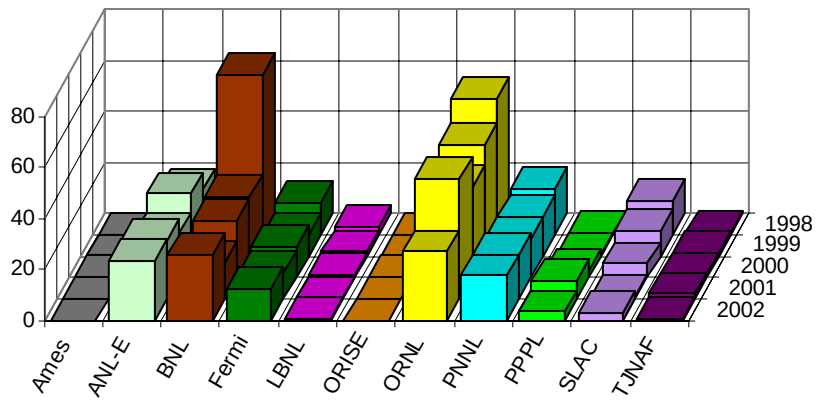
Radiological Control Profile for the Office of Science Laboratories 1998-2002

Collective Dose at SC Laboratories (Person-Rem)



Office of Laboratory Operations
and Environment, Safety and Health (SC-80)
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 dropped about 36 percent overall, from 183 person-rem in 1998 to 116 person-rem in 2002. By comparison, the collective dose at all Department of Energy (DOE) laboratories increased by about four percent in the same period - from 1,309 person-rem in 1998 to 1,360 person-rem in 2002.

During 2002, the largest decrease in collective dose was at Oak Ridge National Laboratory (ORNL), from 47 person-rem in 2001 to 27 person-rem in 2002. The decrease in dose was attributable to the fact that the High Flux Isotope Reactor (HFIR) was not operating fully until late in 2002.

The largest increase in collective dose was at Brookhaven National Laboratory (BNL), from 15 person-rem in 2001 to 26 person-rem in 2002. The increase at BNL was attributable to maintenance work from the High Energy Proton (HEP) run in the summer of 2002, which will not be repeated since the HEP has been phased out.

In 2002, there were six workers who had an annual dose exceeding 1,000 millirem, which is 20 percent of the DOE limit. All six workers were technicians at the Alpha Gamma Hot Cell Facility (AGHCF) at Argonne National Lab - East.

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 who had 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://rems.eh.doe.gov/, 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 dose distribution showing the frequency distribution for the total number of exposed workers at selected ranges of dose.

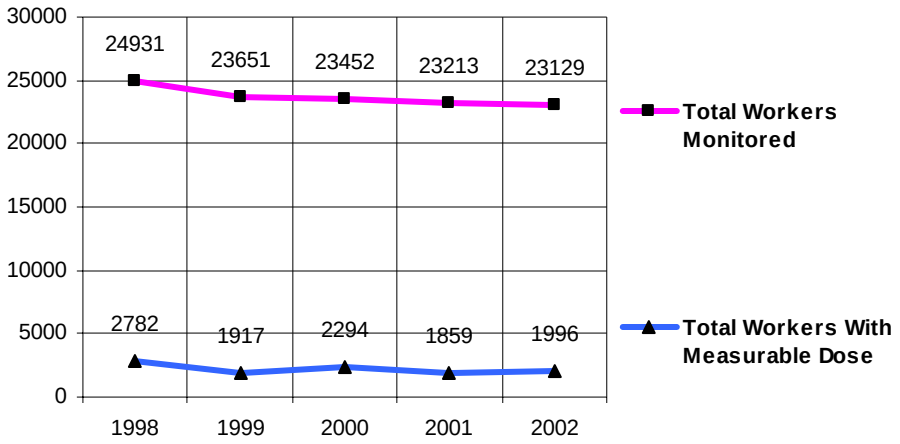
Another characteristic of a robust radiological safety program is that, for a constant workload, both individual and group doses should drop over time, as experience and lessons learned combine to improve radiological work practices. This analysis provides a five-year retrospective of occupational and 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 trends slightly down, from 24,931 in 1998 to 23,129 in 2002 (see Figure 1). However, only a fraction of those monitored actually received a measurable dose. The number of workers with a measurable dose has dropped from 2,782 in 1998 to 1,996 in 2002.

