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DRAFT REGULATORY GUIDE

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DRAFT REGULATORY GUIDE DG-1186

(Proposed Revision 2 of Regulatory Guide 1.21)

MEASURING, EVALUATING, AND REPORTING RADIOACTIVE MATERIAL IN LIQUID AND GASEOUS EFFLUENTS AND SOLID WASTE

A. INTRODUCTION

This guide describes a method the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in measuring, evaluating, and reporting radioactivity in effluents and solid radioactive waste shipments. The regulatory guide also provides guidance on determining and reporting the public dose from nuclear power plant operations. The regulatory basis for the radiological effluent control program is established in:

1. Title 10, Section 20.1501, "Surveys," of the *Code of Federal Regulations* (10 CFR 20.1501) (Ref. 1);
2. 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors" (Ref. 2);
3. 10 CFR 20.1302, "Compliance with Dose Limits for Individual Members of the Public," and
4. 10 CFR 72.44(d), "License Conditions."

10 CFR 20.1501 requires surveys that may be necessary and are reasonable to evaluate the magnitude and extent of potential radiological hazards. 10 CFR 20 defines "survey" as an evaluation of the radiological conditions and potential hazards related to radioactive material or other sources of radiation, including

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This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received final staff review or approval and does not represent an official NRC final staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rulemaking, Directives, and Editing Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; emailed to nrcrep.resource@nrc.gov; submitted through the NRC's interactive rulemaking Web page at http://www.nrc.gov; faxed to (301) 415-5144; or hand-delivered to Rulemaking, Directives, and Editing Branch, Office of Administration, US NRC, 11555 Rockville Pike, Rockville, MD 20852, between 7:30 a.m. and 4:15 p.m. on Federal workdays. Copies of comments received may be examined at the NRC's Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by December 30, 2008.

Electronic copies of this draft regulatory guide are available through the NRC's interactive rulemaking Web page (see above); the NRC's public Web site under Draft Regulatory Guides in the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/doc-collections/; and the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML080660617.

(1) a physical survey of the location of radioactive material and (2) measurements or calculations or levels of radiation or concentrations or quantities of radioactive material present. 10 CFR 50.36a requires the use of plant technical specifications and operating procedures to keep radioactive effluents as low as reasonably achievable (ALARA) per the numerical design guidance of 10 CFR 50 Appendix I. 10 CFR 50.36a also requires reporting (1) the quantity of each of the principal radionuclides released to unrestricted areas in liquid and gaseous effluents and (2) other information used to estimate the maximum potential annual radiation doses to the public from radioactive effluents. 10 CFR 20.1302, establishes requirements for surveys in the unrestricted and controlled areas and for radioactive materials in effluents released to unrestricted and controlled areas. The purpose of these surveys is to demonstrate compliance with (1) the (TEDE) dose limits of 10 CFR 20.1301 (e.g., 100 mrem/year) for individual members the public. Although 10 CFR 20.1302(b)(2) provides a second method of demonstrating compliance with dose limits for individual members of the public, nuclear power plant Technical Specifications essentially require use of method 10 CFR 20.1302 (b)(1) to determine the TEDE to the individual likely to receive the highest dose. This requirement is based on actual, credible exposure pathways to a real individual that has been located during a land use census. (See also Regulatory guide 1.109 and Attachment 6 of SECY-03-0069) In addition, 10 CFR 72.44(d) establishes requirements for the independent spent fuel storage installation (ISFSI), high level nuclear waste, and reactor-related greater than class "C" waste. This regulatory guide describes methods for implementing these requirements for all fuel cycle activities (i.e., fuel storage and plant operation) at a commercial nuclear power plant.

The reports required under (1) Subpart M, "Reports," of 10 CFR Part 20, "Standards for Protection Against Radiation," (2) 10 CFR 50.72, "Immediate Notification Requirements for Operating Power Reactors," and (3) 10 CFR 50.73, "Licensee Event Report System," or other licensee requirements must be made in accordance with the applicable regulations. In addition, effluent discharges and radioactive material losses reported under those regulatory provisions should also be reported in the ARERR described in this regulatory guide.

The NRC issues regulatory guides to describe methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with them is not required. The methods and practices outlined in regulatory guides are one acceptable method for implementing the regulations. Licensees may use other methods, but in those cases, additional written justifications or evaluations may be necessary to demonstrate compliance with the regulations. Because of this, the use of terms such as "shall," "must," and "should" in this regulatory guide should be viewed in the context of emphasis rather than regulatory compliance.

This regulatory guide contains information collections covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

1. Regulatory Guidance

Five basic documents contain the regulatory guidance for implementing the 10 CFR Part 20 regulatory requirements and plant technical specifications related to monitoring and reporting of radioactive material in effluents and environmental media, solid radioactive waste disposal, and resultant public dose:

(1) Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants" (Ref. 3)

(2) Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants" (Ref. 4)

(3) Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination)—Effluent Streams and the Environment," (Ref. 5)

(4) NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," (Ref. 6)

(5) NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors," (Ref. 7)

These five documents, when used in an integrated manner, provide the basic principles and implementation details for developing and maintaining effluent and environmental monitoring programs at nuclear power plants. The three regulatory guides specify the principles of radiological monitoring, and the two NUREGs provide the specific implementation guidance for baseline monitoring programs.

Regulatory Guide 1.21 addresses the measuring, evaluating, and reporting of effluent releases, solid radioactive waste, and public dose from nuclear power plants. It describes the important concepts in planning and implementing an effluent and solid radioactive waste program. Concepts covered include meteorology, release points, monitoring methods, identification of principal radionuclides, unrestricted area boundaries, continuous and batch release methods, representative sampling, composite sampling, radioactivity measurements, decay corrections, quality assurance (QA), solid radioactive waste shipments, and public dose assessments.

Regulatory Guide 4.1 addresses the environmental monitoring program. It discusses principles and concepts important to environmental monitoring at nuclear power plants. The regulatory guide addresses the need for preoperational and background characterization of radioactivity. It also addresses onsite and offsite monitoring, including the principal exposure pathways and the significant exposure pathways. The guide defines the principal exposure pathways, the program scope of sampling media and sampling frequency, and the methods of comparing environmental measurements to effluent releases in the annual environmental report.

Regulatory Guide 4.15 provides the basic principles of QA in all types of radiological monitoring programs. It does not specifically address nuclear power plants but covers all types of licenses and licensees. It provides the principles for structuring organizational lines of communication and responsibility, using qualified personnel, implementing standard operating procedures, defining data quality objectives, performing quality control (QC) checking for sampling and analysis, auditing the process, and taking corrective actions.

NUREG-1301 and NUREG-1302 provide the detailed implementation guidance by describing baseline effluent and environmental monitoring programs. The NUREGs specify effluent monitoring and environmental sampling requirements, surveillance requirements for effluent monitors, types of monitors and samplers, sampling and analysis frequencies, types of analysis and radionuclides analyzed, lower limits of detection (LLDs), specific environmental media to be sampled, and reporting and program evaluation and revision.

2. Objectives of the Radiological Effluent Control Program

The requirements for the radiological effluent control program (RECP) are in 10 CFR Part 20 and 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents." Specific requirements described in a facility's technical specifications (TS), in conjunction with the regulatory positions provided in this guide, can be used as a basis for establishing the radiological effluent control program. The radiological effluent control program for a nuclear power plant has the following six basic objectives:

(1) Ensure that effluent instrumentation has the functional capability to measure and evaluate effluent releases

(2) Ensure that effluent treatment systems are used to reduce effluent releases to as low as is reasonably achievable (ALARA) levels

(3) Establish instantaneous release rate limitations on the concentrations of radioactive material

(4) Limit the annual and quarterly doses or dose commitment to members of the public in liquid and gaseous effluents to unrestricted areas

(5) Measure, evaluate, and report the quantities of radioactivity in gaseous effluents, liquid effluents, and solid radioactive waste

(6) Evaluate the dose to members of the public

The radioactive effluent release report, submitted annually prior to May 1 (unless a licensing basis exists for a different submittal date), in conjunction with the annual radiological environmental operating report submitted annually by May 15, are used to demonstrate compliance with TS for the radioactive effluent control program. The reports demonstrate the following:

(1) Effectiveness of effluent controls and measurement of the environmental impact of radioactive materials

(2) Compliance with the design objectives and limiting conditions for operation required to meet the ALARA criteria in Appendix I to 10 CFR Part 50

(3) Relationship between quantities of radioactive material released in effluents and resultant radiation dose to individuals from principal pathways of exposure

(4) Compliance with the radiation dose limits to members of the public established by the NRC and the U.S. Environmental Protection Agency (EPA)

(5) Compliance with the effluent reporting requirements of 10 CFR 36a

Licensees may also – if they so choose – use the format specified in this regulatory guide for 10 CFR 72.44(d) ISFSI effluent reports. However, the ISFSI effluent reporting requirement of 10 CFR 72.44(d) is not normally satisfied by inclusion as part of the ARERR since the reporting dates may conflict. If the dates are coincident, or can be met with a single report, the 10 CFR 72.44(d) reporting requirements may be fulfilled using the ARERR.

C. REGULATORY POSITION

1. Effluent Monitoring

Guidance for Effluent Monitoring – Monitoring programs should be established to identify and quantify specific radionuclides in effluents. NUREG-1301 (for pressurized-water reactors (PWRs)) and NUREG-1302 (for boiling-water reactors (BWRs)) specify the generic controls and surveillance requirements, including the frequency, duration, and methods of measurement. Site-specific requirements may differ from the generic NUREG-1301/1302 guidance provided there is either a documented evaluation or justification for such deviations as part of an ODCM authorized change, or if submitted as part of the original offsite dose calculation manual (ODCM) in accordance with Generic Letter 89-01 and approved by the NRC. These NUREGs provide specifications for LLDs, requirements for batch releases and continuous releases, sampling frequencies, analysis frequencies and timelines, and composite sample requirements.

Release Points for Effluent Monitoring – The ODCM should identify the facility's release points, that are used to quantify the liquid and gaseous effluent releases to the onsite and offsite environs. For those release points containing contributions from two or more inputs (or systems), it is preferable to monitor each major input (or system) individually to avoid dilution effects which may impede or prevent radionuclide identification. NUREG-1301/1302 contains detailed guidance for the content and format of a licensee's ODCM. For purposes of effluent monitoring the ODCM should contain and/or describe the following:

(a) Significant release points (see definition in glossary) (e.g., stacks, vents, liquid radioactive waste discharge points)

(b) Less significant or intermittent release points (see definition in glossary) (e.g., main steam-line safety valves, steam-driven feed water pumps, turbine building sources, storm drains, evaporative releases, leachate seepage and/or evaporative releases from ponds in the restricted or controlled areas before discharge under 10 CFR 20.2001, "General Requirements")

(c) Site environs map showing the following:

  i. significant release points

  ii. less significant or intermittent release points

  iii. boundaries of the restricted area and the controlled area (per 10 CFR Part 20 definitions)

  iv. boundary of the unrestricted area for liquid effluents (e.g., at the end of the pipe or entrance to a public waterway)

  v. boundary of the unrestricted area for gaseous effluents (e.g., the site boundary)

(d) Dose calculation methodologies for all significant exposure pathways that contribute in excess of 10% of the public dose from all effluent pathways combined.

The unrestricted area may be defined differently (and separately) for each of the following: (1) liquid effluents, (2) gaseous effluents, and (3) if appropriate, for other radiological controls such as direct radiation.

Monitoring a Significant Release Point – A release point is considered a significant release point if either (1) the dose is greater than or equal to 1% of the total from gaseous release points or liquid release points (considered separately), or (2) the activity (e.g., curies) is greater than or equal to 1% of the total effluent activity from gaseous release points or liquid release points (considered separately). Additionally, nuclides are totaled separately by the categories as listed in regulatory position 9.1.1 (e.g., fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha) and 9.2.1 (fission and activation products, tritium, dissolved and entrained noble gases, and gross alpha). Lastly, the summing intervals for dose and activity calculations are either quarterly, annually, each fuel cycle, or longer period as specified by the licensee.

Significant release points should be listed in the ODCM. Releases from a significant release point should be assessed based on an appropriate combination of actual sample analysis results, radiation monitor responses, flow rate indications, tank level indications, and system pressure indications as necessary to ensure the amount of radioactive material released and the corresponding doses are not substantially underestimated (see 10 CFR 50, Appendix I, Section III, "Implementation"). If activity is detected when monitoring a significant release point, it must be reported in the effluent totals (i.e., Table A-1 or Table A-2) in the ARERR (provided the amount released is significant to the 3 significant figures required for the ARERR).

Monitoring a Less-significant Release Point – A release point is considered a less-significant release point if both (1) the dose is less than 1% of the total from gaseous release points or liquid release points (considered separately), and (2) the activity (e.g., curies) is less than 1% of the total effluent activity from gaseous release points or liquid release points (considered separately). Additionally, nuclides are totaled separately by the categories as listed in regulatory position 9.1.1 (e.g., fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha) and 9.2.1 (fission and activation products, tritium, dissolved and entrained noble gases, and gross alpha). Lastly, the summing intervals for dose and activity calculations are either quarterly, annually, each fuel cycle, or longer period as specified by the licensee.

