BROOKHAVEN
NATIONAL
LABORATORY

2001 SITE ENVIRONMENTAL REPORT

Chapter 9

Quality Assurance

Quality assurance is an integral part of every activity at Brookhaven National Laboratory. A comprehensive program is in place to ensure that all environmental monitoring data meet quality assurance and quality control requirements. Samples are collected and analyzed in accordance with standard operating procedures that are designed to ensure that samples are representative and data are reliable and defensible. Quality control in the analytical laboratories is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated as required by project-specific quality objectives before they are used to support decision making.

BNL uses the on-site Analytical Services Laboratory and four off-site contractor laboratories to analyze environmental samples. All analytical laboratories are certified by New York State for the tests they perform for BNL and are subject to oversight that includes state and national performance evaluation testing, review of quality assurance programs, and audits.

The two primary laboratories reporting radiological analytical data (BNL and one off-site laboratory) scored 92 percent and 100 percent satisfactory results, respectively, in state and federal performance evaluation programs. This is an improvement from last year's overall score of 89 percent and 95 percent, respectively. In nonradiological performance evaluation testing under the New York State Environmental Laboratory Approval Program (potable and nonpotable water), BNL received a satisfactory rating of 96.8 percent; the three off-site contractor laboratories scored between 93.3 percent and 94.8 percent. BNL's combined score of 96 percent "overall satisfactory" for the 593 radiological and nonradiological performance evaluation tests carried out in 2001 is considered excellent. The multilayered components of Quality Assurance monitored at BNL ensure that all analytical data reported for the *2001 Site Environmental Report* are reliable and of high quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by DOE Order 5400.1 (1988), *General Environmental Protection Program*, BNL has established a Quality Assurance/Quality Control (QA/QC) Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent with the requirements of 10 CFR 830 Subpart A, "Quality Assurance Requirements" and DOE Order 414.1A (2001), *Quality Assurance.* Responsibility for quality at BNL starts with the Laboratory Director and extends throughout the entire organization. The purpose of the BNL Quality Management (QM) System is to implement QM methodology throughout the various BNL management systems and associated processes to:

- Plan and perform BNL operations in a reliable and effective manner to minimize the impact on the environment, safety, and health of the staff and public
- Standardize processes and support continual improvement in all aspects of BNL operations
- Enable the delivery of products and services that meet or exceed our stakeholders' requirements and expectations.

For environmental monitoring, QA is defined as an integrated system of management activities that includes planning, implementation, control, reporting, assessment, and continual improvement. Quality Control activities measure each process or service against the QA standards. QA/QC practices and procedures are documented in detail in manuals, plans, and a comprehensive set of environmental monitoring standard operating procedures, or "EM-SOPs" (BNL 1999a). Staff who must follow these procedures and plans are required to sign off on the SOPs or receive training.

The ultimate goal of the environmental monitoring and analysis QA/QC program is to ensure that results are representative and defensible and that data are of the type and quality needed to verify protection of the Laboratory and community environment, as well as BNL employees and the public. Figure 9-1 depicts the flow of the QA/QC elements of BNL's Environmental Monitoring Program and indicates the sections of this chapter that discuss each element in more detail.

First, BNL environmental scientists and engineers determine sampling requirements using the U.S. Environmental Protection Agency Data Quality Objective (or equivalent) process. During this process, the team project manager determines the type, amount, and quality of data needed to support decision making, legal requirements, stakeholder concerns, and technical information. Next, the team prepares an environmental monitoring plan or project-specific sampling plan that specifies the location, frequency, type of sample, analytical methods to be used, and a sampling schedule. These plans or the standard operating procedures also specify data acceptance criteria. Contracts with off-site analytical laboratories are established as necessary. Detailed SOPs direct sampling technicians on proper sample collection, preservation, and handling requirements. Field quality control samples are prepared as necessary. Samples are analyzed in the field or at certified laboratories in accordance with SOPs. The results are then validated or verified in accordance with published procedures. Finally, data are reviewed and evaluated by environmental professionals and management in the context of expected results, related monitoring results, historical data, and applicable regulatory requirements (*e.g.*, drinking water standards, permit limits, etc.). Data are then used to support decision making. Data are also reported as required, and summarized annually in the *Site Environmental Report*. Tables and figures on QA/QC results for calendar year 2001 are presented in this chapter and in Appendix F. Most of the data contained in this report are condensed and summarized from a separate document, *Year 2001 ASL Quality Assurance Report* (Scarpitta and Heotis 2002).

9.2 SAMPLE COLLECTION AND HANDLING

In 2001, environmental monitoring samples were collected as specified by procedures, the *BNL Environmental Monitoring Plan* (BNL 2000), and project-specific work plans, as applicable. For example, the *BNL Groundwater Monitoring Program Quality Assurance Project*

Plan (BNL 1999b) describes the QA program and QC requirements followed for groundwater monitoring. This plan documents organizational structure, documentation requirements, sampling requirements, field QA/QC sample collection, acceptance criteria, sample custody requirements, data validation procedures, and general data handling/database procedures. (As almost half of all environmental monitoring samples collected for BNL are of groundwater, this chapter uses groundwater procedures for many of the examples.)

BNL has prepared sampling SOPs for all environmental media, including groundwater, surface water, soil, sediment, air, flora, and fauna (BNL 1999a). These procedures contain detailed information on how to prepare for sample collection; what type of field equipment to use and how to calibrate it; how to properly collect, handle, and preserve samples; and how to manage any wastes generated during sampling. The procedures ensure consistency between samples collected by BNL employees or outside contractors, whether those samples are collected under the environmental restoration or environmental surveillance programs.

