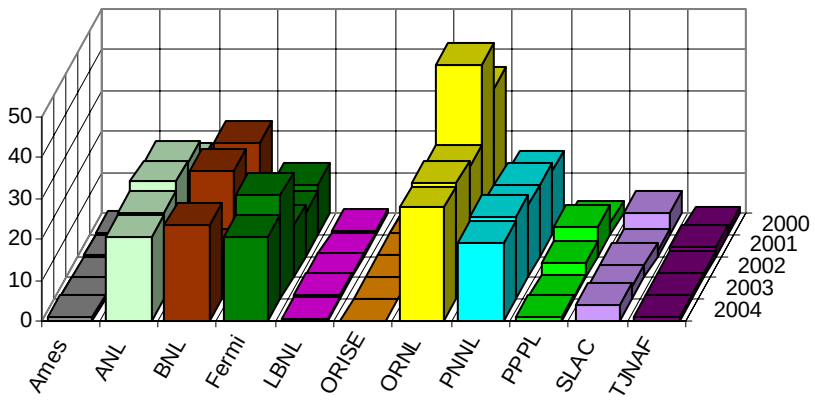
Radiological Control Profile for the Office of Science Laboratories 2000-2004

Collective Dose at SC Laboratories (Person-Rem)



Office of Laboratory Policy and Infrastructure (SC-31)
Office of Science
U.S. Department of Energy

Executive Summary

Looking back at the trend over the past five years, the collective dose from all Office of Science (SC) laboratories has increased about 4 percent overall, from 115 person-rem in 2000 to 120 person-rem in 2004. By comparison, the collective dose at all Department of Energy (DOE) laboratories dropped by about 14 percent in the same period, from 1,266 to 1,094 person-rem, due to suspension of non-essential work at Los Alamos during the second half of the year and completion of remediation work at several sites.

The increase in collective dose is mostly attributable to acceleration of Environmental Management remediation activities at Brookhaven National Laboratory (BNL). One area of significant increased exposure was due to the Brookhaven Graphite Research Reactor (BGRR) Project, where the collective dose increased from approximately 2 rem in 2003 to approximately 12 rem in 2004. It is expected that radiation exposures at BNL will decrease significantly next year due to the completion of remediation activities.

The largest decrease in collective dose was at Fermi National Accelerator Laboratory (Fermilab), dropping from 26 person-rem in 2003 to 21 person-rem in 2004. The principal activities at Fermilab that resulted in occupational radiation exposures were associated with maintenance activities of the accelerator. Nearly all of the collective dose to personnel was due to exposures to items activated by the accelerator beams. Many maintenance activities were necessary as the Fermilab accelerator complex was challenged to meet the scientific objectives of Tevatron Run II while simultaneously operating the proton beam needed for the MiniBooNE experiment. The vast majority of this work occurred during a major shutdown of the accelerator carried out during the late summer and autumn of 2004. Fermilab accomplished several vital accelerator upgrades during this shutdown.

The number of workers who received an annual dose exceeding 1,000 millirem increased from one in 2003 to two in 2004. The two workers in this category were both at Argonne National Laboratory, working at the Alpha Gamma Hot Cell Facility (AGHCF).

Most workers who were monitored for radiation exposure at SC laboratories received no measurable dose at all. Of those who did, approximately 85 percent received less than 100 millirem per year (the threshold for when a dosimeter must be issued). More than 98 percent of those with a measurable dose received an annual dose under 500 millirem, which is one-tenth of the DOE annual limit of 5,000 millirem (5 rem).

Reportable occurrences for radiation exposure, personnel contamination, and loss of control of radioactive material do not show any clear trend, although they generally correspond to the amount of work performed. Off-site doses to members of the public from releases of radionuclides to the environment are all well within regulatory limits. Some SC laboratories have issues with legacy contamination in groundwater and soils from historical releases of radionuclides, but there are no issues of non-compliance with applicable standards for protection of the public.

Introduction

This is a current assessment of the performance of SC laboratories with respect to radiological control. It provides a five-year retrospective look at occupational radiation exposures and radionuclide releases to the environment at all SC laboratories, including results for all DOE employees, contractors, subcontractors, and visitors. The scope of the report includes occupational doses for all workers at each facility and is not limited to just those funded by SC.

The occupational exposure data in this report is taken from the DOE Radiation Exposure Monitoring System (REMS), which serves as the central repository of radiation exposure information for DOE Headquarters. The REMS data is available on the web at http://www.eh.doe.gov/rems/rems/ri.htm and is also published annually in the *DOE Occupational Radiation Exposure Report*. Information on radionuclide releases to the environment was taken from the Annual Site Environmental Reports.

Excellence in Radiological Control

The Department strives to maintain radiation exposures to its workers and the public below administrative control levels and regulatory limits and to further reduce these exposures to levels that are "As Low As Reasonably Achievable" (ALARA). The ALARA methodology considers both individual and group doses and involves a cost/benefit analysis that considers social, technical, economic, practical, and public policy aspects of the overall goal of dose reduction.

To evaluate how well ALARA is being implemented for workers at SC laboratories, it is necessary to look at several different measures of occupational dose. The analysis in this report considers the total number of individuals who are monitored for dose, the number of those who actually receive a measurable dose, their average dose, and the group (or total collective) dose for all monitored individuals at all SC laboratories.

One characteristic of a good ALARA program is that the majority of worker dose should be at relatively low levels, with only a small percentage of workers receiving doses approaching administrative control levels. For this reason, this report also includes a frequency distribution for the total number of exposed workers at selected ranges of dose.