Less-significant release points are, to the extent reasonable, required to be listed in the ODCM. Releases from a less-significant or intermittent release point may be assessed to the extent reasonable using assumptions and bounding calculations (in lieu of, or in addition to, sampling and analysis). Sampling and analysis should occur, however, if changing plant conditions may reasonably affect the status of a less-significant release point (e.g., significant change is primary-to-secondary leakage in PWRs or substantial cross-contamination between systems). The guidance in this regulatory guide regarding monitoring less-significant release points for purposes of accountability (via the ARERR) does not replace, supersede, or otherwise modify any responsibility for monitoring systems, normally not contaminated, as outlined in NRC IE Bulletin 80-10 (Ref. 36). If monitoring a less-significant release point using actual samples (e.g., grab samples or composite sampling), principal radionuclides should be monitored in accordance with the predetermined and appropriate analytical sensitivity (e.g., LLD). If activity is detected when monitoring a less-significant release point, it must be reported in the effluent totals (i.e., Table A-1 or Table A-2) in the ARERR (provided the amount released is significant to the 3 significant figures required for the ARERR).

Monitoring Leaks and Spills -- Areas where leaks or spills have occurred should be identified as an "impacted area" for decommissioning purposes in accordance with NUREG-1757, "Consolidated Decommissioning Guidance," issued September 2006 (Ref. 10). A leak or spill should be assessed to estimate the parameters listed in regulatory position 9.5 (Supplemental Information). Sampling and analyses of the source of the leak (undiluted effluent) and sampling of soil and/or contaminated ground water should be performed if – and as soon as – practical. In some instances sampling, particularly soil sampling, may not be practical if the leak occurred in inaccessible areas, or if there are extenuating considerations. In this respect, groundwater monitoring may be used as a surrogate for soil sampling. If

sampling is not practical, this information (about the inaccessible areas or safety considerations) should be included in the 10 CFR 50.75(g) records. The leak/spill location should be estimated to identify the extent of the impacted area and predicted size or extent and movement of the contaminated plume. If a spill is promptly remediated (e.g., within 48 hours), and if surveys of the remediated area indicate no detectable residual contamination remaining in the soil or groundwater, and the excavated material is stored, disposed (or otherwise dispositioned) as solid radioactive waste, then – by definition – there was no liquid release to the unrestricted area, and the spill need not be reported in the ARERR for purposes of liquid release accountability. However, the 10 CFR 50.75(g) decommissioning file should be updated to include the appropriate information. Additionally, the licensee may choose to report any or all portions of the decommissioning file (e.g., "spills or leaks") in the ARERR for purposes of transparency of disclosure regarding decommissioning records.

Prompt response and timely actions should be taken to the extent reasonable, including isolating the leak or spill at the source, preventing the spread of the leak or spill, and remediation of the leak or spill. The dose to members of the public from the leak or spill should be evaluated using realistic exposure scenarios (see Attachment 6 to SECY-03-0069, "Results of the License Termination Rule Analysis," dated May 2, 2003, (Ref. 11) for more information). Local authorities should be notified of the leak or spill when the leak or spill exceeds the threshold established with local authorities. When notifying local authorities, licensees should ensure effective communication using the guidance provided in NUREG/BR-0308, "Effective Risk Communication," issued January 2004 (Ref. 12) especially with respect to ensuring the risk is described in the appropriate context. In addition, an evaluation should be made as to whether to notify the NRC of the event in accordance with 10 CFR 50.72 and NUREG-1022 (Ref. 35). In general, notifications to the NRC should be made for large leaks and spills or when significant public concern is raised.

The licensee should use its problem identification and resolution program (corrective action program) in the evaluation of the event, and appropriate documentation should be placed in or cross-referenced to the 10 CFR 50.75(g) files. Remediation should be evaluated and implemented as appropriate, based on factors such as the location and accessibility of the contamination, the concentrations of and extent of the contamination, rates of monitored natural attenuation, and the decommissioning criteria described in NUREG-1757.

Monitoring Continuous Releases -- For continuous releases, gross radioactivity measurements are often the only practical means of continuous monitoring. These gross radioactivity measurements are typically used to actuate alarms and terminate (trip) effluent releases, but by themselves, they are generally not acceptable for demonstrating compliance with effluent release limits. Grab samples should be collected at scheduled frequencies (see NUREG-1301 and NUREG-1302 or as approved in GL 89-01 submittals) to quantify specific radionuclide concentrations and release rates. The frequency of sample collection and radionuclide analyses should be based on the degree of variance in (1) the magnitude of the release and (2) the relative radionuclide composition from an established norm. Where the magnitude of the release and the relative nuclide composition of a continuous release vary significantly over the course of the discharge period, a combination of grab samples and continuous monitor readings can assist in accurately estimating the release. Continuous monitoring data (e.g., chart recorder data), as well as grab sample data, should be reviewed periodically and used to identify this variance from the established norm. Periodic evaluations should be made between gross radioactivity measurements and grab sample analyses of specific radionuclides. These evaluations should be used to establish the conversion factors between monitor readings and concentrations of radionuclides when determining monitor alarm setpoints and effluent trip setpoints.

Monitoring Batch Releases -- For batch releases, measurements should be performed to identify specific radionuclides before a release to the environment. In those cases in which an analysis of specific

radionuclides (such as strontium-89/90 and iron-55) cannot be done before release (see NUREG-1301 and NUREG-1302), representative samples should be collected for the purpose of subsequent composite analysis. The composite samples should be analyzed at the scheduled frequencies specified in NUREG-1301 and NUREG-1302.

Principal Radionuclides for Effluent Monitoring – NUREG 1301/1302 provides a list of "principal gamma emitters" for which the LLD control applies. In this revised regulatory guide, the term "principal radionuclide" is introduced from a risk-informed perspective. In this context, the term "principal radionuclide" has special significance with respect to the (1) monitoring methods and the (2) required sensitivity levels (e.g., LLDs) for an analytical method. From a risk-informed perspective, a list of "principal radionuclides" may be evaluated by the licensee and identified for use at a particular site. Although the LLD list from NUREG-1301/1302 may be used as a starting point for any determination of "principal radionuclides," the list from NUREG-1301/1302 is not a required list of principal radionuclides. Instead, the "principal radionuclides" at a site will be dependent on site-specific factors (e.g., amount of failed fuel, extent of system leakage, sophistication of radwaste processing equipment, and level of expertise in operating radwaste processing systems). As a result, the "principal radionuclides" may vary from site to site depending on the list contained in the licensee's ODCM.

One method of determining the "principal radionuclides" is to classify all nuclides as "principal radionuclides," and apply the LLDs directly from NUREG-1301/1302. This method is simple to implement, but in certain cases it may entail inappropriately long count times or alternate methods of analysis for low-activity nuclides with no—or extremely low—dose significance.

Alternatively, a risk-informed approach may be used based on an extension of the guidance provided in Revision 1 of Regulatory Guide 1.109 (Ref. 23), section C (see discussion of "significant exposure pathways"). In a risk-informed approach, the "principal radionuclides" may be determined based on their relative contribution to (1) the public dose or (2) the amount of activity discharged. Under this concept, radionuclides that have either a significant activity or a significant dose contribution should be monitored in accordance with a predetermined and appropriate analytical sensitivity level (LLD). In the context of required sensitivity levels for an analytical method (i.e., LLD), a radionuclide is a "principal radionuclide" if it contributes more than 1% of the public dose or constitutes more than 1% of the total activity [in a particular reporting interval, and for a particular radionuclide category listed in Appendix A, Table A-1 (for gas releases) or Table A-2 (for liquid releases)].

If a risk-informed approach is used, "principal radionuclides" should be determined based on an evaluation over a time period that includes a refueling outage (e.g., one fuel cycle). A periodic reevaluation should be performed to determine whether the radionuclide mix has changed and/or to identify new "principal radionuclides." If a risk-informed approach is applied to the determination of "principal radionuclides," the ODCM specifies the list of "principal radionuclides." The list in NUREG-1301/1302 is not a regulatory requirement; however, the list in the ODCM is the requirement. Licensees are allowed to revise the ODCM in accordance with the ODCM change process as described in the plant's technical specifications (which includes documented evaluations of such changes). Once a nuclide is identified as a "principal radionuclide," its release from "significant release points" must be monitored in accordance with the LLDs specified in the ODCM.

For radionuclides that are not "principal radionuclides," licensee discretion may be applied to (1) the sensitivity of analysis and (2) the monitoring methods for those nuclides. If analytical sensitivities or monitoring methods (e.g., sample frequencies, analysis frequencies) are chosen which are different from NUREG-1301/1302, the basis for the deviations should be documented. For example, data quality

objectives (DQOs) and other concepts from Regulatory Guide 4.15, Revision 2, (Ref. #5) may be useful for determining risk-informed sensitivity levels for an analytical method.

However, the concept of "principal radionuclides" does not reduce the burden for reporting nuclides detected in effluents. In addition to "principal radionuclides," other radionuclides detected during routine monitoring of release points must be reported in the radioactive effluent release report and included in dose assessments to members of the public.

The production (and the release) of Carbon-14 from commercial nuclear power plants in the United States is relatively constant and is typically proportional to the power rating of the reactor. The quantity of carbon-14 discharged can be determined by measurement or by use of a normalized C-14 source term and scaling factors based on power generation; see National Council on Radiation Protection and Measurements Report No. 81,"Carbon-14 in the Environment" (Ref. 9). Because the production of C-14 is expected to be relatively constant, if sampling is performed for C-14, the sampling frequency may be adjusted to that interval that allows adequate reporting of effluents.

2. Effluent Sampling

Representative Sampling – The baseline schedule for sample collection and analyses appears in NUREG-1301 and NUREG-1302 or as approved by the NRC and put in the original ODCM approvals submitted as part of Generic Letter 89-01. Additional samples should be obtained as needed to characterize abnormal releases or significant operational evolutions. Samples should be representative of the overall effluent in the bulk stream, collection tank, or container. Representative samples should be obtained from well-mixed streams or volumes of effluent at sampling points by using proper equipment and sampling procedures.

Sampling Liquid Radwaste – Before sampling, large volumes of liquid waste should be mixed to ensure that sediments or particulate solids are distributed uniformly in the waste mixture. For example, a large tank may be mixed using a sparger system or re-circulated by up to three volumes to ensure that a representative sample can be obtained, as recommended by American Society for Testing and Materials (ASTM) D 3370-07, "Standard Practices for Sampling Water from Closed Conduits" (Ref. 13). If tank mixing practices deviate from industry standards (i.e., re-circulation or otherwise), a technical evaluation or other justification should be provided. Sample points should be located where there is a minimum of disturbance of flow caused by fittings and other physical characteristics of the equipment and components. Sample nozzles should be inserted into the flow or liquid volume to ensure sampling of the bulk volume of pipes and tanks. Sample lines should be flushed for a sufficient period of time before sample extraction to remove sediment deposits and air and gas pockets. Generally, three line volumes should be purged (see ASTM D 3370-07) before withdrawing a sample, unless a technical evaluation or other justification is provided. Periodically, a series of samples should be taken during the interval of discharge to determine whether any differences exist as a function of time and to ensure individual samples are indeed representative of the effluent mixture. In some instances, this may be accomplished by collecting one or more samples (either by "grab" or composite sampler) during the discharge and comparing with one or more samples taken prior to the discharge. If a series of samples are collected, these samples can be used to assess the amount of measurement uncertainty in obtaining representative samples.

Sampling Gaseous Radwaste – Regulatory Guide 4.15, American National Standards Institute (ANSI) N42.18-2004, "Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents" (Ref. 14), and ANSI/Health Physics Society (HPS) N13.1-1999, "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities" (Ref. 15), contain the general principles for designing and conducting monitoring programs for airborne effluents, including obtaining valid samples of airborne radioactive material in effluents and the guidelines for sampling from ducts and stacks. In addition, evaluations should be performed to validate

representative samples (e.g., evaluate the potential for inaccurate sampling of a gaseous effluent stream that may bypass a particulate filter and collect on an iodine collection cartridge), as well as inaccurate sample analyses configurations or counting geometries.

Sampling Bias – Sampling and storage techniques that could bias quantitative results for effluent measurements should be evaluated and corrections applied as necessary. These biases include inaccurate measurement of sample volumes resulting from pressure drops in long sample lines and loss of particulates or iodine in sample lines resulting from deposition or plate-out. Samplers for gaseous waste should be evaluated for particulate deposition using ANSI N13.1-1999 (Ref. 15).

Composite Sampling – Composite samples should be representative of the average quantities and concentrations of radioactive materials released in liquid and gaseous effluents. Composite samples should be collected in proportion to the rate of flow of the effluent stream or in proportion to the volume of each batch of effluent releases.

Sample Preparation and Preservation – Methods of sample preparation and/or sample storage should minimize the potential for loss of radioactive material (i.e., deposition of analyte on walls of the sample container or volatilization of analyte). Composite sample storage time should be as short as practical to preclude deposition on the storage container, or sample stabilization should be considered. Before quantitative radionuclide analyses for liquid effluent composites, samples should be mixed thoroughly so that the sample is representative of the released effluent.