Quality control checks of sampling processes include the collection of field duplicates, matrix spike samples, field blanks, trip blanks, and equipment blanks. In addition, specific sampling methodologies include QC checks, such as field analysis of stability parameters, so that all parameters are within expected or acceptable limits. As another example, the low-flow sampling technique includes checks to ensure proper purging of the monitoring wells.

All wastes generated during sampling (contaminated equipment, purge water from wells, etc.) are managed in accordance with applicable requirements. One factor considered during sample collection is minimizing the amount of waste generated, consistent with the

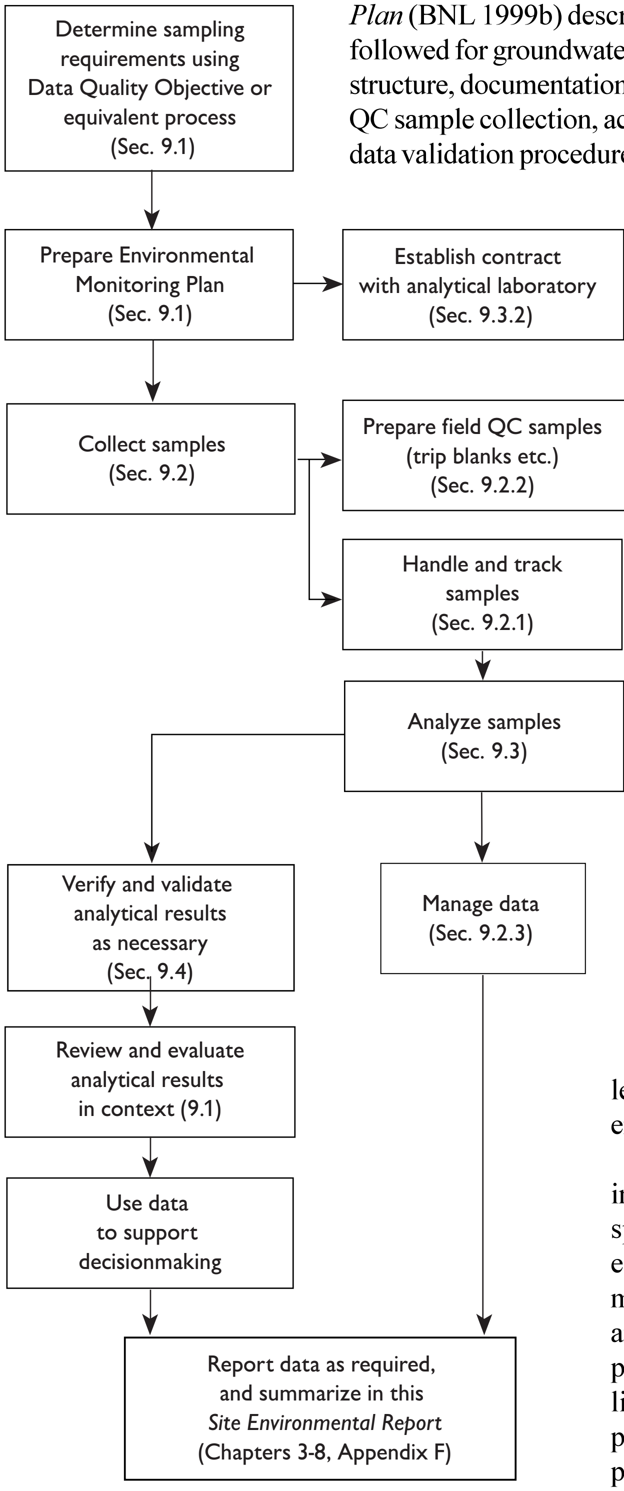

Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements

Pollution Prevention Program described in Chapter 2. In 1999, BNL implemented new procedures that dramatically reduced the volume of wastewater that is generated when groundwater wells are sampled. These new procedures were EM-SOP-302, *Groundwater Sampling Procedure – Low Flow Purging and Sampling Using Dedicated Bladder Pumps*, and EM-SOP-307, *Groundwater Sampling Procedure – Low Flow Purging and Sampling Using Non-Dedicated Electrical Pumps* (BNL 1999a).

9.2.1 Field Sample Handling

To ensure the integrity of samples, chain-of-custody (COC) was maintained and documented for all samples collected. A sample or evidence file is considered to be in the custody of a person if any of the following rules of custody are met: a) the person has physical possession of the sample or file, b) the sample or file remains in view of the person after being in possession, c) the sample or file is placed in a secure location by the custody holder, or d) the sample or file is in a designated secure area. These procedures are outlined in EM-SOP-109, *Chain-of-Custody Procedure* (BNL 1999a). All environmental monitoring samples maintained a valid COC from the time of sample collection through sample disposal.

9.2.1.1 Custody and Documentation

The field sampling team leader was responsible for the care and custody of samples until they were transferred to a receiving group or analytical laboratory. Samples requiring refrigeration were placed immediately into a refrigerator or a cooler with cooling media, and kept under custody rules. The team member who maintained custody of the samples signed the COC form when relinquishing custody of them. The laboratory or group receiving the samples signed the COC form when accepting custody.

