LMS/AMC/40815

Environmental Sampling Plan for the Amchitka, Alaska, Site 2023 Sampling Event

February 2023

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Abbreviations

AEC	U.S. Atomic Energy Commission
Alaska DEC	Alaska Department of Environmental Conservation
ANOVA	analysis of variance
AWG	Amchitka Working Group
Bq	becquerels
Bq/L	becquerels per liter
BTV	background threshold value
CRESP	Consortium for Risk Evaluation with Stakeholder Participation
CSM	conceptual site model
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQO	data quality objective
DRI	Desert Research Institute
EDD	electronic data deliverable
EDGE	Environmental Quality Information System Data Gathering Engine
EQuIS	Environmental Quality Information System
FDA	U.S. Food and Drug Administration
ft	feet
HDPE	high-density polyethylene
kg	kilogram
L	liter
LLNL	Lawrence Livermore National Laboratory
LM	Office of Legacy Management
LTHMP	Long-Term Hydrologic Monitoring Program
LTSP	Long-Term Surveillance Plan
m	meters
µm	micrometers
MOU	memorandum of understanding
MT	magnetotelluric
pCi/L	picocuries per liter
QA/QC	quality assurance/quality control
SAGe	small anode germanium
UAF	University of Alaska Fairbanks
USFWS	U.S. Fish and Wildlife Service

Isotopic Symbols

^{134}Cs	cesium-134
^{137}Cs	cesium-137
^{3}H	tritium
^{127}I	iodine-127
^{129}I	iodine-129
^{239}Pu	plutonium-239
^{240}Pu	plutonium-240

Radiation Units

Becquerel (Bq) The International System of Units (SI) measure of a radioactive source activity and is defined as one disintegration per second.

Picocurie (pCi) A pCi is defined as 2.2 disintegrations per minute. One pCi is equivalent to 1×10^{-12} curies, or 1 trillionth of a curie. The curie, an older measure of radioactive source activity, has been replaced by the Bq as the SI unit.

1.0 Introduction

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) has prepared this sampling plan to describe the data collection and data management activities to be conducted as indicated in the July 2014 *Long-Term Surveillance Plan for the U.S. Department of Energy Amchitka, Alaska, Site* (LMS/AMC/S01980-1.0) (LTSP). The sampling activities described in this environmental sampling plan are to be implemented in 2023.

1.1 Purpose of the 2023 Sampling Event

The purpose of this sampling plan is to carry out LM's responsibility, described in the LTSP for the Amchitka Island site, to further assess the possibility that selected residual radionuclides from nuclear tests may have entered the freshwater and marine food chains, which could result in potential human health and ecological effects. Figure 1 shows the locations where three underground nuclear tests, Cannikin, Long Shot, and Milrow, were conducted on Amchitka Island between 1965 and 1971. Figure 1 also shows the Alaska Maritime National Wildlife Refuge and Aleutian Islands Wilderness lands managed by the U.S. Fish and Wildlife Service (USFWS) and Conveyed and Selected Lands related to the Alaska Native Claims Settlement Act (ANCSA).

Consistent with the LTSP and subsequent discussions with the Amchitka Working Group (AWG) stakeholders, the Alaska Department of Environmental Conservation (Alaska DEC), the USFWS, and Native stakeholders, the primary objective of the 2023 sampling event is to collect water and biota samples to verify that marine foods are safe for human consumption and, secondarily, to determine if migration from the underground nuclear test cavities is potentially occurring through a statistical review of radionuclide concentrations in comparison to background levels and previous site data as described in Section 3. Prior assessment results have demonstrated that selected food resources available on and around Amchitka Island have not been adversely impacted by radionuclides associated with the underground nuclear tests and that subsistence and commercial catch seafood potentially harvested from the region is safe to eat with respect to radionuclides (CRESP 2005; CRESP 2006; DOE 2002; DOE 2013; DOE 2020).

To accomplish the 2023 sampling objectives, biota samples will be collected and analyzed for cesium-137 (^{137}Cs), plutonium-239 (^{239}Pu), and plutonium-240 (^{240}Pu). Freshwater and marine water (or seawater) samples will be analyzed for the same radionuclides with the addition of tritium (^{3}H), iodine-129 (^{129}I), and iodine-127 (^{127}I), a stable isotope. The scope for this sampling event differs from those developed for previous sampling events in the following ways:

- New, more representative, background locations will be sampled.
- New analytes ^{127}I and ^{129}I have been added to the analytical scope.
- Lower detection limits will be used for selected samples.
- Cesium-134 (^{134}Cs) results will no longer be used due its short half-life (2.06 years) and low concentrations in the environment. However, mixed calibration standards will be used with the gamma spectrometer to allow it's software to locate and report detected peaks based on the suite in the standard, which may contain ^{134}Cs. Those results will not be included in the environmental sampling report but will be provided to University of Alaska Fairbanks

scientists to assess the contribution of various sources of fallout in Amchitka's marine waters.

- Additional samples will be collected and stored for possible future radionuclide analysis.
- Optional – Sampling of subsistence and commercial catch species for fast turnaround laboratory analysis may be conducted to provide a food safety check. Subsistence use is defined as 'noncommercial, customary and traditional uses.' While there is some overlap of fish species, caught for subsistence and commercial uses, generally, of the fish to be caught as part of this plan, the commercial catch fish species are rockfish, Pacific halibut, walleye pollock, cod, and Atka mackerel.

Detailed rationales supporting these changes are documented in Section 4.1.

1.2 Background

Amchitka Island is near the far western end of the Aleutian Islands, approximately 1340 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 USFWS. Since World War II, Amchitka Island 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 mid-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 (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 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 conducted on November 6, 1971. Except for anomalous concentrations of tritium detected in surface water for a short time after the Long Shot test, there is no evidence that test-related radionuclides have migrated from the detonation zones to the freshwater or marine environments on or around Amchitka Island.

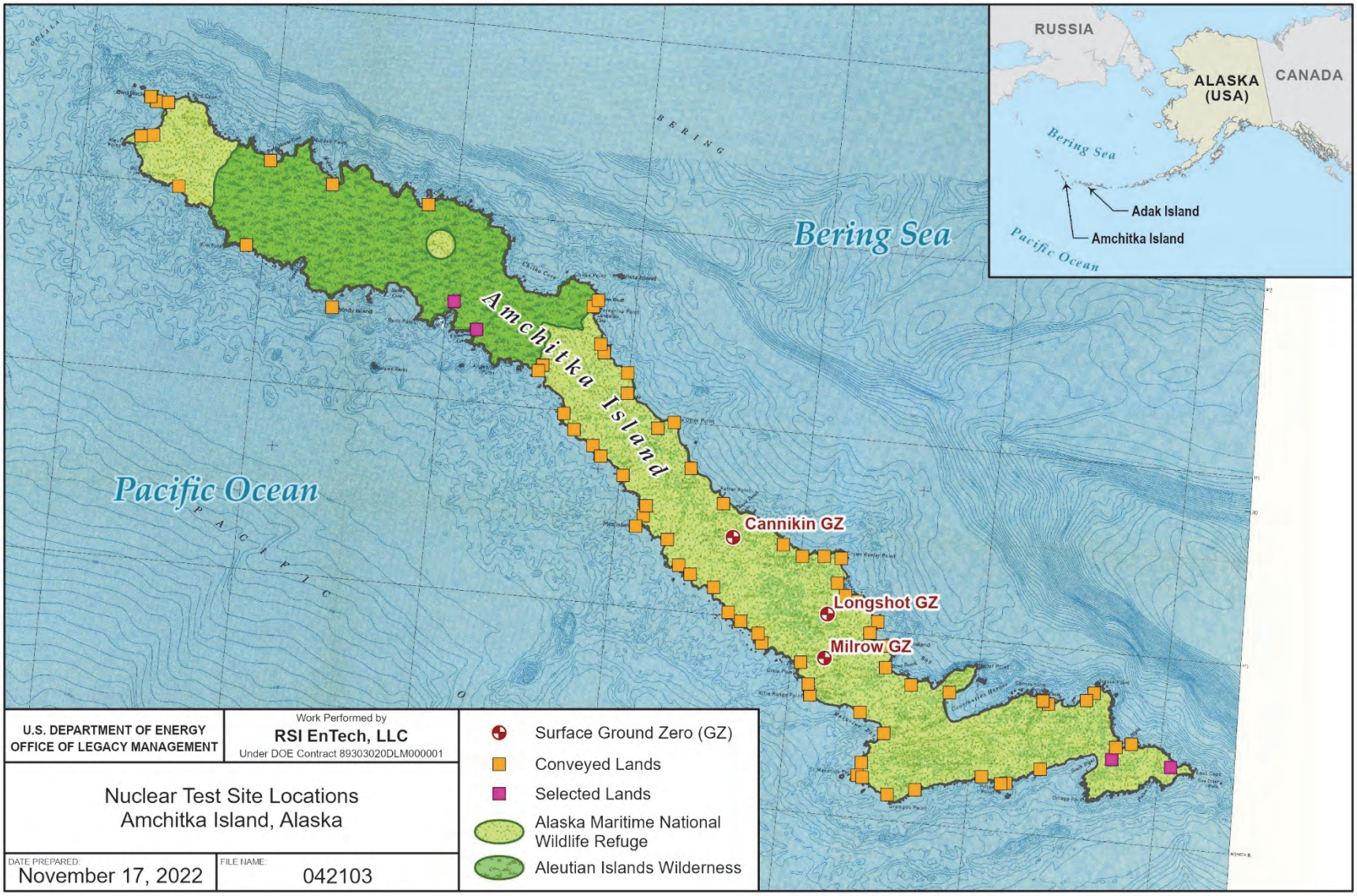


Figure 1. Amchitka Test Site Locations

1.3 Historical Sampling Activities

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 Island 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 Island. Migration 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, as evidenced by increased tritium concentrations in surface water and freshwater plants near the test site.

Another program, the Off-Site Environmental Monitoring Program for the Nevada Test Site and Other Test Areas Used for Underground Nuclear Detonations, began in 1977 and continued through 1989, after which samples were collected intermittently (in 1991, 1993, 1997, and 2001). Implemented by the U.S. Environmental Protection Agency, the program entailed measurement of levels and trends of radioactivity in the environment surrounding the test sites to ensure that levels were below corresponding radiation protection standards. Over time, the program became known as the Long-Term Hydrologic 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 anthropogenic radionuclides were leaking into the surface environment from nuclear test cavities several thousand feet (ft) below the surface of the island (DOE 2000). Briefly summarized, the results of the 1997 LTHMP radiobiological sampling indicated there was no evidence of migration from the underground test cavities into the terrestrial or freshwater environments on Amchitka Island (DOE 2000; Dasher et al. 2002).

In 2004, the Consortium for Risk Evaluation with Stakeholder Participation II (CRESP), a group of independent universities, prepared the *Final Report of the Consortium for Risk Evaluation with Stakeholder Participation, Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposures in the Amchitka Marine Environment* (CRESP 2005). CRESP demonstrated that concentrations of target radionuclides measured in marine species were safe relative to risk guidelines. One of the studies drawn upon in CRESP's 2005 report was the groundwater flow and transport model developed by the Desert Research

Institute (DRI) in 2002 (Hassan et al. 2002). Using two-dimensional numerical simulations, this initial model indicated that, if contaminant migration from the test cavities were to occur, the shortest arrival times would be at the Long Shot site (Hassan et al. 2002). This prediction was based on the relatively shallow detonation depth (2297 ft) at Long Shot relative to the other test sites, 4003 ft at Milrow and 5873 ft at Cannikin. As such, the travel distance from the cavity to the seafloor is shortest for Long Shot and longest for Cannikin. DRI updated this model in 2006 to incorporate the new magnetotelluric (MT) and bathymetric survey data collected by CRESP, which allowed reduction in uncertainty in some of the parameters incorporated in the initial model (Hassan and Chapman 2006). CRESP's MT surveys were used to determine the salinity and porosity structure of the subsurface and the bathymetric surveys were used to map areas offshore from the Long Shot and Cannikin sites. Based on DRI's updated model, no breakthrough resulted for any of the three test sites within the 2200-year model time frame, despite ignoring all retardation mechanisms, such as sorption or decay.

In 2011, a sampling event conducted by DOE addressed the safety of seafood consumption by paying particular attention to available diet information and considering the species included in the diet and portions consumed (DOE 2013). The diet information was used as the basis for the collection of samples and subsequent data interpretation including risk estimates. The risk estimates for the 2011 sampling event indicated that lifelong consumption of subsistence seafood from Amchitka and Adak Islands yields a potential risk of below 1×10^{-5}, which is considered safe by the Alaska DEC.

In 2016, DOE performed another sampling event on and around Amchitka Island. Consistent with the findings of previous environmental monitoring and risk evaluations, ^{137}Cs, ^{239}Pu, and ^{240}Pu levels measured in biota samples collected in 2016 near Amchitka Island are below both site-specific risk-based consumption levels and established food safety guidelines (DOE 2020).

1.4 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. The organizational chart for the 2023 environmental sampling event is shown in Figure 2.

LM developed the specific objectives of the 2023 environmental sampling event in a major collaborative effort with a group of stakeholders representing the federal government, the USFWS, the State of Alaska, the University of Alaska, and Native stakeholders. This group is collectively referred to as the Amchitka Working Group (AWG).

LM retains RSI EnTech, LLC (RSI), as its Legacy Management Support (LMS) contractor. RSI will 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. The LMS contractor will continue to help LM plan and execute the Amchitka Island work scope.

LM retains Argonne National Laboratory through a work order to help develop the environmental sampling plan and provide technical support with data analysis and other technical issues, as required.

As was done for the 2011 and 2016 environmental sampling events, LM retains Lawrence Livermore National Laboratory (LLNL) through a work order to provide support in the radionuclide analysis of the environmental samples collected in 2023. Through RSI, the University of Miami Rosenstiel School of Marine and Atmospheric Science will perform the tritium analyses on marine water and freshwater samples.

LM has given a financial assistance grant to the Alaska DEC to support participation in activities at the Amchitka, Alaska, Site and regularly meets with Alaska DEC's Division of Spill Prevention and Response. Alaska DEC collaborates with the University of Alaska Fairbanks (UAF) to plan the sampling campaigns and recommend improvements to the LM sampling plan. UAF may also participate in sample collection during the 2023 sampling event.

LM has an MOU with the USFWS. Amchitka Island is within the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge, which was established in 1980 by President Jimmy Carter. It was previously dedicated as a wildlife reserve 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. USFWS issues access permits to LM in conjunction with the periodic monitoring and sampling events. As noted earlier, as part of the AWG, the USFWS is involved in plan development for the environmental sampling.

Native stakeholder input on environmental sampling at Amchitka has been provided for well over a decade by the Alaska Pribilof Island Association (APIA). At the time this plan was prepared, LM was in the process of developing an agreement with an Alaskan Native stakeholder to provide Alaska Native Tribal representation as a collaborative member of the AWG.

2.0 Conceptual Site Models

This section provides two conceptual site models (CSMs). The first one to assess the groundwater flow and transport at the site; and the second, to summarize future potential exposures if radionuclide migration were to occur. Both CSMs were considered in developing this environmental sampling plan and, in particular, the data quality objectives (DQOs) outlined in Section 3.0.

2.1 Conceptual Site Hydrologic Model

A conceptual site hydrologic model showing Amchitka Island's groundwater flow system and a detonation diagram is illustrated in Figure 3. Shallow local flow systems divert much of the precipitation that infiltrates into the subsurface to nearby surface drainages and ponds. The island-scale flow system has a predominantly downward gradient near the center of the island that transitions to lateral toward the shore. Freshwater seeps are expected near the shore, both on land and on the shallow seafloor, as the island-scale flow system transitions from recharge areas to discharge areas. At depth, the volume and velocity of flow decreases in response to lower permeability. The dense brine water below the freshwater lens also limits downward flow, like the effect of a lower permeability zone.

