

Amchitka Mud Pit Caps 2016 Post-Closure Monitoring and Inspection Report Amchitka Island, Alaska

November 2016

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Abbreviations

ADEC	Alaska Department of Environmental Conservation
DOE	U.S. Department of Energy
ft	feet
LM	Office of Legacy Management
USFWS	U.S. Fish and Wildlife Service

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Executive Summary

This Amchitka Mud Pit Caps 2016 Post-Closure Monitoring and Inspection Report describes how the U.S. Department of Energy (DOE) Office of Legacy Management (LM) performed the inspection and vegetation survey of seven mud pit caps on Amchitka Island, Alaska, in June 2016. In accordance with the *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Amchitka, Alaska, Site*, the mud pit caps will be monitored for subsidence, erosion, and vegetation cover on a 5-year basis. The last time the mud pit caps were inspected was in June 2011.

Three reconnaissance-type activities in the past two years were prompted by a 7.9 magnitude earthquake approximately 40 miles off the northwest coast of Amchitka Island in June 2014. Two trips in 2014 and one in 2015 were made to assess the damage to the mud pit caps and collect information on how to repair the damaged mud pit caps.

The current inspection and previous studies and observations of the mud pit caps and appurtenant areas indicate that the sites were generally not severely affected by the earthquake of June 2014. Significant distress occurred at several mud pit caps, but the caps did not rupture or expose contaminated soils to the environment. The following summarizes the observations of this inspection:

- At Site D, a long crack along the south sides of the east and west mud pit caps and associated slumping of cover soils has exposed the geomembrane in a small area. Another slump is in the southwest part of the east cap where it has partially blocked the drainage of water in channel D5.
- At Site F, a long crack and associated slump block are along the south edge of the mud pit cap.
- At Site E, a crack is just north of the mud pit cap and a large slump is just south of the mud pit cap.
- At Long Shot, several crack and slumps along the sides of the mud pit cap may become conduits for erosion.

LM is proposing a graded approach to address the earthquake damage. The graded approach will present an overview of what DOE is proposing, which will facilitate discussion and eventual concurrence with the Alaska Department of Environmental Conservation (ADEC). The actions discussed in the graded approach will then be further developed and detailed in a corrective action plan that will be submitted to ADEC for approval.

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1.0 Introduction

In 2001, the U.S. Department of Energy (DOE) remediated six areas on Amchitka Island, Alaska. The six mud pit release sites – Long Shot, Milrow, Cannikin, Site D, Site E, and Site F – are associated with U.S. Department of Defense (DOD) and U.S. Atomic Energy Commission (AEC) underground nuclear testing. Remediation was conducted by the DOE National Nuclear Security Administration Nevada Operations Office (NNSA/NV), now the NNSA Nevada Site Office (NNSA/NSO). The objective of the remediation was to cap the drilling mud pits and eliminate human and ecological exposure to contaminants associated with the drilling mud (NNSA/NV 2001).

Remediation of the six mud pit release sites in 2001 created seven mud pit caps where the contaminated materials were encapsulated in an engineered earthen disposal cell. The remediation at the Cannikin Site created two mud pit caps, Cannikin Ground Zero (north) and Cannikin South. Additionally, the Milrow mud pit release site was taken to an area called the Rifle Range for disposal.

To ensure the integrity and effectiveness of the remedial action, the mud pit caps are inspected every 5 years as part of the DOE Office of Legacy Management (LM) *Long-Term Surveillance Plan for the U.S. Department of Energy Amchitka, Alaska, Site* (DOE 2014a). The first 5-year inspection occurred in 2006, and the second 5-year inspection occurred in June 2011. The mud pit caps were inspected in accordance with the *Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, Amchitka, Alaska* (DOE 2016a).

This post-closure monitoring report provides the 2016 mud pit cap inspection results. The report provides the details of the monitoring, inspection, and vegetation survey work performed at the mud pit caps.

1.1 Mobilization/Demobilization

The inspection crew arrived on Amchitka Island early morning Friday, June 17, 2016, via the U.S. Fish and Wildlife Service (USFWS) Research Vessel *Tiglox*. Upon arrival, the five all-terrain vehicles (ATV) and miscellaneous equipment were unloaded onto the Constantine Harbor pier. The first mud pit cap inspection began mid-morning on June 17. Island activities were concluded by early afternoon on Tuesday, June 21, 2016, and equipment and vehicles were then loaded onto the *Tiglox*. The vessel departed that same day.

1.2 Key Personnel

The inspection crew consisted of the following personnel:

- Paul S. Darr, Navarro Research and Engineering, Inc., task manager
- Stephen Pitton, Navarro Research and Engineering, Inc., engineer and inspection team support
- Craig Goodknight, Navarro Research and Engineering, Inc., inspection team lead
- Linda Sheader, Navarro Research and Engineering, Inc., senior ecologist
- Danika Marshall, Navarro Research and Engineering, Inc., ecologist

1.3 Work Activities

Two tasks were scheduled for the on-island work:

- Inspection of seven earthen mud pit caps
- Vegetation survey of the seven earthen mud pit caps

1.3.1 Mud Pit Cap Inspection

A physical inspection of each mud pit cap was conducted and consisted of visual observations and photo documentation of the mud pit caps, energy dissipaters, and areas adjacent to the mud pit cap. Notable damage to or degradation of the mud pit cap (e.g., subsidence, rills, erosion, small holes), loss of vegetation over significant portions of the mud pit cap, erosion along the base of or adjacent to the mud pit cap, or erosion of drainage ditches or energy dissipaters was also documented and reported. All findings from the site inspections are documented on a post-closure monitoring checklist for each site (see Appendix A) for submittal to DOE and for future reference and monitoring. The seven mud pit cap sites are shown in the map of Amchitka Island in Figure 1 along with their location in respect to mile markers along Infantry Road.

1.3.2 Vegetation Survey

Each mud pit cap was monitored to document percentage of vegetation on the cover and the presence of weeds, disease, pests, and plant die-out. The percentage of vegetation on the mud pit cap was estimated as identified in Section 3.0. Monitoring consisted of identifying plant species and cover types found on each mud pit cap, collecting plant cover data, and taking representative photographs.

1.4 Island Overview

Amchitka Island is located in a maritime tundra ecosystem with low-energy dynamics, including; low primary productivity and decomposition rates, relatively few plant taxa, slow rates of change in the species composition of plant communities, and limited nutrient availability. Climatic conditions of Amchitka are typified by narrow seasonal and diurnal temperature fluctuations, frequent high winds, high relative humidity, and low solar input due to persistent cloud ceilings. Mean annual temperature is about 4.5 °C (40 °F) and precipitation ranges from approximately 76 to 89 centimeters (cm) (30 to 35 inches), falling as both rain and snow (Amundsen 1972). Although freeze/thaw events occur frequently, mean temperatures are not low enough to sustain permafrost. The attributes of undisturbed soils reflect the slow rate of ecosystem processes on the island; they tend to be acidic with abundant organic material, which can form a peat substrate up to 4 meters (m) thick, especially in lower-elevation tundra. Soil drainage generally increases and peat accumulation decreases with increasing elevation, which results in very wet lowland soils and a much drier topoenvironment for higher-elevation tundra (Amundsen 1972).

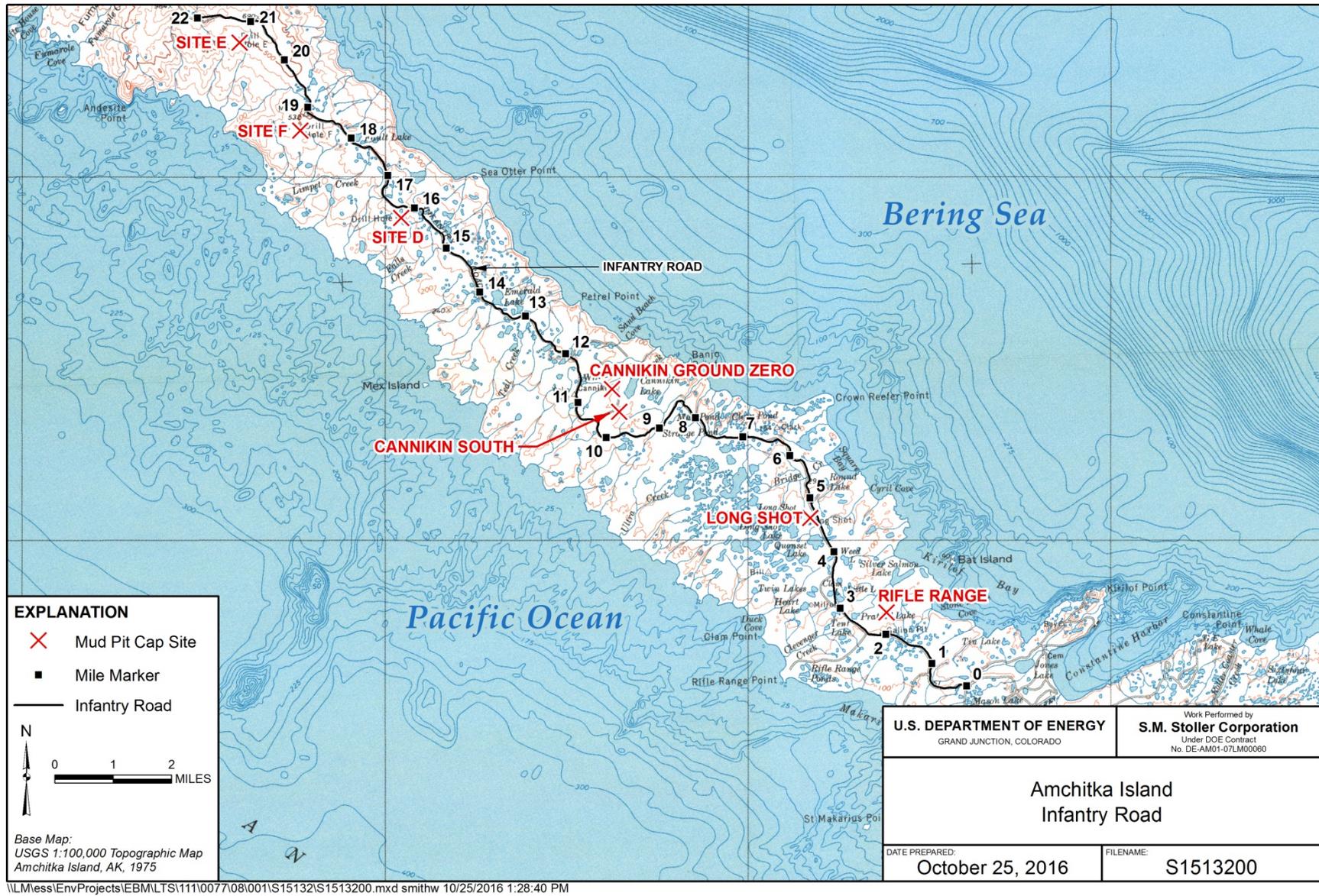


Figure 1. Location of Seven Mud Pit Cap Sites and Infantry Road on Amchitka Island, Alaska

By 1972, about 5 % of the total area of Amchitka Island had been disturbed by anthropogenic activities, primarily related to military occupation (Amundsen 1972). Additional disturbance occurred during the late 1960s and early 1970s to support underground nuclear testing by the DOD and the AEC. In 2001, six sites containing drilling mud from drilling associated with underground testing were remediated, resulting in seven mud pit caps. Remediation at all sites included stabilizing the drilling mud, installing a geomembrane fabric and soil cap over the stabilized mud, revegetating the mud pit cap, and installing drainage ditches and energy dissipaters around the mud pit cap (NNSA/NSO 2003).

Monitoring and inspection of the mud pit caps are required once every 5 years (DOE 2008a). Previous inspections occurred in 2006 (DOE 2006) and 2011 (DOE 2012). During the 2011 inspection, maintenance was also done on Infantry Road to ensure the temporary passage of vehicles. Also in 2011, the site's two wells were abandoned in place utilizing bentonite chips because they were not functioning as installed.

1.5 June 2014 Earthquake

On June 23, 2014, a 7.9 magnitude earthquake occurred 11 miles northwest of Amchitka Island. This earthquake was followed by several other earthquake aftershocks of magnitudes ranging from 6 to 6.9 within a 100-mile radius. The intensity of these earthquakes prompted LM to send an engineer and scientist to the island to inspect the mud pit cap sites.

On August 26 and 27, 2014, the inspection team, along with a representative from USFWS, inspected all seven of the mud pit cap sites. Of the seven mud pit caps inspected, two showed no sign of damage (Cannikin Ground Zero and South), three had minor cracks along the edge of the mud pit caps (Rifle Range, Long Shot, and Site F), and two had moderate damage (Sites D and E). The moderate damage observed on one of the mud pit caps (Site D) was where the soil cover had slumped away from the side of the mud pit cap, exposing the geomembrane fabric that covers the drill cuttings. The other mud pit cap (Site E) with moderate damage had a significant crack along the uphill side of the mud pit, and the land surface downgradient of the mud pit cap had slumped away. The mud pit cap was still intact, but native soils upgradient and downgradient of the mud pit cap have cracked or slumped. No release from any of the mud pit caps was observed (DOE 2014b).

In early June 2015, another inspection team conducted field reconnaissance, drilled exploratory borings with a hand auger, and collected geotechnical and environmental samples on selected mud pit caps. The detailed descriptions of the site visit and conditions observed are presented in the *Alternatives Analysis Amchitka Island Mud Pit Cap Repair, Amchitka, Alaska* (DOE 2016b). Briefly summarized, this report concluded that current and previous studies and observations of the mud pit caps and appurtenant areas indicate that the sites were generally not severely affected by the earthquake of June 2014. Significant distress occurred at some of the mud pit caps, but the caps did not rupture or expose contaminated soils to the environment. The report analyzed a range of alternatives from continued monitoring to repair of the sites and mitigation of the damage that did occur. The repair alternatives have been developed to a level of detail to support path forward discussions between DOE and the ADEC.

1.6 Pier and Roads

The dock (pier) on Constantine Harbor is in good condition. The island's roads, with the exception of Infantry Road near mile markers 4 and 8, were passable. Infantry Road was completely washed out near mile marker 4, just south of the Long Shot site, and near mile marker 8, just north of the intersection of the RX site road. The June 2014 earthquake also damaged Infantry Road at mile marker 18 to a point that the road was impassable for even ATV traffic.

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2.0 Mud Pit Cap Inspection

2.1 Introduction

This section summarizes the methods used to document the mud pit cap inspections, the differences in the 2016 inspection from the previous 2006 and 2011 inspections, and the recommendations from the inspection results. Mud pit cap inspections proceeded from the farthest to the northwest back to the southwest and followed the protocol shown for each mud pit cap in Table 3, “Proposed Cap Inspection Specifications,” in the Post-Closure Monitoring and Inspection Plan (DOE 2016a). The transects, visual inspection routes, and photopoints for each mud pit cap established during the 2006 and 2011 inspections were reported for the 2016 inspection. Documentation for each mud pit cap inspection included a drawing of the constructed mud pit generated from the 2001 as-built drawings, a monitoring checklist, and photographs. The drawings, checklists, and photographs are provided in Appendix A, “Inspection Reports.”

2.2 Mud Pit Cap Drawings

An inset in the mud pit cap drawing for each site (Figures A-1 through A-7) shows the access route to Infantry Road. The drawings were generated using the as-built drawings from the 2001 closure survey. Each drawing includes the transect lines, inspection path and end points (photopoints), findings of the inspection, and additional photo locations. Findings include areas of subsidence, small holes, seeps, and effects of erosion. The two mud pit caps in Site D were designated as West Cap and East Cap. At Site F, a new transect line, F-1, was established for the 2011 inspection along the center axis of the mud pit cap. This adjustment was made because the GPS (global positioning system) locations of the end points of the F-1 transect for the 2006 inspection placed the transect well down the south flank of the mud pit cap.

2.3 Monitoring Checklists

The Field Conclusions section of each monitoring checklist contains a discussion of all findings from the inspection. The findings are shown on the mud pit drawing for each site and include items that require monitoring during future inspections. Some of the findings identify deficiencies, and the discussion includes recommendations for possible future repairs.

2.4 Photographs

Photographs taken during the inspection are listed and described in the Photograph Log. Photopoints, generally of the USFWS monument and at the ends of the transects, are designated. Additional photographs included in the log document conditions or findings such as small holes, seeps, erosion, subsidence, and ponded water. Additional photographs were also included to show the mud pit cap from a distance, if possible; otherwise, photographs of parts of the cap were provided. Photographs are shown in Appendix A following the Photograph Log for each site.

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3.0 Vegetation Survey

3.1 Introduction

The purpose of the vegetation monitoring is to document the abundance and composition of vegetation on the cover and the presence of any weeds, excessive grazing, disease, pests, or significant areas of dead vegetation (DOE 2016a). The 2016 vegetation monitoring also compares current vegetation cover to that of previous monitoring years and describes any changes that may have resulted from the 7.9 magnitude earthquake in June 2014.

The mud pit caps were seeded in 2001 with two grass species (Bering hairgrass, *Deschampsia behringensis*; and red fescue, *Festuca rubra* [DOE 2006]) using a seed mat product called North American Green SC150, which consisted of erosion-control blanket embedded with seed (DOE 2003). The blanket was made of straw and coconut fiber placed between two natural-fiber nets. During the 2006 inspection, inspectors found low vegetation cover on the three highest-elevation caps (Drill Sites D, E, and F). These caps were reseeded in 2008 using the same species of grass at the rate of 43 pounds of seed per acre. Fertilizer consisting of 20% nitrogen, 20% phosphoric acid, and 10% potash was applied at the time of seeding at a rate of 500 pounds per acre (DOE 2008b).

3.2 Plant Ecology of Amchitka Island

Vegetation communities on Amchitka Island are maritime tundra communities characterized by bryophytes, lichens, and low-growing vascular plant species. Low temperatures result in a low-energy environment, although no permafrost is present. On the island, plant communities tend to intergrade, with many of the same species appearing in multiple communities in different proportions (Shacklette et al. 1969, Amundsen 1972). Most of the species on the island are native to Alaska, and no invasive weeds are known to be present. In the late 1960s, Hansford T. Shacklette and others characterized vegetation on Amchitka Island for the U.S. Geological Survey (Shacklette et al. 1969), and C.C. Amundsen described the plant ecology of the island for the U.S. Atomic Energy Commission (Amundsen 1972).

Amundsen described three “topoenvironmental units” on the island. Two of these, lowland tundra and upland tundra, surround the mud pit cap sites. Lowland and upland tundra are distinguished not by elevation but by degree of drainage; upland tundra is well-drained, and lowland tundra tends to retain moisture. Plant community types within the upland and lowland tundra surrounding the mud pit cap sites include (1) crowberry meadow (crowberry-sedge-grass and crowberry-grass-sedge types), (2) crowberry-grass stripe, (3) secondary succession, and (4) wet tundra (ephemeral pools, “breakaway tundra,” and sedge-lichen meadow). Crowberry meadows are ecologically mature communities dominated by Pacific reedgrass (*Calamagrostis nutkaensis*), sedges, and crowberry (*Empetrum nigrum*). Crowberry-grass stripe describes communities where crowberry meadow alternates in “stripes” with grass meadow or bare patches. This community is believed to be formed by wind erosion and patterns of plant succession. It is found at elevations over 400 feet (ft). Secondary succession communities are areas that were extensively disturbed by historical military occupation. These communities contain many of the same species as the surrounding heath, but at different densities; for example, Nootka lupine (*Lupinus nootkatensis*) is much more common and vigorous in secondary succession communities than in crowberry meadows. Wet tundra communities exist

along lakes, ephemeral pools, and streams as well as low-lying areas with poorly drained soils. “Breakaway tundra” is dominated by sedges and lichens; because of past disturbances, it contains few well-rooted plants.

Ecological succession is complex on Amchitka Island. Early and secondary successional communities are present in places disturbed by military operations, underground nuclear testing, and remediation. However, these successional communities do not progress toward a single “climax” community. Rather, mature plant communities on the island constantly change due to peat accumulation and movement, which causes drying and swamping patterns over space and time. Solifluction, the process of downslope soil movement related to saturation and freeze/thaw cycles, also causes constant changes in plant cover. Although ecological changes are constant, they progress slowly because of the low-energy environment of maritime tundra communities.

The seven mud pit caps occur at different elevations and are surrounded by various ecological communities, resulting in different conditions that may affect revegetation success. Table 1 compares some of the ecological conditions that may affect the mud pit caps.

Table 1. Comparison of Ecological Conditions at Seven Mud Pit Caps at Amchitka Island

Mud Pit Cap	Location Relative to Constantine Harbor	Elevation (ft)	Main Surrounding Plant Community	Approximate Size (acres)^a
Site F	21.5 miles northwest	475	Crowberry meadow	0.5
Site E	24 miles northwest	475	Crowberry-grass stripe	0.1
Site D	18.5 miles northwest	310	Crowberry meadow	6.2
Cannikin Ground Zero	14 miles northwest	215	Crowberry meadow	0.7
Cannikin South	13.5 miles northwest	237	Crowberry meadow	0.4
Long Shot	7.5 miles northwest	165	Crowberry meadow and wet tundra	1.5
Rifle Range	5.5 miles northwest	56	Crowberry meadow	0.8

Note:

^a The acreage of the mud pit caps was calculated from engineering drawings in 2016; the 2016 figures resolve discrepancies in values published in previous reports for the Amchitka site.

3.3 Methods

Inspectors estimated plant cover on the mud pit caps using a point interception method, as in past inspections. In 2006 and 2011, point interception frames were used (DOE 2006, DOE 2012). Access to the mud pit caps has since been restricted by road damage, making it impossible to access some of the caps with a full-sized vehicle. As a result, bulky point interception frames are no longer practical. Instead, a transect tape method of point interception was selected. As in the past, samples on the mud pit caps were placed using a stratified random sampling design along previously established permanent transects. At random points along the permanent transects, 10-meter-long sampling transect tapes were placed perpendicular to the permanent transects, intersecting at the 5-meter mark. A plant species or other type of cover (bare ground, litter, or rock) was counted when it intercepted the edge of the transect tape at 1-decimeter intervals. Table 2 summarizes the number of permanent transects and transect tapes sampled on each mud pit cap and compares sample designs to those used in 2011.

Table 2. Comparison of Sample Designs for Vegetation Surveys on Amchitka Island During 2016 and 2011 Monitoring

Mud Pit Cap	Number of Permanent Transects	Number of Transect Tapes, 2016	Number of Frames, 2011	Total Number of Points Recorded, 2016	Total Number of Points Recorded, 2011
Rifle Range	4	34	80	3400	2880
Long Shot	5	48	123	4800	4428
Cannikin South	2	11	30	1100	1080
Cannikin Ground Zero	5	23	62	2300	2232
Drill Site D	11	49	134	4900	4824
Drill Site E	2	11	30	1100	1080
Drill Site F	3	13	35	1300	1260
Total	32	189	494	18,900	17,784

Hultén (1968) was used for species identification, and nomenclature follows the USDA PLANTS database (USDA 2016). Bryophytes were represented by mosses, the most abundant of which belong to the genus *Sphagnum*. Lichens were identified by form—crustose, foliose, or fruticose—but were not identified to species.