The sampling team is also required to maintain a bound, weatherproof logbook. When samples are collected, the logbook is used to record sample designation, collection time, description, and collection method, as well as notes on daily weather conditions, field measurements, and other appropriate site-specific observations.

9.2.1.2 Preservation and Shipment

Samples shipped to off-site laboratories were managed as follows. Before sample collection, the team prepared all bottle labels and put them on the appropriate containers, as defined in the QA Program Plan and/or applicable EM-SOPs. Appropriate preservatives were added to the containers before or immediately after collection; in appropriate cases, samples were refrigerated.

Sample preservation was maintained as required throughout shipping. If samples were sent via commercial carrier, a bill-of-lading was used. COC seals were placed on the shipping containers; their intact status indicated that custody was maintained during shipment.

9.2.2 Field Quality Control Samples

Field QC samples collected for the Environmental Monitoring Program include equipment blanks, trip blanks, field blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples. The rationale for selecting specific field QC samples and minimum requirements for their use in the Environmental Monitoring Program are provided in EM-SOP-200, *Collection and Frequency of Field Quality Control Samples* (BNL 1999a). Equipment (rinsate) blanks and trip blanks were generally collected for all media except air and flora and fauna.

An *equipment blank* is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool before sample collection. The rinsate is collected to demonstrate that the sampling tool was not contaminated. Equipment blank samples were collected, as needed, to verify the effectiveness of the decontamination procedures on nondedicated or reusable sampling equipment. For the groundwater monitoring program, equipment blanks were collected from the final rinse water that was generated during decontamination.

A *trip blank* is provided with each shipping container of samples to be analyzed for volatile organic compounds (VOCs). Analysis of trip blanks shows whether a sample bottle was contaminated during shipment from the manufacturer, while in bottle storage, in shipment to the laboratory, or during analysis at a lab. For the Groundwater Monitoring Program, trip blanks consist of an aliquot of distilled water sealed in a sample bottle, prepared either by the analytical laboratory prior to shipping the sample bottles to BNL or by field sampling personnel. Under the Groundwater Monitoring Program, trip blanks were included with all shipments of aqueous samples for VOC analysis.

Field blanks were collected to check for cross-contamination that might occur during sample collection. For the Groundwater Monitoring Program, one field blank was collected for every twenty samples, or one per sampling round, whichever was more frequent. On any given day, the field blanks were analyzed for the same parameters as the groundwater samples.

Contaminants in trip, field, and equipment blanks included methylene chloride, acetone, toluene, and phthalate esters. When these contaminants were detected, validation and/or verification procedures were used, where applicable, to qualify the associated data as nondetects, as described in procedures EM-SOP-203 through 211 (see Section 9.4). The results from blank samples collected during 2001 did not indicate any significant impact to the quality of groundwater results. Typically, the only compounds detected in the blanks were toluene, chloroform, methylene chloride, and acetone. These compounds are commonly detected in blanks and do not pose significant problems with the interpretation of the analytical results.

Field duplicate samples were analyzed to check the reproducibility of sampling and analytical results. For the Groundwater Monitoring Program, duplicates were collected for 5 percent of the total number of samples collected for a project per sampling round. Table F-1 in Appendix F summarizes the number of field duplicate samples collected during 2001 that were acceptable for input into the Environmental Information Management System (EIMS) database. Field duplicate acceptability was based on EPA Region II guidelines (EPA 1996).

The relative percent difference for concentrations above the contract reporting limits is required to be less than 20 percent between the sample and the duplicate (see Section 9.6.3 for more information on the relative percent difference statistic). Although there were several instances where individual compounds did not meet the 20 percent relative percent difference limit, the overall list of parameters analyzed for those samples did meet the 20 percent requirement. This indicated that the field sampling personnel and the laboratories were performing the sampling analyses at a consistently high level of quality.

Matrix spike and *matrix spike duplicates* for organic analyses were performed to determine whether the sample matrix adversely affected the sample analysis. Matrix spikes are used to evaluate the effect of the sample matrix on the accuracy of a specific analysis and to evaluate the precision of a specific analysis. They were performed at a rate of approximately one per twenty samples collected per project. For groundwater samples, no significant matrix effects were observed.

Several results for media other than groundwater were considered suspect after field quality control sample results were evaluated. These specific instances are discussed in detail in Chapters 3 through 8.

9.2.3 Tracking and Data Management

9.2.3.1 Sample Tracking

Most Environmental Monitoring Program samples and analytical results were tracked in the Environmental Information Management System. Tracking was initiated when a sample was recorded on a COC. Copies of the COC form and supplemental forms were provided to the project manager or the sample coordinator and forwarded to the data coordinator to be entered into the EIMS. Each analytical laboratory also maintains its own internal sample tracking system.

9.2.3.2 Data Management

Data management procedures are in place to govern tracking, validation, verification, and distribution of the analytical data. When samples were shipped to an analytical laboratory, COC information was entered into the EIMS. Following sample analysis, the laboratory provided the results to the project manager or designee and, when applicable, to the validation subcontractor in accordance with their contract.

9.2.3.3 Distribution of Analytical Data

Once data were entered into the Environmental Information Management System, reports were generated by one of two means. Project personnel and DOE-Brookhaven Area Office staff have a data query tool that allows access to all analytical sample results and printed reports. If a project required a special report format, the data management group was contacted to design and print it.

9.3 SAMPLE ANALYSIS

Environmental samples were analyzed either by the on-site BNL Analytical Services Lab (ASL) or by one of four contractor laboratories, whose selection is discussed in Section 9.3.2.

