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Idaho National Laboratory Offsite Environmental Surveillance Program Report: Fourth Quarter 2005

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EXECUTIVE SUMMARY

None of the radionuclides detected in any of the samples collected during the fourth quarter of 2005 could be directly linked with INL activities. Levels of detected radionuclides were no different than values measured at other locations across the United States or were consistent with levels measured historically at the INL. All detected radionuclide concentrations were well below guidelines set by the U.S. Department of Energy (DOE) and regulatory standards established by the U.S. Environmental Protection Agency (EPA) for protection of the public. (See Table E-1.)

This report for the fourth quarter, 2005, contains results from the Environmental Surveillance, Education and Research (ESER) Program's monitoring of the Department of Energy's Idaho National Laboratory's (INL) offsite environment, October 1 through December 31, 2005. All sample types (media) and the sampling schedule followed during 2005 are listed in Appendix A. Specifically, this report contains the results for the following:

- Air sampling, including air filters and charcoal cartridges, atmospheric moisture, and 10-micron particulate matter (PM_{10});
- Drinking water, surface water, and precipitation sampling;
- Agricultural product sampling, including milk and potatoes;
- Large game animal sampling;
- Measurement of external exposure, using environmental dosimetry.

Gross alpha and gross beta measurements are used as general indicators of the presence of radionuclides. Gross alpha and gross beta results were found to have no discernable statistical distribution during the fourth quarter of 2005. Because of this, these data were statistically analyzed using nonparametric methods, including the use of the median to represent central tendency. At no time during the fourth quarter were monthly or quarterly gross alpha or gross beta concentrations in air collected at Boundary locations statistically greater than corresponding data for Distant locations, as one would expect if the INL were a significant source of radionuclide contamination. There were no statistical differences between gross alpha or gross beta results when grouped by location on a quarterly basis. Statistical analysis by month also showed no statistical difference between locations for gross alpha or gross beta.

Weekly comparisons of gross alpha concentrations at Distant and Boundary locations showed no statistical differences during the fourth quarter of 2005. Gross beta results were statistically greater at Boundary locations than at Distant locations during the weeks of November 16, 2005 and December 28, 2005, but this appears to be due to random variability in the data.

Iodine-131 (^{131}I) was not detected in any batch of charcoal cartridges during the fourth quarter.

Selected quarterly composite filter samples were analyzed for gamma emitting radionuclides, strontium-90 (^{90}Sr), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}Pu$), and americium-241 (^{241}Am). No manmade gamma-emitting radionuclides or transuranic radionuclides were detected. Strontium-90 was found at one distant location within the range of historical measurements.

Fourteen atmospheric moisture samples were obtained during the fourth quarter of 2005 and analyzed for tritium. Two samples from Idaho Falls and one sample each from Atomic City, Blackfoot, and Rexburg exceeded their respective 3s levels. The maximum value was well below the DOE DCG for tritium in air.

The ESER Program operates three PM_{10} samplers for particulate sampling, one each at Rexburg, Blackfoot, and Atomic City. Sampling of PM_{10} is primarily informational as no analyses are conducted for contaminants. PM_{10} concentrations were well below all health standard levels for all samples. The maximum 24-hour particulate concentration was 43.56 $\mu g/m^3$ on December 11, 2005, at Atomic City. This is well below the EPA Air Quality Standard of 150 $\mu g/m^3$.

Sufficient precipitation occurred to allow collection of 12 samples—three each from Idaho Falls and the Central Facilities Area (CFA) and six from the Experimental Field Station (EFS) on the INL. Three of the samples contained detectable concentrations of tritium, within the range reported by the EPA across the western United States.

Fourteen drinking water samples and one duplicate were collected from selected taps throughout southeast Idaho during the fourth quarter of 2005. Samples were analyzed for gross alpha, gross beta, and tritium (^3H). None of the samples exceeded its 3s value for gross alpha. Six samples contained tritium above the detection limit, but within historical measurements. The maximum value was below the EPA limits established under the Safe Drinking Water Act and DOE DCGs. Eleven samples exceeded the 3s value for gross beta. The maximum gross beta concentration measured, (8.57 ± 1.05) pCi/L, was from Fort Hall and was below the EPA Safe Water Drinking Water Act (SDWA) screening limit of 50 pCi/L and the DOE DCG of 100 pCi/L. Levels of gross beta activity observed are not unusual given the basaltic terrain.

Six surface water samples (including one duplicate) were collected from locations throughout southeast Idaho. Samples were analyzed for gross alpha, gross beta, and tritium (^3H). None of the samples exceeded their 3s value for gross alpha and two exceeded the 3s value for tritium. Gross beta activities were detected in all six samples. Results were less that SDWA screening limits and DOE DCGs and were typical of historical and regional measurements.

Milk samples were collected weekly in Idaho Falls and monthly at eight other locations around the INL. All samples were analyzed for gamma-emitting radionuclides and selected samples were analyzed for tritium and Strontium-90. No manmade gamma-emitting radionuclides or tritium were found in any sample. Strontium-90 was measured above the 3s uncertainty level in three of four samples analyzed, at levels consistent with those previously found. Strontium-90 is detected as a result of uptake of historical weapons derived fallout.

Eleven potato samples were collected from farms around the INL and from Colorado. No gamma-emitting radionuclides were found in any sample. Strontium-90 was found in three samples at concentrations consistent with those found in previous years attributed to uptake of historical weapons derived fallout.

Cesium-137 was detected in the muscle tissue taken from one of two game animals killed on INL roads. The detected concentration was similar to those found in both onsite and offsite tissues during recent years.

Environmental dosimeter locations are also divided into Boundary and Distant groupings. Boundary exposure rates ranged from a low of 0.27 mR/day to 0.37 mR/day. The overall Boundary average was 0.33 mR/day. The Distant group ranged from 0.29 mR/day to 0.40 mR/day, with an overall average exposure also of 0.33 mR/day. No statistical difference existed between Boundary and Distant locations. All exposure results are consistent with those measured historically.

Table E-1 Summary of results for the fourth quarter of 2005.

Media	Sample Type	Analysis	Results
Air	Filters	Gross alpha, gross beta	There were no statistical differences noted for monthly or quarterly gross alpha or gross beta concentrations measured at INL, Boundary, and Distant locations. Gross beta concentrations were statistically higher at Distant locations than at Boundary locations during the weeks of November 16 and December 28. However, no result exceeded the DCG for gross alpha or gross beta activity in air.
		Gamma-emitting radionuclides, select actinides, ^{90}Sr	No manmade gamma-emitting radionuclides or actinides were detected. Detectable ^{90}Sr was found at one distant location, well below DOE limits.
	Charcoal Cartridge	Iodine-131	No detections of ^{131}I were made during the fourth quarter.
	PM_{10}	Particulate matter	Forty-five valid samples were collected from three locations. No regulatory limits were exceeded.
Atmospheric Moisture	Liquid	Tritium	Fourteen atmospheric moisture samples were collected. Five of the results were greater than the 3s uncertainty. No sample result exceeded the DCG for tritium in air.
Precipitation	Liquid	Tritium	A total of six monthly and six weekly samples were collected. Three of these samples had tritium results greater than the 3s uncertainty. Concentrations were consistent with those reported across the region and with previous results.
Drinking Water	Liquid	Gross alpha, gross beta, tritium	Gross alpha activity was not detected in any sample. Gross beta activity was measured in 11 of 15 samples. The maximum was well below the EPA Safe Drinking Water Act limits. Tritium was detected in six samples at concentrations many times lower than the EPA regulatory level.
Surface Water	Liquid	Gross alpha, gross beta, tritium	No gross alpha activity was detected in any of the six samples collected. Tritium was measured in two samples. Gross beta activity was measured above the 3s values in all six samples. All concentrations were below EPA and DOE limits, and were within historical measurements.
Milk	Liquid	Iodine-131, gamma emitting radionuclides, tritium, and ^{90}Sr	No manmade gamma-emitting radionuclides or tritium were found in any sample. Strontium-90 was detected in three of four samples at values consistent with those previously reported and attributed to weapons testing fallout.
Potatoes	Solid	Gamma emitting radionuclides (including ^{137}Cs), and ^{90}Sr	Eleven potato samples were collected. Strontium-90 was detected in three samples. The measurements were within historical concentrations. Cesium-137 was not detected in any sample.
Game Animals	Tissue	Iodine-131,	Cesium-137 was found in the muscle sample

		gamma emitting radionuclides	from one of the two game animals available for sampling during the fourth quarter. The detected value was well within the range of historical values.
Environmental Radiation	TLD	Ambient ionizing radiation	Values were consistent with expected exposures given the altitude and location of the TLD's. There were no statistical differences between Boundary and Distant location results.

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LIST OF ABBREVIATIONS

AEC	Atomic Energy Commission
CFA	Central Facilities Area
CMS	community monitoring station
DCG	Derived Concentration Guide
DOE	Department of Energy
DOE – ID	Department of Energy Idaho Operations Office
EAL	Environmental Assessment Laboratory
EFS	Experimental Field Station
EPA	Environmental Protection Agency
ERAMS	Environmental Radiation Ambient Monitoring System
ESER	Environmental Surveillance, Education, and Research
ICP	Idaho Cleanup Project
INL	Idaho National Laboratory
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
ISU	Idaho State University
MDC	minimum detectable concentration
MFC	Materials and Fuels Complex
M&O	Management and Operating
NRTS	National Reactor Testing Station
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometers in diameter
RTC	Reactor Technology Complex
SI	Systeme International d'Unites
TLDs	thermoluminescent dosimeters
UI	University of Idaho
WSU	Washington State University

LIST OF UNITS

Bq	becquerel
Ci	curie
g	gram
L	liter
µCi	microcurie
mL	milliliter
mR	milliroentgens
mrem	millirem (rem = unit of dose equivalent [roentgen-equivalent-man])
mSv	millisieverts
pCi	picocurie
R	Roentgen
µSv	microsieverts

1. ESER PROGRAM DESCRIPTION

Operations at the Idaho National Laboratory (INL) are conducted under requirements imposed by the U.S. Department of Energy (DOE) under authority of the Atomic Energy Act, and the U.S. Environmental Protection Agency (EPA) under a number of acts (e.g. the Clean Air Act and Safe Drinking Water Act). The requirements imposed by DOE are specified in DOE Orders. These requirements include those to monitor the effects of DOE activities both inside and outside the boundaries of DOE facilities (DOE 2003). During calendar year 2005, environmental monitoring within the INL boundaries was primarily the responsibility of the INL Management and Operating (M&O) contractor, while monitoring outside the INL boundaries was conducted under the Environmental Surveillance, Education and Research (ESER) Program. The ESER Program is led by the S.M. Stoller Corporation in cooperation with its team members, including the University of Idaho (UI), Idaho State University (ISU), the Wildlife Conservation Society, and Teledyne Brown Engineering. This report contains monitoring results from the ESER Program for samples collected during the fourth quarter of 2005 (October 1 – December 31, 2005).

The surveillance portion of the ESER Program is designed to satisfy the following program objectives:

- Verify compliance with applicable environmental laws, regulations, and DOE Orders;
- Characterize and define trends in the physical, chemical, and biological condition of environmental media on and around the INL;
- Assess the potential radiation dose to members of the public from INL effluents, and;
- Present program results clearly and concisely through the use of reports, presentations, newsletter articles, and press releases.

The goal of the surveillance program is to monitor different media at a number of potential exposure points within the various exposure pathways, including air, water, agricultural products, wildlife, and soil, that could possibly contribute to the radiation dose received by the public.

Environmental samples collected include:

- air at 16 locations on and around the INL;
- moisture in air at four locations around the INL;
- precipitation from three locations on and around the INL;
- surface water at five locations on the Snake River;
- drinking water at 14 locations around the INL;
- agricultural products, including milk at 10 dairies around the INL, potatoes from at least five local producers, wheat from approximately 10 local producers, lettuce from approximately nine home-owned gardens around the INL and two maintained by ESER at Atomic City and the EFS, and four sheep from two operators which graze their sheep on the INL;
- soil from 12 locations around the INL biennially;
- environmental dosimeters from 15 locations semi-annually; and
- various numbers of wildlife including big game (pronghorn, mule deer, and elk), waterfowl, doves, and marmots sampled on and near the INL.

Table A-1 in Appendix A lists samples, sampling locations and collection frequency for the ESER Program.

The ESER Program used two laboratories to perform analyses on routine environmental samples collected during the quarter reported here. The Idaho State University (ISU) Environmental Assessment Laboratory (EAL) performed routine gross alpha, gross beta, tritium, and gamma spectrometry analyses. Analyses requiring radiochemistry including strontium-90 (^{90}Sr), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am) were performed by Teledyne Brown Engineering, Inc. of Knoxville, Tennessee.

In the event of non-routine occurrences, such as suspected releases of radioactive material, the ESER Program may increase the frequency of sampling and/or the number of sampling locations based on the nature of the release and wind distribution patterns. Any data found to be outside historical norms in the ESER Program is thoroughly investigated to determine if an INL origin is likely. Investigation may include re-sampling and/or re-analysis of prior samples.

In the event of any suspected worldwide nuclear incidents, like the 1986 Chernobyl accident, the EPA may request additional sampling be performed through RadNet [previously known as the Environmental Radiation Ambient Monitoring System (ERAMS) network] (EPA 2006). The EPA established the ERAMS network in 1973 with an emphasis on identifying trends in the accumulation of long-lived radionuclides in the environment. ERAMS was renamed RadNet in 2005 to reflect a new mission. RadNet is comprised of a nationwide network of sampling stations that provide air, precipitation, drinking water, and milk samples. The ESER Program currently operates a high-volume air sampler and collects precipitation and drinking water in Idaho Falls for this national program and routinely sends samples to EPA's Eastern Environmental Radiation Facility for analyses. The RadNet data collected at Idaho Falls are not reported by the ESER Program but are available through the EPA RadNet website (http://www.epa.gov/narel/radnet/).

Once samples have been collected and analyzed, the ESER Program has the responsibility for quality control of the data and for preparing quarterly reports on results from the environmental surveillance program. The quarterly reports are then consolidated into the INL Annual Site Environmental Report for each calendar year. Annual reports also include data collected by other INL contractors.