Absolute cover for each plant species or nonvegetated cover (bare ground, rock, or litter) was calculated as a percentage of points intercepted out of total points sampled. Mean values were calculated for each mud pit cap by averaging data from all line tapes sampled within the cap.

3.4 Results

A total of 50 vascular plant species were found on the mud pit caps in 2016 along with many types of bryophytes and lichens. Vascular plants include club mosses such as *Selaginella*, ferns, horsetails, forbs (nonwoody herbs), graminoids (grasses and grass-like plants such as sedges and rushes), and woody plants (shrubs and trees). All of the plant species are native to Alaska except common mouse-ear chickweed (*Cerastium fontanum*) and common sheep sorrel (*Rumex acetosella*); neither of these is weedy or invasive. Appendix C-1 contains a list of all plant species identified at the Amchitka Island site in 2016. Detailed monitoring data for each mud pit cap is included in Appendix C-2.

Vascular plant species richness—a count of the total number of plant species present, excluding bryophytes and lichens—is summarized by mud pit cap in Table 3. Species richness increased at all of the mud pit caps between 2011 and 2016. The increases are likely indicators of continued colonization from surrounding plant communities. In 2011, species richness was generally correlated with elevation (higher-elevation caps of Sites D, E, and F had fewer vascular plant species), but this correlation was no longer apparent in 2016. The majority of the plant species identified in 2016 were perennial forbs that were found in very small numbers.

Table 3. Vascular Plant Species Richness on Mud Pit Caps

Monitoring Year	Site F	Site E	Site D	Cannikin Ground Zero	Cannikin South	Long Shot	Rifle Range
2016	23	15	27	19	19	32	22
2011	10	11	14	14	9	22	21
2006	5	4	8	12	10	13	14

Mean absolute vegetation cover (which includes vascular plants, bryophytes, and lichens) is summarized in Table 4. Some mud pit caps (e.g., Site D and Long Shot) contained larger proportions of nonvascular plant cover than others. Vascular plant cover is preferred on the mud pit caps because these plants provide root structure that stabilizes soils over the longer term. Although bryophytes and lichens are generally colonizers with shallow subsurface structure, they do help protect soils from wind erosion. They also conserve moisture and concentrate organic matter near the ground surface, developing habitat that often facilitates the establishment of vascular plant species.

Table 4. Mean Percent Absolute Cover for Mud Pit Caps on Amchitka Island, 2016

	Site F	Site E	Site D	Cannikin Ground Zero	Cannikin South	Long Shot	Rifle Range
Vegetated cover							
Vascular plants							
Shrubs (subshrubs)	0.1	0.1	0.6	0.4	0.0	5.6	0.1
Graminoids	23.0	10.8	13.8	13.6	15.8	17.5	14.7
Forbs	9.1	10.8	7.7	6.4	6.8	16.7	22.5
Total vascular plant cover	32.2	21.7	22.1	20.4	22.6	39.8	37.3
Nonvascular plants							
Bryophyte cover	7.5	9.2	50.2	1.0	1.1	20.1	5.8
Lichen cover	1.0	0.8	1.9	0.1	0.3	1.2	0.0
Total nonvascular plant cover	8.5	10.0	52.1	1.1	1.4	21.3	5.8
Total vegetated cover	40.7	31.7	74.2	21.5	24.0	61.1	43.1
Nonvegetated cover							
Bare ground	47.6	55.8	10.8	65.8	58.8	25.0	40.1
Rock	0.8	1.7	1.7	2.7	1.3	1.2	1.3
Litter	10.9	10.8	13.3	10.0	15.9	12.7	15.5
Total nonvegetated cover	59.3	68.3	25.8	78.5	76.0	38.9	56.9

In 2016, graminoids represented the majority of the vascular plant cover at Site F, Site E, Cannikin Ground Zero, and Cannikin South; forbs represented the majority of the vascular plant cover at the Rifle Range, and cover values were similar for graminoids and forbs at Site D and Long Shot. Shrubs made up less than 1% of the cover on all of the caps. As in 2011, red fescue (*Festuca rubra*) was the most abundant grass, followed by Bering's tufted hairgrass (*Deschampsia beringensis*), both of which were seeded species. Common woodrush (*Luzula multiflora*) and Alaska brome (*Bromus sitchensis*) were the most abundant naturally colonizing graminoids in 2016. Nootka lupine (*Lupinus nootkatensis*) made up the majority of forb cover, although Hornemann's willowherb (*Epilobium hornemannii* ssp. *behringianum*) and creeping

sibbaldia (*Sibbaldia procumbens*) were also common. Shrub cover consisted almost entirely of black crowberry (*Empetrum nigrum*), but least willow (*Salix rotundifolia*) and arctic azalea (*Loiseleuria procumbens*) were also found on some of the caps.

The highest total vegetated cover was at Site D, followed by Long Shot. Cover at both of these caps exceeded 50% in 2016; however, a large percentage of the cover at Site D was provided by nonvascular plants. Vegetated cover was below 50% at five of the seven mud pit caps. The lowest total vegetated cover was at Cannikin Ground Zero, followed by Cannikin South and Site E. Figure 2 shows changes in vegetated cover at the mud pit caps since 2006. Since 2011, cover values have declined by more than 10% at Site E, Site F, and Cannikin South but increased at Site D. At Cannikin Ground Zero, Long Shot, and the Rifle Range, 2016 vegetated cover values differed by less than 5% from 2011 values.

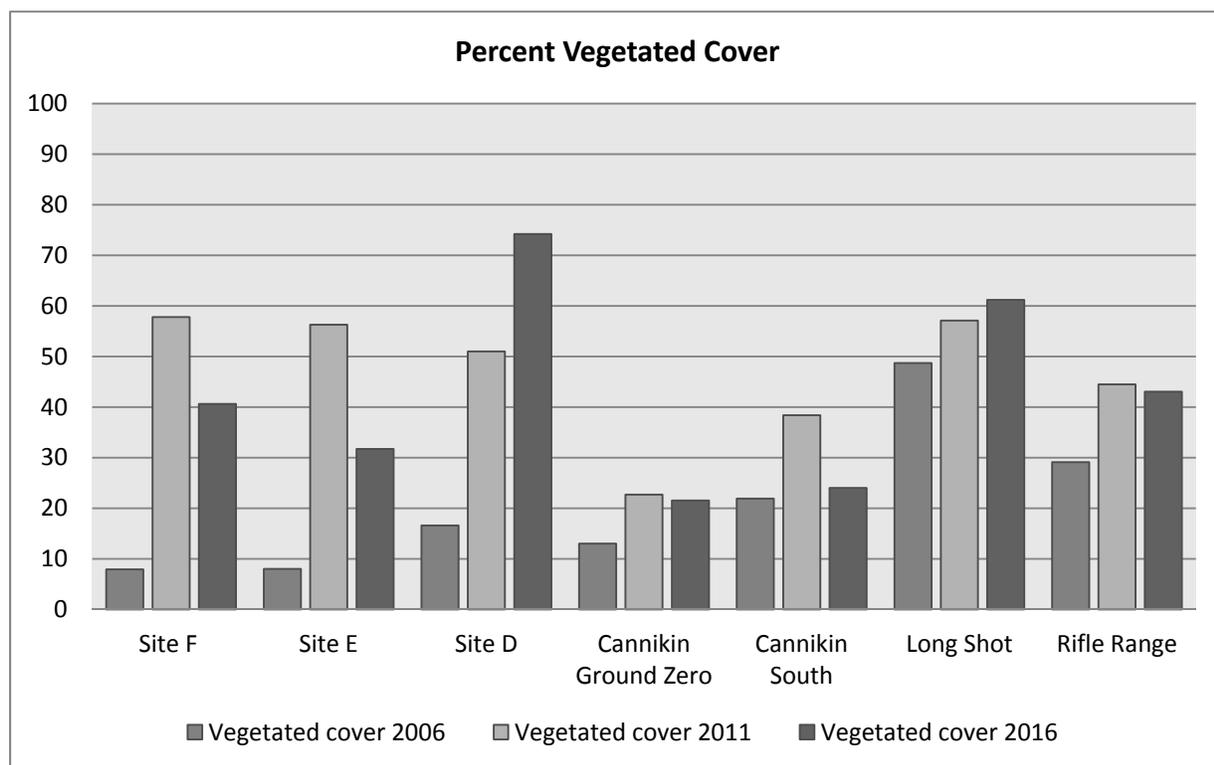


Figure 2. Mean Absolute Vegetated Cover for Mud Pit Caps on Amchitka Island

Vegetation establishment on the mud pit caps on Amchitka Island is a slow process mainly because of the low-energy environment of the maritime tundra. Many factors work against establishing plant communities on the mud pit caps. Vascular and nonvascular plants are often susceptible to wind erosion. Winds remove moisture and organic nutrients from the soil surface and expose roots. Solifluction is also a disturbing factor that can hinder plant establishment, especially at elevations over 400 ft (i.e., Sites E and F). Factors that encourage plant establishment include the presence and conservation of organic materials, as evidenced by the positive effects of fertilizer applied to Sites D, E, and F in 2008 and described during 2011 monitoring. Topography also affects plant establishment; the sloped surfaces of the mud pit caps can expose plants to increased wind. Even microtopography (features measured on a scale of inches rather than feet) can protect establishing plants from the impacts of wind in a tundra environment.

Increases in vascular plant species richness indicate that ecological succession continues to occur on all of the mud pit caps as more species become established. Although more species were present in 2016 than in previous years, total vegetated cover generally did not increase. On some caps, vegetated cover has declined since 2011, and the greatest increase (on Site D) was mainly an increase in nonvascular plant cover. Climate-related factors may be responsible for decreases in vegetated cover on the mud pit caps. The historical average annual temperature in the Aleutian Islands is about 40.3 °F (U.S. Climate Data 2016). In the Aleutian Islands¹, average annual temperatures were above this value in 2014 and 2015 (41.7 and 42.1 °F, respectively), and annual total precipitation has been substantially below average (54.1 inches) every year since the 2011 inspection². Moisture is particularly important to the establishment and persistence of maritime tundra vegetation. It is also possible that soil disturbances resulting from the 2014 earthquake may have affected the vegetation cover on the mud pit caps, but no specific conditions attributable to the earthquake were observed in 2016.

¹ As no weather data are available for Amchitka Island, temperature and precipitation data from both Adak Island and Dutch Harbor were analyzed (Weather Underground 2016).

² Inches of rainfall in 2012: 24.2”; 2013: 40.5”; 2014: 27.6”; and 2015: 31.1.”

4.0 Conclusions

Existing conditions of the mud pit caps have been documented in previous reports (DOE 2014b, 2016b). The current inspection maintained the same protocol used for previous 5-year inspections with the exception that no maintenance repairs were performed this year due to the impacts to four of the mud pit caps from the 2014 earthquake. Repairs of deficient site conditions noted during this inspection are categorized as either maintenance or structural. Deficiencies in a cap, energy dissipater, or drainage ditch were evaluated and assigned to the appropriate repair category, as described below.

4.1 Maintenance Repairs

Site deficiencies that are considered maintenance repairs result from typical site conditions, including normal weather conditions, seasonal vegetation growth/die-out, and normal animal activity, and are minor in nature. If possible, these deficiencies will be corrected during the inspection. Those maintenance repair deficiencies that cannot be corrected at the time of the inspection were noted and appropriate actions are being negotiated with ADEC.

4.2 Structural Repairs

Site deficiencies that are considered structural repairs result from atypical site conditions, including earthquakes, severe weather conditions, excessive vegetation growth/die-out, excessive animal activity, and vandalism. These conditions are considered significant and cannot be corrected during the inspection.

Structural repairs might involve regrading an area to modify drainage to reduce runoff or erosion problems. All repair work will attempt to preserve the original cover as-built design; however, permanent modification might be required to prevent a recurrence of detrimental site conditions. In that case, the area will be resurveyed to establish new baseline conditions. The method of and schedule for repairs will be developed in consultation between ADEC and DOE.

The effects from the 2014 earthquake are visible on four of the mud pit caps and are structural in nature. DOE has documented the deficiency in this report and is beginning to prepare a corrective action plan, as a standalone document, that provides details for how the damaged mud pit caps will be repaired.

The following summarizes the observations of this inspection:

- At Site D, a long crack along the south sides of the east and west mud pit caps and associated slumping of cover soils has exposed the geomembrane in a small area. Another slump is in the southwest part of the east cap where it has partially blocked the drainage of water in channel D5.
- At Site F, a long crack and associated slump block are along the south edge of the mud pit cap.
- At Site E, a crack is just north of the mud pit cap and a large slump is just south of the mud pit cap.
- At Long Shot, several crack and slumps along the sides of the mud pit cap may become conduits for erosion.

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5.0 Recommendations

LM is proposing a graded approach to address the earthquake damage. The graded approach will facilitate discussion and eventual concurrence with ADEC. The actions discussed in the graded approach will then be further developed and detailed in a corrective action plan that will be submitted to ADEC for approval.

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6.0 References

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Appendix A

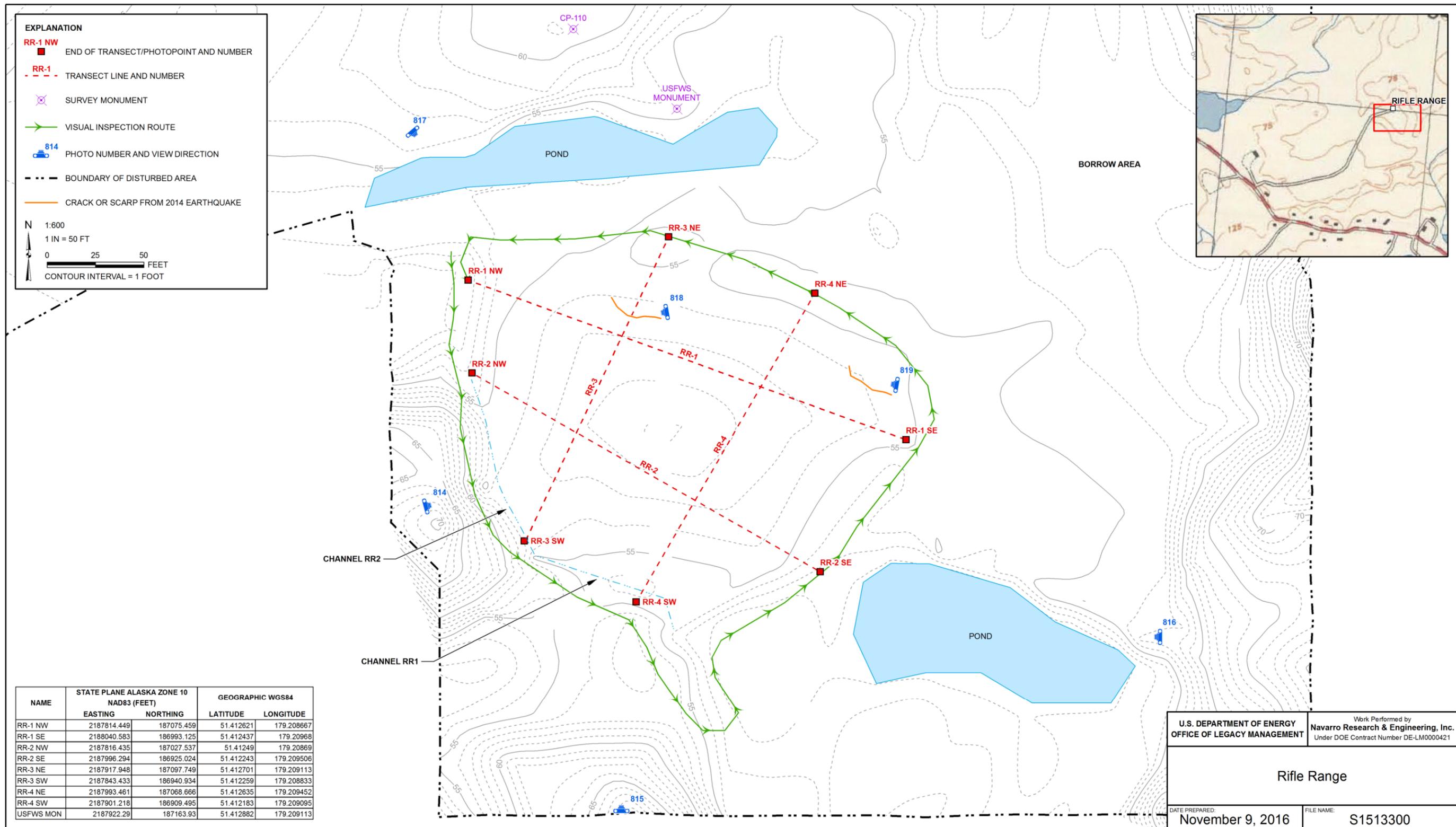
Inspection Reports

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Appendix A-1

Rifle Range

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Figure A-1. Rifle Range

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AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST

Mud Pit Site: Rifle Range (RR)

Date of Inspection: June 20 and 21, 2016

Responsible Agency: U.S. Department of Energy –
Legacy Management

Project Manager: Mark Kautsky

Inspector (name, title, organization): Craig Goodknight, Inspection Team Lead, Navarro

A. General Instructions

1. All checklist items must be completed and detailed comments made to document the results of the site inspection.
2. The completed checklist is part of the field record of the inspection. Additional pages should be used as necessary to ensure that a complete record is made. Number and attach the additional pages upon completion of the inspection.
3. Any checklist line item marked by an inspector in a SHADED BOX must be fully explained or an appropriate reference to previous reports provided. The explanation should include the inspector’s rationale for conclusions and recommendations, if appropriate. Explanations are to be placed on additional attachments and cross-referenced appropriately, and may take the form of sketches, measurements, and/or annotated site maps.
4. The site inspection is a walking inspection of the entire site, including the perimeter and sufficient transects to be able to inspect the entire surface and all features specifically described in this checklist. Attach a drawing indicating the starting and ending points and the direction and pattern of the inspection.
5. A standard set of color 35 mm photographs (or equivalent) is required. In addition, all anomalous features or new features (such as changes in adjacent area land use) are to be photographed. A photo log entry will be made for each photograph taken.

B. Preparation (to be completed prior to site visit)

YES	NO	EXPLANATION
-----	----	-------------

1. Site as-built plans and site base map reviewed	X		Mud Pit Closure Plans and As-Built
2. Previous inspection reports reviewed	X		2006 and 2011 Inspection Reports
a. Were anomalies or trends detected on previous inspections?	X		From 2014 Post-Earthquake Investigation
b. Was maintenance performed on areas with anomalies?		X	No maintenance has been done on any of the effects resulting from the earthquake
3. Site maintenance and repair records reviewed		X	No previous maintenance activities were done
a. Has site repair resulted in a change from as-built conditions?		X	No detectable changes from as-built condition
b. Are revised as-builts available that reflect repair changes?			Not Applicable. No repairs have been made

C. Site Inspection (to be completed during inspection)

YES	NO	EXPLANATION
-----	----	-------------

1. Adjacent offsite features within mud pit site area			
a. Changes in use of adjacent area?		X	Wildlife refuge
b. Any new roads or trails?		X	Per previous photos and as-built drawings
c. Change in the position of nearby washes?		X	None detected
d. Erosion/deposition of nearby washes?		X	None detected
e. New drainage channels?		X	None detected
f. Change in surrounding vegetation?		X	None detected
2. Security markers; signs			
a. Displacement of site markers, boundary markers, or monuments?		X	USFWS Monument was present/Good condition
b. Signs damaged or removed?		X	New sign installed at USFWS Monument. Other signs are in good condition.
3. Cap			
a. Evidence of subsidence?		X	
b. Evidence of cracking?	X		Two cracks from the 2014 earthquake are in N part of mud pit cap
c. Evidence of erosion (wind or water)?		X	
d. Evidence of animal burrowing?		X	
e. Are site markers disturbed? By man? _____ By natural processes? _____		X	
f. Do natural processes threaten the integrity of cap or site marker?		X	

AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST (continued)

Mud Pit Site: Rifle Range (RR)

Date of Inspection: June 20 and 21, 2016

C. Site inspection (continued)

	YES	NO	EXPLANATION
4. Vegetative cover			
a. Is plant cover adequate to prevent erosion?	X		See discussion in Section 3.0
b. Are weedy annual plants present? Do they require removal?		X	See discussion Section 3.0
c. Evidence of animals on cap?		X	See discussion Section 3.0
d. Evidence of excessive plant mortality?		X	See discussion Section 3.0
e. Has a vegetative cover log been completed?	X		See Vegetative Cover Log
5. Photo Documentation			
a. Has a photo log been prepared?	X		See Photograph Log
b. How many photos were taken?			15 photos as noted in the Photograph Log

D. Field Conclusions

1. Imminent hazard to integrity of cap? (If yes, immediate report required. Note the person or agency the report will be made to.)		X	
2. Are more frequent inspections required?		X	
3. Are existing maintenance actions satisfactory?			Not Applicable. No maintenance was done or required.
4. Are existing repair actions satisfactory?			Not Applicable. No repairs were done or required.
5. Is other maintenance/repair necessary?		X	
6. Rationale for field conclusions: Conclusions were based on walkover visual inspections and plant counts. Two minor cracks are in the north part of the mud pit cap. The cracks were formed as a result of the June 2014 7.9-magnitude earthquake and several strong aftershocks. In August 2014, soon after the earthquake, an inspection team found that the cracks were as deep as 18 inches. A site visit in June 2015 indicated that the cracks were in better condition and were filling in. This inspection found the cracks were only as much as 6 to 9 inches deep (photos 0818 and 0819). Continued filling and healing of the cracks along with establishment of more vegetation should be monitored in future inspections.			

7. Factors contributing to or impacting inspection: None noted

E. Certification

I certify that I have conducted an inspection of the Rifle Range Mud Pit Site cap in accordance with the Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, dated March 2016, as recorded on this checklist, discussion in Sections 2.0 and 3.0, field notes, vegetative cover log, photograph log, and photos.

