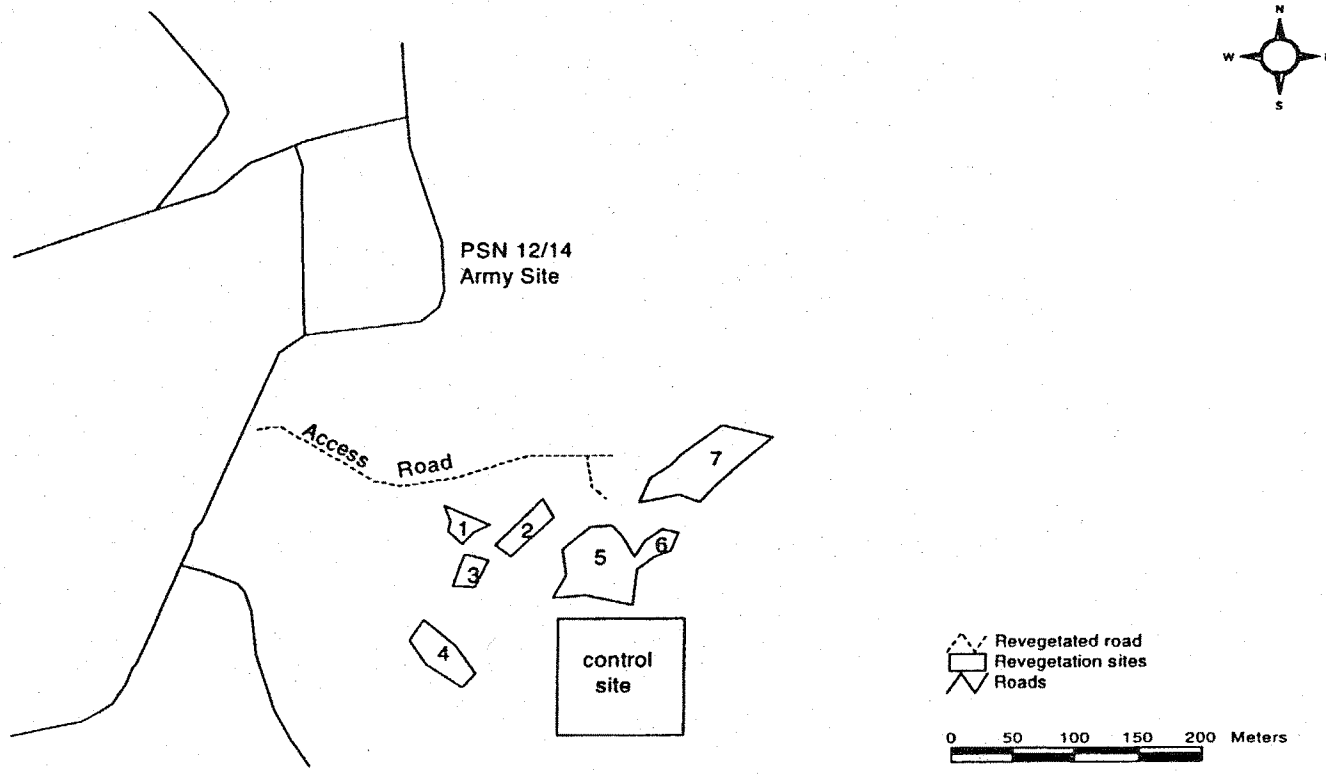


Figure 5. PSN 12/14 Revegetation Sites.



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6.0 NORTH SLOPE CHEATGRASS AREA

Sagebrush seedlings were planted in an old burn area on the Saddle Mountain Wildlife Refuge where wildfires have removed large tracts of sagebrush (Figures 1 and 6). The objective of this planting was to provide a seed source in the burn areas to promote sagebrush regeneration.

