LMS/AMC/S05725

Sampling Plan for the Amchitka, Alaska, Site 2011 Sampling Event

March 2011

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1.0 Introduction

In its implementation of the *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Amchitka, Alaska, Site* (DOE 2008) (LTSMP), the U.S. Department of Energy (DOE) Office of Legacy Management (LM) prepared this sampling plan to describe the data collection and data management activities that will be conducted as indicated in the LTSMP. The sampling activities described in this plan are to be implemented in 2011.

1.1 Background

Amchitka Island is near the far western end of the Aleutian Islands, approximately 1,340 miles west-southwest of Anchorage, Alaska. It is part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge, which is administered by the U.S. Fish and Wildlife Service (USFWS). Since World War II, Amchitka has been used by multiple U.S. government agencies for various military and research activities. From 1943 to 1950, it was used as a forward air base for the U.S. Armed Forces. During the middle 1960s and early 1970s, the U.S. Department of Defense (DOD) and the U.S. Atomic Energy Commission (AEC) (predecessor agency to DOE) used a portion of the island as a site for underground nuclear tests. During the late 1980s and early 1990s, the U.S. Navy constructed and operated a radar station on the island.

Three underground nuclear tests were conducted on Amchitka Island. DOD, in conjunction with AEC, conducted the first nuclear test (named Long Shot) in 1965 to provide data that would improve the United States' capability of detecting underground nuclear explosions. The second nuclear test (Milrow) was a weapons-related test conducted by AEC in 1969 as a means to study the feasibility of detonating a much larger device. Cannikin, the third nuclear test on Amchitka Island and the largest underground nuclear test conducted in the United States, was a weapons-related test detonated on November 6, 1971. With the exception of anomalous concentrations of tritium detected in surface water shortly after the Long Shot test, radioactive fission products from the tests remain in the subsurface at each test location.

1.2 Purpose of the 2011 Sampling Event

The purpose of this sampling plan is to carry out LM's responsibility—described in the LTSMP for the Amchitka Site and the reference site, Adak, Alaska—to further assess the possibility that selected residual radionuclides from nuclear tests may enter the marine food chain, resulting in potential ecological and human health effects. Previous scientific studies were performed on and around Amchitka Island that were similar in purpose to this plan. Some of these activities are described below.

The Environment of Amchitka Island, Alaska (Merritt and Fuller 1977), a multidisciplinary work, provides a concise review of the geology, ecology, and radionuclides in air, water, and biota with an emphasis on "the search for and identity of radionuclides of Amchitka origin in the samples and [contributing] to the general knowledge of the distribution of radionuclides in the environment." This evaluation showed that no radionuclides had escaped from the underground sites of the three nuclear detonations at Amchitka Island except for trace quantities of radionuclides, principally tritium, in water and soil gas samples taken in the immediate vicinity of the Long Shot test.

The Amchitka Radiobiological Program began in 1970 and continued through 1979. The program's principal objective was to collect biological and environmental samples for radiobiological analyses, and to determine the extent of radionuclide contamination from worldwide atmospheric fallout and from the detonation of the three underground nuclear tests on Amchitka. Leakage of radionuclides from the underground test sites would be suspected if the amount of contamination were significantly greater than could be attributed to worldwide fallout or if an unexpected assemblage of radionuclides were detected. In the *Amchitka Radiobiological Program Final Report July 1970 to December 1979* (DOE 1982), it was determined that no radionuclides from the underground sites were detected, except for tritium from the Long Shot test, which produced increased tritium concentrations in surface water and freshwater plants near the site.

Another DOE program that monitored Amchitka radioactivity levels in groundwater was the Off-Site Environmental Monitoring Program for the Nevada Test Site and Other Test Areas Used for Underground Nuclear Detonations. Amchitka monitoring under this program began in 1977, and since then, sampling has occurred intermittently. Samples were taken from 1977 through 1989, in 1991, in 1993, in 1997, and in 2001. The U.S. Environmental Protection Agency (EPA) carried out this program and monitored Amchitka to measure levels and trends of radioactivity in the off-site environment surrounding testing areas to ensure that radioactive levels comply with existing radiation protection levels.

Over time, the program became known as the Long-Term Hydrological Monitoring Program (LTHMP). In 1997, the LTHMP at Amchitka Island was expanded to include radiobiological sampling and analyses. This change was based on the results of a survey of selected aquatic biota that Greenpeace conducted on the island (Greenpeace 1996). Greenpeace speculated that several long-lived manmade radionuclides were leaking into the surface environment from nuclear test cavities several thousand feet below the surface of the island (DOE 2000). Briefly summarized, the results of the 1997 LTHMP radiobiological sampling indicated there was no evidence for leakage from the underground test cavities into the terrestrial or freshwater environments on Amchitka (DOE 2000; Dasher et al. 2002).

In 2004, the Consortium for Risk Evaluation and Stakeholder Participation II (CRESP), a group of independent universities, composed the *Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposures in the Amchitka Marine Environment* (CRESP 2005). CRESP found that radionuclide levels in marine resources were too low to put people or the environment at risk.

For the samples collected during the upcoming 2011 sampling event, DOE has selected laboratory analytical methods with low detection limits to measure the baseline activities of radionuclides in important biological media, ocean-bottom sediments, and seawater. DOE will also collect baseline data on tritium in seawater. In addition, Star reindeer lichen and soil beneath the lichen will also be collected and tested for cesium-137.

2.0 Project Goals

The collection of biological samples, seawater samples for tritium, marine sediment, and Star reindeer lichen and soil beneath the lichen are the primary objectives of the 2011 sampling effort. These sampling activities are specified in the LTSMP and agreed to with the Stakeholders. The laboratory analytical method detection limits that will be used in the 2011 samples are lower than those used previously. The lower detection limits should provide data that would enable DOE to delineate background activity concentrations of the radionuclides of interest included for analyses as part of the 2011 plan. Data from the 2011 sampling event will be used to assess food safety, and provide baseline activity concentrations that will support quantitative statistical trending analysis with future sampling results. Sampling conducted in 2016 and beyond will include the objective of assessing the statistical trends of activity concentrations in biota, soil, and ocean water.

2.1 Specific Objectives for the 2011 Sampling Event

Consistent with the discussion in the LTSMP and subsequent discussions with the various stakeholders, the primary objective of the 2011 sampling event is to add to the current biological database and provide continued assurance that seafood harvested for the Aleut diet is safe.

In addition to providing data regarding radionuclide levels in harvested seafood, the data will be used to input into the RESRAD-BIOTA code (DOE 2004) to evaluate ecological health relative to the radionuclide levels determined from this sampling event. RESRAD-BIOTA calculates absorbed radiation doses to terrestrial and aquatic species resulting from external and internal exposures. For external exposure, it considers the living pattern of an organism that dwells in the targeted media (e.g., ocean water). For internal exposure, it considers the intake of radionuclides through inhalation and ingestion pathways. RESRAD-BIOTA is a code DOE developed to provide biota concentration guides, which include estimates of radionuclide concentrations that would not exceed recommended dose rate guidelines. We can compare concentrations from collected samples against the biota concentration guides or calculate absorbed doses. The code is based on an independently peer-reviewed and user-tested method.

Seawater will also be collected to determine tritium levels using sensitive, enriched-tritium analyses. The 2011 data will be used to develop baseline tritium information at the biota sampling locations and other previously sampled locations.

Star reindeer lichen, soil underneath the lichen layer, and marine sediment sampling will also be performed on Amchitka and at Adak to provide baseline cesium-137 data. Lichen is a recognized indicator of environmental conditions at a given area because of their documented ability to accumulate deposited radionuclides. The underlying soil also serves as an indicator of deposited radionuclides. Because marine sediment can concentrate particle reactive radionuclides such as cesium-137, this is a useful environmental media to monitor.

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3.0 Project Organization

LM's mission is to manage post-closure responsibilities and ensure the long-term protection of human health and the environment. LM implements its environmental-stewardship mission on Amchitka Island via contracts, work orders, cooperative agreements, and memoranda of understanding (MOUs) with private entities and government agencies.

LM retains the S.M. Stoller Corporation (Stoller) as its Legacy Management Support Services contractor (Figure 3–1). Stoller is a privately owned corporation headquartered in Broomfield, Colorado. Stoller uses the most current management tools to plan the work scope, execute project tasks, measure progress throughout the performance of the project, and provide timely reports with regard to schedule and cost. Stoller helps DOE plan and execute the Amchitka work scope and will continue that function through 2012.

LM retains Argonne National Laboratory (Figure 3–1) through a work order to help develop the biological sampling plan and provide technical support with data analysis, risk assessment (human health and ecological), and other technical issues, as required. Argonne National Laboratory will conduct the RESRAD-BIOTA modeling described in the previous section of this sampling plan.

LM also retains Lawrence Livermore National Laboratory through a work order to provide support in the radionuclide analysis of the biological samples collected in 2011.

LM has a cooperative agreement with Aleutian Pribilof Islands Association Inc. (APIA) (Figure 3–1). APIA is the federally recognized tribal organization of the Aleut people in Alaska, and as such, it enjoys the autonomy accorded a sovereign nation. APIA is an important component of the LM mission at Amchitka Island because APIA represents the interests of, and communicates with, the Aleut people and the Alaska Department of Environmental Conservation (ADEC). APIA actively participates in developing important aspects of work scope related to the LM mission on Amchitka, participates in regular planning meetings, and will assist with specialized sample collection during the 2011 sampling event.

LM has a cooperative agreement with ADEC (Figure 3–1) and regularly meets with team partners from ADEC's Division of Water and Division of Spill Prevention and Response. These two groups collaborate with the University of Alaska Fairbanks (UAF) to plan the sampling campaigns and recommend improvements to the LM sampling plan. Not only will UAF provide technical assistance, but the UAF marine biology team will support the periodic monitoring efforts on Amchitka; its cold-water certified diving group will retrieve biological samples from the marine environment. UAF will also provide a resident review team that will assess the technical validity of the LM mission and the conclusions LM forms.

LM has an MOU with USFWS (Figure 3–1). Amchitka Island is within the Aleutian Island Unit of the Alaska Maritime Refuge, created through an executive order by President William Howard Taft in 1913. The purpose of the MOU between LM and USFWS is to define the roles and responsibilities of both agencies, specify the means of access and egress to Amchitka Island, and explain how LM will exercise institutional controls, if necessary. USFWS will issue access permits to LM in conjunction with the periodic monitoring and sampling events.

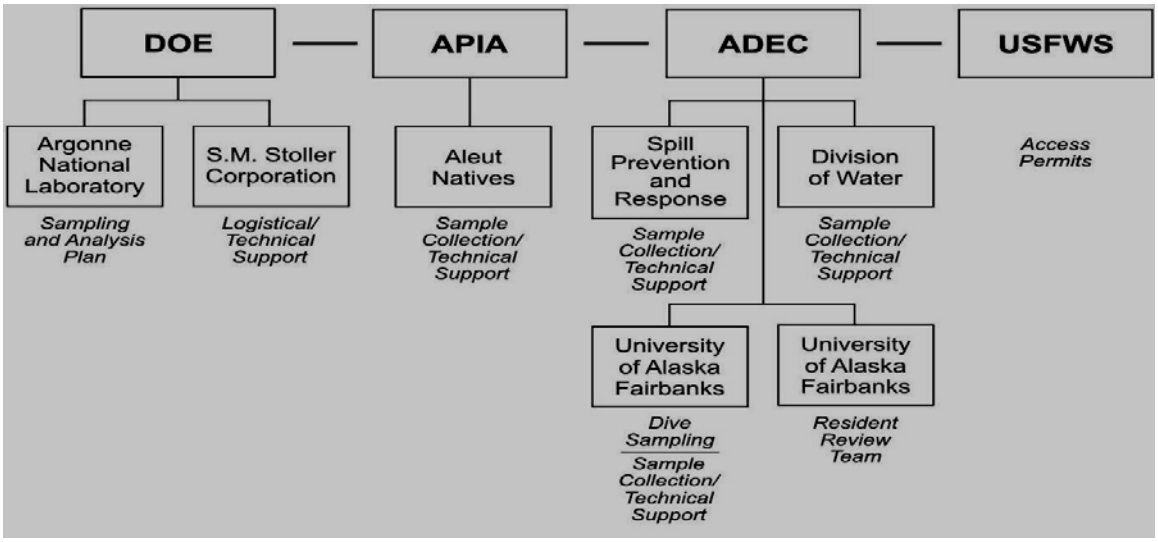

Figure 3–1. Organization Chart

4.0 Data Quality Objectives

Four sets of data quality objectives (DQOs) provide the rationale for the 2011 sampling effort. The first set provides supporting information for the biota sampling event. The second set provides the rationale for using biota data from the first objective for input into the RESRAD-BIOTA code to analyze the potential ecological risks from the radionuclides of interest. The third set supports the collection of tritium data in seawater. The fourth set supports the collection of Star reindeer lichen and soil beneath the lichen and marine sediment.

The DQO process is a strategic planning approach, based on the scientific method, to prepare for an effective data collection. The process clarifies where and when to collect samples, how many samples need to be collected, and the tolerance limits for potential errors in the data results.

4.1 DQOs for Biota Sampling

The seven steps associated with the development of the DQOs for the biological sampling effort are presented below.

