

8.0 LABORATORY QUALITY ASSURANCE

It is the policy of the U.S. Department of Energy Nevada Operations Office (DOE/NV) that all data produced for its environmental surveillance and effluent monitoring programs be of known quality. Therefore, a quality assurance (QA) program is used for collection and analysis of samples for radiological and nonradiological parameters to ensure that data produced by the laboratory meets customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, data quality objectives (DQOs), and performance evaluation programs (PEPs). The external QA program for radiological data consists of participation in the Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML), the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates, the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology (NIST), and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Idaho National Engineering and Environmental Laboratory (INEEL). External radiation measurement QA for the onsite program is assessed by participation in the DOE's Laboratory Accreditation Program (DOELAP) and intercomparisons provided by the DOE Environmental Measurements Laboratory every two to three years. EPA's Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE-LV) offsite thermoluminescent dosimeter (TLD) programs consists of participation in the National Voluntary Laboratory Accreditation Program (NVLAP), operated by the National Institute of Standards and Technology (NIST). The nonradiological data QA program was accomplished by using commercial laboratories with appropriate certification or accreditation by state or government agencies.

The environmental surveillance program off the Nevada Test Site (NTS) was performed by R&IE-LV. The QA program developed by R&IE-LV, for the Offsite Radiological Safety Program (ORSP), meets all requirements of EPA policy and also includes applicable elements of the requirements and regulations of DOE/NV QA. The ORSP QA program defines DQOs, which are statements of the quality of data a decision maker needs to ensure that a decision based on these data is defensible.

8.1 POLICY

Environmental surveillance, conducted onsite by Bechtel Nevada (BN) and offsite by EPA's R&IE-LV, is governed by the DOE QA policy as set forth in DOE Order 5700.6C (DOE 1991a). The Order outlines ten specific elements that must be considered for compliance with the QA policy. These elements are:

1. Program
2. Personnel Training and Qualification
3. Quality Improvement
4. Documents and Records
5. Work Processes
6. Design
7. Procurement
8. Inspection and Acceptance Testing
9. Management Assessment
10. Independent Assessment

In addition, R&IE-LV meets the EPA policy which states that all decisions which are dependent on environmental data must be supported by data of known quality. The EPA's policy requires participation in a centrally managed QA Program by all EPA elements as well as those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements. Further, the EPA's policy requires participation in a QA Program by all EPA organizational units involved in environmental data collection. The QA policies and requirements of R&IE-LV are summarized in the "Quality Management Plan" Office of Radiation and Indoor Air (EPA 1996). The QA policies and requirements specific to the ORSP are documented in the "Quality Assurance Program Plan for the Center for Environmental Restoration, Monitoring, and Emergency Response and the Center for Radioanalysis and Quality Assurance for the Offsite Environmental Monitoring Program," (EPA 1998). The requirements of these documents establish a framework for consistency in the continuing application of QA standards and implementing procedures in support of the ORSP. Administrative and technical implementing procedures based on these QA requirements are maintained in appropriate manuals or are described in standard operating procedures of the R&IE-LV.

8.2 OVERVIEW OF THE LABORATORY QA PROGRAM

The BN Analytical Services Laboratory (ASL) implements the requirements of the DOE Order 414.1A through integrated quality procedures. The quality of data and results is ensured through both process-based and procedure-specific QA.

Procedure-specific QA begins with the development and implementation of work instructions (WIs), which contain the analytical methodologies and required quality control samples for a given analysis. Personnel performing a given analysis are

trained and qualified for that analysis, including the successful analysis of a quality control sample. Analysis-specific operational checks and calibration standards traceable to either the NIST or the EPA are required. Quality control samples, e.g., spikes, blanks, and replicates, are included for each analytical procedure. Compliance with analytical procedures is measured through procedure-specific assessments or surveillances.

