INL/EXT-15-34909
Revision 0
DRAFT

Data Quality Objectives Supporting the Environmental Soil Monitoring Program for the INL Site

February 2016

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

INL/EXT-15-34909
Revision 0
DRAFT

Data Quality Objectives Supporting the Environmental Soil Monitoring Program for the INL Site

February 2016

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Data Quality Objectives Supporting the Environmental Soil Monitoring Program for the INL Site

INL/EXT-15-34909
Revision 0
DRAFT
February 2016

Approved by:

Scott Lee Manager, Regulatory and Environmental Services	Date
Tom Haney Media Lead, Environmental Support and Services	Date

ABSTRACT

This document describes the process used to develop data quality objectives for the Idaho National Laboratory (INL) Environmental Soil Monitoring Program in accordance with U.S. Environmental Protection Agency guidance. This document also develops and presents the logic that was used to determine the specific number of soil monitoring locations at the INL Site, at locations bordering the INL Site, and at locations in the surrounding regional area. The monitoring location logic follows the guidance from the U.S. Department of Energy for environmental surveillance of its facilities.

CONTENTS

FIGURES

TABLES

ACRONYMS

DOE	U.S. Department of Energy
DQO	data quality objective
DS	decision statement
EFS	Experimental Field Station
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MFC	Materials and Fuels Complex
PSQ	principal study question
RESL	Radiological and Environmental Sciences Laboratory
REST	U.S. Highway 20/26 Rest Stop
RWMC	Radioactive Waste Management Complex
UTL	upper tolerance limit

Data Quality Objectives Supporting the Environmental Soil Monitoring Program for the INL Site

1. INTRODUCTION

This document describes the process used to develop data quality objectives (DQOs) for the Idaho National Laboratory (INL) Environmental Soil Monitoring Program. These DQOs were developed in accordance with the U.S. Environmental Protection Agency (EPA) DQO process (EPA 2006), which helps users clarify objectives, define types of data, and specify limits on the likelihood of making potential decision errors. The DQOs contained herein use historical data, current emissions data, and soil-deposition modeling for establishing the quality and quantity of data needed to support decision-making for protecting human health and the environment. These data and analyses used are discussed in detail in a separate companion document entitled *Historical Data Analysis Supporting the Data Quality Objectives for the INL Site Environmental Soil Monitoring Program* (INL 2016)

The *DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE-HDBK-1216-2015) states that soil sampling and analysis should be used to evaluate the long-term accumulation trends and to estimate environmental radionuclide inventories. It notes that soil provides an integrating medium that can account for contaminants released to the atmosphere either directly in gaseous effluents or indirectly from resuspension of onsite contamination or through liquid effluents released to a stream that is subsequently used for irrigation. However, while soil sampling is a useful approach for determining the accumulation of initially airborne radionuclides that have been deposited on the ground, such sampling generally serves a supplementary role in environmental surveillance monitoring programs (Gallegos 1995; Hardy and Krey 1971; EML 1997). In addition, soil sampling is of questionable value in attempting to estimate small increments of deposition over a period of a few years or less because of the large uncertainties in sampling and the inherent variability in soil and because it is not recommended as a routine method of environmental monitoring except in preoperational surveys (EML 1997).

1.1 Background and Scope

In the early 1970s, the U.S. Department of Energy (DOE) Radiological and Environmental Sciences Laboratory (RESL) established a routine program for collecting surface soils (0 to 5 and 5 to 10 cm deep) on and around the INL Site, although some soil was collected around various facilities as far back as 1960. RESL analyzed all samples (onsite and offsite) for gamma-emitting radionuclides with a subset onsite analyzed for Sr-90, Am-241, and isotopes of plutonium. In addition, all soil from the surface component (0 to 5 cm deep) of the offsite samples was analyzed for Sr-90 and alpha emitting-radionuclides (Am-241 and isotopes of plutonium).

Between 1970 and 1978, RESL extensively sampled the onsite grids outside INL Site facilities and then reduced the onsite sampling frequency to a 7-year rotation that ended in 1990 with sampling at the Test Reactor Area (now known as the Advanced Test Reactor Complex). Surface soils were sampled at distant and boundary locations off the INL Site annually from 1970 to 1975. The collection interval for offsite soils was extended to every 2 years starting in 1978.

At the end of 1993, the DOE environmental monitoring program conducted by RESL was divided into separate onsite and offsite programs. Responsibility for the onsite program was transferred to the managing and operating contractor, and the offsite monitoring program was transferred to the Environmental Surveillance, Education, and Research Program contractor.

As happened at many other DOE sites, the effort to investigate and clean up the legacy of the widely varied and fast-paced work that took place at the INL Site over half a century began with a series of agreements that provided a legal and regulatory framework. The most far-reaching of these agreements was signed by DOE, the EPA, and the state of Idaho in 1991 under the Comprehensive Environmental Response, Compensation, and Liability Act remedial investigation/feasibility study process. This agreement, called the Federal Facility Agreement and Consent Order (DOE 1991a) was the impetus for much of the onsite soil sampling throughout the 1990s.

In situ analyses of gamma-emitting radionuclides in surface soils using a field-based gamma spectroscopy system began in 2001, with some additional grab samples analyzed radiochemically for alpha-emitting radionuclides. Over the years, in situ analysis became the main annual method used to assess Cs-137 and other gamma-emitting radionuclide concentrations in surface soils outside of and between INL Site facilities. Soil sampling and laboratory analyses were used for depth profiling that supplemented the in situ method or if the need was indicated by unusual in situ results or other factors. Soil sampling with laboratory analyses (gamma spectroscopy and radiochemistry) are used exclusively at boundary and distant locations to assess concentrations of Cs-137 and other gamma-emitting radionuclides, Sr-90, Am-241, and plutonium isotopes.

1.1.1 INL Site Soil Monitoring and Modeling Results

The INL Site has a long history of operation that includes various large-scale experiments and large user facilities such as reactors. The primary sources of soil contamination were the operation of reactors, management of radioactive material, processes such as calcining, and unplanned releases to native soil, such as when the Subsurface Disposal Area at the INL's Radioactive Waste Management Complex (RWMC) was flooded in 1962 and 1969. However, current operations are significantly reduced, and all but one reactor has been shut down. Moreover, the majority of historical and current releases from INL Site releases are noble gases, which do not bind to soil particles or airborne particulates. The data from years of routine sampling and analyses that characterized the nature and extent of the contamination in these areas show slowly declining trends in the concentrations of short-lived manmade radionuclides, with no evidence of detectable concentrations depositing onto surface soil from ongoing INL Site releases, as discussed in INL (2016). In addition to routine monitoring both by RESL and the prime contractors, as mentioned, contamination near INL Site facilities has been extensively investigated under the Comprehensive Environmental Response, Compensation, and Liability Act remedial investigation/feasibility study process, and radionuclide-contaminated soil sites outside facility fences that showed unacceptable risk have been remediated as described in the *Engineering Evaluation/Cost Analysis for Operable Unit 10-06 Radionuclide-Contaminated Soils Removal Action at the Idaho National Engineering Laboratory* (INEL 1995).

Finally, deposition of airborne particulates released from each INL facility was modeled using CALPUFF, a non-steady-state Lagrangian puff dispersion model (Rood and Sondrup 2014), and estimated particulate deposition rates (INL 2016). The modeling results show that only RWMC has the potential for soil contaminant accumulations to be detectable in a time period less than the range of decades. Dispersion and deposition modeling of source terms at other facilities (e.g., the Idaho Nuclear Technology and Engineering Center [INTEC] and the Materials and Fuels Complex [MFC]) shows the potential for surface accumulations to be detectable only after hundreds to thousands of years (INL 2016).

1.1.2 INL Site Boundary and Distant Location Soil Monitoring and Modeling Results

To establish background levels of natural and fallout radioactivity in surface soil and to assess any potential buildup of radioactivity offsite from INL Site operations, soil samples have been collected from undisturbed distant and boundary locations most years since 1970, except 1972, 1977, and 1979 (DOE-ID 1983). A biennial sampling program was established in 1978 and currently includes the distant locations of Blackfoot and St. Anthony, as well as boundary locations that currently include Atomic City, Butte City, the Federal Aviation Administration (FAA) Tower, Howe, Monteview, Mud Lake (two stations) and Reno Ranch.

Historical data from 1970 through 2014 were statistically analyzed for trends. The surface data do not suggest any concentration changes in long-lived radionuclides, specifically Am-241 and plutonium isotopes, over time and therefore do not indicate any accumulation from INL Site operations (INL 2016). Concentrations of Cs-137 and Sr-90, however, show that concentrations of these radionuclides have decreased over time in surface soil.

A plot of average areal Cs-137 concentrations over time, from 1975 through 2014, indicates an exponential rate of decrease in areal concentration that is indicative of radioactive decay (Figure 1). The data were plotted as nCi/m^2, as recommended in EML (1997).