Collective Occupational Dose

The collective dose, or total radiation dose, is the sum of all annual doses received by every individual with a measurable dose. It is typically measured in units of person-rem, and it includes doses to visitors, as well as DOE employees, contractors, and subcontractors. The collective dose is monitored by DOE as one measure of the overall performance of radiation protection programs.

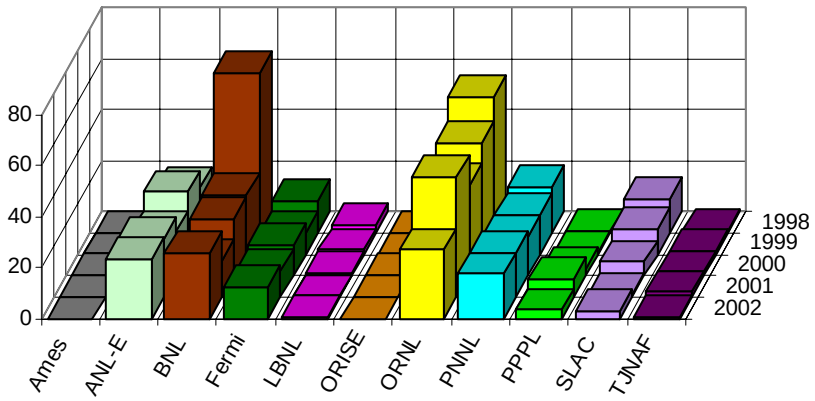
Looking back at the trend over the past five years, the collective dose from SC laboratories has dropped about 36 percent overall, from 183 person-rem in 1998 to 116 person-rem in 2002. As shown in Figure 2, in 2002 the collective dose went down significantly at Oak Ridge National Laboratory (ORNL) and up significantly at Brookhaven National Laboratory (BNL). At ORNL, the collective dose dropped from 47 person-rem in 2001 to 27 person-rem in 2002. The decrease in dose was attributable to the fact that the High Flux Isotope Reactor (HFIR) was not operating fully until late in 2002. The collective dose in 2002 was the lowest in the 60 year history of ORNL.

At BNL, the collective dose increased from 15 person-rem in 2001 to 26 person-rem in 2002. The increase in dose was attributable to maintenance work from the High Energy Proton (HEP) run in the summer of 2002, which will not be repeated since the HEP has been phased out at BNL. Operations at the Relativistic Heavy Ion Collider (RHIC) typically only account for less than 2 person-rem per year. Doses in 2003 are running substantially less than 2002.

In 2002 Argonne National Laboratory – East (ANL-E) had the third highest collective dose among all SC laboratories, 23 person-rem. About half of the dose is attributable to the Alpha Gamma Hot Cell Facility (AGHCF), used to analyze irradiated nuclear fuel.

Lawrence Berkeley National Laboratory (LBNL) continued to have the lowest collective dose among all the SC multi-program laboratories (0.9 person-rem in 2002), and the dose has trended down during the past five years.

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



The collective dose at Pacific Northwest National Laboratory (PNNL) remained steady at about 18 person-rem. A large part of the collective dose is attributable to work at the Radiochemical Processing Laboratory, which analyzes waste from Hanford.

At Princeton Plasma Physics Laboratory (PPPL), the collective dose decreased from about 7.4 person-rem in 2001 to 3.7 person-rem in 2002. This represents a return to more typical doses, because the Decontamination and Decommissioning (D&D) project at the Tokamak Fusion Test Reactor (TFTR) was completed in September of that year. The more dose intensive tasks, such as removal of components attached to the magnetic field coils and vacuum vessel, were completed in 2001.

