United States General Accounting Office

GAO

Report to the Vice Chairman, Joint Economic Committee, U.S. Congress

September 1993

FEDERAL RESEARCH

Aging Federal Laboratories Need Repairs and Upgrades

GAO/RCED-93-203

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-254151

September 20, 1993

The Honorable Paul S. Sarbanes
Vice Chairman, Joint Economic Committee
Congress of the United States

Dear Mr. Vice Chairman:

Citing the importance of federal research and development (R&D) to economic growth and national well-being, you expressed concern that federal research agencies may be underinvesting in maintaining, repairing, and upgrading their laboratories. Accordingly, you requested that we assess the (1) condition of federal laboratory facilities, (2) effect of inadequate laboratory facilities on agencies' scientific productivity and research capabilities, and (3) funding needed to repair or upgrade these facilities.

As agreed with your office, the information in this report is based primarily on data provided by eight federal agencies for 220 government-owned laboratories that spent about $18.1 billion of the estimated $24.9 billion obligated for R&D at federal laboratories in fiscal year 1992. These agencies are the Departments of Commerce, Defense (DOD), and Energy (DOE); the Environmental Protection Agency (EPA); the National Aeronautics and Space Administration (NASA); the Agricultural Research Service (ARS), within the Department of Agriculture (USDA); the National Institutes of Health (NIH), within the Department of Health and Human Services; and the Geological Survey (USGS), within the Department of the Interior. We also interviewed facilities managers for each agency and laboratory management, researchers, and facilities managers at the eight federal laboratories we visited.

Results in Brief

Overall, 54 percent of the floor space of the eight federal agencies' laboratories was more than 30 years old. Typical problems among the agencies' laboratories included leaking roofs and inadequate ventilating systems that do not meet industry standards for circulating air through laboratories, according to agencies' facilities managers. In addition, many older laboratories were not designed to meet today's advanced R&D needs and health and safety code requirements. In recent years, DOE, EPA, and NASA have reported deteriorating laboratory facilities and inadequate funding as material management weaknesses under the Federal Managers' Financial Integrity Act (31 U.S.C. 3512).[1]

The federal laboratory facilities managers and researchers we interviewed identified several instances, particularly involving old ventilating systems and power outages, in which aging laboratory facilities substantially reduced scientific productivity. In addition, several agencies cited the need for advanced laboratory facilities that provide greater flexibility to respond to new programs and scientists' research needs. For example, NIH facilities managers stated that the clinical center, completed in 1955 at NIH's main campus in Bethesda, Maryland, limits productivity and scientific capabilities primarily because many of its utility systems are at the end of their useful lives. In particular, demands on its heating, ventilating, and air conditioning systems exceed capacity by 50 percent, and electrical systems are outmoded and inadequate.

Facilities managers at most of the eight agencies stated that funding for laboratory facilities' maintenance was moderately adequate. However, the eight agencies reported a backlog of more than $3.8 billion in needed repairs for their laboratories, and facilities managers for four agencies said that funding for repairs was only slightly adequate or inadequate. Furthermore, funding to renovate existing laboratory facilities or construct new ones was either only slightly adequate or inadequate at six agencies.

In attempting to address these funding issues, the eight federal agencies have improved the management oversight of their laboratory facilities. In addition, four of the eight agencies recently initiated task forces to reexamine their R&D mission and/or improve the effectiveness and efficiency of their laboratory facilities. Reassessing agencies' R&D missions is critical before spending large sums of money. Such task force efforts provide a basis for determining whether to realign, consolidate, or close laboratories and to increase funding for laboratory facilities considered essential for fulfilling agencies' R&D missions.

Background

Laboratory facilities, along with scientists and research equipment, provide the basis for conducting advanced R&D at federal laboratories. These facilities include laboratory buildings; heating, ventilating, and air conditioning systems; electrical power supply systems; and water and

[1]The act requires each federal agency to report annually on the adequacy of its internal accounting and administrative controls.

sewerage systems. Laboratory facilities need to be properly maintained and repaired to continue to work well. In addition, aging laboratory facilities may need to be upgraded—either by renovating existing buildings or constructing new ones—to improve researchers' productivity or enable them to conduct state-of-the-art R&D. Federal laboratories also spend facilities funds to improve (1) workers' health and safety by, for example, removing asbestos or installing fire sprinklers and alarms; (2) access to buildings for the handicapped; (3) the environment by, for example, replacing chloro-fluoro-hydrocarbon refrigerants in air conditioning systems, refrigerators, and freezers, in compliance with the Clean Air Act Amendment of 1990; and (4) non-research-related facilities such as roads and parking lots.

In a June 1990 report, the National Research Council's Building Research Board found that underfunding is a widespread and persistent problem that undermines the maintenance and repair of public buildings.[2] In concluding that procedures and allocations of resources must be changed to recognize the full costs of ownership of these assets, the Board stated that an appropriate budget allocation for routine maintenance and repair for a substantial inventory of facilities will typically be in the range of 2 to 4 percent of the aggregate current replacement value of those facilities. The Board further stated that where neglect of maintenance has caused a backlog of needed repairs, spending must exceed this minimum level (2 to 4 percent) until the backlog has been eliminated. The General Services Administration and other federal agencies have begun to use the Board's recommendations as a general guideline for assessing maintenance and repair funding for their buildings and other facilities.

Aging Federal Laboratories Need Repairs and Upgrades

Federal laboratory facilities grew rapidly between 1943 and 1972 as agencies expanded their R&D missions. By the early 1990s, these facilities had aged—31 percent of the eight federal agencies' laboratory space was more than 40 years old, and 54 percent of the space was more than 30 years old. Only 24 percent of the eight agencies' laboratory space was less than 20 years old. In addition, some federal laboratories are using government facilities not designed for R&D. For example, Commerce's National Oceanic and Atmospheric Administration (NOAA) is using Fort Crockett, an Army post built in the early 1900s in Galveston, Texas, as a sea turtle and shrimp research laboratory. A NOAA facilities manager told us that about $4 million is needed to repair and renovate this laboratory

[2]Building Research Board, Committing to the Costs of Ownership: Maintenance and Repair of Public Buildings (June 1990).

because the buildings (1) have deteriorated in their advanced age and (2) were designed as barracks for soldiers rather than as laboratories for scientists.