4.1.1 State the Problem

Radioactive material remains in the subsurface environment in and adjacent to the test cavities at the three test sites on Amchitka. Biota sampling conducted by CRESP in 2004 indicates that levels of test-related radionuclides in biota (including subsistence- and commercial-catch species) are safe for consumption (CRESP 2005).

Subsistence- and commercial-catch seafood near Amchitka continues to be harvested for consumption; therefore, the presence of selected (test-related) radionuclides will be targeted for analysis to ensure that these seafoods continue to be safe to eat. The 2011 sampling event will provide the first set of data to address the objectives of the LTSMP (2008). Results from the 2011 sampling event will be compared qualitatively to CRESP (2005) results and will also become the basis for future trending to begin in 2016.

4.1.2 Identify the Decision

Data analyses will assess the concentrations of radionuclides from the 2011 samples to determine protectiveness to human health and the environment. Table 4–1 lists concentrations equivalent to 10^{-5} excess risk of cancer for each nuclide for each category of biological species. The excess risk of cancer from exposure to a chemical or radionuclide is described in terms of the probability that an exposed individual will develop cancer by age 70 because of that exposure. These concentrations were estimated based on ingestion rates representative of the Aleut diet as shown in Table 4–2. The CRESP data collected in 2004 indicate that levels were within or below the acceptable risk range of 10^{-4} to 10^{-6} excess risk of cancer (see Table 4–3). The 2004 samples and their respective radionuclide concentrations were determined to be safe for consumption; risk levels based on these data were presented in the LTSMP and are included in Table 4–3. The risk estimates shown in Table 4–3 were calculated using the maximum 2004 radionuclide levels. Risk calculations for the 2011 samples will be based on 95 percent upper confidence limit (UCL95) of the mean as the exposure point concentration, assuming that an adequate number of samples are successfully collected, analyzed, and validated.

Table 4–1. Comparison of 2004 Radionuclide Concentrations to the Diet-Based Risk Equivalent Concentration

Species to Be Sampled	Radionuclide Analysis	10^{-5} Diet-Based Risk Equivalent Concentration[a] (pCi/kg ww)	2004 Amchitka[b] Max Detected (pCi/kg ww)	2004 Kiska[b] Max Detected (pCi/kg ww)
Dolly Varden, rockfish (dusky or black), halibut, Cod, greenling (kelp or rock), Red or Yellow Irish Lord	Cesium-137	80	30	8.5
	Americium-241	22	<MDA	0.78
	Plutonium-239	17	0.47	<MDA
	Plutonium-240	17	0.47	<MDA
	Uranium-234	25	32	59
	Uranium-235	31	1.3	3.1
	Uranium-238	31	20	50
Glaucous-winged Gull egg Octopus	Cesium-137	240	8.2	<MDA
	Americium-241	67	<MDA	0.67
	Plutonium-239	52	<MDA	Not sampled
	Plutonium-240	52	<MDA	Not sampled
	Uranium-234	74	NA	NA
	Uranium-235	92	NA	NA
	Uranium-238	92	NA	NA
Green sea urchin, Blue mussel, Gumboot chiton	Cesium-137	480	<MDA	<MDA
	Americium-241	130	<MDA	0.67
	Plutonium-239	100	<MDA	<MDA
	Plutonium-240	100	<MDA	<MDA
	Uranium-234	150	23	26
	Uranium-235	180	1.2	<MDA
	Uranium-238	180	22	23

[a] Based on Aleut diet of 10 ounces of fish per day, 4 ounces of mammals per day, 2 ounces of crustaceans per day, and 2 ounces of mollusks per day.

[b] Maximum values based on CRESP data reported in 2004. All values rounded to two significant figures. Samples were collected on Amchitka and Kiska Islands, in or over the ocean at both islands, and from trawls near both islands. Results found to be false positives by CRESP are excluded from the table.

pCi/kg = picocuries per kilogram

<MDA = all samples below the minimum detectable activity

"NA" indicates the radionuclide was not analyzed for in the samples.

ww = wet weight

Table 4–2. Aleut Dietary Intake

Type of Food	Average Yearly Intake of 3-Ounce Portions	
	Portions	Grams
Halibut (includes cooked and dried)	304	25,854.7
Silver salmon (includes cooked, raw, smoked, and dried)	256.8	21,840.4
Red salmon (includes cooked, raw, smoked, and dried)	232.9	19,813.4
Pink salmon (includes cooked, raw, smoked, and dried)	174.2	14,815.4
Geese (includes geese, Aleutian geese, Canadian geese, and Black Brandt geese)	84.9	7,720.6
Dolly Varden	82.5	7,016.5
Seal oil (includes seal oil, harbor/hair seal oil, and northern fur seal oil)	61.2	5,204.9
Pintail duck	55.8	4,745.7
Cod	48.5	4,068.2
Reindeer meat	35.5	3,019.2
Putschke	30.5	2,594.0
Badarki	23.1	1,964.6
Mussels	23.1	1,964.6
Black duck	22.0	1,871.1
Pitruske	21.8	1,845.1
Teal	19.4	1,649.9
Sea lion meat	17.8	1,513.8
Scoter duck	14.2	1,207.7
Sea lion oil	12.9	1,097.0
King salmon	12.8	1,088.6
Gull eggs	12.6	1,071.6
High bush salmonberries	10.5	893.0
Moose	9.8	833.0
Blueberries	9.1	773.9
Octopus	8.0	680.4
Crowberries (also called blackberries and mossberries)	7.3	620.8
Sea bass	5.8	504.6
Harbor seal meat	4.5	354.3
Sea urchin	4.0	340.2
King crab	2.2	187.1
Northern fur seal meat	1.8	153.1
Low bush salmonberries	1.5	127.5
Shrimp	0.5	42.5
Snow crab	0.1	8.5

Data taken from Hamrick and Smith (2003)

Table 4–3. Maximum Detected Radionuclide Concentrations in Biota from Amchitka and Kiska Islands (2004) and the Corresponding Estimated Risk for the Ingestion Pathway Based on the Aleut Diet Intake Amounts. All units are pCi/kg[a].

Biota	Number of Samples	Cesium-137	Americium-241	Plutonium-239	Plutonium-240	Uranium-234	Uranium-235	Uranium-238	Total[b]
Dragon kelp	27	<MDA	<MDA (NC)	5.6 (NC)	5.6 (NC)	56 (NC)	4.3 (NC)	57 (NC)	NC
Rockweed	20	<MDA	0.94 (NC)	<MDA	1.6 (NC)	140 (NC)	6.9 (NC)	120 (NC)	NC
Gumboot Chiton	1	<MDA	<MDA	NA	NA	NA	NA	NA	NA
Blue Mussel	11	<MDA	0.67 ($5x10^{-8}$)	<MDA	<MDA	26 ($1x10^{-6}$)	1.2 ($7x10^{-8}$)	23 ($2x10^{-6}$)	$3x10^{-6}$
Green Sea Urchin	7	<MDA	<MDA	NA	NA	NA	NA	NA	NA
Octopus	4	8.2 ($3x10^{-7}$)	<MDA	NA	NA	NA	NA	NA	$3x10^{-7}$
Dolly Varden	10	21($3x10^{-6}$)	<MDA	NA	NA	NA	NA	NA	3x10-6
Black Rockfish	23	5.1($6x10^{-7}$)	0.78 ($4x10^{-7}$)	<MDA	<MDA	59 ($2x10^{-5}$)	3.1($1x10^{-6}$)	50 ($2x10^{-5}$)	$4x10^{-5}$
Rock Greenling	36	<MDA	<MDA	NA	NA	NA	NA	NA	NA
Red Irish Lord	8	<MDA	<MDA	NA	NA	NA	NA	NA	NA
Yellow Irish Lord	28	30 ($4x10^{-6}$)	<MDA	<MDA	<MDA	15 ($5x10^{-6}$)	<MDA	16 ($6x10^{-6}$)	$2x10^{-5}$
Halibut	9	12 ($2x10^{-6}$)	<MDA	0.47 ($3x10^{-7}$)	0.47 ($3x10^{-7}$)	32 ($1x10^{-5}$)	1.3 ($4x10^{-7}$)	20 ($8x10^{-6}$)	$2x10^{-5}$
Pacific Cod	54	16 ($2x10^{-6}$)	0.39 ($2x10^{-7}$)	<MDA	<MDA	7.8 ($3x10^{-6}$)	<MDA	7 ($3x10^{-6}$)	$8x10^{-6}$
Glaucous-winged Gull Egg	2	<MDA	<MDA	NA	NA	NA	NA	NA	NA

pCi/kg = Picocuries per kilogram
CRESP data from 2004. Samples collected on Amchitka and Kiska islands, in or over the ocean at Amchitka and Kiska islands, and from ocean trawls near Amchitka and Kiska islands. Results found to be false positives by CRESP are excluded from the table.
"<MDA" indicates that all samples were below the minimum detectable activity for the particular radionuclide.
"NA" indicates the radionuclide was not analyzed for in the samples.
Values in parenthesis are risk equivalent values and are presented to one significant figure.
"NC" indicates that risk equivalent was not calculated as the given species is not part of the diet.
[a] The risk estimates are based on assuming 18 ounces per day intake for 364 days per year. The 18 ounces would consist of 10 ounces of fish, 4 ounces of mammal (including oils), 2 ounces each of crustaceans and mollusks.
[b] Based on the values given in Table 4–3, an example diet of 10 ounces of Black Rockfish (maximum risk equivalent value for the Fish group), 4 ounces of Octopus (maximum risk equivalent value for the Mammals group), and 4 ounces of Blue Mussel (maximum value for Mussel/Crustacean groups), the total estimated risk Would be about 4 x 10^{-5}.
Shaded boxes contain Kiska data.

4.1.3 Identify the Inputs to the Decision

The safety of consuming subsistence and commercial catches near Amchitka is addressed by establishing the following information:

- Radionuclide concentrations equivalent to the 10^{-5} excess risk of cancer based on Aleut diet (Table 4–1)
- Species and dietary intake amounts included in the Aleut diet (Table 4–2)
- Selected species and radionuclides of interest (Table 4–4)
- Species and sample collection philosophy (Table 4–5)
- Adequate number of samples to be collected (Table 4–6)
- Appropriate sampling locations
- Adequately sensitive analytical methods and detection limits

Table 4–1 presents maximum concentrations reported in 2004. The 2004 data were considered safe (i.e., fall within the acceptable risk range of 10^{-4} to 10^{-6} recommended by the EPA); see Table 4–3. For the 2011 data, follow-up actions would be considered if radionuclide concentrations in the biota were to exceed the diet-based 10^{-5} excess risk of cancer equivalent concentrations developed for this plan (also shown in Table 4–1). However, since the 2004 data which were considered safe already indicated concentrations greater than the 10^{-5} diet-based risk equivalent for some species and some radionuclides, i.e., uranium isotopes (see Table 4–1), any decisions to conduct follow-up actions would have to take the 2004 levels into consideration.

Stakeholders will be notified immediately if radionuclide concentrations in the biota differ significantly from background and global fallout, and exceed the diet-based 10^{-5} excess risk of cancer developed for this plan.

4.1.4 Define the Study Boundaries

To meet the objective of qualitatively comparing the 2011 data to the 2004 data, the sampling locations will be in the same general areas as those included in the CRESP sampling event with one exception: Adak Island, instead of Kiska Island, would be the new reference location. The Amchitka working group selected Adak as the reference location for the 2011 sampling event because Adak is easier to access for sampling purposes. It is expected that like Kiska, data from Adak would be representative of an area considered to be not influenced by the underground tests conducted at Amchitka and would therefore provide data useful for comparison with the Amchitka data.

Section 5.0 describes the locations and why they were selected. Values representative of global fallout for the radionuclides of interest will be established by the Amchitka working group to be used to compare against the 2011 sampling results and will be presented in subsequent reports that summarize the 2011 sampling event.

The period of sampling will be from June to July in 2011. Section 6.0 presents a sampling schedule.

Table 4–4. Amchitka Monitoring: Sample Species and Radionuclides Selected for Analysis

Species to Be Sampled	Cesium-137 (gamma spectroscopy)	Americium-241	Plutonium-239	Plutonium-240	Uranium-234	Uranium-235	Uranium-238	Enriched Tritium
Ocean Sampling								
Dragon kelp (*Eualaria*)	X	X	X	X	X	X	X	
Chiton (*Cryptochiton stelleri*)	X	X	X	X	X	X	X	
Horse mussel (*Modiolus modiolus*)	X	X	X	X	X	X	X	
Sea urchin (*Strongylocentrotus spp*)	X	X	X	X	X	X	X	
Octopus (*Enteroctopus dofleini*)	X	X	X	X	X	X	X	
Rockfish (*Sebastes spp*), greenling (*Hexagrammos spp*), and/or Irish lord (*Hemilepidotus spp)*	X	X	X	X	X	X	X	
Halibut (*Hippoglossus stenolepis*)	X	X	X	X	X	X	X	
Pacific cod (*Gadus macrocephalus*)	X	X	X	X	X	X	X	
Seawater								X
Marine Sediment	X							
Terrestrial Sampling								
Blue mussel (*Mytilus trossulus*)	X	X	X	X	X	X	X	
Rockweed (*Fucus distichus*)	X	X	X	X	X	X	X	
Star reindeer lichen (*Cladina stellaris*)	X							
Glaucous-winged gull (*Larus glaucescens*) eggs	X	X	X	X	X	X	X	
Dolly Varden (*Salvelinus malma*)	X	X	X	X	X	X	X	
Soil[a]	X							

[a] Soil will be collected from beneath the lichen sample.