The collective dose from SC accelerator laboratories and single-purpose laboratories represented only a small fraction of the total. During 2002, record beam intensities for all Fermilab accelerators were achieved. As a result, the collective dose at Fermilab increased slightly, from to 10.6 person-rem in 2001 to 12.8 person-rem in 2002. During

2002, the principal activities that resulted in radiation exposure were associated with maintenance activities on the accelerator.

The collective dose at Stanford Linear Accelerator Center (SLAC) increased slightly from 1 person-rem in 2001 to 3 person-rem in 2002. The increase was attributable to an increased beamline power level and operation time, as compared to the previous year. Overall, the dose remains small and well below previous years.

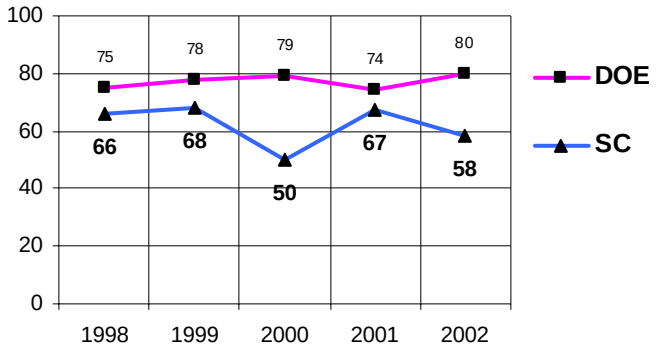
The collective dose at Thomas Jefferson National Accelerator Facility (TJNAF) dropped slightly last year, from 2.3 person-rem in 2001 to 1.1 person-rem in 2002. The number of workers with a measurable dose dropped from 89 in 2001 to 34 in 2002. Approximately two-thirds of the monitored individuals at TJNAF are visitors.

Both the Ames Laboratory and the Oak Ridge Institute for Science Education (ORISE) have maintained the smallest collective doses of any SC laboratory, running at less than 0.5 person-rem every year.

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 68 millirem during the last five years (see Figure 3).

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



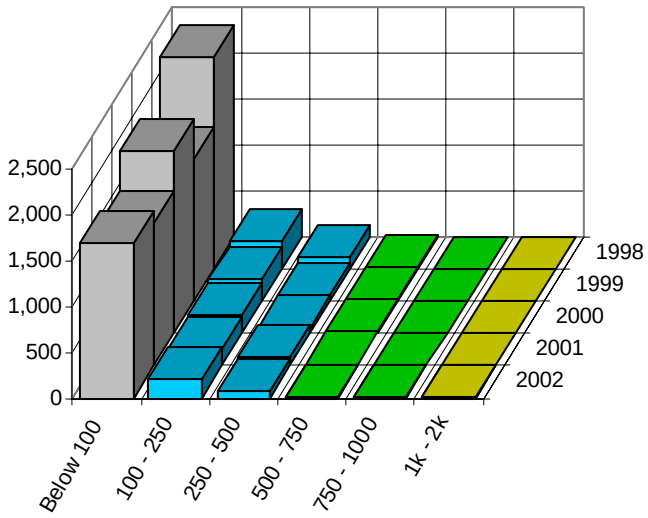
While the average measurable dose is one useful indicator for dose to workers (and visitors) at SC laboratories, it can be misunderstood if taken out of context. For example, the average dose can drop if there is an overall increase in the number of workers who receive very low levels of measurable dose. 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 (1998-2002): Total Number of Workers in Each Dose Range



Dose Range (millirem/year)

The number of workers who received an annual dose exceeding 1,000 millirem decreased from seven in 2001 to six in 2002. All six workers were at the AGHCF at ANL-E.