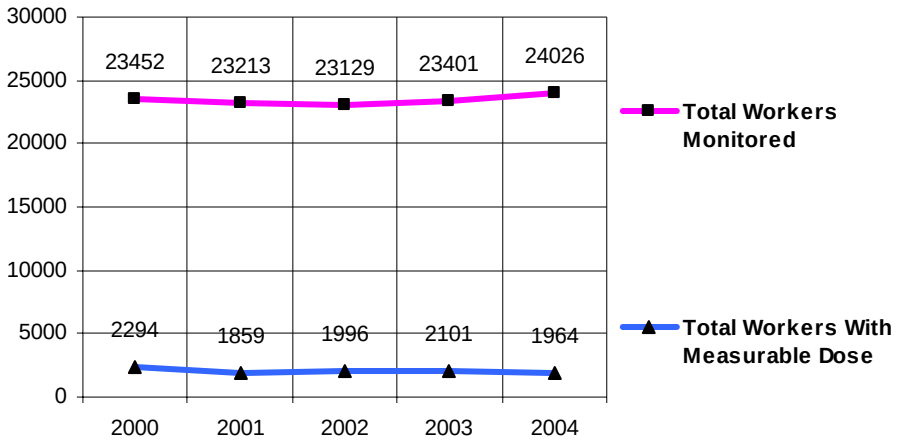
Another characteristic of a robust radiological safety program is that, for a constant workload, both individual and group doses should drop over time, as experience and lessons learned combine to improve radiological work practices. This analysis provides a five-year retrospective of occupational and environmental radiation exposures to evaluate where reductions have occurred. It is important to note that an increase in dose does not necessarily indicate a problem if it can be attributed to increased work activity rather than a decrease in radiation control practices.

Number of Monitored Workers

Personnel dosimetry is required for DOE workers who are likely to receive a dose greater than 100 millirem per year. Also, visitors are monitored at half that limit (50 millirem per year) if they are members of the public and not employees.

In practice, most sites prudently provide dosimetry in excess of this requirement, for reasons of administrative convenience, legal liability, and security. While the total number of monitored workers gives a good indication of the overall scope of the dosimetry program, it is not necessarily a good indicator of the actual exposed work force.

Figure 1: Number of Monitored Workers at SC Laboratories



The total number of monitored workers at all SC laboratories has changed very little, from 23,452 in 2000 to 24,026 in 2004 (see Figure 1). However, only a fraction of those monitored actually received a measurable dose. The number of workers with a measurable dose decreased slightly from 2,294 in 2000 to 1,964 in 2004.

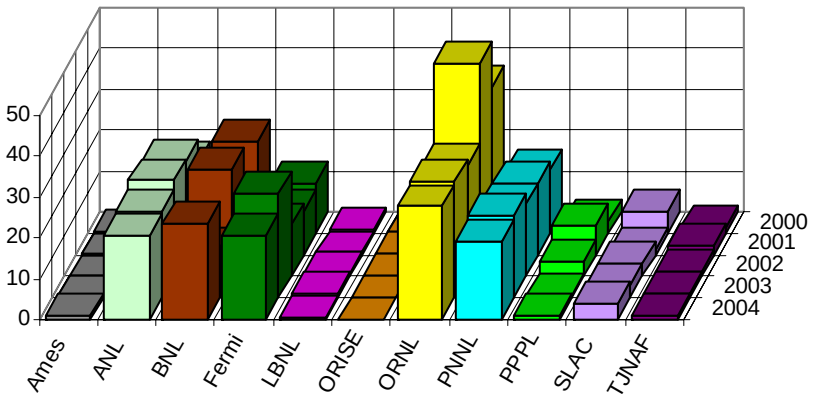
Collective Occupational Dose

Looking back at the trend over the past five years, the collective dose from all Office of Science (SC) laboratories has increased about 4 percent overall, from 115 person-rem in 2000 to 120 person-rem in 2004. By comparison, the collective dose at all Department of Energy (DOE) laboratories dropped by about 14 percent in the same period, from 1,266 to 1,094 person-rem, due to suspension of non-essential work at Los Alamos during the second half of the year and completion of remediation work at several sites.

The increase in collective dose is mostly attributable to acceleration of Environmental Management remediation activities at Brookhaven National Laboratory (BNL). One area of significant increased exposure was due to the Brookhaven Graphite Research Reactor (BGRR) Project, where the collective dose increased from approximately 2 rem in 2003 to approximately 12 rem in 2004. It is expected that radiation exposures at BNL will decrease significantly next year due to the completion of remediation activities.

The largest decrease in collective dose was at Fermi National Accelerator Laboratory (Fermilab), dropping from 26 person-rem in 2003 to 21 person-rem in 2004. The principal activities at Fermilab that resulted in occupational radiation exposures were associated with maintenance activities of the accelerator. Nearly all of the collective dose to personnel was due to exposures to items activated by the accelerator beams. Many maintenance activities were necessary as the Fermilab accelerator complex was challenged to meet the scientific objectives of Tevatron Run II while simultaneously operating the proton beam needed for the MiniBooNE experiment. The vast majority of this work occurred during a major shutdown of the accelerator carried out during the late summer and autumn of 2004. Fermilab accomplished several vital accelerator upgrades during this shutdown. This work included extensive ALARA pre-job planning, implementation of specific ALARA activities during radiological work, and post-job analyses.

Figure 2: Collective Dose at SC Laboratories (Person-Rem)



Year	Ames	ANL	BNL	Fermi	LBNL	ORISE	ORNL	PNNL	PPPL	SLAC	TJNAF
2000	0.311	17.244	22.384	12.340	1.114	0.299	35.848	15.378	2.941	5.464	1.616
2001	0.174	23.033	14.627	10.650	0.682	0.327	47.039	17.639	7.420	1.368	2.317
2002	0.076	23.560	26.244	12.790	0.895	0.274	27.046	17.690	3.707	3.075	1.113
2003	0.448	21.379	12.183	25.670	1.037	0.289	28.591	20.407	0.593	3.127	0.992
2004	1.152	20.514	23.678	20.570	0.739	0.249	27.675	19.340	1.141	3.916	1.074

In 2004, the collective dose at ORNL decreased slightly, from 29 person-rem in 2003 to 28 person-rem in 2004. The major contribution to the collective dose at ORNL is the work at the Radiochemical Engineering Development Center (REDC) and the High Flux Isotope Reactor (HFIR). The collective dose at ORNL will remain a challenge because of future projects and activities, including the return of liquid and gaseous waste operations to ORNL, continued cleanup of legacy radioactive materials, and the operation of the Spallation Neutron Source. There is an ALARA Steering Committee and an ALARA Working Committee which discuss ongoing projects and share lessons learned on dose reductions. The ALARA awards are routinely presented to employees who develop methods of reducing dose for particular jobs.