An essential component of process-based QA is data review and verification to assess data usability. Data review requires a systematic, independent review against pre-established criteria to verify that the data are valid for their intended use. Initial data processing is performed by the analyst or health physicist generating the data. An independent review is then performed by another analyst or health physicist to ensure that data processing has been correctly performed and that the reported analytical results correspond to the data acquired and processed. Supervisory review of data is required prior to release of the data to sample management personnel for data verification. Data verification ensures that the reported results correctly represent the sampling and/or analyses performed and includes assessment of quality control sample results. Data processing by sample management personnel ensures that analytical results meet project requirements. Data discrepancies identified during the data review and verification processes are documented on data discrepancy reports (DDRs). DDRs are reviewed and compiled quarterly to discern systematic problems. Data checks are made by Environmental Surveillance of BN for internal consistency, proper identification, transmittal errors, calculation errors, and transcription errors.

Process-based QA programs also include periodic operational checks of analytical parameters such as reagent water quality and storage temperatures. Periodic calibration is required for all measuring equipment such as analytical balances, analytical weights, and thermometers. The

overall effectiveness of the QA program is determined through systematic assessments of analytical activities. Systematic problems are documented and corrective actions tracked through System Deficiency Reports.

Similar procedures and methodologies are used by R&IE-LV to ensure the quality of environmental radiological data collected off the NTS.

8.3 DATA AND MEASUREMENT QUALITY OBJECTIVES

DATA QUALITY OBJECTIVES

DQOs delineate the circumstances under which measurements are made and define the acceptable variability in the measured data (EPA 1994). DQOs are based on the decision(s) to be made, the range of sampling possibilities, what measurements will be made, where the samples will be taken, how the measurements will be used, and what calculations will be performed on the measurement data to arrive at the desired result(s). Associated measurement quality objectives (MQOs), which define acceptable variability in the measured data, are established to ensure the quality of the measurements.

DECISIONS TO BE MADE

The primary decisions to be made, based on radiological environmental surveillance measurements, are whether, due to NTS activities (1) any member of the general public, outside the site boundaries, receives an effective dose equivalent (EDE) that exceeds regulatory limits; (2) there is detectable contamination of the environment; or (3) there is a biological effect. A potential EDE to a member of the public from NTS activities is much more likely to be due to inhalation or ingestion of radionuclides which have reached the person through one or more pathways, such as transport through the air (inhalation

exposure), or through water and/or foodstuffs (ingestion exposure), than to be due to external exposure. A pathway may be quite complex; e.g., the food pathway could include airborne radioactivity falling on soil and plants, also being absorbed by plants, which are eaten by an animal, which is then eaten by a member of the public. At the NTS, because of the depth of aquifers, negligible horizontal or vertical transport, lack of surface water flows and little rain, very sparse vegetation and animal populations, lack of food grown for human consumption, and large distances to the nearest member of the public, the airborne pathway is by far the most important for a possible EDE to a member of the public.

Decisions made based on nonradiological data are related to waste characterization, extent and characterization of spills, compliance with regulatory limits for environmental contaminants, and possible worker exposure(s).

RANGE OF SAMPLING POSSIBILITIES

Determination of the numbers, types, and locations of radiological sampling stations is based on factors such as the location of possible sources, isotopes of concern, wind and weather patterns, the geographical distribution of human populations, the levels of risk involved, the desired sensitivity of the measurements, physical accessibility to sampling locations, and financial constraints. The numbers, types, and location of nonradiological samples are typically defined by regulatory actions on the NTS and are determined by environmental compliance or waste operations activities. Workplace and personnel monitoring to determine possible worker exposures is conducted by Industrial Hygienists and Health Physicists from the Environment, Safety and Health Division (ESHD) of BN.

MEASUREMENTS TO BE MADE

Radioanalyses are made of air, water, or other media samples to determine the types and amounts of radioactivity in them. These measurements are then converted to

radioactivity concentrations by dividing by the sample volume or weight, which is measured separately. Nonradiological inorganic or organic constituents in air, water, soil, and sludge samples are analyzed and reported by commercial laboratories under contract to BN. Methods and procedures used to measure possible worker exposures to nonradiological hazards are defined by Occupational Safety and Health Administration or National Institute of Occupational Safety and Health protocols.