The results reported in the quarterly and annual reports are assessed in terms of data quality and statistical significance with respect to laboratory analytical uncertainties, sample locations, reported INL releases, meteorological data, and worldwide events that might conceivably have an effect on the INL environment. First, field collection and laboratory information are reviewed to determine identifiable errors that would invalidate or limit use of the data. Examples of such limitations include insufficient sample volume, torn filters, evidence of laboratory cross-contamination or quality control issues. Data that pass initial screening are further evaluated using statistical methods. Statistical tools are necessary for data evaluation particularly since environmental measurements typically involve the determination of minute concentrations, which are difficult to detect and even more difficult to distinguish from other measurements.

Results are presented in this report with an analytical uncertainty term, *s*, where "*s*" is the estimated sample standard deviation (σ), assuming a Gaussian or normal distribution. All results are reported in this document, even those that do not necessarily represent detections. The term "detected", as used for the discussion of results in this report, does not imply any degree of risk to the public or environment, but rather indicates that the radionuclide was measured at a concentration sufficient for the analytical instrument to record a value that is

statistically different from background. The ESER has adopted guidelines developed by the United States Geological Survey (Bartholomay, et al. 2003), based on an extension of a method proposed by Currie (1984), to interpret analytical results and make decisions concerning detection. Most of the following discussion is taken from Bartholomay et al (2003).

Laboratory measurements involve the analysis of a target sample and the analysis of a prepared laboratory blank (i.e., a sample which is identical to the sample collected in the environment, except that the radionuclide of interest is absent). Instrument signals for the target and blank vary randomly about the true signals and may overlap making it difficult to distinguish between radionuclide activities in blank and in environmental samples (Figure 1). That is, the variability around the sample result may substantially overlap the variability around a net activity of zero for samples with no radioactivity. In order to conclude that a radionuclide has been detected, it is essential to consider two fundamental aspects of the problem of detection: (1) the instrument signal for the sample must be greater than that observed for the blank before the decision can be made that the radionuclide has been detected; and (2) an estimate must be made of the minimum radionuclide concentration that will yield a sufficiently large observed signal before the correct decision can be made for detection or non-detection.

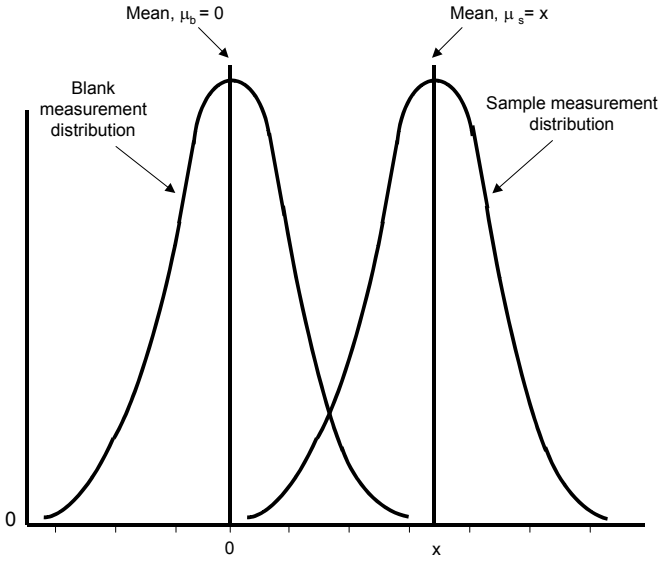

Figure 1. Example of overlap of blank and sample measurement distributions.

In the laboratory, instrument signals must exceed a critical level of 1.6s before the qualitative decision can be made as to whether the radionuclide was detected in a sample. At 1.6s there is about a 95-percent probability that the correct conclusion—not detected—will be made. Given a large number of samples, approximately 5 percent of the samples with measured concentrations greater than or equal to 1.6s, which were concluded as being detected, might not contain the radionuclide. These are referred to as false positives. For purposes of simplicity and consistency with past reporting, the ESER has rounded the 1.6s critical level estimate to 2s.

Once the critical level has been defined, the minimum detectable concentration may be determined. Concentrations that equal 3s represent a measurement at the detection level or minimum detectable concentration. For true concentrations of 3s or greater, there is a 95-percent probability that the radionuclide was detected in the target sample. In a large number of samples, the conclusion—not detected—will be made in 5 percent of the samples with true concentrations at the minimum detectable concentration of 3s. These measurements are known as false

negatives. The ESER reports measured radionuclide concentrations greater than or equal to their respective 3s uncertainties as being "detected with confidence."

Concentrations between 2s and 3s are reported as "questionably detected". That is, the radionuclide may be present in the sample; however, the detection may not be reliable. Measurements made between 2s and 3s are examined further to determine if they are a part of a pattern (temporal or spatial) that might warrant further investigation or recounting. For example, if a particular radionuclide is typically detected at > 3s at a specific location, a sample result between 2s and 3s might be considered detected.

If a result is less than or equal to 2s there is little confidence that the radionuclide is present in the sample. Analytical results in this report are presented as the result value ± one standard deviation (1s) for reporting consistency with the annual report. To obtain the 2s or 3s values simply multiply the uncertainty term by 2 or 3.

For more information concerning the ESER Program, contact the S.M. Stoller Corporation at (208) 525-9358, or visit the Program's web page (http://www.stoller-eser.com).

2. THE INL

The INL is a nuclear energy and homeland security research and environmental management facility. It is owned and administered by the U.S. Department of Energy, Idaho Operations Office (DOE-ID) and occupies about 890 mi^2 (2,300 km^2) of the upper Snake River Plain in Southeastern Idaho. The history of the INL began during World War II when the U.S. Naval Ordnance Station was located in Pocatello, Idaho. This station, one of two such installations in the U.S., retooled large guns from U.S. Navy warships. The retooled guns were tested on the nearby, uninhabited plain, known as the Naval Proving Ground. In the years following the war, as the nation worked to develop nuclear power, the Atomic Energy Commission (AEC), predecessor to the DOE, became interested in the Naval Proving Ground and made plans for a facility to build, test, and perfect nuclear power reactors.

The Naval Proving Ground became the National Reactor Testing Station (NRTS) in 1949, under the AEC. By the end of 1951, a reactor at the NRTS became the first to produce useful amounts of electricity. Over time the site has operated 52 various types of reactors, associated research centers, and waste handling areas. The NRTS was renamed the Idaho National Engineering Laboratory (INEL) in 1974, and the Idaho National Engineering and Environmental Laboratory (INEEL) in January 1997. With renewed interest in nuclear power the DOE announced in 2003 that Argonne National Laboratory and the INEEL would be the lead laboratories for development of the next generation of power reactors. On February 1, 2005 the INEEL and Argonne National Laboratory-West became the Idaho National Laboratory (INL). The INL is committed to providing international nuclear leadership for the 21st Century, developing and demonstrating compelling national security technologies, and delivering excellence in science and technology as one of the Department of Energy's multiprogram national laboratories.

The cleanup operation, Idaho Cleanup Project (ICP), is now a separately managed effort. The ICP is charged with safely and cost-effectively completing the majority of cleanup work from past laboratory missions by 2012.

3. AIR SAMPLING

The primary pathway by which radionuclides can move off the INL is through the air and for this reason the air pathway is the primary focus of monitoring on and around the INL. Samples for particulates and iodine-131 (^{131}I) gas in air were collected weekly for the duration of the quarter at 16 locations using low-volume air samplers. Moisture in the atmosphere was sampled at four locations around the INL and analyzed for tritium. Concentrations of airborne particulates less than 10 micrometers in diameter (PM_{10}) were measured for comparison with EPA standards at three locations. Air sampling activities and results for the fourth quarter, 2005 are discussed below. A summary of approximate minimum detectable concentrations (MDCs) for radiological analyses and DOE Derived Concentration Guide (DCG) (DOE 1993) values is provided in Appendix B.

LOW-VOLUME AIR SAMPLING

Radioactivity associated with airborne particulates was monitored continuously by 18 low-volume air samplers (two of which are used as replicate samplers) at 16 locations during the fourth quarter of 2005 (Figure 2). Four of these samplers are located on the INL, eight are situated off the INL near the boundary, and six have been placed at locations distant to the INL. Samplers are divided into INL, Boundary, and Distant groups to determine if there is a gradient of radionuclide concentrations, increasing towards the INL. Each replicate sampler is relocated every year to a new location. One replicate sampler was placed at Howe (Boundary location) and one at the INL Main Gate (onsite location) during 2005. An average of 15,712 ft^3 (445 m^3) of air was sampled at each location, each week, at an average flow rate of 1.56 ft^3/min (0.04 m^3/min). Particulates in air were collected on membrane particulate filters (1.2-µm pore size). Gases passing through the filter were collected with an activated charcoal cartridge.

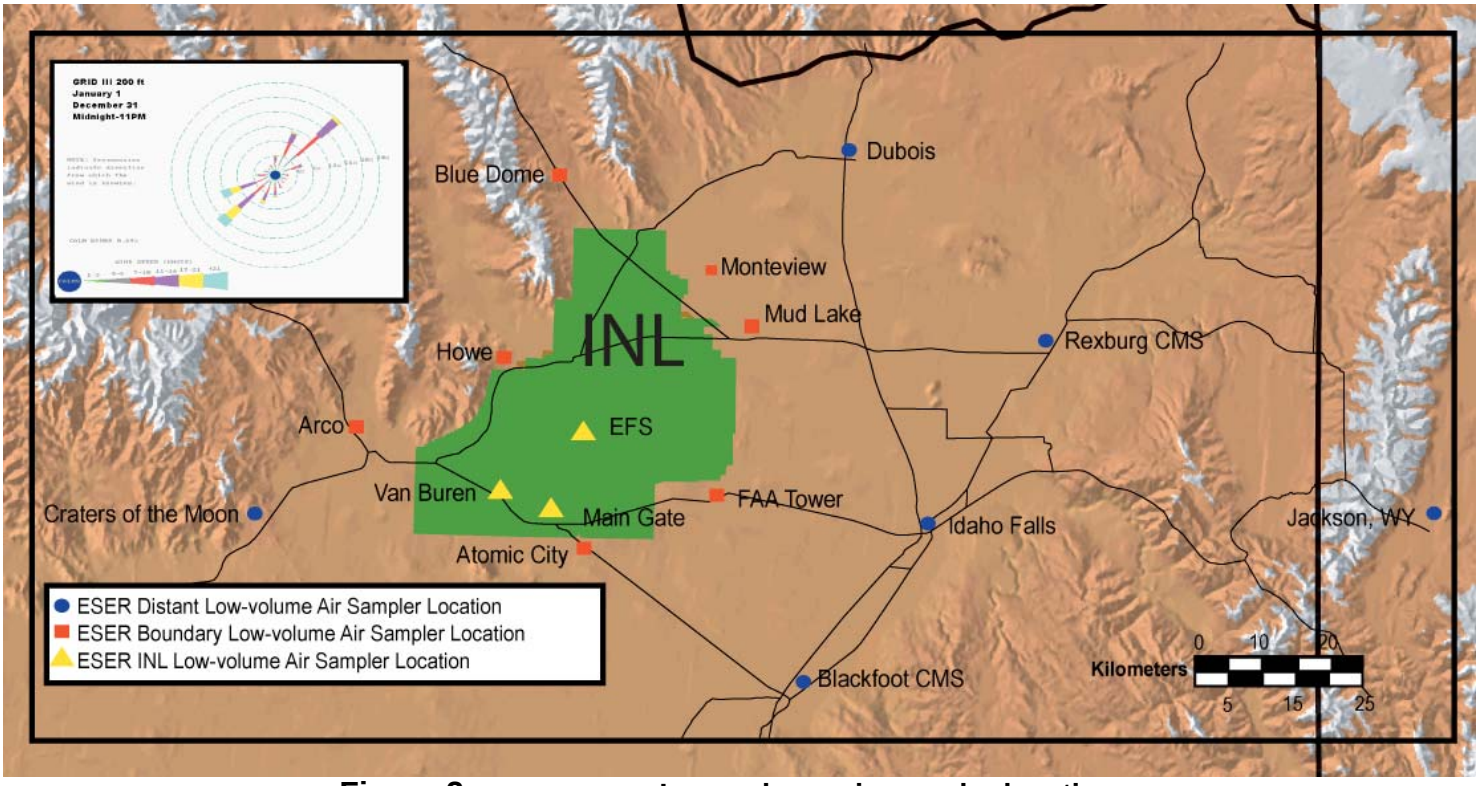

Figure 2. Low-volume air sampler locations.

Filters and charcoal cartridges were changed weekly at each station during the quarter. Each particulate filter was analyzed for gross alpha and gross beta radioactivity using thin-window gas flow proportional counting systems after waiting about four days for naturally-occurring daughter products of radon and thorium to decay.

The weekly particulate filters collected during the quarter for each location were composited and analyzed for gamma-emitting radionuclides. Composites were also analyzed by location for ^{90}Sr, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am as determined by a rotating quarterly schedule.

Charcoal cartridges were analyzed for gamma-emitting radionuclides, specifically for iodine-131 (^{131}I). Iodine-131 is of particular interest because it is produced in relatively large quantities by nuclear fission, is readily accumulated in human and animal thyroids, and has a half-life of eight days. This means that any elevated level of ^{131}I in the environment could be from a recent release of fission products.

Gross alpha results are reported in Table C-1. Median gross alpha concentrations in air for INL, Boundary, and Distant locations for the fourth quarter of 2005 are shown in Figure 3. Gross alpha data are tested for normality prior to statistical analyses, and generally show no consistent discernable distribution. Box and whisker plots are commonly used when there is no assumed distribution. Each data group in Figure 3 is presented as a box and whisker plot, with a median (small red square), a box enclosing values between the 25th and 75th percentiles, and whiskers representing the non-outlier range. Note that outliers and extreme values are identified separately from the box and whiskers. Outliers and extreme values are atypical, infrequent, data points that are far from the middle of the data distribution. For this report, outliers are defined as values that are greater than 1.5 times the height of the box, above or below the box. Extreme values are greater than 2 times the height of the box, above or below the box. Outliers and extreme values may reflect inherent variability, may be due to errors associated with transcription or measurement, or may be related to other anomalies. A careful review of the data collected during the fourth quarter indicates that the outlier values were not due to mistakes in collection, analysis, or reporting procedures, but rather reflect natural variability in the measurements. The outlier and extreme values lie within the range of measurements made within the past five years. Thus, rather than dismissing the outliers, they were included in the subsequent statistical analyses.