Procedures should be instituted for handling, packaging, and storing samples to ensure that losses of radioactive materials or other factors causing sample deterioration do not invalidate the analysis. For example, filters should be stored carefully so as to prevent loss of radioactive material from the filter paper.

Short-lived Nuclides and Decay Corrections – In the analysis of short-lived radionuclides, measurements should be made as soon as practical after collection to minimize loss by radioactive decay (e.g., short-lived noble gases). In other cases, when needed to improve the detection of the longer lived nuclides, time should be allowed for the decay of short-lived, interfering nuclides.

Radiological decay corrections should be made as though the effluent were released uniformly throughout the sampling period (unless it is shown that the majority of the effluent was released during a particularly short interval). The time intervals between sample collection and analysis should be recorded. To estimate radioactive decay during composite sample collection, the midpoint of the sampling period may be used as the sample time. If the midpoint of the compositing interval is chosen as the sample time, those nuclides whose half-lives are short relative to the compositing period may be underestimated (if those nuclides appeared only in the early part of the compositing period) or overestimated (if those nuclides appeared in the last part of the compositing period). In order to avoid such bias, an alternate method of determining the effective sample time may be employed for composite samples. One such alternate approach involves application of weighting factors to compensate for (1) the decay time of each individual composited portion, and (2) the quantity of each individual composited portion in relation to the total quantity of the final composite sample. Another alternate approach would be to decrease the composite sampling interval.

3. Effluent Dispersion (Meteorology and Hydrology)

Meteorological Data – Gaseous effluents discharged into the atmosphere are transported and diluted as a function of (1) the atmospheric conditions in the local environment, (2) the topography of the region, and (3) the characteristics of the effluents. Site-specific meteorological data should be measured in accordance with Regulatory Guide 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants" (Ref. 16). The meteorological data does not need to be reported in the ARERR, but the data must be summarized and

maintained for inspection. An annual meteorological summary report that provides the joint frequency distributions of wind direction and wind speed by atmospheric stability class (see Regulatory Guide 1.23) should be prepared and maintained on-site for the life of the plant. In addition, hourly meteorological data should be recorded, and available, if needed for assessing abnormal gaseous releases.

Atmospheric Transport and Diffusion – Site specific meteorological data collected should be analyzed and used to generate gaseous effluent dispersion factor(s) χ/Q and deposition factor(s) D/Q in accordance with Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors" (Ref. 17). The use of annual average meteorological conditions (χ/Q and D/Q) is appropriate for continuous releases. This practice may also be acceptable for calculating doses from intermittent releases if the releases occur randomly and with sufficient frequency to justify the use of annual average meteorological conditions (see Regulatory Guide 1.111). When calculating long-term, annual average frequency distributions, the use of 5 (or more) years of data should be used. If long-term, annual average χ/Q and D/Q values are used, the values must be revalidated or updated periodically (e.g., every 3 to 5 years).

Release Height – The release height affects the transport and dispersion of radioactive materials especially with respect to "downwash" and building wake effects. For facilities with both ground-level and elevated releases, an evaluation should be made to determine the proper location of the highest exposed individual. From a dispersion perspective, when determining the highest exposure location (submersion and/or deposition), the evaluation should consider the magnitude of release originating as an elevated release and the magnitude of release originating as a ground-level release. For example, a close-in, downwind location in one sector may have a higher χ/Q (i.e., less dispersion) for a ground-level release; however, the majority of the source term may be originating as an elevated release, causing a higher concentration (χ) at a more distant location, possibly in a different sector.

Aquatic Dispersion (Surface Waters) – Liquid radioactive effluent may be discharged in accordance with 10 CFR 20.2001 into a variety of receiving surface water bodies, including non-tidal rivers, lakes, reservoirs, cooling ponds, estuaries, and open coastal waters. This effluent is dispersed by various mechanisms (i.e., turbulent mixing, stream flow in the water bodies, and internal circulation or flow-through in lakes, reservoirs, and cooling ponds). Parameters influencing the dispersion patterns and concentrations near a site include the direction and speed of flow of currents, both natural and plant-induced, in the receiving water; the intensity of turbulent mixing; the size, geometry, and bottom topography of the receiving water; the location of effluent discharge in relation to the receiving water surface and shoreline; the amount of recirculation of previously discharged effluent; the characteristics of suspended and bottom sediments; and sediment sorption properties. Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Releases for the Purpose of Implementing Appendix I" (Ref. 18), describes calculational models for estimating aquatic dispersion to surface water bodies. However, the dispersion characteristics may be highly site dependent, and local characteristics should be considered when performing dispersion modeling and dose assessments.

Spills and Leaks to the Ground Surface – Liquid effluents discharged onto the land surface are transported and diluted as a function of hydrologic processes and properties of the effluent. The effluents may temporarily accumulate, pool, and/or run off to natural and/or engineered drainage systems. During this process, water may also be absorbed into the soil (addressed in the next paragraph). Regulatory Guide 1.113 discusses the use of simple models to estimate transport of effluents through surface water bodies and considers water usage effects. Spills or leaks of radioactive material to the ground surface should initiate some spill or leak run-off characterization. These characterization activities should – at a minimum – satisfy (1) the requirements of 10 CFR 50.75(g) as well as (2) the effluent reporting requirements of NUREG-1301/1302 typically associated with planned effluents (e.g., sampling prior to discharge to

unrestricted areas). Refer to sections 9.5.1, 9.5.2, and 9.5.9 for guidance on the general format for reporting abnormal releases and effluents to unrestricted areas.

Spills and Leaks to the Ground Water – Liquid radioactive leaks and spills may be inadvertently discharged to onsite (or offsite) ground water. In addition to surface water run-off (as described in the above paragraph), leaks and spills onto the ground surface can be absorbed into the soil. Once in the soil some of the material in the leak or spill may, depending on the local-soil properties and associated liquid flux of the release, eventually reach the water table. The dispersion of this material depends on the local subsurface geology and hydrogeology characteristics. Liquid releases into the subsurface will be transported as a function of ground water flow processes and conditions (e.g., hydraulic gradients, permeability, porosity, and geochemical processes).

A ground water site conceptual model should be developed to predict the subsurface water flow parameters to include direction and rate and to be used as the basis for estimating the dispersion of inadvertent liquid effluent releases into ground water (see Regulatory Guide 4.1). References that can be used in developing an adequate ground water site conceptual model include:

1. ANSI/American Nuclear Society (ANS) 2.17-2007, "Evaluation of Subsurface Radionuclide Transport at Commercial Nuclear Power Production Facilities" (Ref. 19);

2. NUREG/CR-6948, "Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites," issued November 2007 (Ref. 20); and

3. various other industry documents.

Simple analytical models or more rigorous numerical codes (i.e., simulations) may be used to evaluate subsurface transport following a release. These models and codes will depend on the release rate, depth of the release, ground water flow directions, ground water flow rates, geochemical conditions, and other geochemical processes (e.g., geochemical retardation). Additionally, water usage such as ground water pumping from wells may create local groundwater depression(s) that can alter the natural groundwater flow.

In general, sites with low-level spills or leaks (e.g., resulting in residual contamination that is within approximately a factor of 10 to 100 above the laboratory LLD for the nuclide of concern) generally do not require extensive site characterization and monitoring. Conversely, sites with a highly contaminated subsurface, which are likely to exceed applicable radiation protection standards (e.g., 10 CFR 20.1402 or 10 CFR 20.1403, also refer to Table A-8), require more extensive evaluation. Initial assessments should be conducted with very simple models using scoping surveys and/or bounding assumptions. The complexity of the models should increase only as (1) more knowledge is obtained about the system under evaluation and as (2) the dose estimates rise above significant residual radioactivity levels (see definition in glossary). Many industry standard documents (Ref. 8, 19, 32) contain details of various industry practices that have been used as part of a groundwater monitoring program.

Spills or leaks of radioactive material to the ground water should initiate some scoping or characterization activities. These scoping or characterization activities may be direct (i.e., occurring at, or very near, the source of the leak) or indirect (i.e., occurring at some distance from the source of the leak) depending on the accessibility of the source of the spill or leak. For spills or leaks occurring below the soil surface in inaccessible locations, direct scoping and characterization may not be possible. In these cases, indirect monitoring techniques (e.g., groundwater monitoring wells in a down gradient direction) should be used to satisfy existing regulatory requirements. These scoping or characterization activities should – at a

minimum – satisfy (1) the requirements of 10 CFR 50.75(g) as well as (2) the effluent reporting requirements of NUREG-1301/1302 typically associated with routine, planned effluents (e.g., sampling prior to discharge to unrestricted areas). Refer to sections 9.5.1, 9.5.2, and 9.5.9 for guidance on the general format for reporting abnormal releases and effluents to unrestricted areas.

Scoping or characterization surveys may include elements such as groundwater monitoring wells, groundwater sampling, or soil sampling. However, the need for scoping or characterization surveys are sometimes incorrectly interpreted as a need for additional monitoring (e.g., sampling and additional wells) beyond that constituting a reasonable and necessary survey. Judicious use of site conceptual modeling together with a strategic and carefully planned monitoring program can ensure necessary and reasonable surveys are performed. Scoping and characterization surveys beyond what are necessary and reasonable to meet the regulatory requirements (e.g., surveys that are part of a voluntary industry initiative) may be reported in the ARERR. Indeed, the inclusion of such information in the ARERR is encouraged if it assists in the assessment of the annual effluents from the site. Groundwater information that is not related to the current year's effluents or dose assessments, as required by the ARERR, may be more appropriately reported in the AREOR as part of the ongoing radiological environmental monitoring program (REMP). Refer to Regulatory Guide 4.1 and NUREG-1301/1302 for additional information on the REMP.

Although licensees may conduct a groundwater monitoring effort for many different reasons, for purposes of this regulatory guide, the surveys, characterization activities, conceptual models, and other components of any groundwater monitoring effort should be sufficient to:

1. appropriately report, for purposes of accountability, effluents discharged to unrestricted areas,

2. document information in a format consistent with Table A-7 and regulatory position 9.5 (Abnormal Releases),

3. provide advance indication of potential future effluents to unrestricted areas (to ensure releases are planned and monitored prior to discharge),

4. sufficiently demonstrate significant residual radioactivity has not migrated offsite to an unrestricted area in the annual reporting interval, and to

5. communicate pertinent information to the NRC.

4. Quality Assurance

Regulatory Guidance – A range of quality control checks and tests should be applied to the analytical process. Regulatory Guide 4.15, Revision 1 and Revision 2, describe the QA program activities for ensuring radioactive effluent monitoring systems and operational programs meet their intended purpose. The applicability of Revision 1 or Revision 2, as a licensing commitment, is contained in each licensee's licensing basis. Licensees with programs in operation prior to the issuance of Regulatory Guide 4.15, Revision 2 may rely exclusively in Revision 1. Regulatory Guide 4.15, Revision 2, contains guidance on determining appropriate sensitivity levels for analytical instrumentation based on data quality objectives (DQO). The use of DQO may provide a better technical basis for determining sensitivity levels (LLDs) than the use of default values supplied in NUREG-1301/1302. A combination approach (using both Regulatory Guide 4.15 Revision 1 and Revision 2) can be used to determine appropriate sensitivity levels (LLDs) different (i.e., higher or numerically larger) than those listed in NUREG-1301/1302.

QC Checks – QC checks of laboratory instrumentation should be conducted daily or before use, and background variations should be monitored at regular intervals to demonstrate that a given instrument is in

working condition and functioning properly. QC records should include results of routine tests/checks, background data, calibrations, and all routine maintenance and service.

Functional Checks – Routine qualitative tests/checks (e.g., channel operational tests, channel checks, or source checks to demonstrate that a given instrument is in working condition and functioning properly) may be performed using radioactive sources that are not National Institute of Standards and Technology (NIST) traceable. The schedule for source checks, channel checks, channel calibrations, and channel operational tests should be in accordance with NUREG-1301 and NUREG-1302.

Procedures – Individual written procedures should be used to establish specific methods of calibrating installed radiological monitoring systems and grab sampling equipment. Calibration practices used for ancillary equipment and systems (e.g., meteorological equipment, airflow measuring equipment, in-stack monitoring pitot tubes) should be documented in written procedures. Calibration procedures may be compilations of published standard practices or manufacturers' instructions that accompany purchased equipment, or they may be specially written in house to include special methods or items of equipment not covered elsewhere. Calibration procedures should identify the specific equipment or group of instruments to which the procedures apply.

Written procedures should be used for maintaining counting room instrument accuracy, including maintenance, storage, and use of radioactive reference standards; instrumentation calibration methods; and QC activities such as collection, reduction, evaluation, and reporting of QC data.

Calibration of Lab Equipment and Radiation Monitors – Calibrations (e.g., laboratory equipment and continuous radiation monitoring systems) should be performed using reference standards certified by NIST or standards that have been calibrated against NIST-certified standards. Calibration standards should have the necessary accuracy, stability, and range required for their intended use. Continuous radioactivity monitoring systems should be calibrated against appropriate NIST standards. The relationship between concentrations and monitor readings should be determined over the full range of the readout device. Adequacy of the system should be judged on the basis of reproducibility, time stability, and sensitivity. Periodic in-service correlations, that relate monitor readings to the concentrations and/or release rates of radioactive material in the monitored release path, should be performed to validate the adequacy of the system. These correlations should be based on the results of analyses for specific radionuclides in grab samples from the release path.