Table 4–5. Amchitka Monitoring: Sample Species and Collection Philosophy

Species to Be Sampled	Diver-Collected	Hook-and-Line Caught	Collected by Hand from Land
Ocean Sampling			
Dragon kelp (*Eualaria*)	X	-	-
Chiton (*Cryptochiton stelleri*)	X	-	-
Horse mussel (*Modiolus modiolus*)	X	-	-
Sea urchin (*Strongylocentrotus spp*)	X	-	-
Octopus (*Enteroctopus dofleini*)	X	-	-
Rockfish (*Sebastes spp*), greenling (*Hexagrammos spp*), and/or Irish lord (*Hemilepidotus spp)*	X	X	-
Halibut (*Hippoglossus stenolepis*)	-	X	-
Pacific cod (*Gadus macrocephalus*)	-	X	-
Seawater	X[a]	-	-
Marine sediment	X		
Terrestrial Sampling			
Blue mussel (*Mytilus trossulus*)	-	-	X
Rockweed (*Fucus distichus*)	-	-	X
Star reindeer lichen (*Cladina stellaris*)	-	-	X
Glaucous-winged gull (*Larus glaucescens*) eggs	-	-	X
Dolly Varden (*Salvelinus malma*)	-	X	-
Soil[b]	-	-	X

[a] Seawater will also be collected from the vessel off the shoreline of the Cannikin site.
[b] Soil from beneath the lichen will be collected.

4.1.5 Develop a Decision Rule

(1) If the concentrations at Adak for a given species and analyte are equal to or greater than the Amchitka samples and are all lower than 10^{-5} risk equivalent, data would be documented and used for comparison (as baseline) against future (2016) data.

(2) If the Amchitka concentrations are higher than the Adak and global fallout concentrations but lower than the diet-based 10^{-5} excess risk of cancer concentrations, the Alaska Stakeholder group will be notified to discuss the need for follow-up activities.

(3) If radionuclide concentrations are higher than the diet-based 10^{-5} excess risk of cancer levels, the Alaska Stakeholder group will be notified to discuss the need for follow-up activities; this discussion would take into account 2004 data. Follow-up action could include a reanalysis of archived samples from LM's 2011 sampling event.

Table 4–6. Amchitka Island 2011 Biological Sampling Event Field Collection Sampling Requirements

Species	Sample Wet Weight Needed (Kg)	Average Weight per Species per Sample (Kg)	Number of Specimens Required for Sample Weight Requirement	Cannikin				Long Shot				Milrow				Adak North				Adak South				Total Number of Samples
				T1[a]	T2	T3	D[b]	T1	T2	T3	D	T1	T2	T3	D	T1	T2	T3	D	T1	T2	T3	D	
Ocean Sampling																								
Dragon kelp[d]	5	>10	1	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	50
Chiton	0.5	0.5	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	15
Horse mussel[e]	0.1	0.01	10	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	15
Sea urchin	0.5	0.05	10	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	15
Octopus	5	>5	1	1[f]			0	1[f]			0	1[f]			0	1[f]			0	1[f]			0	5
Black or dusky rockfish	0.5	~0.5	1-3	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	50
Rock or kelp greenling/red or yellow Irish lord	0.5	~0.25	1-3	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	50
Rockfish, greenling and Irish Lords	0.5	~0.25	1-3	1[g]			0	1[g]			0	1[g]			0	1[g]			0	1[g]			0	5
Halibut	5	>5	1	1[f]			0	1[f]			0	1[f]			0	1[f]			0	1[f]			0	5
Pacific cod	5	>5	1-3	1[f]			0	1[f]			0	1[f]			0	1[f]			0	1[f]			0	5
Seawater (diver-collected)[h]	NA[c]	NA	NA	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	50
Seawater (collected from vessel)[i]	NA	NA	NA	66																				66
Marine sediment[j]	NA	NA	NA	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	15
																							Total number of samples	**346**
Terrestrial Sampling																								
Blue mussel[e]	0.1	0.01	10	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	15
Rockweed	5	~0.5	10	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	3	3	3	1	50
Star reindeer lichen[k]	0.5	~0.1	6																					6
Soil beneath lichen[l]	NA	NA	6																					6
Gull eggs[m]	2	0.1	20																					2
Dolly Varden[n]	3	~0.25	12																					2
																							Total number of samples	**81**

[a] T1, T2, and T3 represent transects.
[b] D = duplicate sample to be taken.
[c] NA = not applicable.
[d] Sample volume to be of sufficient size to provide a sample split with UAF.
[e] Due to lack of blue mussel adjacent Amchitka and Adak, horse mussel has been substituted. Blue mussels will be collected where available from the intertidal area.
[f] One sample of adequate size per site for octopus and halibut and one to three samples for Pacific cod.
[g] One to three samples collected in deeper waters off the coastline of the sample transects area.
[h] One 1-liter high density polyethylene bottle will be filled.
[i] Two depths, ~2 feet below surface and ~2 feet off bottom. Includes three duplicates.
[j] Three wide mouth, square, 16 oz. HDPE bottles will be filled with surface marine sediment (to 5 centimeters deep) to accommodate UAF grain size analyses and analytical testing.
[k] Sample area to be three, 1-meter^2, sample areas on Amchitka and Adak Islands. Split sample with UAF.
[l] Soil beneath lichen will be sampled. Split sample with UAF.
[m] Up to 20 eggs will be collected from each of Amchitka and Adak Islands.
[n] Sample size is 3 kilograms and will be collected from Cannikin Lake and, if available, at Adak.

4.1.6 Specify Tolerance Limits on Decision Errors

Data will be analyzed by comparing the UCL95 with the diet-based 10^{-5} excess risk of cancer levels.

4.1.7 Optimize the Design

Table 4–6 presents the planned number of samples to be collected. EPA recommends the collection of 9 to 10 samples at contaminated sites to support a statistical analysis of results. The number of samples planned for the 2011 event satisfies this recommendation with the exception of that for a few species (e.g., Halibut, octopus, and gull eggs) for which fewer samples are planned to be collected for logistical reasons. The statistical analysis would answer the following questions (as incorporated into Step 1 of the DQO for biological sampling): (1) are the radionuclide concentrations in the biota samples protective of the Aleut diet (from the ingestion of both subsistence and commercial catch), and (2) are the concentrations similar to the reference location (Adak), global fallout, or to historical data (e.g., 2004 CRESP data)?

A statistical analysis indicated that as few as three samples could be an adequate number and would answer the following questions (as incorporated into Step 1 of the DQO for biological sampling) with 95 percent confidence: (1) are the radionuclide concentrations in the biota samples protective of the Aleut diet (from the ingestion of both subsistence and commercial catch), and (2) are the concentrations similar to the reference location (Adak), global fallout, or to 2004 CRESP data?

The statistical analysis considered assumed expected values (based on CRESP data), an assumed sample distribution (based on RESRAD-BIOTA default fish-food transfer factors for the radionuclides of interest), and health-based levels.

4.2 DQOs for Input to Ecological Health Evaluation (Via Modeling Using the RESRAD-BIOTA Code)

The seven steps associated with the development of DQOs for input to the RESRAD-BIOTA code are presented below.

4.2.1 State the Problem

Evaluate the ecological health of the biota species collected as part of the sampling discussed in Section 4.1.

4.2.2 Identify the Decision

Based on the concentrations of radionuclides collected under Section 4.1, determine how radionuclide levels compare to both 2004 CRESP data and the DOE/International Atomic Energy Agency (IAEA) guideline of 1 rad per day (IAEA 2009).

4.2.3 Identify the Inputs to the Decision

The radionuclide concentrations outlined in Section 4.1 will be used for input into the RESRAD-BIOTA code. The results of the code for each nuclide and species will be compared to the DOE/IAEA guideline of 1 rad per day (IAEA 2009).

4.2.4 Define the Study Boundaries

See Section 4.1.4.

4.2.5 Develop a Decision Rule

If radionuclide concentrations indicated that the ecological health index is below the guideline, no further data analysis will be performed. If the results of the code indicated that the ecological health index was greater than the guideline of 1 rad per day, additional ecological health analyses may be warranted.

4.2.6 Specify Tolerance Limits on Decision Errors

See Section 4.1.6.

4.2.7 Optimize the Design

See Section 4.1.7.

4.3 DQOs for Determining Baseline Tritium Concentrations at Amchitka

The seven steps associated with the development of the DQOs for collecting data for determining baseline tritium concentrations at Amchitka are presented below.

4.3.1 State the Problem

Radioactive materials remain in the subsurface test cavities of the three nuclear test sites on Amchitka Island. The results from numerous historical sampling events have not, either individually or collectively, adequately addressed whether measured values of tritium in seawater near Amchitka are from global fallout sources or whether they are related to the Amchitka nuclear tests.

4.3.2 Identify the Decision

The analytical data will be used to establish the initial baseline tritium concentrations in seawater near Amchitka and Adak, which is the reference site for the long-term monitoring program for the Amchitka project.

The baseline tritium data from the upcoming 2011 sampling event will be compared to available data from previous sampling events conducted by other researchers. The comparison will show whether the activity of tritium in the marine environment surrounding Amchitka and Adak is similar to global fallout concentrations. Data will be collected in subsequent samplings (i.e., in 2016 and during sampling events thereafter) to analyze trends.

Previous modeling of the three Amchitka test sites (Hassan et al. 2002) indicates that radionuclides may arrive at the seafloor as early as 25 or 30 years, or as late as 2,000 or more years, after release from the cavity, depending on the combination of model parameters.

4.3.3 Identify the Inputs to the Decision

The determination of whether tritium concentrations from seawater at Amchitka are similar to global fallout concentrations is addressed by:

- Collecting seawater samples from Amchitka and Adak sampling locations for tritium analysis.
- Ensuring that tritium laboratory methods are adequately sensitive to detect 1 picocurie per liter (pCi/L) or lower concentrations.
- Identifying available data sets to generate global fallout tritium concentrations.
- Generating 2011 tritium statistics for Amchitka and Adak to be compared to global fallout tritium statistics or concentrations.

4.3.4 Define the Study Boundaries

To meet the objective of comparing the 2011 data to global fallout data, the sampling locations will be in areas at Amchitka where biological sampling is also occurring in 2011 and that are near a previously sampled area (Dasher and Jewett 2007). In addition, sampling locations at Adak will provide baseline tritium data at the reference site. Section 5.0 of this sampling plan describes the sampling locations and why they were selected. The period of sampling will be from June to July in 2011.

4.3.5 Develop a Decision Rule

Tritium statistics for 2011 will be compared to global fallout concentrations. If tritium concentrations in seawater near Amchitka are similar to those at Adak (the background or reference site), no further activity will be undertaken until the next scheduled sampling event. Collected data will be documented in the project database as initial baseline concentrations. Trending analyses will be conducted for data collected in the 2016 events and thereafter.

4.3.6 Specify Tolerance Limits on Decision Errors

The tolerance limit for decision errors will be established in future sampling events when data trending begins.

4.3.7 Optimize the Design

Seawater samples collected near the biota sampling locations will be analyzed for tritium activity using a method that could achieve a minimum detection concentration (MDC) of less than 1 pCi/L. A statistically adequate number of samples would be taken, and the samples would be similar to those discussed in Section 4.1.7. The planned number of samples is 10 for each site, which should be adequate for establishing a baseline and comparing the 2011 data set to previous studies. To establish a baseline at both Amchitka and Adak for comparison to global fallout concentrations, it is expected that an average value will be sufficient for the 2011 sampling

event. Therefore, an average, a UCL95 (to address data sets with outliers), or both will be calculated, as appropriate. Data sets with outliers will also be given consideration in planning the 2016 sampling event. A minimum of three samples will be collected at each of the identified transects. One duplicate sample will then be collected from one of the three transects from each site.

4.4 DQOs for Determining Cesium-137 Concentrations in Lichen, Soil Beneath Lichen, and Marine Sediment at Amchitka and Adak

The seven steps associated with the development of the DQOs for collecting data for determining cesium-137 concentrations in Star reindeer lichen, soil beneath the lichen, and marine sediment at Amchitka and Adak are presented below.

4.4.1 State the Problem

Radioactive materials remain in the subsurface test cavities of the three nuclear test sites on Amchitka Island. Star reindeer lichen, soil beneath the lichen, and marine sediment at Amchitka and the reference Adak Site could provide information on whether the Star reindeer lichen or marine sediment have retained radionuclides and could provide additional data to support the interpretation of environmental monitoring results being collected for the Amchitka Site.

4.4.2 Identify the Decision

The analytical data will be used to establish baseline radionuclide (cesium-137) concentrations in Star reindeer lichen, the soil beneath the lichen, and marine sediment. The data from the upcoming 2011 sampling event will be compared against available data from literature sources or previous sampling events if available. Indications of uptake by Star reindeer lichen, the soil beneath the lichen, and marine sediment will be considered in the planning for the 2016 data collection.

4.4.3 Identify the Inputs to the Decision

The determination of whether cesium-137 concentrations in Star reindeer lichen, the soil beneath the lichen, and marine sediment are indicated is addressed by:

- Collecting Star reindeer lichen samples from Amchitka and Adak.
- Collecting soil samples from beneath the lichen at Amchitka and Adak.
- Collecting marine sediment from the seafloor at Amchitka and Adak.
- Identifying available data sets (e.g., representing global fallout levels) to be compared to the 2011 data.
- Generating 2011 statistics for Amchitka and Adak to be used for the comparison.