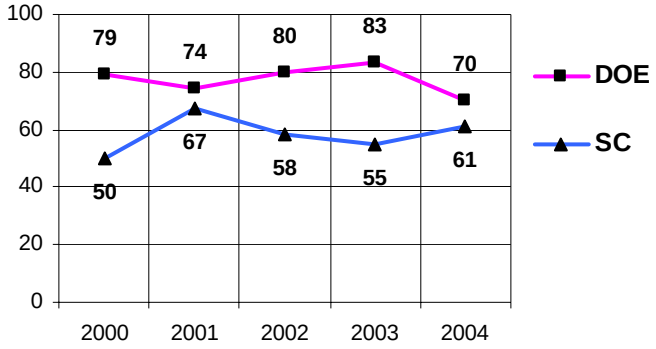
The collective dose at ANL dropped approximately four percent in 2004, compared to the previous year. The number of workers with an annual dose exceeding 1,000 millirem increased from zero in 2003 to two in 2004. The principal dose contributor was the Alpha Gamma Hot Cell Facility (AGHCF). The AGHCF has improved the shielding on several of their gloveboxes by adding leaded glass to the work areas, which resulted in a 50 percent reduction in dose for manipulator repairs.

At PNNL, the collective dose decreased from 20 person-rem in 2003 to 19 person-rem in 2004. Nearly 80 percent of the collective dose is from operations at the Radiochemical Processing Laboratory (RPL). The dose from the RPL correlates primarily to projects that support Hanford Site cleanup, the RPL Inventory Reduction Initiative, the Prostate Seed Development Project, and decontamination and evaluation of nuclear power reactor control rod drive mechanisms.

Average Measurable Occupational Dose

The average measurable dose is calculated by dividing the collective dose by the total number of individuals with a measurable dose. The average dose for all SC facilities has ranged between 50 to 67 millirem during the last five years (see Figure 3).

Figure 3: Average Measurable Dose at SC Laboratories (mrem/yr)



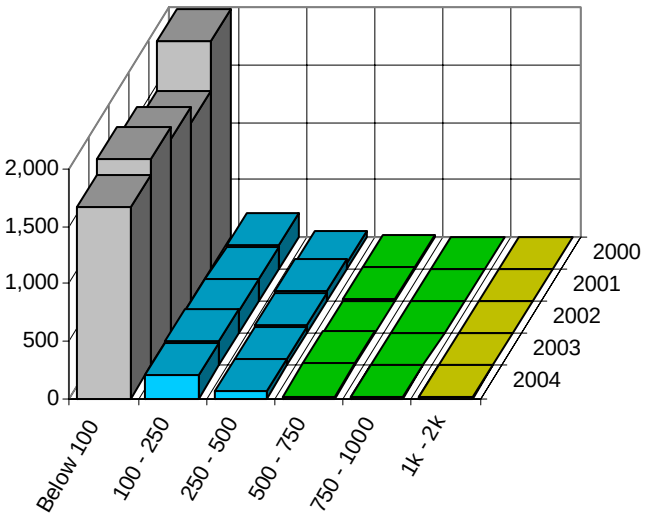
While the average measurable dose is one useful indicator for dose to workers (and visitors) at SC laboratories, it can be misunderstood if taken out of context. For example, the average dose can drop if there is an overall increase in the number of workers who receive very low levels of measurable dose. This may give a mistaken impression that doses are dropping, when in fact they are rising.

Also, since the average is calculated by dividing by the total number of workers with a measurable dose, the average may not be very sensitive to increases in dose to small numbers of workers, which may be of concern. In order to provide a more complete picture of radiation exposures, the following section presents exposure data as a frequency distribution showing the number of workers at selected intervals of annual dose with trends over the past five years.

Occupational Dose Distribution

Of all SC laboratory workers who receive a measurable dose, the majority received an annual dose of less than 100 millirem, which is the DOE threshold for requiring dosimetry (see Figure 4). For the last five years, at least 80 percent of all workers at SC laboratories fell into this category. Also, for this same time period, more than 98 percent of all workers had a dose of less than 500 millirem per year, which is one-tenth of the annual limit of 5,000 millirem in 10 CFR 835.

Figure 4: Dose Distribution for SC Laboratories: Total Number of Workers in Each Dose Range



Dose Range (millirem/year)

Year	Below 100	100 - 250	250 - 500	500 - 750	750 - 1000	1k - 2k
2000	1,997	212	62	19	1	3
2001	1,549	191	88	19	5	7
2002	1,698	201	73	12	6	6
2003	1,802	212	65	17	4	1
2004	1,662	205	64	17	14	2

The number of workers who received an annual dose exceeding 1,000 millirem increased from one in 2003 to two in 2004. The two workers in this category were both at Argonne National Laboratory, working at the Alpha Gamma Hot Cell Facility (AGHCF).