Figure 3 graphically shows that the gross alpha measurements made at INL, Boundary, and Distant locations are similar for the fourth quarter. If the INL were a significant source of offsite contamination, concentrations of contaminants could be statistically greater at Boundary locations than at Distant locations. Because there is no discernable distribution of the data, the nonparametric Kruskal-Wallis test of multiple independent groups was used to test for statistical differences between INL, Boundary, and Distant locations. The use of nonparametric tests, such as Kruskal-Wallis, gives less weight to outlier and extreme values thus allowing a more appropriate comparison of data groups. A statistically significant difference exists between data groups if the (p) value is less than 0.05. Values greater than 0.05 translate into a 95 percent confidence that the medians are statistically the same. The p-value for each comparison is shown in Table D-1. There were no statistical differences in gross alpha concentrations between location groups during the fourth quarter 2005.

Comparisons of gross alpha concentrations were made for each month of the quarter (Figures 4 – 6). Again the Kruskal-Wallis test of multiple independent groups was used to determine if statistical differences exist between INL, Boundary, and Distant data groups.

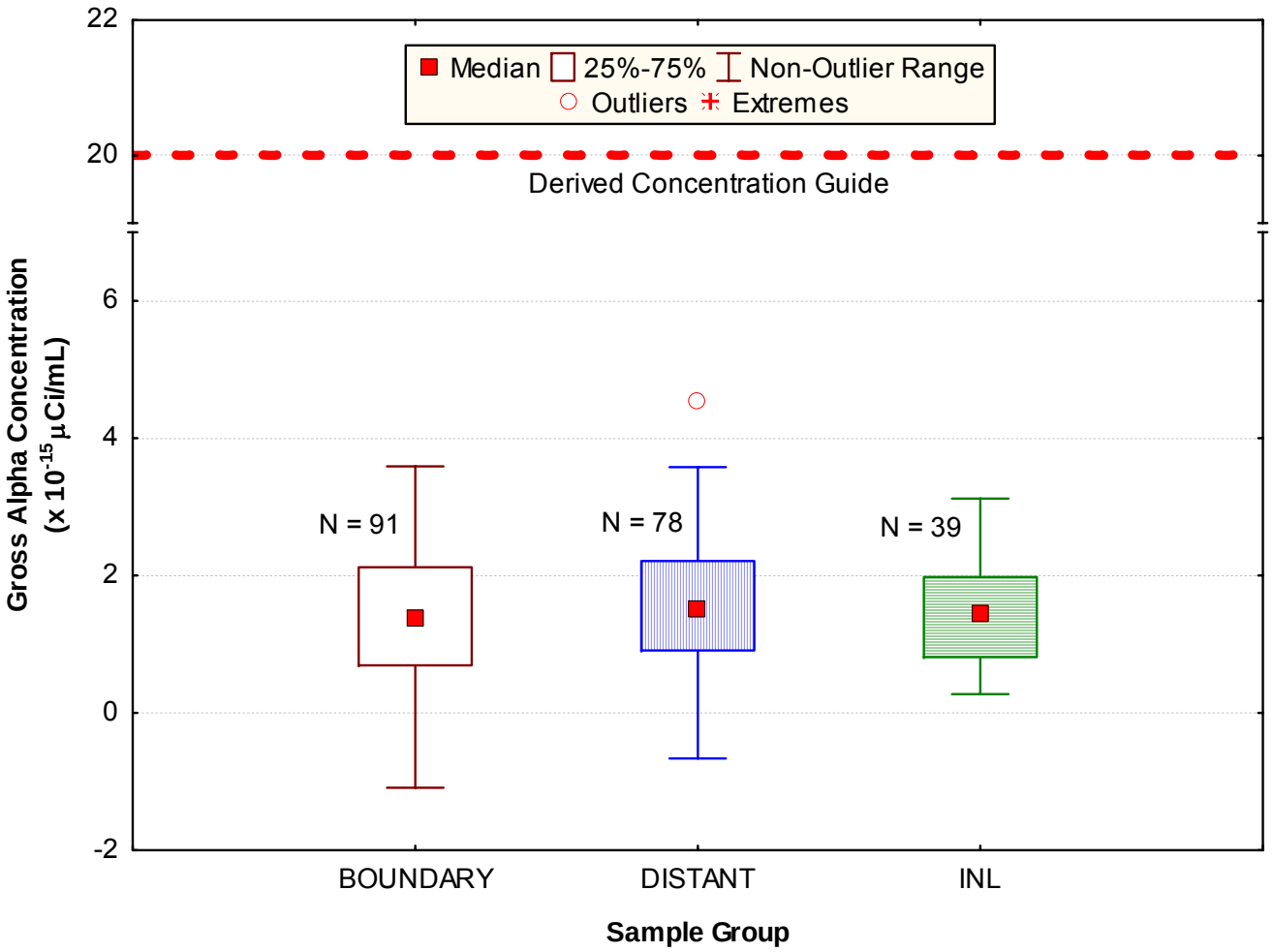

Figure 3. **Gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations for the fourth quarter of 2005.**

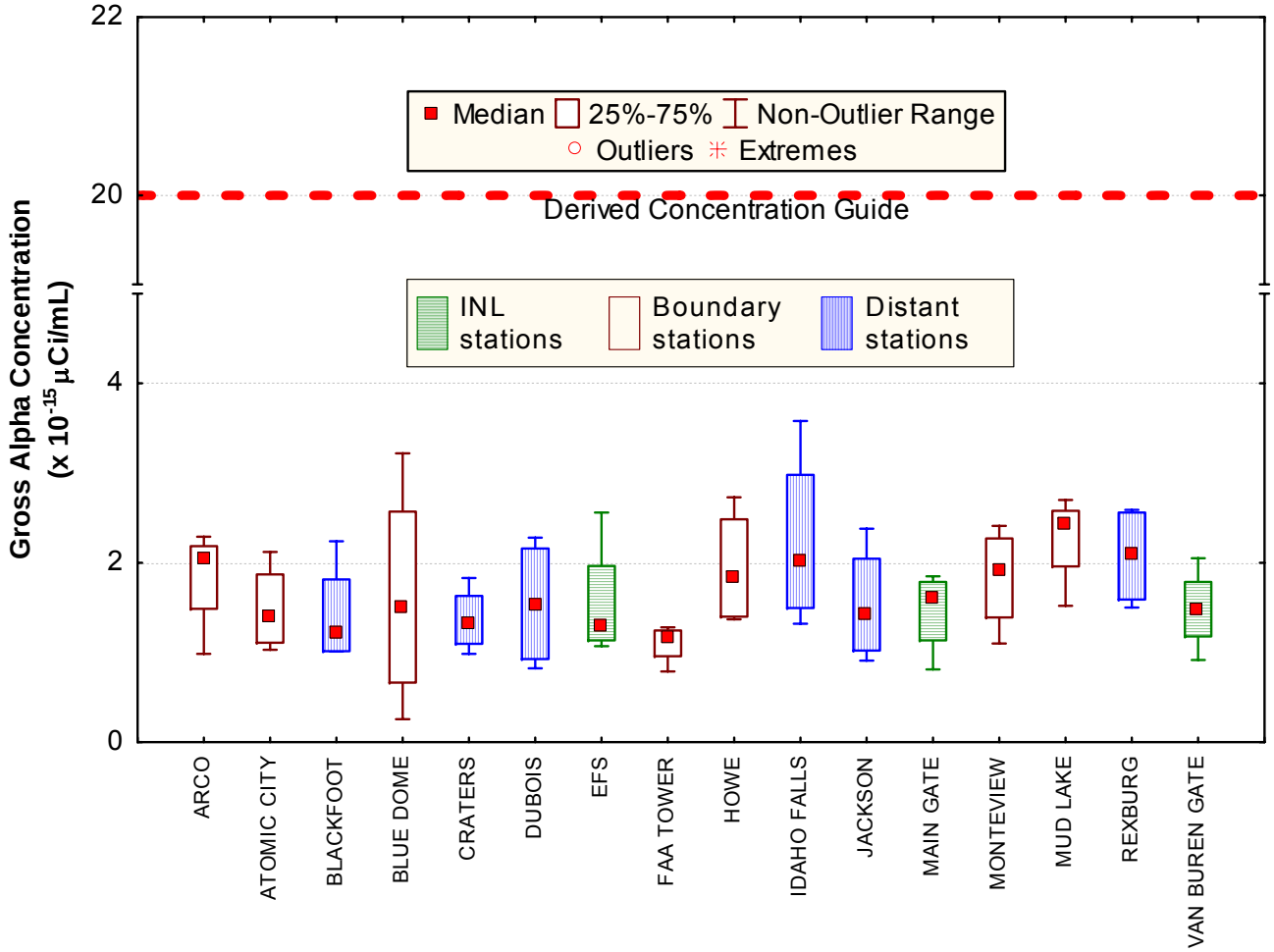

Figure 4. **October gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations. Number of samples (N) = 4 at each location.**

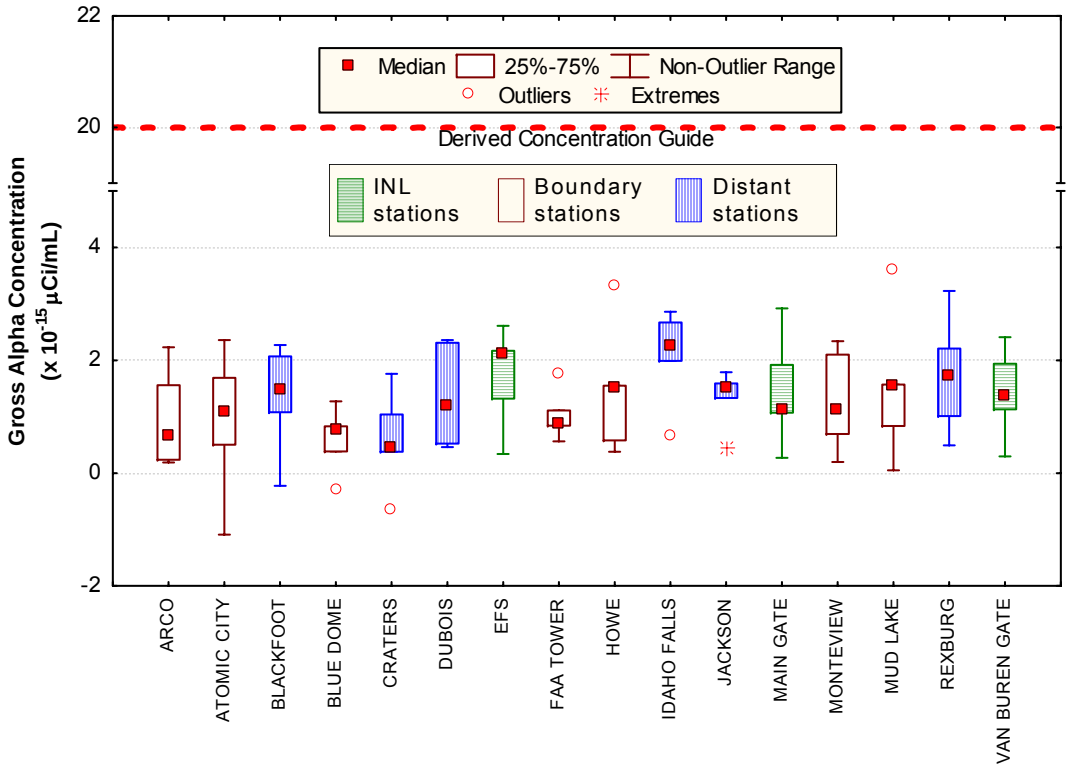

Figure 5. **November gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations. Number of samples (N) = 5 at each location.**

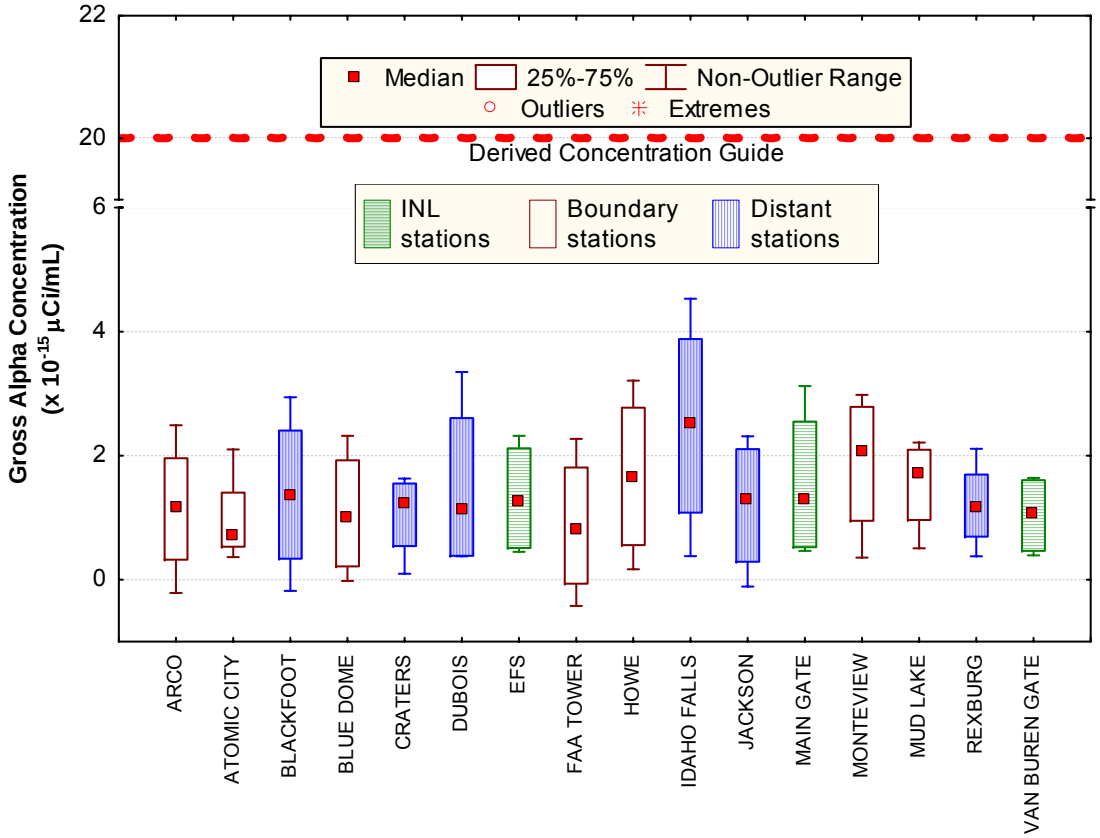

Figure 6. **December gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations. Number of samples (N) = 4 at each location.**

There were no statistical differences in gross alpha results between groups for any month during the fourth quarter (Table D-1).