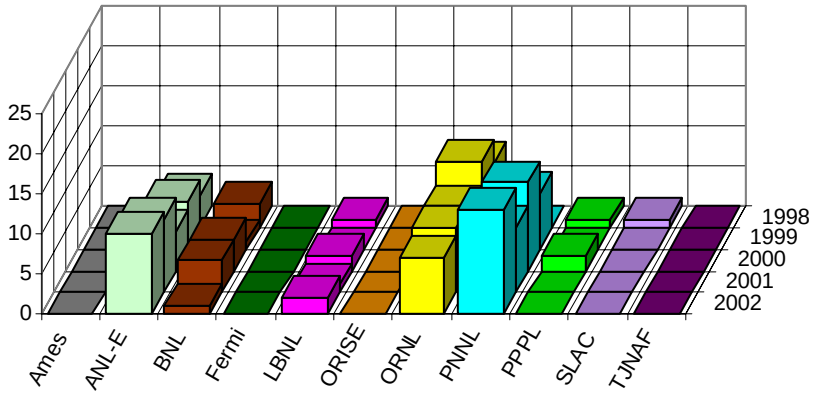
Unplanned Radiation Exposures

During the past five years, there were five reported occurrences of unplanned radiation exposures at SC laboratories. During the same time, a total of 81 of these kinds of occurrences were reported DOE-wide. There were no occurrences of this kind in 2002.

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.

Figure 5: Occurrences at SC Laboratories for Personnel Contamination



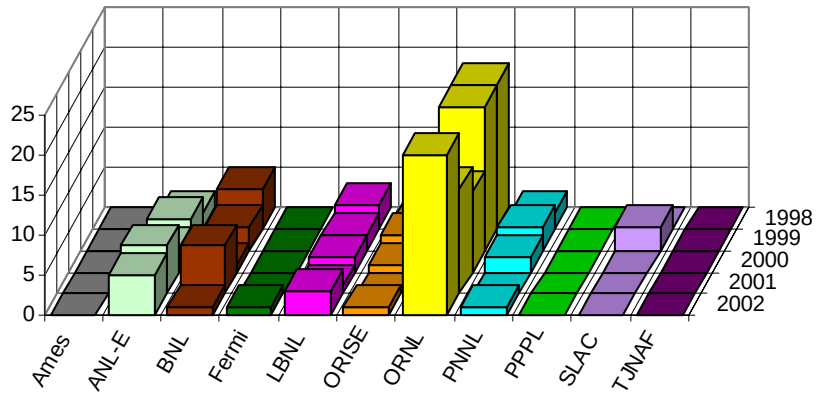
There were 138 occurrences of personnel contamination for SC during the past five years, as compared to 1,401 for all of DOE. These occurrences were predominately at the five SC multi-program laboratories (see Figure 5). These occurrences do not show any clear trend, although they generally correspond 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.

There were 143 reported occurrences for this category during the past five years at SC laboratories, as compared to 1,286 reported DOE-wide. These occurrences were also predominately at the five multi-program laboratories (see Figure 6). Overall, ORNL had the largest number of occurrences in this category, which are mostly due to the legacy contamination found from movement of personnel from old buildings to newer facilities. These types of occurrences may remain elevated since more moves are scheduled for 2003.

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

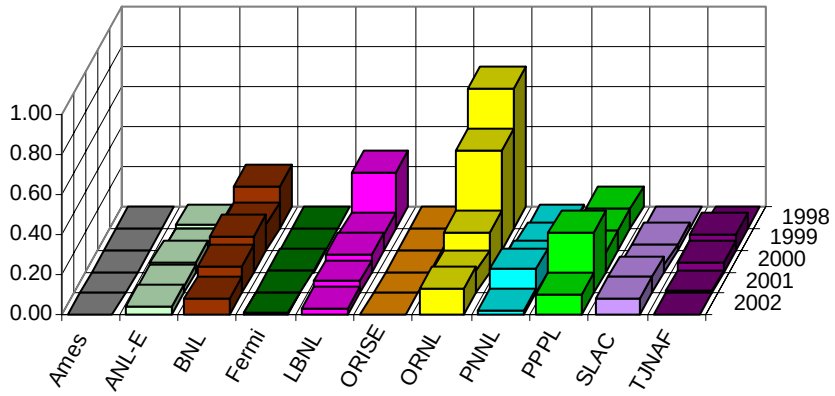


Environmental Releases of Radionuclides

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 2002, the largest dose was at ORNL (0.13 millirem, or 1.3 percent of the limit).