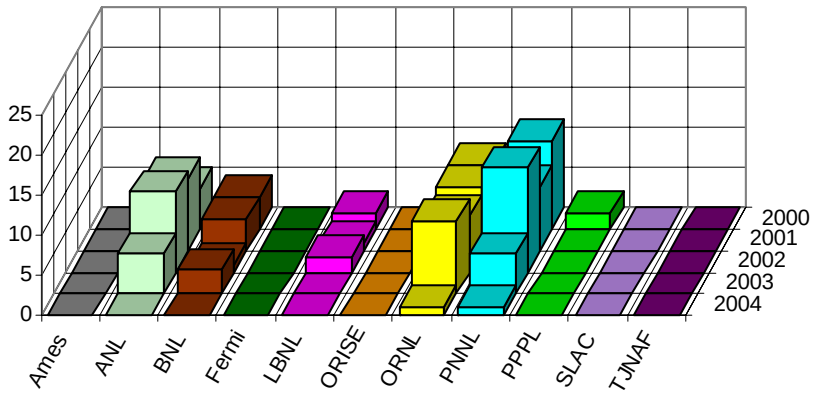
Unplanned Radiation Exposures

There were no occurrences of unplanned radiation exposures at SC laboratories in 2004. During the past five years, there were only three of these types of occurrences at SC laboratories, as compared to 69 for all of DOE.

Personnel Contamination

In addition to unplanned radiation exposures, sites are also required to report occurrences of personnel contamination. Although these kinds of occurrences do not cause any significant dose, they are tracked as a performance indicator for conduct of operations. An increase in the number of contaminations may indicate a degradation in radiological control practices, if not otherwise attributable to a change in work activities. The threshold for reporting personnel contamination occurrences was raised in mid-2003, which generally decreased the total number reported, as compared to previous years.

Figure 5: Occurrences at SC Laboratories for Personnel Contamination



Year	Ames	ANL	BNL	Fermi	LBNL	ORISE	ORNL	PNNL	PPPL	SLAC	TJNAF
2000	0	5	4	0	2	0	8	11	2	0	0
2001	0	9	4	0	1	0	8	8	0	0	0
2002	0	10	1	0	2	0	7	13	0	0	0
2003	0	5	3	0	0	0	9	5	0	0	0
2004	0	0	0	0	0	0	1	1	0	0	0

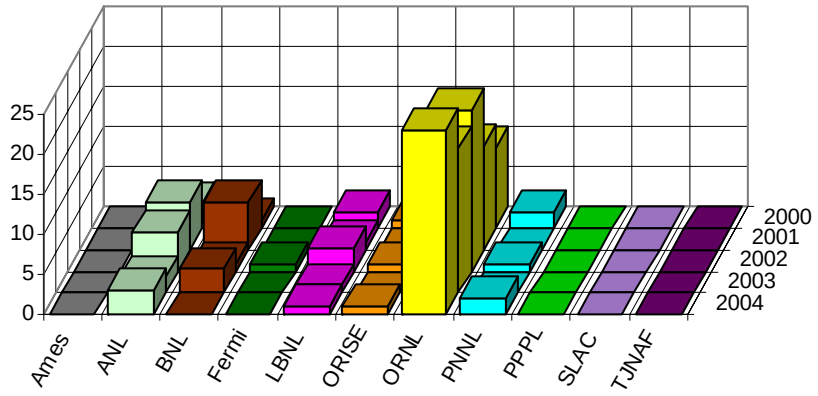
There were two occurrences of personnel contamination in 2004. Over the past five years, there were 119 occurrences, as compared to 1,061 for all of DOE. These occurrences were predominately at the multi-program laboratories (see Figure 5). These occurrences do not show any clear trend, although they generally correspond to the amount of work performed.

Loss of Control of Radioactive Material and Spread of Contamination

In addition to personnel contamination, sites also report occurrences of loss of control of radioactive material, and/or spread of contamination. Like personnel contamination, these occurrences do not cause significant dose, but are used as a performance indicator for conduct of operations. The threshold for reporting these contamination occurrences was raised in mid-2003, which generally decreased the total number reported, as compared to previous years.

There were 131 reported occurrences for this category during the past five years at SC laboratories, as compared to 873 reported DOE-wide. These occurrences were predominately at ORNL (see Figure 6), which are mostly due to the legacy contamination found from movement of personnel from old buildings to newer facilities.

Figure 6: Occurrences at SC Laboratories for Loss of Control of Radioactive Material & Spread of Contamination



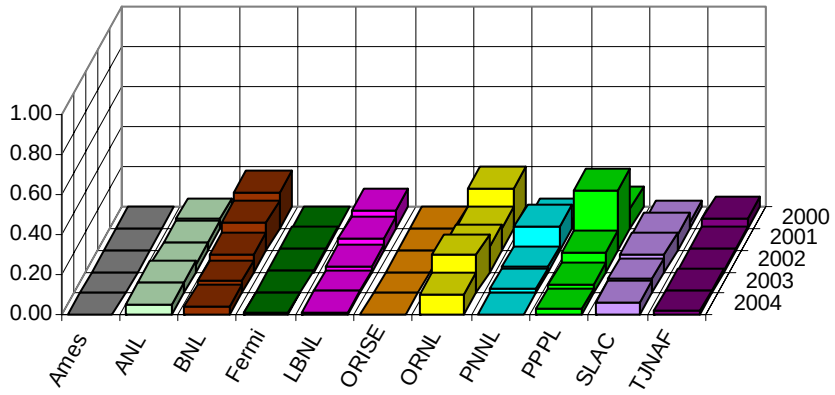
Year	Ames	ANL	BNL	Fermi	LBNL	ORISE	ORNL	PNNL	PPPL	SLAC	TJNAF
2000	0	3	1	0	2	1	10	2	0	0	0
2001	0	6	6	0	1	0	13	0	0	0	0
2002	0	5	1	1	3	1	20	1	0	0	0
2003	0	2	3	0	1	0	18	0	0	0	0
2004	0	3	0	0	1	1	23	2	0	0	0

Environmental Releases of Radionuclides

All DOE facilities are required to demonstrate to the Environmental Protection Agency (EPA) that radionuclides released to air do not cause a dose greater than 10 millirem per year to any member of the public. This standard is found in the National Emission Standards for Hazardous Air Pollutants (NESHAPS) standard 40 CFR 61, Subpart H. This dose of 10 millirem per year is too small to measure because of the much higher natural background radiation (around 300 millirem per year) and must be calculated annually, using EPA-approved computer codes.