As an additional check, comparisons between gross alpha concentrations measured at Boundary and Distant locations were made on a weekly basis. The Mann-Whitney U test was used to compare the Boundary and Distant data because it is the most powerful nonparametric alternative to the t-test for independent samples. INL sample results were not included in this analysis because the onsite data, collected at only three locations, are not representative of the entire INL and would not aid in determining offsite impacts. The gross alpha concentrations measured at Boundary locations were not statistically greater than those measured at Distant locations in any of the thirteen weeks of data evaluated (Table D-2).

Gross beta results are presented in Table C-1. Gross beta concentrations in air for INL, Boundary, and Distant locations for the fourth quarter of 2005 are shown in Figure 7. The data were tested and found to be neither normally nor log-normally distributed. Box and whiskers plots were used for presentation of the data. Outliers and extreme values were retained in subsequent statistical analyses because they are within the range of measurements made in the past five years, and because these values could not be attributed to mistakes in collection, analysis, or reporting procedures. As in the case of alpha activity, the quarterly data for each group appear to be similar and were determined using the Kruskal-Wallace test to be statistically the same (Table D-1).

Monthly median gross beta concentrations in air for each sampling group are shown in Figures 8 – 10. Statistical data are presented in Table D-1. There were no statistical differences in gross beta between groups for any month during the quarter (Table D-1).

Comparison of weekly Boundary and Distant data sets, using the Mann Whitney U test, only showed a statistical difference between Boundary and Distant measurements during the weeks of November 16 and December 28 (Table D-2). During these weeks, the Boundary locations were statistically higher than the Distant locations. Examination of the data indicates that gross beta concentrations were generally lower than average at all locations for these two weeks. During the week of November 16 there was a tendency for the northern stations (Howe, Mud Lake, and Monteview) to have higher gross beta concentrations than the southern stations (e.g. FAA Tower and Craters of the Moon). No particular distribution was seen for the week of December 28. An INL-related cause for the statistical difference is not indicated and it is more likely due to random variability in the data.

No ^{131}I was detected in any of the charcoal cartridge batches collected during the fourth quarter of 2005. Weekly ^{131}I results for each location are listed in Table C-2 of Appendix C. Gamma spectrographic analysis is also done with the ^{131}I analysis. Cesium-137 was detected near the detection limit in 27 of the 234 measured cartridges. The analytical laboratory considers these detections are a result of the materials used in the charcoal filters.

Weekly filters for the fourth quarter of 2005 were composited by location. All samples were analyzed for gamma-emitting radionuclides, including ^{137}Cs. Composites were also analyzed for ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. No manmade gamma-emitting radionuclides or transuranic radionuclides were detected. One composite, from the distant location of Craters of the Moon, had detectable ^{90}Sr. The measured concentration of (118 ± 15) x 10^{-18} μCi/mL is within historical measurements and well below the Derived Concentration Guide of 9,000,000 x 10^{-18} μCi/mL. All results for composite filter samples are shown in Table C-3, Appendix C.

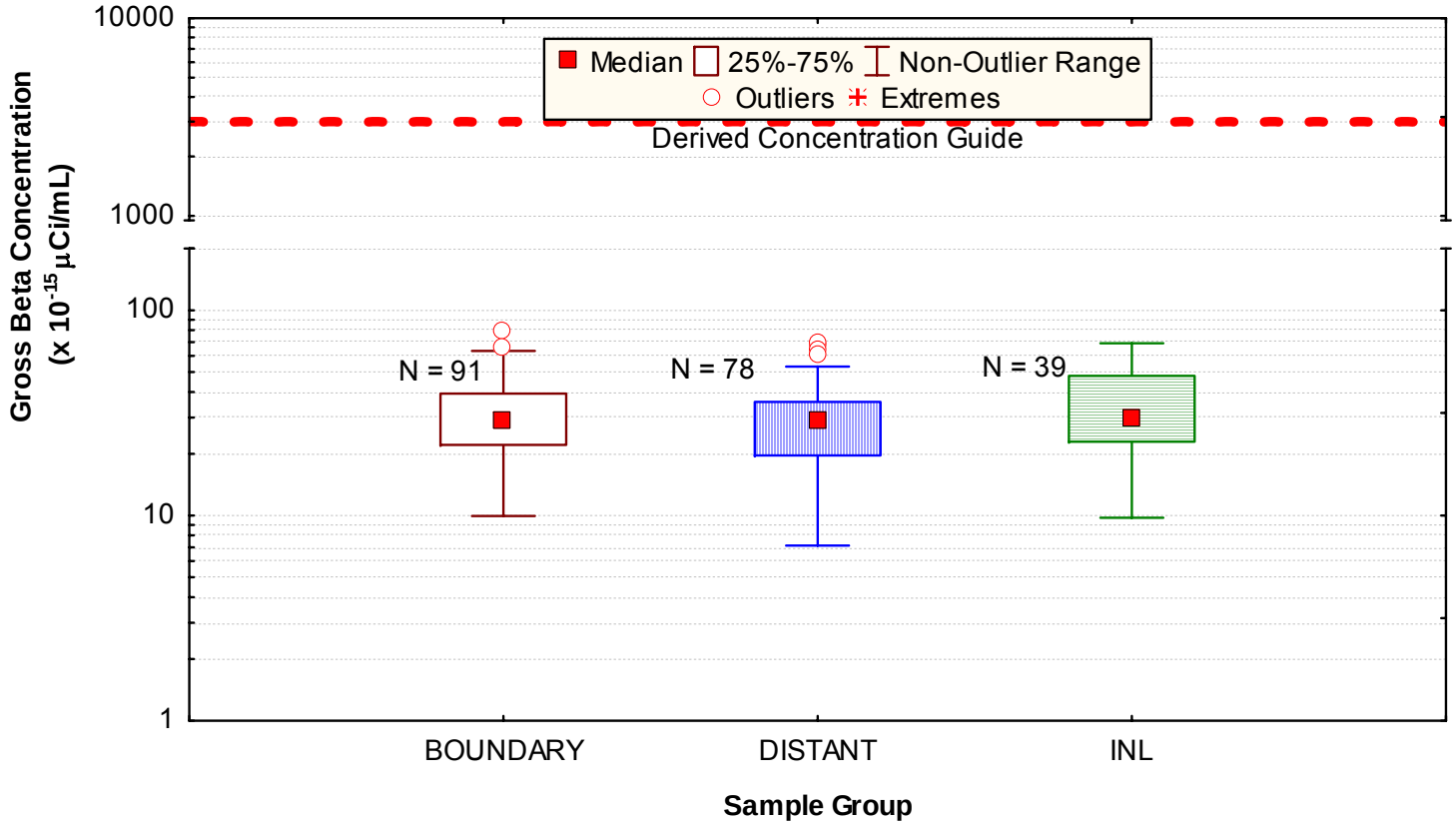

Figure 7. **Gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations for the fourth quarter 2005.**

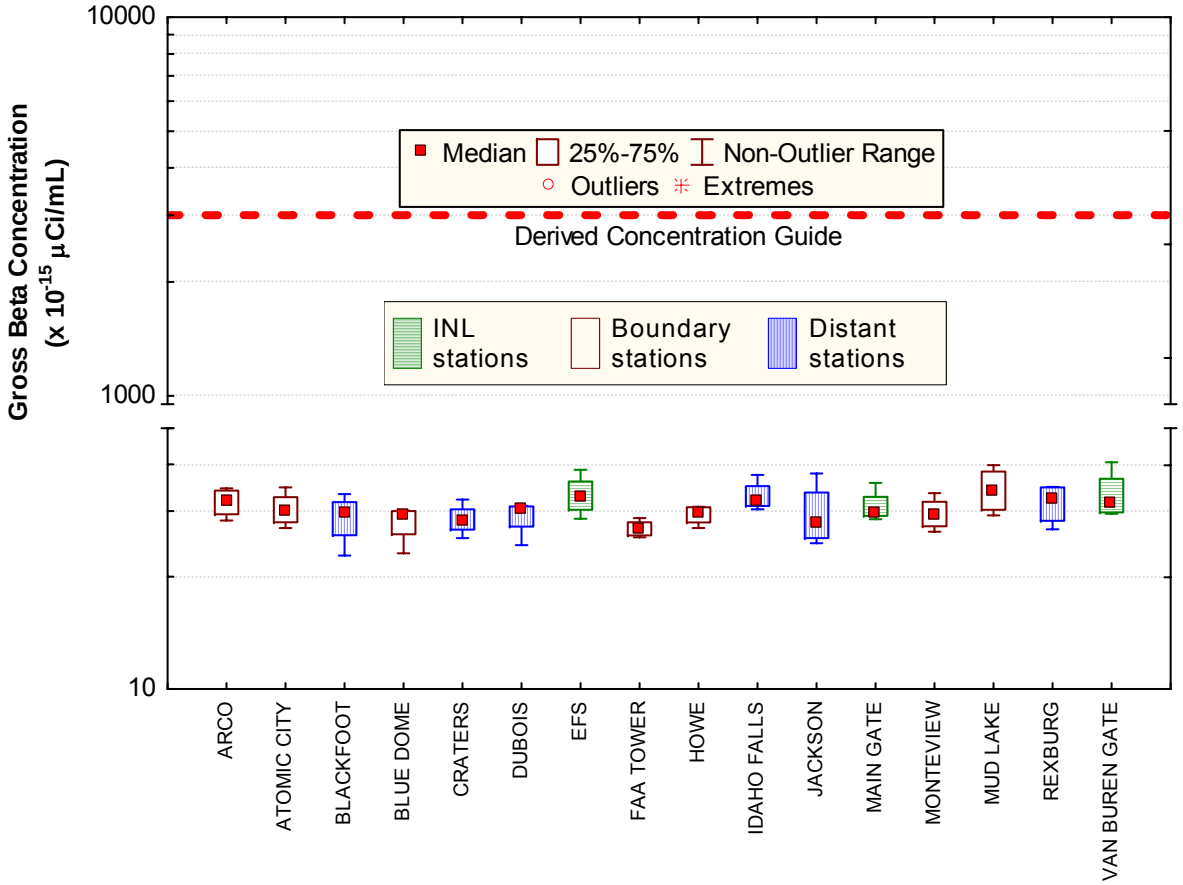

Figure 8. **October gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations. Number of samples (N) = 4 at each location.**

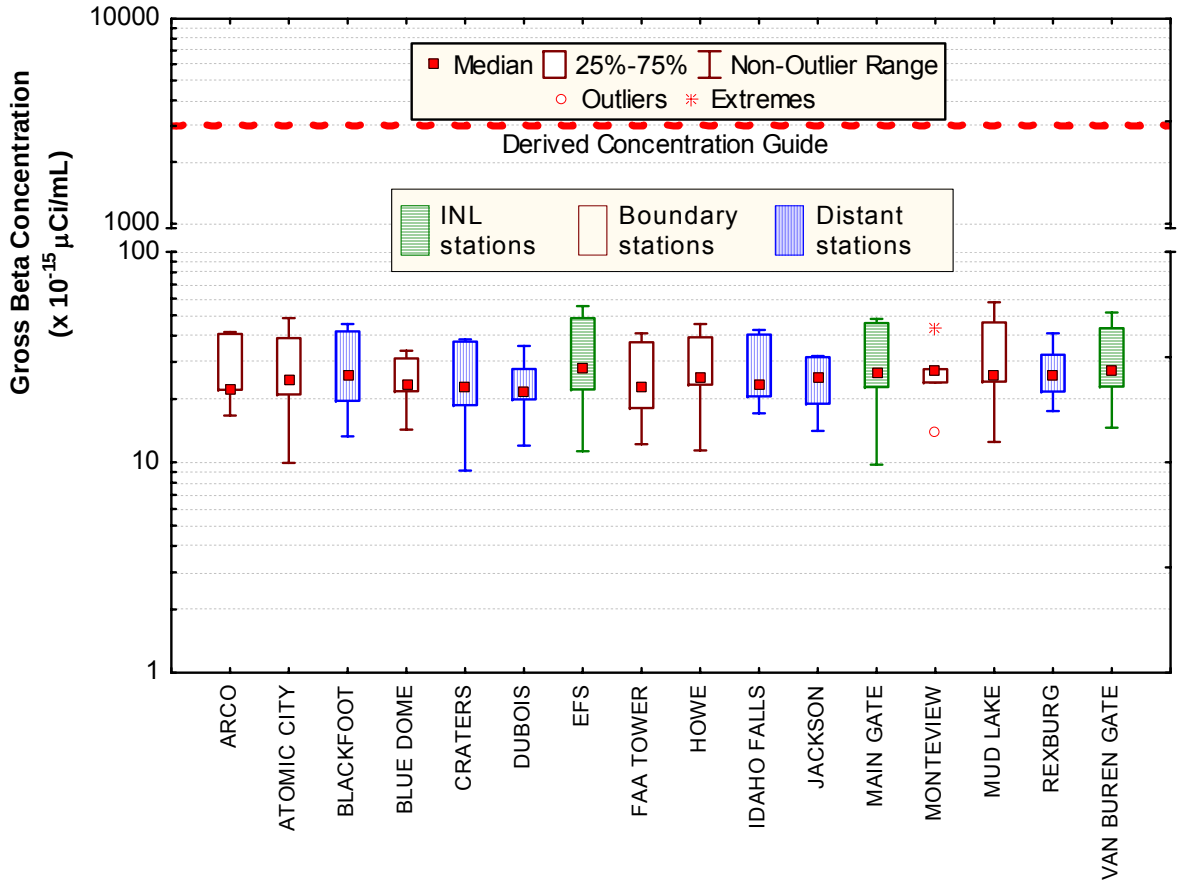

Figure 9. **November gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations. Number of samples (N) = 5 at each location.**