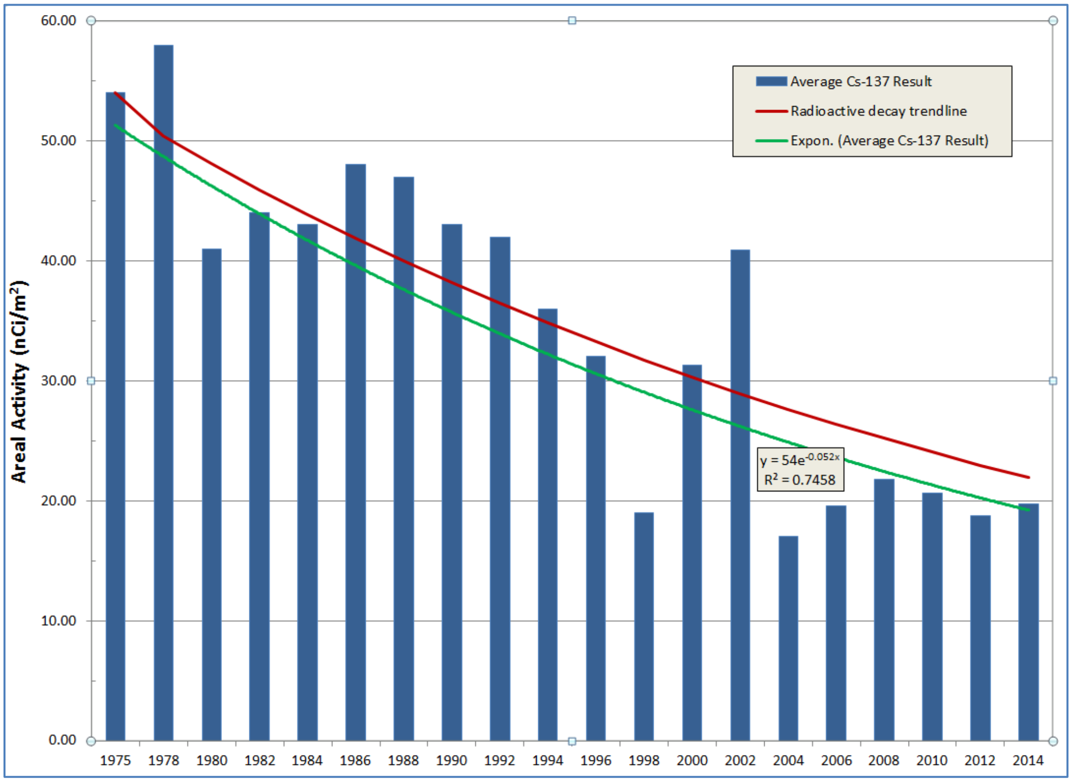

Figure 1. Areal activity of Cs-137 in offsite surface soil sampled from 1975 through 2014. Each column represents the geometric average of all locations for that year. An exponential trend line best approximates the decrease in Cs-137 concentration with time (from INL 2016).

Mean annual concentrations of Sr-90 in surface over time appear to decrease at a rate which exceeds that projected for radioactive decay (Figure 2). Strontium-90 is more mobile than Cs-137 in alkaline soils (Schulz 1965), and the accelerated decrease may be due to other processes in the soil, such as movement into other soil compartments or uptake by plants.

The decreasing trends shown in Figures 1 and 2 indicate that the source of Cs-137 and Sr-90 is not from INL Site operations and is most likely derived from worldwide fallout activity. Air dispersion and deposition modeling of radionuclides released from INL Site emissions confirm that it is unlikely that they can be detected in offsite soils.

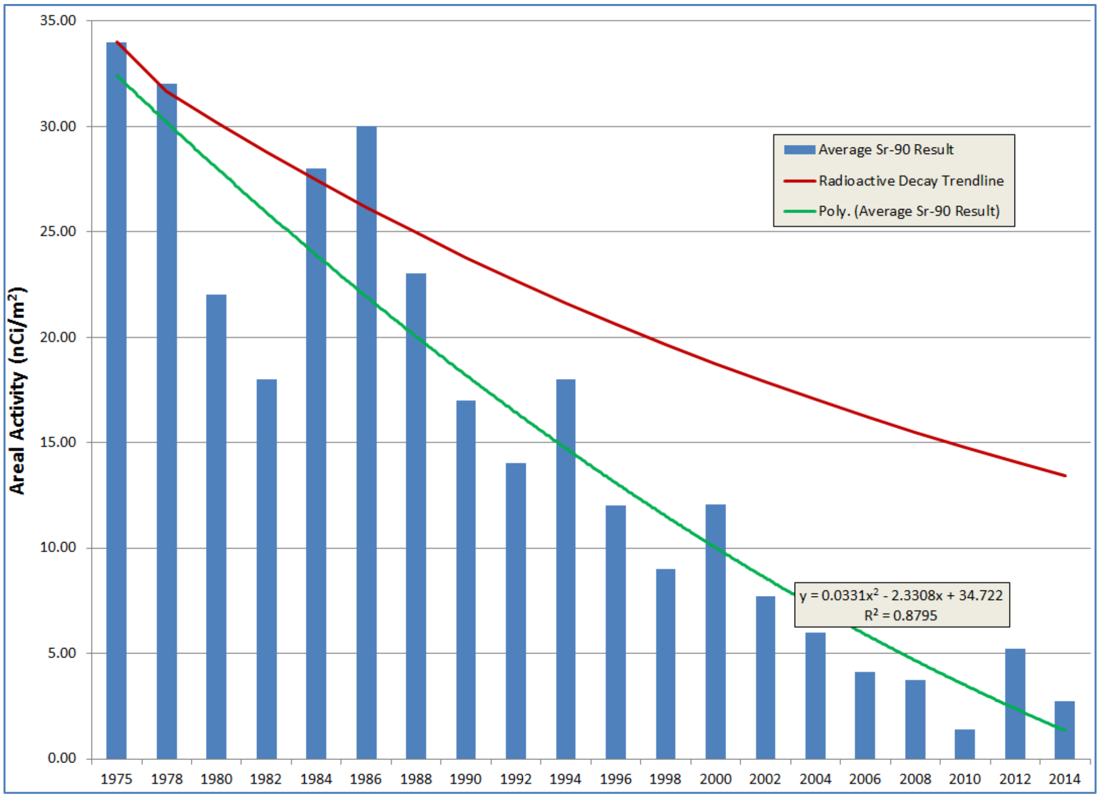

Figure 2. Areal activity of Sr-90 in offsite surface soil sampled from 1975 through 2014. Each column represents the geometric average of all locations for that year. A polynomial trend line best approximates the decrease in Cs-137 concentration with time (from INL 2016).

1.1.3 Approach

Based on the results presented above, a graded approach will be used that takes into account the extensive historical knowledge about soil conditions from past releases and current knowledge about facility emissions (INL 2016). As such, near-facility monitoring will continue only at RWMC in predominant wind directions on a 5-year rotational basis and will focus on the radionuclides that modeling shows to have the potential to accumulate in the relative near term (i.e., plutonium isotopes, Sr-90, and gamma emitters.

Air dispersion and deposition modeling shows that radionuclides released routinely and nonroutinely from INL Site facilities are unlikely to be detected at any ambient air monitor location in the mid-range region outside of site facilities but within the site boundary (INL 2016). However, it is important to establish current inventories for future reference in the event that there is a release of such a scale that it can be detected in soil, as well as in air. Two INL Site ambient air-monitoring locations (U.S. Highway 20/26 Rest Stop [REST] and the Experimental Field Station [EFS]) that have higher modeled deposition potential from major facility emissions will be used as indicators of accumulation in the mid-range region and will be sampled on a 5-year rotation that matches offsite soil sampling protocols. This rotation is appropriate because modeling results show little chance for detectable accumulations anywhere other than near RWMC, past soil data away from the facilities show only background concentrations, and the network of ambient air monitors (where particulate contamination would first be detected) has indicated that detectable air emissions of radioactive particles is not occurring (INL 2016). The mid-range stations would also serve to detect potential fugitive releases from inadvertent disturbance of historically contaminated areas near facilities. These historically contaminated areas are well-characterized and are not currently considered to be sources of measureable emissions.

Boundary and distant soil surveillance will be conducted to continue monitoring the trends in fallout radionuclides associated with background. Because monitoring history and model projections show that it is highly unlikely that deposition from INL Site releases can be measured in offsite soils, sampling will be conducted on a 5-year basis. This will help to ensure that the areas sampled remain relatively undisturbed and that any decreasing trends in radionuclide concentrations are easily distinguishable from uncertainties inherent in soil monitoring.

The DOE Handbook (DOE-HDBK-1216-2015) states that sampling points for environmental monitoring should be located in areas that are susceptible to becoming contaminated. The plan for complying with this approach at the INL Site is described in this document. Note, however, that active monitoring of ongoing work is not in the scope of the Environmental Soil Monitoring Program at INL. The groups that complete ongoing radiological activities control and monitor that work. Responses to and post-event monitoring of unplanned releases from these activities are evaluated on a case-by-case basis.