Typical contaminants for which BN ESHD personnel collect samples and request analyses are asbestos, solvents, and welding metals. Sample media, which are analyzed, include urine, blood, air filters, charcoal tubes, and bulk asbestos.

SAMPLING LOCATIONS

The locations of routine radiological environmental surveillance sampling both on and off the NTS are described in Chapters 4 and 5 of this report. Onsite sampling methodologies are described in BN's Environmental Management Procedures, and offsite methodologies by similar R&IE-LV procedures. The locations of nonradiological environmental sampling and monitoring are determined through site remediation and characterization activities and by permit requirements.

USE OF THE MEASUREMENTS

There are several techniques to estimate the EDE to a member of the public. One technique is to measure the radionuclide concentrations at the location(s) of interest and use established methodologies to estimate the EDE a person at that location could receive. Another technique is to measure radionuclide concentrations at specific points within the site and to use established models to calculate concentrations at other offsite locations of interest. The potential EDE to a person at such a location could then be estimated. Another technique is the one used for most of the environmental surveillance data measured at the NTS.

CALCULATIONS TO BE PERFORMED

The EDE of greatest interest is the EDE to the maximally exposed individual (MEI). The MEI is located, where, based on measured radioactivity concentrations and distances from all contributing NTS sources, the calculational model gives the greatest potential EDE for any member of the public. The assumptions used in the calculational model are conservative; i.e., the calculated EDE to the MEI most certainly exceeds the EDE any member of the public would actually receive. The model used at the NTS is EPA's CAP88-PC, a wind dispersion model approved for this purpose (DOE 1997c).

MEASUREMENT QUALITY OBJECTIVES (MQOs)

MQOs are commonly described in terms of representativeness, comparability, completeness, precision, and accuracy. Although the assessment of the first two characteristics must be essentially qualitative, definite numerical goals may be set and quantitative assessments performed for the latter three.

REPRESENTATIVENESS

Representativeness is the degree to which a sample is truly representative of the sampled medium; i.e., the degree to which measured analytical concentrations represent the concentrations in the medium being sampled (Stanley and Verner 1985).

Representativeness also refers to whether the locations and frequency of sampling are such that calculational models will lead to a correct estimate of potential EDE to a member of the public when measured radioactivity concentrations are put into the model. An environmental monitoring plan for the NTS, "Nevada Test Site Routine Radiological Environmental Monitoring Plan" (DOE 1998a) has been established to achieve representativeness for environmental data. Factors which were considered in designing this monitoring plan

include locations of known and potential sources, historical and operational knowledge of isotopes and pathways of concern, hydrological, and topographical data, and locations of human populations.

COMPARABILITY

Comparability refers to the degree of confidence and consistency we have in our analytical results, or defined as "the confidence with which one data set can be compared to another" (Stanley and Verner 1985). To achieve comparability in measurement data, sample collection and handling, laboratory analyses, and data analysis and validation are performed in accordance with established WIs. Standard reporting units and a consistent number of significant digits are used. Instruments are calibrated using NIST-traceable sources. Each batch of field samples is accompanied by a spiked sample with a known quantity of the compound(s) of interest. Extensive QA measures are used for all analytical processes.

COMPLETENESS

Completeness is defined as the percentage of samples collected versus those which had been scheduled to be collected, or the percentage of valid analysis results versus the results which would have been obtained if all samples had been obtained and correctly analyzed. Realistically, samples can be lost during shipping, handling, preparation, and analysis, or not collected as scheduled. Also data entry or transcription errors can be made. The BN completeness objectives for all radiological samples and analyses have been set at 90 percent for sample collection and 85 percent for analyses, or 75 percent overall. R&IE-LV's completeness objective for the Long-Term Hydrological Monitoring Program is 80 percent and for the other networks it is 90 percent.

Completeness for inorganic and organic analyses is based on the number of valid results received versus the number requested.