Federal laboratories are experiencing many common problems associated with aging facilities—leaking roofs and gutters, drafty window frames, and inefficient ventilating systems that do not bring sufficient fresh air into laboratories. In particular, DOE, EPA, and NASA have cited deteriorating laboratory facilities as a material management weakness in their Financial Integrity Act reports. DOE noted that the average age of its nonnuclear laboratory facilities is 32 years and that many are well beyond the end of their useful lives. EPA also pointed out that most of its Office of Research and Development laboratories are well over 30 years old, stating that its science program is vulnerable if its research facilities do not meet the laboratory standards of the businesses it regulates. NASA's 1989-91 reports cited inadequate maintenance funding for its laboratories and other facilities as a material weakness. In response to a growing list of needed repairs and renovations, NASA's Associate Administrator for Aeronautics and Space Technology initiated a 5-year program to augment maintenance and instrumentation funding at three laboratories with $15 million of R&D funds in fiscal year 1991. This amount rose to $30 million in fiscal year 1993.

In addition, older federal laboratories were not designed for today's health and fire safety standards and advanced R&D needs. Many laboratory buildings do not have sprinkler and alarm systems and adequate fire walls because they were designed to prior, less stringent requirements. Similarly, computers and other electronic equipment have increased the demand for electrical power and air conditioning, while sensitive scientific instruments that make precise measurements have increased the importance of temperature, humidity, air cleanliness, and vibration controls. Furthermore, potential hazards associated with chemistry and biotechnology R&D have increased air ventilation requirements.

Laboratory Facilities Have Limited Productivity and Scientific Capabilities

The agency and laboratory officials we interviewed stated that their laboratories generally have avoided a prolonged shutdown of R&D projects by successfully engineering around emergencies. However, they noted that aging laboratory facilities have reduced scientific productivity, citing various instances in which a facility's problems disrupted R&D programs or reduced confidence in the reproducibility of experimental results. These problems have caused researchers to repeat experiments in many instances. Typical problems reported included (1) ventilating systems that do not meet industry standards for circulating air through laboratories—in three laboratory buildings we visited, inadequate ventilating systems have caused respiratory problems among researchers and/or contaminated laboratory samples; (2) electrical power outages and other systems' malfunctions that ruined long-term experiments; and (3) delays and disruptions in making repairs, limiting researchers' access to equipment or laboratory facilities needed to perform R&D. For example, inadequate ventilation in a 20-year-old laboratory building at ARS' laboratory in Beltsville, Maryland, has caused respiratory problems among researchers and specifically led to the relocation of five researchers from the building. In addition, researchers in one laboratory building at EPA's Gulf Breeze, Florida, facility were relocated to temporary space for 9 months because a newly renovated ventilating system had inadequate air-handling capacity, enabling mold and fungus to grow in the duct work.

NIH has proposed to construct a new $1.6 billion clinical center to replace its existing 38-year-old clinical center, which is at the end of its useful life and does not meet current fire safety requirements. NIH officials stated that the proposed center, which would provide advanced research hospital facilities, is essential for fulfilling NIH's mission because clinical research is fundamental to its biomedical research program. The U.S. Army Corps of Engineers, in a November 1991 report that validated NIH's need, recommended the construction of a new center because the existing clinical center's physical constraints greatly hinder NIH's ability to provide a modern, flexible facility for biomedical research and patient care.

Several Agencies Are Assessing R&D Facility Funding Needs and Missions

Each of the eight federal agencies has taken actions to better identify its laboratories' needs for maintenance, repairs, and upgrades. For example, ARS (in 1985) and NOAA (in 1991) initiated surveys on the condition of their laboratory facilities to identify maintenance and repair needs at their primary laboratories. Similarly, NIH and EPA are updating their laboratories' master site plans for the first time since about 1972 and 1985, respectively.

Funding to maintain laboratory facilities was moderately adequate, according to facilities managers at most of the eight agencies. However, funding constraints limit some agencies' ability to repair and upgrade their laboratory facilities. In fiscal year 1992, only ARS and NASA met the Building Research Board's minimum guideline that 2 percent of a facility's current replacement value be spent for routine maintenance and repair. The eight agencies also reported a total backlog of more than $3.8 billion in needed repairs at their laboratories; some agency and laboratory facilities managers noted that their backlog is growing. In addition, facilities managers at DOD, DOE, EPA, NASA, NIH, and USGS told us that funding to renovate existing laboratory facilities or construct new ones is either inadequate or only slightly adequate. According to the facilities managers, the process for funding and making a major repair, such as replacing the roof of a large laboratory building, typically takes about 3 to 5 years from proposal to completion, while the process for renovating existing facilities or constructing new ones takes about 7 to 10 years from proposal to completion. During either process, a number of lower-priority laboratory projects will be dropped, and the amount of funding made available may be reduced because of competing priorities.

The Congress is funding some major projects to modernize existing research facilities and construct new ones needed to perform advanced R&D. In particular, in fiscal year 1993, the Congress appropriated $110 million of $540 million requested by Commerce's National Institute of Standards and Technology to renovate seven existing laboratory buildings and construct the equivalent of two new laboratory buildings with advanced systems to control temperature, humidity, air cleanliness, and vibrations. In addition, ARS officials stated that the Congress has made available about $70 million of $205 million that ARS proposed in 1988 to modernize its Beltsville laboratory.

In response to budget constraints, several federal agencies have considered alternatives to realign or consolidate their laboratory facilities. For example, within DOD, the Army, Navy, Air Force, and the Armed Forces Radiobiology Research Institute are reducing their combined number of laboratories from 76 to 31, according to DOD research managers. Similarly, USDA is studying whether to close or consolidate some of ARS' 111 laboratories, DOE is considering how to realign its nuclear weapons laboratories in response to the end of the Cold War, and NASA is developing a national facility plan for world-class aeronautics and space facilities. House bill 1432 proposes to establish the Federal Laboratory Mission Evaluation and Coordination Committee, which in part would make recommendations on the advisability of establishing a commission to determine whether specific federal laboratories should be realigned, consolidated, or closed. One criterion that the Committee would be directed to consider is improving the efficiency and effectiveness of the overall federal laboratory system.