1.2 Program Drivers

Sampling of soil is performed on and around the INL Site to meet the following requirements and criteria for environmental surveillance of DOE facilities:

- DOE O 458.1, "Radiation Protection of the Public and the Environment"
- DOE-HDBK-1216-2015, *DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance*," which updates and supersedes the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991b).

Other key drivers of the soil surveillance program include stakeholder inputs and values.

Each facility is responsible for monitoring within the facility boundaries, so those areas are not addressed by this monitoring program.

Soil data will be collected on and around the INL Site at frequencies and locations evaluated using historical measurements and results of modeled deposition of radionuclides released by INL Site activities. The DOE Handbook (DOE-HDBK-1216-2015) states, "Where possible, soil sampling locations should be selected to coincide with air sampling stations, since the comparability of data may be important in achieving the objectives of the overall environmental sampling program." Therefore, in order to support the air surveillance program and comply with the DOE Handbook, soil data should be obtained in the vicinity of air monitoring locations (predetermined with CALPUFF) (Rood and Sondrup 2014) that will most likely be affected by a planned or unplanned release due to INL activities. In addition, soil sampling will be conducted at offsite areas not expected to be impacted by INL Site releases in order to characterize the distribution and fate of naturally occurring and fallout radionuclides in soil and therefore estimate the contribution to onsite soil measurements. Data from offsite locations will also be used to develop and maintain a baseline inventory for those locations.

1.3 Data Quality Objectives Process

The DQOs are discussed in the context of the DQO process, as defined by *Data Quality Assessment: Statistical Methods for Practitioners* (EPA 2006). The EPA developed this process to ensure that the type, quantity, and quality of data used in decision-making are appropriate for the intended application. The DQO process includes seven steps, each of which has specific outputs. Each of the following sections corresponds to a step in the DQO process, and the output for each step is provided, as appropriate. The DQOs do the following:

1. Clarify the study objective
2. Define the most appropriate type of data to collect

3. Determine the most appropriate conditions from which to collect the data
4. Specify tolerable limits on decision errors that will be used as a basis for establishing the quantity and quality of data needed to support the decision(s) to be made using the data.

The DQOs for the INL Environmental Soil Monitoring Program are discussed in the rest of this document.

2. STEP 1: STATE THE PROBLEM

INL Site activities have the potential to increase radionuclide concentrations in soils inside the INL Site boundaries and in the areas surrounding the INL Site. Research activities at the INL Site involve anthropogenic radioactive materials, and therefore the potential exists for soil contamination within INL Site boundaries and in the areas surrounding the INL Site. Thus, the purpose of long-term monitoring of radionuclide concentrations is to evaluate long-term accumulation trends. Soil samples collected during previous sampling events will also be used to create a radionuclide inventory for several onsite and distant locations. Radiological research has been conducted at the INL Site since the 1950s. Years of environmental monitoring data generally show that soil contaminated with manmade radionuclides from past INL releases exists near onsite emission points, that shorter-lived radionuclides (Cs-137 and Sr-90) continue to show a slow but steady decrease, and manmade radionuclides detected offsite are present due to worldwide fallout unrelated to INL activities. Radionuclides also occur naturally, and natural radionuclide concentrations vary in the areas surrounding the INL Site. Therefore, the soil surveillance program has evaluated data collected to date and determined baseline radionuclide concentrations for each localized area (INL 2016).

The problem statement addressed by these DQOs is: Determine the long-term deposition of radionuclides from INL Site activities in the soils on and surrounding the INL Site facilities, determine the radionuclide inventory knowledge base for these soils, and continue to monitor background inventories of ambient radionuclides in soils surrounding the INL Site

3. STEP 2: IDENTIFY THE GOALS OF THE STUDY

The second step in the DQO process is to identify the decisions and the potential actions that will be affected by the data collected. This is done by specifying principal study questions (PSQs) and alternative actions that could result from resolution of the PSQs, and by combining the PSQs and alternative actions into decision statements (DSs). This monitoring effort is designed to answer three PSQs:

<u>PSQ1</u>: What is the baseline inventory of radionuclides of interest in INL Site soils for the areas under investigation?

<u>DS1</u>: Determine the concentration of radionuclides of interest in INL Site soils, and use monitoring data to update the baseline over time.

<u>PSQ2</u>: What is the long-term deposition of radionuclides in soils due to INL Site activities?

<u>DS2</u>: Use air models to determine the most likely locations of deposition of radionuclides due to INL Site activities, and monitor those soils to determine the long-term deposition due to INL activities.

<u>PSQ3</u>: What are the inventories of background radionuclides (including those from global fallout) and how are they changing over time?

<u>DS3</u>: Use historic data and continue to monitor radionuclide concentrations in soil off the INL Site.

4. STEP 3: IDENTIFY INFORMATION INPUTS

Inputs needed to resolve the DSs include the following:

- Identification of radionuclides of interest for soils in INL Site and surrounding areas

- Quantification of the radionuclide concentrations in the soils within the area or region being studied
- Historical radionuclide concentrations in the soils for the area or region being studied
- Pertinent historical information for each area
- Wind patterns within the region to identify the area most likely to be exposed to radioactive fallout from INL Site activities
- Identification of possible source terms of radionuclides
- Identification of areas that may have increased inventories due to past INL Site activities
- Location of population centers in the regional vicinity of the INL Site
- Locations of areas within the INL Site boundaries where planned or unplanned releases may occur due to INL activities.

The historical information obtained from the areas of interest has been used to establish localized baseline radionuclide inventories and offsite background inventories (INL 2016). It is known that the natural level of radiation can vary considerably within the region that is being examined. Therefore, the historical radionuclide concentration information and INL Site history information have been obtained and analyzed to determine the appropriate background levels for each localized area and to establish a baseline for each area (INL 2016). This provides the basis for determining the effect of a planned or an unplanned release in soils. Site information for each area can be used to compare future measurements with what is expected based on historical measurements.

The following radionuclides are of primary concern due to knowledge of historical and current INL facility emissions as well as ambient inventories (INL 2016) and will be monitored under the INL Environmental Soil Monitoring Program: Am-241, Cs-137, Pu-238, Pu-239/240, and Sr-90. The radionuclide I-129 was also evaluated. However, it is not currently emitted by any INL Site activities, and the inventory at the site is constant. Thus, I-129 is not addressed in these DQOs because they address radionuclides that may affect soils due to a release or long-term deposition.

5. STEP 4: DEFINE THE BOUNDARIES OF STUDY

5.1 Physical Boundaries

The physical boundaries of the study, as shown in Figure 3, include areas within the INL Site boundary and the 50-mile (80 km) radius surrounding the INL Site per DOE guidance (DOE-HDBK-1216-2015).