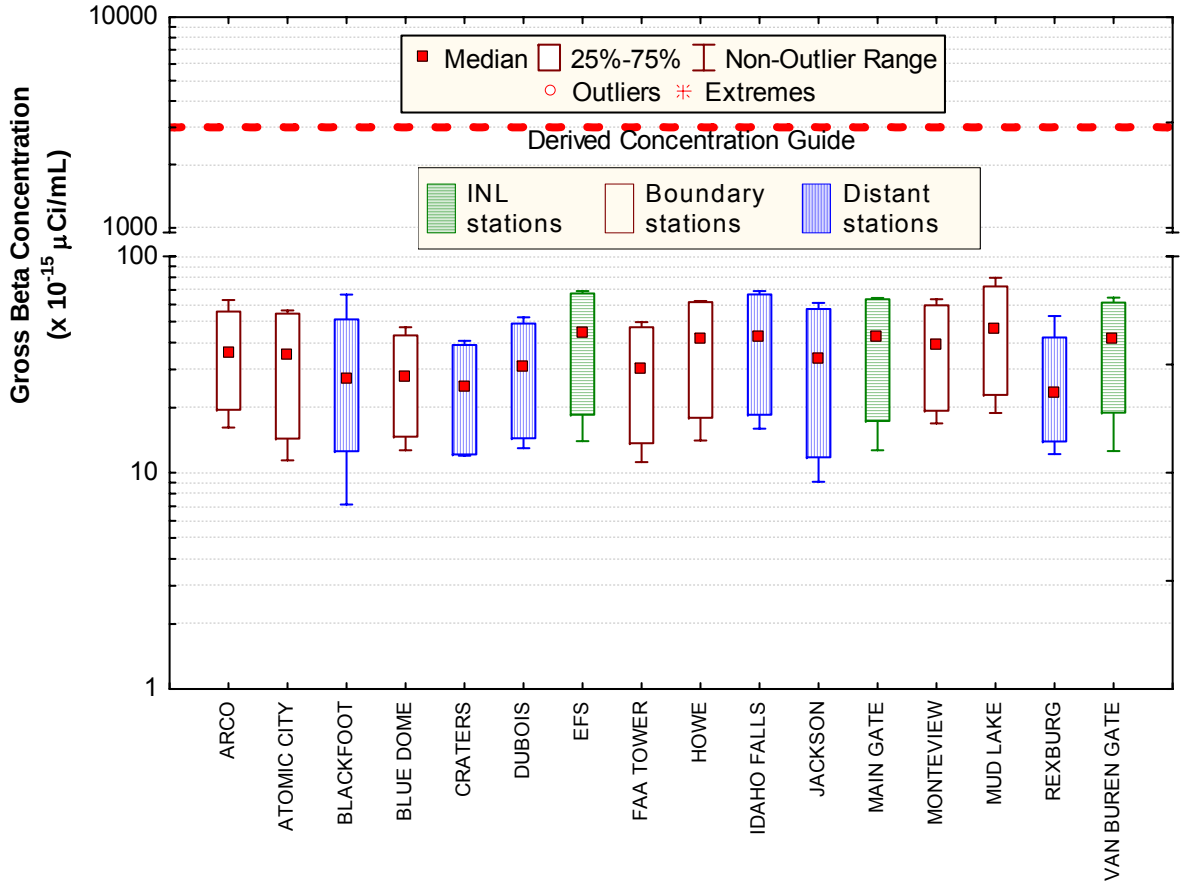

Figure 10. December gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations. Number of samples (N) = 4 at each location.

ATMOSPHERIC MOISTURE SAMPLING

Fourteen atmospheric moisture samples were obtained during the fourth quarter of 2005 from Atomic City, Blackfoot CMS, Idaho Falls, and Rexburg CMS. Atmospheric moisture is collected by pulling air through a column of absorbent material (molecular sieve material) to absorb water vapor. The water is then extracted from the absorbent material by heat distillation. The resulting water samples are then analyzed for tritium using liquid scintillation.

Five samples exceeded the 3s uncertainty level for tritium—two from Idaho Falls and one each from Atomic City, Blackfoot, and Rexburg. All samples with detectable tritium were well below the DOE DCG for tritium in air of 1×10^{-7} μCi/mL, ranging from $(4.9 \pm 1.0) \times 10^{-13}$ $\mu Ci/mL_{air}$ at Rexburg in December to $(10.1 \pm 1.7) \times 10^{-13}$ $\mu Ci/mL_{air}$, in Idaho Falls in October. All results are shown in Table C-4, Appendix C.

PM_{10} AIR SAMPLING

The EPA began using a standard for concentrations of airborne particulate matter (PM) less than 10 micrometers in diameter (PM_{10}) in 1987 (40 CFR 50.6 [CFR 2005]). Particles of this size can be inhaled deep into the lungs and are considered to be responsible for most of the adverse health effects associated with airborne particulate pollution. The air quality standards for these particulates are an annual average of 50 $\mu g/m^3$, with a maximum 24-hour concentration of 150 $\mu g/m^3$.

The ESER Program operates three PM_{10} particulate samplers, one each at the Rexburg CMS and Blackfoot CMS, and one in Atomic City. Sampling of PM_{10} is informational only as no chemical analyses are conducted for contaminants. A twenty-four hour sampling period is scheduled to run once every six days. The maximum 24-hour particulate concentration was 43.56 $\mu g/m^3$ on December 11, 2005, at Atomic City. The average, maximum, and minimum results of the 24-hour samples are shown are shown in Table 1. Results for all PM_{10} samples are listed in Table C-5, Appendix C.

Table 1. Summary of 24-hour PM_{10} values.

	Concentration[a]		
Location	**Minimum**	**Maximum**	**Average**
Atomic City	0.14	43.56	11.26
Blackfoot, CMS	0.07	34.20	12.30
Rexburg, CMS	2.87	38.12	16.19

a. All concentrations are in ($\mu g/m^3$).

4. WATER SAMPLING

The ESER program samples precipitation, surface water, and drinking water. Monthly composite precipitation samples are collected from Idaho Falls and the Central Facilities Area (CFA) on the INL. Weekly precipitation samples are collected from the Experimental Field Station (EFS) on the INL. Surface and/or drinking water are sampled twice each year at 19 locations around the INL. This occurs during the second and fourth quarters. The results of the fourth quarter sampling are reported here.

PRECIPITATION SAMPLING

Precipitation samples are gathered when sufficient precipitation occurs to allow for the collection of the minimum sample volume of approximately 20 mL. Samples are taken of monthly composites from Idaho Falls and CFA, and weekly from the EFS. Precipitation samples are analyzed for tritium. Storm events in the fourth quarter of 2005 produced sufficient precipitation to yield 12 samples – three from Idaho Falls and CFA, and six weekly samples from the EFS.

Tritium was measured above the 3s value in three of the samples collected during the fourth quarter 2005. Low levels of tritium exist in the environment at all times as a result of cosmic ray reactions with water molecules in the upper atmosphere. The EPA's RadNet program collects precipitation samples from across the United States. From 1980 to 2005 tritium measured in samples from Region 10 (which includes Idaho) ranged from -200 to 7500 pCi/L (EPA 2006). Tritium measured in fourth quarter ESER samples were within this range, with a maximum of 306 ± 31 pCi/L at EFS. Data for all fourth quarter 2005 precipitation samples collected by the ESER Program are listed in Table C-6 (Appendix C).

DRINKING WATER

Fourteen drinking water samples and one duplicate were collected from selected taps throughout southeast Idaho (Figure 11). Samples were analyzed for gross alpha, gross beta, and tritium (^{3}H).

None of the samples exceeded the 3s value for gross alpha. Eleven samples exceeded their 3s value for gross beta (Table 2). The EPA Safe Drinking Water Act (SDWA) limits gross beta in drinking water based on an annual exposure of 4 mrem/yr. Since data are reported from the laboratory as a concentration (i.e., pCi/L), a screening concentration of 50 pCi/L is used to meet this level (Appendix B-1). The maximum concentration of gross beta detected was from Fort Hall and was lower than the SDWA screening value. Levels of gross beta observed in drinking water are not unusual given the basaltic terrain (Twinning and Rattray 2003). All values are similar to those recorded in previous years, and are well below the levels outlined for drinking water protection (Table B-1). All drinking water sample results may be found in Appendix C, Table C-7.

Tritium was detected in six of the samples collected. Detectable tritium concentrations ranged from 80 ± 27 pCi/L at Shoshone to 223 ± 31 pCi/L at Idaho Falls. Both values are well below the EPA limit of 20,000 pCi/L and the DOE DCG of 2.0×10^{6} pCi/L. Tritium values were within historical data collected by the ESER and within EPA measurements made through the RadNet program in Region 10 (Alaska, Idaho, Oregon, and Washington), which ranged from -87 ± 37 pCi/L to 1402 ± 63 pCi/L in the period 2000-2005.

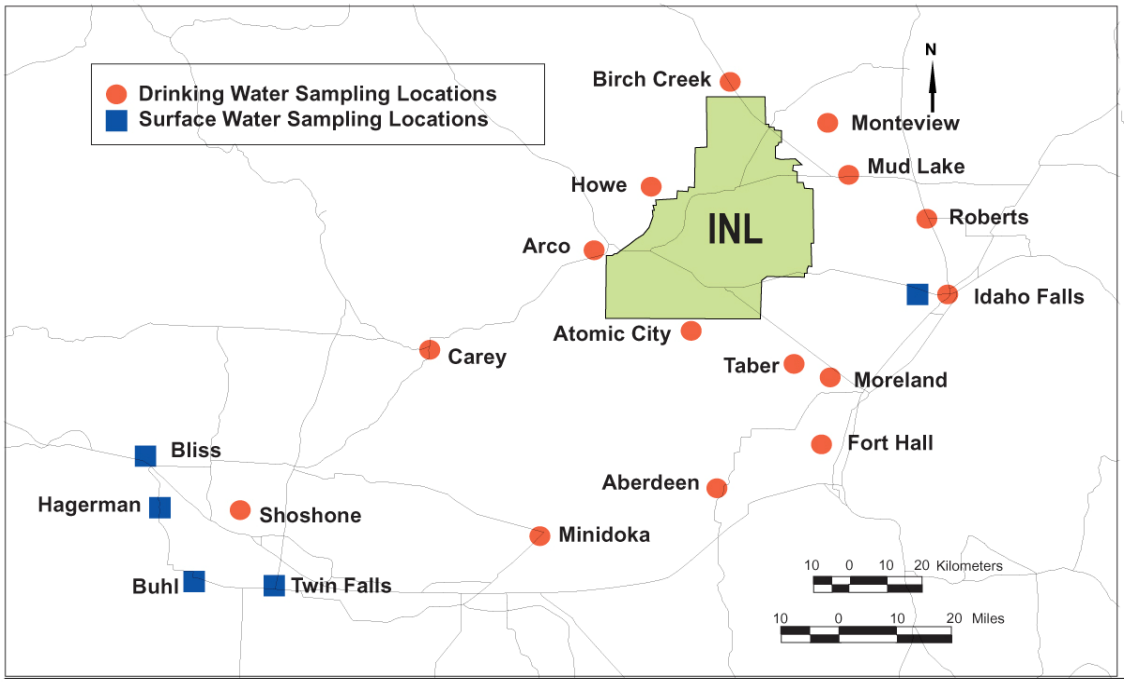

Figure 11. **Drinking and surface water sampling locations.**

Table 2. **Drinking water results greater than (>) 3s.**

Location	Sample Results[a]	Limits for Comparison[a]	
	Result ± 1s	SDWA[b]	DOE DCG[c]
Tritium			
Carey	130 ± 32	20,000	2×10^6
Fort Hall	140 ± 30	20,000	2×10^6
Idaho Falls	223 ± 31	20,000	2×10^6
Minidoka	121 ± 30	20,000	2×10^6
Moreland	121 ± 30	20,000	2×10^6
Shoshone	80 ± 27	20,000	2×10^6
Gross Beta			
Aberdeen	4.79 ± 1.01	50	100
Atomic City	3.57 ± 0.90	50	100
Carey	2.73 ± 0.89	50	100
Fort Hall	7.29 ± 1.05	50	100
Fort Hall (duplicate)	8.57 ± 1.05	50	100
Idaho Falls	2.80 ± 0.91	50	100

Monteview	5.39 ± 0.97	50	100
Moreland	3.57 ± 1.02	50	100
Mud Lake	4.94 ± 0.91	50	100
Shoshone	2.62 ± 0.86	50	100
Taber	3.33 ± 0.92	50	100

a. All values shown are in picocuries per liter (pCi/L).
b. SDWA = Safe Drinking Water Act.
c. DCG – Derived Concentration Guide.

SURFACE WATER

Five surface water samples and one duplicate sample were collected from locations throughout southeast Idaho and were analyzed for tritium, gross alpha, and gross beta. None of the samples had measurable gross alpha activity (all results were less than 3s). Tritium was detected in two of the samples (Table 3), well below the SDWA screening value and the DCG (Table B-1).

All six surface water samples were greater than their associated 3s values for gross beta (Table 3). Even at reported levels, the gross beta values are lower than the SDWA screening value of 50 pCi/L and the DCG values (Table B-1).

Table 3. Surface water results greater than (>) 3s.

		Limits for Comparison[a]	
Location	**Result ± 1s**	**SDWA**	**DOE DCG**
Tritium			
Hagerman (duplicate)	384 ± 33	20,000	2×10^6
Idaho Falls	231 ± 31	20,000	2×10^6
Gross Beta			
Bliss	7.09 ± 0.96	50	100
Buhl	4.82 ± 0.89	50	100
Hagerman	3.88 ± 0.83	50	100
Hagerman (duplicate)	4.76 ± 0.86	50	100
Idaho Falls	3.70 ± 0.82	50	100
Twin Falls	4.07 ± 1.13	50	100

a. All values shown are in picocuries per liter (pCi/L).