Over the past five years the dose to the maximally exposed individual has remained substantially less than one millirem per year at all SC laboratories (see Figure 7). In 2004, the largest dose was at ORNL (0.1 millirem, or 1 percent of the limit).

Figure 7: NESHAPS dose at SC Laboratories (mrem/yr)



Year	Ames	ANL	BNL	Fermi	LBNL	ORISE	ORNL	PNNL	PPPL	SLAC	TJNAF
2000	0.000	0.046	0.180	0.005	0.090	0.000	0.200	0.045	0.098	0.032	0.048
2001	0.000	0.036	0.137	0.006	0.060	0.000	0.110	0.120	0.300	0.080	0.011
2002	0.000	0.039	0.086	0.008	0.030	0.000	0.130	0.023	0.100	0.085	0.007
2003	0.000	0.057	0.060	0.007	0.010	0.000	0.189	0.021	0.047	0.070	0.013
2004	0.000	0.054	0.044	0.008	0.010	0.000	0.100	0.000	0.029	0.060	0.019

In addition to complying with the NESHAPS standard for releases to air, DOE facilities must also comply with the DOE dose limit of 100 millirem per year for members of the public from all pathways (DOE O 5400.5, *Radiation Protection of the Public and the Environment*). Important pathways which are evaluated include releases to both groundwater and surface waters (e.g., drinking water, eating fish, swimming, wading, and shoreline use). Some SC laboratories have outdoor radiological soil contamination from legacy releases which can contribute to the water pathways if the radionuclides migrate from the soil.

Ames Laboratory has not reported any radionuclide releases to groundwater or surface water, or any legacy contamination in soil.

At ANL, the only significant location where radionuclides attributable to operations (primarily tritium and strontium-90) have been found in off-site water was Sawmill Creek, below the wastewater outfall. Although this water is not used for drinking purposes, radionuclide concentrations are regularly monitored and are well below regulatory limits for drinking water.

There are several groundwater tritium plumes at BNL where concentrations exceed the 20,000 picoCuries per liter (pCi/L) drinking water standard. One is associated with the inactive High Flux Beam Reactor (HFBR), and several others are associated with BNL's

accelerator facilities. The portion of the HFBR plume with concentrations exceeding 20,000 pCi/L extends from the HFBR approximately 2,000 feet to the south. Activated soils containing tritium and sodium-22 have been created near a number of BNL's accelerator facilities as the result of secondary particles (primarily neutrons) produced at beam targets, beam stops, and beam line collimators. Tritium (and lesser amounts of sodium-22) has leached into the groundwater in several of these areas where rainwater had infiltrated into the activated soils. BNL has procedures in place to evaluate the potential for soil activation impacts on groundwater quality. In areas where significant soil activation can occur, engineered and operational controls are put in place to limit the extent of soil activation and prevent rainwater infiltration. There are also several strontium-90 plumes where concentrations exceed the 8 pCi/L drinking water standard. Two are associated with the Waste Concentration Facility and the Brookhaven Graphite Research Reactor (BGRR), which is no longer in operation. Strontium-90 is also routinely detected in groundwater in the former Animal/Chemical Pits/Glass Holes area. There is no radiological dose risk from drinking water because residents adjacent to BNL site get their water from Suffolk County Water Authority. Additionally, routine monitoring of BNL's on-site drinking water supply wells has shown that the tritium and strontium-90 contamination is not impacting the wells. The total annual dose from all pathways to the maximally exposed individual remains substantially below regulatory limits.

Surface water monitoring at Fermilab shows tritium concentrations to be well within the DOE Derived Concentration Guides (DCGs) for allowable radionuclide releases to surface waters, and no radionuclides were detected in samples taken at the site boundary.

Although tritium has been found in the groundwater below Lawrence Berkeley National Laboratory (LBNL), it does not extend offsite and does not contribute to the public dose because there is no exposure pathway.

Oak Ridge Institute for Science and Education (ORISE) has not reported any radionuclide releases to groundwater or surface water or any legacy contamination in soil.

There are large areas of outdoor radiological soil contamination at ORNL from legacy releases. The majority of these releases are from legacy waste disposal and aging underground process waste lines. The major radionuclides are strontium-89, strontium-90, cesium-137, and tritium. Waterborne radionuclide concentrations are regularly monitored, and the maximum possible individual dose remains well below regulatory limits for all pathways combined (e.g., drinking water, eating fish, swimming, wading, and shoreline use).

There have not been any known releases of radionuclides to groundwater or surface waters from PNNL that resulted in a significant off-site dose to members of the public. The Hanford Site has legacy soil and groundwater contamination, some of which is located at or near PNNL facilities. However, this contamination is primarily the result of historical Hanford weapons production activities, not PNNL activities.

There had been a substantial tritium inventory at Princeton Plasma Physics Laboratory (PPPL) from 1994-97 for fusion research on the Tokamak Fusion Test Reactor (TFTR). In August 1995, PPPL began to monitor tritium levels in on-site groundwater more comprehensively; all measurements have been well below the EPA drinking water standard and have continued to decrease since the dismantlement of TFTR was completed in 2002.

Tritium exists in minor concentrations in some groundwater at the Stanford Linear Accelerator Center (SLAC). There is no indication that the inventory of tritium in the groundwater exceeds any regulatory limits or is migrating offsite, based on routine monitoring of groundwater wells. Consequently, the groundwater tritium poses negligible potential to affect worker and public environmental doses. Both groundwater and wastewater are regularly monitored and remain well within regulatory limits.