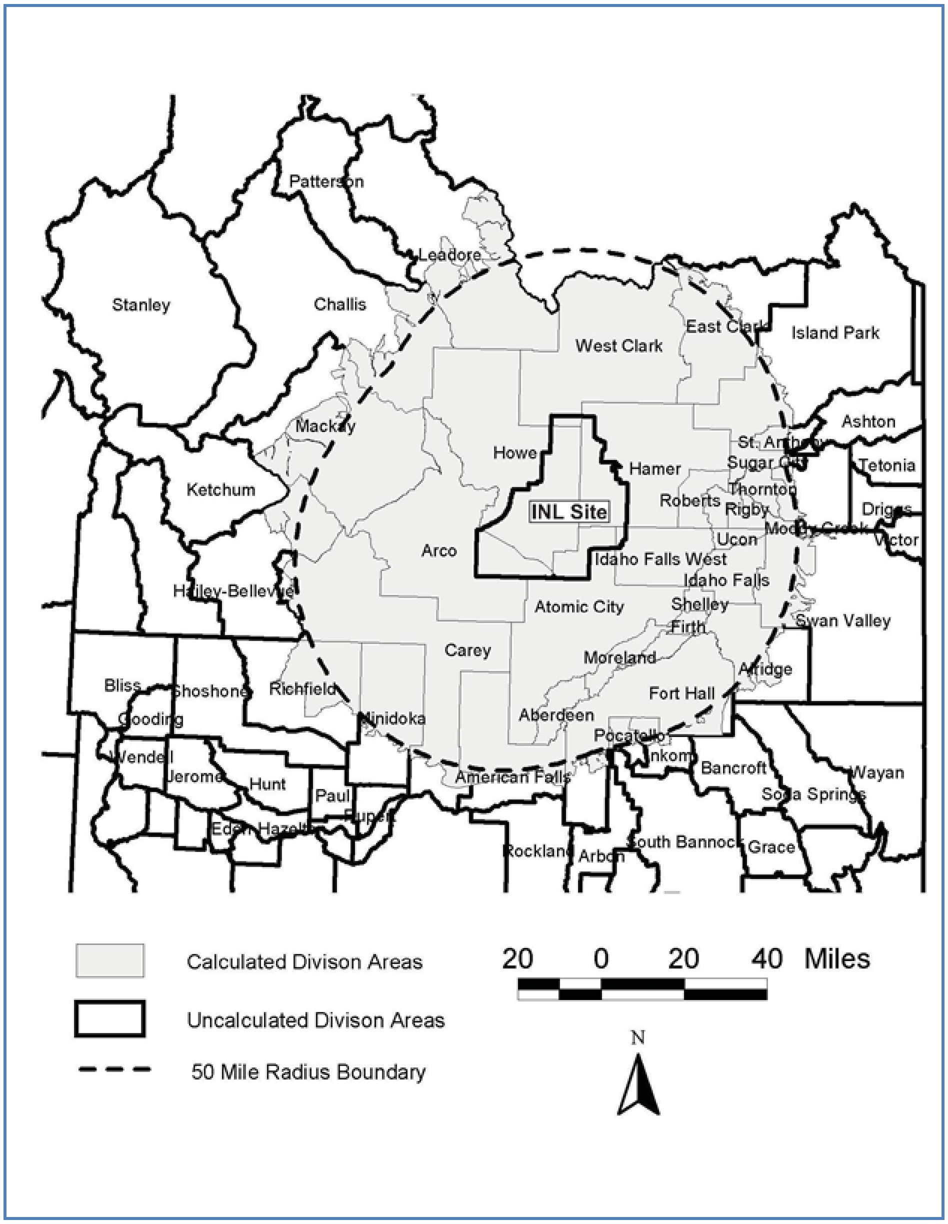

Figure 3. Region within 50 miles (80 km) of INL Site facilities and U.S. Census divisions used in the 50-mile population dose calculation.

This region of interest has been divided into three groups based on proximity to source terms and the public. The three divisions, as detailed in Table 1, are:

- Near-Facility Area
- Mid-Range Region, between the facilities and INL Site boundary
- Boundary and Distant Region, limited to a 50-mile (80 km) radius of the INL Site.

Table 1. Sampling areas within each of the divisions.

Near-Facility Area	Mid-Range Region	Boundary and Distant Region
RWMC Area	REST EFS	***Boundary:*** Atomic City Butte City FAA Tower (may be moved to MFC – new site) Frenchman's Cabin (new site) Howe Monteview Mud Lake (2 locations) Reno Ranch ***Distant:*** Blackfoot Carey St. Anthony

Sampling locations are selected using the following guiding criteria:

- Near-facility areas where a planned or unplanned release is most likely to occur and deposition modeling shows the potential for near-term accumulation (e.g., RWMC, as discussed in Section 1.1.1)
- Mid-range regions where an air monitor exists and air-deposition modeling verifies a viable location to look for contamination if a detectable release from any facility occurs
- Boundary and distant regions for which historical background data are available.

5.2 Temporal Boundaries

The temporal boundaries for soil monitoring are encompassed by the time period between soil sample collections at a location, which may have begun as early as the 1970s, up until soil monitoring is no longer measured under this program. Soil monitoring will continue as long as the site is operational under DOE. This is likely to be long as 100 years into the future. The number of monitoring locations at a specific sampling area and the length of time that a particular sampling location is measured can vary depending on changes in conditions or activities in that particular sampling location.

The DOE Handbook states, "Environmental surveillance measurements may be performed occasionally when potential dose is low, but should be performed at least every 5 years" (DOE-HDBK-1216-2015). Based on historical data and deposition modeling included in INL (2016), an annual sampling frequency is technically unjustifiable for soils because examination of 40 years of data shows that concentrations of radionuclides in these soils are aged fallout products. The longer-lived radionuclide concentrations should remain constant unless soils are disturbed, and shorter-lived radionuclides like Cs-137 and Sr-90 will continue to decrease with time. The decreasing trends are not statistically observable over short time periods (i.e., every 2 years) but require longer periods to distinguish the trends from natural variability in soil samples. In addition, atmospheric dispersion modeling of current releases shows that offsite soil concentrations from INL sources will never be distinguishable from background (INL 2016). For this reason, a 5-year sampling rotation is ample to maintain baselines and confirm predicted and observed trends in each area or region. When monitoring global fallout, short-term changes in radiation concentrations are generally small compared to the variability in the local radionuclide distribution (EML 1997). Select location(s) on the INL Site boundary may be sampled in response to a major unplanned release on the site if it is believed, through modeling or air monitoring, that the location(s) may be affected.

5.3 Practical Considerations

Practical constraints on collecting data are access to the property where samples are to be collected, the presence of undisturbed surface soil, the cost of sampling and analysis, and the time needed to collect and analyze samples. The INL Site is shown in Figure 4. Soil sampling locations have been identified at the INL Site for more than 40 years and are generally focused on the major facilities. Those same locations, along with extensive data and release and deposition evaluations, were used to determine where samples will be collected under this monitoring effort. Per the DOE Handbook (DOE-HDBK-1216-2015), soil sampling locations should be placed at points corresponding to air sampling locations to allow for comparability of data in areas that may be affected by a planned or unplanned release. Two prime onsite ambient air-monitoring locations are REST and the centrally located EFS shown in Figure 5. Figure 5 also shows the distant soil sampling locations established by RESL as background sites.

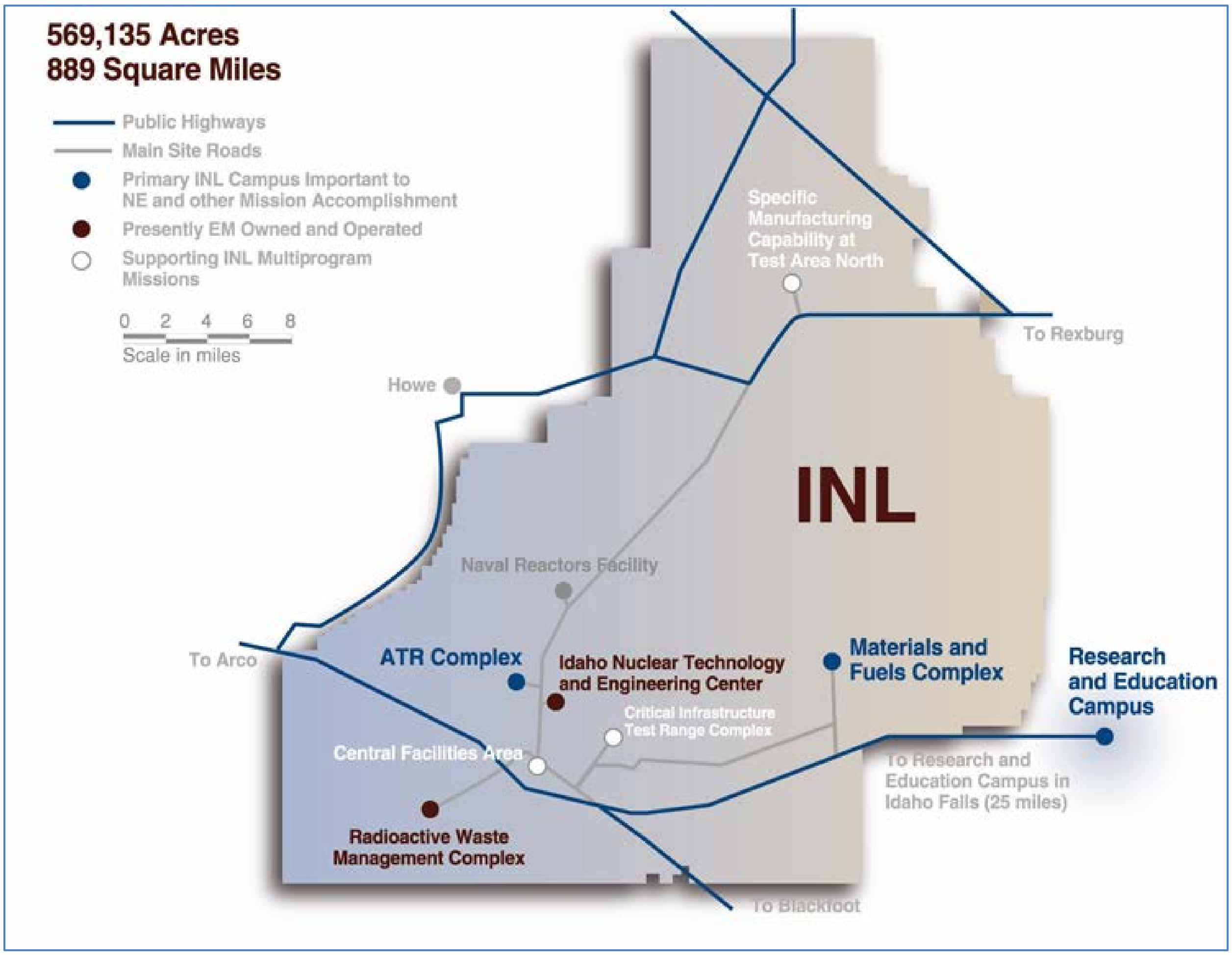

Figure 4. Map of the INL Site showing the locations of major facilities.