Inspector Printed Name: Craig Goodknight

Inspector Signature:

Title: Inspection Team Lead

Date: 7/14/16

PHOTOGRAPH LOG

Mud Pit Site: Rifle Range (RR)				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
06/20/16	0805		Northwest	USFWS Monument and new sign
06/20/16	0806		Southeast	Transect RR-1NW
06/20/16	0807		Southeast	Transect RR-2NW
06/20/16	0808		Northeast	Transect RR-3SW
06/20/16	0809		Northeast	Transect RR-4SW
06/21/16	0810		Northwest	Transect RR-2SE
06/21/16	0811		Northwest	Transect RR-1SE
06/21/16	0812		Southwest	Transect RR-4NE
06/21/16	0813		Southwest	Transect RR-3NE
06/21/16	0814		East-Northeast	View across mud pit cap from high point
06/21/16	0815		North	View across mud pit cap from high point
06/21/16	0816		West	View across mud pit cap from high point just NE of E Pond
06/21/16	0817		Southeast	View across mud pit cap from high point N of RR-1NW and just N of N Pond
06/21/16	0818		West	Crack oriented E-W
06/21/16	0819		West-Northwest	Arcuate crack about 20 ft long

*GPS location datum AK State Plane NAD 1983



IMG_0805 – View NW of USFWS Monument and new sign, Rifle Range



IMG_0806 – View SE at Transect RR-1NW, Rifle Range



IMG_0807 – View SE at Transect RR-2NW, Rifle Range



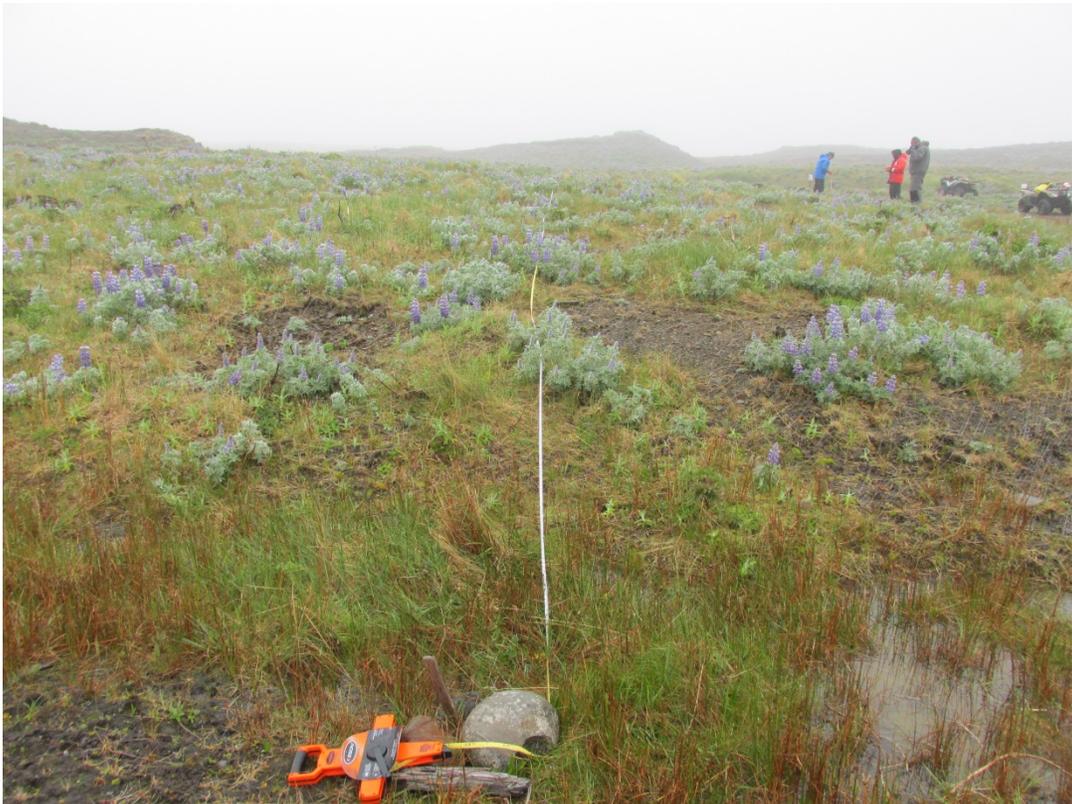
IMG_0808 – View NE at Transect RR-3SW, Rifle Range



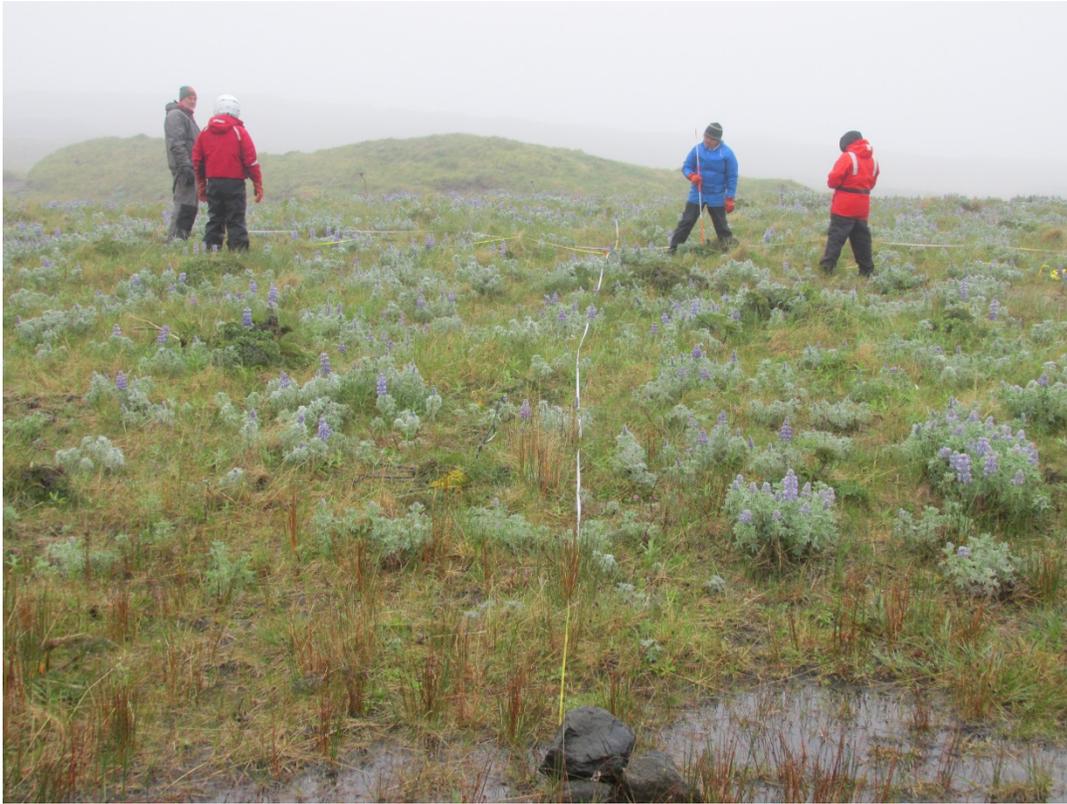
IMG_0809 – View NE at Transect RR-4SW, Rifle Range



IMG_0810 – View NW at Transect RR-2SE, Rifle Range



IMG_0811 – View NW at Transect RR-1SE, L. Sheader, D. Marshall, and P. Darr, Rifle Range



IMG_0812 – View SW at Transect RR-4NE, P. Darr, S. Pitton, L. Sheader, and D. Marshall, Rifle Range



IMG_0813 – View SW at Transect RR-3NE, Rifle Range



IMG_0814 – View ENE across mud pit cap, Rifle Range



IMG_0815 – View N across mud pit cap, Rifle Range



IMG_0816 – View W across mud pit cap, Rifle Range



IMG_0817 – View SE across mud pit cap, Rifle Range



IMG_0818 – View W showing straight slump scarp (~9 in.) near intersection of Transects RR-1 and RR-3, Rifle Range

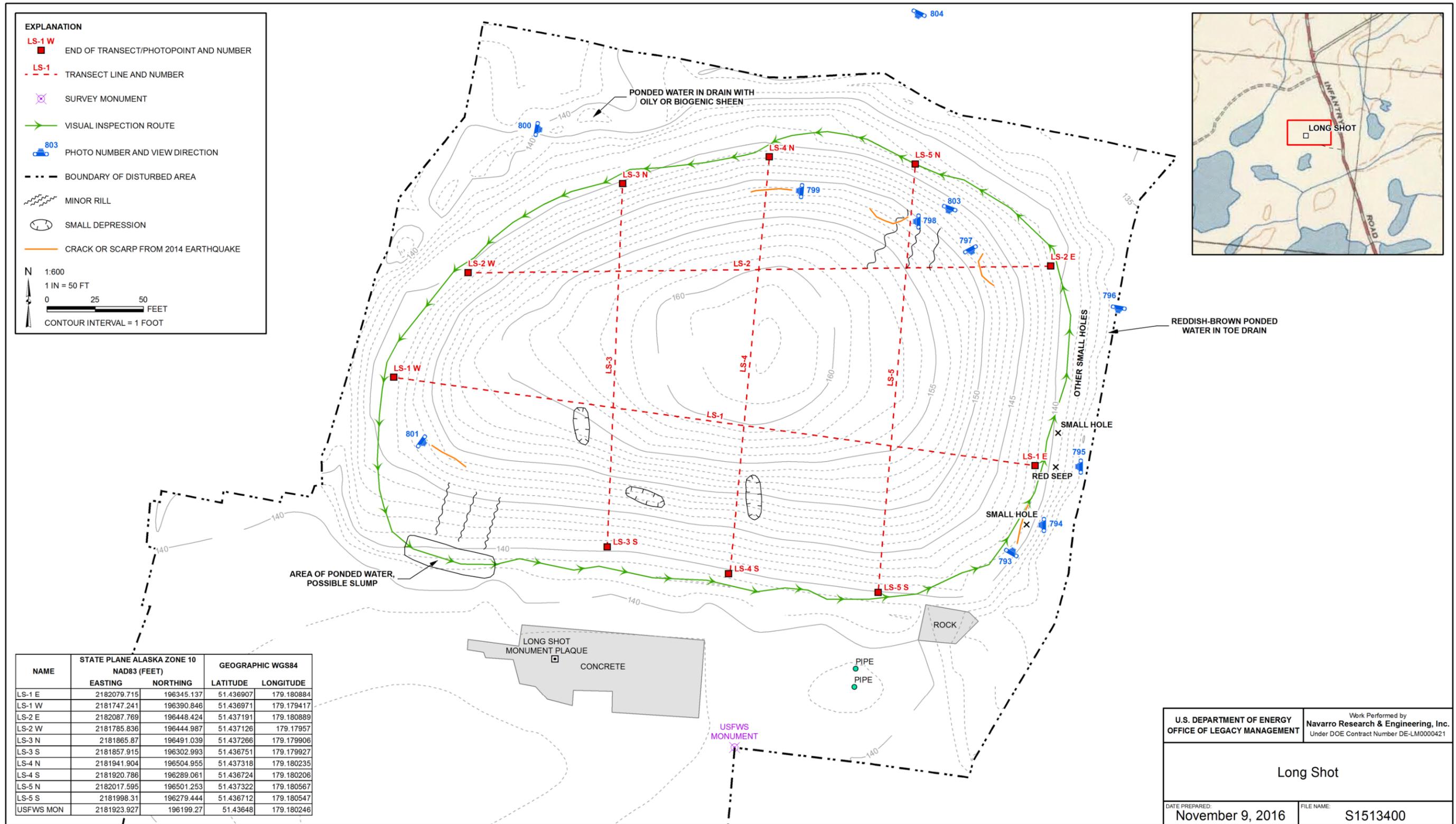


IMG_0819 – View WNW showing arcuate slump scarp (~6 in.) in the NE part of the mud pit cap, Rifle Range

Appendix A-2

Long Shot

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Figure A-2. Long Shot

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AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST

Mud Pit Site: Long Shot (LS)	Date of Inspection: June 19 and 20, 2016
Responsible Agency: U.S. Department of Energy – Legacy Management	Project Manager: Mark Kautsky
Inspector (name, title, organization): Craig Goodknight, Inspection Team Lead, Navarro	

A. General Instructions

- All checklist items must be completed and detailed comments made to document the results of the site inspection.
- The completed checklist is part of the field record of the inspection. Additional pages should be used as necessary to ensure that a complete record is made. Number and attach the additional pages upon completion of the inspection.
- Any checklist line item marked by an inspector in a SHADED BOX must be fully explained or an appropriate reference to previous reports provided. The explanation should include the inspector's rationale for conclusions and recommendations, if appropriate. Explanations are to be placed on additional attachments and cross-referenced appropriately, and may take the form of sketches, measurements, and/or annotated site maps.
- The site inspection is a walking inspection of the entire site, including the perimeter and sufficient transects to be able to inspect the entire surface and all features specifically described in this checklist. Attach a drawing indicating the starting and ending points and the direction and pattern of the inspection.
- A standard set of color 35 mm photographs (or equivalent) is required. In addition, all anomalous features or new features (such as changes in adjacent area land use) are to be photographed. A photo log entry will be made for each photograph taken.

B. Preparation (to be completed prior to site visit)	YES	NO	EXPLANATION
1. Site as-built plans and site base map reviewed	X		Mud Pit Closure Plans and As-Built
2. Previous inspection reports reviewed	X		2006 and 2011 Inspection Reports
a. Were anomalies or trends detected on previous inspections?	X		From 2014 Post-Earthquake Investigation
b. Was maintenance performed on areas with anomalies?		X	No maintenance has been done on any of the effects resulting from the earthquake
3. Site maintenance and repair records reviewed		X	No previous maintenance activities were done
a. Has site repair resulted in a change from as-built conditions?		X	No detectable changes from as-built condition
b. Are revised as-builts available that reflect repair changes?			Not Applicable. No repairs have been made

C. Site Inspection (to be completed during inspection)	YES	NO	EXPLANATION
1. Adjacent offsite features within mud pit site area			
a. Changes in use of adjacent area?		X	Wildlife refuge
b. Any new roads or trails?		X	Per previous photos and as-built drawings
c. Change in the position of nearby washes?		X	None detected
d. Erosion/deposition of nearby washes?		X	None detected
e. New drainage channels?		X	None detected
f. Change in surrounding vegetation?		X	None detected
2. Security markers; signs			
a. Displacement of site markers, boundary markers, or monuments?		X	USFWS Monument was present/Good condition. Ground Zero Monument was intact.
b. Signs damaged or removed?		X	New sign installed at USFWS Monument. Other signs are all in good condition.
3. Cap			
a. Evidence of subsidence?	X		Several small depressions in S part of mud pit cap as noted below
b. Evidence of cracking?	X		Four cracks and associated small slumps from the 2014 earthquake are in the SW, NE, and SE parts of the mud pit cap
c. Evidence of erosion (wind or water)?	X		Some rills on steep slopes in the NE and SW sides of the mud pit cap, as noted below
d. Evidence of animal burrowing?	X		Some small holes along E base of mud pit cap, as noted below
e. Are site markers disturbed? By man? _____ By natural processes? _____		X	
f. Do natural processes threaten the integrity of cap or site marker?		X	

AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST (continued)

Mud Pit Site: Long Shot (LS)

Date of Inspection: June 19 and 20, 2016

C. Site inspection (continued)

	YES	NO	EXPLANATION
4. Vegetative cover			
a. Is plant cover adequate to prevent erosion?	X		See discussion in Section 3.0
b. Are weedy annual plants present? Do they require removal?		X	See discussion in Section 3.0
c. Evidence of animals on cap?		X	See discussion in Section 3.0
d. Evidence of excessive plant mortality?		X	See discussion in Section 3.0
e. Has a vegetative cover log been completed?	X		See Vegetative Cover Log
5. Photo Documentation			
a. Has a photo log been prepared?	X		See Photograph Log
b. How many photos were taken?			23 photos as noted in the Photograph Log

D. Field Conclusions

1. Imminent hazard to integrity of cap? (If yes, immediate report required. Note the person or agency the report will be made to.)		X	
2. Are more frequent inspections required?		X	
3. Are existing maintenance actions satisfactory?			Not Applicable. No maintenance was done or required.
4. Are existing repair actions satisfactory?			Not Applicable. No repairs were done or required.
5. Is other maintenance/repair necessary?		X	
6. Rationale for field conclusions: See attached			

7. Factors contributing to or impacting inspection: None noted

E. Certification

I certify that I have conducted an inspection of the Long Shot Mud Pit Site cap in accordance with the Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, dated March 2016, as recorded on this checklist, discussion in Sections 2.0 and 3.0, field notes, vegetative cover log, photograph log, and photos.

Inspector Printed Name: Craig Goodknight

Inspector Signature:

Title: Inspection Team Lead

Date: 7/25/16

6. Rationale for field conclusions: Conclusions were based on walkover visual inspections and plant counts. Five cracks and associated minor slumps in the SW, SE, and NE parts of the mud pit cap were formed as a result of the June 2014 7.9 magnitude earthquake and several strong aftershocks. These effects were documented in August 2014 by an inspection team soon after the quake. All cracks appear to be much shorter in length than when they were noted and plotted in August 2014, owing to healing (filling in) of the cracks and scarps and to vegetation covering the scarps. A straight scarp striking ESE in the SW part of the mud pit cap is about 20 ft long (photo 0801) and has a displacement of as much as 1 ft. A roughly straight crack striking NNE, with some minor parallel cracks, in the SE part of the mud pit cap is about 20 ft long (photo 0793), and is as much as 6 in. wide and 9 in. deep. An arcuate scarp with associated slump displacement of about 1 ft is about 20 ft long (photo 0797) in the NE corner of the mud pit cap. Two other scarps in the NE part of the mud pit cap include an arcuate scarp about 20 ft long with displacement of about 9 in. (photo 0798) and a straight scarp about 15 ft long with displacement of about 9 in. (photo 0799). These cracks and slumps should be monitored during future inspections to see if they continue to fill in or become channels for erosion. Rills noted in the 2011 inspection in the NE and SW parts of the mud pit cap have significantly filled in and have largely been covered by vegetation (photo 0803). Several small holes (possibly rodent burrows) are along the E base of the mud pit cap (photo 0794); the holes are fewer and less obvious than they were during the 2011 inspection. Several small depressions on the S slope of the mud pit cap are less obvious than they were during the 2011 inspection owing to increased vegetation coverage. Pondered water in drains just outside the mud pit cap to the E, NW, and SW could cause subsidence – trenching may be necessary to drain this water away from the mud pit cap. In places, the water is reddish brown (photo 0796) and has an oily or biogenic sheen (photo 0800). Vegetation coverage of the mud pit cap is much more extensive than seen in the 2011 inspection. Lupine is especially common on the E slope of the mud pit cap.

PHOTOGRAPH LOG

Mud Pit Site: Long Shot (LS)				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
06/19/16	0781		Northwest	USFWS Monument and new sign
06/19/16	0782		North	LS mud pit cap from USFWS Monument
06/19/16	0783		West	Transect LS-1E
06/19/16	0784		West	Transect LS-2E
06/19/16	0785		South	Transect LS-5N
06/19/16	0786		South	Transect LS-4N
06/19/16	0787		South	Transect LS-3N
06/19/16	0788		East	Transect LS-2W
06/19/16	0789		East	Transect LS-1W
06/19/16	0790		North	Transect LS-3S
06/19/16	0791		North	Transect LS-4S
06/19/16	0792		North	Transect LS-5S
06/19/16	0793		North-Northeast	Small cracks in SE part of mud pit cap
06/19/16	0794		West	Small hole along E base of mud pit cap
06/20/16	0795		West	Small reddish-brown seep just E of mud pit cap
06/20/16	0796		South	Drain along E base of cap showing reddish-brown water
06/20/16	0797		South-Southeast	Arcuate slump scarp in NE corner of mud pit cap
06/20/16	0798		West	Arcuate slump scarp along N side slope of mud pit cap
06/20/16	0799		West	Straight slump scarp along N side slope of mud pit cap
06/20/16	0800		East	Water with oily or biogenic sheen in drain along N side of mud pit cap
06/20/16	0801		East-Southeast	Straight slump scarp in SW corner of mud pit cap
06/20/16	0803		Southwest	Rills on steep slope on NE corner of mud pit cap
06/20/16	0804		South-Southwest	View of N side slope of mud pit cap

*GPS location datum AK State Plane NAD 1983



IMG_0781 – View NW of USFWS Monument and new sign, S. Pitton, P. Darr, L. Sheader, Long Shot



IMG_0782 – View N of Long Shot Mud Pit Cap from USFWS Monument, L. Sheader, and D. Marshall



IMG_0783 – View W at Transect LS-1E, Long Shot



IMG_0784 – View W at Transect LS-2E, Long Shot



IMG_0785 – View S at Transect LS-5N, Long Shot



IMG_0786 – View S at Transect LS-4N, Long Shot



IMG_0787 – View S at Transect LS-3N, P. Darr and L. Sheader, Long Shot



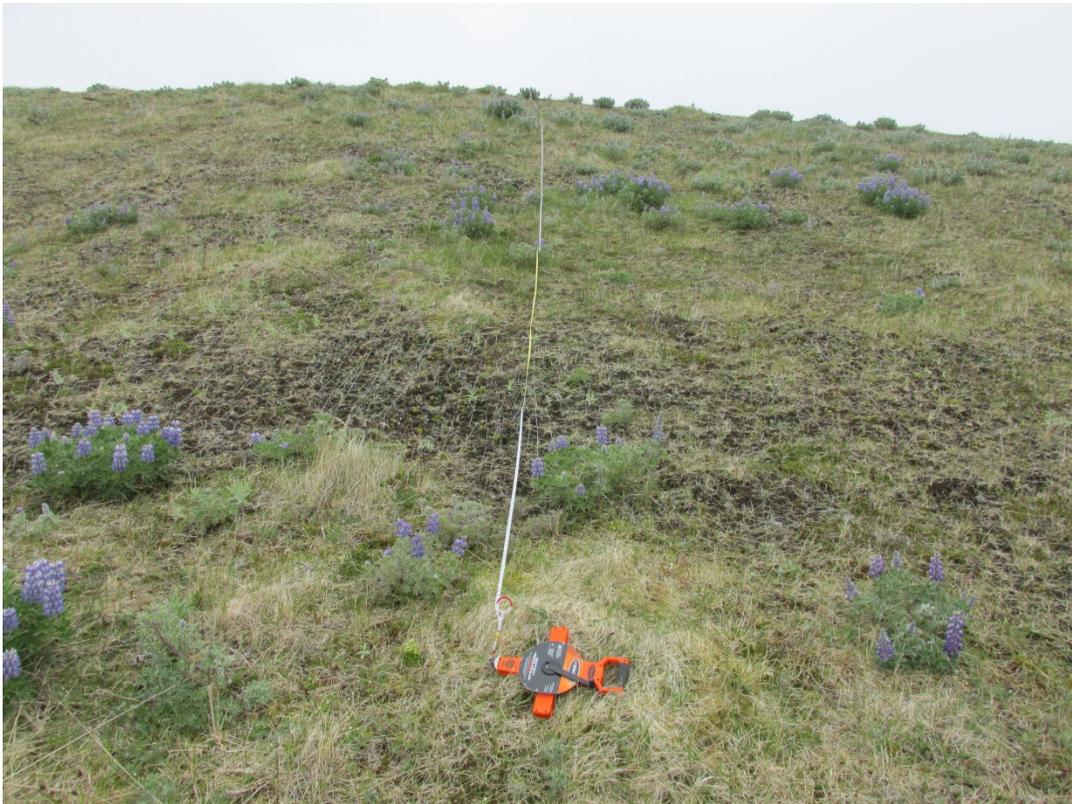
IMG_0788 – View E at Transect LS-2W, L. Sheader and D. Marshall, Long Shot