Conclusions

Most of the eight federal agencies' laboratory facilities are at least 30 years old, requiring increased maintenance and repair funding. In fiscal year 1992, six of the eight agencies did not meet the Building Research Board's minimum guideline for funding routine maintenance and repair, and many agencies have a substantial backlog of needed repairs. In addition, inadequate facilities are limiting research capabilities at some federal laboratories. Substantial funding would be needed to provide the proposed new laboratory facilities.

In recent years, DOD, DOE, NASA, and USDA have initiated task forces to reexamine their R&D mission and/or improve the effectiveness and efficiency of their laboratory facilities. An important consideration in such reviews is to ensure adequate funding to support laboratory facilities, which may involve (1) reducing expenses by realigning, closing, or consolidating laboratories not essential for fulfilling an agency's R&D mission as well as (2) increasing funding to maintain, repair, and upgrade those laboratory facilities considered essential to fulfilling an agency's R&D mission.

Agency Comments

We discussed the report's contents with officials from ARS, Commerce, DOD, DOE, EPA, NASA, NIH, and USGS, who generally agreed with the thrust of our findings. In addition, agencies provided clarifying information to improve the report's technical accuracy, which we incorporated as appropriate. However, as requested, we did not obtain written comments on a draft of this report.

We conducted our review between October 1992 and August 1993 in accordance with generally accepted government auditing standards. Information in this report is based primarily on data provided by the eight agencies and interviews with laboratory facilities managers, laboratory management, and researchers. As agreed with your office, we did not examine other problems with facilities that affect federal agencies' R&D programs, including staffing ceilings for facilities' personnel, delays and added costs associated with federal procurement requirements, and leased laboratory space. See appendix IV for details of our objectives, scope, and methodology.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will provide copies of this report to the

Director, Office of Management and Budget. We also will make copies available to others upon request.

Please contact me at (202) 512-3841 if you or your staff have any questions. Major contributors to this report are listed in appendix V.

Sincerely yours,

Victor S. Rezendes
Director, Energy and Science Issues

Contents

Figures

Abbreviations

AFRRI	Armed Forces Radiobiology Research Institute
ARS	Agricultural Research Service
BARC	Beltsville Agricultural Research Center
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
FIA	Federal Managers' Financial Integrity Act
FY	fiscal year
GAO	General Accounting Office
HVAC	heating, ventilating, and air conditioning
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
OMB	Office of Management and Budget
R&D	research and development
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

Aging Federal Laboratories Need Repairs and Upgrades

The number and size of federal laboratory facilities grew rapidly in the 30 years between 1943 and 1972 as agencies expanded their research and development (R&D) missions. By the early 1990s, however, these laboratory facilities had aged; more than half of the space of the eight federal agencies' laboratory space is more than 30 years old. Common laboratory facilities problems that adversely affected scientists' ability to perform R&D included (1) old systems and equipment that are at the end of their useful lives and need to be repaired or replaced before they break down; (2) insufficient electrical power, ventilation, and chilled water capacity; and (3) scientists' inability to adequately control such factors as temperature, humidity, and air cleanliness. In addition, many laboratory buildings do not meet current health and fire safety standards because they were designed to meet prior, less stringent requirements. In recent years, the Environmental Protection Agency (EPA) and the Department of Energy (DOE) have reported deteriorating facilities, and the National Aeronautics and Space Administration (NASA) has reported inadequate maintenance funding as material management weaknesses under the Federal Managers' Financial Integrity Act (FIA).

Most Federal Laboratory Facilities Are at Least 30 Years Old

As shown in table I.1, federal laboratory space was constructed primarily during the 30-year period between 1943 and 1972. Overall, 31 percent of the floor space of the eight federal agencies' laboratories was more than 40 years old, and 54 percent of the laboratory space was more than 30 years old. Only 24 percent of the federal laboratory space has been constructed since 1972.

Table I.1: Amount of Laboratory Space Constructed by 10-Year Periods

Square feet in thousands

Agency	Year: before 1943	Year: 1943-52	Year: 1953-62	Year: 1963-72	Year: 1973-82	Year: 1983-92	Total
USDA							
ARS	3,895	453	1,485	2,872	2,291	944	11,940
Commerce							
NIST	0	401	23	2,480	29	105	3,038
NOAA[a]							
DOD							
Air Force	821	1,787	2,165	1,761	1,491	2,080	10,105
Army	1,678	1,398	3,080	3,049	1,943	1,294	12,442
Navy[b]	987	1,035	235	675	353	410	3,695
AFRRI	0	0	41	86	37	6	170
DOE	1,130	19,857	16,414	7,725	7,407	7,683	60,216
EPA	1,429	86	23	1,185	482	165	3,370
Health and Human Services							
NIH	600	662	3,648	1,488	2,338	404	9,140
Interior							
USGS	0	442	34	1,046	373	46	1,941
NASA	1,091	3,064	3,579	6,950	1,053	1,477	17,214
Total	**11,631**	**29,185**	**30,727**	**29,317**	**17,797**	**14,614**	**133,271**
Percent	9	22	23	22	13	11	100

[a]Information about the age of NOAA's 936,000 square feet of laboratory space was not readily available because some of its laboratories were originally owned by other agencies.