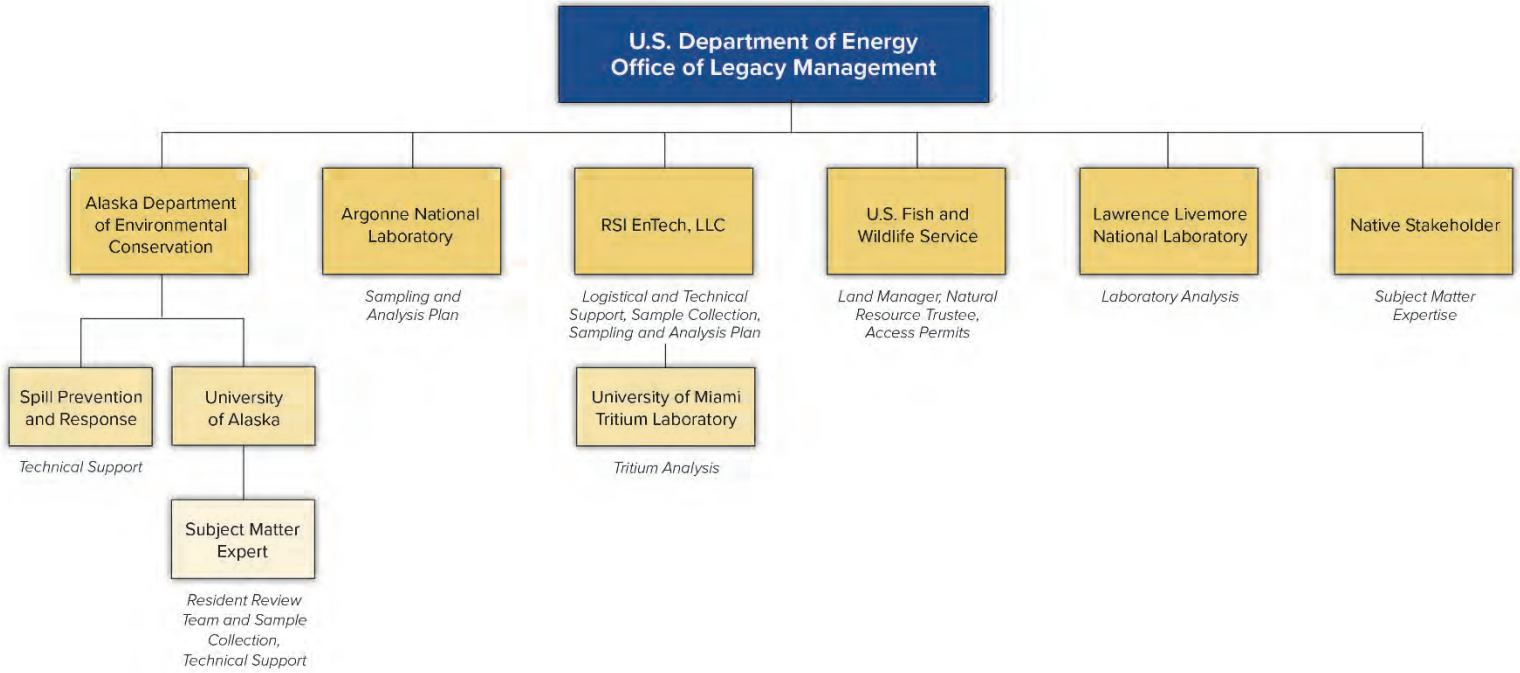


Figure 2. Organizational Chart

As illustrated in the detonation diagram (Figure 3 inset), the former cavity becomes a rubble-filled chimney soon after the detonation when the overlying fractured rock collapses into the void space. The molten rock vaporized by the detonation flows downward, coating the surfaces of rock fragments and solidifying at the bottom of the former cavity. The rapid cooling of the melt rock results in a microcrystalline glassy texture often referred to as melt glass. Radionuclide contamination is concentrated in the detonation zone, the former cavity and collapse chimney, and the surrounding area of increased fracturing induced by the detonation. Given the depth of the test shots and the likely trajectory of movement shown in Figure 3, any migration, were it to occur, would surface on the seafloor rather than on the surface of the island itself.

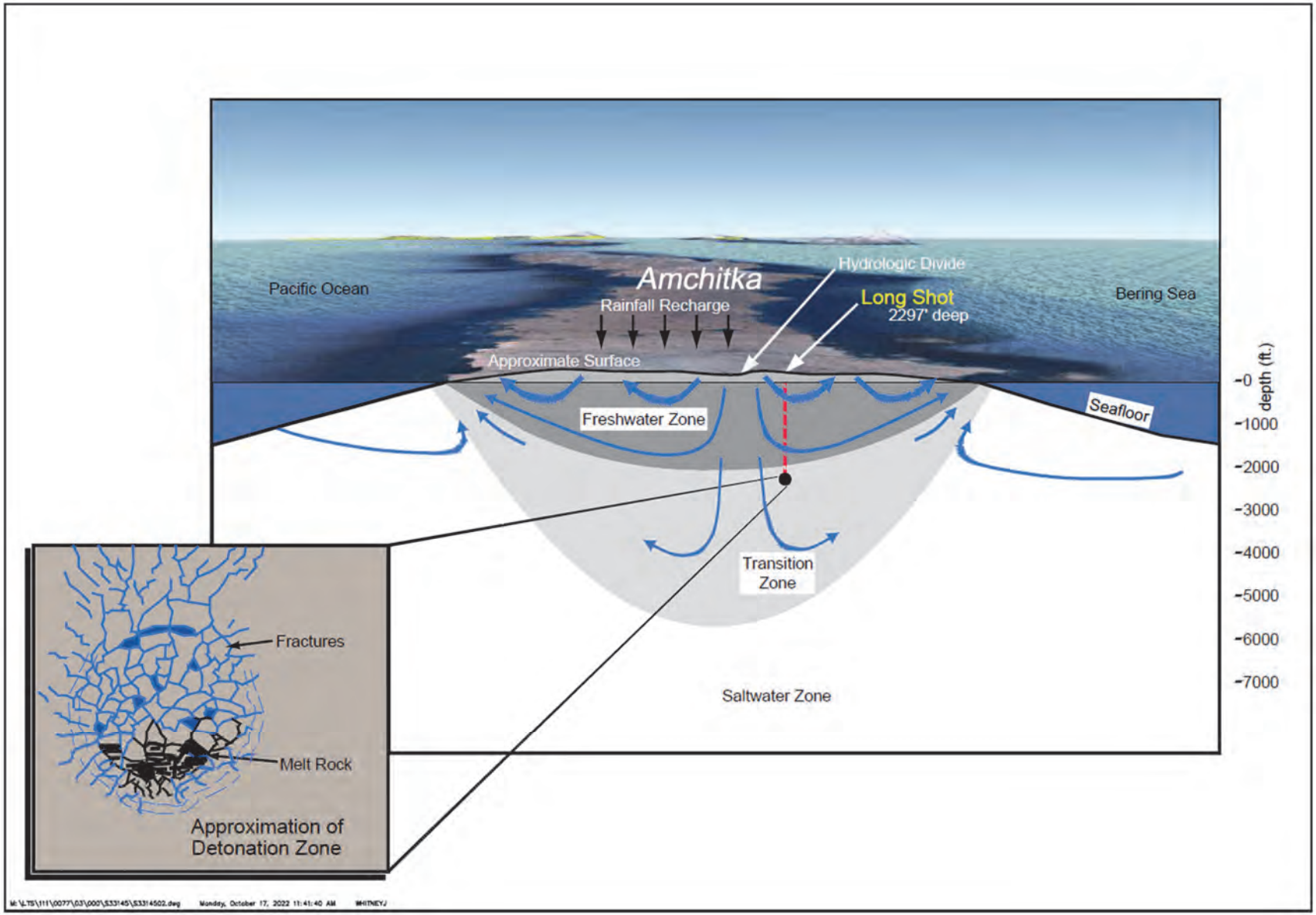
The schematic in Figure 3 was developed based on information provided in CRESP (2005), Hassan et al. (2002), and Hassan and Chapman (2006). The example shown is for Long Shot because the detonation was higher in the transition zone than at Milrow or Cannikin.

2.2 Conceptual Site Exposure Model

Figure 4 is a matrix of exposure routes for human and ecological receptors considered in developing this plan. This figure was developed considering the data collected to date and the most likely potential exposure pathways to future human and ecological receptors should radionuclide migration occur. The exposure pathways assumed to be complete for human receptors are ingestion of affected biota and ingestion, dermal, and gamma irradiation from radionuclide contamination in freshwater and marine water. Direct exposures are assumed for marine biota.

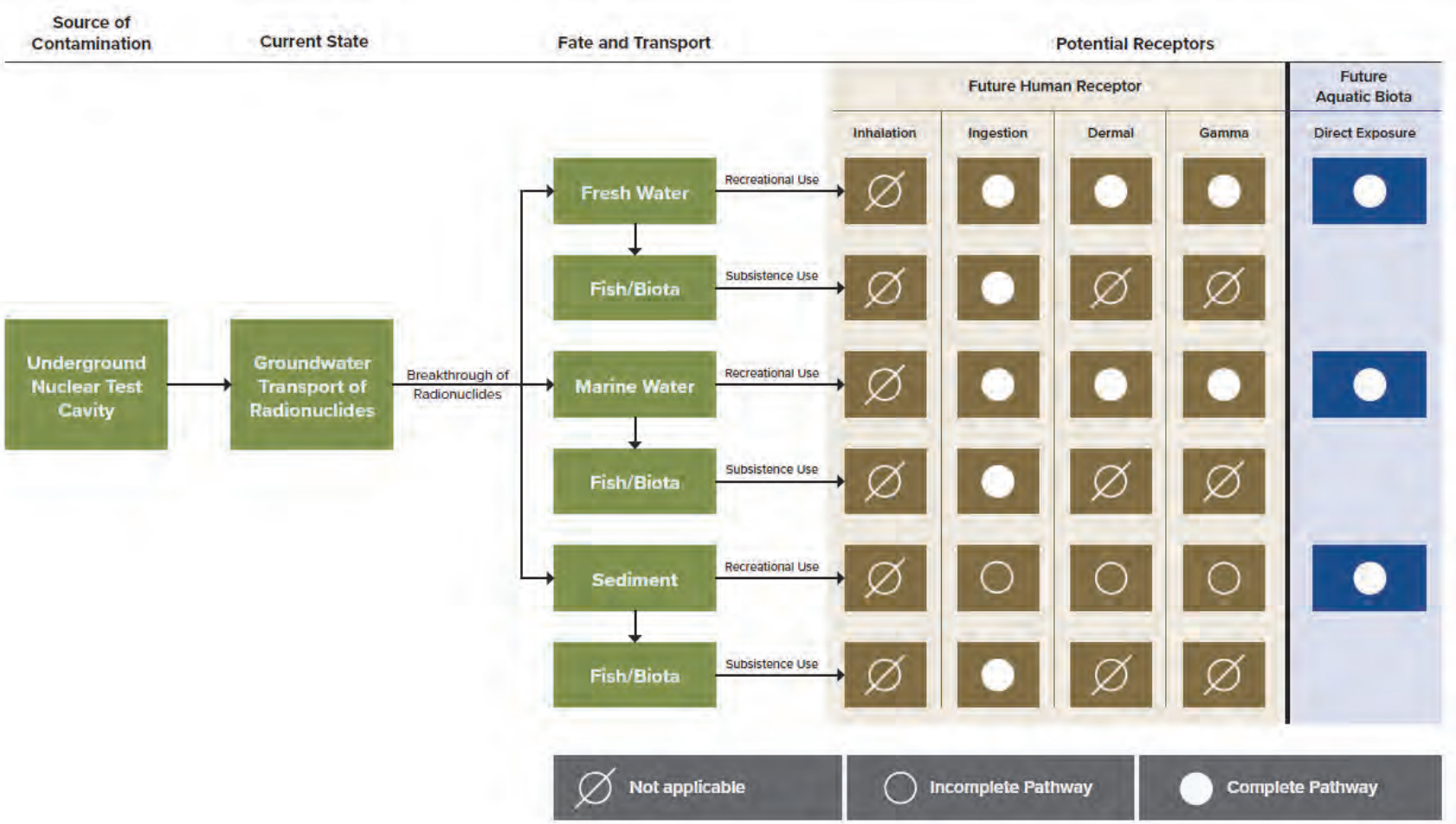
Key features or assumptions of this exposure model are: (1) all routes assume breakthrough of radionuclides to the ocean floor; (2) marine receptors around the Amchitka site are mobile and migratory and can carry radionuclides and contaminants into and out of the Amchitka system; and (3) human exposure pathways are assumed to be complete despite the fact that Amchitka Island is not inhabited and limited commercial and subsistence fishing is known to occur in near-offshore areas. All scenarios assume breakthrough of radionuclides despite modeling results indicating no arrival to the seafloor within the 2200-year modeling time frame assumed by DRI (Hassan and Chapman 2006).

Because Amchitka Island is currently uninhabited, exposure pathways considered for human receptors may not be complete. Although the surrounding marine environment is ecologically rich, there is no evidence that near-offshore areas are fished commercially or for subsistence purposes by people living on neighboring Aleutian Islands.



Note: Schematic was developed based on information provided in CRESP (2005), Hassan et al. (2002), and Hassan and Chapman (2006). The example shown is for Long Shot because the detonation was higher in the transition zone than at Milrow or Cannikin.

Figure 3. Conceptual Site Hydrologic Model



Notes:

1. All scenarios assume breakthrough of radionuclides despite modeling results indicating no arrival to the seafloor within the 2200-year modeling time frame assumed by DRI (Hassan and Chapman 2006).
2. Because Amchitka Island is currently uninhabited, exposure pathways considered for human receptors may not be complete. Although the surrounding marine environment is ecologically rich, there is no evidence that near-offshore areas are fished commercially or for subsistence purposes by people living on neighboring Aleutian Islands.

Figure 4. Conceptual Site Exposure Model

3.0 Data Quality Objectives

Data collected to date provide no evidence that migration of test-related radionuclides from the former detonation zones has occurred. That is, analytical data from background areas unimpacted by the underground nuclear tests have been similar to data from the Amchitka site. This conclusion applies to data collected by LM in 2011 and 2016 and data previously collected by other agencies (refer to Section 1.3). The DQOs outlined in this section for the 2023 sampling effort were developed to support the evaluation of the potential for radionuclide migration from the test sites and the continued demonstration of human health and environmental protection, with an emphasis on food safety. They were derived acknowledging the hydrologic concepts illustrated in Figure 3 and the transport mechanisms and potential human health and ecological exposure routes illustrated in Figure 4.

The seven-step DQO process discussed in this section was applied to the planning cycle of the 2023 environmental sampling plan. LM anticipates that this process will be repeated in subsequent cycles to facilitate trending of the data, as feasible.

3.1 State the Problem

Future migration of radionuclides from the three underground tests could present an unacceptable risk to human or ecological receptors, or both.

Previous evaluations of groundwater flow and transport indicate that migration of test-related radionuclides to discharge points along the seafloor will require in excess of 2200 years. Sampling of marine water and biota immediately after and in subsequent decades after the tests yielded no evidence of contamination in the marine environment from the underground tests. These studies also demonstrated that seafood potentially harvested near Amchitka Island is safe for human consumption. Despite these findings, there are inherent uncertainties associated with the groundwater model and additional data gaps stemming from the lack of monitoring wells (precluding characterization of subsurface conditions) and data related to groundwater movement along faults, the shoreline, or potential offshore groundwater regions. Given these uncertainties, periodic monitoring of biota and the marine and freshwater environments is warranted to ensure that site conditions remain protective of human health and the environment.

3.2 Identify the Decision

The primary objective of the 2023 sampling event is to collect data from freshwater, marine water, and biological tissue that will be used to evaluate if migration of radionuclides from the underground nuclear test cavities is occurring. To determine if migration from the underground nuclear test cavities is potentially occurring, a statistical review of radionuclide concentrations will be performed in comparison to background levels and previous site data. If the review shows a statistical indication of migration, the AWG will be notified within 30 days, or as soon as practical. The AWG will evaluate the data and the next steps.

Data from the biological tissue can also be used to estimate potential risks from ingesting biota or commercial-catch seafood potentially harvested from the region. Given other radionuclide sources in the North Pacific (Layton et al. 1997) and the complexity of the background environment, attributing low levels of radionuclides to the Amchitka Island tests is difficult.

Therefore, new (more representative) background locations have been chosen for the 2023 sampling event and several forensic markers (e.g., iodine isotopes) have been added to the analytical scope.

3.3 Identify the Inputs to the Decision

Biota samples will be analyzed for indicator nuclides (^{137}Cs, ^{239}Pu, and ^{240}Pu) to assess food safety and risk, based on the subsistence dietary information compiled in 2011 (DOE 2013). Data from marine water and freshwater samples will be analyzed for indicator nuclides (^{3}H, ^{137}Cs, ^{239}Pu, ^{240}Pu, ^{127}I, and ^{129}I) to determine if radionuclide migration is indicated from the underground test cavities on Amchitka Island. Because the detection limits for most sample-analyte combinations are lower than those reported previously, the data from the 2023 sample analyses will be used to refine the baseline for future comparisons and trend analysis, as feasible. Table 1 presents the sample types and radionuclides selected for analysis.

Table 1. Sample Types and Radionuclides Selected for Analysis

Sample Type	^{137}Cs	^{239}Pu	^{240}Pu	^{127}I	^{129}I	^{3}H	High-Resolution Gamma Spectrometry
Biota Samples							
Rockweed (*Fucus distichus*)[a]	X	X	X	NA	NA	NA	NA
Greenling (*Hexagrammos* spp.)[a]	X	X	X	NA	NA	NA	NA
Irish lord (*Hemilepidotus* spp.)[a]	X	X	X	NA	NA	NA	NA
Rockfish (*Sebastes* spp.)[a]	X	X	X	NA	NA	NA	NA
Dolly Varden (*Salvelinus malma*)[b]	X	X	X	NA	NA	NA	NA
Optional: Subsistence and commercial catch seafood[c]	NA	NA	NA	NA	NA	NA	X
Water Samples							
Marine water[a]	X	X	X	X	X	X	NA
Freshwater	X	X	X	X	X	X	NA
Precipitation[d]	NA	NA	NA	NA	NA	X	NA

Notes:

[a] Collected offshore from regions corresponding to the three test sites and within the Pacific Ocean and Bering Sea off the southern end of Amchitka Island (refer to Section 4.3 for additional information).