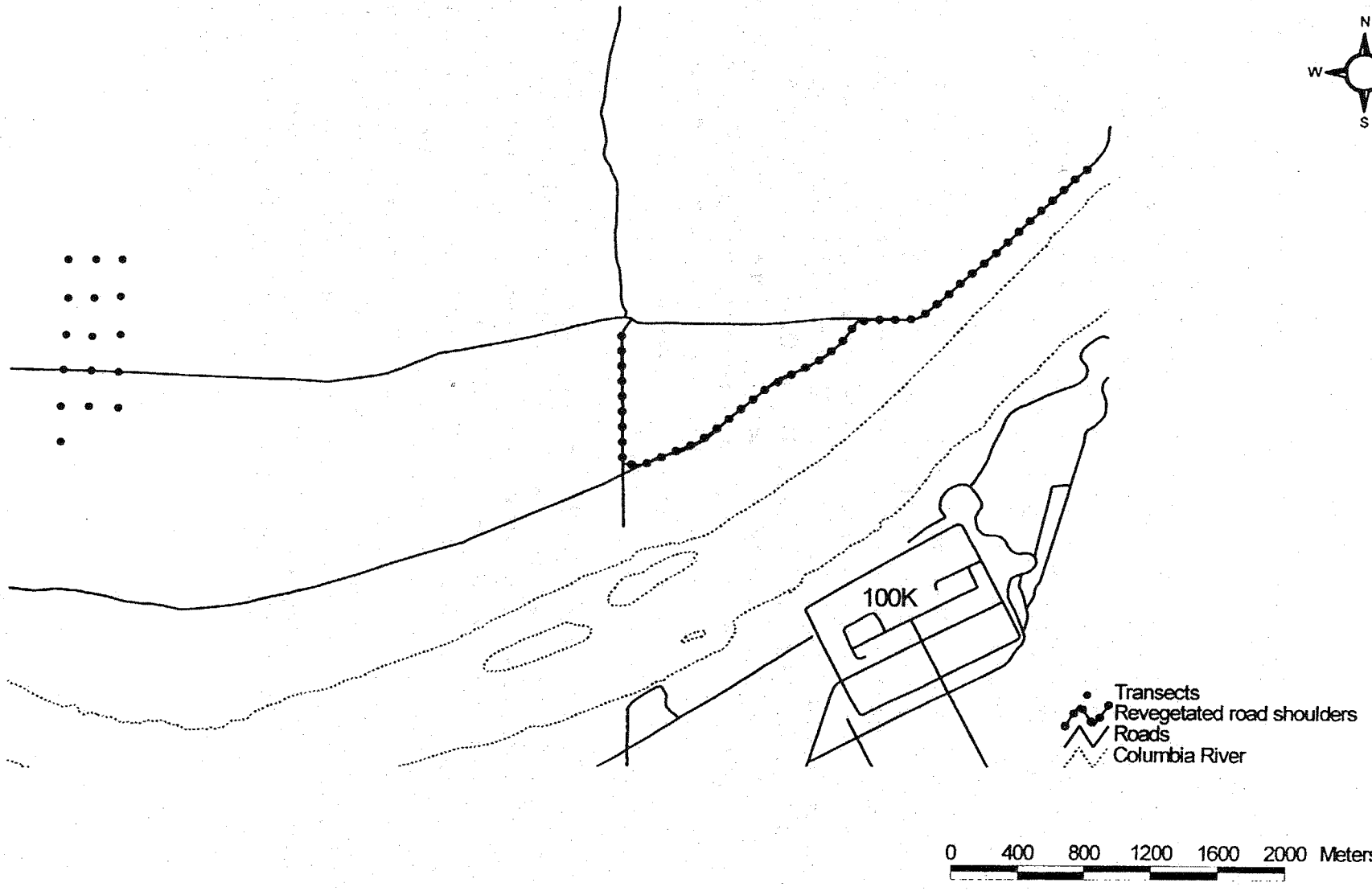
Approximately 3,000 sagebrush were planted in groups of three along the access road in August of 1996. These sagebrush were salvaged as seedlings from gravel pits at the junction of the access road and Route 24. A few different planting methods were used during the August transplanting. All of the sagebrush were planted directly in the ground and then watered; however, a few sagebrush groupings were surrounded by black plastic while others were planted with Dri-Water™[1]. Dri-Water™ is a commercial product that slowly releases water to the soil over an extended time period.