IMG_0789 – View E at Transect LS-1W, Long Shot



IMG_0790 – View N at Transect LS-3S, Long Shot



IMG_0791 – View N at Transect LS-4S, Long Shot



IMG_0792 – View N at Transect LS-5S, Long Shot



IMG_0793 – View NNE of slump scarp near SE base of mud pit cap, Long Shot



IMG_0794 – View W of small hole near E base of mud pit cap, Long Shot



IMG_0795 – View W of small reddish-brown seep just E of mud pit cap, Long Shot



IMG_0796 – View S showing drain just E of the mud pit cap that contains reddish-brown water, Long Shot



IMG_0797 – View SSE showing arcuate slump scarp (~1 ft) in NE corner of mud pit cap, Long Shot



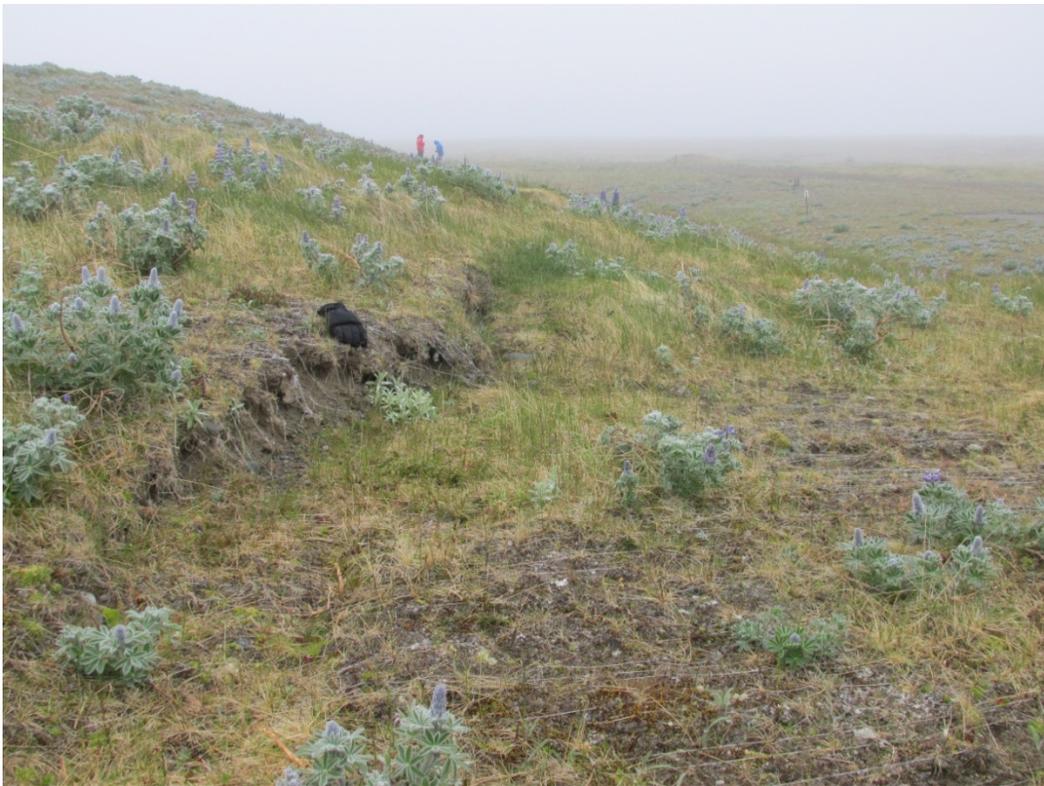
IMG_0798 – View W showing arcuate slump scarp (~9 in.) along N side slope of mud pit cap, Long Shot



IMG_0799 – View W showing straight slump scarp (~9 in.) along N side slope of mud pit cap, Long Shot



IMG_0800 – View E showing drain just N of the mud pit cap that contains reddish-brown water, Long Shot



IMG_0801 – View ESE showing straight slump scarp (~1 ft) in SW corner of mud pit cap, Long Shot



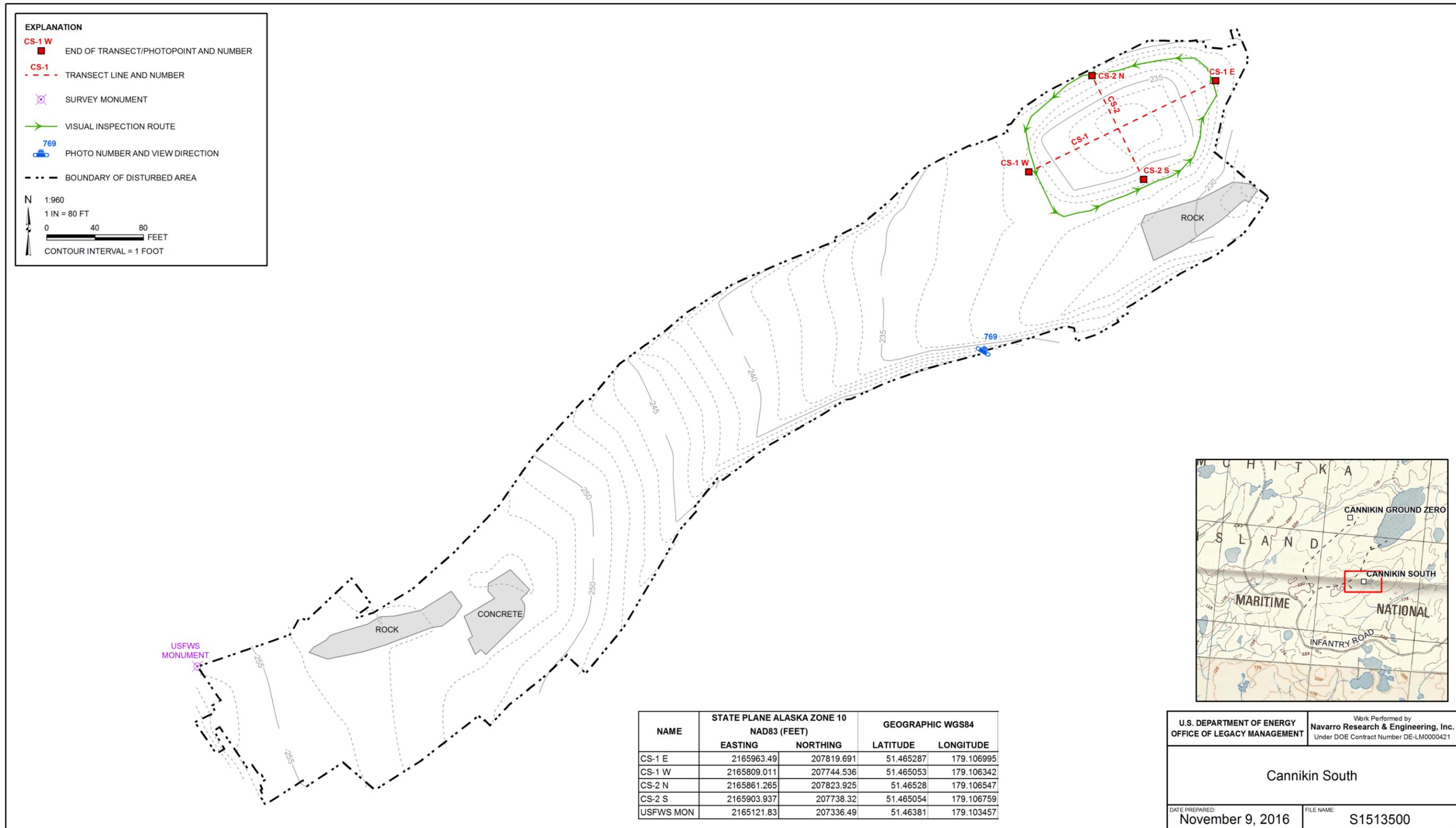
IMG_0803 – View SW of rills on steep slope in NE corner of mud pit cap, Long Shot



IMG_0804 – View SSW of N side slope of mud pit cap, Long Shot

Appendix A-3
Cannikin South

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Figure A-3. Cannikin South

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AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST

Mud Pit Site: Cannikin South (CS)	Date of Inspection: June 19, 2016
Responsible Agency: U.S. Department of Energy – Legacy Management	Project Manager: Mark Kautsky
Inspector (name, title, organization): Craig Goodknight, Inspection Team Lead, Navarro.	

- A. General Instructions**
1. All checklist items must be completed and detailed comments made to document the results of the site inspection.
 2. The completed checklist is part of the field record of the inspection. Additional pages should be used as necessary to ensure that a complete record is made. Number and attach the additional pages upon completion of the inspection.
 3. Any checklist line item marked by an inspector in a SHADED BOX must be fully explained or an appropriate reference to previous reports provided. The explanation should include the inspector’s rationale for conclusions and recommendations, if appropriate. Explanations are to be placed on additional attachments and cross-referenced appropriately, and may take the form of sketches, measurements, and/or annotated site maps.
 4. The site inspection is a walking inspection of the entire site, including the perimeter and sufficient transects to be able to inspect the entire surface and all features specifically described in this checklist. Attach a drawing indicating the starting and ending points and the direction and pattern of the inspection.
 5. A standard set of color 35 mm photographs (or equivalent) is required. In addition, all anomalous features or new features (such as changes in adjacent area land use) are to be photographed. A photo log entry will be made for each photograph taken.

B. Preparation (to be completed prior to site visit)	YES	NO	EXPLANATION
1. Site as-built plans and site base map reviewed	X		Mud Pit Closure Plans and As-Built
2. Previous inspection reports reviewed	X		2006 and 2011 Inspection Report
a. Were anomalies or trends detected on previous inspections?		X	
b. Was maintenance performed on areas with anomalies?			Not Applicable
3. Site maintenance and repair records reviewed		X	No previous maintenance activities were done
a. Has site repair resulted in a change from as-built conditions?		X	No detectable changes from as-built condition
b. Are revised as-builts available that reflect repair changes?			Not Applicable. No repairs have been made

C. Site Inspection (to be completed during inspection)	YES	NO	EXPLANATION
1. Adjacent offsite features within mud pit site area			
a. Changes in use of adjacent area?		X	Wildlife refuge
b. Any new roads or trails?		X	Per previous photos and as-built drawings
c. Change in the position of nearby washes?		X	None detected
d. Erosion/deposition of nearby washes?		X	None detected
e. New drainage channels?		X	None detected
f. Change in surrounding vegetation?		X	None detected
2. Security markers; signs			
a. Displacement of site markers, boundary markers, or monuments?		X	USFWS Monument was present/Good condition
b. Signs damaged or removed?		X	New sign installed at USFWS Monument. Other signs are in good condition.
3. Cap			
a. Evidence of subsidence?		X	
b. Evidence of cracking?		X	
c. Evidence of erosion (wind or water)?		X	
d. Evidence of animal burrowing?		X	
e. Are site markers disturbed? By man? _____ By natural processes? _____		X	
f. Do natural processes threaten the integrity of cap or site marker?		X	

AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST (continued)

Mud Pit Site: Cannikin South (CS)

Date of Inspection: June 19, 2016

C. Site inspection (continued)

	YES	NO	EXPLANATION
4. Vegetative cover			
a. Is plant cover adequate to prevent erosion?	X		See discussion in Section 3.0
b. Are weedy annual plants present? Do they require removal?		X	See discussion in Section 3.0
c. Evidence of animals on cap?		X	See discussion in Section 3.0
d. Evidence of excessive plant mortality?		X	See discussion in Section 3.0
e. Has a vegetative cover log been completed?	X		See Vegetative Cover Log
5. Photo Documentation			
a. Has a photo log been prepared?	X		See Photograph Log
b. How many photos were taken?			7 photos as noted in the Photograph Log

D. Field Conclusions

1. Imminent hazard to integrity of cap? (If yes, immediate report required. Note the person or agency the report will be made to.)		X	
2. Are more frequent inspections required?		X	
3. Are existing maintenance actions satisfactory?			Not Applicable. No maintenance was done or required.
4. Are existing repair actions satisfactory?			Not Applicable. No repairs were done or required.
5. Is other maintenance/repair necessary?		X	
6. Rationale for field conclusions: Conclusions were based on walkover visual inspections and plant counts. Vegetation coverage of the mud pit cap is slightly more than seen in the 2011 inspection.			

7. Factors contributing to or impacting inspection: None noted

E. Certification

I certify that I have conducted an inspection of the Cannikin South Mud Pit Site cap in accordance with the Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, dated March 2016, as recorded on this checklist, discussion in Sections 2.0 and 3.0, field notes, vegetative cover log, photograph log, and photos.

Inspector Printed Name: Craig Goodknight

Inspector Signature:



Title: Inspection Team Lead

Date: 7/14/16

PHOTOGRAPH LOG

Mud Pit Site: Cannikin South (CS)				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
06/19/16	0764		Northeast	USFWS Monument
06/19/16	0765		East-Northeast	Transect CS-1W
06/19/16	0766		North-Northwest	Transect CS-2S
06/19/16	0767		West-Southwest	Transect CS-1E
06/19/16	0768		South-Southeast	Transect CS-2N
06/19/16	0769		Northeast	View of graded area and CS mud pit cap
06/19/16	0770		Southwest	USFWS Monument and new sign

*GPS location datum AK State Plane NAD 1983



IMG_0764 – View NE of USFWS Monument, Cannikin South



IMG_0765 – View ENE at Transect CS-1W, P. Darr, Cannikin South



IMG_0766 – View NNW at Transect CS-2S, P. Darr, Cannikin South



IMG_0767 – View WSW at Transect CS-1E, P. Darr, Cannikin South



IMG_0768 – View SSE at Transect CS-2N, P. Darr, Cannikin South



IMG_0769 – View NE across graded area to Cannikin South Mud Pit Cap



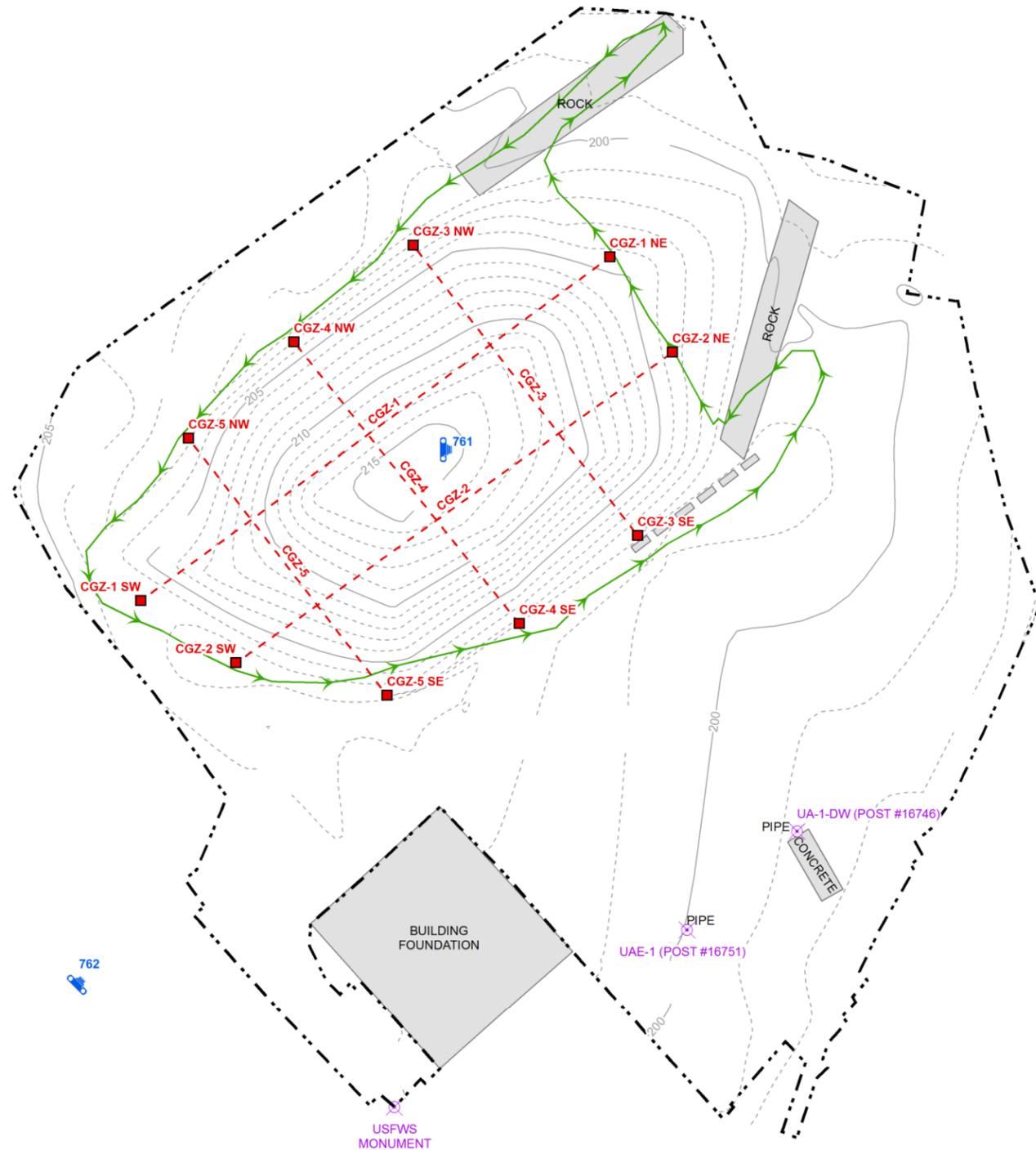
IMG_0770 – View SW of USFWS Monument and new sign, Cannikin South

Appendix A-4

Cannikin Ground Zero

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NAME	STATE PLANE ALASKA ZONE 10 NAD83 (FEET)		GEOGRAPHIC WGS84	
	EASTING	NORTHING	LATITUDE	LONGITUDE
CGZ-1 NE	2165165.52	209754.119	51.470425	179.102926
CGZ-1 SW	2164976.807	209616.163	51.470013	179.102142
CGZ-2 NE	2165190.736	209715.897	51.470325	179.103048
CGZ-2 SW	2165015.05	209591.164	51.469952	179.102317
CGZ-3 NW	2165086.393	209758.862	51.470423	179.102579
CGZ-3 SE	2165176.654	209642.306	51.470122	179.103009
CGZ-4 NW	2165038.425	209720.057	51.470308	179.10238
CGZ-4 SE	2165129.041	209606.936	51.470016	179.102811
CGZ-5 NW	2164995.994	209681.364	51.470195	179.102206
CGZ-5 SE	2165075.863	209578.134	51.469927	179.102587
USFWS MON	2165078.89	209413.208	51.469478	179.10265



GROUND ZERO
MONUMENT PLAQUE
763

UA-1-GH-1 (POST #16713)

UA-1-DW (POST #16746)

UA-1 (POST #16751)

USFWS
MONUMENT

EXPLANATION

- CGZ-1 SW END OF TRANSECT/PHOTOPOINT AND NUMBER
- - - CGZ-1 TRANSECT LINE AND NUMBER
- ⊗ SURVEY MONUMENT
- VISUAL INSPECTION ROUTE
- 📷 762 PHOTO NUMBER AND VIEW DIRECTION
- BOUNDARY OF DISTURBED AREA

N 1:720
1 IN = 60 FT
0 30 60 FEET
CONTOUR INTERVAL = 1 FOOT

U.S. DEPARTMENT OF ENERGY OFFICE OF LEGACY MANAGEMENT	Work Performed by Navarro Research & Engineering, Inc. Under DOE Contract Number DE-LM0000421
Cannikin Ground Zero	
DATE PREPARED: November 9, 2016	FILE NAME: S1513600

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Figure A-4. Cannikin Ground Zero

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AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST

Mud Pit Site: Cannikin Ground Zero (CGZ)	Date of Inspection: June 19, 2016
Responsible Agency: U.S. Department of Energy – Legacy Management	Project Manager: Mark Kautsky
Inspector (name, title, organization): Craig Goodknight, Inspection Team Lead, Navarro	

- A. General Instructions**
- All checklist items must be completed and detailed comments made to document the results of the site inspection.
 - The completed checklist is part of the field record of the inspection. Additional pages should be used as necessary to ensure that a complete record is made. Number and attach the additional pages upon completion of the inspection.
 - Any checklist line item marked by an inspector in a SHADED BOX must be fully explained or an appropriate reference to previous reports provided. The explanation should include the inspector's rationale for conclusions and recommendations, if appropriate. Explanations are to be placed on additional attachments and cross-referenced appropriately, and may take the form of sketches, measurements, and/or annotated site maps.
 - The site inspection is a walking inspection of the entire site, including the perimeter and sufficient transects to be able to inspect the entire surface and all features specifically described in this checklist. Attach a drawing indicating the starting and ending points and the direction and pattern of the inspection.
 - A standard set of color 35 mm photographs (or equivalent) is required. In addition, all anomalous features or new features (such as changes in adjacent area land use) are to be photographed. A photo log entry will be made for each photograph taken.

B. Preparation (to be completed prior to site visit)	YES	NO	EXPLANATION
1. Site as-built plans and site base map reviewed	X		Mud Pit Closure Plans and As-Built
2. Previous inspection reports reviewed	X		2006 and 2011 Inspection Reports
a. Were anomalies or trends detected on previous inspections?		X	
b. Was maintenance performed on areas with anomalies?			Not Applicable
3. Site maintenance and repair records reviewed		X	No previous maintenance activities were done
a. Has site repair resulted in a change from as-built conditions?		X	No detectable changes from as-built condition
b. Are revised as-builts available that reflect repair changes?			Not Applicable. No repairs have been made

C. Site Inspection (to be completed during inspection)	YES	NO	EXPLANATION
1. Adjacent offsite features within mud pit site area			
a. Changes in use of adjacent area?		X	Wildlife refuge
b. Any new roads or trails?		X	Per previous photos and as-built drawings
c. Change in the position of nearby washes?		X	None detected
d. Erosion/deposition of nearby washes?		X	None detected
e. New drainage channels?		X	None detected
f. Change in surrounding vegetation?		X	None detected
2. Security markers; signs			
a. Displacement of site markers, boundary markers, or monuments?		X	USFWS Monument was present/Good condition. Ground Zero Monument was intact.
b. Signs damaged or removed?		X	New sign installed at USFWS Monument. Other signs are in good condition.
3. Cap			
a. Evidence of subsidence?			
b. Evidence of cracking?		X	
c. Evidence of erosion (wind or water)?		X	
d. Evidence of animal burrowing?		X	
e. Are site markers disturbed? By man? _____ By natural processes? _____		X	
f. Do natural processes threaten the integrity of cap or site marker?		X	

AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST (continued)

Mud Pit Site: Cannikin Ground Zero (CGZ)

Date of Inspection: June 19, 2016

C. Site inspection (continued)

	YES	NO	EXPLANATION
4. Vegetative cover			
a. Is plant cover adequate to prevent erosion?	X		See discussion in Section 3.0
b. Are weedy annual plants present? Do they require removal?		X	See discussion in Section 3.0
c. Evidence of animals on cap?		X	See discussion in Section 3.0
d. Evidence of excessive plant mortality?		X	See discussion in Section 3.0
e. Has a vegetative cover log been completed?	X		See Vegetative Cover Log
5. Photo Documentation			
a. Has a photo log been prepared?	X		See Photograph Log
b. How many photos were taken?			16 photos as noted in the Photograph Log

D. Field Conclusions

1. Imminent hazard to integrity of cap? (If yes, immediate report required. Note the person or agency the report will be made to.)		X	
2. Are more frequent inspections required?		X	
3. Are existing maintenance actions satisfactory?			Not Applicable. No maintenance was done or required.
4. Are existing repair actions satisfactory?			Not Applicable. No repairs were done or required.
5. Is other maintenance/repair necessary?		X	
6. Rationale for field conclusions: Conclusions were based on walkover visual inspections and plant counts. Vegetation coverage of the mud pit cap is slightly more than seen in the 2011 inspection.			