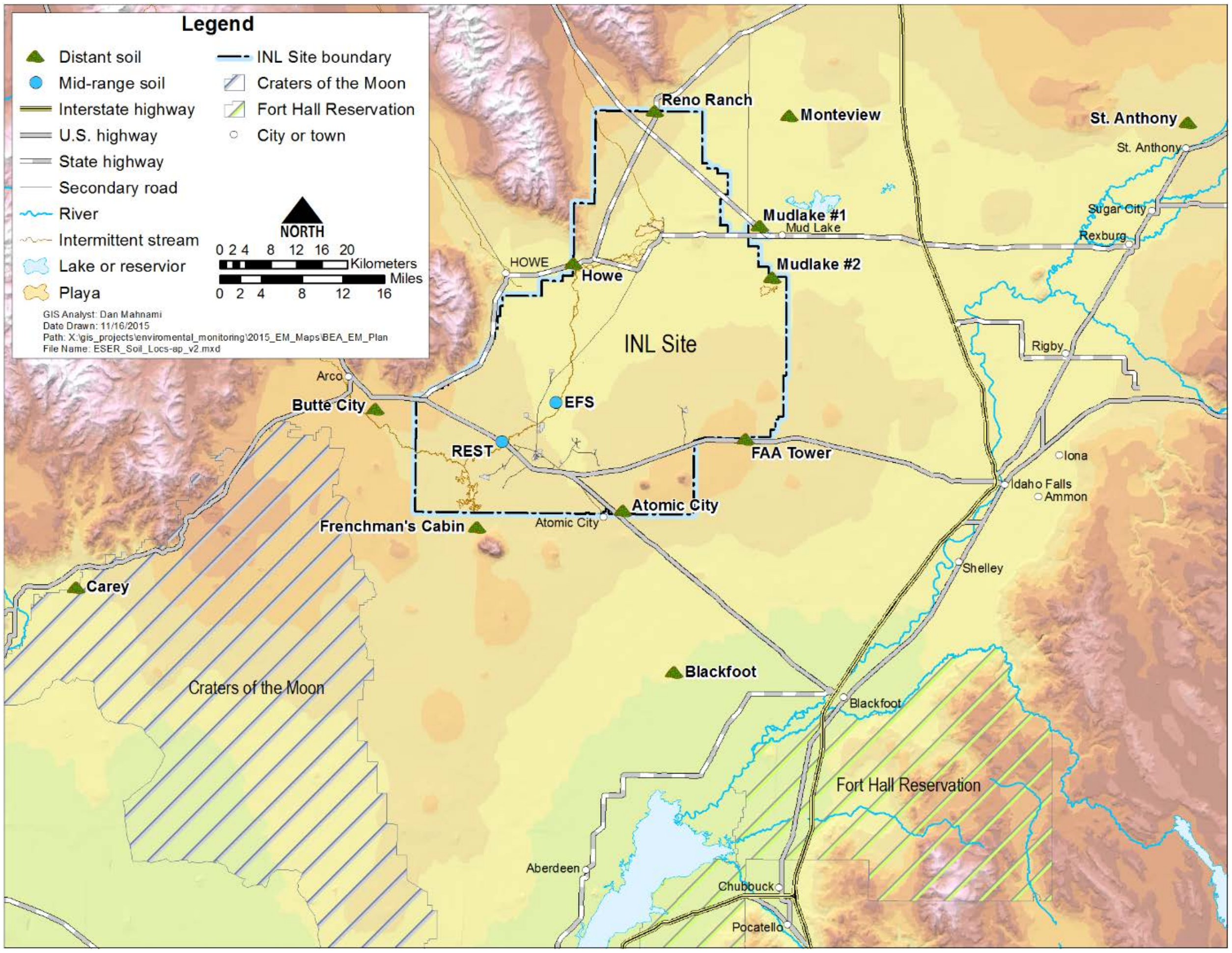

Figure 5. Distant and mid-range soil-monitoring locations.

6. STEP 5: DEVELOP THE ANALYTICAL APPROACH

The analytical approach is defined in Step 5. The analytical approach requires that the population parameters that will be used for decision-making are defined, as well as the action levels and appropriate estimators. The analytical approach is varied and involved. A comprehensive discussion of the approach is dependent on the statistical methods that are used to develop action limits and analyze data as they are obtained. The *Historical Data Analysis Supporting the Data Quality Objectives for the INL Site Environmental Soil Monitoring Program* (INL 2016) contains the details of the statistical analysis involved in the analytical approach while this section provides a high-level overview of the approach.

The first PSQ defined in Section 3 pertains to establishing a baseline radionuclide inventory for the soils associated with each of the near-facility areas and mid-range regions. This baseline has been completed, and it provides a frame of reference in the case of a planned or unplanned release to determine the effect of the release on the soils. A background level has been computed for each near-facility area and distant region to establish the baseline. Individual measurements obtained during sampling events can be compared to the background level to alert the monitoring program that a background level has been exceeded. The background level assumes a parameter of the 99th percentile of all radionuclide concentrations in the soil. Thus, the 99/95% upper tolerance limit (UTL) has been used as the estimate for the background level. This is the level such that 99% of the concentrations will be less than the background level with 95% confidence. The data obtained from future sampling events may be compared to the appropriate set of background levels to determine if any of the measurements exceed the established background level. If the background level is exceeded, the sample will be further investigated to assess the reason for the larger value. It is assumed that 1% of the concentrations will exceed the background level. Thus, a single measurement that exceeds the background level does not necessarily indicate an unusually high amount of that radionuclide in the area. Once the data obtained from a sampling event have been examined and compared to the background levels, the background level will be updated using the new data to ensure that the baseline profile remains current. Table 2 shows the background levels for each of the areas in the near-facility area and distant regions. These background levels were computed using historical data (INL 2016).

Table 2. Background levels (UTLs)[a] for near-facility and distant areas.

Radionuclide	Am-241 (pCi/g)	Cs-137 (pCi/g)	Pu-238 (pCi/g)	Pu-239/240 (pCi/g)	Sr-90 (pCi/g)
INL Site Facilities					
ARA	0.401	133	0.025	0.0577	57
ATR	0.49	223	0.0116	0.0728	1.349
INTEC	0.9	40	0.387	0.73	14.9
MFC	0.008	1.99	0.01	0.0487	0.953
RWMC	8.4	3.54	0.058	2.57	2.47
TAN	0.086	23.8	0.014	0.029	1.754
Boundary/Distant Sites					
Atomic City	0.0278	1.012	0.0227	0.0573	0.734
Blackfoot	0.0405	2.697	0.154	0.239	0.398
Butte City	0.0942	1.248	0.0337	0.0487	0.56
Carey	0.0556	0.963	0.0447	0.0671	0.534
FAA Tower	0.0356	1.623	0.0743	0.0829	0.806
Frenchman's Cabin	Insufficient data to compute a background value				
Howe	0.01	0.7	0.0119	0.0353	0.67
Monteview	0.0194	1.11	0.035	0.0477	0.268
Mud Lake	0.0875	0.624	0.0514	0.0892	0.335
Blue Dome/Birch Creek Hydro	0.0268	1.583	0.0144	0.0677	0.911
St. Anthony	0.0422	1.758	0.0857	0.0954	0.948

a. The 99/95% upper tolerance limit

ARA = Auxiliary Reactor Area
ATR = Advanced Test Reactor
FAA = Federal Aviation Administration
INTEC = Idaho Nuclear Technology and Engineering Center
MFC = Materials and Fuels Complex
RWMC = Radioactive Waste Management Complex
TAN = Test Area North

Data are collected at the mid-range areas, REST and EFS, to determine long-term deposition of radionuclides on the INL Site. A trend analysis will be performed on data obtained from these locations to assess the deposition over time. Historical data are not available for REST or EFS, so trend analysis will begin when sufficient data are available.

Data collected from offsite locations will continue to be monitored to determine the fate and transport of ambient radionuclides in the background. It is highly unlikely that INL Site emissions will ever be detected here, unless there is a major catastrophic release.

7. STEP 6: SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

Decision rules and estimation uncertainty are defined in Step 6. The purpose of the soils monitoring effort is to continue to maintain estimates of the radionuclide inventory in areas within the INL Site boundaries and in the surrounding areas. Thus, the analytical plan is developed for estimation rather than decision-making. The level of confidence for the background doses was chosen to be 95%, and the other uncertainties were minimized by ensuring that sufficient data are collected at each area and that best sampling practices are implemented. Every sampling project has a chance of committing a decision error, but historical data, sampling conducted under other programs, and monitoring of other media such as air and biota help ensure that the chance of missing an authentic increase in radiation from INL is negligible.