[b] Collected from Cannikin Lake and other land-locked lakes and streams on Amchitka Island.

[c] If time allows, subsistence and commercial species will be collected offshore from the test site regions identified in Note (a) for high-resolution gamma spectrometry and short turnaround time analysis.

[d] If sufficient volume of precipitation is collected.

Abbreviations:

NA = not analyzed

spp. = species (more than one)

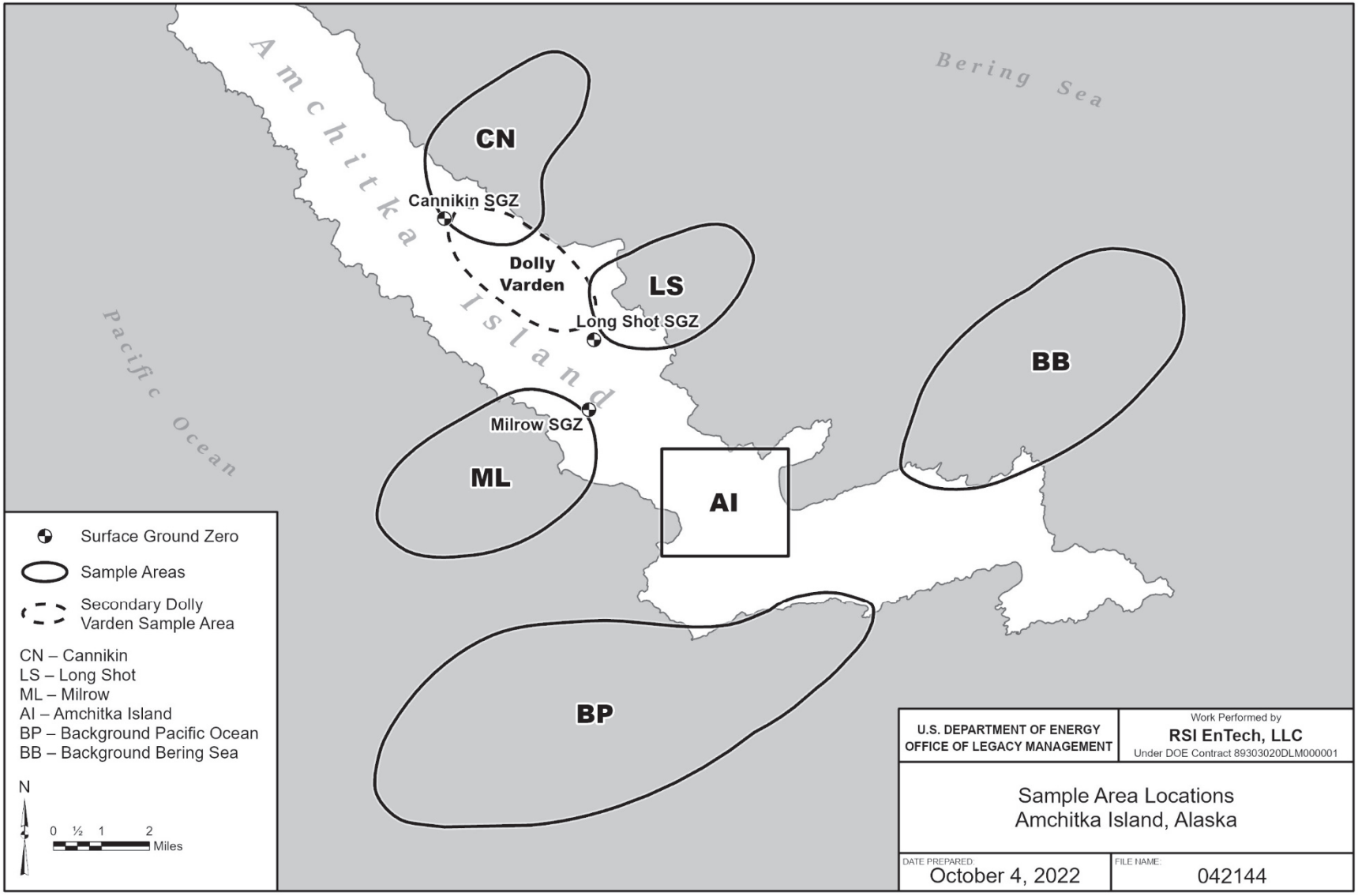
Other inputs to the decision include:

- Verification of diet information and assumptions used to develop the 2011 risk assessment (DOE 2013) to support development of updated risk estimates based on the 2023 sampling data (to be done in coordination with AWG).
- Based on the assumptions above, derivation of updated screening levels corresponding to concentrations of radionuclides in subsistence and commercial catch seafood that would pose a health risk if ingested, assuming a subsistence diet. These screening levels are expected to be lower than national and international standards (FDA 2009; FAO/WHO 2004).
- Concentrations of radionuclides in biota, freshwater, and marine water samples from the newly established reference locations.
- An updated literature review of radionuclide sources and current background concentrations of ^{137}Cs, ^{134}Cs, ^{3}H, ^{239}Pu, ^{240}Pu, ^{127}I, and ^{129}I in the North Pacific Ocean and the Bering Sea (early work done by Layton et al. 1997; more recent data compilations found in Dasher 2017 and Dasher 2020).
- Following a recommendation from AWG, background threshold values (BTVs) will be derived based on 2016 Amchitka site biota and marine water data using EPA's ProUCL Version 5.2.0 (EPA 2022). These BTVs would be treated as background and used to develop nonparametric upper limits for both mean and single point observations to identify potentially elevated concentrations requiring further scrutiny.
- Drawing upon the early work of Dasher et al. (2002), an updated literature review of ^{240}Pu/^{239}Pu atom ratios and (not previously evaluated for the Amchitka site) ^{129}I/^{127}I atom ratios.
- Updated assessment of potential ecological risks or corresponding screening levels in biota and water that would indicate potential risk (e.g., using https://erica-tool.com/ and RESRAD-Biota) (Brown et al. 2016).

3.4 Define the Study Boundaries

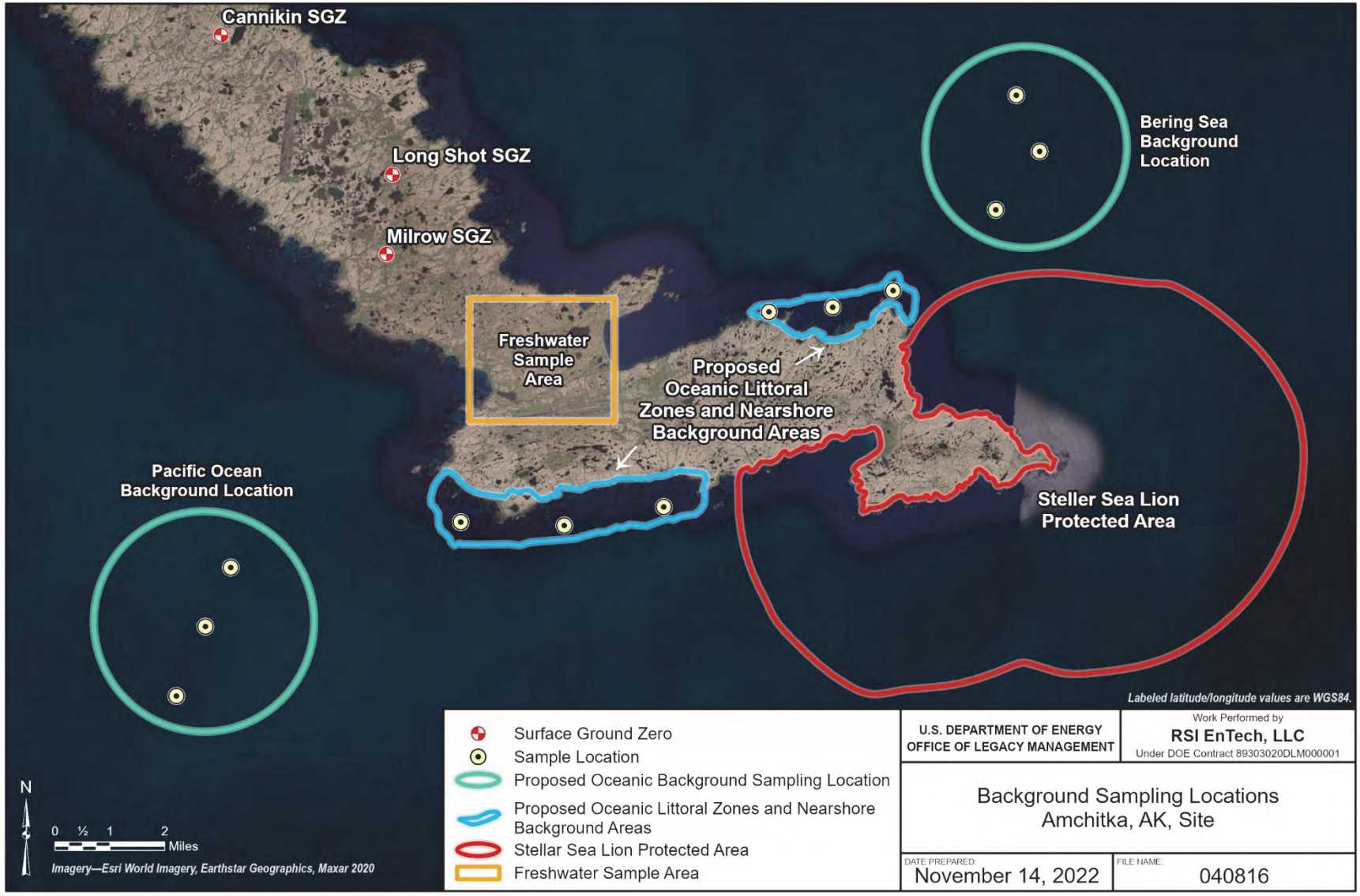
Study boundaries were established based on DRI's modeling predictions (Section 1.3) to ensure that samples are collected from areas most likely to be impacted if contaminant migration were to occur. Figure 5 shows the approximate boundaries of the sample areas for the 2023 sampling event. Specific sample collection locations are described further in Section 4.0.

Freshwater and marine water samples will be collected from all three underground test site regions—Long Shot (LS), Milrow (ML), and Cannikin (CN)—and two background areas, one in the Pacific Ocean (BP) and the other in the Bering Sea (BB). To provide continuity and efficiency in data interpretation for the biota sampling, the Amchitka site sampling locations for 2023 will be in the same general areas, along the shoreline and in ocean areas in probable groundwater discharge zones, as those sampled in 2016. For the new background locations, samples will be collected in the general vicinity of the designated locations shown in Figure 6. A more detailed discussion of Amchitka site and background locations is provided in Section 4.0, with finer resolution illustrated in Figure 7 through Figure 18.



Abbreviation: SGZ = surface ground zero

Figure 5. 2023 Sample Area Locations



Abbreviation: SGZ = surface ground zero

Figure 6. Background Locations for the 2023 Sampling Event

3.5 Develop a Decision Rule

The decision rules outlined in this section draw heavily upon the information inputs identified in Section 3.3. The following general decision rule will be applied to all media as follows:

If concentrations measured in Amchitka site samples are comparable to those collected from reference areas or those reported in the literature, then (1) those levels are considered consistent with sources other than the Amchitka test sites; and (2) no radionuclide migration or human health or environmental risk is indicated.

3.5.1 Marine Water, Freshwater, and Precipitation Samples

Preliminary screening levels for radionuclides in marine water are presented in Table 2.

Table 2. Preliminary Screening Levels for ^{3}H and ^{137}Cs in Marine Water, Amchitka Island, Alaska

Radionuclide	Statistical Basis	Bq/L	pCi/L	mBq/L (= Bq/m^3)	Comments
^{3}H	BTV	0.069	1.85	68.6	Based on 95% USL from the 2016 data set (no decay correction). Intended for comparison with individual sample results.
^{3}H	95% UCL	0.053	1.43	53.1	Intended for comparison with group mean sample results (no decay correction).
^{137}Cs	BTV	0.002	0.052	1.9	Based on 95% USL from the 2016 data set (decay corrected to 2023). Intended for comparison with individual sample results.
^{137}Cs	95% UCL	0.001	0.040	1.5	Intended for comparison with group mean sample results (decay corrected to 2023).

Notes:
The BTV and 95% UCL values are intended for screening of individual results and group means (respectively) for the sampled areas. These values were calculated using EPA's ProUCL Version 5.2.0 (EPA 2022) and are based on the 2016 marine water Amchitka assessment datasets. Preliminary screening levels for ^{137}Cs are radioactive decay corrected to 2023.
Any exceedance of the BTVs or 95% UCLs listed above would require further investigation (e.g., comparisons to actual 2023 measured background concentrations, validation to rule out potential sampling or analytical error, and possible resampling) to confirm if it is an anomalous concentration not representative of 2023 background. Note that these screening values are for the purpose of assisting in the determination of whether migration from the underground nuclear test cavities is potentially occurring. These screening concentrations are below any human or ecological risk levels.

Abbreviations:
Bq/m^3 = becquerels per cubic meter
BTV = Background Threshold Value
mBq/L = millibecquerels per liter
UCL = Upper Confidence Limit
USL= Upper Simultaneous Limit

If marine water concentrations are less than the screening levels in Table 2, these data will then be compared to data from the newly established background locations and North Pacific regional data based on literature reviews. If these screening levels are exceeded, LM will convene with the AWG to discuss follow-up actions, including potential analysis of archived samples. If radionuclide concentrations in marine water samples are below background concentrations and the North Pacific regional data, then no further action is required.

Screening levels for radionuclides in freshwater samples were not derived for this plan because there are insufficient data to do so. The screening levels proposed for marine water (Table 2) are not appropriate for freshwater samples because of differences in salinity and in the nature of the waterbodies. Both ^{3}H and ^{137}Cs concentrations were higher in freshwater samples collected in both 2011 and 2016 than those in marine water samples. Interpretation of data from freshwater samples collected in 2023 will consider data from early studies (e.g., DOE 2000), the limited data from the 2011 and 2016 sampling events, and data from the newly established background locations.

If a sufficient volume of precipitation can be collected for ^{3}H analysis, the data will be used by UAF researchers or students to help interpret marine data and evaluate the sources of ^{3}H in the local environment. The precipitation data will not be included in the environmental sampling report.

3.5.2 Biota Samples

Radionuclide data collected during the 2023 sampling event will be documented in the project database as initial baseline concentrations. Radionuclide concentrations from rockweed and the tissue of three types of fish (greenling, rockfish, and Irish lord) will be compared among sites and between years using analysis of variance (ANOVA) or, more likely given that data are unlikely to be normally distributed, an equivalent comparable nonparametric technique (e.g., the Kruskall-Wallis test). ANOVA is a statistical test used to test whether means (in this case, average concentrations) differ between two or more groups (e.g., Amchitka site samples versus background samples). Consistent with standard practice in the scientific community, a significance level of α (alpha) = 0.05 (5%) will be applied. All statistical tests will be conducted accounting for the distribution of the data, the percentage of nondetects, and potential differences in detection limits over the years that could impact the analysis. For example, if assumption of a normal distribution is not appropriate, nonparametric statistical approaches will be applied. Statistical outliers will not be excluded from the data set unless data validation results warrant their removal. Duplicate sample results will be evaluated but will not be included in statistical summaries (e.g., derivation of the mean). As a conservative measure, the maximum of the duplicate results will be used.

Biota data and the results of corresponding appropriate statistical tests will be evaluated as follows:

- If the radionuclide concentrations measured in 2023 are the same or lower than those measured in 2016 for rockweed, greenling, rockfish, and Irish lord, the results would support a determination that radionuclide migration from the test cavities is not indicated. The 2023 data would be used for comparison against future data. These comparisons will be augmented using the BTV approach discussed in Section 3.3.
- If the radionuclide concentrations measured in 2023 are significantly higher than those measured in 2016 for rockweed, greenling, rockfish, and Irish lord, but equal to or lower than corresponding background location concentrations, these results would support a conclusion that radionuclide migration from the test cavities may not be indicated and further discussion with the AWG would be warranted. The 2023 data would be used for comparison against future data.

- If radionuclide concentrations measured in 2023 are significantly higher than those measured in 2016 for rockweed, greenling, rockfish, and Irish lord, and if the concentrations are higher than corresponding 2023 background data, the AWG will be notified to discuss the need for follow-up actions. These actions could include confirmatory reanalysis of samples, collection of additional samples, or both.
- If radionuclide concentrations measured in 2023 are higher than corresponding 2023 background data, and exceed risk-based screening levels, the AWG will be notified to discuss the need for follow-up actions. These actions could include confirmatory reanalysis of samples, collection of additional samples, or both.
- If the optional sampling of subsistence and commercial catch (Section 4.1.6) occurs, those results will be compared to international guidelines (FDA 2009; FAO/WHO 2004) – e.g., the U.S. Food and Drug Administration's (FDA's) derived intervention levels (DILs). If these levels are exceeded, the AWG will be informed and additional confirmatory analysis will be performed.