The use of NIST traceable sources combined with mathematical efficiency calibrations may be applied to instrumentation used for radiochemical analysis (e.g., gamma spectroscopy systems) if using a method provided by the instrument manufacturer (e.g., Canberra's ISOCS).

Calibration of M&TE – Measuring and test equipment (M&TE) should be calibrated using reference standards certified by NIST or standards that have been calibrated against standards certified by NIST. The calibration standards should be representative of the sample types analyzed and have the necessary accuracy, stability, and range required for their intended use.

Calibration Frequency – Calibrations should generally be performed at regular intervals in accordance with the frequencies established in NUREG-1301 and NUREG-1302. A change in calibration frequency (increased or decreased) should be based on the reproducibility and time stability characteristics of the system. For example, an instrument system that gives a relatively wide range of readings when calibrated against a given standard should be recalibrated at more frequent intervals than one that gives measurements within a more narrow range. Any monitoring system or individual measuring equipment should be recalibrated or replaced whenever it is suspected of being out of adjustment, excessively worn, or otherwise damaged and not operating properly.

Measurement Uncertainty – An estimate should be made of the measurement uncertainty (formerly called measurement error) associated with the measurement of radioactive materials in effluents. Counting statistics can provide an estimate of the statistical counting uncertainty involved in radioactivity analyses. Normally, the statistical counting uncertainty decreases as the amount (concentration) of radioactivity increases. Thus, for the radioactive effluent release report, the statistical counting uncertainty is typically a small component of the total uncertainty. The sampling uncertainty is likely the largest component and includes uncertainties such as the uncertainty in volumetric and flow rate measurements and laboratory processing uncertainties.

The total or expanded uncertainty associated with the effluent measurement will include the cumulative uncertainties resulting from the total operation of sampling and measurement. The objective should be to evaluate the entire measurement process and obtain an approximate measure of the uncertainty associated with reported results. For monitoring batch and continuous releases, uncertainties in the estimates of volume, flow rate, radionuclide concentration, and gross radioactivity should be quantified and collectively assessed. Table 1 summarizes various uncertainty components that should be assessed to quantify the expanded uncertainty in batch and continuous monitoring systems. For each system component, one or multiple methods can be chosen to quantify the uncertainty in each component. The total uncertainty can be calculated by taking the square root of the sum of squares of each system component uncertainty. NUREG-1576, "Multi-Agency Radiological Laboratory Analytical Protocols Manual," issued July 2004 (Ref. 21), and ANSI/HPS N13.1-1999 provide further details for quantifying uncertainty.

Table 1. Calculating Total System Uncertainties

Release Type	System Component	Uncertainty
Batch	Bulk volume in storage/holdup tank	• Calibration tolerance (± %) of volumetric measuring device (volume or pressure gauge) for storage and holdup tanks • % difference between two or more different methods of estimating bulk volume
	Flow rate	• Calibration tolerance (± %) of flow meter • % variation over time of multiple measurements using same flow meter • % variation between two or more different flow meters (each meter should be properly calibrated) • % difference between two or more different methods of estimating flow rate
	Radionuclide concentration	• % variation between results of replicate grab samples • % variation between results of grab and composite samples
Continuous	Flow rate or velocity in effluent and sampling systems	• Performance criterion (% tolerance) of initial check of systems • % variability over time in flow measurements • % tolerance of flow calibrations

		• % difference between two or more different methods of estimating flow rate
	Radionuclide concentration	• % variation between results of replicate grab samples • % variation between results of grab and composite samples
	Continuous radiation monitors for gross radioactivity	• Performance criterion (% tolerance) of initial check of measurement system for gases and aerosols • % tolerance of periodic monitor calibration • % variability over time in continuous radioactivity measurements

5. Dose Assessments for Members of the Public

The regulations referenced in regulatory positions 5.5 through 5.7 contain both dose limits and design objectives that the licensee demonstrates compliance with through calculations. The fundamental parameters associated with the dose calculations are summarized in Table 2. Important concepts for these calculations are discussed in regulatory positions 5.8 through 5.10. Due to differences between these regulations, only demonstrating compliance with radiological effluent technical specifications (based on Appendix I to 10 CFR Part 50) does not necessarily ensure compliance with 10 CFR 20.1301(a) or 40 CFR Part 190, particularly if there is a direct radiation component (e.g., from BWR shine, ISFSI, or radioactive materials storage).

5.1 **Bounding Dose Assessments** may be used for purposes of demonstrating compliance with regulatory dose limits or criteria, particularly in those circumstances where compliance can be readily demonstrated using conservative assumptions. Dose assessments can be performed using conservative assumptions that result in a bounding, overestimation of the dose to the highest real individual. For example, instead of assessing dose to a real individual bounding assessments can be performed at the site boundary. If bounding assumptions are made, the radioactive effluent release report should state such and should annotate the assumptions. Additionally, if bounding assessments are used and are based on hypothetical exposure pathways (which may yield inflated doses), do not use the bounding assessment as the basis for determining "significant exposure pathways" as described in regulatory position "C" of Regulatory Guide 1.109.

5.2 **Occupational Workers** are those individuals who, in the course of employment, are assigned duties involving exposure to radiation, or exposure to radioactive material. Training per 10 CFR 19.12 is required for those individuals that may exceed 100 mrem/year. Each licensee is responsible for classifying individuals (by location) as either members of the public or as occupational workers. See definition of "*occupational dose"* in 10 CFR Part 20. For example a licensee may choose to classify all individuals in the controlled area, including a vending machine delivery person, or a coal plant worker as occupational workers since the assigned duties involve exposure to radiation at the adjacent facility. An occupational worker is a member of the public while in the unrestricted area. For more information, see requirements under 10 CFR 19.11.

5.3 **Members of the public** reside in the unrestricted area, but at times may enter the controlled area of a commercial nuclear power plant. Each licensee is responsible for classifying individuals (by

location) as either members of the public or as occupational workers. See definition of "*members of the public"* in 10 CFR Part 20. An occupational worker is a member of the public while in the unrestricted area.

If bounding assessments are not used, licensees should perform evaluations to determine the highest dose to an actual member of the public, regardless of whether the individual is in an unrestricted area or a controlled area. If no member of the public is allowed in the controlled area, the evaluation need only consider members of the public in the unrestricted area. For example a licensee may choose to classify all individuals in the controlled area, including a vending machine delivery person, as members of the public. A member of the public is a real individual in a designated location where there is a real exposure pathway (e.g., a real garden, real cow, real goat, or actual drinking water supply); not a fictitious fencepost resident or pathway via a virtual goat or cow.

5.4 **Occupancy factors** for members of the public in the unrestricted area should be assumed to be 100 percent unless the land-use census provides site-specific information indicating otherwise. Occupancy factors may be applied inside the controlled area based on site usage characteristics for members of the public or occupational workers.

5.5 **10 CFR Part 50, Appendix I**, contains numerical guidance for design objectives and limiting conditions of operation for radwaste systems to ensure radioactive liquid and gaseous effluents to unrestricted areas are ALARA. This numerical guidance is listed in terms of annual air doses (gamma and beta), annual total body doses, and annual organ doses. Technical Specifications requires that exposure to liquid and gaseous effluents conform to the numerical guidance in 10 CFR 50 Appendix I. Per 10 CFR 50.34a, these numerical guides for design objectives and limiting conditions of operation are not to be construed as radiation protection standards. For these dose calculations, the operative verbiage is:

5.5.1 air doses (gamma and beta), total body doses, and organ doses (based on ICRP-2)

5.5.2 effluent releases only (excludes direct radiation from the facility and ISFSIs)

5.5.3 current annual period (excludes accumulated radioactivity from prior-year effluents)

5.5.4 unrestricted area (excludes individuals in the restricted areas and controlled areas)

5.6 **10 CFR 20.1301(a) through (c)** specifies dose limits for members of the public from all licensed and unlicensed sources associated with the licensed facility (see 10 CFR 20.1001, "Purpose"). This includes doses from (1) current-year effluents released to unrestricted areas, (2) current-year contributions from direct radiation (e.g., nitrogen-16, radioactive materials storage, radioactive waste storage, ISFSIs), and (3) radioactivity remaining in the unrestricted area from prior-year operations. The limits are applicable to members of the public in unrestricted areas and controlled areas. This limit is based on TEDE, which is distinct from total body dose and organ dose (based on ICRP-2).

5.6.1 The "current-year" excludes doses received in prior years.

5.6.2 "TEDE" is a ICRP-26 term (that is distinct from total body dose and organ dose which are ICRP-2 terms).

5.6.3 "Locations" include the unrestricted area and controlled areas (if members of the public are present on-site).

5.6.4 "Sources that exist or remain in the area" includes doses from radioactivity remaining in the environment as a result of prior-years effluents (such as accumulated radioactivity in lake water from prior year releases). For example, based on the land-use census, if drinking water is an actual exposure pathway from a lake containing accumulated radioactivity, the dose assessment must include contributions from both the effluent release during the current year and the accumulated radioactivity from prior-year discharge

5.7 **10 CFR 20.1301(e)** requires compliance with EPA's generally applicable environmental radiation standards promulgated in 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," (Ref. 22). Licensees must assess the highest cumulative (whole body and organ) doses from the uranium fuel cycle to a real individual outside the site boundary. The limits include (1) contributions from current-year effluents, (2) current-year direct radiation from the facility, and (3) accumulated radioactivity from prior-year effluents. These requirements include the following:

5.7.1 "Whole body and organ doses" are ICRP-2 terms.

5.7.2 "Any member of the public" means any individual (i.e., a real person), in an unrestricted area, who is not engaged in nuclear fuel cycle operations.

5.7.3 The "unrestricted area" means in the general environment outside the (boundaries of) locations under the control of persons possessing or using radioactive material. This excludes the controlled area and the restricted area. See definition of "generally applicable environmental radiation standards" in 10 CFR 20.1003.

5.7.4 "Current-year effluents" includes both normal and abnormal releases to the unrestricted area.

5.7.5 "Current-year direct radiation" includes all direct radiation from the facility (e.g., radioactive waste storage, and ISFSIs), but excludes doses from radioactive waste shipments.

5.7.6 "Cumulative" dose means the sum of (1) current year effluent dose, (2) current year direct radiation dose, and (3) dose from accumulated radioactivity.

5.7.7 "Accumulated radioactivity" includes radioactive material from prior-year effluent releases that may have accumulated in lake water.

5.7.8 The "uranium fuel cycle" excludes uranium mining, radioactive waste shipping (in the unrestricted area), operations at waste disposal sites, and reuse of non-uranium special nuclear materials (per 40 CFR 190).

Table 2, Parameters Associated with Dose Calculations

	10 CFR 20.1301(a)-(c)	**10 CFR 50, Appx. I**	**10 CFR 20.1301(e)**
Dose	TEDE	Whole Body, Max of Any Organ, Gamma Air, and Beta Air	Whole Body, Thyroid, and Max of Any Organ

Basis	ICRP-26	ICRP-2	EPA 40 CFR 190
Where	Controlled Area and Unrestricted Area	Unrestricted Area	Unrestricted Area
Individual receptor	Real person/pathway (nearest real residence, real garden, real dairy/meat animal)	Real person/pathway (nearest real residence, real garden, real dairy/meat animal)	Real person/pathway (nearest real residence, real garden, real dairy/meat animal)
Sources	Liquid and Gas Radwaste, Direct Radiation (e.g., Shine, N-16, ISFSI, Rad. Mat. Storage, Outside Tanks, etc…) Residual radioactivity (e.g., lake water, return/recycle)	Liquid and Gas Radwaste,	Liquid and Gas Radwaste, Direct Radiation (e.g., Shine, N-16, ISFSI, Rad. Mat. Storage, Outside Tanks, etc…) Residual radioactivity (e.g., lake water, return/recycle)
Sources	Licensed and Unlicensed	Licensed Only	Licensed and Unlicensed
When	Current year, plus residual radioactivity from previous years.	Current year.	Current year, plus residual radioactivity from previous years.

5.8 **Dose assessments to show compliance with 10 CFR Part 50, Appendix I** design objectives, should include quarterly and annual doses using the considerations of regulatory position 5.5, and should be reported in a format similar to that listed in Table A-4.

5.8.1 Doses from liquid effluents

5.8.1.1 Total body dose, quarterly and annual

5.8.1.2 Organ dose, quarterly and annual (maximum, any organ)

5.8.1.3 Percent of limits for each of the above

5.8.1.4 Sector and distance

5.8.2 Doses from gaseous effluents:

5.8.2.1 beta and gamma air doses, quarterly and annual

5.8.2.2 organ dose commitment from iodine, tritium, and particulate releases with half-lives greater than 8 days, quarterly and annual

5.8.2.3 Percent of limit for each of the above

5.8.2.4 Sector and distance

5.8.3 An evaluation of the local exposure pathways to determine the highest exposed member of the public should be performed. However, maximum doses from various exposure pathways should not be additive from different locations. For example, dose from a downstream drinking water pathway should not be added to the dose to an upstream

resident whose exposure is from gaseous effluents and direct radiation.