4.4.4 Define the Study Boundaries

Section 5.0 of this sampling plan describes the sampling locations and why they were selected. The period of sampling will be from June to July in 2011.

4.4.5 Develop a Decision Rule

Data from the 2011 samples of Star reindeer lichen and marine sediment will be compared to data generated by other studies. Collected data will be considered baseline data and documented in the project database.

Data will be collected in future sampling events to analyze trends, as needed.

4.4.6 Specify Tolerance Limits on Decision Errors

Essentially, the determination will be whether concentrations of cesium-137 in the Star reindeer lichen and marine sediment samples are detectable and, if so, what the cesium-137 levels are.

4.4.7 Optimize the Design

Star reindeer lichen, the soil beneath the lichen, and marine sediment samples will be collected at Amchitka and Adak sampling locations as described in Section 5.0.

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5.0 Sampling Elements

The following sampling elements will be described and developed for implementation in 2011 and be in accordance with the DQOs in Section 4.0 of this sampling plan.

5.1 Analytes

Analytes for the biota samples will be cesium-137, americium-241, plutonium-239 and -240, and uranium-234, -235, and -238. Tritium will be analyzed in seawater samples that will also be collected. The Star reindeer lichen, soil beneath the lichen and marine sediment samples will be analyzed for cesium-137. Table 5–1 lists the analytes and the corresponding detection limits achieved by the analytical methods given.

Table 5–1. Laboratory Method and Estimated Minimum Detection Activity

Analytes	Laboratory Method	Estimated MDA (in pCi)	Apriori MDC (in pCi/kg-wet weight)[a]		
			Based on 100 g Sample	Based on 1,000 g Sample	Based on 5,000 g Sample
Cs-137	Beta	0.3	3	0.3	0.06
Am-241	Alpha	0.03	0.3	0.03	0.006
Pu-239	Quad ICP-MS	0.008	0.08	0.008	0.0016
Pu-240	Quad ICP-MS	0.02	0.2	0.02	0.004
U-238	Quad ICP-MS	3×10^{-7}	3×10^{-6}	3×10^{-7}	6×10^{-8}
U-235	Quad ICP-MS	3×10^{-6}	3×10^{-5}	3×10^{-6}	6×10^{-7}
U-234	Quad ICP-MS	0.003	0.03	0.003	6×10^{-4}

[a] On the basis of the analytical methods identified in this table, a sample size of 0.1 kg on wet-weight basis is indicated to be generally adequate for the radionuclide concentrations of interest (see Tables 4-1 and 4-3), however, to provide ample sample size to further optimize laboratory efficiency, a sample size of 1 kg or greater would be considered, as field conditions allow. Sample sizes indicated on Tables 4-6 and 5-4 reflect realistic sample sizes that considered expected field and other practical limitations determined by the Amchitka Working group.

5.2 Sampling Locations and Sample Nomenclature

Figure 5–1 shows the proposed biological sampling locations for Amchitka Island. Figure 5–2 and Figure 5–3 show the proposed biological sampling locations for Adak Island, the reference sampling location: Figure 5–2 shows the locations for North Adak, and Figure 5–3 shows the locations for South Adak. The exact background sampling locations for North and South Adak have not been determined—hence the three options for North and South Adak. When the sampling begins off the coastline of Adak Island, the sampling team will have the discretion to choose one of three optional sampling locations off the north and south coasts of Adak Island. Figure 5–4 through Figure 5–6 show the three possible sampling locations at North Adak, and Figure 5–7 through Figure 5–9 show the three possible sampling locations at South Adak.

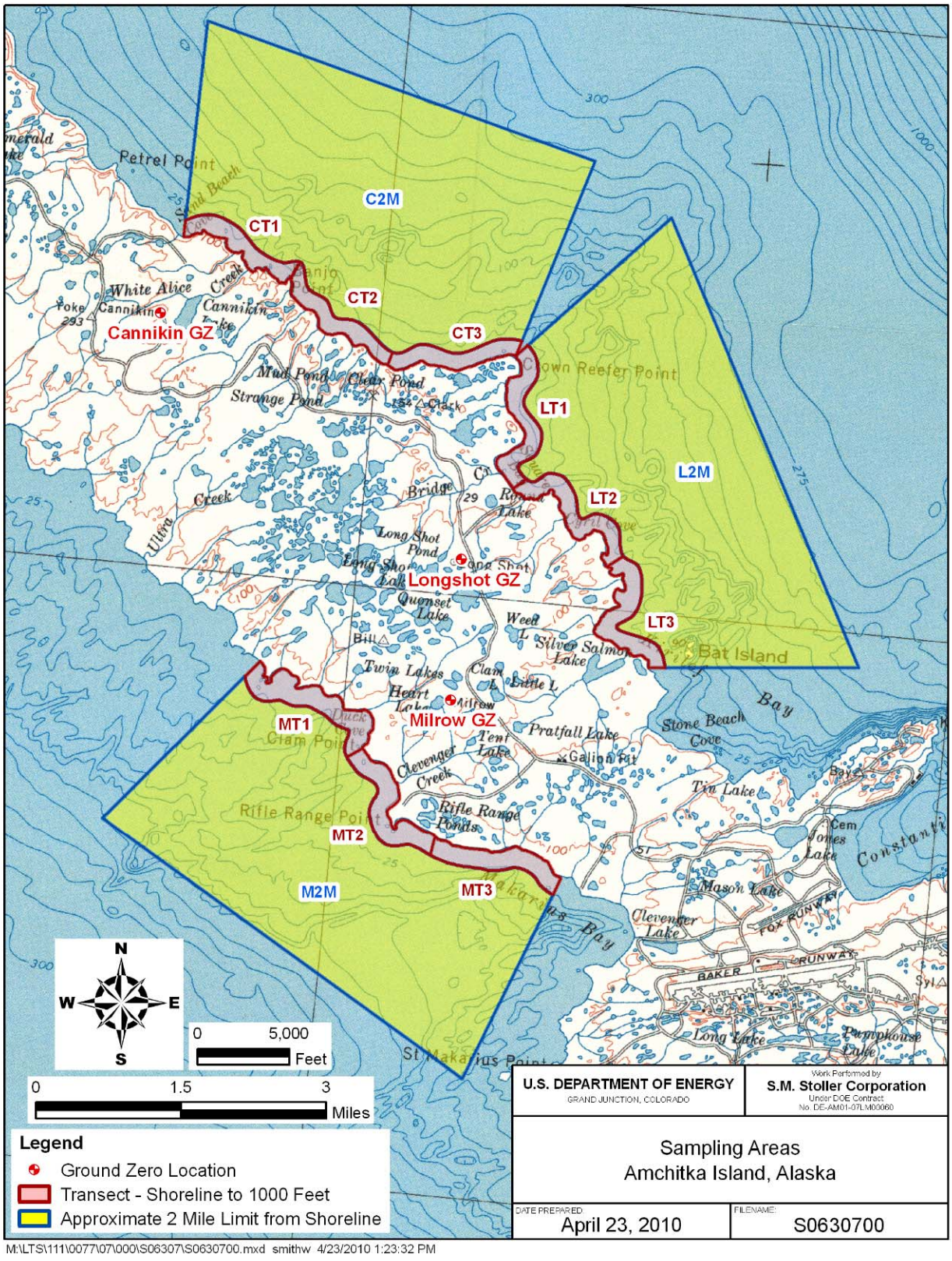

Figure 5–1. Sampling Areas, Amchitka Island, Alaska

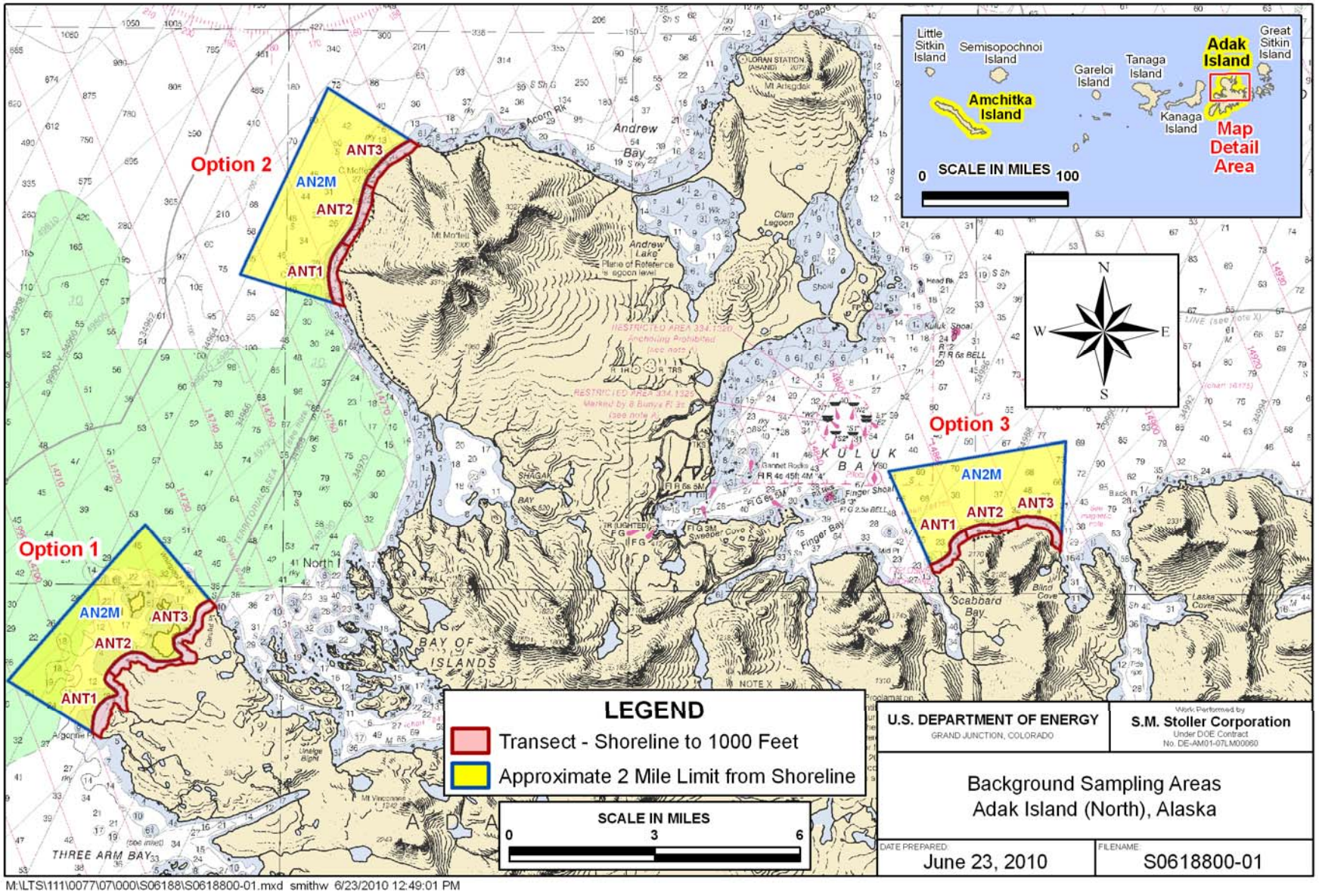

Figure 5–2. Amchitka Sampling Background Reference Sites, Adak Island (North), Alaska