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



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.

At ANL-E, 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, a 50-year effective dose equivalent of 0.016 millirem was calculated in 2002 for a hypothetical individual ingesting all drinking water at the radionuclide concentrations measured at that location.

There is a groundwater tritium plume at BNL which is associated with the High Flux Beam Reactor (HFBR). The portion of the plume with concentrations exceeding the drinking water standard of 20,000 picoCuries per Liter (pCi/L) extends from the HFBR approximately 2,500 feet to the south. Activated soils containing tritium and sodium-22 have been created near a number of Alternating Gradient Synchrotron (AGS) experimental areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. There are also strontium-90 plumes associated with the Waste Concentration Facility and the Brookhaven Graphite Research Reactor (BGRR), which is no longer in operation. Strontium-90 has been routinely detected in groundwater in the Former Landfill, Animal/Chemical Pits, and Glass Holes areas at concentrations above the drinking water standard of 8 pCi/L. The annual effective dose equivalent to an individual was calculated to be 2.5 millirem in 2002, from all pathways.

The release of tritium at LBNL has been an issue with local environmental groups. There is a groundwater tritium plume originating at the National Tritium Labeling Facility (now closed) which covers the areas of Buildings 31, 75, 76, 77, and 78. Tritium has been detected above the drinking water standard (20,000 pCi/L) in only one monitoring well, but this plume does not extend off-site or contribute to public dose.

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. Weekly surveys are conducted to measure the dose rate at these outdoor areas. The measured dose rates are typically less than 0.001 mrem/hour, with a maximum around 0.3 mrem/hour. In 2002, the worst-case analysis of public exposure to waterborne radionuclides from ORNL gave a maximum possible individual dose of about 0.0009 millirem for all pathways combined (e.g., drinking water, eating fish, swimming, wading, and shoreline use).

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 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.

There is a substantial tritium inventory at PPPL for fusion research. 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.

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.

Tritium exists in minor concentrations in some groundwater at 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. SLAC regularly monitors its groundwater to help ensure that the health of the environment is, and continues to be, protected. Tritium discharged in wastewater from SLAC is regularly monitored and remains well within regulatory limits.

Groundwater samples have been monitored at TJNAF since 1987, and no accelerator-produced activity has been detected.

The single-purpose laboratories (Ames Laboratory and ORISE) have not reported any radionuclide releases to groundwater or surface water, nor any legacy contamination in soil.

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

In 2002, Ames had the lowest collective dose among all SC laboratories. 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 14 x-ray systems and approximately 70 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. No radioactive materials research activities were conducted during 2001. Ames Laboratory radiological activities are subject to a readiness review process and ALARA committee review.

Occupational Radiation Dose Distribution (1998-2002)

						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**
1998	113	2	20	10	111	2	0	0	0	0	0
1999	109	3	230	77	106	1	2	0	0	0	0
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

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 – East (ANL-E)

In 2002, ANL-E had the third-highest collective dose among all SC laboratories, 23 person-rem. About half of the dose is attributable to the Alpha Gamma Hot Cell Facility (AGHCF), used to analyze irradiated nuclear fuel. The number of individuals in the dose range of 1k – 2k millirem/year also decreased from 7 in 2001 to 6 in 2002. A large part of the dose is attributable to repair work on remote manipulators at the AGHCF; the manipulators are over 40 years old, and have a design life of two years. The Argonne Tandem Linac Accelerator System (ATLAS) contributes little to the collective dose (less than 0.1 person-rem for the last five years).