The presence of gross alpha and gross beta in surface water (particularly the springs) is typically related to dissolution of naturally occurring radionuclides (i.e., uranium, radium, potassium) by groundwater as it flows through the surrounding basalts (Twinning and Rattray 2003). Levels of gross alpha and gross beta in all samples are similar to results from recent years. All gross alpha, gross beta and tritium results can be found in Appendix C, Table C-7.

5. AGRICULTURAL PRODUCT AND WILDLIFE SAMPLING

Another potential pathway for contaminants to reach humans is through the food chain. The ESER Program samples multiple agricultural products and game animals from around the INL and Southeast Idaho. Specifically, milk, wheat, potatoes, garden lettuce, sheep, big game, doves, waterfowl, and marmots are sampled. Milk is sampled throughout the year and large game animals are sampled whenever available. Sheep are sampled during the second quarter. Lettuce, wheat and waterfowl are sampled during the third quarter, while potatoes are collected during the fourth quarter. See Table A-1, Appendix A, for more details on agricultural product and wildlife sampling. This section discusses results from milk, potatoes, and large game animals sampled during the fourth quarter of 2005.

MILK SAMPLING

Milk samples were collected weekly in Idaho Falls at Reed's Dairy and monthly at eight other locations around the INL (Figure 12) during the fourth quarter of 2005. Near the end of the quarter, a new weekly sampling location was selected north of Idaho Falls in Ucon. All samples were analyzed for gamma emitting radionuclides. Samples are analyzed for ^{90}Sr and tritium during the second and fourth quarters.

No manmade gamma-emitting radionuclides were detected in any of the samples for the fourth quarter. Data for ^{131}I and ^{137}Cs in milk samples are listed in Appendix C, Table C-8.

None of the fourth quarter samples contained tritium above the detection limit. Strontium-90 was measured above the 3s uncertainty level in three of four samples analyzed. Strontium-90 is related to uptake through the food chain of historical weapons derived fallout. The maximum level of ^{90}Sr in milk measured in the Dietrich sample (0.66 ± 0.07 pCi/L) was below the EPA MCL of 8 pCi/L and the DOE DCG of 1000 pCi/L. Data for tritium and ^{90}Sr in milk samples are listed in Appendix C, Table C-9.

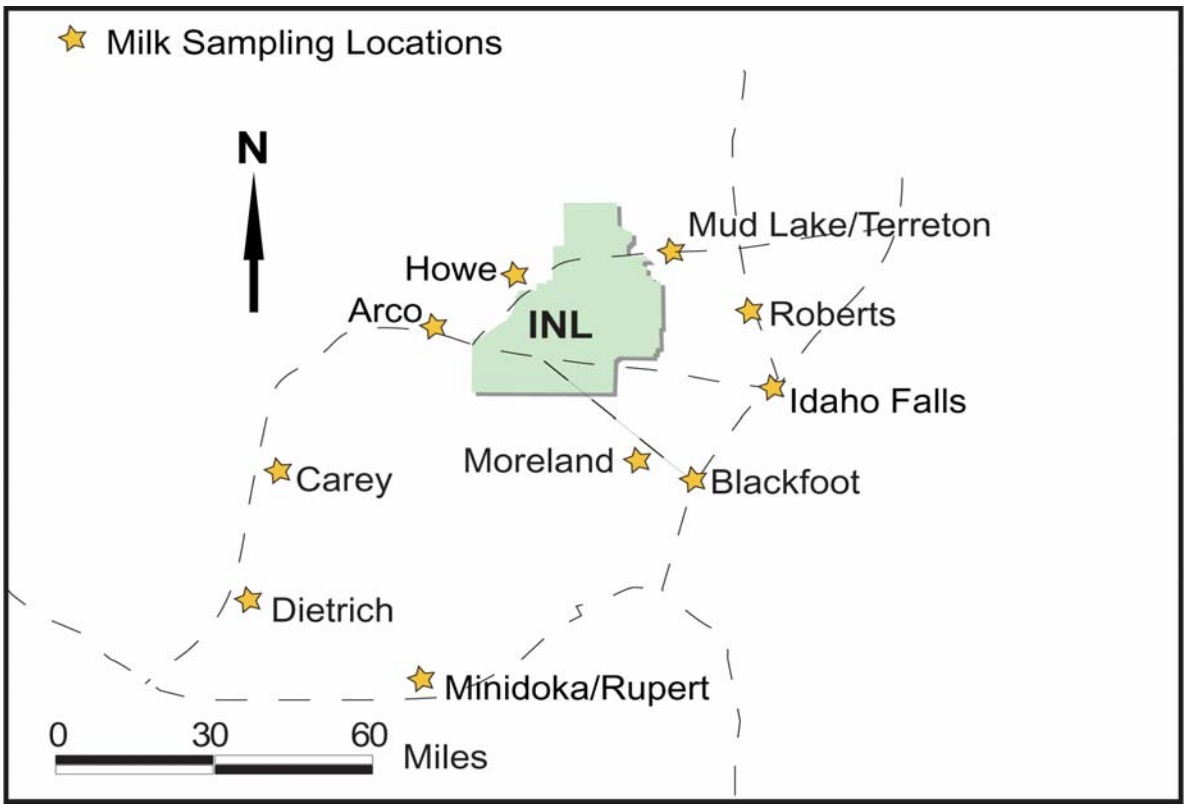

Figure 12. ESER Program milk sampling locations.

POTATOES

Eleven potato samples were collected from area growers and from one out-of-state location. All samples were analyzed for gamma emitting radionuclides and ^{90}Sr. The first analysis for ^{90}Sr failed; sufficient sample remained to re-analyze eight of the samples. No ^{137}Cs was measured in any sample. Strontium-90 was detected in three of the samples above their respective 3s values. The maximum concentration of ^{90}Sr was from a sample collected from Arco at 1.05 ± 0.21 pCi/kg. This value is within historic concentrations measured in potatoes collected from farms surrounding the INL.

Data for ^{137}Cs and ^{90}Sr in all potato samples taken during the fourth quarter are listed in Table C -10 (Appendix C).

LARGE GAME ANIMAL SAMPLING

Two large game animals were sampled during the fourth quarter of 2005. Both (one mule deer and one pronghorn) were killed in the north central portion of the INL in the vicinity of the Naval Reactors Facility. Cesium-137 was detected in the muscle tissue of the pronghorn at a concentration similar to those found in both onsite and offsite game and sheep samples in recent years. Data for ^{137}Cs and ^{131}I in fourth quarter large game samples are listed in Appendix C, Table C-11.

6. ENVIRONMENTAL RADIATION

An array of thermoluminescent dosimeters (TLDs) is distributed throughout the Eastern Snake River Plain to monitor for environmental radiation (Figure 13). TLDs are changed out in May and again in November after six months in the field. The results of the fall sampling of TLDs exposed from May to November 2005 are discussed below.

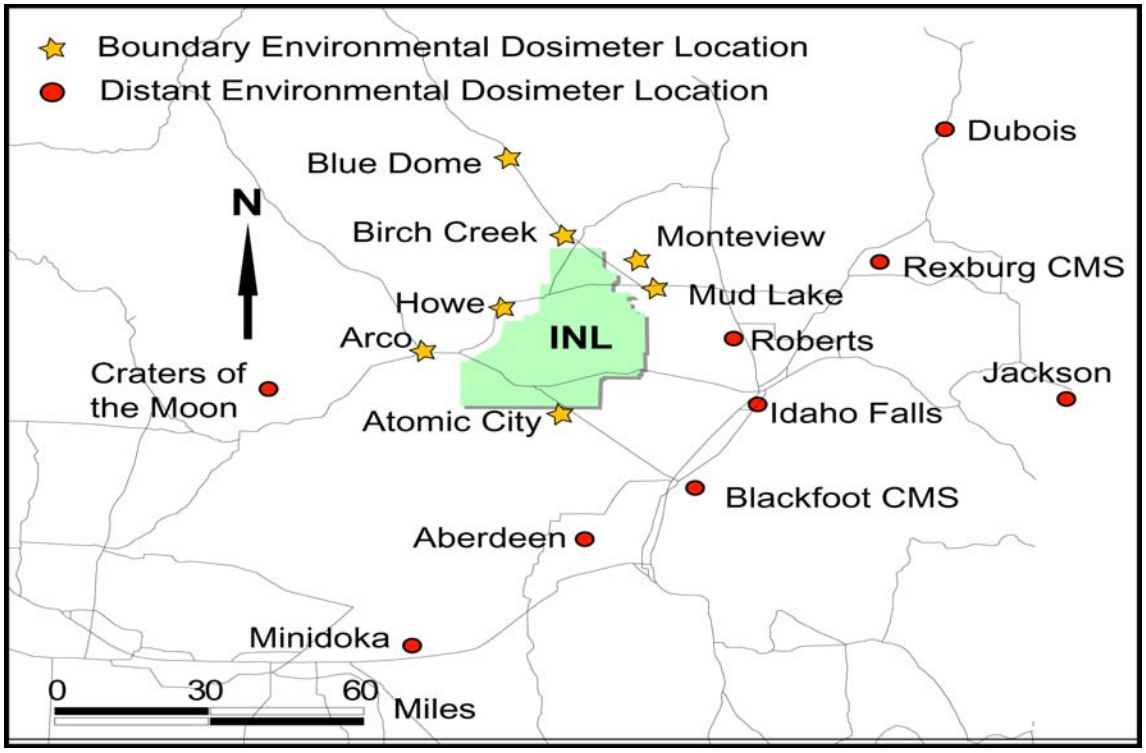

Figure 13. TLD sampling locations.

Similar to the low-volume air results the environmental dosimeter locations are also divided into Boundary and Distant groupings. Boundary average exposure rates ranged from a low of 0.29 mR/day at Birch Creek and Blue Dome to a high of 0.37 mR/day at Arco. The overall Boundary average was 0.33 mR/day. The Distant group had a high of 0.40 mR/day at Rexburg and a low of 0.29 mR/day at the Dubois location. The overall average Distant value was also 0.33 mR/day. There was no statistical difference between Boundary and Distant locations. In addition, all values are consistent with past readings. Table 4 lists the range and average for both groups over a six-month period. All results are listed in Appendix C, Table C-12.

Table 4. TLD Exposures from May 2005 to November 2005.

	Total Exposure[a]	
Location	**Boundary**	**Distant**
Average	59.9	61.1
Maximum	67.1	75.1
Minimum	52.5	53.3

a All values shown are in milliRoentgens (mR).

7. QUALITY ASSURANCE

The ESER Quality Assurance Program consists of five ongoing tasks which measure:

1. method uncertainty;
2. data completeness;
3. data accuracy, using spike, performance evaluation, and laboratory control samples;
4. data precision, using split samples, duplicate samples, and recounts; and
5. presence of contamination in samples, using blanks.

The following discussion briefly summarizes the results of the quality assurance program for the period from October 1 to December 31, 2005.

METHOD UNCERTAINTY

The Quality Assurance Project Plan (QAPP) establishes data quality and method quality objectives for the ESER surveillance program (Stoller 2002). Since the primary concern is with detection, the lower bound for the method uncertainty is set at zero. The upper bound is defined by the ESER program as the maximum concentration for the range of data over the past ten years, excepting those values determined to be extremes using box plots generated by a statistical data program. Each individual result is checked for acceptance on the basis of the result, whether it is below the lower limit (i.e., a negative value), greater than the upper limit, or between the lower and upper limit (the most common occurrence). The calculated method uncertainty is then compared to the 1s measured uncertainty. A sample is deemed acceptable when the measured 1s uncertainty is less than the calculated uncertainty. The upper bound values were recently re-evaluated and revised. Preliminary results indicate that more calculated method uncertainties for detected results were acceptable. In the fourth quarter of 2005, approximately 97 percent of method uncertainties were in the acceptable categories.

DATA COMPLETENESS

The Quality Assurance Project Plan (QAPP) specifies a 98 percent completeness goal for all regularly scheduled sample types (Stoller 2002). Data completeness for sample collection and delivery was 100 percent during the fourth quarter for all sample types with these exceptions: a number of precipitation samples were not collected due to lack of precipitation. All of the 45 scheduled PM_{10} samples were collected; however, one ran from noon to noon instead of midnight to midnight due to a motor change out.

The first analysis for ^{90}Sr in potatoes failed. Sufficient sample was left to resubmit potatoes from eight of the ten sampling locations.

Americium-241 yields for all fourth quarter quarterly composite samples were low. Further discussion is provided in the Other QA Problems Noted section.

DATA ACCURACY

Accuracy is a measure of the degree to which a measured value agrees with the "true" value for a given parameter; accuracy includes elements of both bias and precision.

Spike Samples Submitted with Field Samples

During the fourth quarter of 2005, spikes (samples prepared with known amounts of radionuclides) of the following types were obtained and submitted:

- Milk spike analyzed for Iodine-131 by ISU.
- Precipitation spike analyzed for tritium by ISU.
- Milk spike analyzed for Strontium-90 by Teledyne Brown.

All parameters measured were within the criteria specified in the Quality Assurance Project Plan.

Performance Evaluation Samples

The QAP program was discontinued following the March 2004 distribution. Performance evaluation samples are now prepared through the Mixed Analyte Performance Evaluation Program (MAPEP), administered by the Department of Energy's Radiological and Environmental Sciences Laboratory. DOE has mandated that all laboratories performing analyses in support of the Office of Environmental Management shall participate in MAPEP. The program distributes samples of air, water, vegetation and soil for analysis in approximately January and June. Both radiological and nonradiological constituents are included in the program.