8. STEP 7: DEVELOP THE DETAILED PLAN FOR OBTAINING DATA

Step 7 of the DQO process lays out a detailed plan for obtaining data of sufficient quality to answer the primary questions of the study. It is important that the data are collected in a manner that meets the requirements of the statistical methods that will be used to analyze the data. This study obtains data from several areas both within INL Site boundaries and in surrounding areas as listed in Table 1. The location, history, and purpose of each of these areas differ, so data requirements are not the same for all areas. Monitoring adjacent to RWMC, where modeling shows the potential for accumulation to occur, requires sampling to ensure that the baseline inventory is adequately defined in the case of a planned or unplanned release. Areas that are not in the vicinity of radiological activities (e.g., REST, EFS, and offsite locations) correspondingly require fewer sampling locations to maintain a baseline and examine long-term deposition (INL 2016).

This section outlines the general reasoning behind the number of monitoring locations in each area, the frequency of sampling, and the methodology for selecting sampling locations. Lastly, this section provides a detailed explanation for selecting sampling locations at the INL Site and in the regional area.

8.1 Sampling Design

Statistical methods typically require that sampling locations be determined using a probability sampling design (INL 2016). That is, a random method is used to determine sampling locations. Practical constraints such as predominant wind directions, accessibility, and facility features are incorporated in location selection while still maintaining a sufficient amount of randomness to meet the requirements of the statistical methods. Data have been collected over years from the same locations in many of these areas, and previous sampling locations are taken into account when determining future sampling locations to ensure continuity and optimal information (INL 2016).

The most basic probability sampling method is simple random sampling. It is the method upon which the others are built. A simple random sample consists of identifying every possible sample location and then using a random number generator to select the sample locations that will be used. No human bias is involved in sample location selection. It is important to note that haphazard sampling is acutely biased in nature and is not random sampling (EPA 2002).

Another sampling method is systematic random sampling. Systematic random sampling is where a system, such as fixed intervals along a line or on a systematic grid, is used to select sample locations. The starting location is determined by random selection. Thus, the system is not random, but the placement is random, so the method is still a probability sampling method. This sampling design is applicable when uniform coverage of an area is desired. It is also often easier to implement a systematic method in the field than a non-systematic design (EPA 2002).

Composite sampling is a method where sample locations are determined by a random sampling method, two to five samples are mixed together, and one representative aliquot is collected from the composite and analyzed. Samples that are composited should be close to each other so that as much of the information in regard to variability across the area being sampled can be preserved. Composite sampling has several benefits. This method provides more accurate averages at a lower cost because the information from two to five samples can be obtained for the cost of one analytical sample. Composites are helpful with soil sampling because soil is expressly heterogeneous (EPA 2002). Compositing samples allows the data user to gain a more accurate profile of the area in question. However, composite samples mask some of the variability. This must be considered during data analysis, and it is essential that measures such as UTLs that are computed from composite samples are compared with other composite samples.

A method that is often used with soil is MULTI INCREMENT® sampling. This sampling method was developed by Envirostat Inc. and uses the principles developed by Pierre Gy for his Theory of Sampling method (Gy 1979). MULTI INCREMENT® sampling is often mistaken for composite sampling, but they are very different in implementation and benefits. A MULTI INCREMENT® sampling design is one in which the sampling area is clearly defined and decision units are identified. A decision unit is where a decision would be made, and it often covers a large area. A grid is placed over each decision unit, and many small samples are collected systematically over the grid. All of the samples are combined and thoroughly mixed to ensure the soil is homogenous. One representative sample is collected from the homogenized soils and is analyzed. MULTI INCREMENT® sampling is designed to determine the mean concentration of a particular analyte over a specific area, and it is remarkably effective at determining the mean. However, the variability of the concentrations in that area cannot be measured, and thus MULTI INCREMENT® sampling cannot determine if an individual measurement from the area in question is within the normal range of concentrations.

The primary goals of the INL Environmental Soil Monitoring Program are to measure long-term deposition and to maintain a baseline for different areas inside the INL Site and in the surrounding areas. The baseline profile is defined by UTLs, which can be compared to individual measurements to determine if those individual measurements are within the normal range of concentrations for that area. Thus, MULTI INCREMENT® sampling cannot be used to meet the objectives of the monitoring program. A combination of systematic sampling and composite sampling will be used for this program to ensure even coverage and maximum representation. Each of the areas within INL Site boundaries that are to be monitored to maintain a baseline inventory have sampling locations that have been identified for many years. It is unnecessary to collect samples at all of these locations to establish and maintain a background profile. Thus, a systematic random sampling method will be used to determine which sample locations will be included under the program. Section 8.4 outlines in detail the methodology that is used for the near-facility area.

A composite sample consisting of five individual samples will be used at each sampling location. This will minimize the heterogeneity at each sampling location. Five samples will be collected at the corners of a 10- x 10-m square, and a sample will be collected in the middle. All five samples will be well mixed, and a single composite sample will be analyzed (see Figure 6). This compositing methodology will be used at all sampling locations regardless of location or purpose.

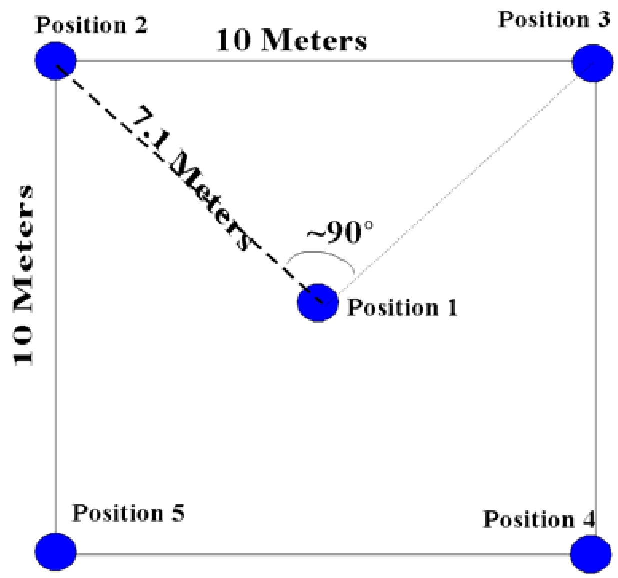

Figure 6. Composite sampling grid.

8.2 Methodology for the Number of Monitoring Locations

This subsection outlines the methodology for determining the number of monitoring locations at a specific area and for the frequency of sample collection. The general guidelines for each type of area are described along with area features that assist in determining the sampling locations and the number samples that are needed in a specific area.

The purpose of the soil monitoring program is to maintain the baseline inventory of radionuclides in the soils within INL Site boundaries and in the surrounding areas, as well as to determine the long-term deposition of radionuclides in the soils due to INL activities. The number of samples needed to perform an analysis is dependent on the statistical methods used to analyze the data and make decisions. Some statistical methods, such as the upper confidence limit, have formulas associated with them to aid the data user in determining how many samples are required to meet certain quality criteria. However, UTLs will be used to compute baseline inventories with the monitoring data, and UTLs do not have sample size equations associated with them to aid in determining an appropriate sample size. Thus, other criteria must be used to determine the appropriate sample size. Characteristics such as variability of the data, history and current activities associated with the area being sampled, and the size of the area are all taken into account when determining the number of samples needed and the location of those samples.

Note again that INL facilities and projects performing radiological activities complete monitoring specific to those activities such as stack monitoring or occupational radiation monitoring under 10 CFR 835, “Occupational Radiation Protection.” There are also areas within the INL Site boundaries and outside of the boundaries that are not in close proximity to radiological activities but are located where the public may be affected. Hence, establishing a baseline radiological inventory of the soils in those areas is of interest in the case of a radiological release. Fewer monitoring locations are needed in these areas because of their distance from the potential sources of INL radiation.

The criteria for determining sample size considers the proximity of the areas to radiological activities, the ability to compute appropriate statistical measures, the variability in radionuclide concentrations across the area exhibited in historical data, the potential for measurable accumulations, and the physical characteristics of the area. Areas are separated into three main categories: near-facility, mid-range, and distant areas. Near-facility areas that were evaluated for the need for routine monitoring are facilities within the INL Site boundaries where radiological activities are taking place or have taken place and where measureable accumulations could occur in terms of decades. As such, not all facilities were selected for routine sampling; only RWMC meets these criteria. Modeling shows that releases from the other facilities would take more than centuries to result in measureable accumulations in surface soil. Mid-range areas will be sampled only to assess long-term deposition. Distant areas may be along the INL Site boundary or outside of the boundary. These include areas where no radiological activities take place but where the public may be present. A baseline radiological inventory will also be developed for these areas; however, fewer sampling locations are required to attain and maintain a baseline for the distant areas than for the near-facility areas.

RWMC requires eight to 15 sampling locations, not including duplicates. This is because a UTL will need to be computed and maintained for the area every 5 years to ensure it remains relevant due to the possibility that the radiation inventory could change as facility activities change. Site characteristics or other motivators may indicate that more than eight monitoring locations are warranted. Historical data were examined to aid in determining the number of samples needed.