Occupational Radiation Dose Distribution (1998-2002)

						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**
1998	2,938	182	17,715	97	2,756	127	40	11	1	2	1
1999	2,888	187	24,583	131	2,701	126	34	14	8	3	2
2000	2,824	183	17,244	94	2,641	140	27	8	5	0	3
2001	2,819	187	23,033	123	2,632	136	32	10	1	1	7
2002	2,793	233	23,560	101	2,560	180	35	10	1	1	6

Contractual Performance Measures for Radiological Control:

Performance expectations for the laboratory include the collective dose equivalent to monitored individuals and also the number of radioactive contaminations and contaminated individuals. The contract provides that a joint committee of Argonne Area Office (AAO) and ANL representatives appointed by the AAO 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 scope of radiological work.

Brookhaven National Laboratory (BNL)

In 2002, the collective dose at BNL increased from 15 person-rem in 2001 to 26 person-rem in 2002. The increase was attributable to maintenance work from the High Energy Proton (HEP) run in the summer of 2002, which will not be repeated since the HEP has been phased out at BNL. Operations at the Relativistic Heavy Ion Collider (RHIC) typically only account for less than 2 person-rem per year. Doses in 2003 are running substantially less than 2002.

Occupational Radiation Dose Distribution (1998-2002)

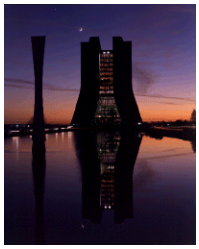
						Total Workers In Each Dose Range (mrem) >					
Year	**Total Workers Monitored**	**Total Workers With Dose**	**Total Person - mrem**	**Avg. Dose (mrem)**	**Total With No Dose**	**Below 100**	**100-250**	**250-500**	**500-750**	**750-1000**	**1k-2k**
1998	5,596	1,055	62,965	60	4,541	885	101	50	15	4	0
1999	5,653	521	23,371	45	5,132	453	59	7	2	0	0
2000	5,484	430	22,384	52	5,054	363	57	8	2	0	0
2001	5,048	387	14,627	38	4,661	351	28	8	0	0	0
2002	4,672	439	26,244	60	4,233	368	48	15	5	3	0

Contractual Performance Measures for Radiological Control:

Performance measures are in place for ALARA collective dose goals. An Outstanding rating is awarded for under-running ALARA goals by more than 20 percent, and an Unsatisfactory rating for over-running by more than 40 percent.

Another measure is for the number of radioactive contaminations reportable under Occurrence Reporting & Processing System (ORPS), which provides an Outstanding rating for four or fewer occurrences, and an Unsatisfactory rating for 17 or more.

Fermilab



During 2002, record beam intensities for all Fermilab accelerators were achieved. As a result, the collective dose at Fermilab increased slightly, from to 10.6 person-rem in 2001 to 12.8 person-rem in 2002. During 2002, the principal activities that resulted in radiation exposure were associated with maintenance activities on the accelerator.

Nearly all of the worker dose was due to exposure to items activated by the accelerator beams. Many maintenance activities were necessary as Fermilab was challenged to meet the scientific objectives of Tevatron Run II, while simultaneously commissioning and operating the proton beam needed for the MiniBooNE experiment.

Occupational Radiation Dose Distribution (1998-2002)

						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**
1998	2,066	441	12,790	29	1,625	421	15	5	0	0	0
1999	1,051	227	8,740	39	824	211	13	2	0	0	1
2000	1,361	406	12,340	30	955	390	14	1	1	0	0
2001	1,344	368	10,650	29	976	352	13	3	0	0	0
2002	1,424	389	12,790	33	1,035	363	21	5	0	0	0

Contractual Performance Measures for Radiological Control:

Performance measures are in place with respect to total effective dose equivalent (TEDE) which are based on the fiscal year and include a time delay to accommodate badge processing. In 2002, an adjectival rating of Excellent was achieved for this measure.