7. Factors contributing to or impacting inspection: None noted

E. Certification

I certify that I have conducted an inspection of the Cannikin Ground Zero Mud Pit Site cap in accordance with the Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, dated March 2016, as recorded on this checklist, discussion in Sections 2.0 and 3.0, field notes, vegetative cover log, photograph log, and photos.

Inspector Printed Name: Craig Goodknight

Inspector Signature:



Title: Inspection Team Lead

Date: 7/14/16

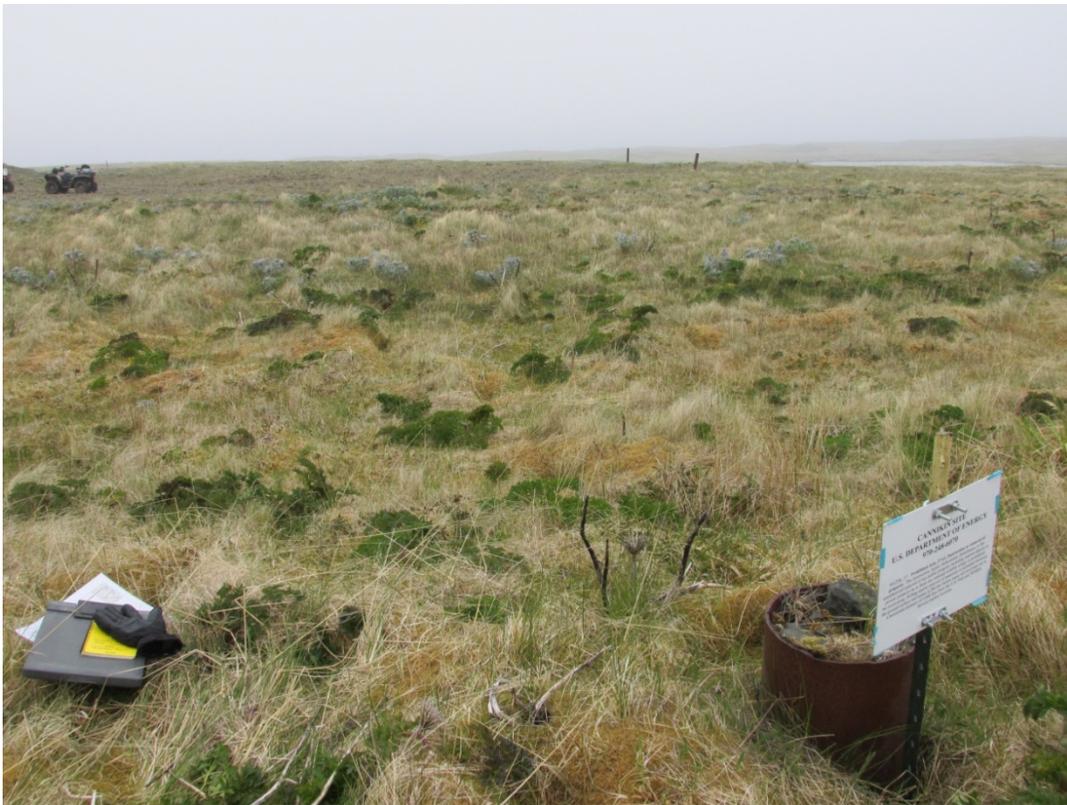
PHOTOGRAPH LOG

Mud Pit Site: Cannikin Ground Zero (CGZ)				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
06/19/16	0748		West	USFWS Monument and new sign
06/19/16	0749		Northeast	Two pipes NE of USFWS Monument
06/19/16	0750		North	CGZ mud pit cap from USFWS Monument
06/19/16	0751		Southwest	Transect CGZ-1NE
06/19/16	0752		Southeast	Transect CGZ-3NW
06/19/16	0753		Southeast	Transect CGZ-4NW
06/19/16	0754		Southeast	Transect CGZ-5NW
06/19/16	0755		Northeast	Transect CGZ-1SW
06/19/16	0756		Northeast	Transect CGZ-2SW
06/19/16	0757		Northwest	Transect CGZ-5SE
06/19/16	0758		Northwest	Transect CGZ-4SE
06/19/16	0759		Northwest	Transect CGZ-3SE
06/19/16	0760		Southwest	Transect CGZ-2NE
06/19/16	0761		East-Northeast	Top of CGZ mud pit cap and Cannikin Lake
06/19/16	0762		Northeast	CGZ mud pit cap and 2 signs along SE margin
06/19/16	0763		Northeast	CGZ Monument Plaque and Cannikin Lake

*GPS location datum AK State Plane NAD 1983



IMG_748 – View W of USFWS Monument and new sign, Cannikin Ground Zero



IMG_749 – View NE of two pipes from USFWS Monument, Cannikin Ground Zero



IMG_750 – View N of Cannikin Ground Zero Mud Pit Cap from USFWS Monument and new sign



IMG_751 – View SW at Transect CGZ-1NE, Cannikin Ground Zero



IMG_752 – View SE at Transect CGZ-3NW, Cannikin Ground Zero



IMG_753 – View SE at Transect CGZ-4NW, Cannikin Ground Zero



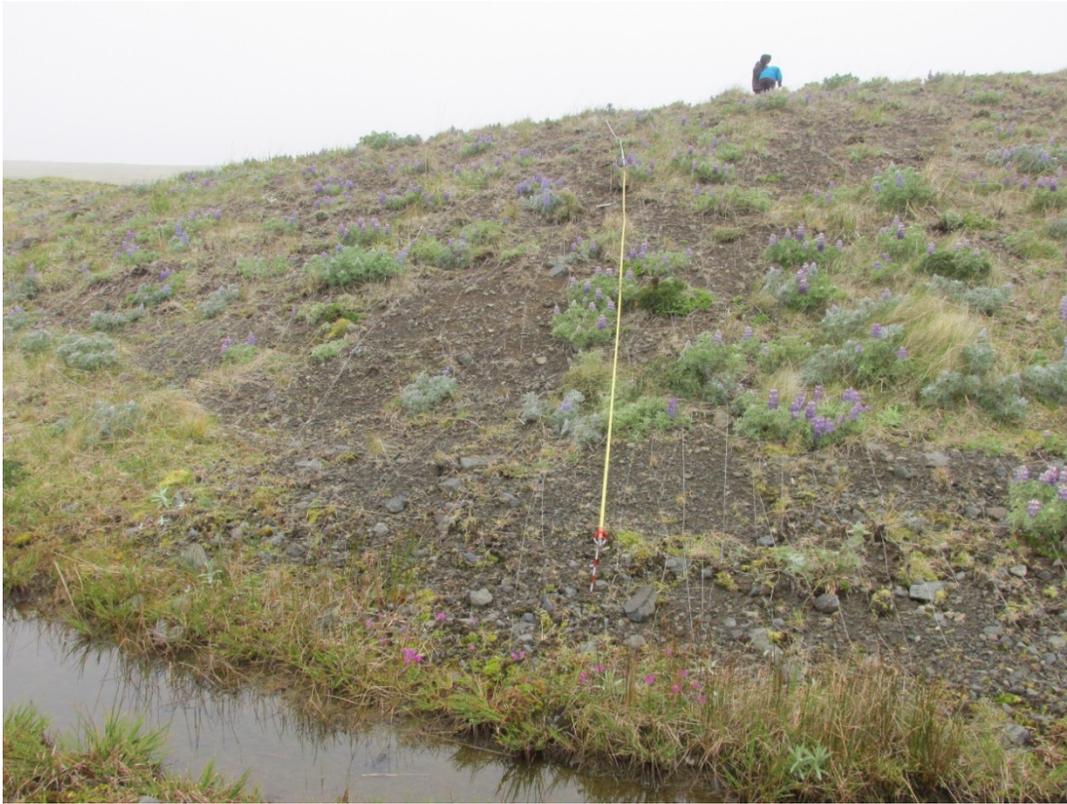
IMG_754 – View SE at Transect CGZ-5NW, D. Marshall and L. Sheader, Cannikin Ground Zero



IMG_755 – View NE at Transect CGZ-1SW, D. Marshall and L. Sheader, Cannikin Ground Zero



IMG_756 – View NE at Transect CGZ-2SW, L. Sheader, Cannikin Ground Zero



IMG_757 – View NW at Transect CGZ-5SE, Cannikin Ground Zero



IMG_758 – View NW at Transect CGZ-4SE, Cannikin Ground Zero



IMG_759 – View NW at Transect CGZ-3SE, Cannikin Ground Zero



IMG_760 – View SW at Transect CGZ-2NE, Cannikin Ground Zero



IMG_761 – View ENE from top of Cannikin Ground Zero Mud Pit Cap toward Cannikin Lake



IMG_762 – View NE of Cannikin Ground Zero Mud Pit Cap and Cannikin Lake in BG



IMG_763 – View NE of Cannikin Ground Zero Monument Plaque and Cannikin Lake in BG

Appendix A-5

Drill Site D

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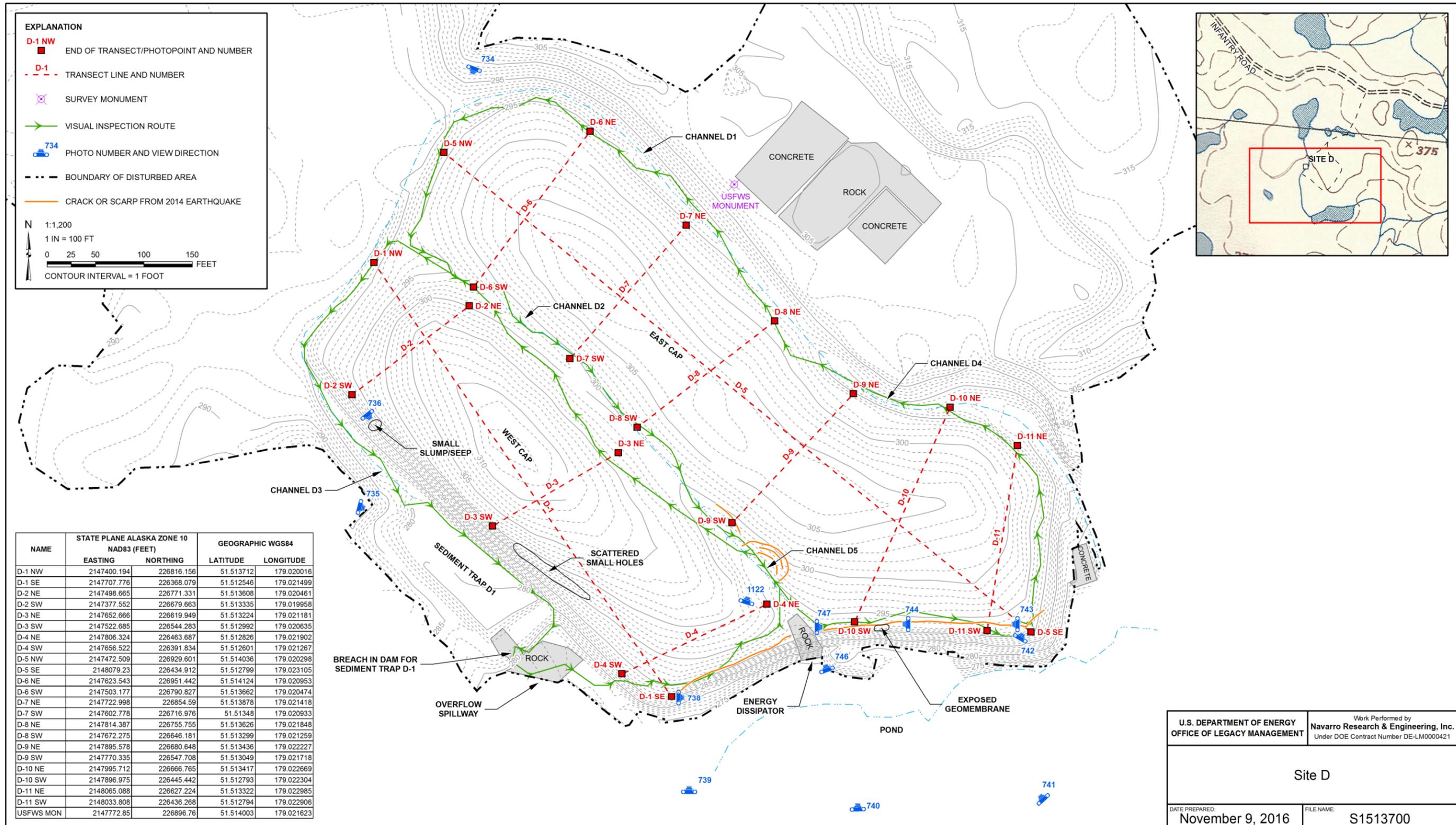


Figure A-5. Drill Site D

U.S. DEPARTMENT OF ENERGY OFFICE OF LEGACY MANAGEMENT	Work Performed by Navarro Research & Engineering, Inc. Under DOE Contract Number DE-LM0000421
Site D	
DATE PREPARED: November 9, 2016	FILE NAME: S1513700

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AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST

Mud Pit Site: Drill Site D

Date of Inspection: June 18, 2016

Responsible Agency: U.S. Department of Energy –
Legacy Management

Project Manager: Mark Kautsky

Inspector (name, title, organization): Craig Goodknight, Inspection Team Lead, Navarro

A. General Instructions

1. All checklist items must be completed and detailed comments made to document the results of the site inspection.
2. The completed checklist is part of the field record of the inspection. Additional pages should be used as necessary to ensure that a complete record is made. Number and attach the additional pages upon completion of the inspection.
3. Any checklist line item marked by an inspector in a SHADED BOX must be fully explained or an appropriate reference to previous reports provided. The explanation should include the inspector’s rationale for conclusions and recommendations, if appropriate. Explanations are to be placed on additional attachments and cross-referenced appropriately, and may take the form of sketches, measurements, and/or annotated site maps.
4. The site inspection is a walking inspection of the entire site, including the perimeter and sufficient transects to be able to inspect the entire surface and all features specifically described in this checklist. Attach a drawing indicating the starting and ending points and the direction and pattern of the inspection.
5. A standard set of color 35 mm photographs (or equivalent) is required. In addition, all anomalous features or new features (such as changes in adjacent area land use) are to be photographed. A photo log entry will be made for each photograph taken.

B. Preparation (to be completed prior to site visit)	YES	NO	EXPLANATION
1. Site as-built plans and site base map reviewed	X		Mud Pit Closure Plans and As-Built
2. Previous inspection reports reviewed	X		2006 and 2011 Inspection Reports
a. Were anomalies or trends detected on previous inspections?	X		From 2014 Post-Earthquake Investigation
b. Was maintenance performed on areas with anomalies?		X	No maintenance has been done on any of the effects resulting from the earthquake
3. Site maintenance and repair records reviewed		X	No previous maintenance activities were done
a. Has site repair resulted in a change from as-built conditions?		X	No detectable changes from as-built condition
b. Are revised as-builts available that reflect repair changes?			Not Applicable. No repairs have been made

C. Site Inspection (to be completed during inspection)	YES	NO	EXPLANATION
1. Adjacent offsite features within mud pit site area			
a. Changes in use of adjacent area?		X	Wildlife refuge
b. Any new roads or trails?		X	Per previous photos and as-built drawings
c. Change in the position of nearby washes?		X	None detected
d. Erosion/deposition of nearby washes?		X	None detected
e. New drainage channels?	X		Breach in dam for Sediment Trap D-1 just W of Overflow Spillway, as noted below
f. Change in surrounding vegetation?		X	None detected
2. Security markers; signs			
a. Displacement of site markers, boundary markers, or monuments?		X	USFWS Monument was present/Good condition
b. Signs damaged or removed?		X	New sign installed at USFWS Monument. Other signs are all in good condition
3. Cap			
a. Evidence of subsidence?		X	
b. Evidence of cracking?	X		A long, semi-continuous crack and associated scarps and slumps are along the S sides of E and W mud pit caps. Several other cracks and small slumps also occur, mostly on the E mud pit cap. All are effects of the 2014 earthquake.
c. Evidence of erosion (wind or water)?		X	Minor water erosion noted in 2006 has not recurred.

AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST (continued)

Mud Pit Site: Drill Site D

Date of Inspection: June 18, 2016

C (continued). Site Inspection (to be completed during inspection)

	YES	NO	EXPLANATION
d. Evidence of animal burrowing?	X		Several small holes are along SW side of W mud pit cap, as noted below
e. Are site markers disturbed? By man? _____ By natural processes? _____		X	
f. Do natural processes threaten the integrity of cap or site marker?	X		Another large earthquake could cause additional slumping along the S sides of the mud pit caps that could breach the geomembrane.
4. Vegetative cover			
a. Is plant cover adequate to prevent erosion?	X		See discussion in Section 3.0
b. Are weedy annual plants present? Do they require removal?		X	See discussion in Section 3.0
c. Evidence of animals on cap?		X	See discussion in Section 3.0
d. Evidence of excessive plant mortality?		X	See discussion in Section 3.0
e. Has a vegetative cover log been completed?	X		See Vegetative Cover Log
5. Photo Documentation			
a. Has a photo log been prepared?	X		See Photograph Log
b. How many photos were taken?			36 photos as noted in the Photograph Log

D. Field Conclusions

1. Imminent hazard to integrity of cap? (If yes, immediate report required. Note the person or agency the report will be made to.)		X	
2. Are more frequent inspections required?		X	
3. Are existing maintenance actions satisfactory?			Not Applicable. No maintenance was done or required.
4. Are existing repair actions satisfactory?			Not Applicable. No repairs were done or required.
5. Is other maintenance/repair necessary?		X	
6. Rationale for field conclusions: See attached			
7. Factors contributing to or impacting inspection: None noted			

E. Certification

I certify that I have conducted an inspection of the Drill Site D Mud Pit Site cap in accordance with the Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, dated March 2016, as recorded on this checklist, discussion in Sections 2.0 and 3.0, field notes, vegetative cover log, photograph log, and photos.

Inspector Printed Name: Craig Goodknight

Inspector Signature:

Craig Goodknight

Title: Inspection Team Lead

Date: 7/28/16

6. Rationale for field conclusions: Conclusions were based on walkover visual inspections and plant counts. A long, semi-continuous crack and associated major and minor slumps extend along the south sides of the E and W mud pit caps (photo 0738). Along the scarp of the largest slump in the W part of the E mud pit cap, black geomembrane is exposed laterally for about 10 ft (photos 0740 and 0744). Several other cracks and associated slumps occur mostly on the E mud pit cap. These cracks and slumps formed as a result of the June 2014 7.9-magnitude earthquake and several strong aftershocks. These effects were documented in August 2014 by an inspection team soon after the quake.

Most cracks appear to be shorter in length than when they were noted and plotted in August 2014 (some are no longer noticeable), owing to healing (filling in) of the cracks and scarps and to vegetation covering the scarps. The scarp along the S side of the W mud pit cap (photo 0739) has a displacement of about 1 ft. This is similar to the E part of the scarp along the S side of the E mud pit cap where displacement is 1 to 2 ft (photo 0743). Displacement is greatest on the scarp along the S end of the E mud pit cap for a distance of about 100 ft immediately E of the Energy Dissipater where a slump has pushed S into the pond (photos 0747, 0740, and 0741). It is likely that slumping such as this will occur on the remainder of the scarp along the rest of the S side of the E mud pit cap and along the S side of the W mud pit cap.

Another significant slump is in the SW part of the E mud pit cap where the slump with multiple scarps has partially blocked the S drainage of water in Channel D5 (photo 1122). Examples of smaller slumps on the E mud pit cap are at its SE end where a scarp is about 15 ft long and displacement is 1 to 2 ft (photo 0742) and at its SW part where a scarp has less than 1 ft displacement (photo 0715). A small slump/seep where exposed water has an oily or biogenic sheen is near the top of the SW side slope of the W mud pit cap. This feature, which is not related to a linear crack, probably is not a result of the earthquake and the slump may increase in size if the seepage persists.

Despite the breach in the dam for Sediment Trap D-1, southwest of the W mud pit cap, and the concern that this could promote erosion by runoff water, no additional runoff erosion was apparent (photo 0735) since the 2011 inspection. No signs of additional erosion were seen on the steep, rocky, unvegetated slope along the SW edge of the W mud pit cap. The area where there were scattered small holes (possibly rodent burrows) noticed during the 2011 inspection along the SW edge of the W mud pit cap was about the same; no additional holes were noted.

In most places, vegetation coverage of the mud pit caps is much more extensive than seen in the 2011 inspection. Particularly noticeable is the vegetation that has nearly completely covered the rock for the Energy Dissipater which spills drainage from Channel D5 (photo 0746).