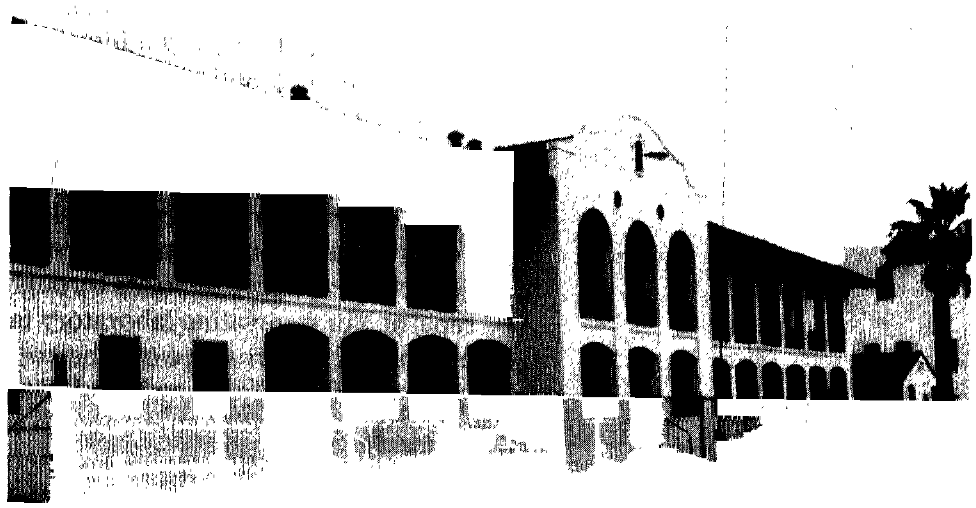
[b]The Navy provided data only for the Naval Research Laboratory.

Source: GAO compilation of data from agencies listed in table.

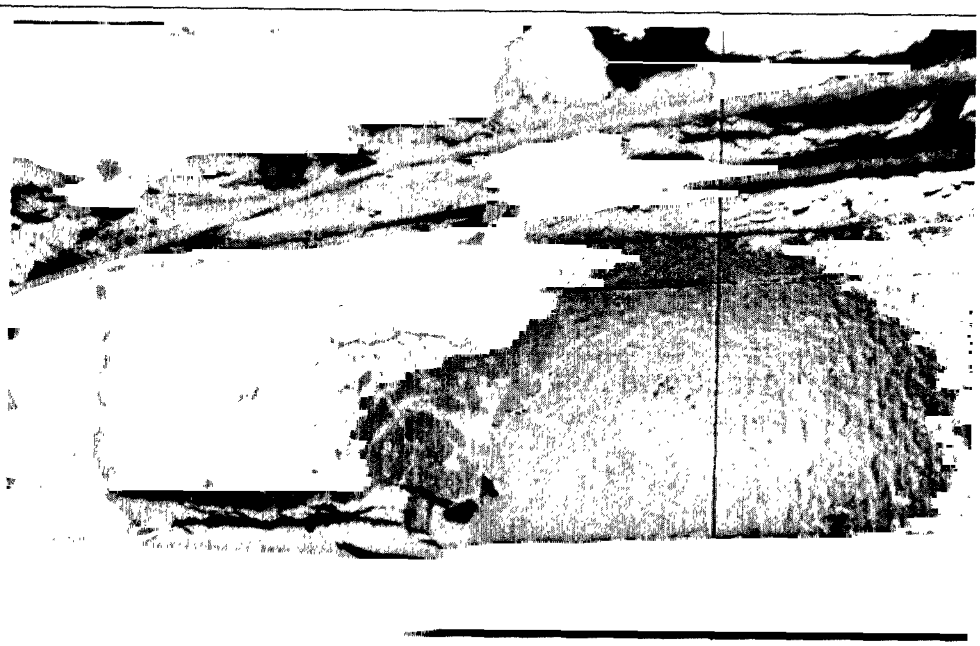
DOE, Department of Defense (DOD), and NASA laboratories accounted for 80 percent of the total floor space. DOE's laboratories, which alone accounted for almost 50 percent of the floor space, are the oldest in the federal laboratory system—35 percent of their floor space is more than 40 years old, and 62 percent of their space is more than 30 years old. Similarly, 29 percent of DOD's laboratory floor space and 24 percent of NASA's laboratory floor space is more than 40 years old.

Many federal laboratory campuses have prominent old buildings that, because their historical significance, cannot be demolished and replaced with modern laboratory facilities and/or office space. For example, the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service and EPA converted old federal facilities into laboratories. The Marine Fisheries' sea turtle and shrimp laboratory in Galveston, Texas, previously was Fort Crockett, an Army post built in the early 1900s. This laboratory needs about $4 million in repairs and renovations, according to a NOAA facilities manager. For example, a facilities condition survey of the laboratory found that the main structural beam and concrete floor slab in two original buildings had deteriorated to the point of failure. (See fig. I.1.) One building, which includes the laboratory director's office, was evacuated during 1992 until temporary repairs were made to support the floor with hydraulic jacks and timbers. Marine Fisheries' laboratories in Tiburon, California; Port Adams, Oregon; and Montlake, Washington, also are using old federal facilities built more than 50 years ago. Similarly, EPA's Environmental Research Laboratory in Gulf Breeze, Florida, originally was a yellow fever quarantine station established by the Public Health Service around 1874. EPA uses the site's original houses mainly for office space and administrative support activities.

Figure I.1: Cracked Support Beam at NOAA's Galveston Laboratory (see below)



Building No. 302 originally was a barracks for Fort Crockett.



Cracked structural beam supporting the first floor of building No. 302.

Source: NOAA.

Federal Laboratories Need Repairs and Upgrades

Many of the eight federal agencies' laboratories had aging buildings, mechanical systems, and utility components that have reached the end of their useful lives and need to be repaired or replaced before they break down. Common problems cited by agency and laboratory facilities managers included leaking roofs; heating, ventilating, and air conditioning (HVAC) systems that cannot provide designed amounts of ventilation needed particularly for biological or chemical R&D; outdated electrical power system components; and water pipes that have corroded or collected excessive deposits through the years. In many cases, the cost of repairing or renovating laboratory facilities is substantially increased because of the presence of asbestos, a known carcinogen used extensively between World War II and the 1970s as a fire retardant and pipe insulation. Special procedures are required to encapsulate or remove asbestos before a repair is made to minimize workers' exposure.