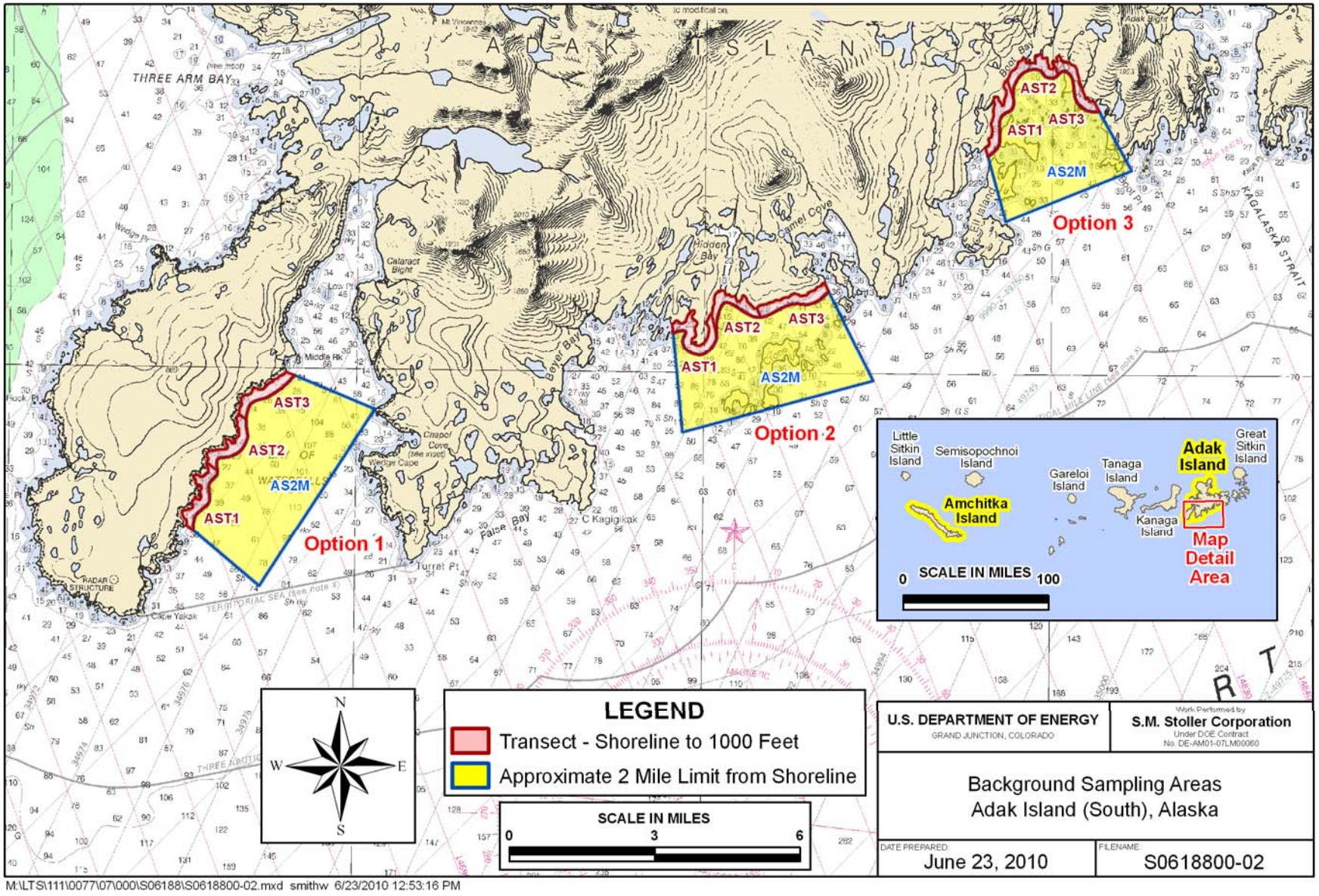

Figure 5–3. Amchitka Sampling Background Reference Sites, Adak Island (South), Alaska

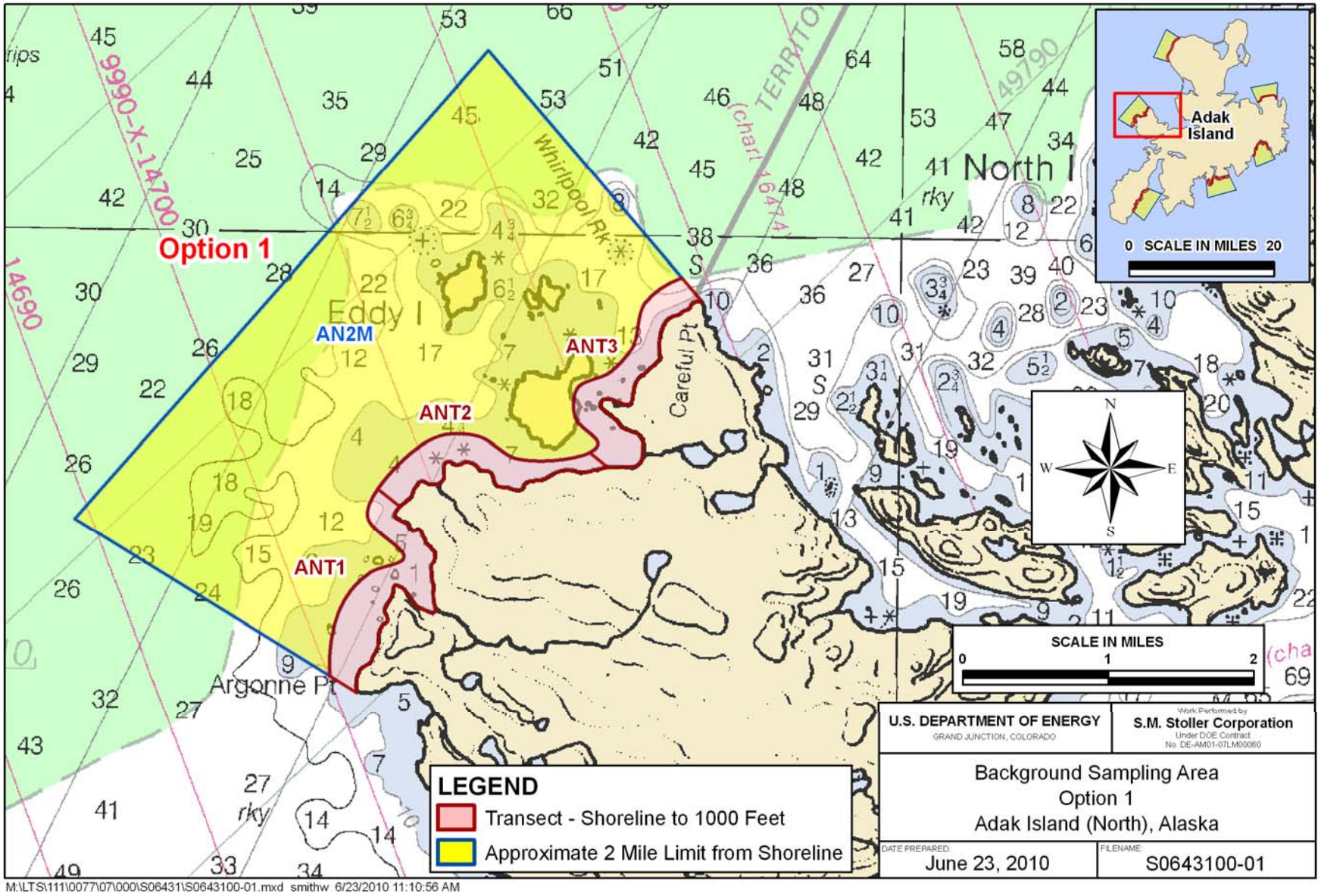

Figure 5–4. Amchitka Sampling Background Reference Site - Option 1 Adak Island (North), Alaska

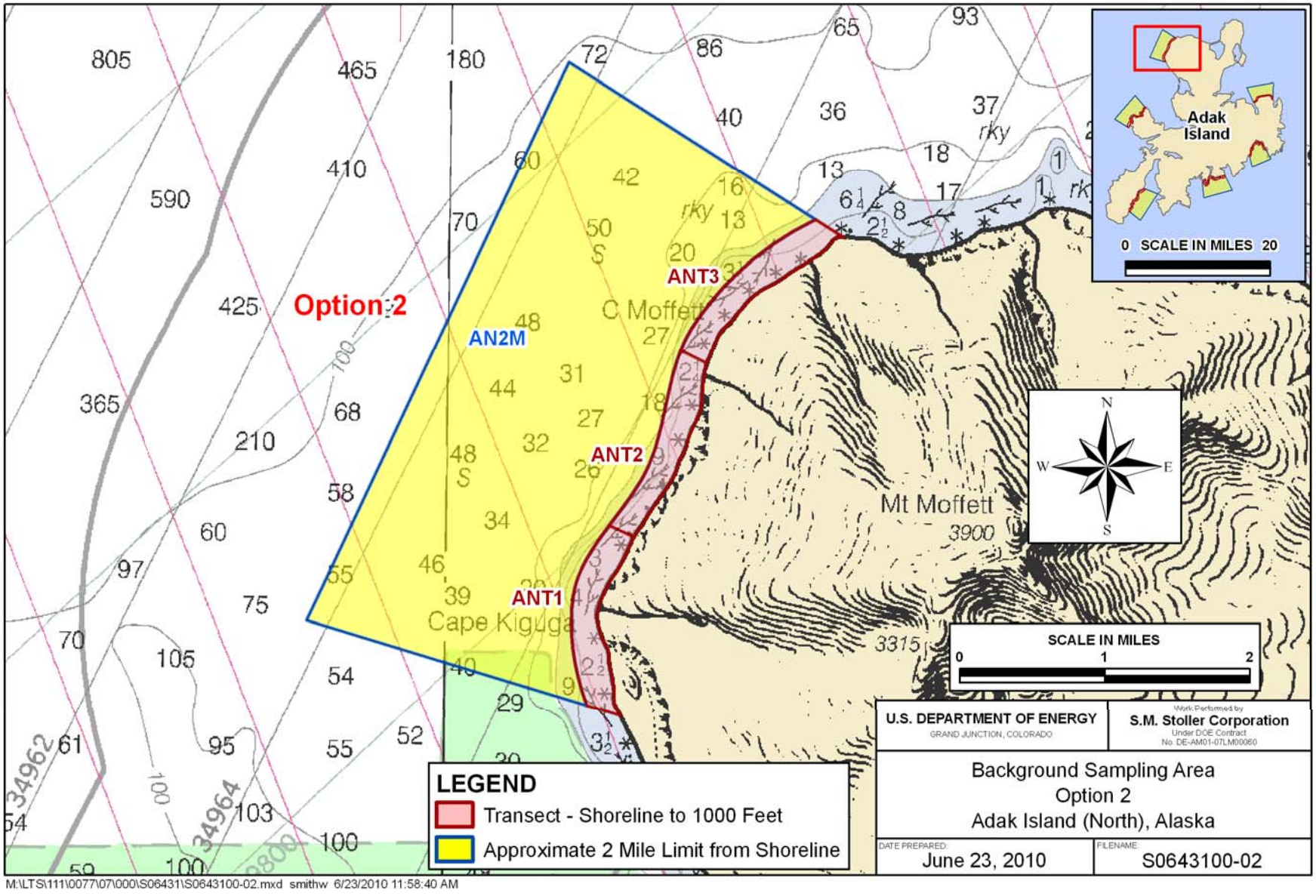

Figure 5–5. Amchitka Sampling Background Reference Site - Option 2 Adak Island (North), Alaska

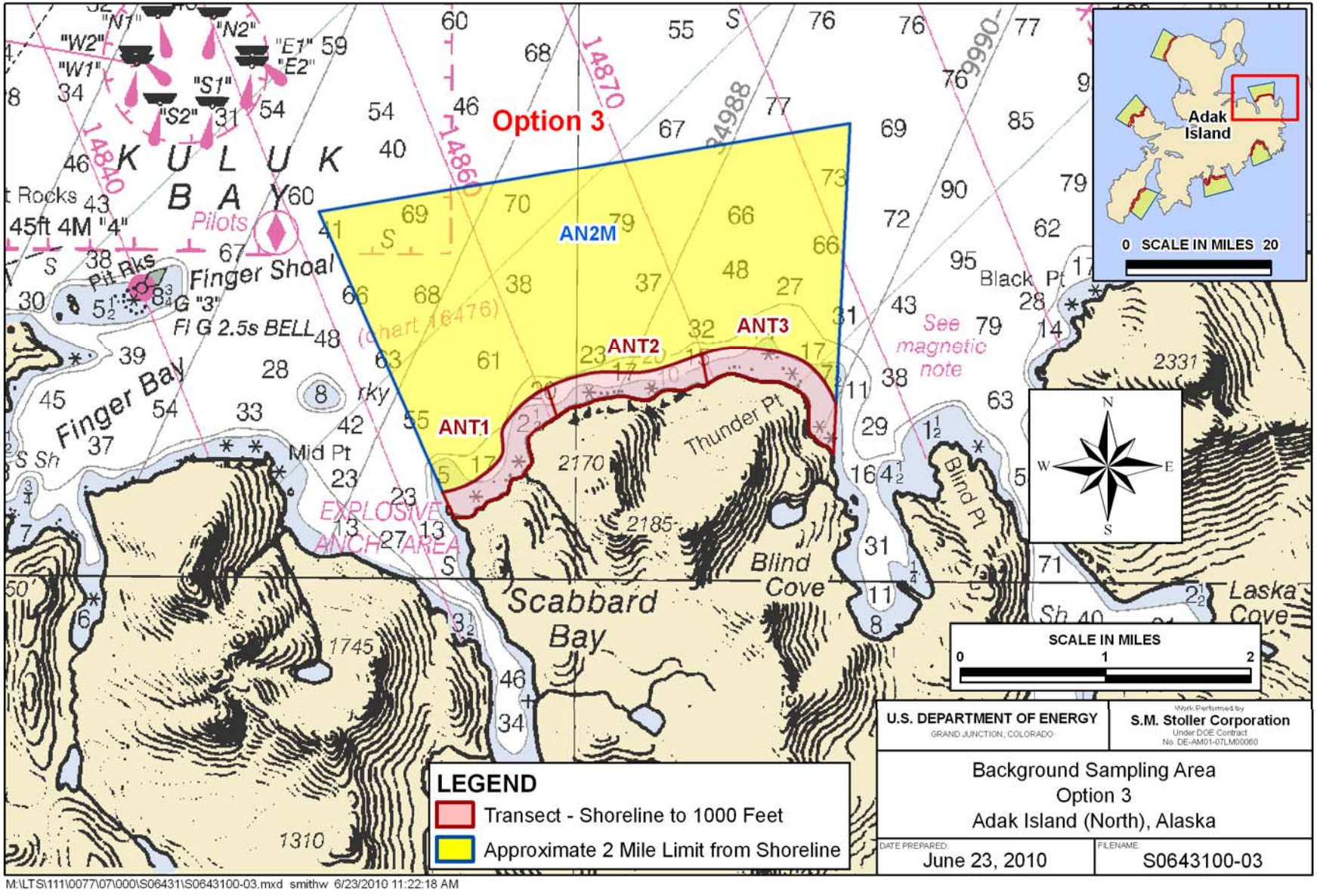

Figure 5–6. Amchitka Sampling Background Reference Site - Option 3 Adak Island (North), Alaska