PHOTOGRAPH LOG

Mud Pit Site: Drill Site D				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
06/18/16	0733		Southwest	USFWS Monument and new sign.
	0711		Southeast	Transect D-5NW
	0712		Northeast	Transect D-6SW
	0713		Northeast	Transect D-7SW
	0714		Northeast	Transect D-8SW
	0715		Northeast	Transect D-9SW
	0716		North-Northeast	Transect D-10SW
	0717		North	Transect D-11SW
	0718		Northwest	Transect D-5SE
	0719		South	Transect D-11NE
	0720		South-Southwest	Transect D-10NE
	0721		Southwest	Transect D-9NE
	0722		Southwest	Transect D-8NE
	0723		Southwest	Transect D-7NE
	0724		Southwest	Transect D-6NE
	0725		Southeast	Transect D-1NW
	0726		Northeast	Transect D-2SW
	0727		Northeast	Transect D-3SW
	0728		East-Northeast	Transect D-4SW
	0729		Northwest	Transect D-1SE
	0730		West-Southwest	Transect D-4NE
	0731		Southwest	Transect D-3NE
	0732		Southwest	Transect D-2NE
	0734		Southwest	NW ends of E and W mud pit caps
	0735		Southeast	Sediment Trap D-1 and SW side slope of W mud pit cap
	0736		Southeast	Small slump/seep along SW side slope of W mud pit cap
	0738		East	Crack and slump along S end of W mud pit cap and larger slump beyond at S end of E mud pit cap
	0739		North	Crack and slump along S side of W mud pit cap
	0740		North	W part of large slump exposing geomembrane

Mud Pit Site: Drill Site D				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
				along S end of E mud pit cap
	0741		Northwest	Larger slump along S end of E mud pit cap and smaller slump (left) along S end of W mud pit cap
	0742		North	Scarp and small slump at SE end of E mud pit cap
	0743		West	E part of large slump along S end of E mud pit cap
	0744		West	Black geomembrane exposed along slump scarp along S end of E mud pit cap
	0746		Northwest	Vegetation-covered Energy Dissipater which spills drainage from Channel D5
	0747		East	W part of large slump along S end of E mud pit cap
	1122		North-Northeast	Slump in SW part of E mud pit cap and ponded water in Channel D5

*GPS location datum AK State Plane NAD 1983



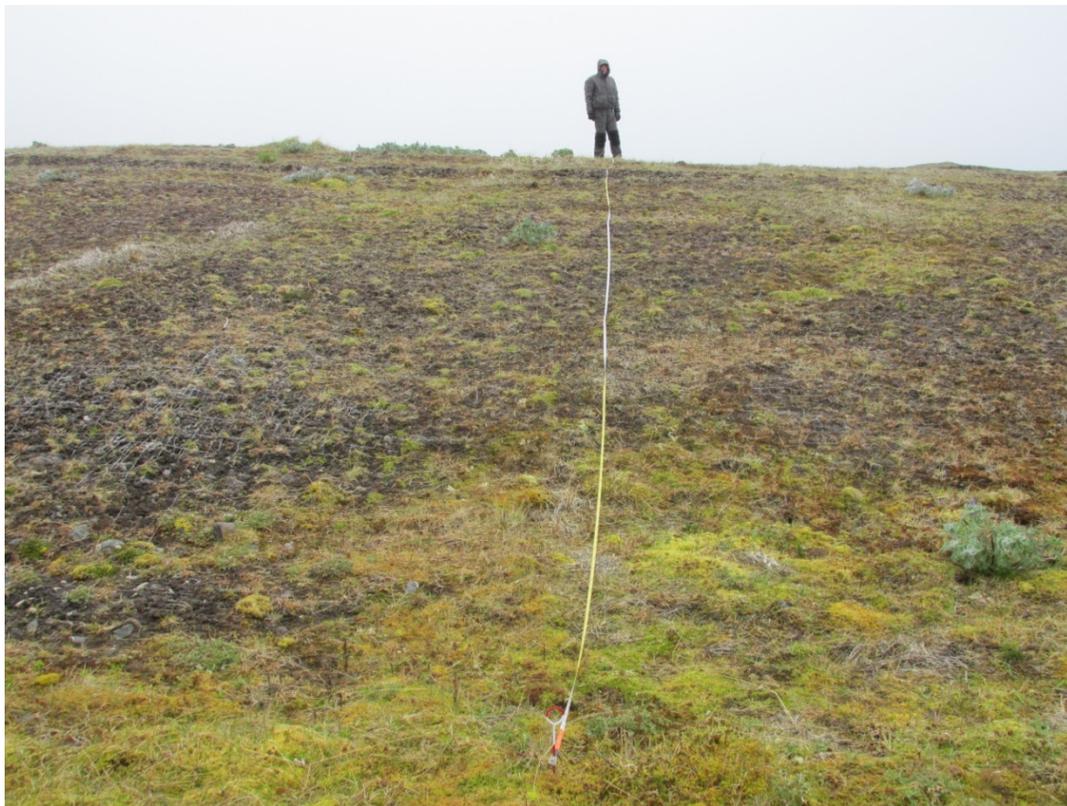
IMG_0733 – View SW of USFWS Monument and new sign, Site D



IMG_0711 – View SE at Transect D-5NW, Site D



IMG_0712 – View NE at Transect D-6SW, P. Darr, Site D



IMG_0713 – View NE at Transect D-7SW, P. Darr, Site D



IMG_0714 – View NE at Transect D-8SW, P. Darr, D. Marshall, and L. Sheader, Site D



IMG_0715 – View NE at Transect D-9SW, small scarp, P. Darr, Site D



IMG_0716 – View NNE at Transect D-10SW, P. Darr, Site D



IMG_0717 – View N at Transect D-11SW, small scarp, P. Darr, Site D



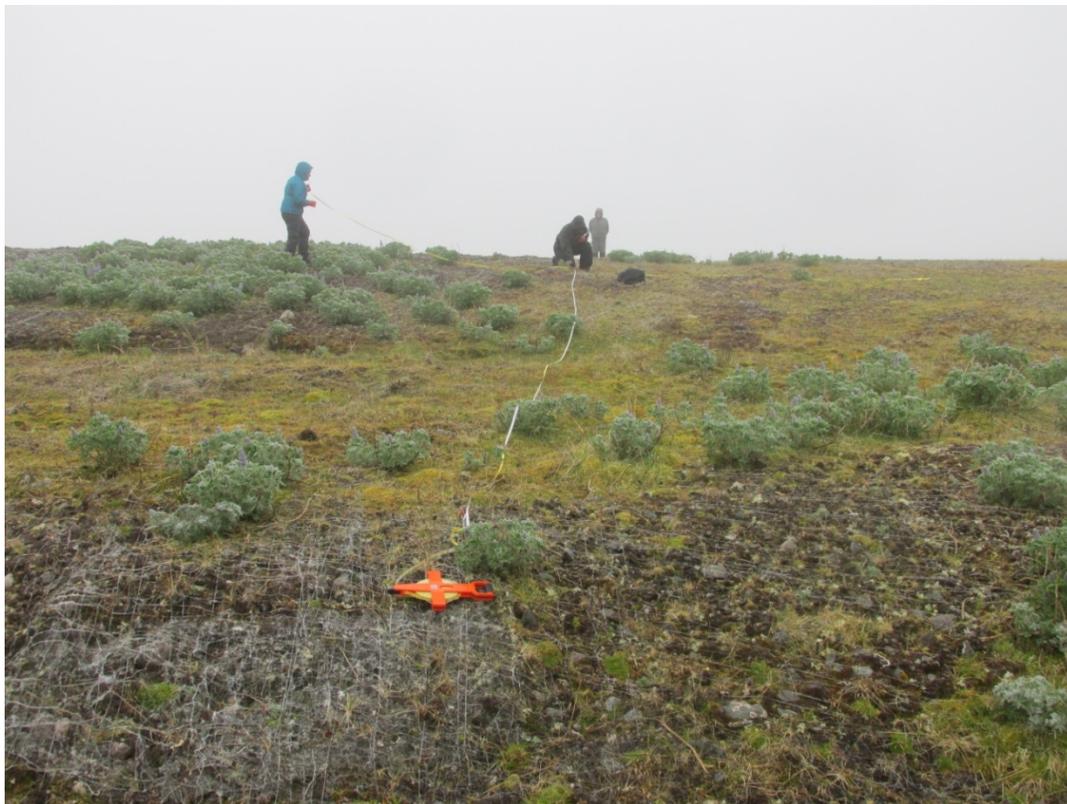
IMG_0718 – View NW at Transect D-5SE, P. Darr, Site D



IMG_0719 – View S at Transect D-11NE, Site D



IMG_0720 – View SSW at Transect D-10NE, Site D



IMG_0721 – View SW at Transect D-9NE, Site D



IMG_0722 – View SW at Transect D-8NE, P. Darr, Site D



IMG_0723 – View SW at Transect D-7NE, P. Darr, Site D



IMG_0724 – View SW at Transect D-6NE, P. Darr, Site D



IMG_0725 – View SE at Transect D-1NW, Site D



IMG_0726 – View NE at Transect D-2SW, Site D



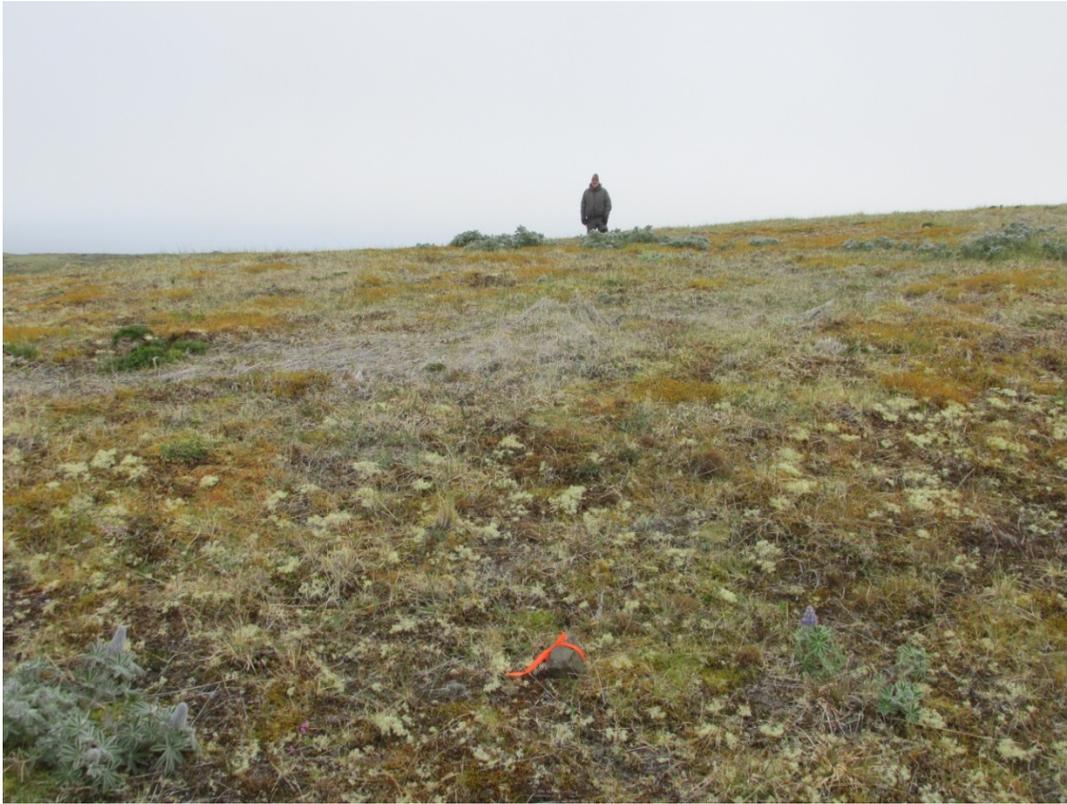
IMG_0727 – View NE at Transect D-3SW, P. Darr, Site D



IMG_0728 – View ENE at Transect D-4SW, P. Darr, Site D



IMG_0729 – View NW at Transect D-1SE, P. Darr, Site D



IMG_0730 – View WSW at Transect D-4NE, P. Darr, Site D



IMG_0731 – View SW at Transect D-3NE, S. Pitton and P. Darr, Site D



IMG_0732 – View SW at Transect D-2NE, P. Darr, Site D



IMG_0734 – View SW along the NW ends of the two mud pit caps, Site D



IMG_0735 – View SE of Sediment Trap D-1 and its dam, and steep slope on SW side of West Mud Pit Cap, Site D



IMG_0736 – View SE of small slump and seep of oily water just SE of D-2SW on SW side of West Mud Pit Cap, Site D



IMG_0738 – View E from D-1SE showing slump (~1 ft) along S end of West Mud Pit Cap and the larger slump at S end of East Mud Pit Cap, Site D



IMG_0739 – View N showing slump scarp along S end of West Mud Pit Cap, Site D



IMG_0740 – View N showing large slump along S end of East Mud Pit Cap and exposed black liner, Site D



IMG_0741 – View NW showing slump scarps along S ends of West and East Mud Pit Caps, Site D



IMG_0742 – View N from D-5SE of small slump along SE end of East Mud Pit Cap, Site D



IMG_0743 – View W of small slump along E part of S end of East Mud Pit Cap, Site D



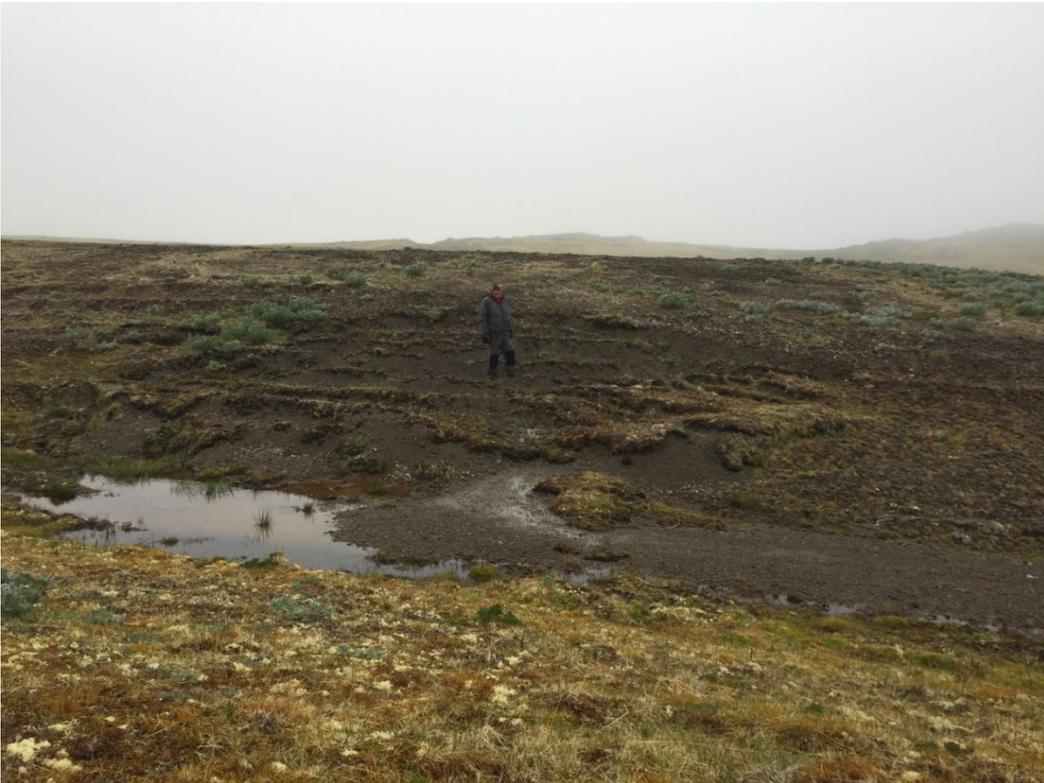
IMG_0744 – View W of exposed black liner in large slump in W part of S end of East Mud Pit Cap, Site D



IMG_0746 – View NW of vegetation covering rock of the Energy Dissipater where drainage spills from Channel D5, Site D



IMG_0747 – View E of large slump at S end of East Mud Pit Cap, Site D



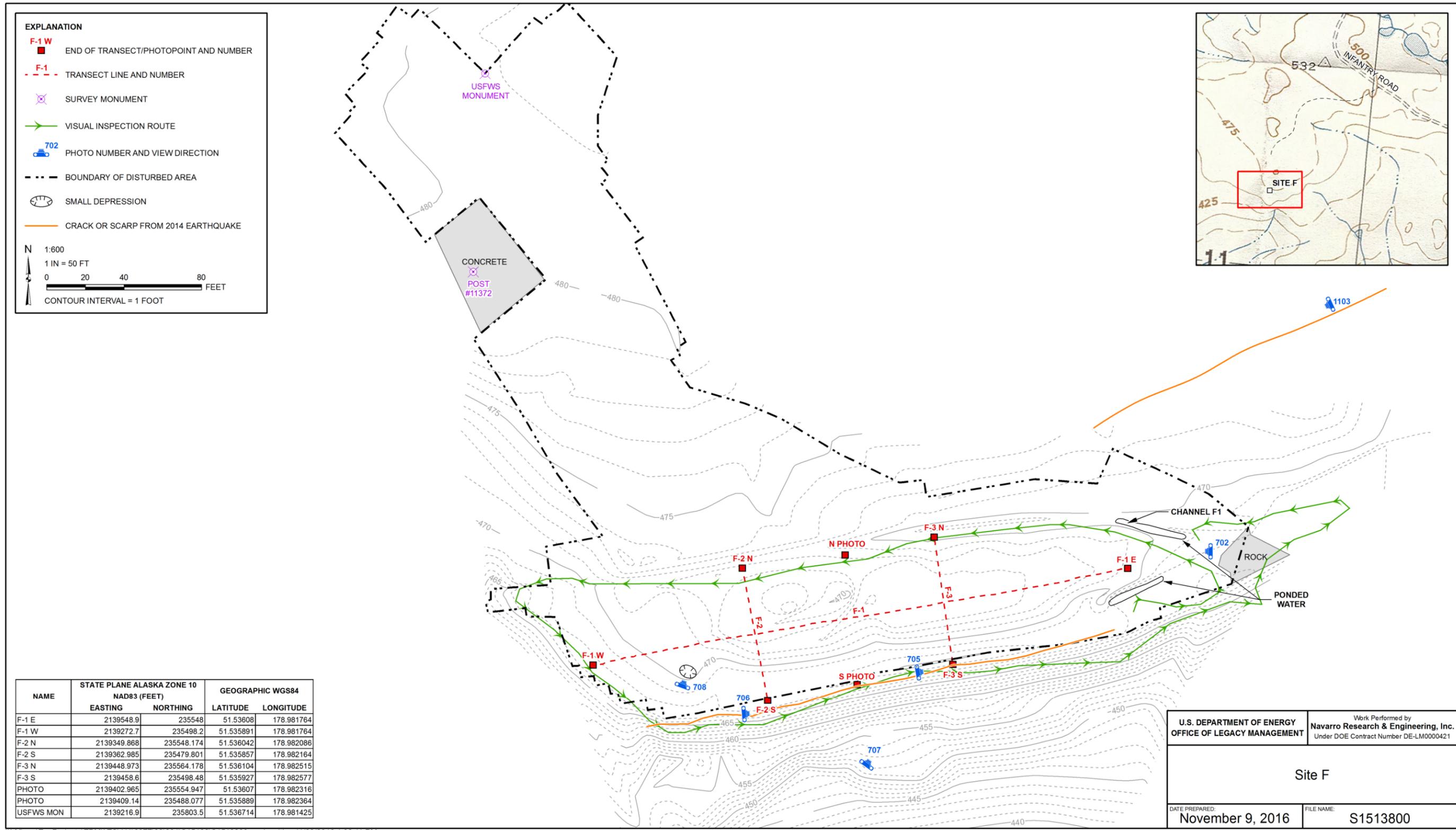
IMG_01122 – View NE of slump in SW part of East Mud Pit Cap and ponded water in Channel D5, P. Darr, Site D

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Appendix A-6

Drill Site F

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Figure A-6. Drill Site F

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AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST

Mud Pit Site: Drill Site F	Date of Inspection: June 17, 2016
Responsible Agency: U.S. Department of Energy – Legacy Management	Project Manager: Mark Kautsky
Inspector (name, title, organization): Craig Goodknight, Inspection Team Lead, Navarro	

- A. General Instructions**
- All checklist items must be completed and detailed comments made to document the results of the site inspection.
 - The completed checklist is part of the field record of the inspection. Additional pages should be used as necessary to ensure that a complete record is made. Number and attach the additional pages upon completion of the inspection.
 - Any checklist line item marked by an inspector in a SHADED BOX must be fully explained or an appropriate reference to previous reports provided. The explanation should include the inspector’s rationale for conclusions and recommendations, if appropriate. Explanations are to be placed on additional attachments and cross-referenced appropriately, and may take the form of sketches, measurements, and/or annotated site maps.
 - The site inspection is a walking inspection of the entire site, including the perimeter and sufficient transects to be able to inspect the entire surface and all features specifically described in this checklist. Attach a drawing indicating the starting and ending points and the direction and pattern of the inspection.
 - A standard set of color 35 mm photographs (or equivalent) is required. In addition, all anomalous features or new features (such as changes in adjacent area land use) are to be photographed. A photo log entry will be made for each photograph taken.

B. Preparation (to be completed prior to site visit)	YES	NO	EXPLANATION
1. Site as-built plans and site base map reviewed	X		Mud Pit Closure Plans and As-Built
2. Previous inspection reports reviewed	X		2006 and 2011 Inspection Reports
a. Were anomalies or trends detected on previous inspections?	X		From 2014 Post-Earthquake Investigation
b. Was maintenance performed on areas with anomalies?		X	No maintenance has been done on any of the effects resulting from the earthquake
3. Site maintenance and repair records reviewed		X	No previous maintenance activities were done
a. Has site repair resulted in a change from as-built conditions?		X	No detectable changes from as-built condition
b. Are revised as-builts available that reflect repair changes?			Not Applicable. No repairs have been made

C. Site Inspection (to be completed during inspection)	YES	NO	EXPLANATION
1. Adjacent offsite features within mud pit site area			
a. Changes in use of adjacent area?		X	Wildlife refuge
b. Any new roads or trails?		X	Per previous photos and as-built drawings
c. Change in the position of nearby washes?		X	None detected
d. Erosion/deposition of nearby washes?		X	None detected
e. New drainage channels?		X	None detected
f. Change in surrounding vegetation?		X	None detected
2. Security markers; signs			
a. Displacement of site markers, boundary markers, or monuments?		X	USFWS Monument was present/Good condition
b. Signs damaged or removed?		X	New signs installed at USFWS Monument. Other signs are in good condition.
3. Cap			
a. Evidence of subsidence?	X		Vegetation continues to cover the small area of subsidence seen in the 2006 inspection
b. Evidence of cracking?	X		A long crack and associated slump from the 2014 earthquake are along the S edge of the mud pit cap. Another long crack is NE of the mud pit cap.
c. Evidence of erosion (wind or water)?		X	Ponded water in Channel F1 at the E end of the mud pit cap noted in this and past inspections could lead to future erosion
d. Evidence of animal burrowing?		X	
e. Are site markers disturbed? By man? _____ By natural processes? _____		X	
f. Do natural processes threaten the integrity of cap or site marker?		X	

AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST (continued)

Mud Pit Site: Drill Site F

Date of Inspection: June 17, 2016

C. Site inspection (continued)

	YES	NO	EXPLANATION
4. Vegetative cover			
a. Is plant cover adequate to prevent erosion?	X		See discussion in Section 3.0
b. Are weedy annual plants present? Do they require removal?		X	See discussion in Section 3.0
c. Evidence of animals on cap?		X	See discussion in Section 3.0
d. Evidence of excessive plant mortality?		X	See discussion in Section 3.0
e. Has a vegetative cover log been completed?	X		See Vegetative Cover Log
5. Photo Documentation			
a. Has a photo log been prepared?	X		See Photograph Log
b. How many photos were taken?			15 photos as noted in the Photograph Log

D. Field Conclusions

1. Imminent hazard to integrity of cap? (If yes, immediate report required. Note the person or agency the report will be made to.)		X	
2. Are more frequent inspections required?		X	
3. Are existing maintenance actions satisfactory?			Not Applicable. No maintenance was done or required.
4. Are existing repair actions satisfactory?			Not Applicable. No repairs were done or required.
5. Is other maintenance/repair necessary?		X	
6. Rationale for field conclusions: See Attached			
7. Factors contributing to or impacting inspection: None noted			

E. Certification

I certify that I have conducted an inspection of the Drill Site F Mud Pit Site cap in accordance with the Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, dated March 2016, as recorded on this checklist, discussion in Sections 2.0 and 3.0, field notes, vegetative cover log, photograph log, and photos.