All samples were analyzed according to EPA-approved methods, where such methods exist. Where no EPA-approved methods exist, standard industry methods were approved by BNL personnel. In addition, sampling technicians performed field analyses of certain wastewaters for residual chlorine and pH.

Samples sent off site for radiological analyses were those requiring methods (either EPA or DOE) that ALS does not perform, such as actinide analyses in soil, vegetation, animal tissue, and water. Most samples used to verify compliance with permitting requirements were sent off site, as were samples requiring semivolatile organic analysis or the toxicity characteristic leachate procedure (TCLP). In addition, when demand exceeded ASL capacity, some samples to be tested for strontium-90, metals, and polychlorinated byphenyls (PCBs) were sent to a contractor laboratory.

9.3.1 ASL Qualifications

BNL's ASL performs approximately 5,000 radiological and nonradiological (chemical) analyses per year on environmental samples to support both environmental monitoring and facility operations. The ASL is certified by the New York State Department of Health (NYSDOH) for tritium, gross alpha/beta, and gamma in potable and nonpotable water analysis in several matrices, all of which are approved EPA methods.

9.3.2 Contractor Lab Qualifications

BNL procured and maintained contracts with the following off-site laboratoriess:

- General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes
- H2M Lab in Melville, New York, for nonradiological analytes
- Severn-Trent Lab (STL) in Monroe, Connecticut and St. Louis, Missouri, for radiological and nonradiological analytes
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes.

The process of selecting contractor laboratories involves a number of factors: 1) their record on proficiency evaluation (PE) tests, 2) preselection bidding, 3) post-selection auditing, and 4) their adherence to their own QA/QC programs. Once a contract has been awarded, the laboratory must follow the QA requirements and analytical and QC requirements in the BNL Statement of Work. Routine QC procedures that labs must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. All the analytical labs that BNL uses are certified by NYSDOH for the relevant analytes. The laboratories also are subject to PE testing (Section 9.7) and audits (Section 9.8).

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject either to data verification or data validation performed in accordance with established procedures, when the data quality objectives of the project require this step. The data verification process involves checking for common errors associated with analytical data. The following criteria cause data to be rejected during the data verification process:

- *Holding time missed* - The analysis was not initiated or the sample was not extracted within the time frame required by EPA or by the contract.

- *Incorrect test method* - The analysis was not performed according to a method required by the contract.
- *Poor recovery* - The compounds or radioisotopes added to the sample prior to laboratory processing were not recovered at the recovery ratio required by the contract.
- *Insufficient QA/QC data* - Supporting data received from the analytical laboratory were insufficient to allow validation of results.
- *Incorrect minimum detection limit (MDL)* - The laboratory reported extremely low levels of analytes as "less than minimum detectable," but the contractually required limit was not used.
- *Invalid chain-of-custody* - There was a failure to maintain proper custody of samples, as documented on chain-of-custody forms.
- *Instrument failure* - The instrument did not perform correctly or was broken.
- *Preservation requirements not met* - The requirements identified by the specific analytical method were not met or properly documented.
- *Contamination of samples from outside sources.*
- *Matrix interfaces.*
- *Incomplete data package or report*.

Data *validation* is a more exhaustive process that includes all the verification checks as well as checks for less common errors, including calibration that was not conducted as required, internal standard errors, transcription errors, and calculation errors.

The amount of data that is checked varies, depending on the environmental media and on the data quality objectives for each project. Data for some projects, such as long-term groundwater monitoring, may be verified only. Data from initial investigations receive the more rigorous validation testing, performed on 20 percent to 100 percent of the analytical results. The results of the verification or validation process are entered into the EIMS.

9.4.1 Verifying and Validating ASL Results

For samples analyzed by Brookhaven's Analytical Services Lab in 2001, the QA officer or group leader verified that all analytical batches fulfilled internal QA/QC acceptance criteria. These criteria, which include precision, accuracy, recovery, instrument background checks, and stable instrument efficiency performance, are fully described in ASL's *QA Program Plan* (BNL 1999c). All QA/QC data were reviewed before ASL results were reported.

9.4.2 Verifying and Validating Off-Site Results

A subject matter expert in either radiological analyses or analytical chemistry reviewed a percentage of the 2001 results from off-site labs. Nonradiological data analyzed off site were verified and validated using EPA Contract Laboratory Program guidelines (EPA 1992, 1996). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 1997, DOE 1994).

9.5 ANALYTICAL LABORATORY QA/QC

Sample results for environmental restoration and environmental surveillance were analyzed by the on-site BNL lab ASL, or by one of the off-site contract labs: STL, GEL, or H2M.

For ASL analyses, procedures for calibrating instruments, analyzing samples, and assessing quality control (Appendix D) are consistent with EPA methodology. QC checks that were performed include analyzing blanks and instrument background; using Amersham Radiopharmaceutical Company or National Institute for Standards and Technology (NIST) traceable standards; and analyzing reference standards, spiked samples, and duplicate samples. The ASL supervisor, QA officer, or group leaders reviewed all ASL analytical and QA results before data were reported. More details of the ASL QA program are in Section 9.6.

Off-site contractor laboratories that perform radiological and chemical analyses for BNL also are required to maintain stringent QA programs. Their contracts specify analytes, methods, required detection limits, and deliverables—which include standard batch QA/QC performance checks. As part of the contract lab selection process, contract labs were required to provide BNL with copies of their QA/QC manuals, as well as their QA program plans.