Mid-range areas only require a single composite sample consisting of five grab samples on a schedule and for laboratory analyses coinciding with the distant-area sampling.

Boundary and distant areas may be maintained with a single composite sample at each location consisting of five grab samples. Background trends can be monitored with one sample at each location because at previously selected locations historical data are available to trend the fate of ambient radionuclides. It is possible to use data acquired over time to compute area-specific background doses because the doses at the distant locations have not previously exhibited evidence of increased dose from INL Site radiological activities.

The DOE Handbook (DOE-HDBK-1216-2015) guidance allows for surveillance monitoring as infrequently as every 5 years if the projected annual effective dose to the public is less than 0.1 mrem per year, which is the case for INL as identified in the annual INL National Emission Standards for Hazardous Air Pollutants (NESHAP) evaluations (e.g. DOE-ID 2014a). Because the focus of soil monitoring is to establish and maintain a baseline inventory and to assess long-term deposition, sampling on a 5-year rotation schedule is adequate to meet project requirements.

8.3 Methodology for Soil Monitoring Location Selection

The previous subsection provides a minimum number of monitoring locations for each type of area, but it does not indicate the soil sampling locations or how to determine whether more than the minimum number of locations is warranted. This subsection provides guidelines for incorporating this approach in determining specific sampling locations for an area. The guidelines include obtaining knowledge about the location of sources of external radiation that are to be monitored, natural conditions that may affect the spread of radionuclides, the location of air-monitoring locations, the area of elevated simulated air concentrations, and stakeholder concerns.

Proximity to potential source of radiation. The INL Environmental Soil Monitoring Program does not monitor areas inside the outer fence of any INL Site facility; the INL Radiological Control Program is responsible for monitoring those areas. The locations of potential sources of radiation releases that modeling shows as having a potential for detectable accumulation comprise one of the most important factors in determining sampling locations. For near-facility monitoring, only RWMC meets the criterion of being an area with the potential to be affected by a release of current emissions.

Prevailing wind directions. The DOE Handbook (DOE-HDBK-1216-2015) guidance states that sampling should occur in the prevailing wind directions. In most INL Site locations, the predominant wind direction is from the southwest, but there is also a significant component of wind from the northeast. For this reason, sampling locations will be placed both to the northeast and the southwest of RWMC. These soil sampling locations are close to the outer facility fence lines and extend as far as the wind may carry particulates originating from the site (INL 2016).

Low-volume air-monitoring locations. Sampling locations were identified at two low-volume air-monitoring locations for data-integration purposes. This provides measured air concentrations and direct radiation doses that can be compared to simulated air concentrations that are predicted for the annual site environmental reports. As an example, the direct-radiation measurements taken at the regional monitoring location off the INL Site are averaged and compared to the calculated effective dose from natural background sources (see Table 7-6 in the *Technical Basis for Environmental Monitoring and Surveillance at the Idaho National Laboratory Site* [DOE-ID 2014b]). The ability to collocate sampling locations with existing air monitors is limited by the proximity of soil to the air monitor and by the availability of air monitors within areas where soil monitoring is beneficial.

Stakeholder concerns. In some cases, soil sampling locations were chosen to alleviate concerns by public stakeholders. This is generally the case for soil sampling located away from active INL Site facilities and in regional population centers. Monitoring at these background locations contributes to the baseline radionuclide inventory that can be referenced in the case of a planned or unplanned release.

Soil samples (0 to 5 cm) will be collected from surface soils only. As described in Walker (2000), sampling of subsurface soils is of little value in achieving the goals outlined in these DQOs because radionuclides in the region tend to bind to the surface soil, and low annual precipitation means the impact of a release would be most evident on the surface soils.

8.4 RWMC Monitoring Locations

This subsection discusses the specific sampling locations for RWMC. Figure 7 shows the RWMC soil-sampling locations that were selected to meet the DQOs described in Section 3. These locations are designated with a maroon triangle. Historical data collected from the 1970s through 2014 were examined to determine concentration variability and other characteristics that influence the selection and number of monitoring locations. Additionally, as with RWMC, volumes of historical soil data, current release estimates, and modeled deposition potentials were evaluated for soils surrounding the other major INL Site facilities, including the Advanced Test Reactor Complex, Auxiliary Reactor Area, INTEC, MFC, and Specific Manufacturing Capability. The results show that continued routine soil monitoring near these facilities is not warranted unless indications that new releases to the air are occurring or radioactivity in air samples or on environmental dosimeters is detected.

Historical data from RWMC were concentrated southwest and northeast of the facility. The data show that the highest concentrations of radionuclides are along the north fence and at locations RW2-1, RW3-1, and RW3-2 (Figure 7). A systematic random sampling design was used to determine which of these will be used as monitoring locations (INL 2016). It was determined to sample every third location, so the sample identifier numbers were lined up from the smallest number to the largest number, and every third location was selected. A random number generator selected the first sample as the random start location. Because the north and west sides of the fence have much higher concentrations of radionuclides than the other locations, Locations RW2-1, RW2-4, RW3-1, RW3-2, RW5-4, RW5-5, and RW5-8 are included as monitoring locations in addition to those selected through systematic random sampling (Figure 7).

8.5 Mid-Range Locations

Two mid-range onsite areas are monitored under the soil monitoring program to evaluate the long-term accumulation trends on a 5-year rotation. One composite sample composed of five grab samples is collected from each of these locations during each sampling event. Data collected over time are used to compute a baseline inventory for each area. Because extensive historical data exist for most of these offsite areas, the same sampling locations will continue to be used to ensure that there is data comparability over time. Figure 5 shows the mid-range sampling locations.

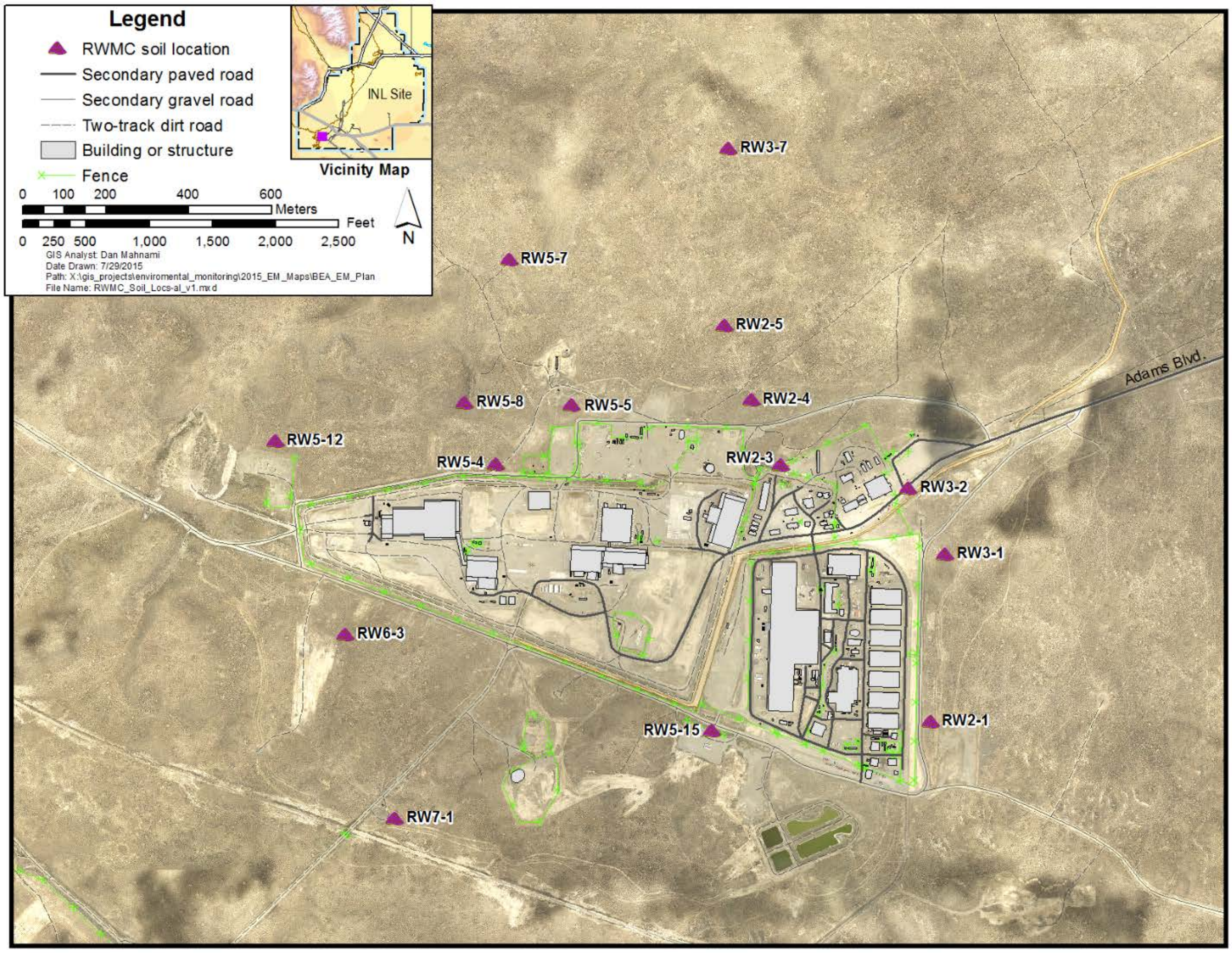

Figure 7. Soil-monitoring locations at RWMC.