Groundwater samples have been monitored at the Thomas Jefferson National Accelerator Facility (TJNAF) since 1987, and no accelerator-produced activity has been detected.

Laboratory Profile Sheets

The following section is one-page synopses for each of the SC laboratories, briefly discussing their radiological operations and a summary of the occupational radiation exposures for the past five years. Contractual performance measures for radiological control are also noted, including both dose and contamination control, as applicable.

The dose distribution tables are highlighted in color for easier reading and to help facilitate comparison of one laboratory with another. The highlight colors are the same as those used in Figure 4, “Dose Distribution for SC Laboratories” (0-100 mrem is gray, 100-500 mrem is blue, 500-1000 mrem is green, and 1000-2000 mrem is yellow).

Ames Laboratory (Ames)

The radiological work at Ames includes use of x-ray devices, remediation of legacy contamination, stewardship of radioactive materials, and intermittent research involving small amounts of radioactive materials. There are currently 17 x-ray systems and approximately 90 trained x-ray workers. Radioactive materials work has been minimal over the past five years, with primary use consisting of sealed source materials and irradiated metals. Ames Laboratory radiological activities are subject to a readiness review process and ALARA committee review. The dose increase in 2003-2004 is attributable to deployment of a more sensitive dosimeter and accounting issues for background radiation levels.

Occupational Radiation Dose Distribution (2000-2004)

Ames — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	122	13	311	24	109	13	0	0	0	0	0
2001	138	13	174	13	125	13	0	0	0	0	0
2002	135	9	76	8	126	9	0	0	0	0	0
2003	138	21	448	21	117	21	0	0	0	0	0
2004	148	40	1152	29	108	40	0	0	0	0	0

Contractual Performance Measures for Radiological Control:

Ames uses the average total effective dose equivalent (TEDE) to measure the effectiveness of management commitments to ALARA. The rating is based on the average TEDE per person who received a measurable dose, as follows:

Outstanding = less than 30 millirem
Excellent = 30-42 millirem
Good = more than 42 and less than 79 millirem
Marginal = between 79-91 millirem
Unsatisfactory = more than 91 millirem

Argonne National Laboratory (ANL)

The collective dose at ANL dropped approximately four percent in 2004, compared to the previous year. The number of workers with an annual dose exceeding 1,000 millirem increased from zero in 2003 to two in 2004.

The principal dose contributor was the Alpha Gamma Hot Cell Facility (AGHCF). The AGHCF has improved the shielding on several of their gloveboxes by adding leaded glass to the work areas, which resulted in a 50 percent reduction in dose for manipulator repairs.

Occupational Radiation Dose Distribution (2000-2004)

ANL — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	2824	183	17244	94	2641	140	27	8	5	0	3
2001	2819	187	23033	123	2632	136	32	10	1	1	7
2002	2793	233	23560	101	2560	180	35	10	1	1	6
2003	2370	231	21379	93	2139	159	51	18	3	0	0
2004	2347	172	20514	119	2175	122	28	12	3	5	2

Contractual Performance Measures for Radiological Control:

Performance expectations for the Laboratory include the collective dose equivalent to monitored individuals, an index based on the number of radioactive contaminations and contaminated individuals, and other radiological measures. The contract provides that a joint committee of Argonne Site Office (ASO) and ANL representatives appointed by the ASO Manager and the ANL Director, respectively, will review the occupational radiation protection performance measures quarterly and agree on adjustments to performance expectations as necessary to account for changes in the scope of radiological work.

Brookhaven National Laboratory (BNL)

In 2004, the collective dose at BNL was almost 24 person-rem, up from 12 person-rem the previous year. The increase can be attributed to the acceleration of Environmental Management remediation activities. One area of significant increased exposure was due to the Brookhaven Graphite Research Reactor (BGRR) Project, where the collective dose increased from approximately 2 rem in 2003 to approximately 12 rem in 2004. It should also be noted that no workers exceeded 1000 mrem for the year. It is expected that radiation exposures will decrease significantly next year due to the completion of remediation activities.

Occupational Radiation Dose Distribution (2000-2004)

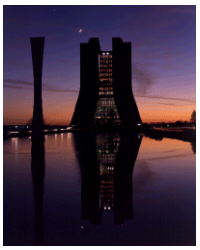
BNL — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	5484	430	22384	52	5054	363	57	8	2	0	0
2001	5048	387	14627	38	4661	351	28	8	0	0	0
2002	4672	439	26244	60	4233	368	48	15	5	3	0
2003	4135	306	12183	40	3829	273	29	3	1	0	0
2004	2639	301	23678	79	2338	246	36	8	5	6	0

Contractual Performance Measures for Radiological Control:

The performance measures define an effective ALARA program as comprised of dose goals and administrative control levels that are challenging and consider both historical exposures and planned operations, is supportive of changes to those goals when operating assumptions change, communicates ALARA initiatives that help to optimize radiological exposures, and ensures dose is shared among all qualified workers.

Fermi National Accelerator Laboratory (Fermilab)



In 2004, the collective dose at Fermilab decreased by almost 20 percent to approximately 21 person-rem, down from 26 person-rem the previous year. The principal activities at Fermilab that resulted in occupational radiation exposures were associated with maintenance activities of the accelerator. Nearly all of the collective dose to personnel was due to exposures to items activated by the accelerator beams. Many maintenance activities were necessary as the Fermilab accelerator complex was challenged to meet the scientific objectives of Tevatron Run II while simultaneously operating the proton beam needed for the MiniBooNE experiment.

The vast majority of this work occurred during a major shutdown of the accelerator carried out during the late summer and autumn of 2004. Fermilab accomplished several vital accelerator upgrades during this shutdown. This work included extensive ALARA pre-job planning, implementation of specific ALARA activities during radiological work, and post-job analyses. Several upgrades and component replacements were conducted in the Linac and Booster. Additionally, a new pulsed beam focusing horn was installed for the MiniBooNE experiment.