Both the Idaho State University EAL and Teledyne Brown Engineering participated in the MAPEP Study reported in November 2005. Results are tabulated below for those analyses performed by each laboratory. (A = Acceptable, W = Acceptable with warning, N = Not acceptable)

Idaho State University Environmental Assessment Laboratory					
Matrix: Air (Bq)					
Analyte	EAL Result	MAPEP Result	Bias (percent)	Acceptable Range	Evaluation
Cesium-134	3.50	3.85	-9.1	2.69-5.01	A
Cesium-137	3.20	3.23	-0.9	2.26-4.20	A
Cobalt-57	6.10	6.20	-1.6	4.34-8.06	A
Cobalt-60	2.80	2.85	-1.8	1.99-3.70	A
Manganese-54	4.20	4.37	-3.9	3.06-5.68	A
Zinc-65	4.40	4.33	1.6	3.03-5.63	A
Gross alpha	0.240	0.482	-50.2	-0.17-0.80	A
Gross beta	0.980	0.827	18.5	0.55-1.22	A
Matrix: Water (Bq/L)					
Cesium-134	148.7	167.0	-11.0	116.9-217.1	A
Cesium-137	326.2	333.0	-2.0	233.1-432.9	A
Cobalt-57	274.5	272.0	0.9	190.4-353.6	A
Cobalt-60	269.2	261.0	3.1	182.7-339.3	A
Tritium	505.8	527.0	-4.0	368.9-685.1	A
Manganese-54	420.6	418.0	0.6	292.6-543.4	A
Zinc-65	361.0	330.0	9.4	231.0-429.0	A
Gross alpha	0.43	0.79	-45.6	0.21-1.38	A
Gross beta	1.56	1.35	15.6	0.85-1.92	A
Matrix: Soil (Bq/kg)					
Cesium-134	490.8	568.0	-13.6	397.6-738.4	A

Cesium-137	413.4	439.0	-5.8	307.3-570.7	A
Cobalt-57	473.0	524.0	-9.7	366.8-681.2	A
Cobalt-60	277.7	287.0	-3.2	200.9-373.1	A
Manganese-54	426.7	439.0	-2.8	307.3-570.7	A
Potassium-40	525.7	604.0	-13.0	422.8-785.2	A
Zinc-65	804.7	823.0	-2.2	576.1-1069.9	A

TELEDYNE BROWN ENGINEERING					
Matrix: Air (Bq)					
Analyte	TBE Result	MAPEP Result	Bias (percent)	Acceptable Range	Evaluation
Americium-241	0.155	0.158	-1.9	0.11-0.21	A
Cesium-134	4.11	3.85	6.8	2.69-5.01	A
Cesium-137	3.16	3.23	-2.2	2.26-4.20	A
Cobalt-57	6.14	6.20	-1.0	4.34-8.06	A
Cobalt-60	2.86	2.85	0.4	1.99-3.70	A
Manganese-54	4.54	4.37	3.9	3.06-5.68	A
Plutonium-238	0.1150	0.0969	18.7	0.07-0.13	A
Plutonium-239/240	0.1020	0.0898	13.6	0.06-0.12	A
Strontium-90	2.12	2.25	-5.8	1.58-2.92	A
Uranium-234/233	0.294	0.273	7.7	0.19-0.35	A
Uranium-238	0.293	0.283	3.5	0.20-0.37	A
Zinc-65	4.28	4.33	-1.2	3.03-5.63	A
Gross Alpha	0.304	0.482	-36.9	-0.17-0.80	A
Gross Beta	0.858	0.827	3.7	0.55-1.22	A
Matrix: Water (Bq/L)					
Americium-241	2.24	2.23	0.4	1.56-2.90	A
Cesium-134	142	167	-15.0	116.9-217.1	A
Cesium-137	302	333	-9.3	233.1-432.9	A
Cobalt-57	251	272	-7.7	190.4-353.6	A
Cobalt-60	243	261	-6.9	182.7-339.3	A
Tritium	547	527	3.8	368.9-685.1	A
Iron-55	194	196	-1.0	137.2-254.8	A
Manganese-54	383	418	-8.4	292.6-543.4	A
Plutonium-238	1.74	1.67	4.2	1.34-2.48	A
Plutonium-239/240	2.46	2.45	0.4	1.92-3.58	A
Strontium-90	8.75	8.98	-2.6	6.29-11.67	A
Technetium-99	63.6	66.5	-4.4	46.55-86.45	A
Uranium-234/233	4.23	4.10	3.2	2.87-5.33	A
Uranium-238	4.22	4.26	-0.9	2.98-5.54	A
Zinc-65	324	330	-1.8	231.0-429.0	A
Gross Alpha	0.858	0.790	8.6	0.21-1.38	A
Gross Beta	1.22	1.35	-9.6	0.85-1.92	A
Matrix: Soil (Bq/kg)					
Americium-241	68.0	81.1	-16.2	56.77-105.43	A
Cesium-134	494	568	-13.0	397.6-738.4	A
Cesium-137	446	439	1.6	307.3-570.7	A
Cobalt-57	506	524	-3.4	366.8-681.2	A

Cobalt-60	289	287	0.7	200.9-373.1	A
Manganese-54	460	439	4.8	307.3-570.7	A
Nickel-63	302	445	-32.1	311.5-578.5	N
Plutonium-238	36.5	60.8	-40.0	42.56-79.04	N
Plutonium-239/240	0.250	--[a]			A
Potassium-40	626	604	3.6	422.8-785.2	A
Strontium-90	571	757	-24.6	529.9-984.1	W
Technetium-99	279	315	-11.4	220.5-409.5	A
Uranium-234/233	57.0	52.5	8.6	36.75-68.25	A
Uranium-238	173	168	3.0	117.6-218.4	A
Zinc-65	889	823	8.0	576.1-1069.9	A
Matrix: Vegetation (Bq)					
Americium-241	0.193	0.230	-16.1	0.16-0.30	A
Cesium-134	4.35	4.09	6.4	2.86-5.32	A
Cesium-137	5.99	5.43	10.3	3.80-7.06	A
Cobalt-57	17.0	13.3	27.8	9.31-17.29	W
Cobalt-60	4.87	4.43	9.9	3.10-5.76	A
Manganese-54	7.40	6.57	12.6	4.60-8.54	A
Plutonium-238	0.0078	--[b]			A
Plutonium-239/240	0.106	0.164	-35.4	0.11-0.21	N
Strontium-90	2.03	2.42	-16.1	1.69-3.15	A
Uranium-234/233	0.320	0.333	-3.9	0.23-0.43	A
Uranium-238	0.311	0.346	-10.1	0.24-0.45	A
Zinc-65	11.8	10.2	15.7	7.14-13.26	A
a. Result was a statistical nondetect.					
b. False positive test.					

Internal Laboratory Spikes

The Idaho State University Environmental Assessment Laboratory uses NIST standards to prepare spiked water samples and uses commercially prepared calibration standards as NIST-traceable spiked samples. ISU considers a performance to be acceptable if results pass either the ±20 percent test specified by the ESER program or the three-sigma test described in the data precision section. A variety of checks are made each quarter on different geometries.

During the fourth quarter of 2005, 20 analyses were conducted on NIST-traceable standards for gamma-emitting radionuclides. Geometries tested included low-volume air filter composites, single charcoal cartridge screening, 500 ml 0.8 g/cc samples, 500 ml 1.0 g/cc samples, and 1 L 1.0 g/cc samples. A total of 127analytical results were generated. There were eight results outside the ±20 percent range. Of these, four results for Te-123m and three results for Sn-113 were within the three-sigma test criterion. One result for Y-88 was outside both criteria. This radionuclide had decayed for approximately 8.5 half-lives, and probably has an activity below detectable levels.

Water samples spiked with tritium received six analyses during the quarterly reporting period. All were well within the ±20 percent criterion, ranging from -4 percent to -9 percent. Gross beta spikes analyzed in the fourth quarter were within 20 percent of the expected values; three of four gross alpha spikes were within 20 percent; the one sample outside this range was within the 3σ criterion. A tritium in milk spike was within 0.5 percent of the expected value.

Teledyne Brown analyzed a laboratory control sample (LCS) with each batch of samples submitted by the ESER. During the fourth quarter this consisted of strontium-90 and actinides in air, and strontium-90 in milk and potatoes.

Media	Analyte	QAPjP Accuracy	LCS Result	Within Criterion?
Air	Strontium-90	±10 percent	+9.1 percent	Yes
Air	Americium-241	±10 percent	-10.6 percent	No
Air	Plutonium-239/240	±10 percent	+2.2 percent	Yes
Milk	Strontium-90	±25 percent	+10.6 percent	Yes
Potatoes	Strontium-90	±25 percent	-8.4 percent	Yes

DATA PRECISION

Data precision is a measure of the variability associated with a measurement system. Precision is measured using duplicate samples, split samples, and recounts. Data precision is measured using duplicate samples, split samples, and recounts. The Quality Assurance Project Plan specifies that sample results should agree within ±20 percent or 3σ, whichever is greater. For environmental samples at levels that are within the normal range found by the ESER, the 3 standard deviation criterion is the one that applies in nearly all cases. The standard deviation criterion is considered to be met if the values of the duplicate samples differ by less than the root mean square of three standard deviations of each sample result. Mathematically, this is expressed as:

$|X-Y| < 3\,(\mathrm{sqrt}(\sigma_x^2 + \sigma_y^2))$, where:

X is the result of the regular sample

Y is the result of the duplicate sample

σ_x is the uncertainty of the regular sample

σ_y is the uncertainty of the duplicate sample

Another measure of duplicate sample results is the relative percent difference. This value is the difference in the two results divided by the mean of the two results.

Field Duplicate Samples

Duplicate milk samples were collected from Moreland and Roberts on December 6 and analyzed for gamma-emitting radionuclides. All results were within the 3σ criteria. Results also met the acceptability criteria for gamma-emitting radionuclides in a duplicate potato sample from Aberdeen.

A duplicate drinking water sample was obtained from Fort Hall and a duplicate surface water sample was collected from Hagerman. These were analyzed for gross alpha, gross beta and tritium. The tritium result for the surface water sample was outside the 3σ criterion. All other results met the acceptability criteria.

Duplicate air samplers are operated at two locations adjacent to regular air samplers. In the fourth quarter of 2005 these samplers, designated as QA-1 and QA-2, were in operation at the INL Main Gate and Howe, respectively. Particulate filters receive the standard analysis for gross alpha and gross beta; charcoal cartridges are analyzed specifically for iodine-131. All gross alpha and gross beta results for the co-located samplers met the acceptability criteria.

Charcoal cartridge results are difficult to present because cartridges are counted in batches of ten.

Composite air samples from the two QA samplers were submitted for analysis at the end of the fourth quarter for gamma spectrometry at the EAL and for ^{90}Sr and transuranics at Teledyne Brown. All of these result met the acceptability criteria in the fourth quarter.

A comparison of duplicate results can also show bias in the sampling system. For example, if one set of results is consistently lower or higher than the other one might suspect that this bias was due to a leak in the system or variations in the calibration of the flow meter. Figures 14 and 15 show the difference in results (Main sampler - QA duplicate sampler) over time. The figures show that the bias is generally small and is usually not consistent in one direction. However, the graph for the Howe/QA-2 gross beta comparison during the fourth quarter seems to indicate a bias where the duplicate sampler trends higher than the regular sampler. Further data evaluation is needed to determine whether this trend has continued or whether it is a statistical anomaly.

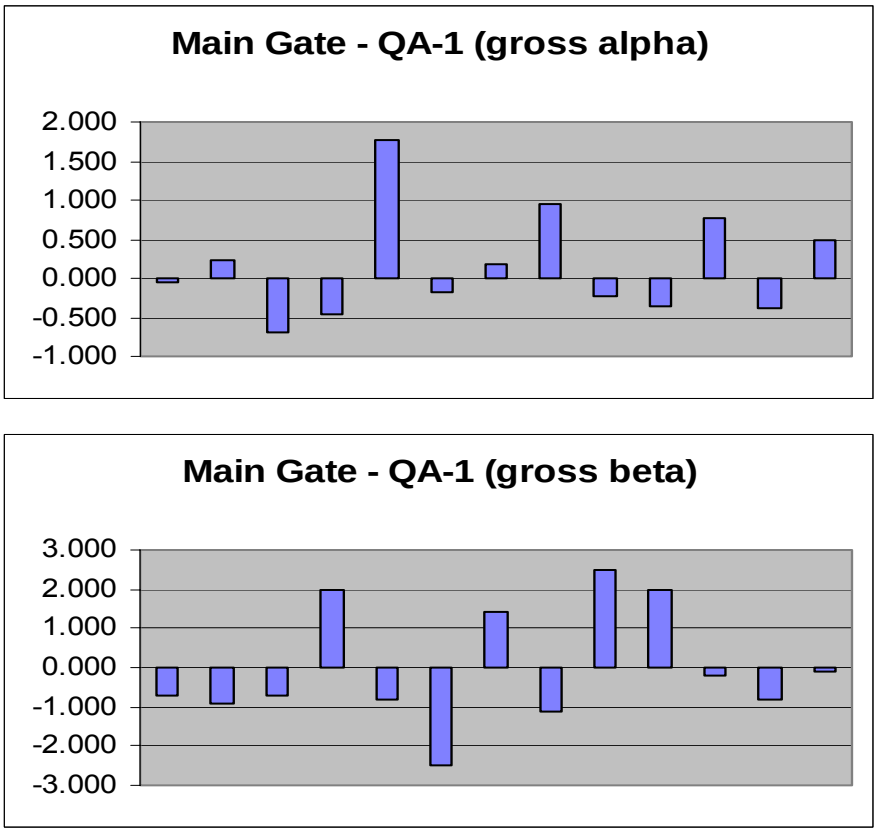

Figure 14. Difference in Main Gate/QA-1 gross alpha and gross beta activities.