During the past 20 years, many federal laboratories have expanded missions, R&D funding, and staffing. This growth has increased the demand for air ventilation for fume hoods—basic laboratory equipment designed to minimize researchers' exposure to noxious gases during chemical testing by directly exhausting fumes outdoors. Federal scientists also are using sophisticated equipment and advanced computers to perform R&D, thus increasing federal laboratories' demand for electrical power and central air conditioning. Furthermore, older federal laboratories were not designed to provide the temperature, humidity, air cleanliness, and vibration controls that today's sensitive scientific instruments need to make precise measurements.

The following discussions of four federal laboratories illustrate some of the issues associated with aging facilities and the need for modern R&D facilities.

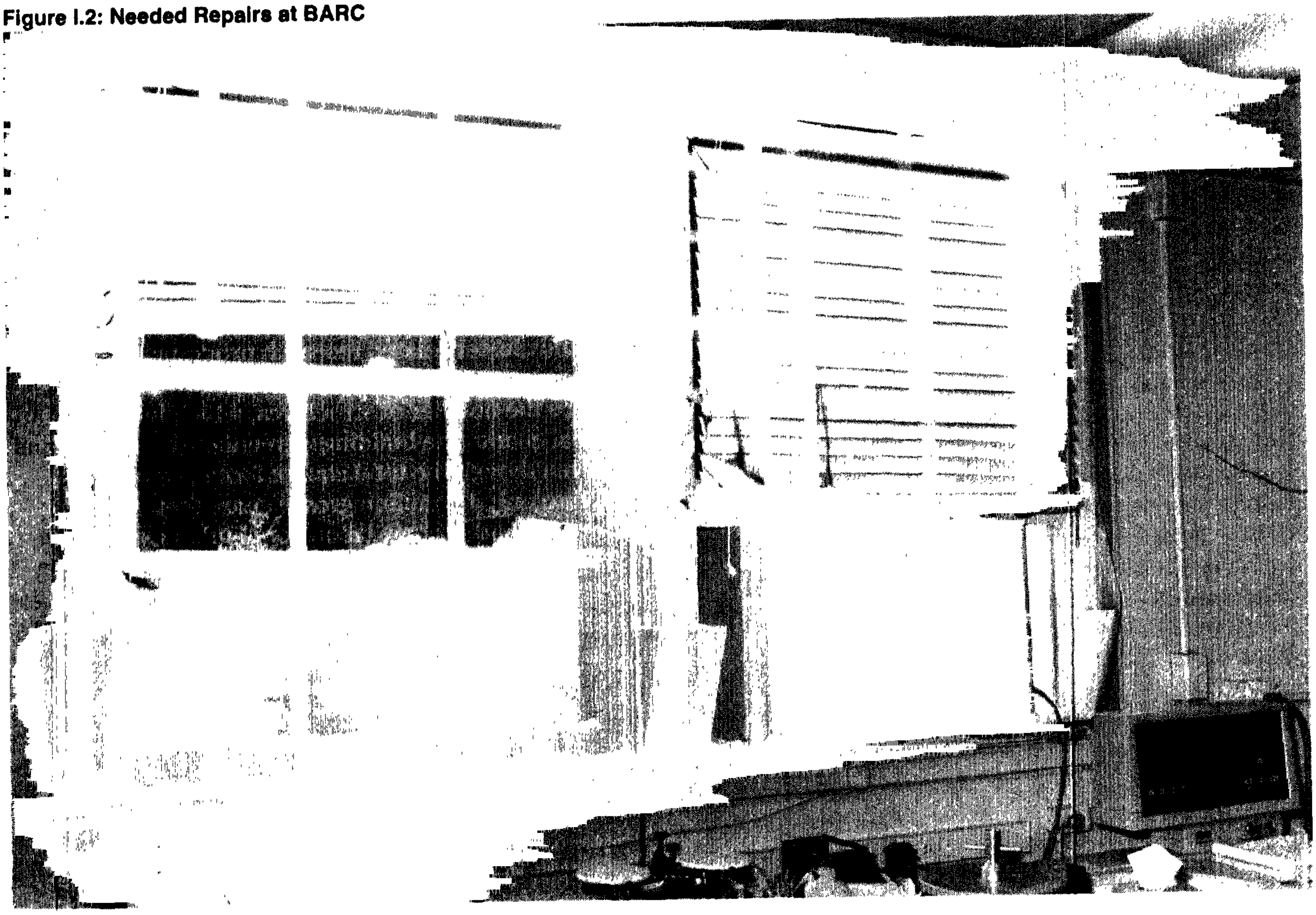
Beltsville Agricultural Research Center

The Beltsville Agricultural Research Center (BARC), established in 1910 in Beltsville, Maryland, is the Agricultural Research Service's (ARS) largest laboratory. About 77 percent of BARC's laboratory space was built before 1943, making it more than 50 years old. These older buildings were not designed with central air conditioning systems, so BARC laboratories and offices use about 2,000 less-efficient room units. Facilities managers estimated that 90 percent of BARC's laboratory facilities would not meet ARS' standard of 10 to 15 air exchanges per hour, year around. BARC facilities managers and scientists also cited a general need to replace leaking roofs, gutters, and drafty window frames in the older buildings.