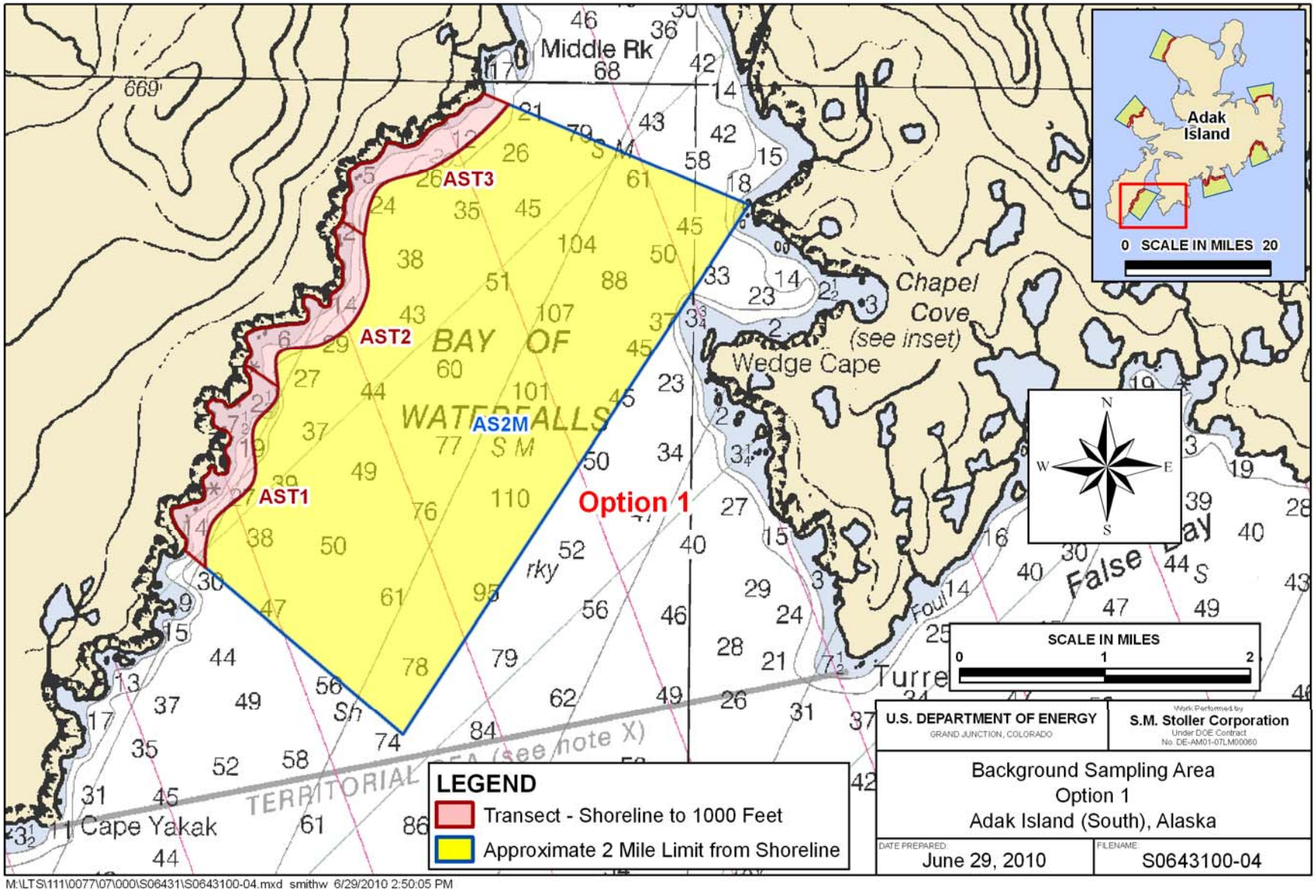

Figure 5–7. Amchitka Sampling Background Reference Site - Option 1 Adak Island (South), Alaska

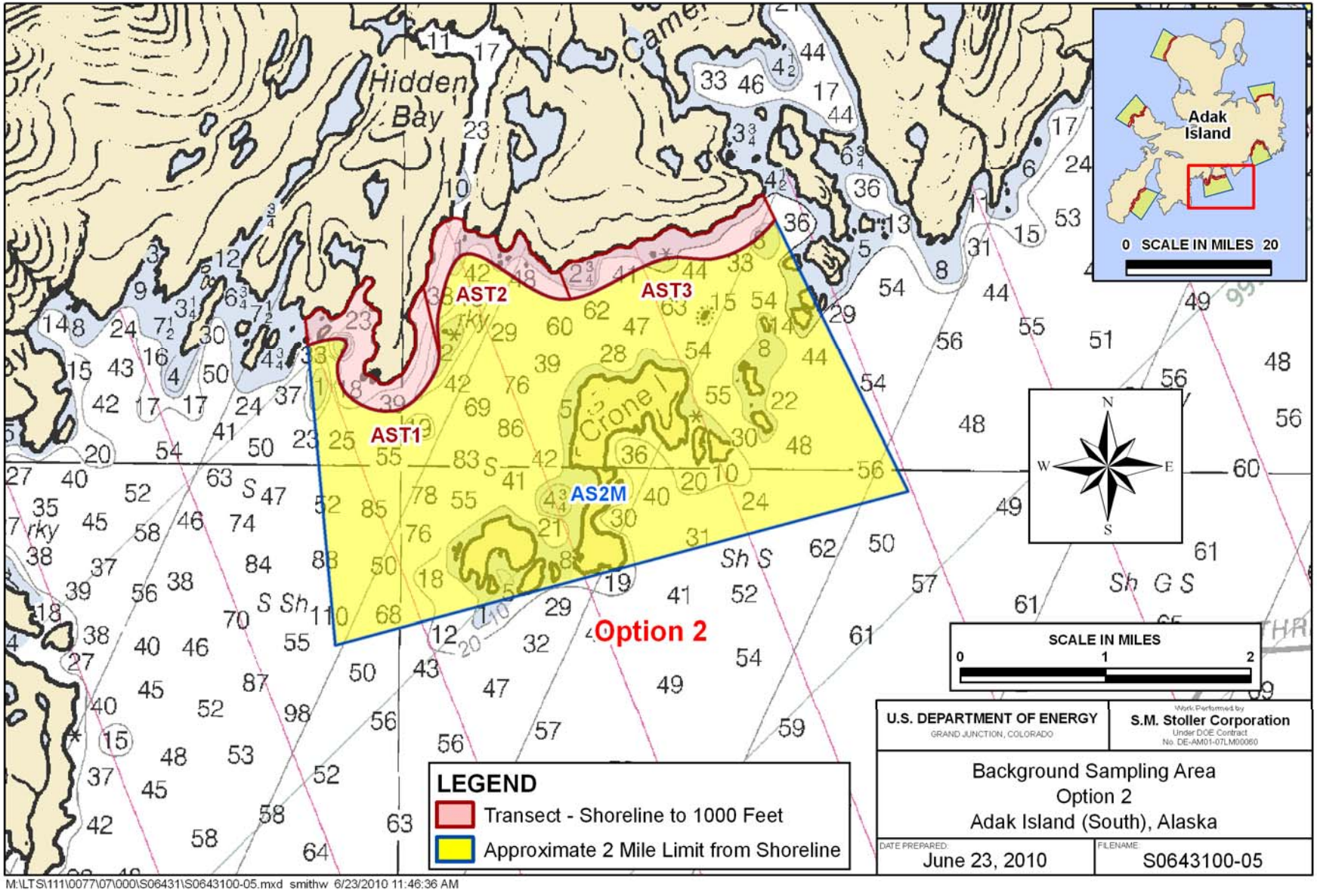

Figure 5–8. Amchitka Sampling Background Reference Site - Option 2 Adak Island (South), Alaska

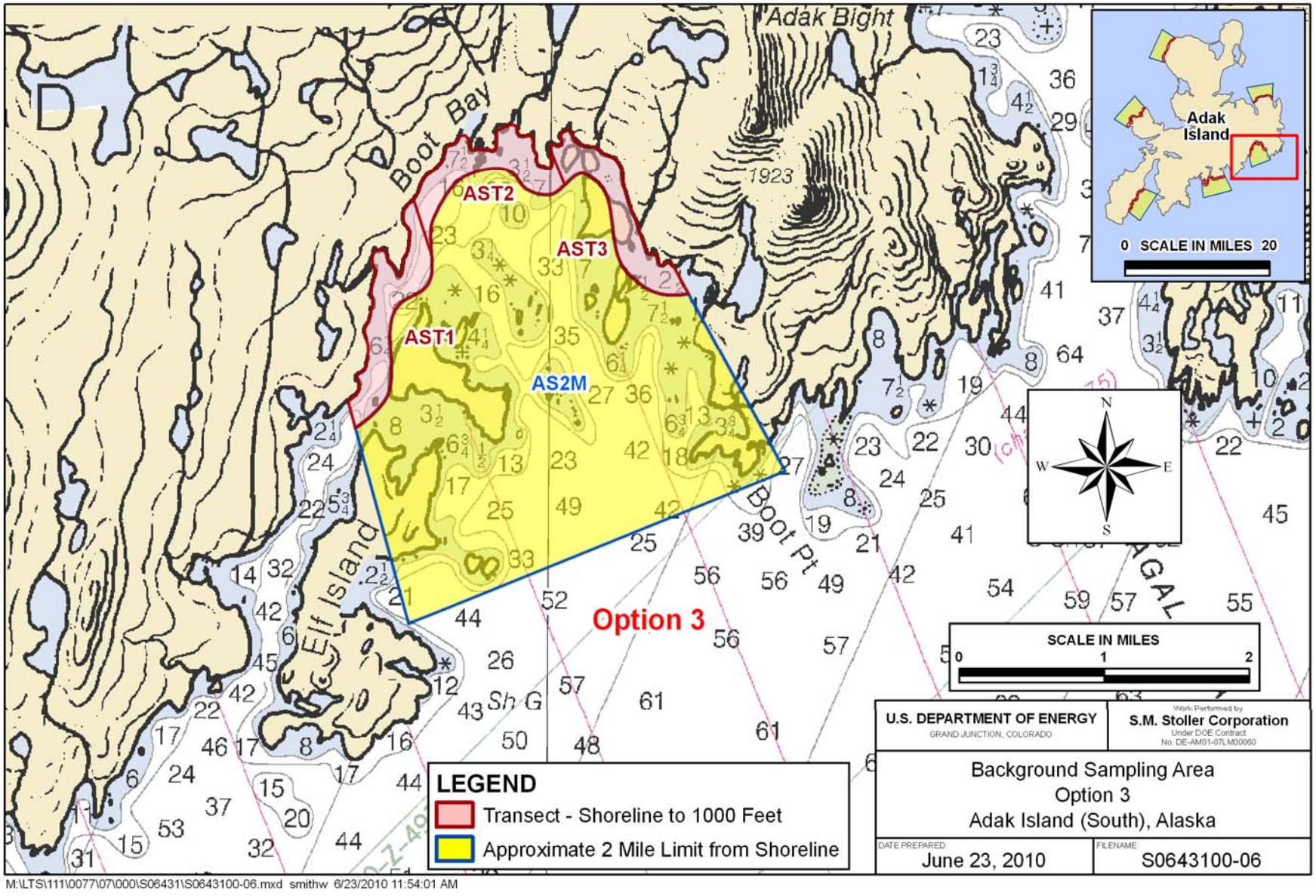

Figure 5–9. Amchitka Sampling Background Reference Site - Option 3 Adak Island (South), Alaska

Each sampling location consists of two separate sample areas, the shoreline transect and the 2-mile limit. For each sampling location, the shoreline transect extends for approximately 1,000 feet from the shoreline into the ocean and for approximately 3 miles along the shoreline. This 3-mile transect is broken into three separate transects each extending approximately 1 mile in length. The shoreline transect is where the divers will collect the nearshore subtidal marine algae, grazers, filter feeders, fish, and octopuses as well as marine sediment. Sampling personnel working in skiffs will also employ hook-and-line fishing for fish in the shoreline transects. Hook and line fishing for fish will also occur from the ship in offshore areas. In addition, the terrestrial sampling will take place along the shoreline transects where littoral zone sampling for algae will occur.

The 2-mile limit extends 2 miles into the ocean from the shoreline and is not divided into smaller transects. The 2-mile limit is where sampling personnel employing hook-and-line fishing techniques will fish for rockfish, greenling, and /or Irish Lords, halibut and Pacific cod.

Additional tritium sampling will be performed along the nearshore marine environment off-shore of the Cannikin and Long Shot nuclear test sites. Figure 5–10 shows where the nearshore seawater tritium samples will be collected. The sampling locations are based on geological maps of the direction and angle of observed faults near the Cannikin and Long Shot detonation sites, previous sampling in 2007 (Dasher and Jewett 2007), and the 2004 CRESP oceanography study.