Inspector Printed Name: Craig Goodknight

Inspector Signature:

Craig Goodknight

Title: Inspection Team Lead

Date: 7/14/16

6. Rationale for field conclusions: Conclusions were based on walkover visual inspections and plant counts. A long, semi-continuous crack and associated slump block extends along the south edge of the mud pit cap. This feature formed as a result of the June 2014 7.9-magnitude earthquake and several strong aftershocks. It was documented in August 2014 by an inspection team soon after the quake. The mostly continuous crack defines a scarp for a slump block 4 to 6 ft wide that shows about 1 ft of displacement to the S (photos 0705 and 0706). Soil is exposed in the steep slope in a bank about 150 ft long just below the S edge of the slump block (photos 0701, 0706, and 0707). This slump block and the exposed soil band should be monitored during future inspections for erosion on the steep slope.

Another long crack formed by the 2014 earthquake is NE of the mud pit cap. This crack was noted by the inspection team in August 2014 and since then it has partially healed by filling in and vegetation cover (photo 1103). This crack should be monitored during future inspections for signs of healing or erosion that could use the crack as a conduit.

Ponded water continues to accumulate at the E end of the mud pit cap (photo 0702) in Channel F1 and in a trench to the S. Minor trenching and filling should be done to allow the water to drain away from the mud pit cap, as designed.

The small depression or subsidence noted since 2006 is covered by vegetation (moss) and has not changed since the 2011 inspection (photo 0708). Overall, vegetation appears to have increased slightly on the mud pit cap since the 2011 inspection.

PHOTOGRAPH LOG

Mud Pit Site: Drill Site F				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
06/17/16	0693		South	USFWS Monument and new sign
06/17/16	0694		West	Transect F-1E
06/17/16	0695		South	Transect F-3N
06/17/16	0696		South	North photo point
06/17/16	0697		South	Transect F-2N
06/17/16	0698		East	Transect F-1W
06/17/16	0699		North	Transect F-2S
06/17/16	0700		North	South photo point
06/17/16	0701		North	Transect F-3S
06/17/16	0702		West	View of E end of mud pit cap showing ponded water in Channel F1 (right) and in trench (left)
06/17/16	0705		East	View along crack and slump block in area of F-3 transect
06/17/16	0706		East	View along slump block and exposed soil near S end of F-2 transect
06/17/16	0707		Northeast	Slumping and exposed soil band along S side of mud pit cap
06/17/16	0708		North	Small subsidence area covered by vegetation
06/17/16	1103		West-Southwest	Crack NE of mud pit cap

*GPS location datum AK State Plane NAD 1983



IMG_0693 – View S of USFWS Monument, new sign, and concrete pad, Site F



IMG_0694 – View W at Transect F-1E, P. Darr, Site F



IMG_0695 – View S at Transect F-3N, P. Darr, Site F



IMG_0696 – View S at N Photo point, P. Darr, Site F



IMG_0697 – View S at Transect F-2N, P. Darr, Site F



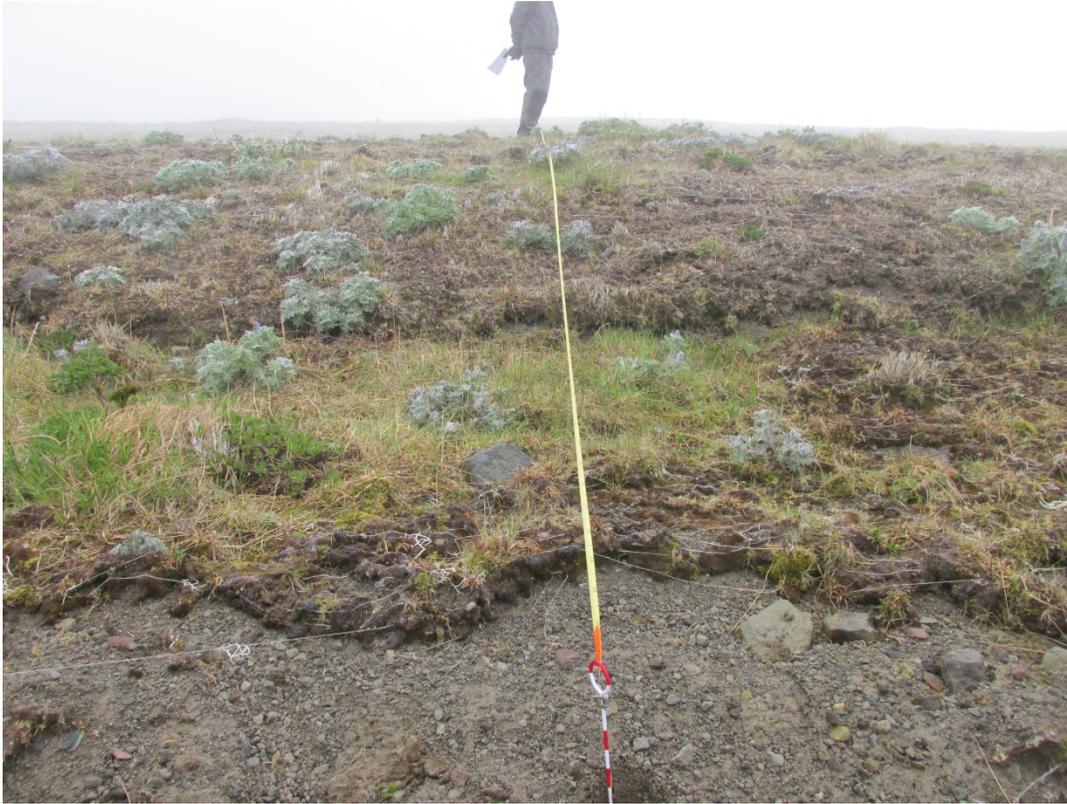
IMG_0698 – View E at Transect F-1W, Site F



IMG_0699 – View N at Transect F-2S, P. Darr, L. Sheader and D. Marshall, Site F



IMG_0700 – View N at S Photo point, P. Darr, Site F



IMG_0701 – View N at Transect F-3S, P. Darr, Site F



IMG_0702 – View W of rock, sign, Channel F1 at right, and E end of mud pit cap, Site F



IMG_0705 – View E along slumped area toward F-3 Transect, L. Sheader and D. Marshall, Site F



IMG_0706 – View E from near S end of F-2 Transect showing slumps along S side of mud pit cap, Site F



IMG_0707 – View NE of slumping along S side of mud pit cap, Site F



IMG_0708 – View N of small depression in SW part of mud pit cap, Site F



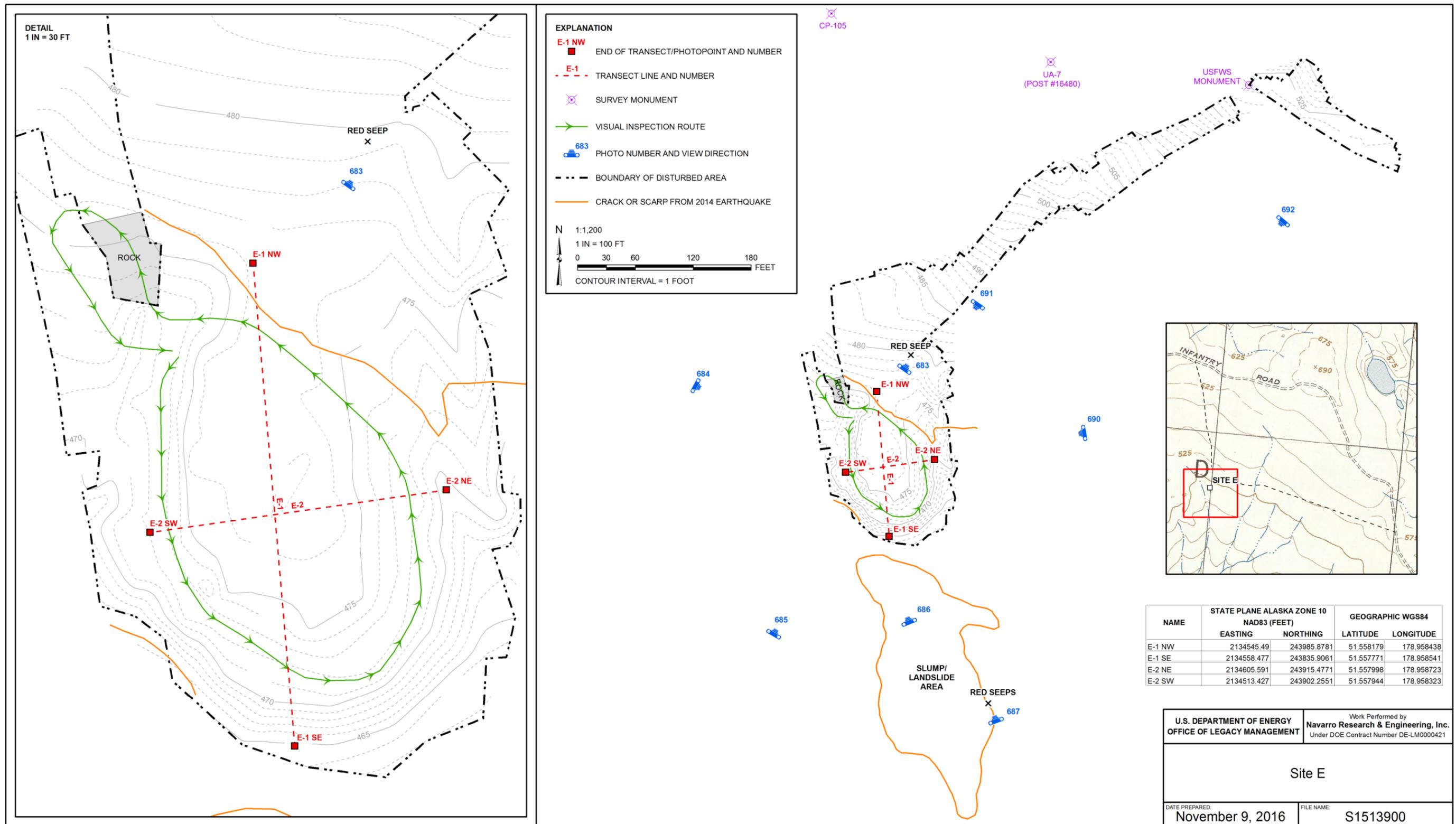
IMG_1103 – View WSW of Crack NE of Mud Pit Cap

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Appendix A-7

Drill Site E

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Figure A-7. Drill Site E

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AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST

Mud Pit Site: Drill Site E	Date of Inspection: June 17, 2016
Responsible Agency: U.S. Department of Energy – Legacy Management	Project Manager: Mark Kautsky
Inspector (name, title, organization): Craig Goodknight, Inspection Team Lead, Navarro	

A. General Instructions

1. All checklist items must be completed and detailed comments made to document the results of the site inspection.
2. The completed checklist is part of the field record of the inspection. Additional pages should be used as necessary to ensure that a complete record is made. Number and attach the additional pages upon completion of the inspection.
3. Any checklist line item marked by an inspector in a SHADED BOX must be fully explained or an appropriate reference to previous reports provided. The explanation should include the inspector’s rationale for conclusions and recommendations, if appropriate. Explanations are to be placed on additional attachments and cross-referenced appropriately, and may take the form of sketches, measurements, and/or annotated site maps.
4. The site inspection is a walking inspection of the entire site, including the perimeter and sufficient transects to be able to inspect the entire surface and all features specifically described in this checklist. Attach a drawing indicating the starting and ending points and the direction and pattern of the inspection.
5. A standard set of color 35 mm photographs (or equivalent) is required. In addition, all anomalous features or new features (such as changes in adjacent area land use) are to be photographed. A photo log entry will be made for each photograph taken.

B. Preparation (to be completed prior to site visit)	YES	NO	EXPLANATION
1. Site as-built plans and site base map reviewed	X		Mud Pit Closure Plans and As-Built
2. Previous inspection reports reviewed	X		2006 and 2011 Inspection Reports
a. Were anomalies or trends detected on previous inspections?	X		From 2014 Post-Earthquake Investigation
b. Was maintenance performed on areas with anomalies?		X	No maintenance has been done on any of the effects resulting from the earthquake
3. Site maintenance and repair records reviewed		X	No previous maintenance activities were done
a. Has site repair resulted in a change from as-built conditions?		X	No detectable changes from as-built condition
b. Are revised as-builts available that reflect repair changes?			Not Applicable. No repairs have been made.

C. Site Inspection (to be completed during inspection)	YES	NO	EXPLANATION
1. Adjacent offsite features within mud pit site area			
a. Changes in use of adjacent area?		X	Wildlife refuge
b. Any new roads or trails?		X	Per previous photos and as-built drawings
c. Change in the position of nearby washes?		X	None detected
d. Erosion/deposition of nearby washes?	X		Active drainage and erosion below slump scarp, just S of mud pit cap. Two areas of reddish-brown seeps are N and S of mud pit cap.
e. New drainage channels?		X	None detected
f. Change in surrounding vegetation?		X	None detected
2. Security markers; signs			
a. Displacement of site markers, boundary markers, or monuments?		X	USFWS Monument was present/Good condition
b. Signs damaged or removed?		X	New sign installed at USFWS Monument. Other signs were in good condition.
3. Cap			
a. Evidence of subsidence?		X	
b. Evidence of cracking?	X		Two cracks from the 2014 earthquake are just N and SW of mud pit cap.
c. Evidence of erosion (wind or water)?		X	
d. Evidence of animal burrowing?		X	
e. Are site markers disturbed? By man? _____ By natural processes? _____		X	
f. Do natural processes threaten the integrity of cap or site marker?		X	

AMCHITKA MUD PIT SITES POST-CLOSURE MONITORING CHECKLIST (continued)

Mud Pit Site: Drill Site E

Date of Inspection: June 17, 2016

C. Site inspection (continued)

	YES	NO	EXPLANATION
4. Vegetative cover			
a. Is plant cover adequate to prevent erosion?	X		See discussion in Section 3.0
b. Are weedy annual plants present? Do they require removal?		X	See discussion in Section 3.0
c. Evidence of animals on cap?		X	See discussion in Section 3.0
d. Evidence of excessive plant mortality?		X	See discussion in Section 3.0
e. Has a vegetative cover log been completed?	X		See Vegetative Cover Log
5. Photo Documentation			
a. Has a photo log been prepared?	X		See Photograph Log
b. How many photos were taken?			13 photos as noted in the Photograph Log

D. Field Conclusions

1. Imminent hazard to integrity of cap? (If yes, immediate report required. Note the person or agency the report will be made to.)		X	
2. Are more frequent inspections required?		X	
3. Are existing maintenance actions satisfactory?			Not Applicable. No maintenance was done or required.
4. Are existing repair actions satisfactory?			Not Applicable. No repairs were done or required.
5. Is other maintenance/repair necessary?		X	

6. Rationale for field conclusions: Conclusions were based on walkover visual inspections and plant counts. Two cracks and a slump near the mud pit cap were formed as a result of the June 2014 7.9-magnitude earthquake and several strong aftershocks. These effects were documented by an inspection team in August 2014. A long, irregular crack that strikes approx. ESE (photo 684) is just N of the mud pit cap, and a short minor crack is just SW of the mud pit cap. These cracks should be monitored during future inspections to see if they fill in or become channels for erosion that could affect the mud pit cap. The large slump area whose head scarp (photo 686) is only 30 ft S of the S edge of the mud pit cap should be monitored during future inspections to see if the head scarp migrates northward toward the mud pit cap where damage would occur. Reddish brown seeps (color probably owing to Fe) are N and S of the mud pit cap. The larger seep area (photo 687) is S of the mud pit cap along the edge of the disturbed area caused by the slump.

7. Factors contributing to or impacting inspection: None noted

E. Certification

I certify that I have conducted an inspection of the Drill Site E Mud Pit Site cap in accordance with the Post-Closure Monitoring and Inspection Plan for Amchitka Island Mud Pit Release Sites, dated March 2016, as recorded on this checklist, discussion in Sections 2.0 and 3.0, field notes, vegetative cover log, photograph log, and photos.

Inspector Printed Name: Craig Goodknight

Inspector Signature:

Title: Inspection Team Lead

Date: 7/14/16

PHOTOGRAPH LOG

Mud Pit Site: Drill Site E				
Date	Photo #	GPS Location*	Direction of Photo	DESCRIPTION (Photopoints indicated by an *)
06/17/16	0674		South	USFWS Monument and new sign
06/17/16	0675		South	Transect E-1NW
06/17/16	0676		East	Transect E-2SW
06/17/16	0677		North	Transect E-1SE
06/17/16	0678		West	Transect E-2NE
06/17/16	0683		North	Small area of reddish-brown seeps N of mud pit cap
06/17/16	0684		East Southeast	View of mud pit cap from ~200 ft and crack along its N side
06/17/16	0685		North- Northeast	View of mud pit cap and slump scarp
06/17/16	0686		North- Northwest	Drainage in slump area S of mud pit cap
06/17/16	0687		North- Northwest	Large area of reddish-brown seeps ~200 ft SE of mud pit cap
06/17/16	0690		West- Southwest	View of mud pit cap from ~200 ft
06/17/16	0691		Southwest	View of mud pit cap from ~200 ft and Pacific Ocean in BG
06/17/16	0692		Southwest	View of mud pit cap from pad for well UAE-7

*GPS location datum AK State Plane NAD 1983



IMG_0674 – View S of USFWS Monument and new sign, Site E



IMG_0675 – View S at Transect E-1NW, P. Darr, Site E



IMG_0676 – View E at Transect E-2SW, P. Darr, Site E



IMG_0677 – View N at Transect E-1SE, P. Darr, Site E



IMG_0678 – View W at Transect E-2NE, P. Darr, Site E



IMG_0683 – View N of small area of reddish-brown seep about 100 ft N of mud pit cap, Site E



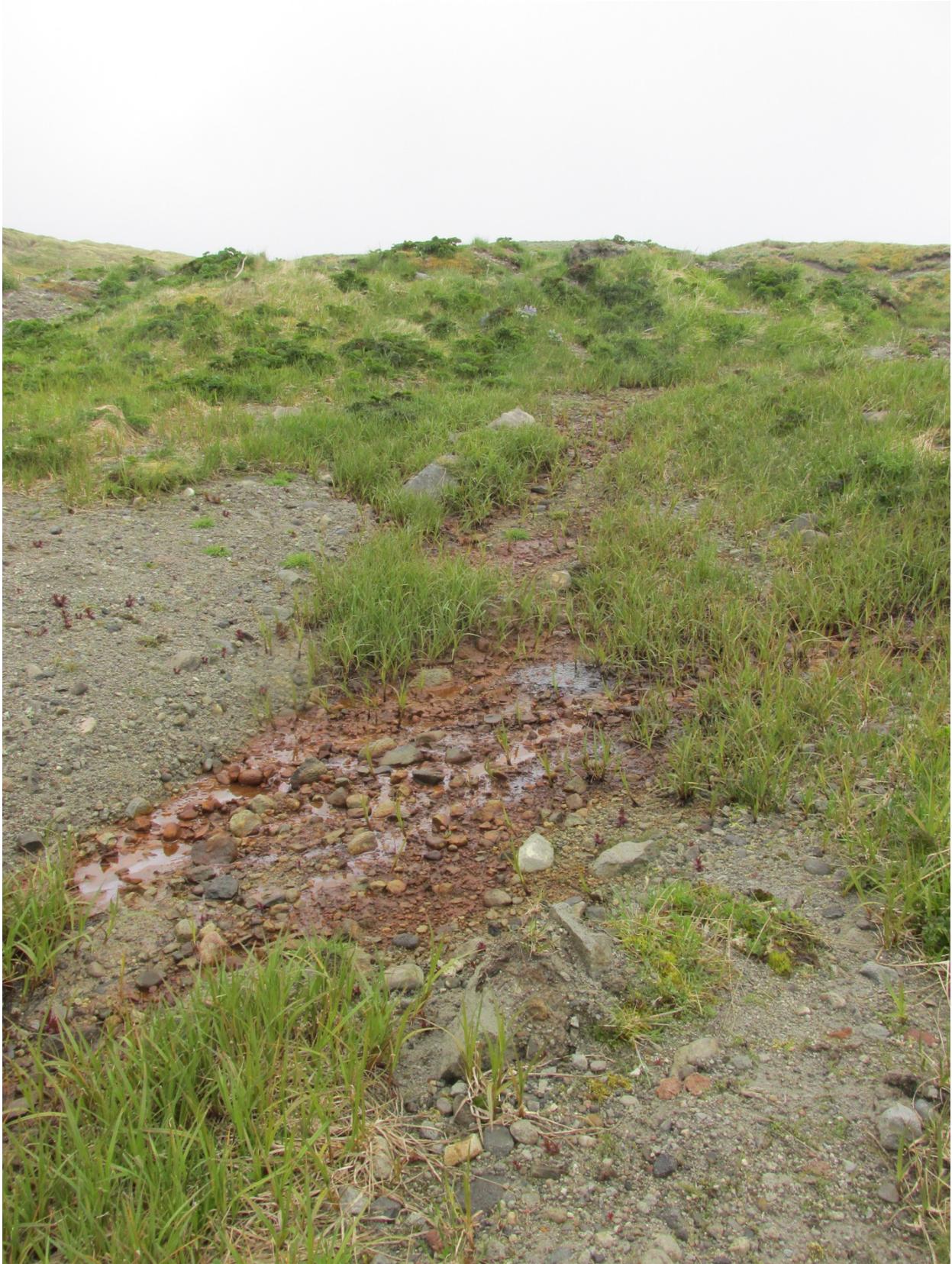
IMG_0684 – View ESE of mud pit cap from about 200 ft, Site E



IMG_0685 – View NNE of mud pit cap and slump scarp from 2014 earthquake, Site E



IMG_0686 – View NNW of mud pit cap and slump scarp from 2014 earthquake, Site E



IMG_0687 – View NNW of large area of reddish-brown seeps about 200 ft SSE of mud pit cap, Site E