3.6 Specify Tolerance Limits on Decision Errors

Any statistical tests applied in the analysis of 2023 sampling data will be run corresponding to a 95% confidence level. This confidence level in turn is used to determine the 95% confidence interval, the range of values or interval around the mean within which the true mean is expected to fall. Depending on the comparison, a sample mean falling outside of (greater than) the specified 95% confidence interval might provide evidence of increased radionuclides and potential migration from the underground tests. However, such a result could also indicate sampling or measurement error, thereby warranting further evaluation and follow-up. All interpretations must be made considering sample number and the other factors discussed in Section 3.5 (e.g., the distribution of the data and proportion of nondetects).

3.7 Optimize the Design

To optimize the 2023 sampling design, statistical power analyses were performed on biota and water sample data from appropriate studies conducted to date to estimate required sample sizes. For biota samples, a 2 to 4 kilogram (4 kg preferred) sample will be collected except for Dolly Varden, whose sample size will be 2 kilograms, and Rockweed, whose sample size will be 5 kilograms. For freshwater and marine water samples, a 40-liter sample will be collected in addition to two 1-liter samples for tritium and iodine analysis.

4.0 Sampling Elements

The following sampling elements will be described and developed for implementation in 2023 in accordance with the DQOs in Section 3.0 of this sampling plan.

4.1 Deviations or Differences Relative to Previous Sampling Efforts

This plan incorporates several changes and additions relative to the scope of previous sampling efforts (e.g., DOE 2016). In summary, the AWG agreed to the following:

- Move the background sampling location from Adak Island, Alaska to locations in the Pacific Ocean and Bering Sea just off the southern part of Amchitka Island
- Add ^{127}I and ^{129}I to the analytical scope
- Use lower detection limits for selected samples
- Remove ^{134}Cs from the analytic suite
- Collect and store additional samples for possible future radionuclide analysis
- Optional - Provide for a food safety check by collecting additional subsistence and commercially caught species

The following sections further describe these changes and the supporting rationales.

4.1.1 Background Location Change

The background location as determined by CRESP in 2004 was Kiska Island. For LM's previous 2011 and 2016 sampling events, Adak Island was the background location. For the 2023 sampling event, areas off the southern part of Amchitka Island are the new background locations. The methodology and criteria used in assessing background locations for the Amchitka site's 2023 sampling event was adapted from general criteria developed by Fritz et al. (2015). While the study was applied to air monitoring locations, the methods were used to determine background sampling locations for assessment of other contaminated sites and media. Relevant definitions and background location selection criteria are outlined below.

- An ideal background marine monitoring location is an area where measured radionuclides of interest are equal to the concentrations that would be measured at the site if no Amchitka Island underground test seafloor breakthrough were occurring.
- Marine water sampled at background locations should be similar to the marine water sampled offshore of Cannikin, Long Shot and Milrow underground tests with the exception that the background locations are relatively uninfluenced by any breakthrough of underground test radionuclide concentrations.
- Similar weather conditions should exist between the Amchitka Island test locations and the background locations as precipitation and prevailing wind patterns control the deposition of atmospheric anthropogenic radionuclides from aboveground nuclear tests and nuclear accidents.
- The background location should be a reasonable distance away from potential breakthrough areas (not too close or too far away) from the underground tests at Amchitka. That is, the background sites should be as close as possible while still meeting the other requirements.

After evaluating Adak, Amchitka, and Kiska Islands against the background definition and criteria, Amchitka was the only one meeting the background requirements for the following reasons:

- Amchitka Island has littoral, nearshore, and offshore areas that are suitable background sites where natural background is like the Amchitka underground nuclear test sites. Figure 6 identifies background areas.
- Both Adak and Kiska islands are distant from Amchitka, separated by different passes, various mixtures of oceanic waters differing in physical and chemical properties, and differing weather regimes, principally regarding wet deposition patterns. These conditions provide for differences in anthropogenic radionuclide distribution in the aquatic, biological, and terrestrial environments from global fallout and near field nuclear testing near these islands.

4.1.2 Addition of ^{127}I and ^{129}I Isotopes

Iodine-127 and ^{129}I have been added to the 2023 sampling event to provide a third forensic marker to assess potential underground test breakthrough contribution to the fresh and marine waters around Amchitka Island.

4.1.3 Lower Detection Limits

The laboratory analytical method detection limits that will be used for the 2023 samples are lower than those used previously. The lower detection limits may provide data to enable DOE to better delineate background activity concentrations of the radionuclides of interest.

4.1.4 Removal of Cesium-134

During the 2016 sampling events, biota and marine water samples were analyzed for ^{134}Cs to identify impacts from the March 2011 Fukushima nuclear power plant discharge to the Pacific Ocean. Given its short half-life (2.06 years) and the very low detection frequencies in 2016 (DOE 2020), it is no longer necessary to monitor for this radiocesium isotope.

4.1.5 Additional Sample Collection

If radionuclide analytical results trigger a decision rule action, then further analysis may be performed. To preempt another sampling trip to Amchitka Island, additional 1-liter freshwater and marine water samples will be collected and stored at the LLNL for possible follow-up analysis. As indicated in Section 3.5, if the 2023 sample concentrations are higher than 2016 results and corresponding 2023 background data, the AWG will be notified to discuss the need for follow-up activities. If additional analyses are determined to not be needed, samples will be immediately disposed of by the LLNL.

4.1.6 Optional – Sampling of Subsistence and Commercial Catch Species

To provide information to the local communities around Amchitka that the seafood that are obtained from commercial means are safe for consumption, although some of the species might be the same as those considered in subsistence use (e.g., halibut), additional biological samples will be collected by the sampling team or vessel staff from the general vicinity of Amchitka Island, if possible, in the time allotted. The team will attempt to collect typical commercial or

subsistence fish (such as Pacific halibut, walleye pollock, cod, or Atka mackerel) for high-resolution gamma spectrometry.

4.2 Analytes

Analytes for the biological samples will be ^{137}Cs, ^{239}Pu, and ^{240}Pu. Marine water and freshwater samples will be analyzed for ^{3}H, ^{137}Cs, ^{239}Pu, ^{240}Pu, ^{127}I, and ^{129}I. Table 3 lists the analytes and the corresponding detection limits achieved by the analytical methods given.

4.3 Sample Locations

4.3.1 Fresh and Marine Water Samples

Samples of freshwater and marine water will be collected during the 2023 sampling event.

Figure 7 shows the three background freshwater sample locations on Amchitka Island. Three background freshwater samples will be collected, one from each location.

Figure 8 and Figure 9 show the marine water background sampling locations for the Bering Sea and Pacific Ocean areas off Amchitka Island. Six samples of marine water will be collected, one from each location.

Figure 10 shows the sampling locations for the Cannikin site. Three freshwater samples and seven marine water samples will be collected.

Figure 11 shows the sampling locations for the Long Shot site. Three freshwater samples and six marine water samples will be collected.

Figure 12 shows the sampling locations for the Milrow site. Three freshwater samples and seven marine water samples will be collected.

Table 4 summarizes the field collection sampling and analytical requirements for all water samples to be collected. Table 5 summarizes the freshwater and marine water sample station locations shown in Figure 7 through Figure 12.

4.3.2 Biota Samples

Figure 13 shows the preferred location for Dolly Varden sample collection in Cannikin Lake. If samples cannot be acquired from Cannikin Lake, collection will be attempted from similar land locked lakes moving southeast from Cannikin toward Long Shot, as close to Cannikin Lake as possible. Dolly Varden samples for background analysis can be collected from any of the lakes within the Amchitka Island (AI) background area shown on Figure 5and Figure 7.

Figure 14 through Figure 18 show the shoreline and nearshore marine water areas where biological samples will be collected.

4.3.3 Precipitation Samples

Precipitation samples will be collected by UAF from up to three locations, if possible, from a location near the Constantine Harbor dock.

Table 3. Laboratory Method and Estimated Minimum Detection Activity

Biota Samples			A Priori MDC (Bq/kg-wet weight)[a]			
Analytes	**Laboratory Method**	**Estimated MDA (Bq)**	**Based on 1 kg Sample**	**Based on 2 kg Sample**	**Based on 4 kg Sample**	**Based on 5 kg Sample**
^{137}Cs	Gamma spectrometry (HPGe)	1	0.3	0.15	0.075	0.06
^{137}Cs	SAGe well detector	0.01	0.01	0.005	0.0025	0.002
^{239}Pu	AMS	1.00 E-05	1.00 E-05	5.00 E-06	2.50 E-06	2.00 E-06
^{240}Pu	AMS	3.00 E-05	3.00 E-05	1.50 E-05	7.50 E-06	6.00 E-06
Marine Water and Freshwater Samples			**A Priori Sample MDC (Bq/L)**			
Analytes	**Laboratory Method**	**Estimated MDA (Bq)**	**Based on 1 L Sample**		**Based on 40 L Sample**	
^{3}H	Electrolytic enrichment followed by gas proportional counting	1.84 E-02	1.18 E-02		1.84 E-02	
^{137}Cs	Gamma spectrometry (SAGe well detector)	3.00 E-03	3.00 E-03		1.84 E-02	
^{239}Pu	AMS	1.00 E-05	1.00 E-05		1.84 E-02	
^{240}Pu	AMS	3.00 E-05	3.00 E-05		1.84 E-02	
^{129}I	AMS	1.00 E-09	1.00 E-09		1.84 E-02	
		Isotopic Lower Sensitivity Limit				
^{129}I/^{127}I	AMS (^{129}I)/ ICP-MS (^{127}I) Isotopic Ratio	1 E-11				

Notes:

[a] On the basis of the analytical methods identified in this table, a sample size of 0.1 kilogram on wet-weight basis is indicated to be adequate for the radionuclide concentrations of interest; however, to provide ample sample size and further optimize laboratory efficiency, a sample size of 2 kilograms was requested, as field conditions allow.

LLNL will screen biota samples on a standard Ge detector. If the analyte cannot be quantified, the sample will be run on the SAGe detector.

Since AMS ^{129}I/^{127}I measurements are normalized to a standard, such as the ISOT-2 that has a ^{129}I/^{127}I ratio of ~1 x 10^{-11}, the lower sensitivity limit will be set at 1 x 10^{-11}.

Abbreviations:

AMS = accelerator mass spectrometry
Bq/kg = becquerels per kilogram
g = grams
ICPMS = inductively coupled mass spectrometry
MDA = minimum detectable activity
MDC = minimum detectable concentration
SAGe = small anode germanium