Approximately 2,700 sagebrush were planted in October of 1996. These sagebrush were salvaged from the initial Environmental Molecular Sciences Laboratory location in north Richland and planted in groups of three along the access road (Road Transect) and in small transect plots that were established perpendicular to the access road. The sagebrush transplants were monitored for survival on June 13, 1997. The percent survival for both the sagebrush planted in August (Small Plots) and those planted in October (Small Plots and Road Transect) is given in Table 5. The percent survival of the sagebrush planted in August was 5.5%. With such a low overall survival, no comparison could be made between the sagebrush planted in black plastic, those planted with Dri-Water, and those without any treatment. The results of this planting shows that sagebrush do not transplant well in August, even with the supplemental water source, as supplied by the Dri-Water™.

Survival of the sagebrush planted in October on the Small Plots and Road Transect was 92.7% and 85.7%, respectively. This dramatic increase in survival clearly shows that planting sagebrush seedlings in August under the conditions described here is not a successful approach. The major factors contributing to the lack of success are likely the harsh conditions of summer heat and drought. The average daily maximum temperature was 92.6°F during August 1996 (Hoitink and Burk 1997). Another contributing factor could have been because the source of sagebrush seedlings came from a very gravelly soil (a nearby borrow site), making it difficult to extract the plants without a large degree of injury to the root systems. This, combined with the existing stressful environmental conditions, may explain the low survival counts. Other methods may or may not increase transplant survival during August; however, the extreme drought conditions will always provide a challenge to survival counts and successful planning.

[1]Dri-Water is a tradename of Dri-Water, Inc., Petaluma, California.

Figure 6. Sagebrush Transplant Sites on the North Slope Cheatgrass Area.



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APPENDIX A

1996 MONITORING RESULTS FOR HORN RAPIDS LANDFILL AND HORSESHOE LANDFILL

Table A-1. Percent Canopy Cover on Horn Rapids Landfill in 1996.

Plant Name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	11	5.2	9.3	25.9	12.8	12
Salsola kali (Russian thistle)	22.7	9.8	12.2	6.0	8.4	14.7
Bromus tectorum (cheatgrass)	1.8	1.1	1.7	0.3	0.1	2.8
Amsinckia lycopsoides (tarweed)	0.3	0.6	0.1	0.1	0.3	0.4
Sisymbrium altissimum (tumblemustard)	1.3	0.4	0.1	0.2	0.3	0.4
Triticum sp (wheat)	2.6	0.3	0.7	0	0	5.6
Ambrosia acanthicarpa (bur ragweed)	1.2	0.7	0.1	0.8	0.9	2.0
Chenopodium sp (lambsquarter)	1.0	4.8	2.4	1.7	1.2	0.1
Lactuca serriola (prickly lettuce)	0.1	0.2	0	0.1	0.1	0
Erodium cicutarium (storksbill)	0.2	0	0	0.1	0	0
Total	41.9	23.2	26.8	35	24.2	38.1

Table A-2. Percent Frequency of Occurrence on Horn Rapids Landfill in 1996.

Plant Name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	92	88	100	100	100	92
Salsola kali (Russian thistle)	100	100	100	100	100	100
Bromus tectorum (cheatgrass)	16	24	12	12	4	36
Amsinckia lycopsoides (tarweed)	12	4	4	4	12	16
Sisymbrium altissimum (tumblemustard)	32	16	4	8	12	16
Triticum sp (wheat)	44	12	28	0	0	32
Ambrosia acanthicarpa (bur ragweed)	28	8	4	12	36	60
Chenopodium sp (lambsquarter)	20	76	76	48	28	4
Lactuca serriola (prickly lettuce)	0	4	8	4	4	4
Erodium cicutarium (storksbill)	0	8	0	0	4	0

Table A-3. Percent Canopy Cover on the Horseshoe Landfill in 1996.