PRECISION

Precision refers to "the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions" (Taylor 1987). Practically, precision is determined by comparing the results obtained from performing the same analysis on split samples, or on duplicate samples taken at the same time from the same location, maintaining sampling and analytical conditions as nearly identical as possible. Precision for samples is determined by comparing results for duplicate samples of particulates in air, tritiated water vapor, and of some types of water samples. For TLDs, precision is assessed from variations in the three CaSO_4 elements of each environmental TLD. Precision is expressed quantitatively as the percent relative standard deviation (%RSD); i.e., the ratio of the standard deviation of the measurements to their mean converted to percent. The smaller the value of the %RSD, the greater is the precision of the measurement. The precision objectives are shown in Table 8.1. They are a function of the concentration of radioactivity in the samples; i.e., the analysis of samples with concentrations near zero will have low precision, while samples with higher concentrations will have proportionately higher precision.

ACCURACY

Accuracy refers to how well we can measure the true value of a given quantity and can be defined as "the degree of agreement of a measured value with the true or expected value of the quantity of concern" (Taylor 1987). For practical purposes, assessments of accuracy for the ASL are done by performing measurements on special QA samples prepared, using stringent quality control, by laboratories which specialize in preparing such samples. The values of the activities of these samples are not known by the staff of the ASL until several months after the measurements are made and the results sent back to the QA

laboratory. These sample values are unknown to the analysts and serve to measure the accuracy of the analytical procedures. The accuracy of these measurements, which is assumed to extend to other similar measurements performed by the laboratory, may be defined as the ratio of the measured value divided by the true value, expressed as a percent. Percent bias is the complement of percent accuracy; i.e., percent bias = 100 minus percent accuracy. The smaller the percent bias, the more accurate are the measurements. Table 8.2 shows the accuracy objectives of the ASL and of the R&IE-LV.

Measurements of sample volumes should be accurate to ± 5 percent for aqueous samples (water and milk) and to ± 10 percent for air and soil samples. The sensitivity of radiochemical and gamma spectrometric analyses must allow no more than a 5 percent risk of either a false negative or false positive value. Control limits for accuracy, monitored with matrix spike samples, are required to be no greater than ± 20 percent for all gross alpha and gross beta analyses and for gamma spectrometric analyses.

Both the R&IE-LV and ASL participate in several interlaboratory PEPs, such as EML's QAP and the DOELAP for TLDs. EPA's Radiation Quality Assurance Program Performance Evaluation Study (PES) program was discontinued for 1999.

The accuracy of the TLD program is tested every two or three years by DOELAP or by NVLAP. This involves a three-part, single blind performance testing program followed by an independent onsite assessment of the overall program. Both BN and R&IE-LV participate in their respective accrediting agency's program.

Once the data have been finalized, they are compared to the MQOs. Completeness, accuracy, and precision statistics are calculated. If data fail to meet one or more of the established MQOs, they may still be used in data analysis; however, the data and

any interpretive results must be qualified. Current and historical data are maintained in an access-controlled database.

All sample results exceeding the traditional natural background activity range are investigated. If data are found to be associated with a non-environmental condition, e.g., a check of the instrument using a calibration source, the data are flagged and are not included in calculations of averages, etc. Only data verified to be associated with a non-environmental condition are flagged; all other data are used in calculation of averages and other statistics, even if the condition is traced to a source other than the NTS.

8.4 RESULTS FOR COMPLETENESS, PRECISION, AND ACCURACY

Summary data for completeness, precision, and accuracy are provided in Tables 8.3 to 8.6, respectively. Complete data used in these MQO's for 1999 are from published reports by EML's QAP (DOE 1998b and 1998c) and other reports from NIST and Environmental Resource Associates (ERA).

COMPLETENESS

The analysis completeness data for calendar year 1999 are shown in Table 8.3. These percentages represent all analyses which were carried to completion and include some analyses for which the results were found to be invalid for other reasons. Had objectives not been met for some analyses, other factors would be used to assess acceptability, e.g., fit of the data to a trend or consistency with results from samples collected before and after.