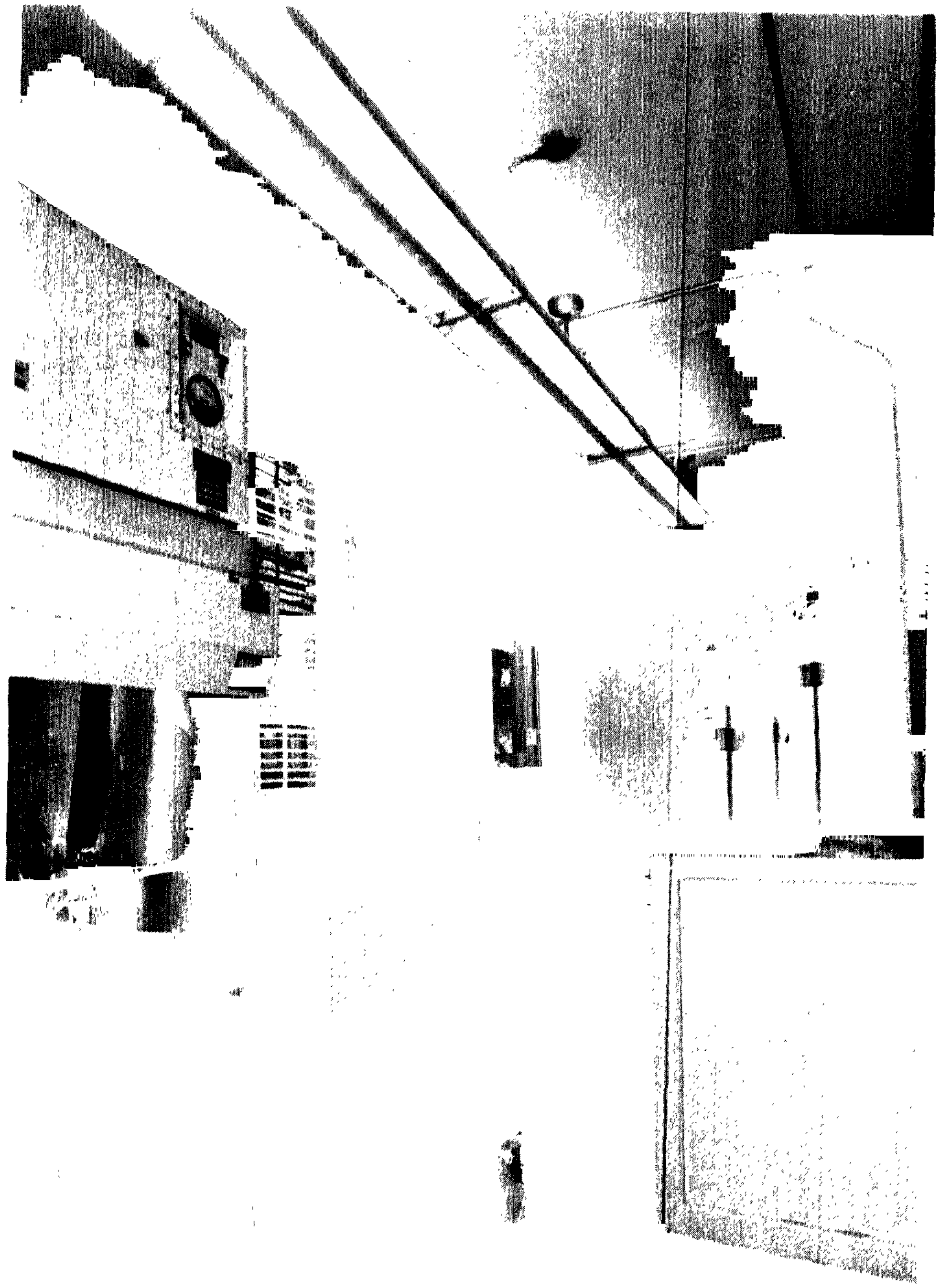
BARC's demand for electrical power has grown over the years without a corresponding increase in electrical capacity. As a result, BARC is subject to "brownouts" during the summer, when the demand for air conditioning peaks. Furthermore, backup generator capacity is limited, and on numerous occasions, backup generators failed to start during a power outage. Other common problems related to aging facilities at BARC include old HVAC systems that have outlived their useful lives, poor drinking water quality, leaking roofs, and drafty window frames. (See fig. I.2.)

In 1988, ARS proposed a $205 million, 10-year program to modernize BARC's laboratory facilities. The modernization program will renovate many of BARC's original buildings and cluster related research programs in larger laboratory buildings to encourage interactions between researchers. Overall, ARS plans to reduce the number of structures, which include laboratories, former animal quarantine buildings, greenhouses, and animal sheds, from 800 to 165, even though the total square footage would be reduced from 1.75 million to only 1.5 million gross square feet. ARS facilities managers estimate that their new laboratory buildings will have an efficiency of 70 to 80 percent in terms of net-to-gross usable space, as compared with an efficiency of only 30 to 40 percent for older facilities. In response to ARS' proposal, the Congress has made available about $70 million, according to ARS officials.