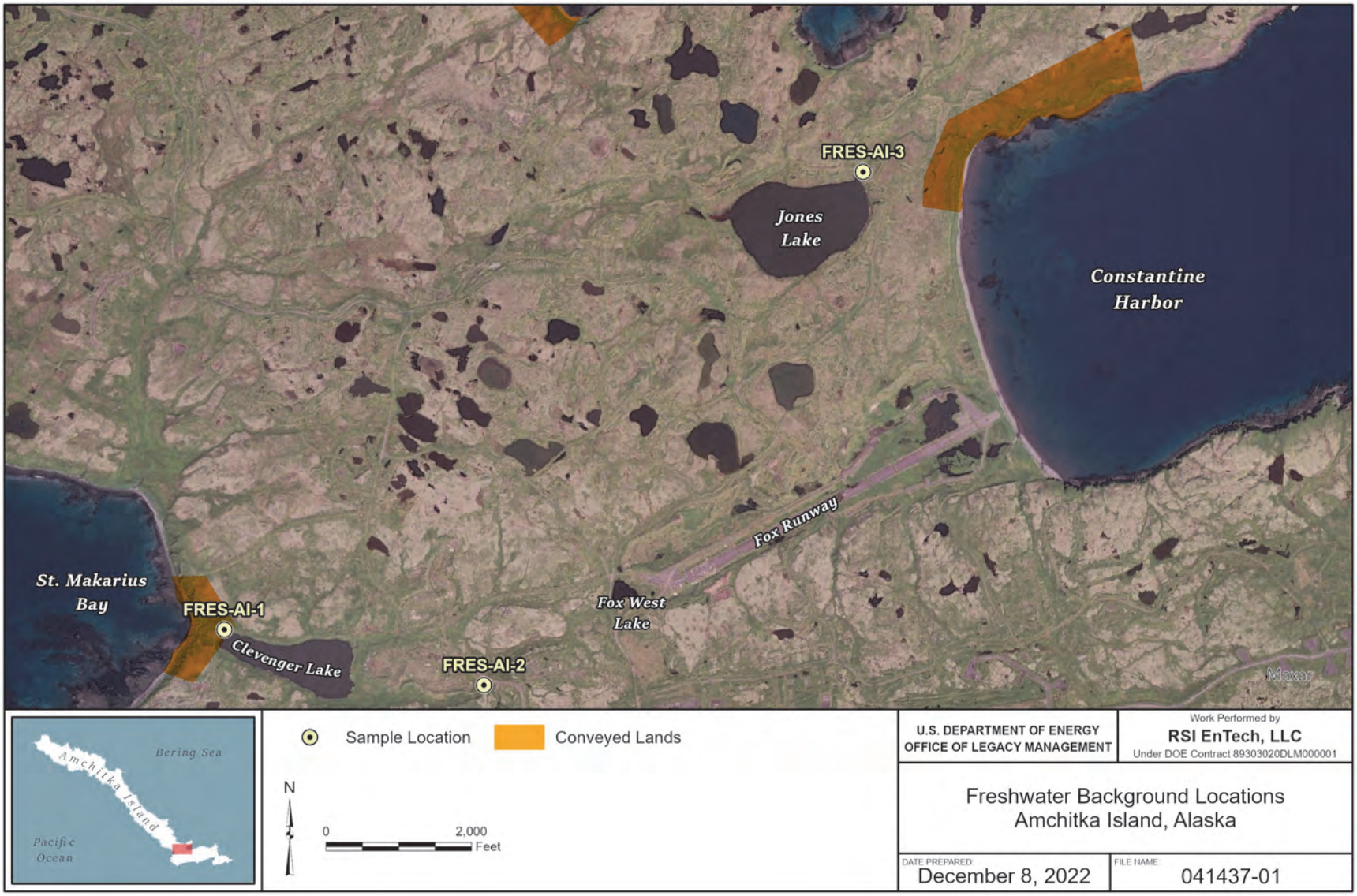


Figure 7. Freshwater Background Locations

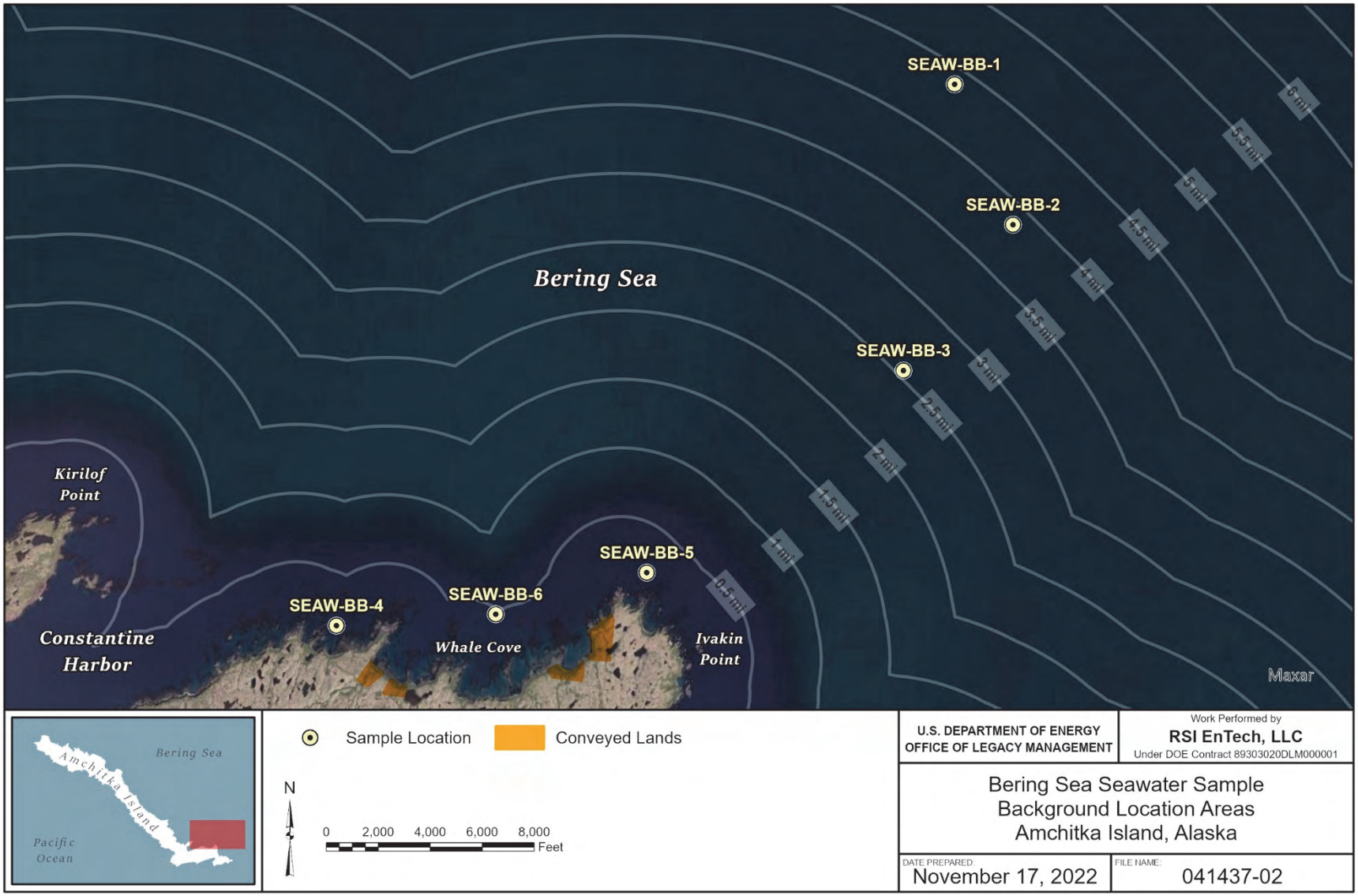


Figure 8. Bering Sea Seawater Sample Background Locations

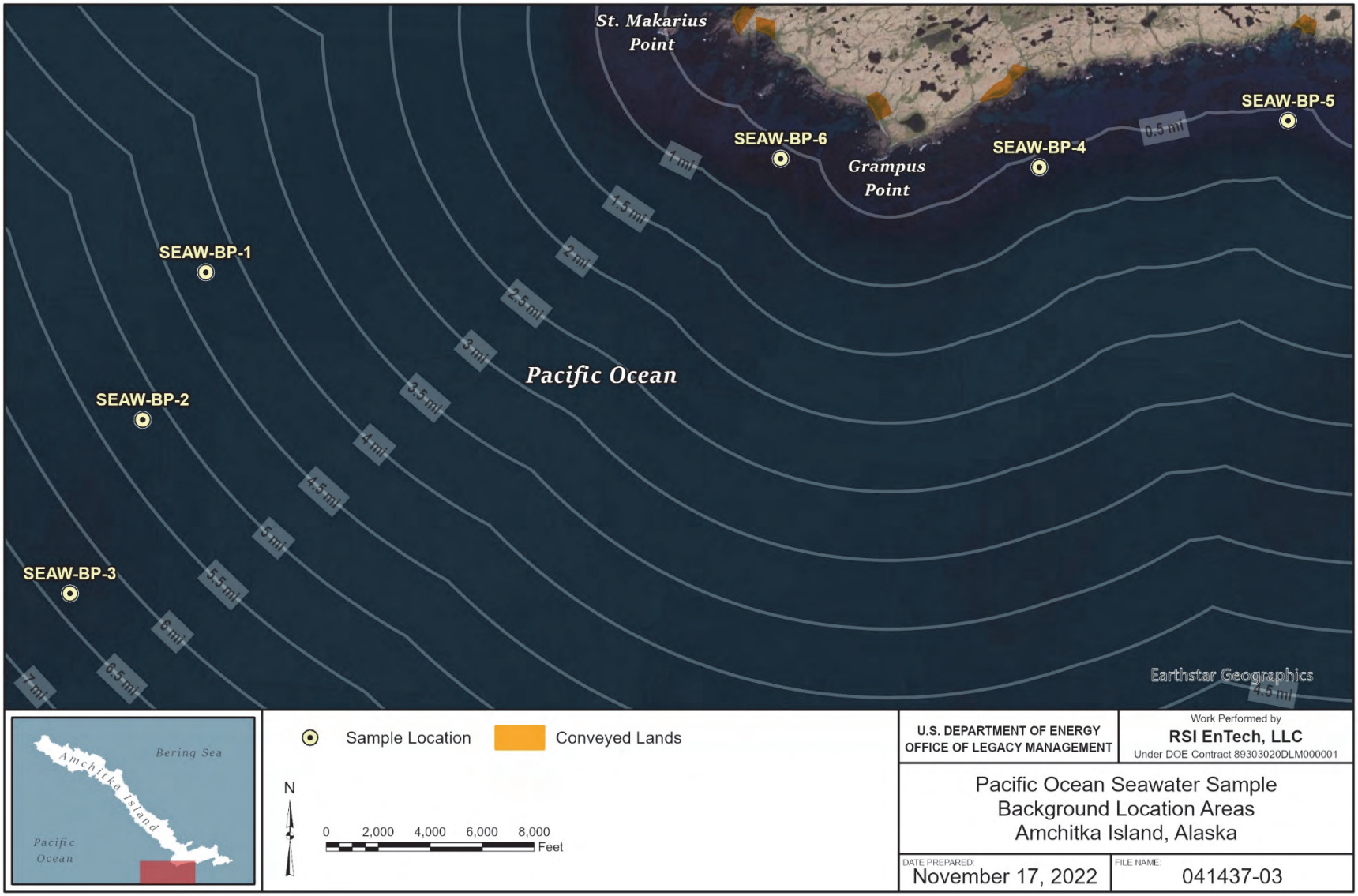
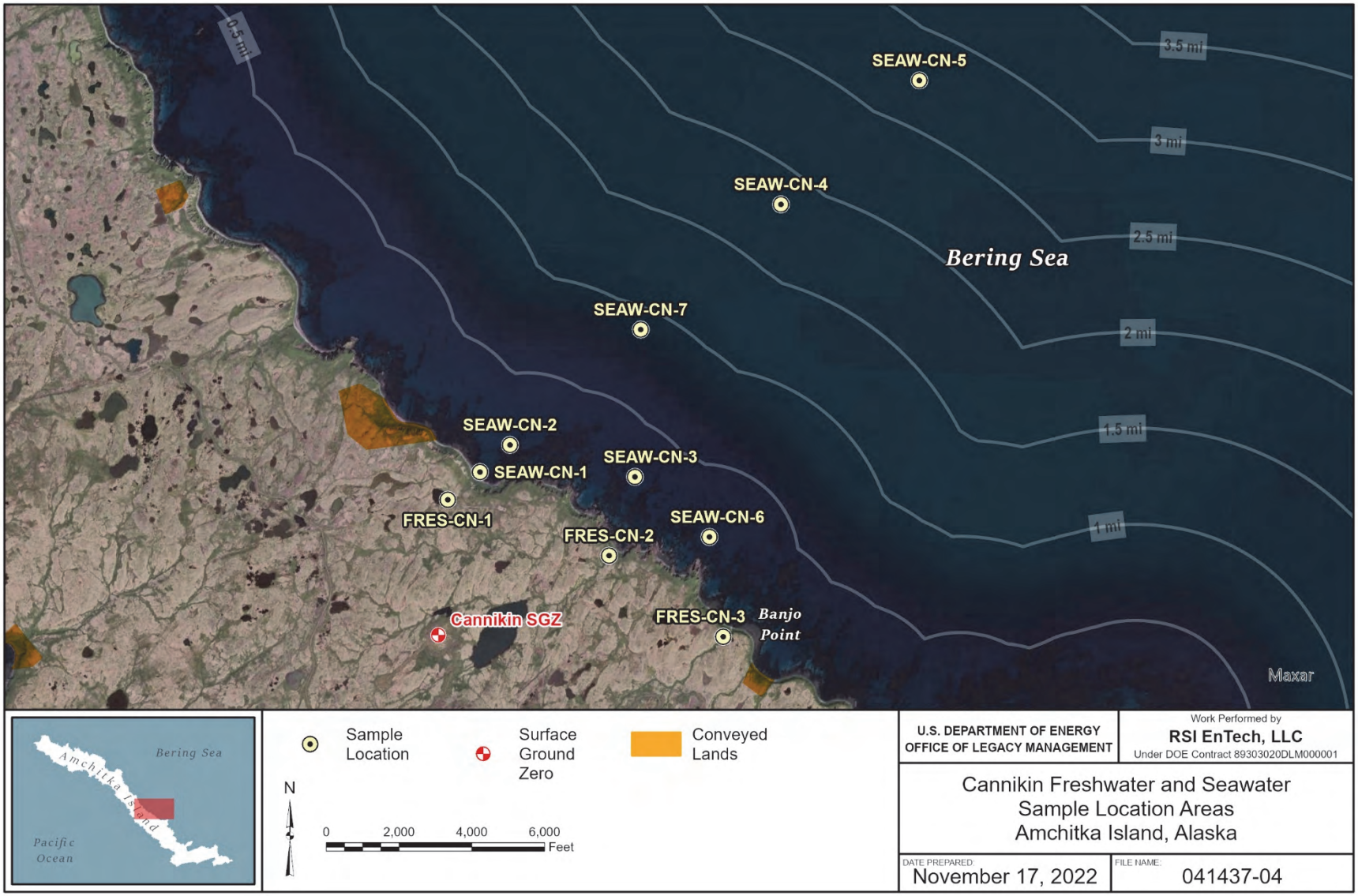
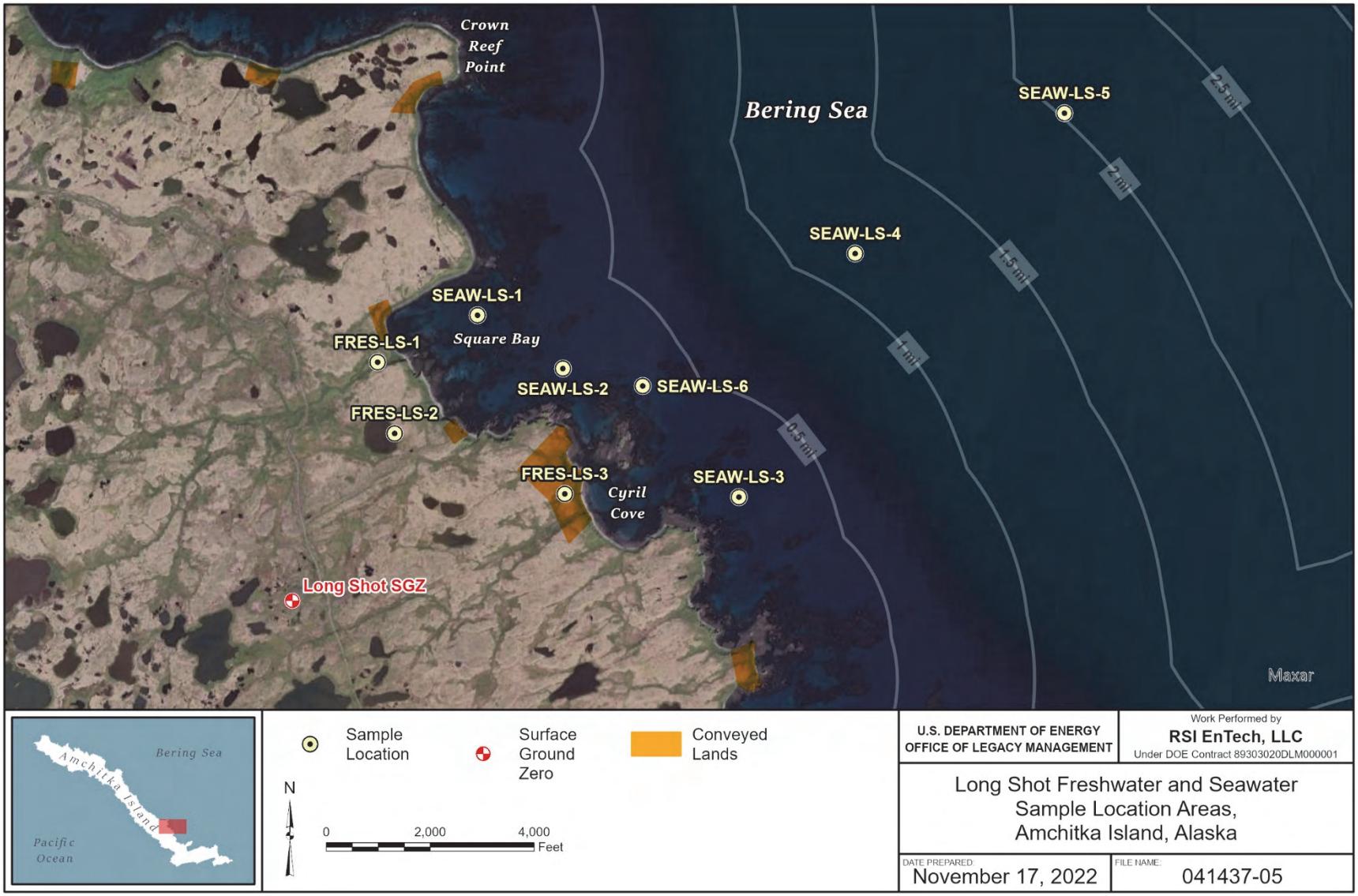


Figure 9. Pacific Ocean Seawater Sample Background Locations



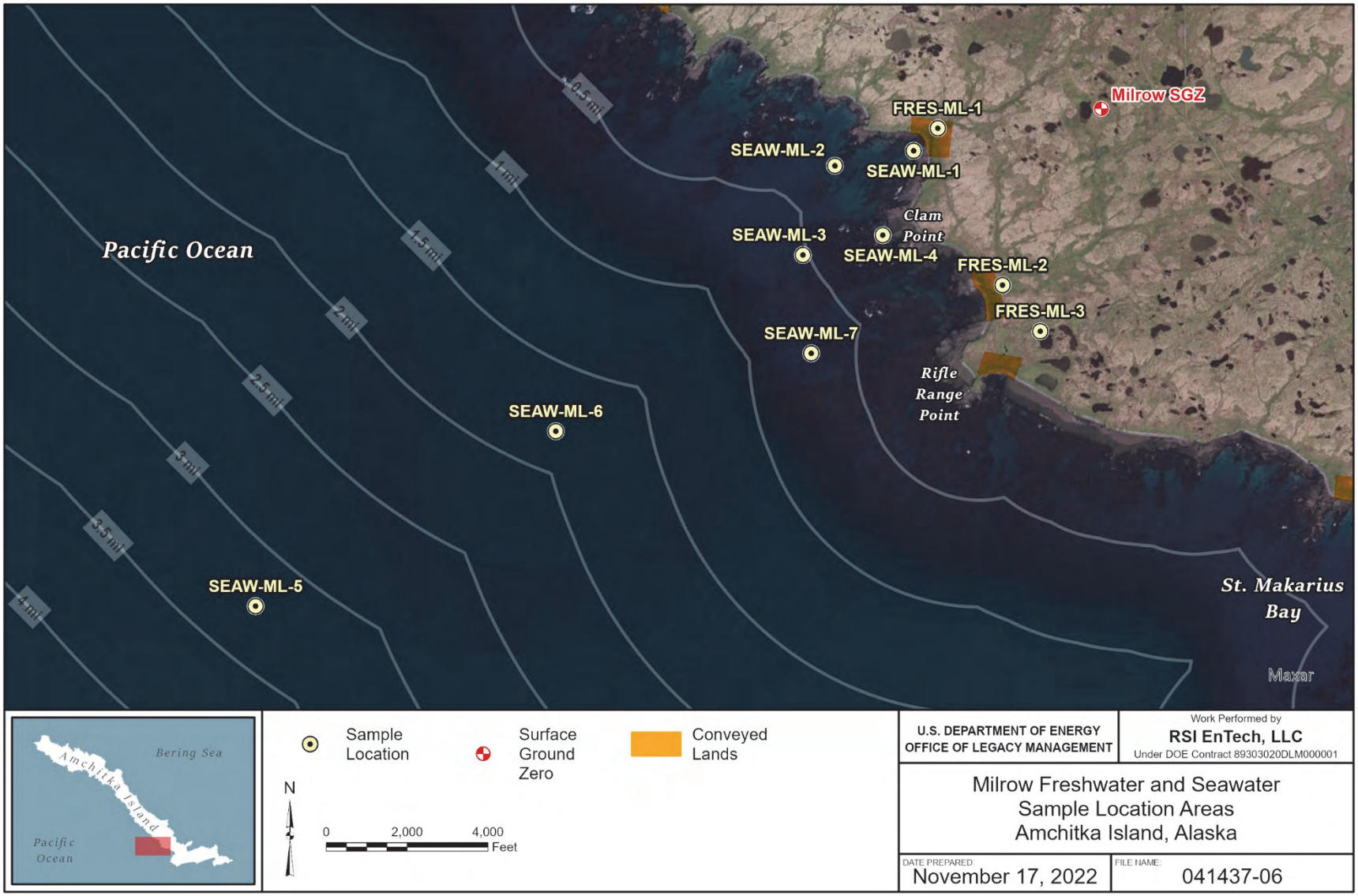
Abbreviation: SGZ = surface ground zero

Figure 10. Cannikin Test Site Freshwater and Seawater Sample Locations



Abbreviation: SGZ = surface ground zero

Figure 11. Long Shot Test Site Freshwater and Seawater Sample Locations



Abbreviation: SGZ = surface ground zero

Figure 12. Milrow Test Site Freshwater and Seawater Sample Locations

Table 4. Field Collection Sampling and Analytical Requirements – Water

Location Sample Type	Total Number of Samples	Analytes			
		^{3}H	^{137}Cs	^{239}Pu and ^{240}Pu	^{127}I and ^{129}I
Cannikin					
Marine Water	7	7	7	3	3
Freshwater	3	3	1	1	1
Long Shot					
Marine Water	6	6	6	3	1
Freshwater	3	3	1	1	1
Milrow					
Marine Water	7	7	7	3	1
Freshwater	3	3	1	1	1
Background					
Pacific Ocean	6	6	6	3	2
Bering Sea	6	6	6	3	2
Freshwater	3	3	1	1	1
Near Constantine Harbor Dock					
Precipitation	Up to 3	0 to 3	'--	'--	'--
Subtotal	47	47	36	19	13
Field Duplicates	6[a]	6[a]	5[b]	3[c]	2[d]
TOTAL	**53**	**53**	**41**	**22**	**15**

Notes:
Field duplicates will be collected for each analysis as follows
[a] 4 marine water and 2 freshwater ^{3}H field duplicates
[b] 4 marine water and 1 freshwater ^{137}Cs field duplicates
[c] 2 marine water and 1 freshwater ^{239}Pu and ^{240}Pu field duplicates
[d] 1 marine water and 1 freshwater ^{127}I and ^{129}I field duplicates

For the marine water samples, LLNL will run ^{137}Cs analysis and Miami will run ^{3}H analysis. Then according to the preliminary screening levels in Table 2, and salinity levels when screening for station anomalous values, the AWG will decide which samples to run for Pu and I. If no anomalous values were observed, professional judgment will be used or samples will be randomly selected for Pu and I sets for each location.