The completeness MQOs for the onsite networks were met or exceeded in all cases. For the offsite networks, the MQOs were met or exceeded except for the pressurized ion chamber (PIC) network. Failure of the

PIC network was due to the loss of telemetry systems for the majority of 1999. Access to PIC data for CTLP stations through satellite telemetry was restored to EPA in the fall of 1998 and was discontinued again at the end of February 1999. Completeness of PIC data for this two-month period approached 100 percent. Secondary data collection systems were used for the remainder of the 1999 calendar year. Those data are not included in this summary as it does not meet minimum quality requirements due to reduced maintenance support of aging equipment and data storage media. EPA personnel collected and reviewed PIC chart media each week for spikes or other anomalies. No significant deviations from the expected background exposure rates were identified.

PRECISION

From replicate samples collected and analyzed throughout the year, the %RSD was calculated for various types of analyses and sampling media. The results of these calculations are shown in Table 8.4 for both the onsite and offsite networks. In addition to examination of %RSDs for individual duplicate pairs, an overall precision estimate was determined by calculating the pooled standard deviation, based on the algorithm given in Taylor (1987). To convert to a unitless value, the pooled standard deviation was divided by the grand mean and multiplied by 100 to yield a %RSD. The table presents the pooled data and estimates of overall precision. The pooled standard deviations and %RSD indicate the estimated achieved precision for sample results.

For the R&IE-LV, precision data for all analyses were well within their respective MQOs, except for plutonium. Plutonium results were rechecked and are believed to be valid. Six of nine duplicate pairs collected had results greater than the analysis MDA for $^{239+240}\text{Pu}$. Of these six, one sample had a significantly high %RSD value contributing to the high average. The remaining five duplicate pairs have an

average deviation of less than 20 percent. None of the duplicate pairs collected had result values above the analysis MDA for ^{238}Pu . The R&IE-LV data presented in Table 8.4 include only laboratory and field duplicate pairs that exceeded the MDC.

For the ASL, the reason for the low precision in some of the analyses was the low activity in these environmental samples. The few that were useful for calculation of precision barely exceeded the MDC.

ACCURACY

The ASL and R&IE-LV accuracy objectives were measured through participation in the interlaboratory comparison and QAPs discussed below.

RADIOLOGICAL PERFORMANCE EVALUATION RESULTS

The external radiological PEs consisted of participation in the QAP conducted by DOE/EML and the PES conducted by ERA. These programs serve to evaluate the performance of the radiological laboratory and to identify problems requiring corrective actions.

Summaries of the 1999 results of the QAPs conducted by the offsite organizations are provided in Tables 8.5 and 8.6. The column or section in each table labeled percent bias is the accuracy of analysis and may be compared to the objectives listed in Table 8.2. The individual radionuclide recoveries are listed in tables which may be found in the DOELAP, MAPEP, and EML reports.

Accuracy, as percent difference or percent bias is calculated by:

$$\%BIAS = \left(\frac{C_m - C_a}{C_a} \right) 100$$

where:

$\%BIAS$ = percent bias
 C_m = measured sample activity
 C_a = known sample activity

The R&IE-LV failed the accuracy MQO in 2 of the 28 analyses attempted in the INEL/MAPEP study. One of the two analyses was outside of the bias MQO but was within the acceptable range for the study. In the EML QAP, all of the eight analyses performed were within the DQO of ± 20 percent. In 1999, the EPA discontinued the EPA Radiological QA PE program. Therefore, no results are shown for that program. R&IE-LV is currently enrolled in and retains accreditation by NVLAP. QA checks are routinely performed to ensure compliance with applicable performance standards.

None of BN's ASL results exceeded the 3 normalized deviation limits for the 50 analyses attempted. The MQOs for accuracy in analysis of DOE/EML and NIST samples were not met in 8 of the 44 analyses attempted. Three of the analyses that failed the MQOs for accuracy were for radionuclides (^{106}Ru -one and ^{244}Cm -two) that were not detected in the environment.