Figure I.2: Needed Repairs at BARC

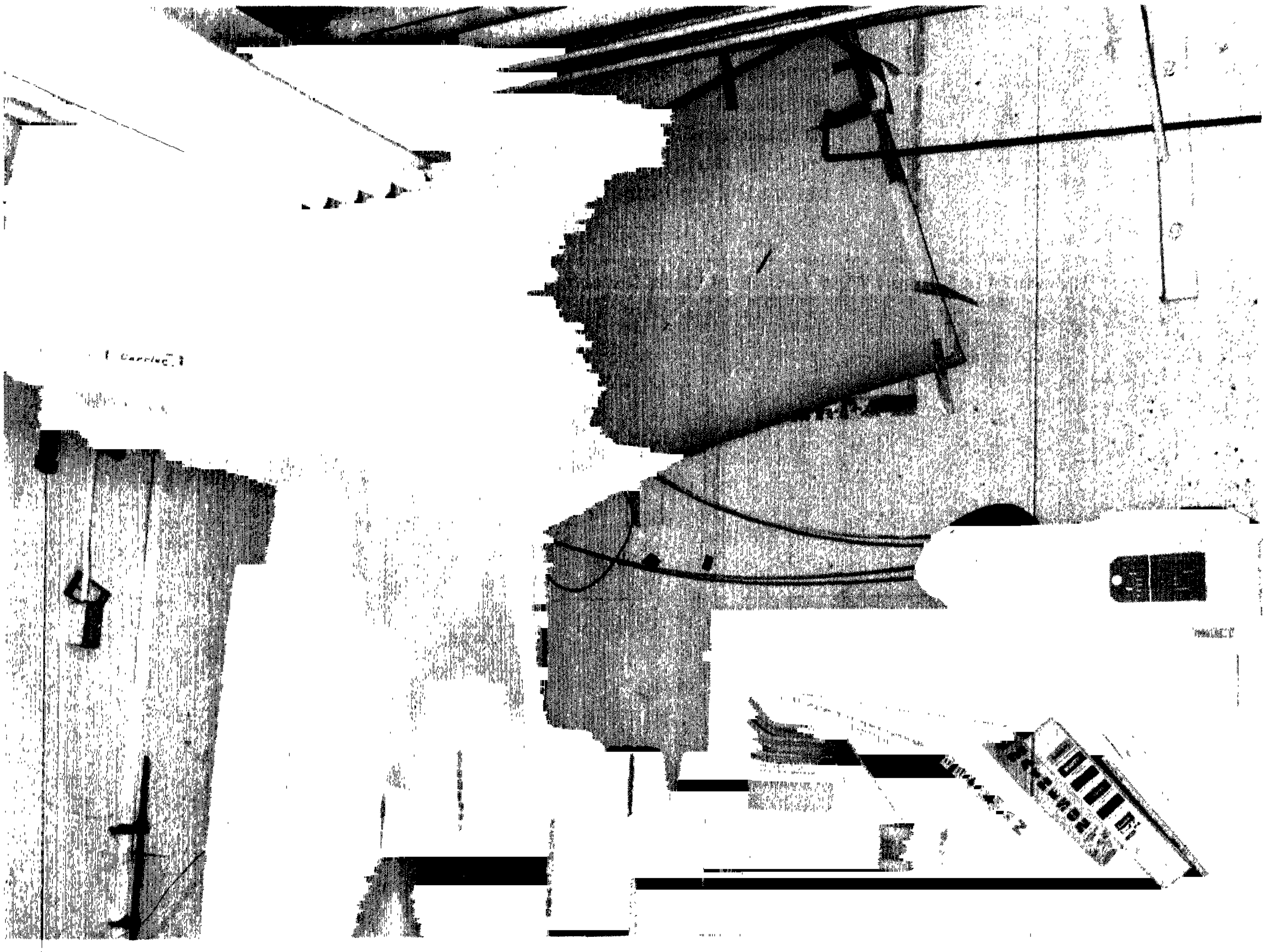


Plastic covering window frame in a laboratory to reduce drafts.



Ceiling hole and puddle on floor caused by roof leak and recent storm.

Vacant laboratory scheduled for repair after building's roof is replaced.



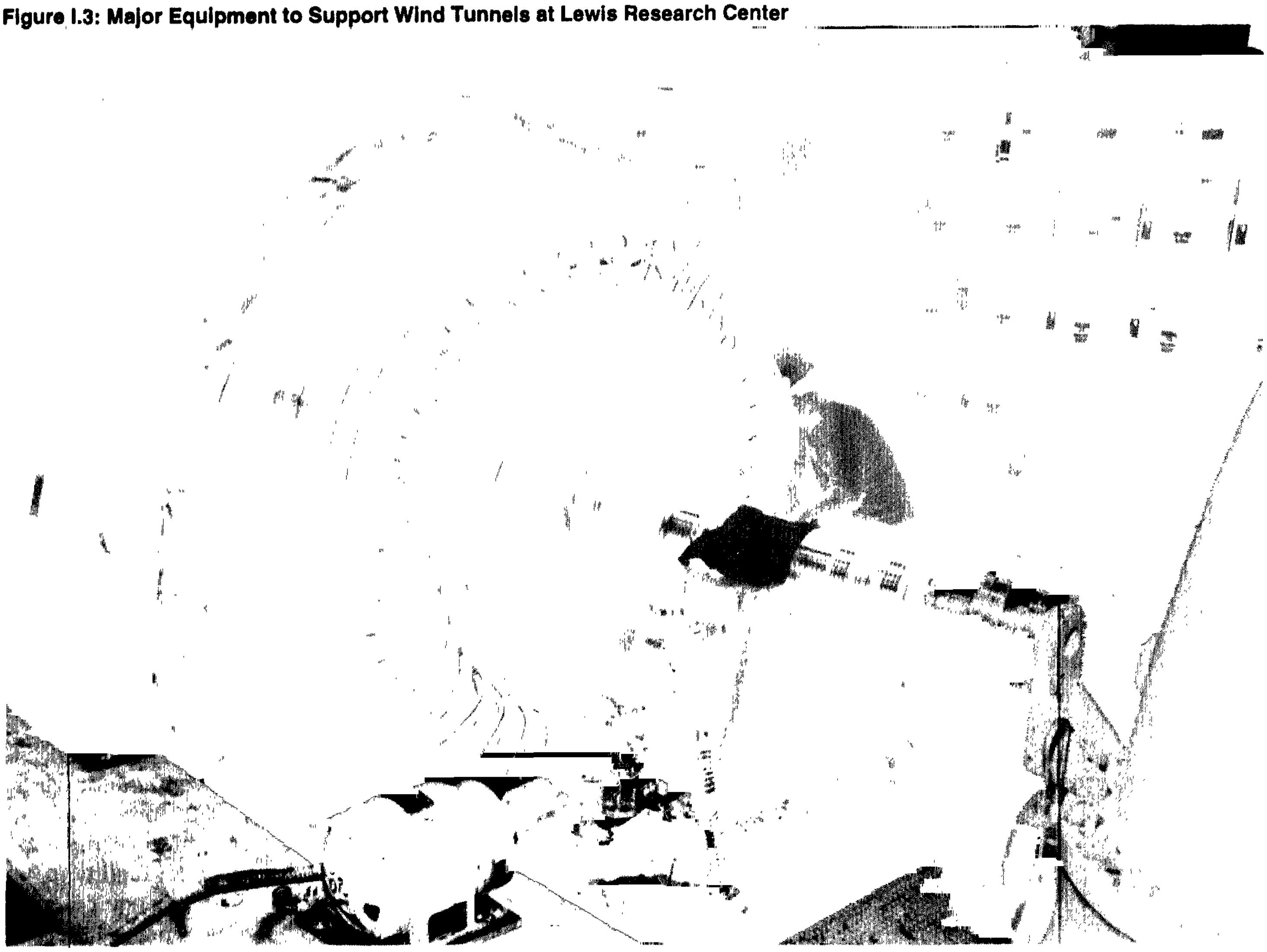
Cardboard covering broken window to keep drafts and dust out of a greenhouse laboratory.