The highest doses (often referred to as the "Maximum" doses) to real individuals are assessed as described in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I" (Ref. 23). The locations and exposure pathways are those where actual individuals are present and exposed. Maximum exposed individuals are characterized as "maximum" with regard to food consumption, occupancy, and other usage of the region in the vicinity of the plant site. For example, licensees should make "maximum" (hypothetical) assumptions for food consumption and occupancy factors at actual locations when assessing dose to the maximum actual exposed individual, unless they have determined and applied site-specific (actual) data. In this context, "hypothetical" applies to the various factors for a particular individual (e.g., consumption factors, occupancy factors, and age groups) and not the individual's location.

5.8.4 The objective of Appendix I is to provide numerical guides for design objectives and limiting conditions for operation to ensure that effluent control equipment is effective in reducing emissions to ALARA levels. The numerical guidance pertains to quarterly and annual dose criteria at or beyond the unrestricted area from current-year effluent releases. The calculations do not include dose from radioactivity in prior-year, accumulated, effluent releases (e.g., last year's radioactivity remaining in lake water is excluded).

5.8.5 Significant exposure pathways should be considered (and included) in all dose assessments. In addition to the exposure pathways identified in Regulatory Guide 1.109, other exposure pathways that may arise because of unique conditions at a specific site (such as inadvertent leaks to ground water) should be considered if they are likely to contribute significantly to the total dose. A pathway is considered significant if a realistic evaluation yields an additional dose increment equal to or more than 10% of the total from all pathways considered (see the regulatory position in Regulatory Guide 1.109). An evaluation of less significant exposure pathways (not included in dose assessments) should be performed and maintained for purposes of demonstrating compliance with this requirement.

5.8.6 Real exposure pathways are identified based on the results of the Land Use Census. Dose calculations should be performed based on realistic exposure pathways. For example, if the land use census does not identify a cow (or goat) milk pathway, the licensee is not required to assess that pathway. Similarly, if a licensee discharges liquid effluent to a body of water that is not a drinking water pathway (e.g., no local intake from private or public supplies), a drinking water assessment is not required for that release point.

5.9 **Dose assessments to show compliance with 10 CFR 20.1301(a) thru (c)** should be reported with consideration of regulatory position 5.6 and in a format similar to that listed in Table A-5.

5.9.1 Report the following

5.9.1.1 Liquid effluent contribution to TEDE dose

5.9.1.2 Gaseous effluent contribution to TEDE dose

5.9.1.3 Direct radiation contribution to TEDE dose

5.9.1.4 TEDE dose (sum from all contributions)

5.9.1.5 Location (on-site or offsite and distance/direction) applicable to the highest exposed member of the public

5.10 **Dose assessments to show compliance with 10 CFR 20.1301(e)** should be reported according to the generally applicable environmental radiation standards promulgated by EPA at 40 CFR Part 190, with consideration of regulatory position 5.7, and in a format similar to that listed in Table A-6.

5.10.1 Report the following:

5.10.1.1 Whole body dose

5.10.1.2 Thyroid dose

5.10.1.3 Dose to any other organ

5.10.1.4 Sector and distance

5.10.1.5 Percent of the applicable limit

5.10.2 One means of demonstrating compliance with 40 CFR 190 is listed in Federal Register 42 FR 2859 that states:

> ***"In the case of light water reactors, … demonstrating conformance with Appendix I of 10 CFR 50 are generally adequate for demonstrating compliance with [EPA 40 CFR 190]."***

As a result, a licensee who (1) can demonstrate external sources of direct radiation are indistinguishable from background and who (2) demonstrates compliance with the numerical dose guidance of 10 CFR 50 Appendix I may cite the above reference as the basis for demonstrating compliance with 40 CFR 190.

However, for licensees who (1) have external sources of direct radiation that are above background, and who (2) demonstrate compliance with the numerical dose guidance of 10 CFR 50 Appendix I may not cite the above reference as the basis for demonstrating compliance with 40 CFR 190.

5.10.3 The dose contributions from direct radiation may be estimated based on either (1) thermoluminescent dosimetry (TLD) measurements, (2) calculations, or (3) a combination of TLD measurements and calculations. When direct radiation dose is determined by TLD, background levels of radiation from selected control locations should be subtracted from applicable indicator locations. The doses measured from control and indicator locations should be taken from the same time period. When choosing the appropriate control location(s) consideration should be given to the variability in doses measured at the control and indicator locations.

5.11 **An Example Calculation** demonstrates how to apply the information contained in regulatory positions 5.8 through 5.10 to calculate the three separate types of doses (i.e., Technical Specifications required compliance with the numerical guidance of 10 CFR 50 Appendix I, 10 CFR 20.1301, and 40 CFR 190). For the calculations, assume the dose components below have been determined.

5.11.1 Annual Whole Body Doses, nearest residence

5.11.1.1 Liquid Radwaste 0.001 mrem

5.11.1.2 Gas Radwaste 0.012 mrem

5.11.2 Annual Organ Doses, nearest residence

5.11.2.1 Liquid Radwaste 0.002 mrem

5.11.2.2 Gas Radwaste 0.015 mrem

5.11.3 Direct Radiation (from ISFSI, shine, etc), nearest residence

Direct Radiation from TLDs and Calculations	True gross mrem/yr	Uncertainty +/- mrem/yr
TLD at First Control Location	47.92	3.06
TLD at Second Control Location	49.95	4.02
TLD, Indicator, 50 ft away, on-site	152.95	26.32
TLD, Indicator, 0.75 mi away, on-site	50.68	5.72
Nearest Residence, 1.2 mi away, (calculated based on extrapolation of Indicator TLDs, Gross)	48.00	4.00

5.11.3.1 Net annual dose at nearest residence = 48.00-47.92 = 0.08 mrem

5.11.3.2 The propagation of uncertainty in measurements = $\sqrt{(4.00)^2 + (3.06)^2} = \pm$ 5.03 mrem. This calculation may or may not be possible at all sites depending on how the Tads are configured in the radiological environmental monitoring program. The calculation may be of interest since it may help demonstrate the relative significance (or insignificance) of the net annual dose at the nearest residence calculated in this example.

5.11.3.3 In this example, the net dose to the nearest residence was based on one of two TLDs at a control location. Either TLD could be used provided it was representative of the background. Alternatively, both control TLDs could be used to generate an average background (provided both were representative of the background).

5.11.4 Accumulated radioactivity (H-3 in on-site pond from previous years of operation)

5.11.4.1 Whole body 0.016 mrem, from on-site pond H-3 evaporation to nearest residence (inhalation and submersion)

5.11.4.2 Each organ 0.016 mrem, from on-site pond H-3 evaporation to nearest residence (inhalation and submersion)

5.11.4.3 Whole body and all organs 0.0017 mrem, from on-site pond H-3 evaporation to nearest residence (ingestion, leafy vegetables)

5.11.4.4 Each organ 0.0017 mrem, from on-site pond H-3 evaporation to nearest residence (ingestion, leafy vegetables)

5.11.5 Based on the above information, the dose calculations are performed as shown below.

5.11.5.1 For 10 CFR 50 Appendix I

5.11.5.1.1 Whole Body Dose = 0.001+0.012+0.016+0.017 = 0.046 mrem

5.11.5.1.2 Organ Dose = 0.002+0.015+0.016+0.017 = 0.050 mrem

5.11.5.2 For 10 CFR 20.1301(a) thru (c) (TEDE)

5.11.5.2.1 TEDE = 0.001+0.012+0.08+0.016+0.017= 0.126 mrem

5.11.5.3 For 40 CFR 190

5.11.5.3.1 Whole Body Dose = 0.001+0.012+0.08+0.016+0.017 = 0.126 mrem

5.11.5.3.2 Organ Dose = 0.002+0.015+0.08+0.016+0.017 = 0.130 mrem

6. Solid Radioactive Waste Shipped for Processing or Disposal

The total curie quantity and radionuclide composition of the solid waste shipped off site should be determined and reported in a format similar to Table A-3 in Appendix A to this guide. The data should be reported separately for shipments made to offsite waste processors and those made directly to low-level waste (LLW) disposal facilities. Shipments for direct disposal using authorizations obtained under 10 CFR 20.2002, "Method for Obtaining Approval of Proposed Disposal Procedures," or equivalent State regulations should also be reported separately. Shipments of processed waste and used (irradiated) fuel for storage should be reported.

7. Reporting Errata in Effluent Release Reports

Errors in radioactive effluent release reports should be classified and reported as follows:

7.1 **Small errors** may be any of the following:

7.1.1 Inaccurate reporting of dose that equates to ≤ 10% of the public dose, after correction

7.1.2 Inaccurate reporting of curies (or release rates, volumes, etc) that equate to ≤ 10% of the affected curie total (or release rate, volume, etc), after correction

7.1.3 Omissions that do not impede the NRCs ability to adequately assess the information supplied by the licensee

7.1.4 Typographical errors or other errors that do not alter the intent of the report

7.2 **Small errors** should be corrected, and the affected pages should be submitted as a supplemental report (referencing the affected calendar year). The supplemental report (or addendum) to the radiological effluent release report may be submitted coincidental with the next (normally scheduled) submittal of the ARERR.

7.3 **Large errors** may be any of the following

7.3.1 Inaccurate reporting of dose that equates to > 10% of public dose, after correction

7.3.2 Inaccurate reporting of curies (or release rates, volumes, etc) that equate to > 10% of the affected curie total (or release rate, volume, etc), after correction

7.3.3 Omissions that may impede the NRCs ability to adequately assess the information supplied by the licensee

7.3.4 Typographical errors or other errors that do significantly alter the intent of the report

7.4 **Large errors** should be corrected, and the affected pages should be submitted as a supplemental report (referencing the affected calendar year). The supplemental report (or addendum) to the

radiological effluent release report should be submitted to the NRC within 90 days of discovery of the error.

8. Data Trending

The annual effluent release data should be trended over a 10-year period and submitted with the ARERR as follows:

8.1 Liquid effluent trends:

- 8.1.1 source term for curies of total mixed fission and activation products
- 8.1.2 source term for curies of tritium
- 8.1.3 Appendix I dose (percent of total body dose numerical guidance)
- 8.1.4 Appendix I dose (percent of maximum organ dose numerical guidance)

8.2 Gaseous effluent trends:

- 8.2.1 source term for curies of total mixed fission and activation products
- 8.2.2 source term for curies of particulates
- 8.2.3 source term for curies of iodine
- 8.2.4 source term for curies of tritium
- 8.2.5 Appendix I dose (percent of gamma air dose numerical guidance)
- 8.2.6 Appendix I dose (percent of beta air dose numerical guidance)
- 8.2.7 Appendix I dose (percent of maximum organ dose numerical guidance)

8.3 Direct radiation trends

- 8.3.1 Dose to the highest exposed real individual

9. Format and Content of the Annual Radioactive Effluent Release Report (ARERR)

In accordance with 10 CFR 50.4, "Written Communications," the annual report should be submitted electronically or in a written communication in a format similar to that given in Tables A-1 through A-6 in Appendix A to this guide. Effluent data should be summarized on a quarterly and annual basis. For purposes of compliance with 10 CFR 50.36a, the ARERR must be submitted by May 1 (unless a licensing basis exists for a different submittal date) for effluents and solid waste from the previous calendar year.

Measurements should be reported for positive values; if results are determined to be below detectable levels, the table entry should be left blank.

The format specified in revision 2 of this regulatory guide differs slightly from that specified in revision 1. The format and content as specified in revision 2 (and listed in the paragraphs below) are one acceptable method of reporting the data. Other formats may be used (e.g., some tables may be combined) as long as the specified content is satisfied (e.g., quarterly totals and annual totals by each release category). All plants are encouraged to use the format listed below to maximize consistency in data reporting. The aspect of consistency aids review by members of the public and allows easier industry-wide comparisons of the data.

9.1 Gaseous Effluents

9.1.1 ***Table A-1—Gaseous Effluents – Summation of All Releases*** contains a summation of all gaseous effluent releases from all release points and all modes of release. The data is subdivided by quarter and year for each radionuclide category: (a) fission and activation gases, (b) iodines/halogens, (c) particulates, (d) tritium, and (e) gross alpha.

9.1.2 ***Table A-1A, Gaseous Effluents—Ground-Level Release—Batch Mode*** contains a summation of gaseous effluent releases from ground-level release points in the batch mode

of release for the five radionuclide categories of fission gases, iodines/halogens, particulates, tritium, and gross alpha. Report the following:

9.1.2.1 curies of each radionuclide released by quarter and year, and

9.1.2.2 total curies released in each radionuclide category (fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha) by quarter and year.

9.1.3 ***Table A-1B, Gaseous Effluents—Ground-Level Release—Continuous Mode*** contains a summation of gaseous effluent releases from ground-level release points in the continuous mode of release for the five radionuclide categories of fission gases, iodines/halogens, particulates, tritium, and gross alpha. Report the following:

9.1.3.1 curies of each radionuclide released by quarter and year, and

9.1.3.2 total curies released in each radionuclide category by quarter and year.