A nonconformance report was generated when discrepancies were found in field sampling designs, documented procedures, chain-of-custody forms, data analyses, data processing systems, QA software, or when failures in PE testing occurred. Following an investigation into the root cause, corrective actions were made and tracked to closure.

9.6 ASL INTERNAL QUALITY ASSURANCE PROGRAM

This section further describes the QA requirements for analytical activities conducted as part of the 2001 BNL Environmental Monitoring Program, and the results of QA checks. ASL's nonradiological chemical group is certified by the NYSDOH Environmental Laboratory Approval Program (ELAP) to perform analyses utilizing EPA Methods 524 and 624 for volatile organic analytes, in potable and wastewaters, respectively. Thirty-seven VOCs are currently provided for analysis with Method 624 (for ground and wastewaters), an additional 26 new analytes since 1998. EPA Method 524 (for potable water) includes 63 organic analytes and was a new addition to ASL's capabilities. Metals are analyzed utilizing both atomic absorption spectroscopy and inductively coupled plasma/mass spectroscopy by EPA methods. ASL is certified for analyses of 17 metals (the entire ELAP list) in potable water as well as 21 metals in wastewater. Certification for three anions has been established for potable and wastewaters using EPA Method 300.

In May 1999, ASL issued its own *QA Program Plan* (BNL 1999c) following EPA Region II guidelines (EPA 1998). Twenty-five internal operating procedures maintained by ASL were also revised in 2000 and into 2001. The QA procedures followed at ASL include daily instrument calibrations, efficiency and background checks, and routine tests for precision and accuracy. A detailed description of these activities can be found in the document titled *Year 2001 Quality Assurance Report of the Analytical Services Laboratory* (Scarpitta and Heotis 2002). A brief summary of that report follows.

9.6.1 Radiological Instrument Calibrations

ASL operates eight high-purity germanium gamma detectors. Each detector was calibrated daily for energy and instrument efficiency using a NIST-traceable cesium-137 standard. Geometry efficiency calibrations are performed annually. Efficiency is the measure by which radiological decaying events are converted into observable counts (counts per minute). During 2001, all eight gamma detectors performed well within the EPA acceptance limit of 1 keV of the 662 keV centroid peak.

ASL operates two gross alpha/beta (GAB) detectors and two liquid scintillation spectrometers for tritium. Instrument background and count-time are used to determine the "minimum detection limit" (MDL) of a radiological analyte. In 2001, there was no unusual drift or variability in instrument background for alpha, beta, and tritium, based on the mean background count-rates (and one standard deviation) values. Instrument efficiencies were determined daily, using a calibration standard, and averaged for the calendar year.

9.6.2 Upgrades

The following upgrades, improvements, or repairs were made within the ASL in 2001. In February 2001, the gamma spectroscopy system was shut down for backup and the computer disk drive was replaced. The system was reconfigured and calibrated using a mixed gamma radionuclide particulate standard. Two sigma uncertainties were reported for gamma results, where previously, one sigma uncertainty was reported. In July, one of eight gamma detectors was sent to the manufacturer for repairs and returned to service in August.

In June, one of the alpha/beta units was taken out of service for approximately two weeks due to a sensor that needed replacement.

A new liquid scintillation counter (LSC) was purchased, replacing an older unit. New quench curves were generated for both units after a new tritium standard was acquired and a QSMART Upgrade Kit was installed on one of the two LSC units. The computer, monitor, and printer were also replaced. A tritium adjustment factor was applied to all tritium data in 2001, resolving the bias problem described in Section 9.6.3.2.

9.6.3 Accuracy and Precision

Accuracy is the percent difference between a measured value and its known (expected) value. Precision is the percent difference between two measured values. The measure of batch precision is the "relative percent difference" statistic. This is defined as the absolute difference between two results, divided by the average of both results, multiplied by 100. Typically, a radioactive tracer solution (*i.e.*, "spike") is added to either a routine sample or tap water sample as a means of determining both precision and accuracy. In the case of nonradiological analyses, the spike is a known amount of a given analyte added to a sample and the accuracy is stated as "percent recovery": the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

9.6.3.1 Gross Alpha/Beta

For gross alpha/beta, the relative percent difference was determined for each batch of analyses performed. Tap water was spiked with known amounts of americium-241 (for alpha) and strontium/yttrium-90 (for beta) in order to determine batch precision. The acceptance criterion for batch precision is a relative percent difference less than 20 percent (for activity concentrations that are five times greater than the method MDL). During 2001, gross alpha/beta batch precision for all 268 batches tested was within the acceptable range; there were no rejected batches.

9.6.3.2 Tritium

Tritium precision was determined for 334 batches processed in 2001. ASL utilizes three sampling protocols for differing sample volumes (*i.e.*, 7 mL distilled, 7 mL undistilled, and 1 mL undistilled). A negative 20 percent tritium bias was observed beginning in the last quarter of CY2000 and into part of CY2001 for the distilled 7 mL tritium using EPA Method 906.0. This bias was not evident in the 1-mL tritium analyses. All internal QA/QC records and logs were reviewed and the primary cause of the problem was eventually isolated. The six-month investigation revealed that differences in scintillation reagent accounted, in part, for most, but not all, of the observed bias. After a new tritium standard was purchased and new quench curves prepared, a negative 10 percent bias still persisted into CY2001. A new LSC was purchased in the spring of 2001 and the bias was still about negative 11 percent.