For the freshwater samples, one station in each watershed was selected for taking a *complete sample set* from a stream draining a large fraction of the watershed (Cannikin [White Alice Creek: FRES-CN-2], Long Shot [Bridge Creek above marine water influence: FRES-LS-1], and background [Clevenger Lake or its discharge creek above marine water influence: FRES-AI-1]) or following a fault line disturbed by the underground nuclear test Milrow [Duck Cove Creek above marine water influence: FRES-ML-1]. The other two samples from each freshwater sampling area receive tritium analysis only. One complete field duplicate set would be taken from one of the locations listed above and one would be taken from one of the locations being analyzed for ^{3}H only.

Table 5. Freshwater and Marine Water Sample Locations, Amchitka Island

#	Longitude	Latitude	Location Name	Sample Designation
1	179.2300758	51.38173718	Amchitka FW BKG 1 (Clevenger Lake)	FRES-AI-1
2	179.2459	51.3803	Amchitka FW BKG 2 (Constantine Springs)	FRES-AI-2
3	179.2666312	51.40052151	Amchitka FW BKG 3 (Jones Lake)	FRES-AI-3
4	179.1230753	51.33046597	Amchitka South BKG MW 1	SEAW-BP-1
5	179.1141487	51.31451431	Amchitka South BKG MW 2	SEAW-BP-2
6	179.1039395	51.29573488	Amchitka South BKG MW 3	SEAW-BP-3
7	179.2618505	51.34737368	Amchitka South BKG NS MW 2	SEAW-BP-4
8	179.3031127	51.35397894	Amchitka South BKG NS MW 3	SEAW-BP-5
9	179.2183018	51.34646555	Amchitka South BKG NS MW 1	SEAW-BP-6
10	179.4401625	51.46812196	Amchitka North BKG MW 1	SEAW-BB-1
11	179.4514885	51.45375644	Amchitka North BKG MW 2	SEAW-BB-2
12	179.4346051	51.4376917	Amchitka North BKG MW 3	SEAW-BB-3
13	179.3419603	51.40705004	Amchitka North BKG NS MW 1	SEAW-BB-4
14	179.3935738	51.41473195	Amchitka North BKG NS MW 3	SEAW-BB-5
15	179.3686332	51.40933054	Amchitka North BKG NS MW 2	SEAW-BB-6
16	179.1037481	51.48038505	Cannikin FW 1	FRES-CN-1
17	179.1236052	51.47701937	Cannikin FW 2	FRES-CN-2
18	179.1379962	51.47151131	Cannikin FW 3	FRES-CN-3
19	179.1073907	51.48263313	Cannikin Shoreline MW	SEAW-CN-1
20	179.1107755	51.48481962	Cannikin NS MW 1	SEAW-CN-2
21	179.1260683	51.48306085	Cannikin NS MW 2	SEAW-CN-3
22	179.1414215	51.50426021	Cannikin Mid MW	SEAW-CN-4
23	179.1570724	51.51426446	Cannikin Far Edge MW	SEAW-CN-5
24	179.1355282	51.47893334	Cannikin NS MW 3	SEAW-CN-6
25	179.1255607	51.49415246	Cannikin 1st Edge MW	SEAW-CN-7
26	179.1856215	51.44941888	Long Shot FW 1	FRES-LS-1
27	179.1874546	51.4457339	Long Shot FW 2	FRES-LS-2
28	179.2021124	51.44315663	Long Shot FW 3	FRES-LS-3
29	179.1937627	51.45224016	Long Shot NS MW 1	SEAW-LS-1
30	179.2012496	51.44973754	Long Shot NS MW 2	SEAW-LS-2
31	179.2167842	51.44360227	Long Shot NS MW 3	SEAW-LS-3
32	179.2252037	51.45680548	Long Shot Mid MW	SEAW-LS-4
33	179.242039	51.46491202	Long Shot Far Edge MW	SEAW-LS-5
34	179.2080656	51.44910265	Long Shot 1st Edge MW	SEAW-LS-6
35	179.1619729	51.41347927	Milrow FW 1	FRES-ML-1
36	179.1701046	51.40317858	Milrow FW 2	FRES-ML-2
37	179.1745156	51.40022828	Milrow FW 3	FRES-ML-3
38	179.1595223	51.4118476	Milrow Shoreline MW	SEAW-ML-1
39	179.1511222	51.41047362	Milrow NS MW 1	SEAW-ML-2
40	179.148312	51.40430318	Milrow NS MW 2	SEAW-ML-3

Table 5. Freshwater and Marine Water Sample Locations, Amchitka Island (continued)

#	Longitude	Latitude	Location Name	Sample Designation
41	179.1567985	51.40600981	Milrow 1st Edge MW	SEAW-ML-4
42	179.0917434	51.37806565	Milrow Far Edge MW	SEAW-ML-5
43	179.122895	51.39126655	Milrow Mid MW	SEAW-ML-6
44	179.1499252	51.39769902	Milrow NS MW 3	SEAW-ML-7

Note:
Station locations and coordinates are in WGS84 and were taken from Google Earth Pro. They were exported as KML files and converted to Microsoft Excel files.

4.4 Sampling Procedures

As part of this 2023 sampling event, marine water, freshwater, and biological samples will be collected. Table 5 summarizes the general field collection sampling requirements for 2023 sampling activities. The following sections describe the procedures for performing these activities.

Information will be collected using paper field forms, as well as the Environmental Quality Information System (EQuIS) Data Gathering Engine (EDGE) described in Appendix B-1 of the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351). For simplicity, field forms are referenced in the procedure below. This includes both hard copy documents, as well as electronic data deliverable (EDD) files.

4.4.1 Marine Water Collection

Identify Location and Deploy Instrumentation

Depending on marine conditions, hazards, and water depth, the sampling may take place from the deck of the charter vessel or a smaller skiff. If the large support vessel cannot access a location, the marine water sampling will be conducted from a small skiff. The sampling location will be confirmed to within 50 meters (m) (~150 ft) with nondifferential GPS. The coordinates for each sampling location will be noted using a GPS from the charter vessel or skiff.

Sampling instrumentation will be deployed from the deck of the vessel using the stern A-frame or a boat crane setup. Each marine water sample will be collected from the desired depth of approximately 25 meters or, half the depth if the depth of water in the sampling location is less than 50 meters. The winch feed out along with cable markings or depth sensor (YSI or similar) will provide sample depth info. The water depth will be confirmed with the charter vessel's depth finder.

4.4.2 Nearshore and Shoreline Water Collection (Marine Water and Freshwater)

Identify Location and Deploy Instrumentation

Navigate over land to the points shown in Figure 7. Samples will be collected from the shore. A battery-powered peristaltic or submersible pump will be used to collect a sample from the desired depth.

4.4.3 Water Sampling Procedure (Marine Water and Freshwater)

The following procedures will be used for both freshwater and marine water sampling:

- Navigate to the predetermined location as described in Section 4.4.1 and 4.4.2 above.
- Collect the coordinates for each sampling location using the GPS and record the coordinates in the field forms.
- Decontaminate all equipment that comes in contact with samples before sampling and between each sample.
  - Rinse all sample contacting surfaces with a diluted detergent solution (such as Dawn dish detergent) followed by an analyte-free water (e.g., deionized or distilled water) rinse.
  - Run three equipment volumes (pump and tubing) at each location before collecting a sample.
- Record salinity, temperature, conductivity, and pH using the multiparameter meter (e.g., YSI or similar) or meters. The meter must be calibrated before use and pass a daily operational check. Data should be collected as described in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites.*
- In order to be sure that freshwater sources such as Ridge Creek are not connected to marine water, check to see if the salinity measurement is in the range of <0.5 to 1 ppt (<500-1000 ppm). Also check salinity at other locations for comparison, for example White Alice Creek below Cannikin Lake. If the salinity is greater than 1 ppt (1000 ppm) the sample location should be adjusted since it is likely not from a freshwater source.
- For freshwater sampling, collect the sample at 1 to 1.5 feet below the water surface. If the depth of water at a marine water sampling location is greater than 50 meters, collect the water sample from a depth of 25 meters. For water that is less than 50 meters deep, collect the water sample at half the depth (i.e., in water that is 25 meters deep, collect the water at 12.5 meters deep).
- Record the depth of water and the depth of sample collection on the field forms.
- Filter and fill sample bottles as appropriate based on analyte. See Table 6, not all samples receive all analyses:
  - Cesium-137, ^{239}Pu, and ^{240}Pu: Filter utilizing a 0.45-micrometer (µm) filter and place into two 20-liter (approximately 5-gallon) plastic carboy containers. Replace the cap and screw it on tightly. Samples for Cs and Pu isotope analysis do not require refrigeration.
  - Iodine-127 and ^{129}I: Do <u>not</u> filter. Place into a 1-liter wide-mouth amber high-density polyethylene (HDPE) bottle. Replace the cap and screw it on tightly. Store in cool and dark.
  - Tritium: Do <u>not</u> filter. Place into a 1-liter HDPE bottle. Replace the cap and screw it on tightly. To avoid cross contamination, do not wear a wristwatch, compass, or similar device with luminescent dials or “beta” lights while taking samples. Collect water for tritium analysis only in fresh containers with no rinsing or overfilling. Fill container slowly with tubing at the bottom of the container to avoid mixing water with ambient air.
  - Additional analytes: Filter utilizing a 0.45µm filter and place into a 1-liter HDPE bottle.

- Leave room at the top of each sample bottle to allow for water expansion during shipping.
- Collect field duplicates at a frequency of 10% for each sample type (i.e., freshwater, marine). See Table 4 for additional information. Field duplicate locations may be selected during the field planning process or selected in the field.

After recording sample name, date, time, and whether the sample has been filtered or not, all labels will be wrapped with clear tape before sampling. Sample numbers for each location have been established and are identified in Table 5. Record the bottle number and information on the field forms, double-checking it against the sample container label.

- Wrap the sample container cap or opening clockwise with a custody seal and tape to secure the cap for shipment and potential laboratory storage. Squeeze each bottle upside down to check for leakage. Contain each sample in a secondary bag for leak protection.
- Once sampling is completed, pack the sample containers securely to avoid breakage during shipment.
- Record all samples on the chain-of-custody form when the sample container enters storage.
- Ship samples collected for ^{137}Cs, ^{239}Pu, ^{240}Pu, ^{127}I, ^{129}I, and potential additional analyte analysis to LLNL.
- Ship ^{3}H samples to the University of Miami Rosenstiel School of Marine and Atmospheric Science Tritium Laboratory.
- Notify laboratories when samples are shipped. Provide a copy or photo of the chain-of-custody form at the time of notification, if possible.

4.4.4 Precipitation Sampling Procedure

Precipitation samples will be collected by UAF staff or students, using UAF provided equipment, following International Atomic Energy Agency (IAEA) Global Network of Isotopes in Precipitation (GNIP) precipitation sampling protocols. The precipitation samples will be placed in a 1-liter HDPE bottle and handled following the procedures for tritium samples listed in the Water Sampling Procedures in Section 4.4.3.

4.4.5 Biota Collection Procedures

Biological samples will consist of greenling (kelp or rock), rockfish (black or dusky), and Irish lord (red or yellow) from marine water; rockweed from along the shoreline; and freshwater Dolly Varden from lakes on the island. Commercial and commonly consumed subsistence varieties of fish may also be collected, time permitting. Figure 7 and Figure 13 through Figure 18 illustrate biota sampling locations.

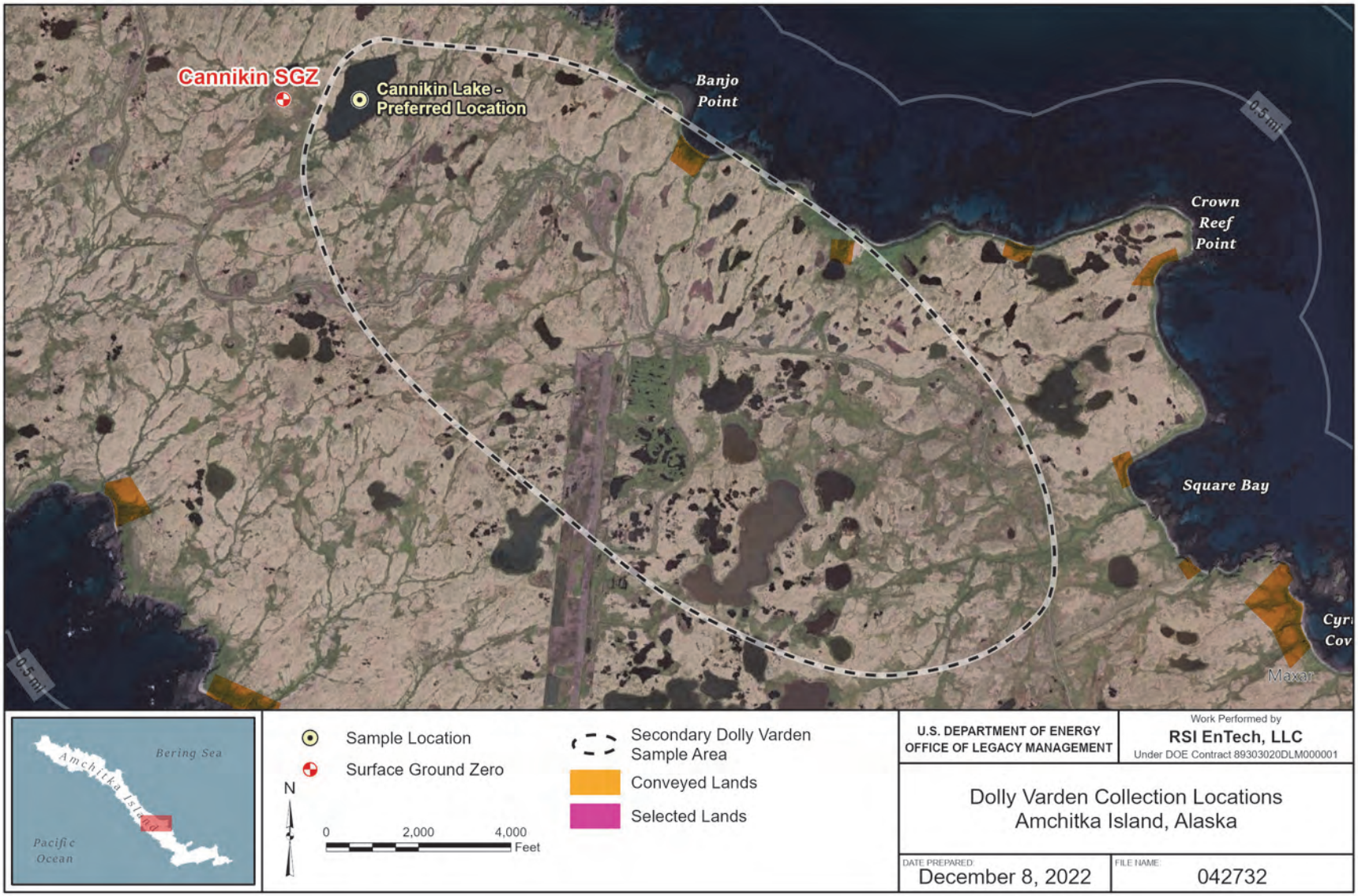
Table 6. Sample Collection Information

Sample Type	Analyte	Filtered?	Container	Analytical Method	Laboratory	Storage
Seawater and Freshwater	^{137}Cs	Yes	(2) 20-liter plastic carboy containers	Gamma spectroscopy (SAGe well detector)	LLNL	Do not refrigerate or ice tritium samples. Refrigerate Iodine samples. No temperature requirements for other analytes.
	^{239}Pu and ^{240}Pu	Yes		AMS		
	^{127}I and ^{129}I	No	(1) 1-liter wide mouth amber HDPE/Nalgene bottle	ICP-MS and AMS		
	^{3}H	No	(1) 1-liter HDPE bottle	Electrolytic enrichment followed by gas proportional counting	University of Miami	
	Additional Analyte	Yes	(1) 1-liter HDPE bottle	TBD	LLNL	
Greenling, Rockfish, and Irish Lord	^{137}Cs	NA	2-4 kg in one plastic bag (one genus or species per sample)	Gamma spectroscopy	LLNL	Freeze
	^{239}Pu and ^{240}Pu	NA		AMS		
Dolly Varden	^{137}Cs	NA	2 kg in one plastic bag	Gamma spectroscopy	LLNL	Freeze
	^{239}Pu and ^{240}Pu	NA		AMS		
Subsistence and Commercial Catch Fish	High Resolution Gamma Spectrometry	NA	2-4 kg in one plastic bag (one genus or species per sample)	Gamma spectrometry	LLNL	Freeze
Rockweed	^{137}Cs	NA	5 kg in one plastic bag	Gamma spectroscopy	LLNL	Freeze
	^{239}Pu and ^{240}Pu	NA		AMS		

Abbreviations:
AMS = accelerator mass spectrometry
ICP-MS = inductively coupled mass spectrometry
kg = kilograms
NA = not applicable
SAGe = small anode germanium
TBD = to be determined

Notes:
If fish samples weigh less than 2 kg, or rockweed samples weigh less than 5 kg, they can be analyzed if the detection limits are adjusted by the laboratory.