9.1.4 ***Table A-1C, Gaseous Effluents—Elevated Release—Batch Mode*** contains a summation of gaseous effluent releases from elevated release points in the batch mode of release for the five radionuclide categories of fission gases, iodines/halogens, particulates, tritium, and gross alpha. Report the following:

9.1.4.1 curies of each radionuclide released by quarter and year, and

9.1.4.2 total curies released in each radionuclide category by quarter and year.

9.1.5 ***Table A-1D, Gaseous Effluents—Elevated Release—Continuous Mode*** contains a summation of gaseous effluent releases from elevated release points in the continuous mode of release for the five radionuclide categories of fission gases, iodines/halogens, particulates, tritium, and gross alpha. Report the following:

9.1.5.1 curies of each radionuclide released by quarter and year, and

9.1.5.2 total curies released in each radionuclide category by quarter and year.

9.1.6 ***Table A-1E, Gaseous Effluents—Mixed Mode Release—Batch Mode*** contains a summation of gaseous effluent releases from mixed-mode release points in the continuous mode of release for the five radionuclide categories of fission gases, iodines/halogens, particulates, tritium, and gross alpha. Report the following:

9.1.6.1 curies of each radionuclide released by quarter and year, and

9.1.6.2 total curies released in each radionuclide category by quarter and year.

9.1.7 ***Table A-1F, Gaseous Effluents—Mixed Mode Release—Continuous Mode*** contains a summation of gaseous effluent releases from mixed-modes release points in the continuous mode of release for the five radionuclide categories of fission gases, iodines/halogens, particulates, tritium, and gross alpha. Report the following:

9.1.7.1 curies of each radionuclide released by quarter and year, and

9.1.7.2 total curies released in each radionuclide category by quarter and year.

9.2 Liquid Effluents

A summary of liquid effluent release information should be reported in the format of Appendix A, Table A-2. The quarterly and annual sums of all releases of radioactive materials in liquid effluents (i.e., routine and abnormal occurrences, continuous, and batch) should be reported in a format similar to that of the Tables A-2A and A-2B.

9.2.1 ***Table A-2, Liquid Effluents - Summation of All Releases*** contains a summation of all liquid effluent releases from all release points and all modes of release. The data is subdivided by quarter and year for each radionuclide category: (a) fission and activation products, (b) tritium, (c) dissolved and entrained noble gases, and (d) gross alpha. Also

include total volume of primary coolant waste (typically batch mode releases), before dilution. This is generally the higher activity waste that is processed through the liquid radioactive waste system. Report the total measured volume or average flow rate of waste from secondary or balance of plant systems (e.g., steam generator blow-down). This is typically very low activity waste that is generally not processed with the liquid radioactive waste treatment system. Report internal plant dilution flow rate during periods of release (in-plant dilution flow, before effluent discharge to receiving water body), and external dilution flow rate, average (river or stream flow rates).

9.2.2 ***Table A-2A, Liquid Effluents - Batch Mode*** contains a summation of liquid effluent releases in the batch mode of release. The table is divided into the four categories of fission and activation products, tritium, dissolved and entrained gases, and gross alpha. Report the following:

9.2.2.1 curies of each radionuclide and gross alpha released by quarter and year,

9.2.2.2 total curies in each radionuclide category by quarter and year,

9.2.3 ***Table A-2B, Liquid Effluents—Continuous Mode*** contains a summation of liquid effluent releases in the continuous mode of release. The table is divided into the four radionuclide categories of particulates and iodines, dissolved and entrained gases, tritium, and gross alpha. Report the following:

9.2.3.1 curies of each radionuclide and gross alpha released by quarter and year,

9.2.3.2 total curies in each radionuclide category by quarter and year,

9.3 Solid Waste Shipments

Appendix A, Table A-3 summarizes the solid radioactive waste (LLW) and used (irradiated) fuel shipments during the reporting period. Quantities should be reported for the following wastes:

9.3.1 shipped for direct disposal to licensed waste disposal facilities,

9.3.2 shipped for processing before disposal or before returned to site,

9.3.3 returned to site for long-term storage,

9.3.4 shipped for 10 CFR 20.2002 disposal, and

9.3.5 used (irradiated) fuel shipments.

The total volume of waste, activity, and principal isotopes should be specified for Waste Classifications A and B. Other waste that does not fit into these categories should also be reported. For the used fuel shipments, the report should summarize the number of shipments, destination, and mode of transport (e.g., rail or truck).

9.4 Dose Assessments

The annual evaluations of public dose should be calculated using the regulatory guidance of section 5 and should be reported in the format of Table A-4, Table A-5, and Table A-6. Dose assessments should be performed to demonstrate compliance with the following:

9.4.1 10 CFR Part 50, Appendix I (Table A-4):

9.4.1.1 Report the calculated dose from liquid effluents on a quarterly and annual basis to the total body and maximum organ and the percentage of the Appendix I design objectives. This is the dose from the annual discharge of liquid effluents to a real individual in the unrestricted area. If a particular pathway is not applicable (i.e., it does not exist at a site) no dose should be calculated for that pathway.

9.4.1.2 Report the highest air dose from gaseous effluents on a quarterly and annual basis at any location that could be occupied by individuals in the unrestricted area and the percentage of the Appendix I design objectives.

9.4.1.3 Report the highest organ dose from iodine, tritium, and particulates with a half-life greater than 8 days to any individual in an unrestricted area from all pathways of exposure (e.g., submersion and ingestion).

9.4.2 10 CFR 20.1301(a)-(c) (Table A-5):

9.4.2.1 Report the TEDE dose from both licensed and unlicensed sources (including accumulated radioactivity from prior-year releases) to a real individual likely to receive the highest dose, whether in the controlled area or unrestricted area. The TEDE can be calculated directly as TEDE dose or converted from whole body and organ dose. Identify whether the real individual likely to receive the highest dose is located within the controlled area or the unrestricted area.

9.4.3 10 CFR 20.1301(e) and 40 CFR Part 190 (Table A-6):

9.4.3.1 Report the whole body, thyroid, and highest dose to any other organ from licensed and unlicensed sources in the uranium fuel cycle, excluding background, to the real individual likely to receive the highest dose. Identify the location (sector and distance) of the highest exposed real individual.

9.5 Supplemental Information

Table A-7 in the appendix can be used to provide supplemental information in a descriptive format in a narrative form. Relevant information and a description of circumstances should be provided as appropriate for each the following categories, adding categories as appropriate. Use the annotation N/A if not applicable.

9.5.1 ***Abnormal Releases***

9.5.1.1 Specific information should be reported concerning abnormal (airborne and/or liquid) releases to the site environs. The report should describe the event in a way that would enable the NRC to adequately understand how the material was released and if there is any offsite impact. In the case of a liquid release, the report should describe the potential impact on ground water or drinking water pathways, as applicable.

9.5.1.2 Low-level radioactive system leakage from minor equipment failures and component aging (wear and tear) may be expected to occur as an anticipated part of the plant operation. If such leakage is directed to a system designed to accept and handle radioactive material, it is not considered an abnormal release. For example, gaseous effluent leakage into a plant ventilation system that was designed to handle leakage from various plant components is not an abnormal release.

9.5.1.3 The following are the thresholds for reporting abnormal releases in the supplemental information section.

9.5.1.3.1 abnormal releases to on-site areas voluntarily reported to local authorities under the industry Ground Water Protection Initiative (Ref. 31);

9.5.1.3.2 abnormal releases to on-site areas exceeding 100 gallons of radioactive liquid (or where the volume is unknown), where the presence of licensed radioactive material is positively identified (in either the site environs or in the source of the leak/spill) as

greater than the minimum detectable activity (MDA) for the laboratory instrumentation;

9.5.1.3.3 abnormal releases to on-site areas that result in detectable residual radioactivity after remediation

9.5.1.3.4 abnormal releases that result in a high effluent radiation alarm without an anticipated system trip occurring.

9.5.1.3.5 abnormal releases to an unrestricted area

9.5.1.4 Information on abnormal releases should include the following

9.5.1.4.1 date of the release and duration,

9.5.1.4.2 location of the release,

9.5.1.4.3 volume of the release,

9.5.1.4.4 estimated activity of each radionuclide,

9.5.1.4.5 effluent monitoring results (if any),

9.5.1.4.6 environmental monitoring results (if any),

9.5.1.4.7 classification(s) of subsurface aquifer(s) (Class I drinking water, Class II impaired aquifer, or Class III unfit for drinking water),

9.5.1.4.8 size and extent of any ground water plume,

9.5.1.4.9 expected movement/mobility of any ground water plume,

9.5.1.4.10 land use characteristics,

9.5.1.4.11 remedial actions considered or taken and results obtained,

9.5.1.4.12 calculated member of the public dose attributable to the release,

9.5.1.4.13 actions taken to prevent recurrence, as applicable,

9.5.1.4.14 whether the NRC and/or local officials were notified and the date(s) and contact person(s),

9.5.1.4.15 residual radioactivity levels and whether any levels exceed the DCGLs provided in Table H.2 in Appendix H to NUREG-1757, Volume 2,

9.5.2 ***Nonroutine Planned Discharges***

9.5.2.1 Report pumping of leaks and spills for remediation or results of ground water monitoring to quantify effluent releases to the offsite environment

9.5.3 ***Radioactive waste treatment system changes***

9.5.4 ***Annual Land Use Census Changes***

9.5.5 ***Effluent Monitoring System Inoperability***

9.5.5.1 Report all effluent radiation monitoring systems that are out of service 30 consecutive days or more in accordance with NUREG-1301 and NUREG-1302, Section 3.3.3.10.b.

9.5.5.2 Note that per NUREG-1301 and NUREG-1302, Section 3.3.3.10.b, a report is only required when the minimum channels operability requirement is not achieved.

9.5.6 ***Offsite Dose Calculation Manual Changes***

9.5.7 ***Process Control Program Changes***

9.5.8 ***Supplemental Reports for previous Annual Radioactive Effluent Release Reports***

9.5.8.1 Omissions from previously submitted Arrears

9.5.8.2 Errata to correct errors identified in previous Arrears

9.5.9 ***Other (narrative descriptions of other information related to radioactive effluents)***

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this draft regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. The NRC will consider all public comments received in development of the final guidance document. In some cases, applicants or licensees may propose an alternative or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license applications, license amendment applications, and amendment requests.

REGULATORY ANALYSIS

1. Statement of the Problem

Regulatory Guide 1.21, Revision 1, was issued in June 1974. The regulatory guide described programs acceptable to the regulatory staff for measuring, evaluating, and reporting releases of radioactive materials in liquid and gaseous effluents and guidelines for classifying and reporting the categories and curie content of solid wastes.

The methods of measuring, reporting, and evaluating releases have evolved and improved over the past 30 years. Revision 1 of Regulatory Guide 1.21 does not fully reflect current staff positions that have changed based on the lessons learned and operating experience gained over the past 30-plus years. 10 CFR 50.75(g) provides that:

> *"Each licensee shall keep records of … spills or other unusual occurrences … when there is reasonable likelihood that contaminants may have spread to inaccessible areas … [and] … these records must include any known information on identification of involved radionuclides, quantities, forms, and concentrations,"*

This revision of Regulatory Guide 1.21 informs licensees of staff approved methods of improved sampling and analysis techniques, including detection and measurements of radioactivity in spills and leaks.

On March 10, 2006, the NRC Executive Director for Operations established the Liquid Radioactive Release Lessons Learned Task Force in response to incidents at some nuclear power plants related to unplanned, unmonitored releases of radioactive liquids into the environment. The task force issued the "Liquid Radioactive Release Lessons Learned Task Force Final Report," dated September 1, 2006 (Ref. 26), which recommended the revision of effluent and environmental monitoring program requirements and guidance and the provision of additional guidance on detecting, evaluating, and monitoring unplanned and unmonitored releases of radioactive liquids into the environment.

2. Objective

The objective of this regulatory action is to update the regulatory guide to describe the improved methods of measuring, evaluating, and reporting radioactivity in solid waste and radioactivity in liquid and gaseous effluents. In addition, this regulatory action would provide other editorial corrections and revisions to enhance clarity.

3. Alternative Approaches

The NRC staff considered the following alternative approaches:

- Do not revise Regulatory Guide 1.21.
- Update Regulatory Guide 1.21.

3.1 Alternative 1: Do Not Revise Regulatory Guide 1.21

Under this alternative, the NRC would not revise the guidance and the current guidance would be retained. If NRC does not take action, there would not be any changes in costs or benefit to the public, licensees or NRC. However, this "no-action" alternative would not address identified concerns with the current version of the regulatory guide. This alternative provides a baseline condition from which any other alternatives will be assessed.