Plant Name	Percent Cover
*Melilotis officinalis** (sweet clover)	7.8
*Bromus tectorum** (cheatgrass)	7.2
Artemisia tridentata (big sagebrush)	2.8
Descurainia sp (tansymustard)	2.7
*Sisymbrium altissimum** (tumblemustard)	2.1
Epilobium paniculatum (tall willowherb)	1.2
Agropyron spicatum (bluebunch wheatgrass)	1.1
Crepis atrabarba (slender hawksbeard)	1.0
Lupinus sulphurous (sulfur lupine)	0.7
Erigeron filifolius (threadleaf fleabane)	0.7
Linum perenne (wild blueflax)	0.7
*Lactuca serriola** (prickly lettuce)	0.6
*Salsola kali** (Russian thistle)	0.5
*Kochia scoparia** (red belvedere)	0.5
Poa sandbergii (Sandberg's bluegrass)	0.3
Sitanion hystrix (bottlebrush squirreltail)	0.3
*Lepidium perfoliatum** (clasping pepperweed)	0.2
Chenopodium leptophyllum (slimleaf goosefoot)	0.2
Amsinckia lycopsoides (tarweed fiddleneck)	0.2
Chaenactis douglasii (hoary falseyarrow)	0.2
Machaeranthera canescens (hoary aster)	0.2
Ambrosia acanthicarpa (bur ragweed)	0.1
Chrysothamnus nauseosus (gray rabbitbrush)	0.1
Total	31.4

* introduced species

Table A-4. Percent Frequency of Occurrence on the Horseshoe Landfill in 1996.

Plant Name	Percent Frequency
*Bromus tectorum** (cheatgrass)	92
Artemisia tridentata (big sagebrush)	52
Agropyron spicatum (bluebunch wheatgrass)	44
*Sisymbrium altissimum** (tumblemustard)	44
*Melilotis officinalis** (sweet clover)	40
Epilobium paniculatum (tall willowherb)	28
*Lactuca serriola** (prickly lettuce)	24
Crepis atrabarba (slender hawksbeard)	20
*Kochia scoparia** (red belvedere)	20
*Salsola kali** (Russian thistle)	20
Descurainia sp (tansymustard)	12
Poa sandbergii (Sandberg's bluegrass)	12
Sitanion hystrix (bottlebrush squirrel)	12
Amsinckia lycopsoides (tarweed fiddleneck)	8
Chaenactis douglasii (hoary falseyarrow)	8
Chenopodium leptophyllum (slimleaf goosefoot)	8
Erigeron filifolius (threadleaf fleabane)	8
*Lepidium perfoliatum** (clasping pepperweed)	8
Linum perenne (wild blueflax)	8
Lupinus sulphurous (sulfur lupine)	8
Machaeranthera canescens (hoary aster)	8
Ambrosia acanthicarpa (bur ragweed)	4
Chrysothamnus nauseosus (gray rabbitbrush)	4

* Introduced species

APPENDIX B

NAME CHANGES INCLUDED IN INTEGRATED TAXONOMIC INFORMATION SYSTEM

Name changes included in Integrated Taxonomic Information System* (ITIS 1997).

Recent name changes for species mentioned in this report. The first name is that used in Hitchcock and Cronquist (1973) and the second is the more recent version.

Chrysothamnus nauseosus = *Ericameria nauseosa* ssp. *nauseosa* var. *nauseosa*
*Cymopterus terebinthinus*** = *Pteryxia terebinthina* var. *terebinthina*
Epilobium paniculatum = *Epilobium brachycarpum*
Festuca octoflora = *Vulpia octoflora* var. *octoflora*
Koeleria cristata = *Koeleria macrantha*
Microsteris gracilis = *Phlox gracilis* ssp. *gracilis*
Oryzopsis hymenoides = *Achnatherum hymenoides*
Poa sandbergii = *Poa secunda*
Psoralea lanceolata = *Psoralidium lanceolatum*
Sitanion hystrix = *Elymus elymoides* ssp. *elymoides*
Stipa comata = *Hesperostipa comata* ssp. *comata*

*Integrated Taxonomic Information System can be found on the world wide web at http://www.itis.usda.gov/itis/info.html

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