A standard labeling system will be followed for all specimens. The labels will take the following form:

[*Species or sample material*]-[*Site*]-[*Transect*]-[*Sample Number*]

For example:

- Dive Team 3 collects a single dragon kelp (*Eualaria*) from the area of transect 2 at Cannikin. The entire plant is bagged and labeled “EUAL-CN-CT2-1.”
- Dive Team 1 collects 10 sea urchins, >60 millimeters, from transect 1 at the south side of Adak. The entire amount is bagged and labeled “URCH-AS-AST1-1.”
- The Aleuts collect a dozen gull eggs from Amchitka. The entire amount is bagged and labeled “GWGU-AL-XXX-1.” “XXX” denotes that there was no transect location.
- The Aleuts are fishing for Pacific cod and halibut off the coast of Milrow and catch one 15-pound Pacific cod and one 30-pound halibut. Each fish has a portion cut from it that meets the sampling weight criteria and that extracted portion from each fish is then bagged separately, the cod is labeled “PCOD-ML-M2M-1,” and the halibut is labeled “HALI-ML-M2M-1.”
- Dive Team 2 collects three rockfish, four greenlings, and seven Irish lords from T3 at Long Shot site. All three fish species are bagged together and labeled “MIX1-LS-LT3-1.” Dive Team 3 was also diving and collecting from T3 at Long Shot, and collects 1 rockfish, six greenling and four Irish lords. All three fish species are bagged together and labeled “MIX1-LS-LT3-2” for the second group of fish collected from this transect at Long Shot.
- Dive Team 1 collects dragon kelp (*Eualaria*) from the area of transect 2 at the north side of Adak. It is agreed that this sample will be split with UAF. The entire plant is segregated into two samples, and each sample is bagged and labeled “EUAL-AN-ANT2-1.”

- The Aleuts are fishing for Pacific cod and halibut off the coast of Long Shot and catch several rockfish, greenlings and Irish lords and no Pacific cod or halibut. All the fish from these species are bagged and labeled “MIX2-LS-L2M-1.”

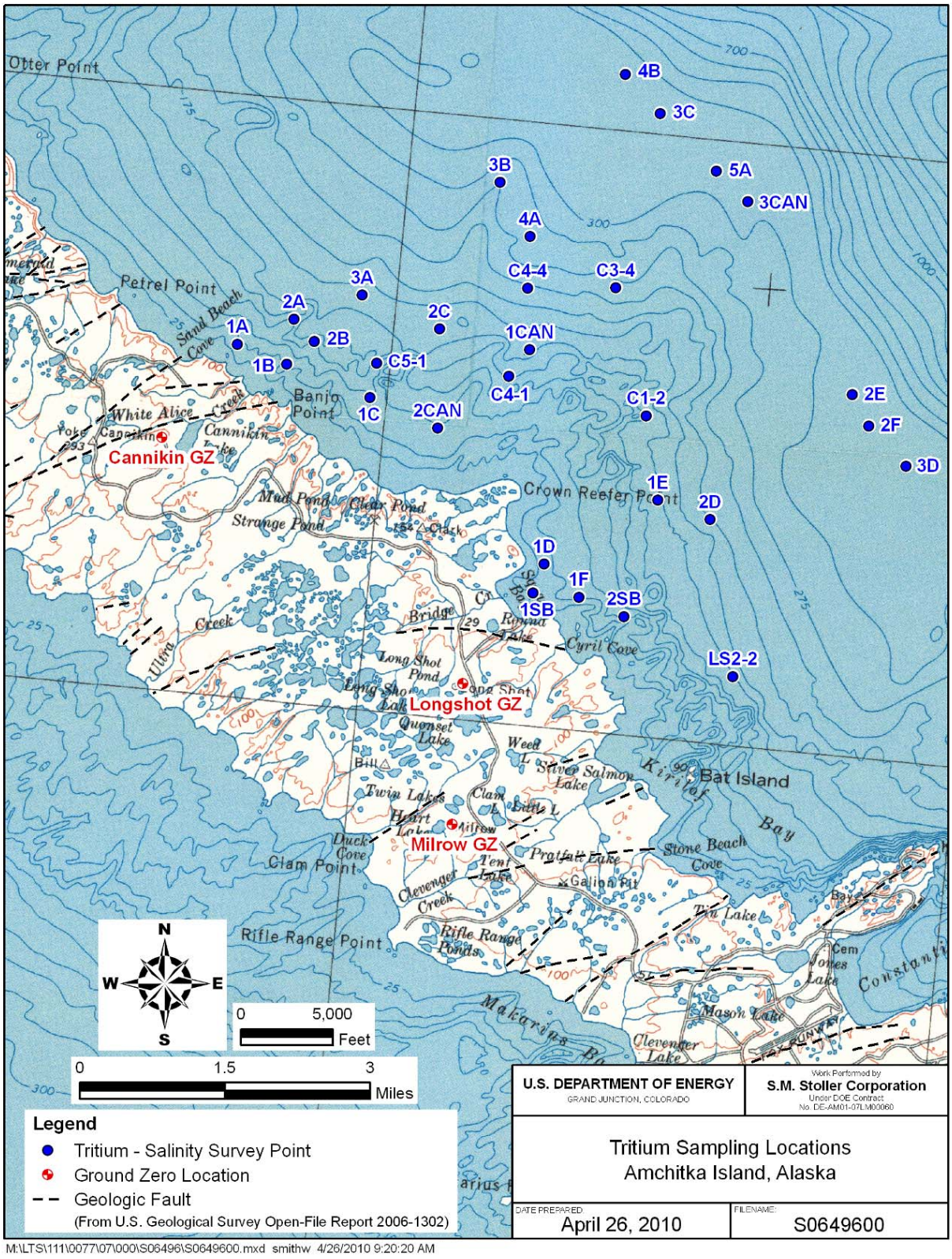

Figure 5–10. Tritium Sampling Locations Amchitka Island, Alaska

Table 5–2 shows the labeling system to be used for sample identification.

Table 5–2. Labeling System

Species/Media to Be Sampled	Species/Media Identification
Dragon Kelp	EUAL
Rockweed	FUCU
Chiton	CHIT
Horse mussel	HMUS
Blue mussel	BMUS
Sea urchin	URCH
Octopus	OCTP
Rockfish	ROCK
Rock or kelp greenling/red or yellow Irish lord	MIX1
Rockfish, greenling and Irish lord	MIX2
Halibut	HALI
Pacific cod	PCOD
Glaucous-winged gull eggs	GWGU
Dolly Varden	DOLL
Star reindeer lichen	STRL
Seawater	SEAW
Marine sediment	SEDI
Soil	SOIL
Site Location	**Location Identifier**
Amchitka Island	AI
Adak Island	AD
Cannikin	CN
Long Shot	LS
Milrow	ML
Adak, North	AN
Adak, South	AS
Transect Location	**Transect Identifier**
Cannikin	CT1, CT2, CT3, and C2M
Long Shot	LT1, LT2, LT3, and L2M
Milrow	MT1, MT2, MT3, and M2M
Adak, North	ANT1, ANT2, ANT3, and AN2M
Adak, South	AST1, AST2, AST3, and AS2M
Sample Number	
Sample Number	1-3

5.3 Number and Size of Biota Samples

Biota samples will consist of Glaucous-winged gull eggs, dragon kelp, sea urchins, horse and blue mussels, chitons (gumboots), octopuses, Pacific cod, Dolly Varden, greenlings (kelp or rock), halibut, and rockfish (black or dusky). Table 4–6 summarizes the number of samples for each biological species to be collected at the specified sampling locations. Table 5–1 also specifies the approximate wet weight needed to achieve the MDCs.

5.4 Field Sampling Methods

Table 5–4 summarizes the field sampling and handling procedures for the samples collected in 2011. The exact location of each sampling site will be noted using a global positioning system (GPS) from the dive skiffs.

Field duplicates will be collected at a target frequency of 10 percent. Fish, marine algae, and Star reindeer lichens are sufficiently abundant to warrant field duplicates. Field duplicates will be obtained by collecting an extra sample of fish, marine algae, or lichen collected from one of three transects at each site. They will be bagged separately and labeled as a duplicate sample for each transect and site from which they were collected. Field duplicates will be processed by the laboratory in the same way as all other samples.

5.4.1 Seawater Sampling Procedure from Vessel

Sixty seawater samples (and six duplicates) will be collected at 30 locations off the Cannikin shoreline from the deck of a vessel. At each seawater sampling site, seawater samples for tritium will be collected approximately 2 feet below the water surface and 2 feet off the bottom. Figure 5–10 shows the locations where sampling will take place, and Table 5–3 provides the coordinates for sample collection. Depending on marine conditions, hazards, and water depth, the sampling may take place from the deck of the vessel or a smaller skiff.

Table 5–3. Cannikin Offshore Seawater Sampling Locations

	Sample Site ID[a]	Location (WGS 84)	
1	SEAW-CN-C2M-1A	N51 29.101	E179 07.245
2	SEAW-CN-C2M-1B	N51 28.953	E179 07.971
3	SEAW-CN-C2M-1C	N51 28.702	E179 09.191
4	SEAW-CN-C2M-1CAN	N51 29.229	E179 11.433
5	SEAW-CN-C2M-1D	N51 27.320	E179 11.849
6	SEAW-CN-C2M-1E	N51 27.959	E179 13.420
7	SEAW-CN-C2M-1F	N51 27.043	E179 12.381
8	SEAW-CN-C2M-1SB	N51 27.055	E179 11.719
9	SEAW-CN-C2M-2A	N51 29.359	E179 08.028
10	SEAW-CN-C2M-2B	N51 29.174	E179 08.342
11	SEAW-CN-C2M-2C	N51 29.359	E179 10.127
12	SEAW-CN-C2M-2CAN	N51 28.472	E179 10.192
13	SEAW-CN-C2M-2D	N51 27.817	E179 14.187
14	SEAW-CN-C2M-2E	N51 29.019	E179 16.106
15	SEAW-CN-C2M-2F	N51 28.744	E179 16.372
16	SEAW-CN-C2M-2SB	N51 26.897	E179 13.043
17	SEAW-CN-C2M-3A	N51 29.616	E179 08.981
18	SEAW-CN-C2M-3B	N51 30.709	E179 10.851
19	SEAW-CN-C2M-3C	N51 31.420	E179 13.085
20	SEAW-CN-C2M-3CAN	N51 30.685	E179 14.425
21	SEAW-CN-C2M-3D	N51 28.410	E179 16.940
22	SEAW-CN-C2M-4A	N51 30.242	E179 11.337
23	SEAW-CN-C2M-4B	N51 31.748	E179 12.544
24	SEAW-CN-C2M-5A	N51 30.936	E179 13.940
25	SEAW-CN-C2M-C1-2	N51 28.707	E179 13.171
26	SEAW-CN-C2M-C3-4	N51 29.834	E179 12.612
27	SEAW-CN-C2M-C4-1	N51 28.976	E179 11.166
28	SEAW-CN-C2M-C4-4	N51 29.777	E179 11.349
29	SEAW-CN-C2M-C5-1	N51 29.016	E179 09.255
30	SEAW-CN-C2M-LS2-2	N51 26.424	E179 14.662

[a] There will be an S, for shallow, and D, for deep, at the end of the designator of the Sample Site ID.

Table 5–4. Field Sampling Procedures

	Species	Where	Who Would Collect	Collection Procedure	Onboard Ship Handling	Comment
				Ocean Sampling		
1.	Dragon kelp (*Eualaria*)	Nearshore subtidal	Dive team	For each transect, three individual samples weighing approximately 5 kg each, or three composited samples if necessary, will be collected. A duplicate sample will also be collected from one of the three transects. The duplicate sample will be split with the UAF. The holdfast will not be collected.	Sample bagging and labeling will be performed on board the vessel. Information on the estimated algae length and the wet weight of the algae collected from one location will be recorded in the database. Prior to bagging, 1 meter of the plants' proximal and distal ends will be cut off and bagged as the sample. Once the necessary collection weight is reached, the sample will be bagged and the sample bag will be labeled twice with a unique location identification number (once inside the bag and once on the outside) and frozen. The duplicate sample will be split with UAF.	This brown algae is a dominant primary producer. This canopy-forming species is an annual and can attain lengths of up to 25 meters.
2.	Chiton (*Cryptochiton stelleri*)	Nearshore subtidal	Dive team	For each transect, whole chiton will be collected and a total combined weight of approximately 0.5 kg per sample is required. Divers will pry the brick-red organisms off of rocks.	Further labeling and packaging as above.	The low density of specimens will dictate the number of samples collected, with only two to six individuals likely to be collected at each site. Individual weights have been reported in the 500-to-800-gram range.
3.	Horse Mussel (*Modiolus modiolus*)	Nearshore subtidal	Dive team	For each transect, the entire horse mussel will be collected and composited and a total combined weight of approximately 0.1 kg per sample is required. This will require approximately 10 horse mussels to be collected per sample. Divers will pry the horse mussels off of rocks.	Further labeling and packaging as above.	This species is not abundant, and likely only four to six individuals will be collected by divers, where possible.