8.6 Boundary and Distant Locations

Twelve boundary and distant offsite areas will be monitored on a 5-year basis. Because extensive historical data exist for most of these offsite areas, the same sampling locations and methods will continue to be used to ensure that there is data comparability over time. The exception is the historical location at Crystal Ice Caves. This station is currently in the Craters of the Moon National Monument and Preserve and can no longer be used. Instead, soil will be collected at Frenchman's Cabin, near the Big Southern Butte. This has typically been the location of the Maximally Exposed Individual estimated by the EPA CAP-88 PC air dispersion model (DOE-ID 2015). Figure 8 shows the current locations of the boundary and distant soil monitoring program.

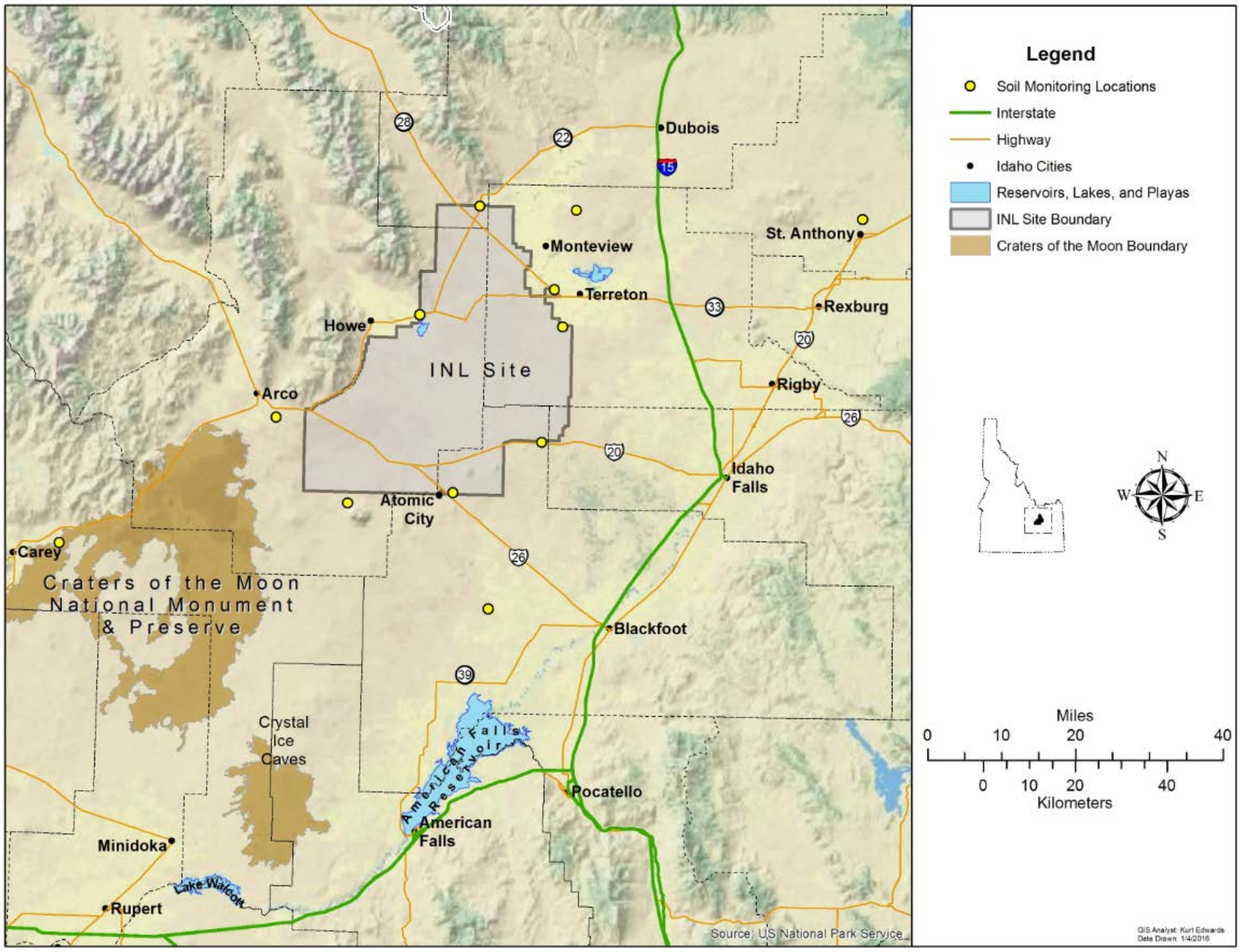

Figure 8. Soil-monitoring locations at boundary and distant areas.

9. CONCLUSIONS

Current and future activities in relation to soil monitoring at the INL Site and in the surrounding areas will proceed in accordance with the DQOs outlined in this document. These DQOs provide a technical explanation and justification for the process used to select sampling locations, analyze results, and make decisions based on acquired data. The number and location of soil sampling locations at each area may change as INL activities change. However, as long as changes are reflected in revisions to this document, such changes will not be in violation of the DQO parameters.

10. REFERENCES

10 CFR 835, "Occupational Radiation Protection," Code of Federal Regulations, Office of the Federal Register.

DOE 1991a, *Idaho National Engineering Laboratory Federal Facility Agreement and Consent Order*, U.S. Environmental Protection Agency, Region 10; Department of Health and Welfare; and U.S. Department of Energy, December 9, 1991.

DOE, 1991b, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, DOE/EH-0173T, U.S. Department of Energy, January 1991.

DOE-ID, 1983, *1982 Environmental Monitoring Program Report for Idaho National Engineering Laboratory Site*, DOE/ID-12082(82), May 1983.

DOE-ID, 2014a, *National Emissions Standards for Hazardous Air Pollutants-Calendar Year 2013 INL Report for Radionuclides*, DOE/ID-11441, June 2014.

DOE-ID, 2014b, *Technical Basis for Environmental Monitoring and Surveillance at the Idaho National Laboratory Site*, DOE/ID-11485, February 2014.

DOE-ID, 2015, *Idaho National Laboratory Site Environmental Report Calendar Year 2014*, DOE/ID-12082(14), September 2015.

DOE-HDBK-1216-2015, *DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance*, U.S. Department of Energy.

DOE O 458.1, "Radiation Protection of the Public and Environment," U.S. Department of Energy, February 2011.

EML, 1997, *EML Procedures Manual*, 28th Edition, HASL-300, U.S. Department of Energy-Environmental Measurements Laboratory, 1997.

EPA, 2002, *Guidance on Choosing a Sampling Design for Environmental Data Collection*, EPA QA/G-5S, U.S. Environmental Protection Agency, December 2002.

EPA, 2006, *Data Quality Assessment: Statistical Methods for Practitioners*, EPA QA/G-9S, U.S. Environmental Protection Agency, February 2006.

Gallegos, G., 1995, "Surveillance Monitoring of Soils for Radioactivity: Lawrence Livermore National Laboratory 1976 to 1992," *Health Physics*, Vol. 69, No. 4, pp. 487–493.

Gy, P. M., 1979, *Sampling of Particulate Materials: Theory and Practice*, New York: Elsevier Scientific Publishing Company.

Hardy, E. P. and P. W. Krey, 1971, "Determining the Accumulated Deposit of Radionuclides by Soil Sampling and Analysis," in *Proceedings of Environmental Plutonium Symposium,* Los Alamos Scientific Laboratory, August 4–5, 1971, Eric B. Fowler, Richard W. Henderson, Morris F. Milligan, eds., LA-4756.

INEL, 1995, *Engineering Evaluation/Cost Analysis for Operable Unit 10-06 Radionuclide-Contaminated Soils Removal Action at the Idaho National Engineering Laboratory*, INEL-95/0259, June 1995.

INL, 2016, *Historical Data Analysis Supporting the Data Quality Objectives for the INL Site Environmental Soil Monitoring Program*, INL/INT-15-37431, February 2016.

Rood, R. S. and A. J. Sondrup, 2014, *Quantitative Assessment of Detection Frequency for the INL Ambient Air Monitoring Network*, INL/EXT-14-33194, November 2014.

Shultz, R. K., 1965, "Soil Chemistry of Radionuclides," *Health Physics,* Vol. 11, No. 12, December 1965.

Walker, D. W., 2000, *Comparison of In Situ Gamma-Ray Spectrometry Measurements to Conventional Soil Sampling Methods at the Idaho National Engineering and Environmental Laboratory (INEEL)*, Pocatello, Idaho: Idaho State University.