Occupational Radiation Dose Distribution (2000-2004)

Fermi — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	1361	406	12340	30	955	390	14	1	1	0	0
2001	1344	368	10650	29	976	352	13	3	0	0	0
2002	1424	389	12790	33	1035	363	21	5	0	0	0
2003	1879	612	25670	42	1267	556	43	10	3	0	0
2004	1855	498	20570	41	1357	451	34	13	0	0	0

Contractual Performance Measures for Radiological Control:

The ES&H Section Radiation Protection Group led formal reviews focused on ALARA and designed to identify both significant innovations recently made and opportunities for further improvement. For this measure, an identified innovation or opportunity for improvement that credibly can improve the control of radiation exposures is considered to be "significant." The measure was evaluated based on the number of reviews conducted and the number of significant actions identified and documented. In 2004, an adjectival rating of "Outstanding" was achieved for this measure, with 17 significant innovations identified.

Lawrence Berkeley National Laboratory (LBNL)

In 2004, LBNL continued to have the lowest collective dose among the five SC multi-program laboratories, and the second lowest collective dose among all SC laboratories. Radiological work includes research in life sciences and physical sciences involving small amounts of radioactive materials, operation of the Advanced Light Source and 88-inch Cyclotron, and closure activities at the former Bevatron accelerator. The laboratory has a number of policies within the framework of Integrated Safety Management that contribute to maintaining occupational radiation doses ALARA. Radiation safety professionals perform a "walk down" on any operation that yields a dosimeter reading exceeding 50 millirem to any worker. Also, the LBNL Radiation Safety Committee (RSC) meets quarterly, and the "top 5" worker doses are reviewed to ensure that the doses are commensurate with the work performed. The RSC also evaluates dose trends for each building.

Radiopharmaceutical development and functional imaging with positron emission tomography represent areas of growth in radiological work with increasing numbers of research protocols.

Occupational Radiation Dose Distribution (2000-2004)

LBNL — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	1835	44	1114	25	1791	42	2	0	0	0	0
2001	1694	21	682	32	1673	21	0	0	0	0	0
2002	1538	33	895	27	1505	32	1	0	0	0	0
2003	1384	20	1037	52	1364	17	2	1	0	0	0
2004	1290	18	739	41	1272	17	1	0	0	0	0

Contractual Performance Measures for Radiological Control:

An Outstanding rating requires that the number of individual exposures exceeding 100 millirem must be less than or equal to the control level of 10, plus the average individual positive dose is less than the control level of 50 millirem, all without an increase in workload.

The LBNL performance measure for reportable occurrences of personnel contamination provides an Outstanding rating for a weighted number of contaminated individuals less than or equal to 4.0 (with unusual occurrences having a weighting factor of 1.5, and off-normal at 1.0). The performance measure for control of radioactive material and spread of contamination provides an Outstanding rating for 2.0 or less weighted occurrences (with unusual occurrences using a weighted factor of 1.5 and off-normals 1.0). In 2004, the only reportable occurrence was one incident of legacy material outside a radiological area.

Oak Ridge Institute for Science and Education (ORISE)

In 2004, ORISE had the lowest number of monitored employees and the lowest collective dose for all SC laboratories. For the last five years, ORISE has never had a worker with a dose exceeding 100 millirem. The only sources of radiological exposure are some sealed sources for calibration and some environmental samples for analysis.

Occupational Radiation Dose Distribution (2000-2004)

ORISE — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	94	58	299	5	36	58	0	0	0	0	0
2001	87	55	327	6	32	55	0	0	0	0	0
2002	99	69	274	4	30	69	0	0	0	0	0
2003	89	59	289	5	30	59	0	0	0	0	0
2004	68	48	249	5	20	48	0	0	0	0	0

Contractual Performance Measures for Radiological Control:

A performance measure is in place for worker radiation dose to assess the effectiveness of the ORISE personnel exposure program and to document that the ALARA Program is in place and active. The average ORISE employee occupational dose is calculated by dividing the collective total effective dose equivalent for all monitored ORISE employees by the total number of employees with a measurable dose. A rating of Meets Expectation is assessed for the quarter if the average dose falls below 10 millirem, and a rating of Does Not Meet Expectation is assessed if the average exceeds 10 millirem.

Oak Ridge National Laboratory (ORNL)

In 2004, the collective dose at ORNL decreased slightly, from 29 person-rem in 2003 to 28 person-rem in 2004. The major contribution to the collective dose at ORNL is the work at the Radiochemical Engineering Development Center (REDC) and the High Flux Isotope Reactor (HFIR). The collective dose at ORNL will remain a challenge because of future projects and activities, including the consolidation of hot cell facilities, continued cleanup of legacy radioactive materials, and the operation of the Spallation Neutron Source. There is an ALARA Steering Committee and an ALARA Working Committee which discuss ongoing projects and share lessons learned on dose reductions. The ALARA awards are routinely presented to employees who develop methods of reducing dose for particular jobs.

Occupational Radiation Dose Distribution (2000-2004)

ORNL — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	5954	371	35848	97	5583	258	77	27	8	1	0
2001	5345	389	47039	121	4956	255	73	43	14	4	0
2002	5995	354	27046	76	5641	273	55	22	4	0	0
2003	6562	375	28591	76	6187	296	52	22	4	0	1
2004	6489	342	27675	81	6147	262	55	19	3	3	0

Contractual Performance Measures for Radiological Control:

Performance measures are in place for both worker radiation dose and radiological operations. The measure for worker radiation dose is based on the average measurable dose for workers with a positive dose; ratings range from Outstanding for 90 millirem or less, to Marginal for more than 110 millirem.