Lawrence Berkeley National Laboratory (LBNL)

In 2002, LBNL continued to have the lowest collective dose among all the SC multi-program laboratories, and the dose has trended dramatically down during the past five years. Radiological work includes research involving small amounts of radioactive materials and closure activities at the former National Tritium Labeling Facility. 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 10" doses are reviewed to ensure that the doses are commensurate with the work performed. The RSC also evaluates dose trends for each building.

The collective dose from the 88-Inch Cyclotron has been reduced from 1.0 person-rem in 1998 to 0.05 person-rem in 2002 and continues to contribute only six percent to the site total. Improved shielding, additional cave entry survey requirements, and stay time restrictions, as well as the use of the more accurate CR-39 dosimetry, have contributed to the dramatic dose reduction at the 88-Inch Cyclotron.

Occupational Radiation Dose Distribution (1998-2002)

						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
1998	1,992	76	2,912	38	1,916	75	1	0	0	0	0
1999	1,781	46	1,822	40	1,735	41	5	0	0	0	0
2000	1,835	44	1,114	25	1,791	42	2	0	0	0	0
2001	1,694	21	682	32	1,673	21	0	0	0	0	0
2002	1,538	33	895	27	1,505	32	1	0	0	0	0

Contractual Performance Measures for Radiological Control:

A performance measure is in place to manage occupational radiation dose, which provides an Outstanding rating for no individual exposures in excess of 500 millirem without an increase in workload (unless authorized in writing by the Radiological Control Manager). Also, 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).

Oak Ridge Institute for Science and Education (ORISE)

In 2002, ORISE had the lowest number of monitored employees and the second lowest collective dose for all SC laboratories. For the last five years, ORISE has never had 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 (1998-2002)

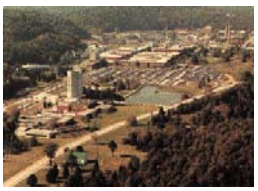
						Total Workers In Each Dose Range (mrem) >					
Year	**Total Workers Monitored**	**Total Workers With Dose**	**Total Person - mrem**	**Avg. Dose (mrem)**	**Total With No Dose**	**Below 100**	**100-250**	**250-500**	**500-750**	**750-1000**	**1k-2k**
1998	55	1	20	20	54	1	0	0	0	0	0
1999	48	8	42	5	40	8	0	0	0	0	0
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

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.

Beginning in January 1999, ORISE began using the Luxel Thermo Luminescent Dosimeter (TLD) with a threshold of 1.0 millirem, compared to the previously used K-100 TLD that had a threshold of 10.0 millirem. This increased TLD sensitivity has resulted in a statistically higher dose per individual.

Oak Ridge National Laboratory (ORNL)



In 2002, the collective dose at ORNL dropped significantly, from 47 person-rem in 2001 to 27 person-rem in 2002. The decrease in dose was attributable to the fact that the High Flux Isotope Reactor (HFIR) was not operating fully until late in 2002. The collective dose in 2002 was the lowest in the 60 year history of ORNL.

The major contribution to the collective dose at ORNL is the work at the Radiochemical Engineering Development Center (REDC) and the HFIR. The Holifield Radioactive Ion Beam Facility (HRIBF) and the Oak Ridge Electron Linear Accelerator (ORELA) contribute little to the collective dose (approximately 0.283 person-rem in 2002).

Occupational Radiation Dose Distribution (1998-2002)

						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**
1998	6,388	527	53,005	101	5,861	389	79	43	10	3	3
1999	6,159	506	43,740	86	5,653	376	89	28	9	2	2
2000	5,954	371	35,848	97	5,583	258	77	27	8	1	0
2001	5,345	389	47,039	121	4,956	255	73	43	14	4	0
2002	5,995	354	27,046	76	5,641	273	55	22	4	0	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; 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
- loss of control of radioactive material or spread of contamination

Pacific Northwest National Laboratory (PNNL)

The collective dose at PNNL ranked fourth highest in 2002 among all SC laboratories. The collective dose remained almost unchanged from 2001, at about 18 person-rem. Over 80 percent of the collective dose is attributable to work at the Radiochemical Processing Laboratory, which analyzes waste from Hanford.