3.2 Alternative 2: Update Regulatory Guide 1.21

Under this alternative, the NRC would update Regulatory Guide 1.21 to provide current staff guidance. The impact to the NRC would be the costs associated with preparing and issuing the regulatory guide revision. There will be minimal impact to licensees since the information to be supplied in accordance with this draft guide (with the exception of the groundwater data) was required by the previous version (Revision 1) of this Regulatory Guide. Since licensees have been reporting ground water information in Arrears since 2006 (in accordance with industry guidance, Ref. 31) there will be minimal impact on licensees. The impact to the public would be the voluntary costs associated with reviewing and providing comments to NRC during the public comment period. The value to NRC staff and users of the regulatory guide would be the benefits associated with enhanced efficiency and effectiveness gained by using a common guidance document as the technical bases for license applications and other interactions between the NRC and its regulated entities. There is additional benefit in updating this Regulatory Guide in that the revised guidance is current with new industry practices and new (or revised) analytical techniques developed since publication of the last revision of this Regulatory Guide.

4. Conclusion

Based on this regulatory analysis, the staff recommends revision of Regulatory Guide 1.21. The staff concludes that the proposed action will enhance compliance with NRC regulations associated with measuring, evaluating and reporting radioactive releases, and guidance on detecting, evaluating and monitoring unplanned and unmonitored releases of radioactive liquids into the environment.

GLOSSARY

A priori - Not based on prior study or examination; before the fact. In this regulatory guide, "a priori" describes the concept that the sensitivity (lower limit of detection) of an analytical technique (isotopic radiological measurement) should be determined (1) before an analysis is run and (2) before interference from other radionuclides occurs during actual measurements.

Abnormal Release - An unplanned or uncontrolled release of licensed radioactive material, including leaks and spills, to the site environs. The site environs in this context encompasses locations outside of nuclear power plant systems, structures, and components (SSCs), where the SSCs are as described in the final safety analysis report or ODCM. Abnormal releases can occur in restricted areas, controlled areas, or unrestricted areas. System leakage captured by effluent ventilation control systems or sumps is not an abnormal release. See also the definitions of "unplanned release" and "uncontrolled release" below. In certain circumstances, there may be some subjectivity (or measures of degree) associated with the definitions of "unplanned release" and "uncontrolled release." In these situations, additional circumstances should be considered before a final determination of abnormal release is made. Generally, releases that may reasonably be categorized as both unplanned <u>and</u> uncontrolled should be considered abnormal releases. A volume of gas from the containment atmosphere that escapes the equipment hatch during a RFO (especially during the time interval when the containment purge exhaust fans are off) would generally not be considered an abnormal release if (1) the duration was short, (2) the containment activity (gas, particulate, and iodine) was known and very low, and (3) an evaluation was completed to identify a limiting (or "trigger") level of activity that would initiate remedial/mitigating action (e.g., close the equipment hatch to control gases escaping containment).

Accumulated Radioactivity – Radioactivity from prior-year effluent releases that may still be present in the media of concern.

Batch Release – The discharge of a discrete volume of radioactive gases or liquids occurring over a finite period of time (usually hours or days).

Channel Calibration - The adjustment, as necessary, of the channel output such that it responds within the necessary range and accuracy to known values of the parameter that the channel monitors. See also the definition in NUREG-1302/1302.

Channel Check - The qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and/or status to other indications and/or status derived from independent instrument channels measuring the same parameter.

Channel Operational Test (COT) - The injection of a simulated or actual signal into the channel as close to the sensor as practicable to verify operability of all devices in the channel required for channel operability. The COT shall include adjustments, as necessary, of the required alarm, interlock, and trip setpoints required for channel operability such that the setpoints are within the necessary range and accuracy. The COT may be performed by means of any series of sequential, overlapping, or total channel steps.

Continuous Release - An essentially uninterrupted release of gaseous or liquid effluent for extended periods during normal operation of the facility. A continuous release is the discharge of a nondiscrete volume of radwaste (i.e., from a volume or system that has input flow during the release).

Controlled Area - The licensee-defined area, outside of a restricted area but inside the site boundary, to which the licensee can limit access for any reason.

Conversion Factor - A factor (e.g., microcuries per cubic centimeter per counts per minute (μCi/cc/cpm)) used to estimate a radioactivity concentration in an effluent based on a gross radioactivity measurement (e.g., cpm).

D/Q – A dispersion parameter for estimating the dose to an individual at a specified (e.g., controlling) location. D/Q may be described as the downwind surface or ground concentration (D) (e.g., in units of microcuries per square meter (μCi/m^2)) of radioactive material at a location, divided by the release rate (Q) (e.g., in units of microcuries, μCi). D/Q is thus a normalized downwind surface concentration per unit release and can be used to determine the surface or ground radioactivity concentration during a measured effluent release. The units of D/Q are reciprocal square meters.

Determination - A quantitative evaluation of the release or presence of radioactive material under a specific set of conditions. A determination may be made by direct or indirect measurements (e.g., with the use of scaling factors).

Effluent Discharge (Radioactive) - A discharge of licensed material through a liquid or gaseous pathway from a facility into the site environs.

Effluent Monitor Inoperability - A monitor is classified as inoperable if the instrument is unavailable for a period of time greater than 30 continuous days (in accordance with NUREG-1301 and NUREG-1302, Section 3.3.3.10.b).

Elevated Release - A gaseous effluent release made from a height that is more than twice the height of adjacent solid structures, or releases made from heights sufficiently above adjacent solid structures that building wake effects are minimal or absent.

Ground-level Release - A gaseous effluent release made from a height that is at – or less than – the height of adjacent solid structures, or where the degree of plume rise is unknown or is otherwise insufficient to avoid building wake effects.

Ground Water - All subsurface water, or simply water in the ground, regardless of its quality, including saline, brackish, or fresh water. Ground water can be moisture in the ground that is above the regional water table in the unsaturated or vadose zone, or ground water can be at and below the water table in the saturated zone.

Impacted Areas – An area with some reasonable potential for residual radioactivity in excess of natural background or fallout levels (see 10 CFR 50.2, "Definitions," and NUREG-1757, "Consolidated Decommissioning Guidance," issued September 2006). Impacted areas include locations where radiological leaks or spills have occurred within the onsite environs (i.e., outside of the facility's systems, structures, and components). (See also the definition of "significant contamination.")

Leach ate - Water containing contaminants that is percolating downward from a pond or lake into the subsurface.

Licensed Material - Source material, special nuclear material, or byproduct material received, possessed, used, transferred, or disposed of under a general or specific license issued by the Commission.

Lower Limit of Detection (LLD) - The a priori detection capability for the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95-percent probability with only 5-percent probability of falsely concluding that a blank observation represents a real signal (NUREG-1301, NUREG-1302, and NUREG/CR-4007, "Lower Limit of Detection Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," issued September 1984 (Ref. 27).

Member of the Public - Any individual except an individual receiving an occupational dose. This includes onsite personnel who are not receiving an occupational dose.

Minimum Detectable Concentration - The smallest activity concentration measurement that is practically achievable with a given instrument and type of measurement procedure. It depends on factors involved in the survey measurement process (surface type, geometry, backscatter, and self-absorption). (See NUREG-1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions," issued June 1998) (Ref. 28).

Minor Release Point – A specific component, system, or building which is a source of (liquid or gaseous) radwaste and for which an evaluation indicates (1) the dose is less than 1% of the total from all release points, and (2) the activity (e.g., curies) is less than 1% of the total effluent activity from all release points (where liquid and gas releases are considered separately, and nuclides are totaled separately by the categories listed in regulatory position 9.1.1 and 9.2.1, and the summing intervals for doses and activity are either quarterly, annually, each fuel cycle, or longer period as specified by the licensee). The evaluation should be documented and may be based on samples, bounding assessments, or a combination of both.

Mixed Mode Release – A gaseous effluent release made from a height higher than a ground-level release, but less than an elevated release, where, due to lack of plume rise (e.g., buoyancy, momentum, and wind speed), a proper estimate of radionuclide transport and dispersion require mathematically splitting the plume into (1) and elevated component, and (2) a ground level component to properly account for building wake effects. See Regulatory Guide 1.111 (Ref. 17) for further guidance.

Monitoring – The process of measuring and analyzing the release characteristics of radioactive material.

Non-routine, Planned Discharge – An effluent release from a release point that is not defined in the ODCM but that has been planned, monitored, and discharged in accordance with 10 CFR 20.2001 (e.g., the discharge of water recovered during a spill or leak from a temporary storage tank).

Nuclear Fuel Cycle – The operations defined to be associated with the production of electrical power for public use by any fuel cycle through utilization of nuclear energy. (40 CFR 190.02)

Operability (Operable) – The ability of a system, subsystem, train, component, or device to perform its specified safety function(s) and the ability of all necessary attendant instrumentation, controls, normal or emergency electrical power, cooling and seal water, lubrication, and other auxiliary equipment (required for the system, subsystem, train, component, or device to perform its specified safety function(s)) to perform their related support function(s).

Principal Exposure Pathways – The primary exposure pathways to mankind (e.g., direct radiation, airborne exposure, waterborne exposure, and ingestion exposure pathways).

Principal Radionuclide – A radionuclide that contributes in excess of 1 percent of the dose to a member of the public or in excess of 1 percent of the total effluent activity in a particular reporting interval (e.g., a calendar year), and for the particular radionuclide categories listed in Table A-1 (for gas releases) and Table A-2 (for liquid releases).

Release Point – A location from which radioactive materials are released to the environment from a system, structure, or component (including evaporative releases and leaching from ponds in the controlled or restricted area before discharge under 10 CFR 20.2001) (see also the definition for "significant release point").

Restricted Area – An area where the licensee limits access for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

Scaling Factor – A factor used to estimate the activity of an unknown radionuclide based on its ratio to the activity of a readily measured radionuclide or other parameter (e.g., carbon-14 scaled to power generation).

Significant Contamination (as used for 10 CFR 50.75(g) recordkeeping) – A quantity and/or concentration of residual radioactivity that would require remediation during decommissioning in order to terminate the license by meeting the unrestricted use criteria stated in 10 CFR 20.1402, "Radiological Criteria for Unrestricted Use" (see NUREG-1757).

Significant Residual Radioactivity – Synonymous with significant contamination.

Significant Exposure Pathway – An exposure pathway that contributes in excess of 10% of the public's effluent dose from all exposure pathways (see also the definition for "principal exposure pathway").

Significant Release Point – A specific component, system, or building which is a source of (liquid or gaseous) radwaste and for which both (1) the dose is greater than or equal to 1% of the total from gaseous release points or liquid release points (considered separately), and (2) the activity (e.g., curies) is greater than or equal to 1% of the total effluent activity from gaseous release points or liquid release points (considered separately). Additionally, nuclides are totaled separately by the categories as listed in regulatory position 9.1.1 (e.g., fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha) and 9.2.1 (fission and activation products, tritium, dissolved and entrained noble gases, and gross alpha). Lastly, the summing intervals for dose and activity calculations are either quarterly, annually, each fuel cycle, or longer period as specified by the licensee.

Site Boundary – That line beyond which the licensee does not own, lease, or otherwise control the land or property.

Site Environs – Locations outside of the nuclear power plants systems, structures, or components as described in the final safety analysis report or the ODCM.

Source Check – A qualitative assessment of the channel (instrument) response when the channel sensor is exposed to a radioactive source.

Unlicensed Material – Byproduct material that is no longer under a general or specific license issued by the Commission. This includes radioactive material in the site environs that has been disposed of

in accordance with 10 CFR 20.2001, unless concentrations exceed the limits in 10 CFR 30.14, "Exempt Concentration" (Ref. 28). In addition, exempt radioactive sources under 10 CFR 30.15, "Certain Items Containing Byproduct Material," or 10 CFR 30.18, "Exempt Quantities," are unlicensed material.

Uncontrolled Release – The release of licensed radioactive material in which (1) the release path is not monitored (e.g., with a continuously indicating/recording radiation monitor in the discharge pathway, or with a flow indicator/recorder in the discharge pathway, or without benefit of grab samples), **AND** (2) there is reasonable potential that the combination of flow rate and release activity could result in significant amounts of radioactive material discharged, **AND** (3) there is not a preplanned method of terminating the release to the environment.

Unplanned Release – The unintended discharge of a volume of liquid or airborne radioactivity to the environment. Examples of unplanned releases include
(1) the unintentional discharge of a wrong waste gas decay tank (or bulk liquid radwaste tank),
(2) the failure of a radiation monitor to divert liquid to the radwaste system in the case where radioactivity is present and the automatic alarm/trip function fails to divert material to liquid radwaste and that material (or a portion of that material) is instead discharged to the environment, or
(3) the release of a sufficiently large amount of radioactive material (via a leak or a plant operational occurrence) such that a 10 CFR 50.72 or a 10 CFR 50.73 report is required.
If a licensee has prepared a preliminary release permit in advance of a discharge, it is a planned release. If a preliminary release permit was not prepared (or considered/evaluated) prior to the discharge, additional information (as described below) should be considered before categorizing the release as an "unplanned" release. The magnitude of the release should be considered before categorizing a discharge as "unplanned." For example, for routine small liquid leaks from pipes and valves where the liquid leakage is collected in sumps or drains (as designed), and where the discharge is monitored in accordance with the licensee's radioactive effluent control program (as defined in the ODCM), the release is not unplanned. Similarly, for minor leaks (e.g., valves, pipes, or routine plant evolutions) that result in some radioactive gases escaping to the plant ventilation system, where the gases do not cause the installed plant vent stack radiation monitoring system to deviate significantly from the routine variance in the baseline, and where accountability is controlled and reported in accordance with the licensee's radioactive effluent control program (as defined in the ODCM), such routine, typical releases are not considered unplanned releases. (Ref. 30).