CORRECTIVE ACTIONS IMPLEMENTED IN RESPONSE TO PERFORMANCE EVALUATION PROGRAMS

BN results were generally within the control limits determined by the program sponsors.

Results which were not within acceptable performance limits were investigated and corrective actions taken to prevent reoccurrence.

In the R&IE-LV, the 1999 results that did not meet analysis criteria were investigated to determine the cause of the reported error. Corrective actions were then implemented.

COMPARABILITY

The EML/QAP provides results to each laboratory participating in each study that includes a grand average for all values, excluding outliers. A normalized deviation statistic compares each laboratory's result (mean of three replicates) to the known value and to the grand average. If the value of this statistic (in multiples of standard normal deviate, unitless) lies between control limits of -3 and +3, the accuracy (deviation from known value) or comparability (deviation from grand average) is within normal statistical variation.

The onsite ASL results in the EML QAP were acceptable. There were only two instances in which the ASL results were greater than the MQO.

Table 8.1 Precision Objectives Expressed as Percents

<u>Analysis</u>	<u>ASL</u>	
	<u>Conc. > 10 MDC</u>	<u>4 MDC ≤ Conc. ≤ 10 MDC</u>
Gross Alpha	±30	±60
Gross Beta	±30	±60
Gamma Spectrometry	±30	±60
Scintillation Counting	±30	±60
Alpha Spectrometry	±20	±50

Note: The precision objective for TLDs at environmental levels is 10 percent.

<u>R&IE-LV</u>		
Conventional Tritium	±10	±30
Strontium (in milk)	±10	±30
Thorium	±10	±30
Uranium	±10	±30
Enriched Tritium	±20	±30
Strontium (in other media)	±20	±30
Plutonium	±20	±30

Table 8.2 Accuracy Objectives Expressed as Percent Bias

<u>Analysis</u>	<u>ASL</u>	
	<u>Conc. > 10 MDC</u>	<u>4 MDC ≤ Conc. ≤ 10 MDC</u>
Gross Alpha	±20	±50
Gross Beta	±20	±50
Gamma Spectrometry	±20	±50
Scintillation Counting	±20	±50
Alpha-Spectrometry	±20	±50

TLDs Meet DOELAP Criteria

<u>R&IE-LV</u>		
Tritium, Conventional	±10	±30%
Strontium (Milk)	±10	±30%
Thorium	±10	±30%
Uranium	±10	±30%
Tritium, Enriched	±20	±30%
Strontium (other media)	±20	±30%
Plutonium	±20	±30%

TLDs Meet NVLAP Criteria

Table 8.3 Analysis Completeness Data for Calendar Year - 1999

<u>Analysis</u>	<u>Medium</u>	<u>Completeness Percent</u>	
		<u>BN</u>	<u>R&IE-LV</u>
Gross Alpha/Beta	Low Volume Particulate Air Filter	99.6	98.0
Plutonium	High Volume Particulate Air Filter	100.0	90.3
Plutonium	Low Volume Particulate Air Filter	99.7	(a)
Gamma Spectrometry	Low Volume Particulate Air Filter	100.0	98.0
Gamma Spectrometry	Low Volume Charcoal Air Filter	(a)	98.0
Gamma Spectrometry	High Volume Particulate Air Filter	99.7	90.3
Tritiated Water	Air	99.2	(a)
Gross Alpha	Potable Water Taps	100.0	(a)
Gross Beta	Potable Water Taps	100.0	(a)
Gamma Spectrometry	Potable Water Taps	100.0	(a)
Tritiated Water	Potable Water Taps	100.0	(a)
Plutonium	Potable Water Taps	100.0	(a)
Gross Beta	Wells, Ponds	86.5	(a)
Plutonium	Wells, Ponds	86.5	(a)
Gamma Spectrometry	Wells, Ponds	86.5	93.5
Tritiated Water	Wells, Ponds	86.5	95.1
Strontium-90	Wells, Ponds	86.5	(a)
Pressurized Ion Chamber	Ambient Radiation	(a)	15.7 ^(b)
TLDs, Environmental	Ambient Radiation	97.1	96.0
TLDs, Personnel	Ambient Radiation	(a)	99.0

(a) Analyses not performed.