There were two individuals in the dose range of 750 – 1000 mrem in 2002. Their actual doses were 779 mrem and 756 mrem.

Occupational Radiation Dose Distribution (1998-2002)

						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
1998	1,718	263	18,289	70	1,455	205	43	11	4	0	0
1999	1,609	236	15,569	66	1,373	190	30	15	1	0	0
2000	1,396	174	15,378	88	1,222	133	20	18	3	0	0
2001	1,474	207	17,639	85	1,267	160	29	15	3	0	0
2002	1,788	212	17,690	83	1,576	168	21	19	2	2	0

Contractual Performance Measures for Radiological Control:

Performance measures were in place in FY 2002 to manage unplanned dose, spread of radioactive contamination, and loss of control of radioactive material as part of their evaluation of the effectiveness of ISM. In FY 2003, the Battelle Performance Evaluation and Fee Agreement had performance measures for spread of radioactive contamination, but not unplanned dose or loss of control of radioactive material.

The laboratory received an Outstanding rating in FY 2002, in part due to its record of zero unplanned dose events; zero spread of radioactive contamination events; and zero loss of control of radioactive material events during this rating period.

Princeton Plasma Physics Laboratory (PPPL)

The collective dose at PPPL decreased last year, from about 7.4 person-rem in 2001 to 3.7 person-rem in 2002. This represents a return to more typical doses, because the TFTR D&D project was completed in September of that year. The more dose-intensive tasks, such as removal of components attached to the magnetic field coils and vacuum vessel, were completed in 2001.

Occupational Radiation Dose Distribution (1998-2002)

						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**
1998	275	35	1,080	31	240	33	2	0	0	0	0
1999	406	34	817	24	372	33	1	0	0	0	0
2000	466	59	2,941	50	407	51	8	0	0	0	0
2001	484	108	7,420	69	376	87	11	9	1	0	0
2002	426	145	3,707	26	281	130	15	0	0	0	0

Contractual Performance Measures for Radiological Control:

Performance measures are in place for both collective dose and personnel contamination control. A total effective dose equivalent of 0-4 person-rem for routine operations and 0-8 person-rem for D&D is rated as Outstanding.

A total of zero contamination events is rated as Outstanding. Contamination events are defined as the number of ORPS-reportable skin or clothing contamination events (excluding protective clothing contamination).

Stanford Linear Accelerator Center (SLAC)

The collective dose at SLAC increased slightly from 1 person-rem in 2001 to 3 person-rem in 2002. The increase was attributable to an increased beamline power level and operation time, as compared to the previous year. Overall, the dose remains small and well below previous years.

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; the collective dose at SLAC has dropped every year for the last five years.

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 (1998-2002)

						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**
1998	2,283	157	13,137	84	2,126	126	19	12	0	0	0
1999	2,493	104	10,192	98	2,389	78	17	7	2	0	0
2000	2,424	489	5,464	11	1,935	483	6	0	0	0	0
2001	3,155	35	1,368	39	3,120	32	3	0	0	0	0
2002	2,676	79	3,075	39	2,597	76	1	2	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 dropped slightly last year, from 2.3 person-rem in 2001 to 1.1 person-rem in 2002. The number of workers with a measurable dose dropped from 89 in 2001 to 34 in 2002. 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.

Occupational Radiation Dose Distribution (1998-2002)

						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**
1998	1,507	43	1,039	24	1,464	42	1	0	0	0	0
1999	1,454	45	1,370	30	1,409	43	2	0	0	0	0
2000	1,492	67	1,616	24	1,425	66	1	0	0	0	0
2001	1,625	89	2,317	26	1,536	87	2	0	0	0	0
2002	1,583	34	1,113	33	1,549	30	4	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.