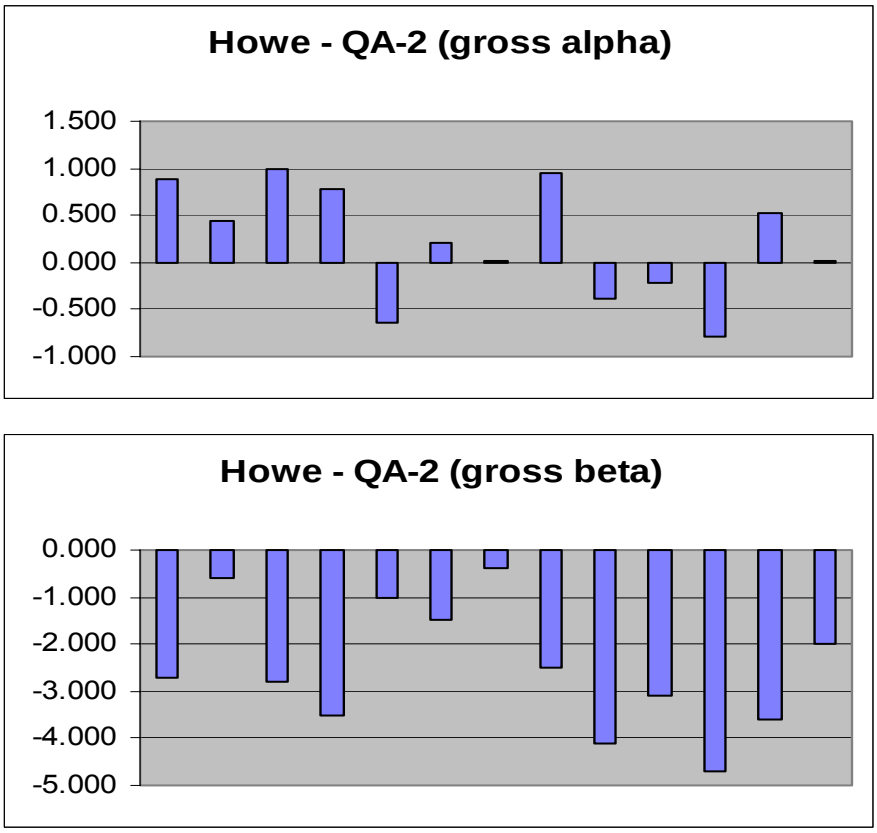

Figure 15. Difference in Howe/QA-2 gross alpha and gross beta activities.

Lab Split Samples

The EAL splits and analyzes a number of milk, precipitation, and atmospheric moisture samples each quarter. The laboratory tests each result using both the ±20 percent criterion and the 3s criterion, although it considers the former test meaningless for analyses producing fewer than 15 total counts and questionable even where counts are on the order of 100. The latter criterion is applied in nearly all cases at the levels seen in environmental samples analyzed for the ESER program. Results of the EAL split sample analyses met the criteria for acceptance during the fourth quarter 2005.

Sample Recounts

The ISU EAL recounts a number of samples of each media type. The lab tests each recount using both the 20 percent criterion and the 3σ criterion, subject to the limitations described in the previous section. For the fourth quarter reporting period, all 199 recounts met the criteria for acceptance.

BLANKS

Field blanks

The ESER program submits field blanks along with the regular samples to test for the introduction of contamination during the process of field collection, laboratory preparation, and laboratory analysis. The current program includes the use of two field blanks, designated as Blank A and Blank B, that each accompanies one of the air filter routes. Quarterly composites

of the blanks are also submitted. After gamma spectrometry analysis, one of the blanks is analyzed for Sr-90 and the other for transuranics. Blanks are also submitted for milk and some other sample types.

Ideally blank results should be within ±2σ of zero and preferably within ±1σ of zero on most analyses. It would be expected, based on counting statistics for a sample that was truly a blank (i.e., the true value of the analyte was zero), that 68.3 percent of analyses would fall within one standard deviation, 95.5 percent would fall within two standard deviations, and 99.7 percent would fall within three standard deviations. In the fourth quarter, all results were within the 3σ significance level except for one gross alpha blank.

Reagent Blanks

The Environmental Assessment Laboratory prepares and analyzes reagent blanks to help determine if the analysis will yield a zero result when no activity is present. ISU considers the result within specification if the concentration is less than the minimum detectable concentration (MDC) for the analysis. One such blank was analyzed for tritium in the fourth quarter for milk. The blank was below the MDC for the analysis and less than two standard deviations. Two water reagent blanks were analyzed for tritium and were also within two standard deviations.

Teledyne Brown analyzes a blank with each set of results. All blanks for fourth quarter samples met Teledyne Brown's acceptance limits.

OTHER QA PROBLEMS NOTED

Teledyne Brown Engineering issued a Nonconformance Report regarding the spike sample from the third quarter where the known/reported ratio of Americium-241 was good, but the result was below three standard deviations and therefore did not pass. The laboratory has been experiencing an increased frequency of low recoveries for Am-241. In the fourth quarter, Am-241 recoveries were as follows:

05-QT-0064	0.2 percent
05-QT-0065	10.2 percent
05-QT-0071	6.9 percent
05-QT-0072	2.8 percent
05-QT-0075	2.3 percent
05-QT-0076	2.4 percent
05-QT-0078	2.7 percent
05-QT-0079	4.9 percent
05-QT-0080	3.1 percent
05-QT-0082	No recovery

The problem is attributed in the report to a difficulty with the pre-packed resin columns. As the pre-packed columns age, they can release chemicals that impair the performance of the columns. The laboratory plans to buy bulk resin and pack the columns at the time of the analysis as a corrective action. Testing has indicated that columns packed at the laboratory produce significantly higher recoveries.

8. REFERENCES

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APPENDIX A

SUMMARY OF SAMPLING SCHEDULE

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Table A-1. Summary of the ESER Program's Sampling Schedule

Sample Type Analysis	Collection Frequency	LOCATIONS		
		Distant	Boundary	INL
AIR SAMPLING				
LOW-VOLUME AIR				
Gross Alpha, Gross Beta, ^{131}I	weekly	Blackfoot, Craters of the Moon, Dubois, Idaho Falls, Jackson WY, Rexburg	Arco, Atomic City, FAA Tower, Howe, Monteview, Mud Lake, Blue Dome	Main Gate, EFS, Van Buren
Gamma Spec	quarterly	Blackfoot, Craters of the Moon, Dubois, Idaho Falls, Jackson WY, Rexburg	Arco, Atomic City, FAA Tower, Howe, Monteview, Mud Lake, Blue Dome	Main Gate, EFS, Van Buren
^{90}Sr, Transuranics	quarterly	Rotating schedule	Rotating schedule	Rotating schedule
ATMOSPHERIC MOISTURE				
Tritium	4 to 13 weeks	Blackfoot, Idaho Falls, Rexburg	Atomic City	None
PRECIPITATION				
Tritium	monthly	Idaho Falls	None	CFA
Tritium	weekly	None	None	EFS
PM-10				
Particulate Mass	every 6th day	Rexburg, Blackfoot	Atomic City	None
WATER SAMPLING				
SURFACE WATER				
Gross Alpha, Gross Beta, ^{3}H	semi-annually	Twin Falls, Buhl, Hagerman, Idaho Falls, Bliss	None	None
DRINKING WATER				
Gross Alpha, Gross Beta, ^{3}H	semi-annually	Aberdeen, Carey, Fort Hall, Idaho Falls, Minidoka, Moreland, Roberts, Shoshone, Taber	Arco, Atomic City, Howe, Monteview, Mud Lake	None
ENVIRONMENTAL RADIATION SAMPLING				
TLDs				
Gamma Radiation	semiannual	Aberdeen, Blackfoot (2), Craters of the Moon, Dubois, Idaho Falls, Jackson WY, Minidoka, Rexburg, Roberts	Arco, Atomic City, Birch Creek, Howe, Monteview, Mud Lake	None
SOIL SAMPLING				
SOIL				
Gamma Spec, ^{90}Sr, Transuranics	biennially	Carey, Crystal Ice Caves (Aberdeen), Blackfoot, St. Anthony	Butte City, Monteview, Atomic City, FAA Tower, Howe, Mud Lake (2), Birch Creek	None

Table A-1. Summary of the ESER Program's Sampling Schedule (continued)

Sample Type Analysis	Collection Frequency	LOCATIONS		
		Distant	Boundary	INL
FOODSTUFF SAMPLING				
MILK				
Gamma Spec (^{131}I)	weekly	Idaho Falls	None	None
Gamma Spec (^{131}I)	monthly	Blackfoot, Carey, Dietrich, Minidoka, Moreland, Roberts	Howe, Terreton	None
Tritium, ^{90}Sr	Semi-annually	Blackfoot, Carey, Dietrich, Idaho Falls, Minidoka, Moreland, Roberts	Howe, Terreton	None
POTATOES				
Gamma Spec, ^{90}Sr	annually	Aberdeen, Blackfoot, Fort Hall, Idaho Falls, Rupert, Taber, occasional samples across the U.S.	Arco, Monteview, Mud Lake, Terreton	None
WHEAT				
Gamma Spec, ^{90}Sr	annually	Am. Falls, Blackfoot, Dietrich, Idaho Falls, Minidoka, Carey	Arco, Monteview, Mud Lake, Tabor, Terreton	None
LETTUCE				
Gamma Spec, ^{90}Sr	annually	Blackfoot, Carey, Idaho Falls, Pocatello	Arco, Atomic City, Howe, Mud Lake	None
BIG GAME				
Gamma Spec	varies	Occasional samples across the U.S.	Public Highways	INL roads
SHEEP				
Gamma Spec	annually	Blackfoot or Dubois	None	N. INL (Circular Butte), S. INL (Tractor Flats)
WATERFOWL				
Gamma Spec, ^{90}Sr, Transuranics	annually	Varies among: Heise, Firth, Fort Hall, Mud Lake and Market Lake	None	Wastewater disposal ponds
MARMOTS				
Gamma Spec	varies	Pocatello Zoo, Tie Canyon	None	RWMC

APPENDIX B

SUMMARY OF MDC'S AND DCG'S

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Table B-1. Summary of Approximate Minimum Detectable Concentrations for Radiological Analyses Performed During Fourth Quarter 2005

Sample Type	Analysis	Approximate Minimum Detectable Concentration[a] (MDC)	Derived Concentration Guide[b] (DCG)
Air (particulate filter)[e]	Gross alpha[c]	1.24×10^{-15} µCi/mL	2×10^{-14} µCi/mL
	Gross beta[d]	2.30×10^{-15} µCi/mL	3×10^{-12} µCi/mL
	Specific gamma (^{137}Cs)	9.33×10^{-17} µCi/mL	4×10^{-10} µCi/mL
	^{238}Pu	3.21×10^{-18} µCi/mL	3×10^{-14} µCi/mL
	$^{239/240}$Pu	2.19×10^{-18} µCi/mL	2×10^{-14} µCi/mL
	^{241}Am	2.43×10^{-16} µCi/mL	2×10^{-14} µCi/mL
	^{90}Sr	5.78×10^{-17} µCi/mL	9×10^{-12} µCi/mL
Air (charcoal cartridge)[e]	^{131}I	9.72×10^{-16} µCi/mL	4×10^{-10} µCi/mL
Air (atmospheric moisture)[f]	^{3}H	1.08×10^{-7} µCi/mL$_{water}$	1×10^{-7} µCi/mL$_{air}$
Air (precipitation)	^{3}H	1.08×10^{-7} µCi/mL	2×10^{-3} µCi/mL
Drinking Water	Gross Alpha	2.34 pCi/L	30 pCi/L
	Gross Beta	2.82 pCi/L	100 pCi/L
	^{3}H	104.72 pCi/L	2×10^{6} pCi/L
Surface Water	Gross Alpha	2.34 pCi/L	30 pCi/L
	Gross Beta	2.82 pCi/L	100 pCi/L
	^{3}H	104.72 pCi/L	2×10^{6} pCi/L
Milk	^{131}I	0.66 pCi/L	--
	^{137}Cs	2.66 pCi/L	--
	^{90}Sr	0.20 pCi/L	--
Potatoes	^{137}Cs	2.08 pCi/kg	--
	^{90}Sr	0.76 pCi/kg	--
Game Animal Tissue[g]	^{137}Cs	8.99 pCi/kg	--
	^{131}I	22.4 pCi/kg	--

Sample Type	Analysis	Approximate Minimum Detectable Concentration[a] (MDC)	Derived Concentration Guide[b] (DCG)

a The MDC is an estimate of the concentration of radioactivity in a given sample type that can be identified with a 95 percent level of confidence and precision of plus or minus 100 percent under a specified set of typical laboratory measurement conditions.

b DCGs, set by the DOE, represent reference values for radiation exposure. They are based on a radiation dose of 100 mrem/yr for exposure through a particular exposure mode such as direct exposure, inhalation, or ingestion of water.

c The DCG for gross alpha is equivalent to the DCGs for $^{239,240}Pu$ and ^{241}Am.

d The DCG for gross beta is equivalent to the DCGs for ^{228}Ra

e The approximate MDC is based on an average filtered air volume (pressure corrected) of 445 m^3/week.

f The approximate MDC is expressed for tritium (as tritiated water) in air, and is based on an average filtered air volume of 39 m^3, assuming an average sampling period of eight weeks.

g The approximate MDC assumes a sample size of 500 g.

APPENDIX C

SAMPLE ANALYSIS RESULTS

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APPENDIX D

STATISTICAL ANALYSIS RESULTS

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Table D-1. Results of the Kruskal-Wallace statistical test between INL, Boundary, and Distant sample groups by month.

Parameter	P[a]
Gross Alpha	
Quarter	0.63
October	0.38
November	0.61
December	0.98
Gross Beta	
Quarter	0.32
October	0.23
November	1.00
December	0.92

a. A 'p' value greater than 0.05 signifies no statistical difference between data groups.

Table D-2. Statistical difference in weekly gross alpha and gross beta concentrations measured at Boundary and Distant locations.

		Mann-Whitney U test
Parameter	**Week**	**P[a]**
Gross Alpha		
	October 5th	0.39
	October 12th	0.62
	October 19th	0.43
	October 26th	0.67
	November 2nd	0.20
	November 9th	0.89
	November 16th	0.39
	November 23rd	0.72
	November 30th	0.35
	December 7th	0.39
	December 14th	0.32
	December 21st	0.67
	December 28th	0.25
Gross Beta		
	October 5th	0.89
	October 12th	0.67
	October 19th	0.78
	October 26th	0.89
	November 2nd	0.32
	November 9th	0.62
	November 16th	0.05
	November 23rd	0.15
	November 30th	0.67
	December 7th	0.15
	December 14th	0.78
	December 21st	0.15
	December 28th	0.03

a. A 'p' value greater than 0.05 signifies no statistical difference between data groups.