Table 5–4 (continued). Field Sampling Procedures

	Species	Where	Who Would Collect	Collection Procedure	Onboard Ship Handling	Comment
4.	Sea Urchin (*Strongyloce-ntrotus spp*)	Nearshore subtidal	Dive team	For each transect, the entire sea urchin will be collected and composited, requiring approximately ten specimens, each approximately 60 millimeters in size.	Wide mouth, square, 64 oz. HDPE containers will be used to package the sea urchins. For each composite sample, the total wet weight of all of the urchins will be measured, and the size of each individual urchin will be recorded. Once that is done the total weight of the composited tissue will be measured. Further labeling and packaging as above.	This species is a dominant grazer and should be abundant in the sampling locations.
5.	Octopus (*Enteroctopus dofleini*)	Nearshore subtidal	Dive team	Divers will collect one or two specimens of adequate size (if possible) at each sample site, not transect location.	The total wet weight and size of the octopus will be measured and recorded in the database. Once that is done the octopuses' arms will be severed and discarded and the remaining portion will be bagged. Further labeling and packaging as above.	This species is the only invertebrate predator to be collected.
6.	Rockfish (*Sebastes spp*), greenling (*Hexagrammos spp*), and/or Irish lord (*Hemilepidotus spp)*	Nearshore subtidal and offshore	Nearshore collected by dive team. Offshore collected by hook-and-line crew.	For each transect, the entire specimen will be collected and one to three specimens each from each transect will be collected. Additionally one to three samples will be collected in deeper waters off the coastline of each site. Because the sex typically cannot be readily determined when fish samples are harvested the sampling objective is to minimize the size effect by compositing fish of similar size classes.	Once the fish are returned to the main vessel, they will be placed in a holding cooler for processing. Each fish will have its taxonomic identification checked, sex determined (if possible), length measured (total or fork length, dependent on the fish species) in centimeters, and weight recorded in grams. Further labeling and packaging as above.	Radionuclide concentrations in fish can vary within a species, based on the size, age, and sex of the fish.
7.	Halibut (*Hippoglossus stenolepis*)	Offshore	Hook-and-line crew	One fish per sample site, not transect location, will be caught.	Same as above.	Individual fish are to be sampled, as their size is adequate for obtaining the desired amount of ash weight for analysis. Preference will be for similar-size fish of the same species, with one fish per sample site area being collected.
8	Pacific cod (*Gadus macrocephalus*)	Offshore	Hook-and-line crew	One to three fish per sample site, not transect location, will be caught.	Same as above.	Individual fish are to be sampled, as their size is adequate for obtaining the desired amount of ash weight for analysis. Preference will be for similar-size fish of the same species, with one fish per sample site area being collected.

Table 5–4 (continued). Field Sampling Procedures

	Species	Where	Who Would Collect	Collection Procedure	Onboard Ship Handling	Comment
9.	Marine sediments	Nearshore sampling at each transect (if possible)	Dive team	Wherever soft substrate is encountered, one sample of sediment from each transect location will be collected.	Three wide mouth, square, 16 oz. HDPE containers will be filled with surface marine sediment (to 5 centimeters deep). Container numbers will be recorded on original field data sheets, and information will be recorded on the container label. The samples will be kept cool.	Samples will be collected to assess residual radionuclide content of the sediment.
10.	Seawater	At each transect and at additional specified locations off Cannikin shoreline	Dive team and others from aboard ship	From each transect, divers will collect three samples of seawater from approximately one meter above the ocean substrate. The diver will use 1-liter HDPE bottles for sample collection. The bottles will be clean and dry, with good caps. Seawater collection from the vessel is described in detail in Section 5.4.1.	Container numbers will be recorded on original field data sheets, and information will be recorded on the bottle label. Nothing will be added to the water sample. The samples will be kept cool.	Two sets of seawater samples will be collected; one by the divers from each transect location and from the deck of the vessel off the coastline of Cannikin.
				Terrestrial Sampling		
11.	Blue mussel (*Mytilus trossulus*)	Intertidal	Land crew	For each transect, the entire blue mussel will be collected and composited and a total combined weight of approximately 0.1 kg per sample is required. This will require approximately 20 blue mussels to be collected per sample. Sampling personnel will pry the blue mussels off of rocks in the intertidal zone.	Sample bagging and labeling will be performed on board the vessel. Once the necessary collection weight is reached, the sample will be bagged and the sample bag will be labeled twice with a unique location identification number (once inside the bag and once on the outside) and frozen.	This species is not abundant, and likely only four to six individuals will be collected by sampling personnel, where possible.
12.	Rockweed (*Fucus distichus*)	Intertidal	Land crew	For each transect, three individual samples weighing approximately 5 kg each of the whole plants will be collected and composited. Epibiotic growth and residual sedimentary debris will be removed by shaking fronds in local seawater.	Onboard ship, composites will be placed separately in plastic bags, labeled, and frozen.	This algae is a good integrator of many radionuclides in the marine environment comparable to or potentially better than *eualaria*.

Table 5–4 (continued). Field Sampling Procedures

	Species	Where	Who Would Collect	Collection Procedure	Onboard Ship Handling	Comment
13.	Star reindeer lichen (*Cladina stellaris*)	On-island	Land crew	Samples of Star reindeer lichen will be collected by hand, while wearing gloves, to allow separation of any associated debris or vascular plants from within a 1-square-meter frame so that the areal extent of lichen sampled can be estimated. At each sampling location, three sample sets, each set having a wet weight of 3 kilograms, will be composited into plastic bags with internal and external labels. The samples' wet weight will be measured by placing the sample bags on a Pesola scale. Sediment beneath the lichen will also be collected and placed into one 32 oz HDPE plastic containers. Repeat the above for sample split with UAF.	Once the samples are returned onboard, the bags will be placed within a larger bag. Field photos of the lichens will be taken for identification. Once the necessary collection weight is reached and bagged, the sample bag will be labeled twice with a unique location identification number (once inside the bag and once on the outside) and frozen. Samples of lichen and soil beneath the lichen will be split with UAF.	Estimates of the areal extent of lichens collected at a sample site can be used to estimate inventory of radionuclides within the watershed.
14.	Glaucous-winged Gull (*Larus glaucescens*) Eggs	On-island	Land crew	Sampling personnel will locate gull nests in the general vicinity of each of the test sites (Cannikin, Long Shot, and Milrow) on Amchitka and opportunistically on Adak. Once a nest has been located, and if eggs are present, sampling personnel will place the eggs in a rigid container and carry the container in a collecting box for transportation back to the ship. If any dead chicks are found, they will be salvaged (put into plastic bags in an ice chest for transport back to the ship). The exact location of each collection site will be noted using GPS.	Information on the weight of the whole egg collected from each location will be recorded in the database. Once the necessary collection weight is reached and bagged, the sample bag will be labeled twice with a unique location identification number (once inside the bag and once on the outside). Further labeling and packaging as above.	Glaucous-winged gulls' nesting habitats are in the grass in small colonies on the island surface near lakes. Generally, gulls are attentive to their nest, and by patiently and carefully watching the gulls' behavior, sampling personnel can discover even well-hidden nests.
15.	Dolly Varden (*Salvelinus malma*)	Cannikin Lake (also at Adak, if possible)	Hook-and-line crew	Twelve fish will be collected for each composite sample (one composite sample each from Cannikin Lake and a lake on Adak).	Once the fish are returned to the main vessel, they will be placed in a holding tank for processing. Each fish will have its taxonomic identification checked, sex determined (if possible), length measured (total or fork length, dependent on the fish species) in centimeters, and weight recorded in grams. Samples will be placed in plastic bags and labeled accordingly (as one composite sample). Further labeling and packaging as above.	Dolly Varden is to be sampled from Cannikin Lake to determine long-term trends in cesium-137 and for statistical comparison with Dolly Varden reference background lake on Adak.

Sample bottles, 1-liter high density polyethylene, will be labeled with the sample number, location code, and date and wrapped with clear tape prior to field sampling. The sampling location will be confirmed to within 150 feet with non-differential GPS. The actual station depth will be confirmed with a depth finder on the boat. Two Niskin bottles will be set for sampling at approximately 2 feet below the surface and 2 feet off the bottom on a single line with a messenger to trip both bottles. The recovered Niskin bottles will be anchored to a holding board after the seawater samples are collected. Unfiltered sample transfer will occur outdoors as follows (adapted from the University of Miami Tritium Laboratory's advice on tritium sampling (http://www.rsmas.miami.edu/groups/tritium/advice-sampling-tritium.html):

a. Do not wear a wristwatch, compass, or similar device with luminescent dials or "beta" lights while taking samples.

b. Keep the Niskin bottle sealed, and withdraw the sample through the sampling tube on the side.

c. Rinse the bottle with sample water, and then fill the bottle using the tube near the bottom, slowly withdrawing as you fill it to leave air in the neck of the bottle, allowing for pressure changes during air shipment. Minimize air contamination.

d. Replace the cap, and screw it on tightly.

e. Record the bottle number and information on the field data sheets, double-checking it against the bottle label.

f. Wrap the bottle cap clockwise with electrical tape to help secure the cap for shipment.

g. Once sampling is completed, wrap the bottles in bubble wrap, and pack them securely.

h. Store the water sample at ~4^{o} Celsius.

i. Initiate the chain-of-custody form when the sample enters storage.

j. Collect a field duplicate for every 10 samples in accordance with the procedures above.

5.5 Laboratory Sample Handling and Analytical Methods

The samples will be sent to three laboratories for analysis. With the exception of the seawater samples, the majority of the samples will be sent to the Lawrence Livermore National Laboratory. A smaller subset of rockweed (*Fucus distichus*) samples and Star reindeer lichen and soil beneath the lichen will be sent to UAF for cesium-137 analysis. Marine sediment samples will also be collected and sent to UAF for geotechnical testing. The seawater samples will be sent to the University of Miami Tritium Laboratory for tritium analysis. Generally, biological samples will be labeled and sealed in plastic bags and frozen. Water, marine sediment, and soil samples will be labeled and sealed in plastic jars.

5.6 Data Interpretation and Use

Data obtained from the analysis of biological, seawater, lichen, marine sediment, and soil samples from the 2011 sampling event will be reviewed against quality assurance and quality control requirements and validated accordingly for inclusion in LM's database for the Amchitka project.

Representative statistics from applicable subsets of data, including the range, maximum, mean, and UCL95, will be generated and compiled. Associated statistical information (e.g., standard deviation) will also be documented.

5.6.1 Biological Data

Data statistics for each species collected for each of the site areas will be reviewed against previous data sets to determine whether 2011 levels are protective of the Aleut diet (both subsistence and commercial catches) and whether the data are comparable to levels previously reported.

The maximum or UCL95 will be used as input into the RESRAD-BIOTA code to determine potential absorbed doses of the given species and will be compared to previous data sets, as available.

Initial observations or conclusions will be documented in the data report and used in the planning for the next sampling event (in 2016 or sooner as the results dictate).

5.6.2 Tritium Data from Seawater

The data collected will be documented in the database as initial baseline data. Comparisons will be made to other available data from the area and to literature data for global fallout.

5.6.3 Star Reindeer Lichen, Soil Beneath the Lichen, and Marine Sediment Data

The data collected will be documented in the database as initial baseline data. Comparisons will be made to other available data from the area and to literature data for global fallout.

6.0 Sampling Schedule

Table 6–1 presents the schedule for performing the on-island and biological sampling tasks in 2011. No dates are provided as the actual schedule will depend upon the availability of the chartered vessel at the time of procurement. The window for this work will tentatively be from mid-May to early July 2011. The chartered vessel will depart its home port and travel to Adak, Alaska. Adak will be the pick up and drop off point for the biological and terrestrial sampling teams.

Table 6–1. 2011 Schedule for On-Island and Biological Sampling

Task	Number of Days
Pick up Terrestrial Work Team	0
Go from Adak to Amchitka	1
Moored at Constantine Harbor	5
Go from Amchitka to Adak	1
Drop off Terrestrial Work Team and pick up Biological Sampling Team	0
Go from Adak to Amchitka	1
Perform operations off Cannikin site	4
Perform operations off Long Shot site	4
Perform operations off Milrow site	4
Go from Amchitka to Adak	1
Perform operations off North Adak	4
Perform operations off South Adak	4
Go to Adak and drop off Biological Sampling Team	1
Total number of days ship is required	**30**

Commercial airline service is only available from Anchorage to Adak twice a week on Thursday and Sunday. Depending upon what sampling team goes first, a typical schedule will be as follows. The Terrestrial Work Team will arrive in Adak on a Thursday. Personnel and equipment will be transported from the airport to the pier, where the chartered vessel will be tied up and waiting to board passengers and equipment. Once passengers have boarded and equipment has been loaded onto the ship, the ship will get underway for the approximately 20-hour transit time from Adak to Amchitka Island. Upon arrival at Amchitka Island, the vessel will tie up to the pier in Constantine Harbor, on the southeastern side of Amchitka Island, and remain there the entire time the on-island work is being performed. It is estimated that it will take 5 days to inspect the seven caps on the island; inspect three wells; perform minor road repairs; and collect the gull eggs from wherever they can be found, Star Reindeer lichen, and soil beneath the lichen samples from three designated locations, and rockweed samples from the shoreline adjacent to the three test sites.

Upon completion of the Terrestrial Work Team's on-island task, the chartered vessel will be back in Adak on the following Thursday to drop off the Terrestrial Work Team.

The Biological Sampling Team will arrive in Adak on a Thursday and personnel and equipment will be transported from the airport to the pier, where the chartered vessel will be tied up and waiting to board passengers and equipment. Once passengers have boarded and equipment has been loaded onto the ship, the ship will get underway.

Depending on weather conditions, the chartered vessel may go directly to Amchitka to begin the biological work at one of the three sites along the coastline of Amchitka, or go to one of the two sites along the coastline of Adak to begin the biological work there. Regardless of where the biological sampling starts or finishes, the chartered vessel is scheduled to be back in Adak approximately 21 days after the start date.

7.0 References

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