Due to the large size of halibut, Atka mackerel, and cod, only fillets, collars, and cheeks are needed.
For all other fish, collect the whole fish.



Abbreviation: SGZ = surface ground zero
Collection of Dolly Varden will be targeted at non-anadromous resident fish (i.e., from land locked lakes not connected to the ocean/sea).

Figure 13. Dolly Varden Collection Locations

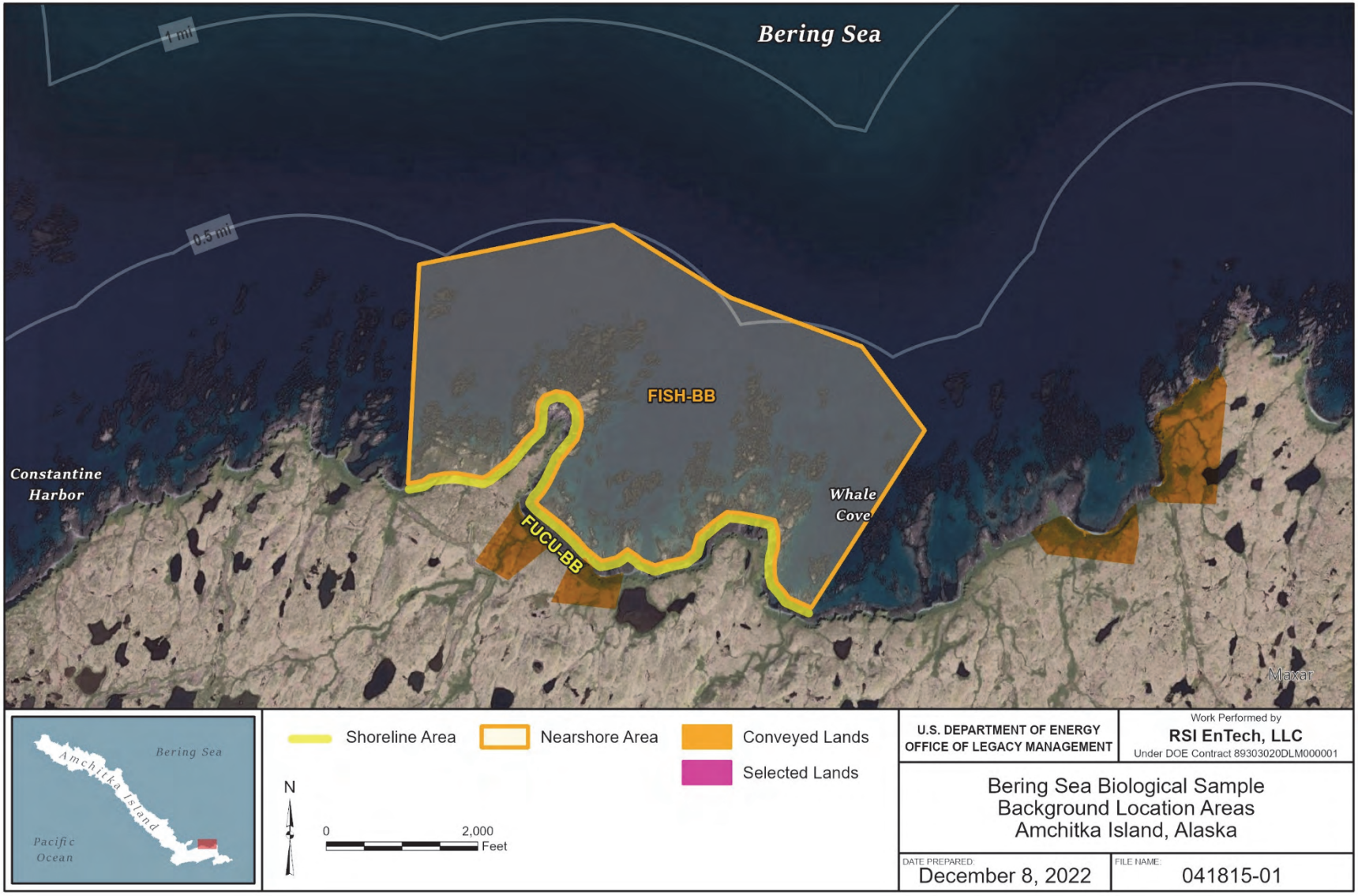


Figure 14. Bering Sea Biological Sample Background Locations

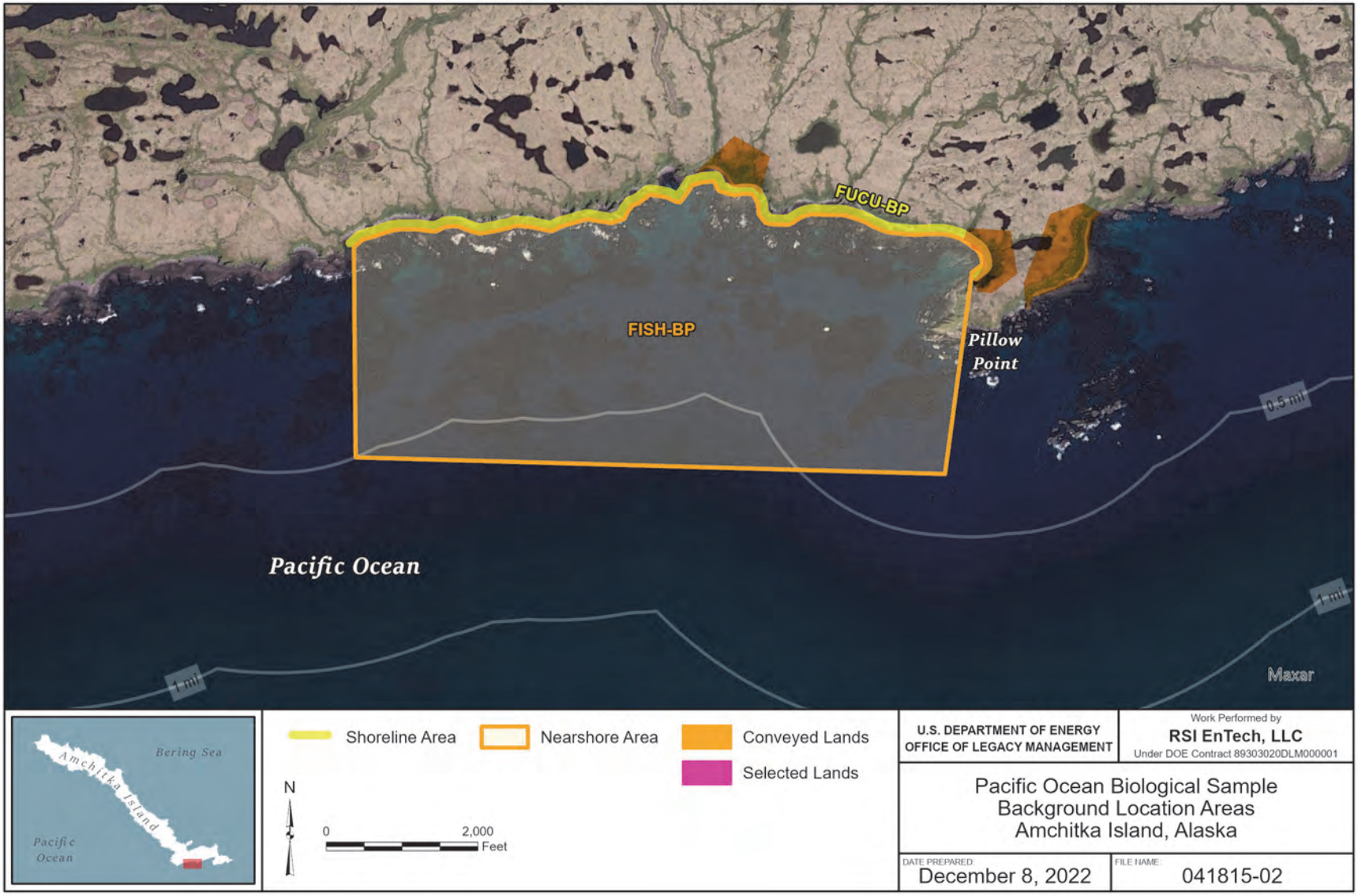
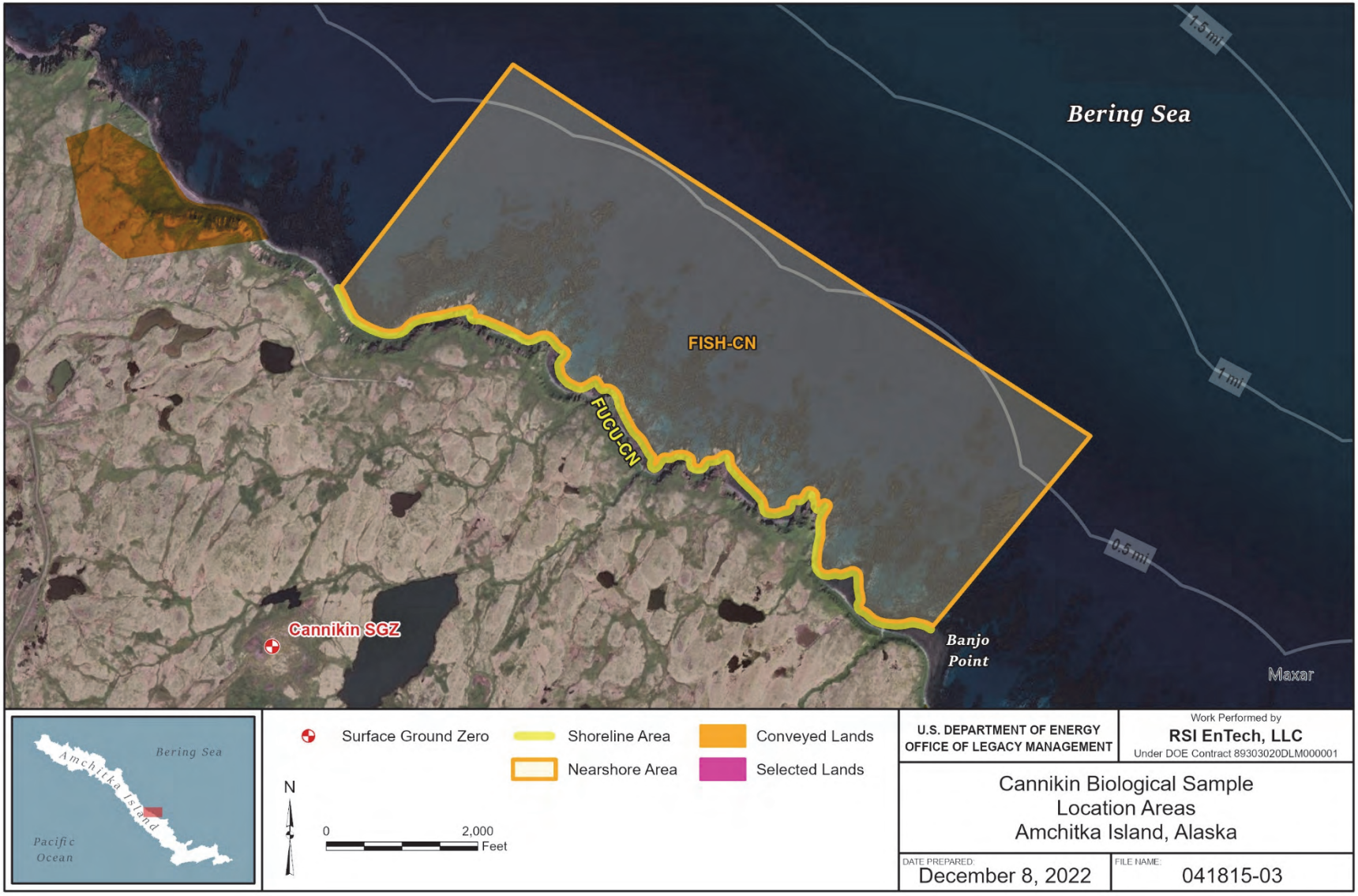
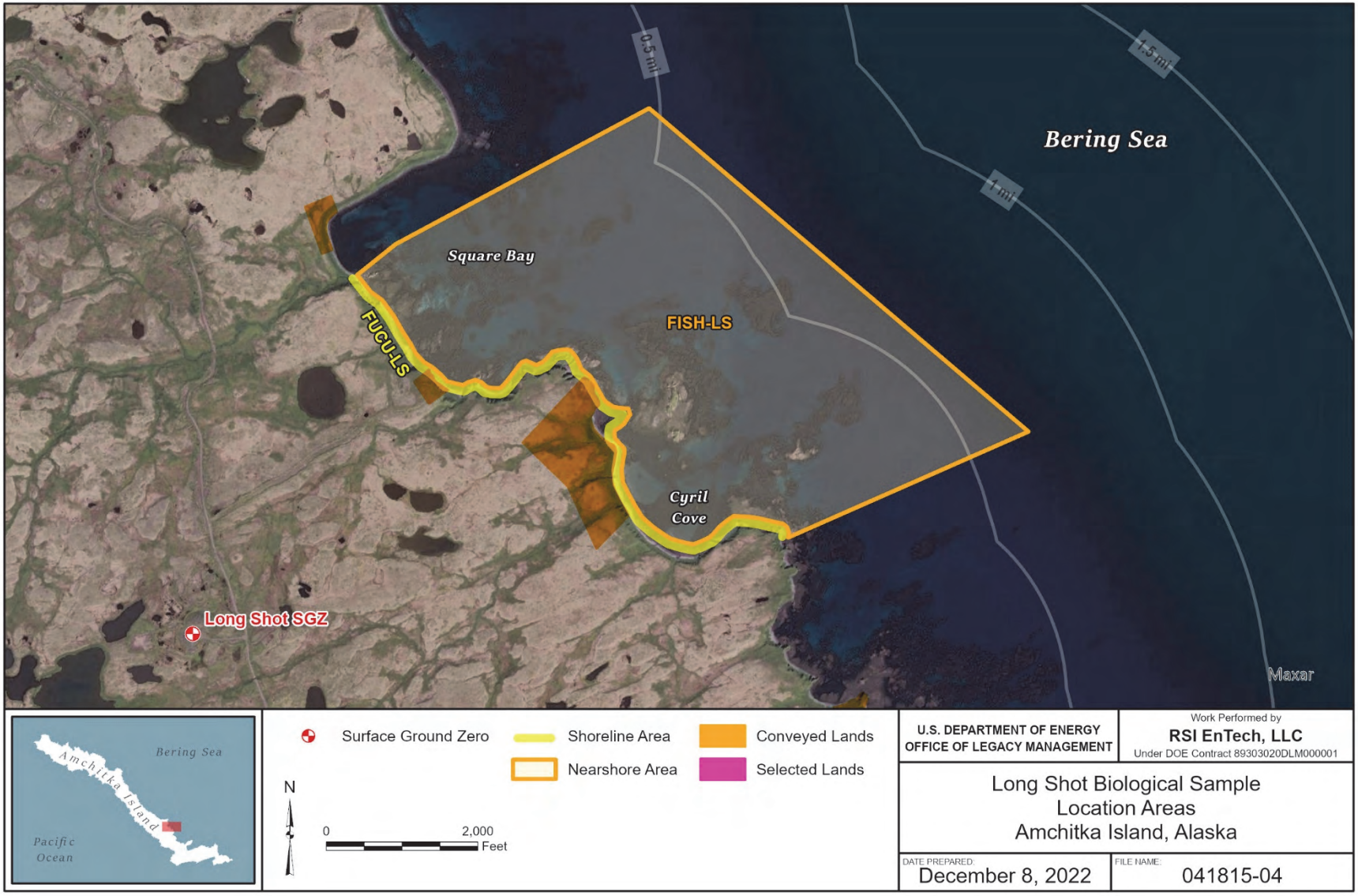