Since no root cause of the negative 11 percent bias was discovered, the ASL adjusted all 7-mL tritium results for the bias of the day, regardless of instrument. Blind proficiency evaluation test scores for tritium were satisfactory. There were no rejected batches for tritium in 2001.

9.6.3.3 Strontium-90

The eight batches of strontium-90 processed in 2001 all met standard precision and accuracy requirements. There were no rejected batches.

9.6.4 Nonradiological Organic and Inorganic Analyses

Method precision was determined for 14 volatile organic compounds, 3 anions (discussed below), and 21 metals processed by ASL in 2001. With the exception of 3 metals, all analytes had relative percent differences within ASL's internal acceptance limit of ± 20 percent. The three standard deviation uncertainties were also within the EPA acceptance criteria.

ASL has an internal QC program for the ion chromatography, ICP/MS, and atomic absorption methods used for inorganic analyses. Several QC checks were performed for each batch of metals and anions. For the 21 certified metals analyzed by ASL, beryllium, zinc, and aluminum exceeded the three standard deviation EPA acceptance criteria for recovery. For these three metals, this was attributable to a single daily excursion that resulted in an overall three-sigma standard deviation value that was higher than acceptable. For this reason, analytical data for aluminum, zinc, and beryllium for the months in question were "qualified" but still usable.

ASL has an internal QC program for the gas chromatography/mass spectroscopy method used for 14 primary VOCs. Recoveries and 99 percent confidence intervals were determined for 69 independent VOC batches. Average recoveries for all of the 14 analytes were within their target ranges of ± 25 percent for both EPA 524.0 and EPA 624.0 methods.

The 99 percent confidence intervals for surrogate recoveries were also determined for four analytes in 2001. The recovery for 4-bromofluorobenzene, toluene, and dibromo-fluoromethane were within three-sigma acceptance criteria. All surrogate recoveries were within EPA acceptance limits.

9.7 PROFICIENCY EVALUATION TESTING

As in prior years, ASL and three contractor laboratories (GEL, STL, and H2M) participated in several national and state proficiency evaluation testing programs. Results of those PE tests provide information on the quality of a laboratory's analytical capabilities.

During 2001, ASL, GEL, STL, and H2M participated in either the NYSDOH ELAP (for radiological and nonradiological proficiency evaluation testing) or the DOE Environmental Measurements Laboratory (EML) Quality Assessment Program (for radiological PE testing only). These laboratories participated in at least one proficiency evaluation program, although several labs participated in multiple programs. The results from these blind, independent tests are discussed in Section 9.7.1.

Effective December 21, 1998, EPA terminated its PE programs for both radiological and nonradiological analytes. To replace that program, ASL chose Environmental Resource Associates (ERA), a private, independent PE program.

PE test data are not presented in this report for the fourth contractor, Chemtex Laboratory, because there are no ERA or NYSDOH PE testing programs for the specific analytes analyzed by this laboratory. Chemtex performed four chemical analyses for BNL on the following analytes: dibromo-nitrilo-propionamide, tolytriazole, polypropylene-glycol-monobutyl-ether, and 1,1-hydroxyethylidene-diphosphonic acid.

9.7.1 Summary of Test Results

During 2001, ASL's (BNL's) scores on radiological PE tests in the NYSDOH ELAP and DOE EML program were 100 percent and 95.3 percent "Overall Satisfactory," respectively. BNL's off-site contractor laboratory for radiological work, GEL, scored 100 percent in both programs. In the voluntary ERA radiological program, BNL and GEL achieved scores of 91.3 percent and 96 percent, respectively.

For nonradiological results, the Overall Satisfactory results ranged from 86 percent to 99 percent for BNL, H2M, GEL, and STL in both the ERA and NYSDOH testing programs.

BNL's combined score of 96 percent Overall Satisfactory on the 593 radiological and nonradiological PE tests performed in 2001 is considered excellent.

Figures 9-2 and 9-3 summarize the 2001 scores of BNL's ASL and the three contractor laboratories that participated in the mandatory DOE EML program (for radiological analytes only) and the NYSDOH ELAP, as well as the voluntary ERA program. The bar graphs of Figures 9-2 and 9-3 summarize all tabulated radiological and nonradiological results (as percentage scores) that were "Acceptable," "Warning (But Acceptable)," or "Not Acceptable," for each analytical laboratory, by PE test program. A Warning is considered "Satisfactory," being within two and three standard deviations of the target value. (An "Overall Satisfactory" score is the sum of results rated as Acceptable and those rated as Warning, divided by the total number of results reported.) A "Not Acceptable" rating reflects a result that is greater than three standard deviations of the target value. Tabulated results are presented in Appendix F and described in detail in Sections 9.7.2 and 9.7.3.

9.7.2 Radiological Assessments

Both ASL and GEL participated in the DOE EML Quality Assessment Program, the NYSDOH ELAP, and the ERA program. Results are detailed in Appendix F, Tables F-2 through F-4, and discussed below.