IMG_0690 – View WSW of mud pit cap from about 200 ft, Site E



IMG_0691 – View SW of mud pit cap from about 200 ft and Pacific, Site E



IMG_0692 – View SW of mud pit cap from pad for well UAE-7, Site E

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Appendix B

Plant Species Identified on Amchitka Island in 2016

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Scientific Name	Common Name	Type	On Mud Pit Caps?
<i>Achillea millefolium</i> L.	Common yarrow	perennial forb	X
<i>Agrostis exarata</i> Trin.	Spike bentgrass	perennial graminoid	X
<i>Anaphalis margaritacea</i> (L.) Benth.	Western pearly everlasting	perennial forb	X
<i>Anemone narcissiflora</i> L.	Narcissus anemone	perennial forb	
<i>Angelica lucida</i> L.	Seacost angelica	perennial forb	X
<i>Antennaria dioica</i> (L.) Gaertn.	Stoloniferous pussytoes	perennial forb	X
<i>Arnica unalaschcensis</i> Less.	Alaska arnica	perennial forb	X
<i>Bromus sitchensis</i> Trin.	Alaska brome	perennial graminoid	X
<i>Calamagrostis nutkaensis</i> (J. Presl) J. Presl ex Steud.	Pacific reedgrass	perennial graminoid	
<i>Caltha palustris</i> L.	Yellow marsh marigold	perennial forb	
<i>Cardamine oligosperma</i> Nutt. var. <i>kamtschatica</i> (Regel) Detling	Umbel bittercress	perennial forb	X
<i>Carex lyngbyei</i> Hornem.	Lyngbye's sedge	perennial graminoid	X
<i>Carex macrochaeta</i> C.A. Mey.	Longawn sedge	perennial graminoid	X
<i>Cerastium fontanum</i> Baumg.	Common mouse-ear chickweed	perennial forb	X
<i>Chrysanthemum arcticum</i> L.	Arctic daisy	perennial forb	X
<i>Cladonia</i> sp.	Reindeer lichen	lichen	X
<i>Conioselinum chinense</i> (L.) Britton, Sterns & Poggenb.	Eastern hemlockparsley	perennial forb	X
<i>Coptis trifolia</i> (L.) Salisb.	Threeleaf goldthread	perennial forb	X
<i>Cornus canadensis</i> L.	Bunchberry dogwood	perennial forb	
<i>Deschampsia beringensis</i> Hultén	Bering's tufted hairgrass	perennial graminoid	X
<i>Empetrum nigrum</i> L.	Black crowberry	perennial shrub	X
<i>Epilobium hornemannii</i> Rchb. subsp. <i>behringianum</i> (Hauskn.) Hoch & P.H. Raven	Hornemann's willowherb	perennial forb	X
<i>Equisetum arvense</i> L.	Field horsetail	perennial graminoid	X
<i>Eriophorum russeolum</i> Fr. ex Hartm.	Red cottongrass	perennial graminoid	
<i>Festuca rubra</i> L.	Red fescue	perennial graminoid	X
<i>Geranium erianthum</i> DC.	Woolly geranium	perennial forb	
<i>Geum calthifolium</i> Menzies ex Sm.	Calthaleaf avens	perennial forb	
<i>Geum macrophyllum</i> Willd.	Largeleaf avens	perennial forb	
<i>Juncus arcticus</i> Willd.	Arctic rush	perennial graminoid	X
<i>Leymus mollis</i> (Trin.) Pilg.	American dunegrass	perennial graminoid	X
Lichen - crustose form	Crustose lichen	lichen	X
Lichen - foliose form	Foliose lichen	lichen	X
Lichen - fruticose form (1)	Fruticose lichen (1)	lichen	X
Lichen - fruticose form (2)	Fruticose lichen (2)	lichen	
<i>Ligusticum scoticum</i> L.	Scottish licorice-root	perennial forb	
<i>Loiseleuria procumbens</i> (L.) Desv.	Alpine azalea	perennial shrub	X
<i>Lupinus nootkatensis</i> Donn ex Sims	Nootka lupine	perennial forb	X
<i>Luzula arctica</i> Blytt	Arctic woodrush	perennial graminoid	
<i>Luzula multiflora</i> (Ehrh.) Lej.	Common woodrush	perennial graminoid	X

Scientific Name	Common Name	Type	On Mud Pit Caps?
Moss - mixed species	Moss	bryophyte	X
<i>Parnassia kotzebuei</i> Cham. ex Spreng.	Kotzebue's grass of Parnassus	perennial forb	
<i>Phleum alpinum</i> L.	Alpine timothy	perennial graminoid	X
<i>Plantago maritima</i> L.	Goose tongue	perennial forb	
<i>Platanthera dilatata</i> (Pursh) Lindl. ex Beck	Scentbottle	perennial forb	X
<i>Poa eminens</i> J. Presl.	Largeflower speargrass	perennial graminoid	X
<i>Potentilla</i> sp.	Potentilla, cinquefoil	forb	X
<i>Potentilla villosa</i> Pall. ex Pursh	Villous cinquefoil	perennial forb	X
<i>Primula cuneifolia</i> Ledeb.	Wedgeleaf primrose	perennial forb	X
<i>Ranunculus occidentalis</i> Nutt.	Western buttercup	perennial forb	
<i>Rumex acetosella</i> L.	Common sheep sorrel	perennial forb	X
<i>Rubus arcticus</i> L.	Arctic raspberry	perennial forb	
<i>Rumex fenestratus</i> L.	Western dock	perennial forb	X
<i>Salix arctica</i> Pall.	Arctic willow	perennial shrub	
<i>Salix rotundifolia</i> Trautv.	Least willow	perennial shrub	X
<i>Saxifraga nelsoniana</i> D. Don ssp. <i>nelsoniana</i>	Heartleaf saxifrage	perennial forb	X
<i>Saxifraga</i> sp.	Saxifrage	forb	X
<i>Selaginella selaginoides</i> (L.) P. Beauv. ex Mart. & Schrank	Club spikemoss	perennial forb	X
<i>Senecio pseudoarnica</i> Less.	Seaside ragwort	perennial forb	X
<i>Sibbaldia procumbens</i> L.	Creeping sibbaldia	perennial forb	X
<i>Sphagnum</i> L. sp.	Sphagnum moss	bryophyte	X
<i>Stellaria calycantha</i> (Ledeb.) Bong.	Northern starwort	perennial forb	
<i>Taraxacum officinale</i> F.H. Wigg.	Common dandelion	perennial forb	X
<i>Taraxacum officinale</i> F.H. Wigg. subsp. <i>ceratophorum</i> (Ledeb.) Schinz ex Thell.	Dandelion	perennial forb	X
<i>Veronica serpyllifolia</i> L.	Thymeleaf speedwell	perennial forb	X
<i>Veronica wormskjoldii</i> Roem. & Schult. var. <i>stelleri</i>	American alpine speedwell	perennial forb	X
<i>Viola langsдорffii</i> Fisch. ex Gingins	Aleutian violet	perennial forb	X
<i>Woodsia scopulina</i> D.C. Eaton	Rocky Mountain woodsia	perennial forb	X

Appendix C
Vegetation Survey

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Table C1. Cover at the Rifle Range Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Vascular plant cover	37.3	86.5	-
Graminoids	14.7	34.1	-
<i>Agrostis exarata</i>	0.2	0.5	18
<i>Bromus sitchensis</i>	0.1	0.2	12
<i>Carex macrochaeta</i>	0.5	1.2	24
<i>Deschampsia beringensis</i>	1.5	3.5	68
<i>Festuca rubra</i>	9.0	20.9	97
<i>Luzula multiflora</i>	2.3	5.3	68
<i>Phleum alpinum</i>	1.0	2.3	47
Forbs	22.5	52.2	-
<i>Achillea millefolium</i>	1.9	4.4	68
<i>Anaphalis margaritacea</i>	4.0	9.3	85
<i>Angelica lucida</i>	3.1	7.2	50
<i>Conioselinum chinense</i>	0.03	0.06	3
<i>Epilobium hornemannii</i>	0.6	1.2	32
<i>Equisetum arvense</i>	0.1	0.2	6
<i>Lupinus nootkatensis</i>	11.9	27.6	97
<i>Platanthera dilatata</i>	0.1	0.2	12
<i>Potentilla villosa</i>	0.1	0.2	6
<i>Senecio pseudoarnica</i>	0.2	0.5	18
<i>Sibbaldia procumbens</i>	0.03	0.06	3
<i>Taraxacum officinale</i>	0.5	1.2	24
Shrubs	0.03	0.06	-
<i>Empetrum nigrum</i>	0.03	0.06	3
<i>Loiseleuria procumbens</i>	observed	-	-
Nonvascular plant cover	5.8	13.5	-
Bryophytes			
<i>Sphagnum</i> + other mosses	5.8	13.5	65
Lichens			
Foliose lichens	0.03	0.06	3
Non vegetated cover	56.9	-	-
Litter	15.5	-	-
Bare ground	40.1	-	-
Rock	1.3	-	-

Numerical values may not precisely add up due to rounding.

Absolute cover is the percentage of points intercepted by a species out of the total number of points sampled, and it is an estimate of how much ground is covered by a given species or non vegetated cover type.

Relative cover is the percentage of points intercepted by one species compared to the number of points intercepted by all vegetated cover, and it estimates the relative importance of one species or group in the plant community.

Frequency is the percentage of sample tapes in which a species occurs out of the total tapes sampled, and it is an indicator of the distribution of a species across the mud pit cap.

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Table C2. Cover at the Long Shot Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Vascular plant cover	39.8	65.0	-
Graminoids	17.5	28.6	-
<i>Bromus sitchensis</i>	0.1	0.2	11
<i>Carex lyngbyei</i>	0.02	0.03	2
<i>Deschampsia beringensis</i>	2.4	3.9	73
<i>Festuca rubra</i>	11.3	18.5	100
<i>Juncus arcticus</i>	0.2	0.3	13
<i>Luzula multiflora</i>	3.0	4.9	88
<i>Phleum alpinum</i>	0.4	0.7	33
<i>Poa eminens</i>	0.1	0.2	10
Forbs	16.7	27.3	-
<i>Achillea millefolium</i>	0.8	1.3	38
<i>Anaphalis margaritacea</i>	1.8	2.9	71
<i>Angelica lucida</i>	0.1	0.2	11
<i>Antennaria dioica</i>	0.02	0.03	2
<i>Cardamine oligosperma</i>	observed	-	-
<i>Cerastium fontanum</i>	0.04	0.07	4
<i>Chrysanthemum arcticum</i>	0.4	0.7	25
<i>Coptis trifolia</i>	0.9	1.5	38
<i>Epilobium hornemannii</i>	1.4	2.3	54
<i>Equisetum arvense</i>	observed	-	-
<i>Lupinus nootkatensis</i>	10.7	17.5	98
<i>Platanthera dilatata</i>	observed	-	-
<i>Potentilla villosa</i>	observed	-	-
<i>Primula cuneifolia</i>	0.1	0.2	6
<i>Saxifraga</i> sp.	observed	-	-
<i>Selaginella selaginoides</i>	0.02	0.03	2
<i>Senecio pseudoarnica</i>	0.02	0.03	2
<i>Sibbaldia procumbens</i>	0.4	0.7	35
<i>Taraxacum officinale</i>	observed	-	-
<i>Veronica serpyllifolia</i>	0.04	0.07	4
<i>Veronica wormskjoldii</i>	0.1	0.2	10
<i>Viola langsdorffii</i>	observed	-	-
Shrubs	5.5	9.0	-
<i>Empetrum nigrum</i>	5.1	8.3	81
<i>Loiseleuria procumbens</i>	0.4	0.7	25
Nonvascular plant cover	21.4	35.0	-
Bryophytes			
<i>Sphagnum</i> + other mosses	20.1	32.8	94
Lichens			
Crustose lichens	1.1	1.8	44
Foliose lichens	0.1	0.2	15

Table C2 (continued). Cover at the Long Shot Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Non vegetated cover	38.8	-	-
Litter	12.7	-	-
Bare ground	25.0	-	-
Rock	1.2	-	-

Numerical values may not precisely add up due to rounding.

Absolute cover is the percentage of points intercepted by a species out of the total number of points sampled, and it is an estimate of how much ground is covered by a given species or non-vegetated cover type.

Relative cover is the percentage of points intercepted by one species compared to the number of points intercepted by all vegetated cover, and it estimates the relative importance of one species or group in the plant community.

Frequency is the percentage of sample tapes in which a species occurs out of the total tapes sampled, and it is an indicator of the distribution of a species across the mud pit cap.

Table C3. Cover at the Cannikin South Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Vascular plant cover	22.6	94.2	-
Graminoids	15.8	65.8	-
<i>Bromus sitchensis</i>	0.2	0.8	18
<i>Carex lyngbyei</i>	0.2	0.8	18
<i>Deschampsia beringensis</i>	1.5	6.3	55
<i>Festuca rubra</i>	10.5	43.8	100
<i>Luzula multiflora</i>	3.3	13.8	91
<i>Phleum alpinum</i>	0.2	0.8	18
Forbs	6.8	28.3	-
<i>Achillea millefolium</i>	1.8	7.5	82
<i>Anaphalis margaritacea</i>	0.5	2.0	36
<i>Epilobium hornemannii</i>	0.5	2.0	36
<i>Equisetum arvense</i>	0.2	0.8	9
<i>Lupinus nootkatensis</i>	1.9	7.9	55
<i>Potentilla villosa</i>	0.1	0.4	9
<i>Primula cuneifolia</i>	observed	-	-
<i>Selaginella selaginoides</i>	observed	-	-
<i>Senecio pseudoarnica</i>	0.3	1.3	27
<i>Sibbaldia procumbens</i>	1.5	6.3	64
<i>Veronica serpyllifolia</i>	observed	-	-
<i>Woodsia scopulina</i>	observed	-	-
Shrubs			
<i>Empetrum nigrum</i>	observed	-	-
Nonvascular plant cover	1.4	5.8	
Bryophytes			
<i>Sphagnum</i> + other mosses	1.1	4.6	45
Lichens			
<i>Cladonia</i> sp.	observed	-	-
Foliose lichens	0.3	1.3	27
Non vegetated cover	76.0	-	-
Litter	15.9	-	-
Bare ground	58.8	-	-
Rock	1.3	-	-

Numerical values may not precisely add up due to rounding.

Absolute cover is the percentage of points intercepted by a species out of the total number of points sampled, and it is an estimate of how much ground is covered by a given species or non-vegetated cover type.

Relative cover is the percentage of points intercepted by one species compared to the number of points intercepted by all vegetated cover, and it estimates the relative importance of one species or group in the plant community.

Frequency is the percentage of sample tapes in which a species occurs out of the total tapes sampled, and it is an indicator of the distribution of a species across the mud pit cap.

Species designated as “**observed**” were found on the mud pit cap but did not occur within sampling transects.

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Table C4. Cover at the Cannikin Ground Zero Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Vascular plant cover	20.5	95.3	-
Graminoids	13.6	63.2	-
<i>Carex lyngbyei</i>	0.1	0.5	13
<i>Deschampsia beringensis</i>	7.1	33.0	91
<i>Festuca rubra</i>	4.1	19.1	83
<i>Leymus mollis</i>	0.2	0.9	9
<i>Luzula multiflora</i>	0.7	3.3	61
<i>Phleum alpinum</i>	0.2	0.9	13
<i>Poa eminens</i>	1.2	5.6	35
Forbs	6.5	30.2	-
<i>Anaphalis margaritacea</i>	observed	-	-
<i>Angelica lucida</i>	0.4	1.9	9
<i>Conioselinum chinense</i>	observed	-	-
<i>Epilobium hornemannii</i>	0.3	1.4	17
<i>Equisetum arvense</i>	observed	-	-
<i>Lupinus nootkatensis</i>	4.5	20.9	52
<i>Potentilla villosa</i>	0.04	0.2	4
<i>Senecio pseudoarnica</i>	0.04	0.2	4
<i>Sibbaldia procumbens</i>	0.3	1.4	22
<i>Veronica serpyllifolia</i>	0.1	0.5	9
Shrubs	0.4	1.9	-
<i>Empetrum nigrum</i>	0.4	1.9	13
Nonvascular plant cover	1.0	0.5	-
Bryophytes			
<i>Sphagnum</i> + other mosses	1.0	0.5	17
Lichens			
<i>Cladonia</i> sp.	observed	-	-
Foliose lichens	0.1	0.5	9
Non vegetated cover	78.5	-	-
Litter	10.0	-	-
Bare ground	65.8	-	-
Rock	2.7	-	-

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Relative cover is the percentage of points intercepted by one species compared to the number of points intercepted by all vegetated cover, and it estimates the relative importance of one species or group in the plant community.

Frequency is the percentage of sample tapes in which a species occurs out of the total tapes sampled, and it is an indicator of the distribution of a species across the mud pit cap.

Species designated as “**observed**” were found on the mud pit cap but did not occur within sampling transects.

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Table C5. Cover at the Site D Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Vascular plant cover	22.1	29.8	-
Graminoids	13.8	18.6	-
<i>Bromus sitchensis</i>	0.2	0.3	14
<i>Care lyngbyei</i>	0.1	0.1	4
<i>Deschampsia beringensis</i>	2.6	3.5	84
<i>Festuca rubra</i>	9.0	12.1	100
<i>Juncus arcticus</i>	observed	-	-
<i>Luzula multiflora</i>	1.9	2.6	73
<i>Phleum alpinum</i>	0.04	0.05	4
Forbs	7.5	10.1	-
<i>Achillea millefolium</i>	0.5	0.7	33
<i>Anaphalis margaritacea</i>	0.04	0.05	4
<i>Angelica lucida</i>	0.1	0.1	4
<i>Cerastium fontanum</i>	0.2	0.3	12
<i>Chrysanthemum arcticum</i>	observed	-	-
<i>Epilobium hornemannii</i>	1.8	2.4	63
<i>Lupinus nootkatensis</i>	4.1	5.5	59
<i>Platanthera dilatata</i>	observed	-	-
<i>Potentilla</i> sp.	0.02	0.03	2
<i>Potentilla villosa</i>	0.1	0.1	10
<i>Primula cuneifolia</i>	observed	-	-
<i>Rumex fenestratus</i>	0.02	0.03	2
<i>Selaginella selaginoides</i>	observed	-	-
<i>Senecio pseudoarnica</i>	0.1	0.1	6
<i>Sibbaldia procumbens</i>	0.3	0.4	22
<i>Taraxacum officinale</i>	0.02	0.03	2
<i>Veronica serpyllifolia</i>	0.02	0.03	2
<i>Woodsia scopulina</i>	observed	-	-
Shrubs	0.6	0.8	-
<i>Empetrum nigrum</i>	0.6	0.8	22
<i>Loiseleuria procumbens</i>	0.02	0.03	2
Nonvascular plant cover	52.4	70.6	-
Bryophytes			
<i>Sphagnum</i> + other mosses	50.2	67.7	100
Lichens			
<i>Cladonia</i> sp.	0.2	0.3	16
Crustose lichens	0.3	0.4	20
Foliose lichens	1.6	2.2	63
Fruticose lichens	0.04	0.05	4
Non vegetated cover	25.8	-	-
Litter	13.3	-	-
Bare ground	10.8	-	-
Rock	1.6	-	-

Numerical values may not precisely add up due to rounding.

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Relative cover is the percentage of points intercepted by one species compared to the number of points intercepted by all vegetated cover, and it estimates the relative importance of one species or group in the plant community.

Frequency is the percentage of sample tapes in which a species occurs out of the total tapes sampled, and it is an indicator of the distribution of a species across the mud pit cap.

Species designated as “**observed**” were found on the mud pit cap but did not occur within sampling transects.

Table C6. Cover at the Site F Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Vascular plant cover	32.0	78.8	-
Graminoids	23.0	56.7	-
<i>Bromus sitchensis</i>	1.2	3.0	85
<i>Deschampsia beringensis</i>	4.0	9.9	92
<i>Festuca rubra</i>	12.2	30.0	100
<i>Juncus arcticus</i>	0.1	0.2	8
<i>Luzula multiflora</i>	5.5	13.6	100
Forbs	8.9	21.9	-
<i>Achillea millefolium</i>	0.2	0.5	15
<i>Anaphalis margaritacea</i>	0.1	0.2	8
<i>Angelica lucida</i>	0.3	0.7	15
<i>Arnica unalaschensis</i>	0.5	1.2	31
<i>Cerastium fontanum</i>	0.5	1.2	38
<i>Chrysanthemum arcticum</i>	0.6	1.5	46
<i>Epilobium hornemannii</i>	1.6	3.9	92
<i>Equisetum arvense</i>	0.1	0.2	8
<i>Lupinus nootkatensis</i>	3.5	8.6	92
<i>Platanthera dilatata</i>	0.2	0.5	15
<i>Primula cuneifolia</i>	observed	-	-
<i>Rumex acetosella</i>	observed	-	-
<i>Senecio pseudoarnica</i>	0.3	0.7	31
<i>Sibbaldia procumbens</i>	1.2	3.0	62
<i>Veronica serpyllifolia</i>	0.1	0.2	8
<i>Woodsia scopulina</i>	observed	-	-
Shrubs	0.1	0.2	-
<i>Empetrum nigrum</i>	0.1	0.2	8
<i>Salix rotundifolia</i>	observed	-	-
Nonvascular plant cover	8.6	21.2	-
Bryophytes			
<i>Sphagnum</i> + other mosses	7.5	18.5	100
Lichens			
<i>Cladonia</i> sp.	0.2	0.5	15
Foliose lichens	0.6	1.5	31
Fruticose lichens	0.4	1.0	23
Non vegetated cover	59.4	-	-
Litter	10.9	-	100
Bare ground	47.6	-	100
Rock	0.8	-	54

Numerical values may not precisely add up due to rounding.

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Relative cover is the percentage of points intercepted by one species compared to the number of points intercepted by all vegetated cover, and it estimates the relative importance of one species or group in the plant community.

Frequency is the percentage of sample tapes in which a species occurs out of the total tapes sampled, and it is an indicator of the distribution of a species across the mud pit cap.

Species designated as "**observed**" were found on the mud pit cap but did not occur within sampling transects

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Table C7. Cover at the Site E Mud Pit Cap

Cover type	Absolute Cover (percent)	Relative Cover (percent)	Frequency (percent)
Vascular plant cover	21.5	67.8	-
Graminoids	10.8	34.1	-
<i>Deschampsia beringensis</i>	4.0	12.6	100
<i>Festuca rubra</i>	6.5	20.5	100
<i>Luzula multiflora</i>	0.4	1.3	36
Forbs	10.6	33.4	-
<i>Achillea millefolium</i>	0.4	1.3	36
<i>Anaphalis margaritacea</i>	0.2	0.6	18
<i>Angelica lucida</i>	0.5	1.6	45
<i>Cerastium fontanum</i>	0.3	0.9	18
<i>Epilobium hornemannii</i>	1.4	4.4	73
<i>Equisetum arvense</i>	0.4	1.3	9
<i>Lupinus nootkatensis</i>	7.5	18.0	100
<i>Primula cuneifolia</i>	observed	-	-
<i>Rumex acetosella</i>	observed	-	-
<i>Saxifraga nelsoniana</i>	0.1	0.3	9
<i>Sibbaldia procumbens</i>	observed	-	-
Shrubs	0.1	0.3	-
<i>Empetrum nigrum</i>	0.1	0.3	9
Nonvascular plant cover	10.2	32.2	-
Bryophytes			
<i>Sphagnum</i> + other mosses	9.2	29.0	100
Lichens			
<i>Cladonia</i> sp.	0.2	0.6	18
Foliose lichens	0.8	2.5	36
Fruticose lichens	observed	-	-
Non vegetated cover	68.3	-	-
Litter	10.7	-	-
Bare ground	55.8	-	-
Rock	1.7	-	-

Numerical values may not precisely add up due to rounding.

Absolute cover is the percentage of points intercepted by a species out of the total number of points sampled, and it is an estimate of how much ground is covered by a given species or non-vegetated cover type.

Relative cover is the percentage of points intercepted by one species compared to the number of points intercepted by all vegetated cover, and it estimates the relative importance of one species or group in the plant community.

Frequency is the percentage of sample tapes in which a species occurs out of the total tapes sampled, and it is an indicator of the distribution of a species across the mud pit cap.

Species designated as “**observed**” were found on the mud pit cap but did not occur within sampling transects.

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