Figure 15. Pacific Ocean Biological Sample Background Locations



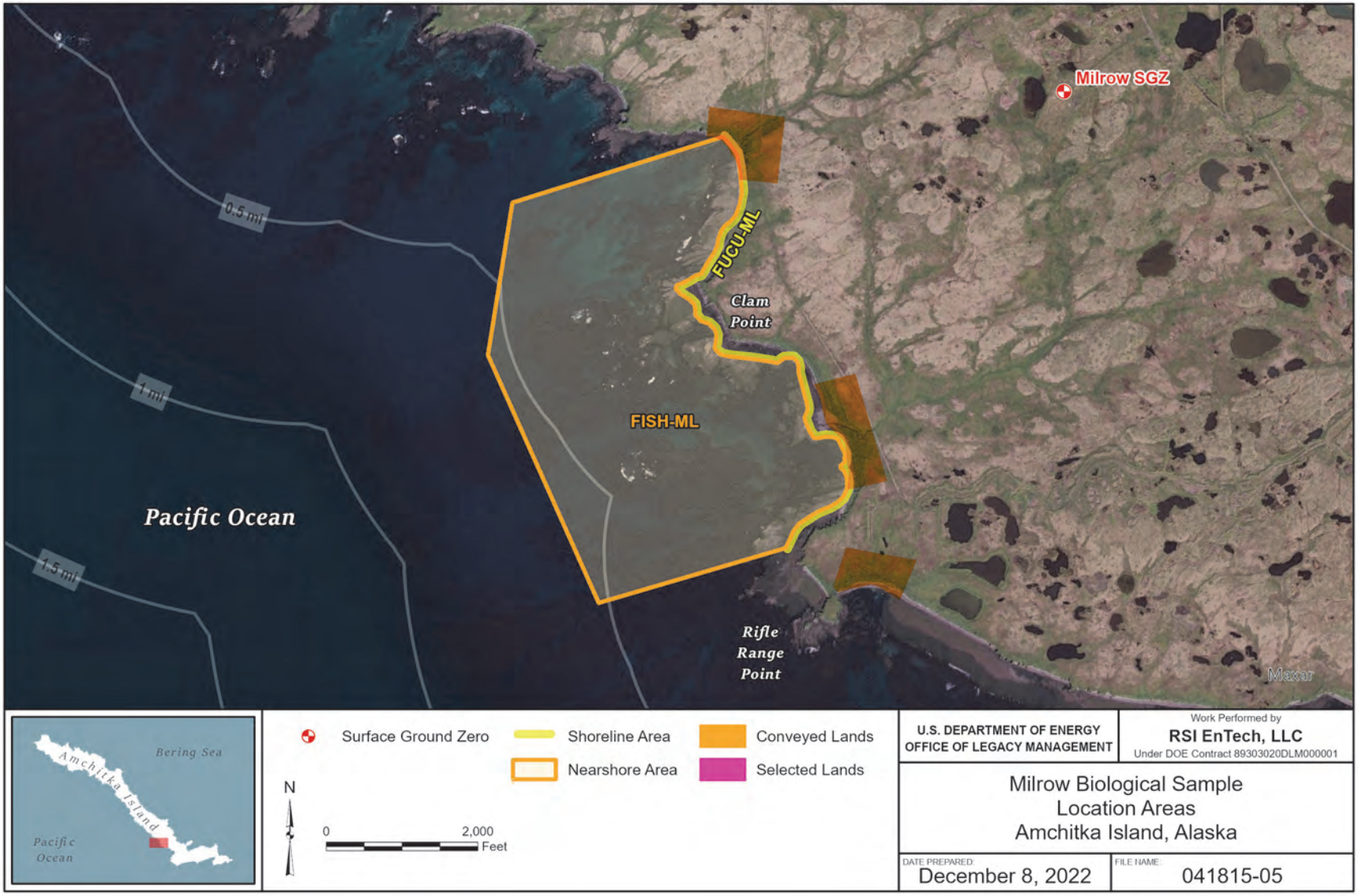
Abbreviation: SGZ = surface ground zero

Figure 16. Cannikin Test Site Biological Sample Locations



Abbreviation: SGZ = surface ground zero

Figure 17. Long Shot Test Site Biological Sample Locations



Abbreviation: SGZ = surface ground zero

Figure 18. Milrow Test Site Biological Sample Locations

4.4.5.1 Fish Collection and Processing

Permits will be obtained from the Alaska Department of Fish and Game and the International Pacific Halibut Commission (IPHC) prior to sample collection.

Fish collection in each sampling location (i.e., lake or nearshore area) should be spread across the collection area if possible (i.e., try not to collect them all from one spot).

Due to the large size of halibut, Atka mackerel, and cod, only fillets, collars, and cheeks are needed. For all other fish, collect the whole fish. If fish samples weigh less than 2 kg, or rockweed samples weigh less than 5 kg, they can be analyzed if the detection limits are adjusted by the laboratory.

Species not listed below, if caught, will not be collected for sampling but will be returned in accordance with applicable regulations.

Saltwater fish: Kelp or rock Greenling (Hexagrammos decagrammus or H. lagocephalus), black or dusky rockfish (Sebastes melanops or S. ciliatus), and red or yellow Irish lord (Hemilepidotus hemilepidotus or H. ciliatus)

- Collect marine water fish using skiffs and employ hook-and-line fishing, fish traps, or another permitted method for sampling the shoreline.
- Hook-and-line fishing, fish traps, or another permitted method will also occur from the ship in offshore areas.

Dolly Varden (Salvelinus malma)

- Collect from the shoreline of land-locked lake(s) only using hook-and-line fishing, fish traps, or another permitted method.

Subsistence and Commercial Catch Fish (Pacific halibut, walleye pollock, cod, Atka mackerel, or other commonly consumed species)

- Obtain fish using hook-and-line fishing from the ship in offshore areas.
- The fish can be collected from any of the three test locations and combined to achieve the desired sample requirement of 2 to 4 kilograms.

All fish will be collected and processed as follows:

- Navigate to the predetermined location and collect fish as described above.
- Whole fish will be collected; however, multiple fish may be required to complete a 2 to 4-kilogram sample.
    - For greenling (Kelp or Rock), rockfish (Black or Dusky), and Irish lord (Red or Yellow), the species may be different from sample to sample, but each sample will consist of only one genus.
    - For subsistence and commercial catch fish (e.g., Pacific halibut, walleye pollock, cod, Atka mackerel) the species may be different from sample to sample, but each sample will consist of only one genus

- Collect the coordinates for each sampling location using the GPS and record the coordinates in the field forms.
- Collect field duplicates at a frequency of 10% for samples. Preferred samples for field duplicates may be identified during the field planning process or selected in the field.
- Record for each *fish*:
  - taxonomic identification
  - sex (if possible)
  - length (total or fork length, dependent on the fish species) in centimeters (cm)
  - weight in grams (g)
  - the name of the corresponding sample that includes the fish
- Place 2 to 4 kilograms (at least 2 kilograms and preferably 4 kilograms) of fish in a thick plastic bag to create one sample. If the desired sample size is not reached, partial samples will still be collected.
- All labels will be wrapped with clear tape before sampling. Label the sample bag with the sample number, date, and requested analyses. Sample numbers have not been designated for biota samples and must be assigned in the field. Not all samples will receive all analyses (see Table 7 for additional information).
- Record the sample number and information on the field forms, double-checking it against the sample label.
- Seal the sample bag with a custody seal and tape to secure the sample.
- Record all samples on the chain-of-custody form when the samples enter freezer storage.
- Ship all biota samples to LLNL.
- All biota samples need to remain frozen throughout shipment to the laboratory.

4.4.5.2 Rockweed Collection and Processing

Rockweed (*Fucus distichus*) will be collected along the shorelines identified in Figure 14 through Figure 18. Samples can be collected from any place within the areas identified.

- Navigate to the predetermined shoreline areas by traveling inland or approaching the shoreline from a skiff.
- Collect Rockweed from the shoreline.
- Collect the coordinates for each sampling location using the GPS and record the coordinates in the field forms.
- Collect field duplicates at a frequency of 10% of all Rockweed samples.
- Inspect Rockweed and remove non-Rockweed materials such as rocks, shells, and other biota.
- Place at least 5 kilograms of Rockweed in a plastic bag to create one sample. If the desired sample size is not reached, partial samples will still be collected. Double bag each sample.

- All labels will be wrapped with clear tape before sampling. Label the sample bag with the sample number, date, and requested analyses. Sample numbers have not been designated for biota samples and must be assigned in the field. Not all samples will receive all analyses (see Table 7 for additional information).
- Record the sample number and information on the field forms, double-checking it against the sample label.
- Seal the outer sample bag with a custody seal and tape to secure the sample.
- Record all samples on the chain-of-custody form when the samples enter storage.
- Ship all biota samples to LLNL.

Table 7 lists the field collection and analytical requirements for the biological samples to be collected.

Table 7. Field Collection and Analytical Requirements – Biological Samples

Location Sample Type	Total Number of Samples	Analytes Requested		
		^{137}Cs	^{239}Pu and ^{240}Pu	High-Resolution Gamma Spectrometry
Cannikin				
Marine Fish	3	3	3	--
Rockweed	3	3	3	--
Dolly Varden[a]	3	3	2	--
Long Shot				
Marine Fish	3	3	2	--
Rockweed	3	3	1	--
Milrow				
Marine Fish	3	3	3	--
Rockweed	3	3	3	--
Any Test Location				
Subsistence and Commercial Catch Fish	12	--	--	12
Background – Amchitka Island				
Dolly Varden	3	3	2	--
Background - Pacific Ocean				
Marine Fish	3	3	3	--
Rockweed	3	3	1	--
Background - Bering Sea				
Marine Fish	3	3	3	--
Rockweed	3	3	1	--
Subtotal	48	36	27	12
Field Duplicates	5	4	3	2
TOTAL	**53**	**39**	**30**	**14**

Note:
[a] Cannikin Lake or other lake(s) on Amchitka Island.

4.5 Sample Nomenclature

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

[S*ample identifier*]-[*Location identifier*]-[*Sample Number*]

Table 8 shows the labeling system to be used for sample identification.

Table 8. Labeling System

Sample Type	Sample Identifier
Kelp or Rock Greenling, Black or Dusky Rockfish, Red or Yellow Irish Lord	FISH (Record species and weights in field notes)
Rockweed (*Fucus distichus*)	FUCU
Dolly Varden (*Salvelinus malma*)	DOLL
Commonly consumed fish**	COMM
Marine water	SEAW
Freshwater	FRES
Site Location	**Location Identifier**
Cannikin	CN
Long Shot	LS
Milrow	ML
Background – Amchitka Island	AI
Background – Pacific Ocean	BP
Background – Bering Sea	BB
Sample Number	
Sample Number*	1 through 7
Duplicate Sample Number	9

Notes:
* = Use sample number listed on the related figure or Table 5, or the number of the sample in case of multiple samples from the same location (e.g., the 1st, 2nd, or 3rd Dolly Varden).
** Pacific halibut, walleye pollock, cod, Atka mackerel, or other commonly consumed species may be included if caught.
Water samples have predetermined sample numbers as described in Section 4.3. Fish do not have predetermined sample numbers.

For example:

- Sample collection personnel have collected a 5-kilogram sample of Rockweed from along the shoreline near the Cannikin site. The sample of Rockweed is bagged and labeled "FUCU–CN–1."
- Sample collection personnel have collected a sample containing one dusky rockfish weighing less than 2 kg and three rock greenlings totaling 4 kg from the Milrow site. The sample preparation personnel keep the greenling. This is the second sample collected for the Milrow site. It is bagged and labeled "FISH–ML–2." The number, species, and weights of the fish are recorded in the field notes.

- Sample collection personnel have collected five Dolly Varden from a lake on Amchitka Island. This is the second sample of Dolly Varden collected. All five fish are bagged together and labeled "DOLL–AI–2."
- Sample collection personnel collect a marine water sample about 0.25 mile off the Cannikin site shoreline at the location marked as SEAW-CN-2 on Figure 10 (51.48481962, 179.1107755). This sample is labeled as "SEAW–CN–2."

4.6 Laboratory Sample Handling and Analytical Methods

The samples will be sent to two laboratories for analysis. Biological samples (including seafood) will be submitted frozen and in individual plastic bags for each sample. Marine water and freshwater samples will be submitted in their respective sample containers as indicated in Section 3.4.1. Samples collected for ^{137}Cs, ^{239}Pu, ^{240}Pu, ^{127}I, and ^{129}I analysis will be analyzed by the LLNL using the methods specified in Table 3. Samples collected for ^{3}H analysis will be analyzed by the University of Miami Tritium Laboratory using the methods specified in Table 3.

Each laboratory will perform sample handling and analysis in accordance with laboratory standard operating procedures and quality assurance/quality control (QA/QC) procedures for each method. Any samples stored at the laboratory for follow-up analysis will be stored in a manner to prevent cross contamination of samples. Each laboratory will provide a separate QA/QC report detailing QA/QC methods and procedures used during the analysis.

Data obtained from the analysis of environmental samples from the 2023 sampling event will be reviewed against QA/QC requirements provided by each laboratory and validated following the *Environmental Data Validation Procedure* (LMS/PRO/S15870) for inclusion in LM's database for the Amchitka Island project.

Any sample volume that remains after analysis will be retained in case follow up analysis is warranted.

5.0 Sampling Schedule

Table 9 presents the anticipated schedule for performing the sampling tasks in 2023. 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 2023. The chartered vessel will depart its home port and travel to Adak, Alaska. Adak will be the pickup and drop-off point for the environmental sampling team.

Table 9. 2023 Schedule for Environmental Sampling

Task	Number of Days
Pick up environmental sampling team in Adak, Alaska	0
Charter vessel mobilizes from Adak Island to Amchitka Island	1
Perform operations off Cannikin site	2
Perform operations off Long Shot site	2
Perform operations off Milrow site	2
Perform operations on Amchitka – Background, Cannikin, Long Shot, and Milrow	4
Perform background sampling in the Pacific Ocean	2
Perform background sampling in the Bering Sea	2
Prepare samples for shipping / Potential weather delays	3
Charter vessel returns to Adak Island and drops off environmental sampling team	1
Total number of days the chartered vessel is required	**19**

Commercial airline service is only available from Anchorage to Adak twice a week - currently on Wednesday and Saturday. A general schedule is planned as follows, but may be adjusted based on site conditions or airline schedules:

- The environmental sampling team will arrive in Adak on a Wednesday or Saturday.
- 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 Island to Amchitka Island. Upon arrival at Amchitka Island, the environmental sampling will be performed.
- Sampling teams on the island collect freshwater samples and fish for Dolly Varden, and collect Rockweed near shore, then ferry the fish and Rockweed back to the vessel.
- On the vessel, teams collect marine water and fish and prepare biota samples for laboratory analysis.
- When all samples are collected, or the departure time is reached, the crew will return to Adak Island.

6.0 Logistics

Environmental sampling will be performed by RSI with the support of a subcontracted vessel and their staff. The University of Alaska is responsible for providing the water sample collection procedure(s) and equipment. If arrangements can be made in sufficient time to meet the predeparture schedule and requirements, LM may invite students from the University of Alaska to join the trip and perform the water sampling.

Permits, such as aquatic resource permits from the Alaska Department of Fish and Game and the Pacific halibut collection permit from the International Pacific Halibut Commission, are being prepared and will be in place before sample collection begins. A Special Use Permit is in place

with the USFWS. This plan and subsequent email communication will serve as notice as required by the permit.

The sampling is planned to be performed with a chartered support vessel which will be used as an operations base for on-island and marine work and provide board for the sampling team. Transportation for on island work will be from off-road vehicles (i.e., UTVs or side-by-sides) or on foot using established roads. The specific personnel, contact information, schedule, and other logistical details are currently being worked out and will be finalized as the trip departure date nears.

7.0 Reporting

Data from the high-resolution gamma spectrometry laboratory analysis of subsistence and commercial catch seafood samples from the 2023 sampling event are expected to be reported by the laboratory within approximately 18 weeks from the time the samples are received. A summary of the sampling event and results of the statistical evaluation will be reported in a timely fashion in order to get the results from the subsistence and commercial catch seafood evaluation to the public.

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