9.7.2.1 Table F-2: EML Radiological Results

Overall, ASL's performance in the EML program was satisfactory in 95.3 percent of the analyses performed on four matrices (air, vegetation, water, and soil). Thirty-six of 43

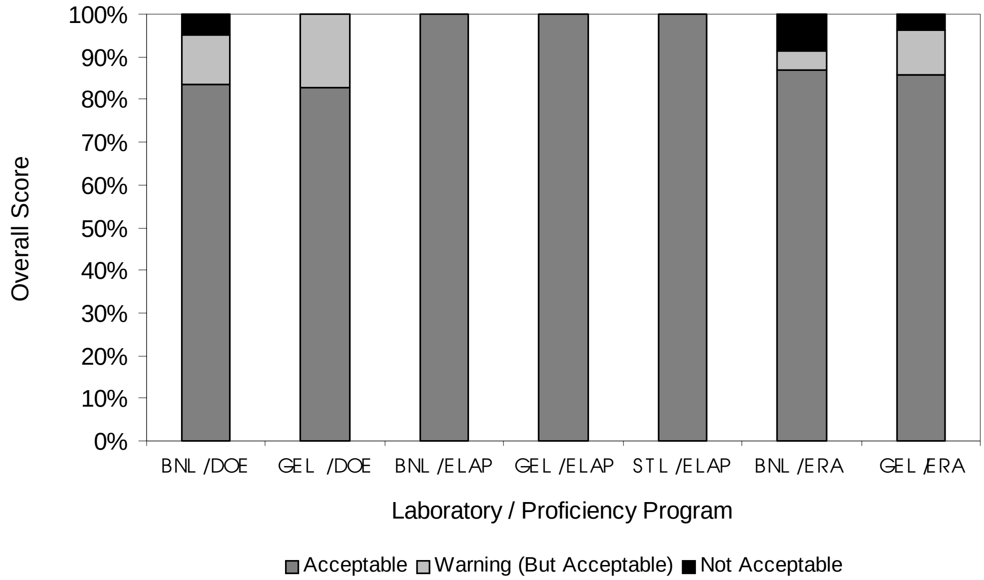

Figure 9-2. Radiological Results Summarized: Labs' Scores in US DOE/EML, NYSDOH ELAP, and ERA PE Programs for 2001.

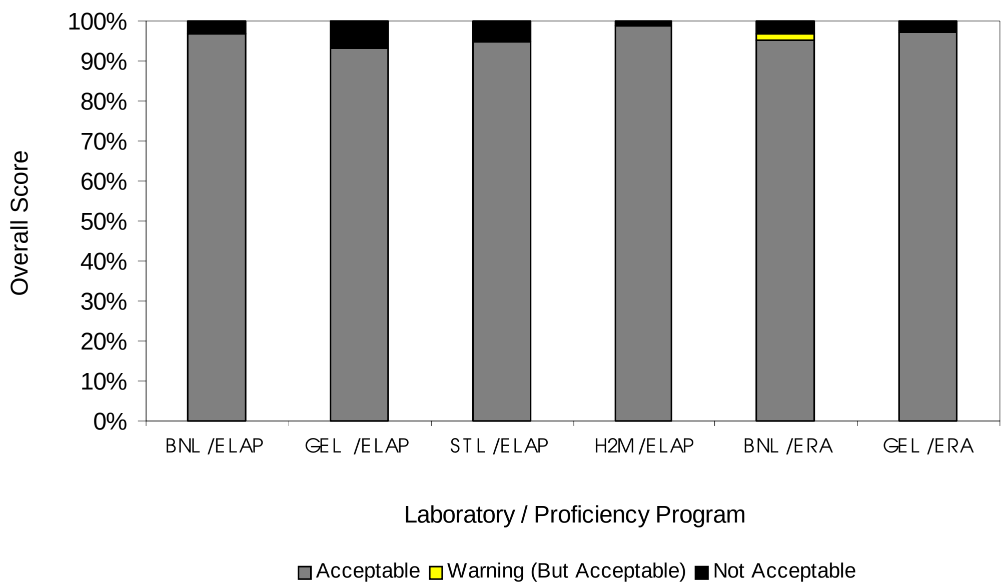

Figure 9-3. Nonradiological Results Summarized: Labs' Scores in NYSDOH ELAP and ERA PE Programs for 2001.

analyses (83.7 percent) were within established DOE EML limits, showing "Acceptable" agreement with the known value. Five results (11.6 percent) were within "Warning" limits, also earning satisfactory status. Two analyses (4.7 percent) fell outside the acceptance limits. The two results that were unacceptable (gross alpha only) occurred in different rounds of testing. The ASL passed gross alpha and beta testing in both the ELAP and the ERA programs and maintained state certification. An investigation is ongoing as to the reason for the two isolated EML failures.

Table F-2 also presents GEL's performance, which was satisfactory (Acceptable or within Warning limits) in 100 percent of the analyses performed on the four matrices (air, vegetation, water, and soil). Seventy-two of 87 analyses (82.8 percent) were within EML's acceptance limit; 15 of 87 analyses (17.2 percent) were within upper and lower warning limits, demonstrating satisfactory agreement; no analyses fell outside the acceptance limits.

9.7.2.2 Table F-3: ELAP Radiological Results

ASL's radiological results for the NYSDOH ELAP program were in 100 percent agreement for the four analyses. STL and GEL also had Overall Satisfactory scores of 100 percent on the eight analytes shown in Table F-3.

9.7.2.3 Table F-4: ERA Radiological Results

ASL and GEL participated in the ERA radiological performance evaluation studies, shown in Table F-4. ASL's overall score for the 23 results reported in 2001 was 91.3 percent, with two unacceptable gamma results (Co-60 and Cs-137). These failures occurred while the ASL gamma system was undergoing upgrades, as described in Section 9.6.2. GEL's overall score in the ERA radiological PE studies was 96.4 percent for 28 analytes.