The radiological operations measure is based on five factors:

- the number of radiological workers that exceed their ORNL ALARA goal by five percent
- the number of radiological workers exceeding 30 percent of any dose limit in 10 CFR 835
- the number of occurrences for radiation exposure
- the number of occurrences for personnel contamination
- the number of occurrences for loss of control of radioactive material or spread of contamination

Pacific Northwest National Laboratory (PNNL)

In 2004, the collective dose at PNNL decreased slightly, from 20 person-rem in 2003 to 19 person-rem in 2004. Nearly 80 percent of the collective dose is from operations at the Radiochemical Processing Laboratory (RPL). The dose from the RPL correlates primarily to projects that support Hanford Site cleanup, the RPL Inventory Reduction Initiative, the Prostate Seed Development Project, and decontamination and evaluation of nuclear power reactor control rod drive mechanisms. The PNNL collective dose was planned to be 23 person rem; however, actual collective dose was significantly below anticipated levels, primarily due to highly effective implementation of ALARA controls supporting the Waste Inventory Reduction Initiative within the RPL. Use of the robotics system resulted in a dose savings of over 3 rem.

Occupational Radiation Dose Distribution (2000-2004)

PNNL — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	1396	174	15378	88	1222	133	20	18	3	0	0
2001	1474	207	17639	85	1267	160	29	15	3	0	0
2002	1788	212	17690	83	1576	168	21	19	2	2	0
2003	2067	218	20407	94	1849	166	31	11	6	4	0
2004	2204	229	19340	84	1975	170	41	12	6	0	0

Contractual Performance Measures for Radiological Control:

Performance measures were in place to manage spread of radioactive contamination, with the threshold for acceptable performance set at three or fewer occurrences. There was one occurrence for spread of radioactive contamination during this rating period.

Princeton Plasma Physics Laboratory (PPPL)

The collective dose at PPPL increased last year, from 0.6 person-rem in 2003 to 1.1 person-rem in 2004. This change was due to a substantial increase in fabrication activities for the National Compact Stellarator Experiment (NCSX) taking place in the former TFTR Test Cell (now known as the Coil Winding Facility). This area contains components and materials that were activated during TFTR operations and were not removed during the TFTR D&D project (1999-2002).

Occupational Radiation Dose Distribution (2000-2004)

PPPL — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	466	59	2941	50	407	51	8	0	0	0	0
2001	484	108	7420	69	376	87	11	9	1	0	0
2002	426	145	3707	26	281	130	15	0	0	0	0
2003	348	111	593	5	237	111	0	0	0	0	0
2004	355	124	1141	9	231	123	1	0	0	0	0

Contractual Performance Measures for Radiological Control:

Performance measures are in place for collective dose. A TEDE that is 15% below the annual radiological goal established per the PPPL ALARA Plan is rated as Outstanding.

Stanford Linear Accelerator Center (SLAC)

The collective dose at SLAC increased slightly to 3.9 person-rem, up from 3.1 person-rem the previous year. The majority of the worker dose comes from maintenance activities. In 1997, SLAC began replacing original beamline equipment, which was slightly activated after 20 years of use. Replacing the aged, activated equipment has helped reduce radiation exposures overall.

In 2000, SLAC experienced an unexpectedly large number of small positive doses (most less than 10 millirem) for some workers who normally receive no measurable dose. The results could not be attributed to any known exposures or quality control problems, and a new dosimetry system was instituted. As a result, the number of workers with doses below 100 millirem decreased.

Occupational Radiation Dose Distribution (2000-2004)

SLAC — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	2424	489	5464	11	1935	483	6	0	0	0	0
2001	3155	35	1368	39	3120	32	3	0	0	0	0
2002	2676	79	3075	39	2597	76	1	2	0	0	0
2003	3023	109	3127	29	2914	106	3	0	0	0	0
2004	5156	149	3916	26	5007	141	8	0	0	0	0

Contractual Performance Measures for Radiological Control:

Performance measures are in place for unplanned radiation exposures and personnel contamination control. An Outstanding rating requires no occurrences of ORPS-reportable radiation doses or contamination. An unplanned radiation exposure includes a dose in excess of 100 millirem/year to nonradiological workers.

Thomas Jefferson National Accelerator Facility (TJNAF)

The collective dose at TJNAF increased slightly to 1.1 person-rem in 2004, up from 0.99 person-rem the previous year. The number of workers with a measurable dose increased to 43, up from 39 in 2003. It should be noted that the bulk of the collective dose at TJNAF is obtained by performing maintenance in the High Power Beam Dump Enclosures. Approximately two-thirds of the monitored individuals at TJNAF are visitors.

There is a "Level of Concern" set at 60 millirem per quarter; any individual dose exceeding this level triggers an ALARA review. Additionally, any individual who receives a total dose exceeding 50 mrem in a six month period, either through analysis of supplementary dosimetry used in conjunction with a Radiation Work Permit or through Thermo Luminescent Dosimeter (TLD) badge readings, is placed on a monthly TLD badge frequency for the remainder of the monitoring year. This enables closer monitoring for individuals who may be approaching administrative alert levels.

Occupational Radiation Dose Distribution (2000-2004)

TJNAF — Total Workers In Each Dose Range (mrem) >

Year	Total Workers Monitored	Total Workers With Dose	Total Person - mrem	Avg. Dose (mrem)	Total With No Dose	Below 100	100-250	250-500	500-750	750-1000	1k-2k
2000	1492	67	1616	24	1425	66	1	0	0	0	0
2001	1625	89	2317	26	1536	87	2	0	0	0	0
2002	1583	34	1113	33	1549	30	4	0	0	0	0
2003	1406	39	992	25	1367	38	1	0	0	0	0
2004	1475	43	1074	25	1432	42	1	0	0	0	0

Contractual Performance Measures for Radiological Control:

Performance measures are in place for the number of reportable and recordable exposures to radiation as off-normal occurrences; this measure weights unusual occurrences by a factor of five.

Another measure requires a peer review of the Radiological Control Program in even-numbered fiscal years.