Unrestricted Area – An area for which the licensee neither controls nor limits access.

Uranium Fuel Cycle – The operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and by-product materials from the cycle.

χ/Q - A mathematical model depicting the atmospheric transport and diffusion of radioactive material in gaseous effluents at some distance from the source (origin). χ/Q is the average atmospheric effluent concentration, χ, normalized by source strength, Q, at a distance (or location) in a given downwind direction. Expressed in another way, χ/Q is the concentration (χ) of airborne

radioactive material (e.g., in units of $\mu Ci/m^3$) divided by the release rate (Q) (e.g., in units of $\mu Ci/s$) at a specified distance and direction downwind of the release point. χ/Q is thus a normalized airborne radioactivity concentration per unit release rate and as such is readily suitable for use in determining the ground level airborne radioactivity concentration, at some distance from the origin of the release, simply by multiplying by a known source release rate Q.

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APPENDIX A

Table A-1, Gaseous Effluents - Summation of All Releases

Total Release	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Fission and Activation Gases	Ci					
Iodines	Ci					
Particulates	Ci					
Tritium	Ci					
Alpha	Ci					

Table A-1A, Gaseous Effluents - Ground-Level Release - Batch Mode

Fission Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
C-14	Ci					
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131M	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
Other	Ci					
Total	Ci					

Iodines/halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Zn-72	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95m	Ci					
Tc-99m	Ci					
Te-132	Ci					
Cs-134	Ci					
Cs-138	Ci					
Ba-139	Ci					
La-142	Ci					
Ce-143	Ci					
Ce-144	Ci					
Rh-188	Ci					
Other	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1B, Gaseous Effluents - Ground-Level Release - Continuous Mode

Fission Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
C-14	Ci					
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131M	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
Total	Ci					

Iodines/halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Zn-72	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95m	Ci					
Tc-99m	Ci					
Te-132	Ci					
Cs-134	Ci					
Cs-138	Ci					
Ba-139	Ci					
La-142	Ci					
Ce-143	Ci					
Ce-144	Ci					
Rh-188	Ci					
Other	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1C, Gaseous Effluents - Elevated Release - Batch Mode

Fission Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
C-14	Ci					
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131M	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
Other	Ci					
Total	Ci					

Iodines/halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Zn-72	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95m	Ci					
Tc-99m	Ci					
Te-132	Ci					
Cs-134	Ci					
Cs-138	Ci					
Ba-139	Ci					
La-142	Ci					
Ce-143	Ci					
Ce-144	Ci					
Rh-188	Ci					
Other	Ci					
Other	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1D, Gaseous Effluents - Elevated Release - Continuous Mode

Fission Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
C-14						
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131M	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
Other	Ci					
Total	Ci					

Iodines/halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Zn-72	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95m	Ci					
Tc-99m	Ci					
Te-132	Ci					
Cs-134	Ci					
Cs-138	Ci					
Ba-139	Ci					
La-142	Ci					
Ce-143	Ci					
Ce-144	Ci					
Rh-188	Ci					
Other	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1E, Gaseous Effluents - Mixed Mode Release - Batch Mode

Fission Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
C-14						
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131M	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
Other	Ci					
Total	Ci					

Iodines/halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Zn-72	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95m	Ci					
Tc-99m	Ci					
Te-132	Ci					
Cs-134	Ci					
Cs-138	Ci					
Ba-139	Ci					
La-142	Ci					
Ce-143	Ci					
Ce-144	Ci					
Rh-188	Ci					
Other	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1F, Gaseous Effluents - Mixed Mode Release - Continuous Mode

Fission Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
C-14	Ci					
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131M	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
Other	Ci					
Total	Ci					

Iodines/halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Zn-72	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95m	Ci					
Tc-99m	Ci					
Te-132	Ci					
Cs-134	Ci					
Cs-138	Ci					
Ba-139	Ci					
La-142	Ci					
Ce-143	Ci					
Ce-144	Ci					
Rh-188	Ci					
Other	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-2, Liquid Effluents

Summation of All Releases

Total Release	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Uncertainty (%)
Fission and Activation Products (excluding tritium, gases, and alpha)	Ci						
Tritium	Ci						
Dissolved and Entrained Gases	Ci						
Alpha	Ci						
Volume of Primary System Liquid Effluent (Before Dilution)	Liters						
Volume of Secondary or Balance of Plant Liquid Effluent (e.g., Low-Activity or unprocessed) (Before Dilution)	Liters						
Dilution Water Used	Liters						
Average Stream Flow	m^3/sec						

Table A-2A, Liquid Effluents - Batch Mode

Fission and Activation Products	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Cr-51	Ci					
Mn-54	Ci					
Fe-55	Ci					
Fe-59	Ci					
Co-57	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Y-91m	Ci					
Y-92	Ci					
Nb-95	Ci					
Nb-95m	Ci					
Mo-99	Ci					
Tc-99m	Ci					
Ru-103	Ci					
Ru-106	Ci					
Ag-110m	Ci					
Sn-113	Ci					
Sb-122	Ci					
Sb-124	Ci					
Sb-125	Ci					
Te-129	Ci					
Te-132	Ci					
I-131	Ci					
I-133	Ci					
I-135	Ci					
Cs-134	Ci					
Cs-137	Ci					
Ba-139	Ci					
Ba-140	Ci					
La-140	Ci					
Ce-143	Ci					
Cs-144	Ci					
W-187	Ci					
Np-239	Ci					
Other	Ci					
Totals	Ci					

Table A-2A (continued), Liquid Effluents - Batch Mode

Dissolved and Entrained Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Other	Ci					
Totals	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-2B, Liquid Effluents - Continuous Mode

Particulates and Iodines	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Cr-51	Ci					
Mn-54	Ci					
Fe-55	Ci					
Fe-59	Ci					
Co-57	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Y-91m	Ci					
Y-92	Ci					
Nb-95	Ci					
Nb-95m	Ci					
Mo-99	Ci					
Tc-99m	Ci					
Ru-103	Ci					
Ru-106	Ci					
Ag-110m	Ci					
Sn-113	Ci					
Sb-122	Ci					
Sb-124	Ci					
Sb-125	Ci					
Te-129	Ci					
Te-132	Ci					
I-131	Ci					
I-133	Ci					
I-135	Ci					
Cs-134	Ci					
Cs-137	Ci					
Ba-139	Ci					
Ba-140	Ci					
La-140	Ci					
Ce-143	Ci					
Cs-144	Ci					
W-187	Ci					
Np-239	Ci					
Other	Ci					
Totals	Ci					

Table A-2B (continued), Liquid Effluents - Continuous Mode

Dissolved and Entrained Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Other	Ci					
Totals	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-3, Low-Level Waste and Used Fuel

1 LLW Shipped for Direct Disposal (to licensed waste disposal facilities)	**Number of Shipments**	**Volume**	**Activity**	**Principal Isotopes**
Class A Resins, Filters, Evap bottoms		ft^3	Ci	
Class B Resins, Filters, Evap bottoms		ft^3	Ci	
Class A Dry Active Waste		ft^3	Ci	
Class A Irradiated Components		ft^3	Ci	
Class A Other Waste (e.g., sewage sludge, ventilation charcoal)		ft^3	Ci	
Other Waste (not fitting in above categories)		ft^3	Ci	
2 LLW Shipped for Processing (before disposal or return to site)	**Number of Shipments**	**Volume**	**Activity**	**Principal Isotopes**
Class A Resins, Filters, Evap bottoms		ft^3	Ci	
Class B Resins, Filters, Evap bottoms		ft^3	Ci	
Class A Dry Active Waste		ft^3	Ci	
Class A Irradiated Components		ft^3	Ci	
Class A Other Waste (e.g., sewage sludge, ventilation charcoal)		ft^3	Ci	
Other Waste (not fitting in above categories)		ft^3	Ci	
3 LLW Returned to Site (from radioactive waste processors for long-term storage)	**Number of Shipments**	**Volume**	**Activity**	**Principal Isotopes**
Class A Resins, Filters, Evap bottoms		ft^3	Ci	
Class B Resins, Filters, Evap bottoms		ft^3	Ci	
Other Waste		ft^3	Ci	
4 LLW Shipped for 10 CFR 20.2002 Disposal	**Number of Shipments**	**Volume**	**Activity**	**Principal Isotopes**
Class A Resins, Filters, Evap bottoms		ft^3	Ci	
Class A Dry Active Waste		ft^3	Ci	
Class A Irradiated Components		ft^3	Ci	
Class A Other Waste (e.g., sewage sludge, ventilation charcoal)		ft^3	Ci	
Other Waste (not fitting above categories)		ft^3	Ci	
5 Used (Irradiated) Fuel Shipments (Offsite Disposal)	**Number of Shipments**	**Destination**	**Mode of Transport**	**Principal Isotopes**

Table A-4, Dose Assessments, 10 CFR Part 50, Appendix I

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Yearly	Sector/ Distance
Liquid Effluent Dose Limit Total Body	1.5 mrem	1.5 mrem	1.5 mrem	1.5 mrem	3 mrem	
Total Body Dose						
% of Limit						
Liquid Effluent Dose Limit Any Organ	5 mrem	5 mrem	5 mrem	5 mrem	10 mrem	
Organ Dose						
% of Limit						
Gaseous Effluent Dose Limit Gamma Air Dose	5 mrad	5 mrad	5 mrad	5 mrad	10 mrad	
Gamma Air Dose						
% of Limit						
Gaseous Effluent Dose Limit Beta Air Dose	10 mrad	10 mrad	10 mrad	10 mrad	20 mrad	
Beta Air Dose						
% of Limit						
Gaseous Effluent Dose Limit Any Organ (Iodine, Tritium, Particulates with >8-day half-life)	7.5 mrem	7.5 mrem	7.5 mrem	7.5 mrem	15 mrem	
Gaseous Effluent Organ Dose (Iodine, Tritium, Particulates with > 8-Day half-life)						
% of Limit						

Table A-5, Dose to a Member of the Public Per 10 CFR 20.1301 (a) thru (c)

	Liquid Effluents (mrem)	Gaseous Effluents (mrem)	Direct Radiation (mrem)	Total (mrem)	Location/ Area (i.e., controlled area or unrestricted area)	Sector/ Distance
TEDE Limit				100 mrem	controlled area or unrestricted area	
TEDE Dose						
% of Limit						

Table A-6, EPA 40 CFR Part 190 Individual in the Unrestricted Area

	Whole Body	Thyroid	Any other organ	Sector/Distance
Dose Limit	25 mrem	75 mrem	25 mrem	
Dose				
% of Limit				

Table A-7, Supplemental Information

1. Abnormal releases (e.g., leaks and spills)

2. Nonroutine, Planned Discharges (e.g., pumping of leaks and spills for remediation, results of ground water monitoring to quantify effluent releases to the offsite environment)

3. Radioactive Waste Treatment System Changes

4. Annual Land-Use Census Changes

5. Effluent Monitor Instrument Inoperability

6. Offsite Dose Calculation Manual Changes

7. Process Control Program Changes

8. Errata/Supplemental Report(s) (e.g., errors or omissions in previous reports)

9. Other (narrative description of other information that is provided to the U.S. Nuclear Regulatory Commission)

Table A-8, Residual Radioactivity Screening Values for Surface Soil (Partial List of Common Nuclear Power Plant Radionuclides) (from Appendix H to NUREG-1757, Volume 2, Revision 1)

Radionuclide	Symbol	pCi/g	pCi/kg
Hydrogen-3	^{3}H	110	110,000
Carbon-14	^{14}C	12	12,000
Manganese-54	^{54}Mn	15	15,000
Iron-55	^{55}Fe	10,000	10,000,000
Cobalt-60	^{60}Co	3.8	3,800
Nickel-59	^{59}Ni	5,500	5,500,000
Nickel-63	^{63}Ni	2,100	2,100,000
Strontium-90	^{90}Sr	1.7	1,700
Niobium-94	^{94}Nb	5.8	5,800
Technetium-99	^{99}Tc	19	19,000
Cesium-134	^{134}Cs	5.7	5,700
Cesium-137	^{137}Cs	11	11,000

Notes:

These values represent surficial surface soil concentrations of individual radionuclides that would be deemed in compliance with the 25 millirem/year (0.25 millisievert/year) unrestricted release dose limit in 10 CFR 20.1402, "Radiological Criteria for Unrestricted Use." For radionuclides in a mixture, the "sum of fractions" rule applies (see Section 2.7 of NUREG-1757).

Screening values are in units of picocuries per gram equivalent to 25 millirem/year. These values were derived using Decontamination and Decommissioning (D&D) screening methodology (NUREG/CR-5512, Volume 3, "Residual Radiation Contamination from Decommissioning: Parameter Analysis," issued October 1999). They were derived based on selection of the 90th percentile of the output dose distribution for each specific radionuclide (or radionuclide with the specific decay chain). Behavioral parameters were set at the mean of the distribution of the assumed critical group. The metabolic parameters were set at "Reference Man" or at the mean of the distribution for an average human.