9.7.3 Nonradiological Assessments

During 2001, ASL, GEL, STL, and H2M participated in the NYSDOH ELAP, which certifies laboratories that test for nonpotable water, potable water, and solid wastes. The results of this evaluation are summarized in Tables F-5 through F-7 for each of the four laboratories (note that STL has two labs: one in Missouri and one in Connecticut). Although participation in the ERA water supply and water pollution studies is not required for New York State certification, ASL and GEL also participated in the ERA evaluation; results are presented in Table F-8.

9.7.3.1 Table F-5: ELAP Nonpotable Water Results

Table F-5 shows results for the NYSDOH ELAP for nonpotable water. Of the 139 results reported for ASL, there were four cases of "Unsatisfactory," earning ASL an Overall Satisfactory score of 97.1 percent. GEL's results for 499 analytes included 22 instances of "Unsatisfactory," leading to a score of 95.6 percent. H2M reported 531 results with eight Unsatifactory results, scoring 98.5 percent. STL's Missouri lab reported 520 results and scored 93.5 percent; the Connecticut lab reported 354 results and scored 97.1 percent.

9.7.3.2 Table F-6: ELAP Solid and Hazardous Waste Chemistry

Table F-6 shows results for the NYSDOH ELAP Solid and Hazardous Waste Chemistry Proficiency Program for BNL's ASL only. ASL scored 100 percent in this category for the 13 results reported.

9.7.3.3 Table F-7: ELAP Potable Water Results

Table F-7 summarizes results of the potable water category of the NYSDOH ELAP. Brookhaven's ASL reported 146 results with five Unsatisfactorys, earning an Overall Satisfactory score of 96.6 percent. GEL reported 176 results with 23 Unsatisfactorys, scoring 86.9 percent. H2M reported 211 results with seven Unsatisfactorys, generating a score of 96.7 percent. STL (Missouri) reported 219 results with 12 Unsatisfactorys, scoring 94.5 percent.

9.7.3.4 Table F-8: Voluntary ERA PE Studies

GEL and Brookhaven's ASL participated in the voluntary ERA water pollution and water supply performance evaluation studies, as shown in Table F-8. For these studies combined, ASL reported 233 results: 223 Acceptables, two within warning limits ("Check for Error"), and eight "Not Acceptables." The Overall Satisfactory score for ASL in ERA's water supply and water pollution studies was 96.6 percent. GEL reported 320 results, with 311 Acceptables, two Check for Errors, and seven Not Acceptables. GEL's score in these voluntary PE studies was 97.8 percent.

9.8 LABORATORY AUDITS

In addition to PE testing, BNL conducts a program of internal and external audits to verify the effectiveness of the environmental sampling, analysis, and database activities. Contractor laboratories were subject to audits by BNL personnel at the time of contract renewal. To verify competence in analytical methodology and implementation of a comprehensive QA program, the contractor laboratories are also audited periodically by ASL, the Quality Programs and Services Office, or the Environmental Restoration Program staff.

ASL audited GEL and H2M during contract renewal and bid processes in the spring of 2000; there were no significant findings. An audit of Chemtex is planned for late 2002 when the existing contract expires.

A three-day audit of Brookhaven's ASL was conducted in the spring of 2001 by NYSDOH using the U.S. EPA National Environmental Laboratory Accreditation Program (NELAP) guidelines. The NELAP audit follows a checklist of more than 250 items that can be viewed at http://www.epa.gov/ttnnela1/checklst.html. Analytical labs performing environmental measurements must be certified by the state to this EPA program or risk losing state certification.

Prior to the audit, ASL was required to prepare a *Quality Manual* using the NELAP guidelines. The ASL passed the NELAP audit without qualifications. There were four recommendations for corrective action. Two recommendations related to record-keeping issues (*i.e.*, maintaining logbooks), one recommendation was for an update on the ASL tritium SOP, and one recommendation was for improvement in uniquely identifying sample bottles listed on the BNL Chain-of-Custody Form. The first three items were rectified within two months of the audit and a revision was made to the BNL COC Form to satisfy the last item.

The Quality Programs and Services Office, DOE Brookhaven Group, DOE Chicago Operations, regulatory agencies, and other independent parties also periodically audit BNL environmental programs, as discussed in Chapters 2 and 3.

9.9 CONCLUSIONS

Detailed data on quality control results for all analyses conducted at BNL's ASL are presented in ASL's *Year 2001 QA Report* (Scarpitta and Heotis 2002). The report presents tables and figures depicting instrument calibration, efficiency, background checks, precision, and accuracy testing. Overall, QC checks were consistently within the EPA guidelines of ± 20 percent.

Detailed data on external performance evaluation testing for the ASL and the three BNL contractor laboratories are also presented in the *Year 2001 QA Report*. Overall, the three laboratories reporting radiological analytical data in the *Site Environmental Report 2001* (ASL, STL, and GEL) had combined satisfactory results of 94 percent, 100 percent, and 100 percent, respectively, in both state and federal performance evaluation programs. For nonradiological performance evaluation testing, ASL and the three BNL contractor laboratories (H2M, GEL, and STL) all scored better than 92 percent in the NYSDOH ELAP evaluations. BNL's combined Overall Satisfactory score of 96 percent on the 593 radiological and nonradiological PE tests performed in 2001 is considered excellent.

Based on implementation and evaluation of the QA/QC program, it can be concluded that the analytical data reported in the *2001 Site Environmental Report* are reliable and of high quality.

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