(b) Telemetry data only.

Table 8.4 Precision Estimates from Replicate Sampling - 1999

<u>Analysis</u>	<u>ASL</u>	<u>Precision Estimate %RSD</u>
	<u>Number of Replicate Analyses</u>	
Gross Alpha in Air	96	18.7
Gross Beta in Air	98	14.8
Gamma in Air	16	11.3
Pu in Air	18	230
Tritium in Air	48	63.0
Gross Alpha in Potable Water	4	33.8
Gross Beta in Potable Water	15	6.64
HTO in Tunnel Effluent	6	1.84
Pu in Tunnel Effluent	6	17.0
TLDs	330	6.4
	<u>R&IE-LV</u>	
Gross Alpha in Air	143	28.9
Gross Beta in Air	166	17.1
Gamma Spectrometry (Low-Vol ⁷ Be)	18	25.1
Gamma Spectrometry (Hi-Vol ⁷ Be)	9	37.4
Plutonium in Air (Hi-Vol)	6	41.2 ^(a)
Tritium in Water (enriched)	16	6.7
Tritium in Water (unenriched)	28	4.3

(a) One of the six plutonium duplicate samples had a %RSD greater than 100 percent for the pair. Average %RSD for the remaining five pairs is 19.6 percent.

Table 8.5 Accuracy of R&IE-LV Radioanalyses (EML QAP and PES MAPEP) - 1999

Percent Bias Range for Analysis of EML QAP Samples

<u>Analysis</u>	<u>No.</u>	<u>Air</u>	<u>Soil</u>	<u>Vegetation</u>	<u>Water</u>
Antimony	1	-10.25	(a)	(a)	(a)
Americium	3	(a)	-2.11	7.05	-2.88
Cobalt	6	-11.93 - 3.08	(a)	(a)	-5.95 - 5.53
Cesium	4	-11.19 - 1.17	(a)	(a)	-40.15 - 4.03
Curium	1	(a)	(a)	-18.1	(a)
Manganese	1	-9.91	(a)	(a)	(a)
Plutonium	6	-2.13 - 7.17	1.52	1.85	-1.05 - 0.73
Ruthenium	1	-19.83	(a)	(a)	(a)
Strontium	1	(a)	(a)	(a)	-1.16
Tritium	2	(a)	(a)	(a)	-13.12 - 1.65
Uranium	2	(a)	(a)	(a)	-22.97 - 13.39

(a) No sample.

Percent Bias Range for Analysis of MAPEP QAP Samples

Americium	1	(a)	-4.63	(a)	(a)
Cesium	1	(a)	(a)	(a)	1.21
Cobalt	1	(a)	(a)	(a)	-3.21
Manganese	1	(a)	(a)	(a)	2.51
Plutonium	4	(a)	1.58	(a)	-7.59 - 1.58
Strontium	1	(a)	(a)	(a)	-15.44
Zinc	1	(a)	(a)	(a)	3.85

(a) No sample.

Table 8.6 Comparability of ASL Radioanalyses (ERA PEP, EML PEP, and NIST) - 1999

Percent Bias Range for Analysis of ERA PEP Samples

<u>Analysis of Water Samples</u>	<u>No.</u>	<u>BN/ASL Average pCi/L</u>	<u>EPA QA Known</u>	<u>Normalized Deviation^(a) Grand Avg.</u>
Gross Alpha	5	20.2 - 83.7	24.0 - 77.4	-0.68 - 0.46
Gross Beta	5	20.9 - 248	20.0 - 278	-0.69 - 0.95
Tritium	2	5,230 - 19,900	6,130 - 21,000	-1.78 - 0.41
⁶⁰ Co	4	58.7 - 103	53.8 - 99.6	-0.42 - 1.25
⁶⁵ Zn	2	228 - 367	199 - 313	1.31 - 2.21
⁸⁹ Sr	3	13.7 - 23.2	16.4 - 27.0	-1.25 - 0.94
⁹⁰ Sr	3	13.1 - 35.1	18.2 - 40.2	-0.73 - 0.48
¹³⁴ Cs	4	10.8 - 63.1	12.3 - 73.4	-1.77 - 0.24
¹³⁷ Cs	4	74.8 - 222	72.2 - 209	-0.14 - 1.67
¹³¹ I	1	24.5	23.3	0.52
¹³³ Ba	2	68.1 - 101	66.6 - 98.2	0.37 - 0.99
²²⁶ Ra	5	3.39 - 15.5	4.05 - 16.5	-1.05 - 5.85
²²⁸ Ra	5	2.15 - 13.1	2.17 - 10.0	-0.86 - 6.36
U (Natural)	5	12.6 - 52.4	12.4 - 53.0	-0.17 - 2.02

Table 8.6 (Comparability of ASL Radioanalyses [ERA PEP, EML PEP, and NIST] - 1999, cont.)

Percent Bias Range for Analysis of EML PEP Samples

<u>Analysis</u>	<u>No.</u>	<u>Air</u>	<u>Soil</u>	<u>Vegetation</u>	<u>Water</u>
Gross Alpha	2	-5.78 - 1.24	(a)	(a)	-7.59 - 3.67
Gross Beta	2	-8.97 - 7.52	(a)	(a)	-5.45 - 27.4 ^(b)
Tritium	2	(a)	(a)	(a)	-0.87 - 7.37
⁴⁰ K	2	(a)	2.00 - 3.46	20.7 ^(b) - 35.1 ^(b)	(a)
⁵⁴ Mn	1	5.18	(a)	(a)	(a)
⁵⁷ Co	2	-13.6 - 5.17	(a)	(a)	3.05 - 7.05
⁶⁰ Co	2	-13.5 - 2.83	(a)	-0.57 - 6.29	(a)
⁹⁰ Sr	2	-34.37 - 4.17	-8.95 - 3.08	-0.56 - 3.53	-23.0 ^(b) - 5.81
¹²⁵ Sb	1	-13.37	(a)	(a)	(a)
¹⁰⁶ Ru	1	-46.2 ^(c)	(a)	(a)	(a)
¹³⁷ Cs	2	-13.6 - 3.11	-1.47 - 1.14	-6.14 - 3.00	3.82 - 6.67
²¹² Bi	1	(a)	-7.86	(a)	(a)
²¹² Pb	2	(a)	5.16 - 11.8	(a)	(a)
²¹⁴ Bi	2	(a)	-12.6 - 5.18	(a)	(a)
²¹⁴ Pb	2	(a)	1.13 - 7.50	(a)	(a)
²²⁸ Ac	2	(a)	-0.81 - 0.11	(a)	(a)
²³⁸ Pu	2	018.5 - 12.4	(a)	(a)	-1.65 - 6.22
²³⁹ Pu	2	-11.3 - 5.88	-11.9 - 1.87	-17.4 - 4.42	-1.61 - 2.08
²³⁴ U	2	0.0 - 9.09	-3.32 - 8.95	(a)	7.81 - 12.7
²³⁸ U	2	-18.0 - 12.3	2.07 - 8.42	(a)	18.3 - 18.9
²⁴¹ Am	2	-17.9 - 6.30	-15.4	-9.71 - 9.03	1.15 - 17.7
²⁴⁴ Cm	2	(a)	(a)	27.3 - 34.1 ^(c)	(a)

(a) No sample.

(b) Result with bias > 20 percent.

(c) Result > 20 percent; however this radionuclide is not detected in the NTS environment.

Percent Bias for Analysis of NIST PEP Samples

<u>Analysis</u>	<u>No.</u>	<u>Air</u>	<u>Soil</u>	<u>Water</u>
⁹⁰ Sr	1	-6.2	11.4	-3.6
²³⁸ Pu	1	-3.9	-6.0	3.1
²³⁸ U	1	-4.4	-4.7	3.1
²⁴¹ Am	1	-5.2	-7.2	13.8