Lewis Research Center

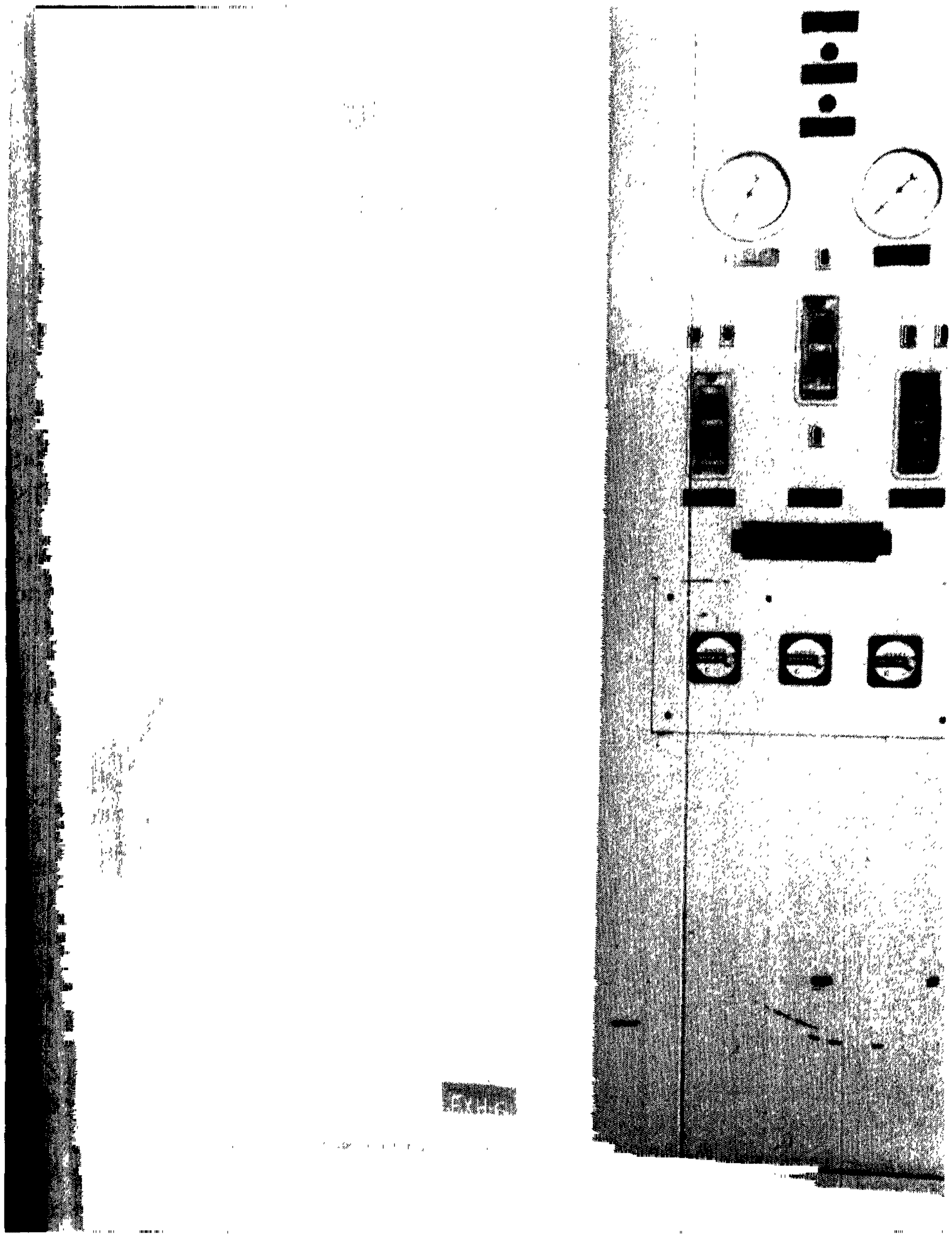
NASA's Lewis Research Center, in Cleveland, Ohio, has several major wind tunnels and other facilities built during the 1940s and 1950s for aircraft engine combustion testing. These facilities rely on large compressors and vacuum pumps (exhausters) in the Lewis Center's central air facility to pull air at high speeds through the test facilities. Because this equipment was installed more than 40 years ago, it has exceeded its expected life.

However, the equipment has been very reliable, and the Lewis Center's facilities managers prefer to rebuild it by, for example, rewinding motors rather than replacing a compressor or exhauster with expensive new equipment that might be less reliable. (See fig. I.3.) The Lewis Center's facilities managers also have established a maintenance and repair program designed to identify and replace components with excessive wear before the equipment fails.

Figure I.3: Major Equipment to Support Wind Tunnels at Lewis Research Center



Worker rewinding the motor of a large compressor.



High-voltage switchgear installed in the 1950s.

Source: Lewis Research Center.

The importance of reliable equipment and preventive maintenance and repair was illustrated when a circuit breaker failed, causing an exhauster to explode in August 1990. According to Lewis facilities managers, the incident shut down the Lewis Center's central air building for 3 months and half of the building for an additional 6 months, closed the Propulsion Systems Laboratory, and limited the use of the Supersonic/Transonic Wind Tunnel.

National Institutes of Health's Clinical Center

The National Institutes of Health's (NIH) original clinical center, a 12-story research hospital on its main campus in Bethesda, Maryland, was completed 38 years ago. Since then, NIH has upgraded the clinical center through several new additions and renovation projects, resulting in utility infrastructure systems of varying ages and conditions. The major systems that provide fire safety, electrical power, lighting, ventilation, air conditioning, and plumbing are old, outmoded, and/or have insufficient capacity to meet current and future research demands. These systems are at the end of their useful life and, according to NIH facilities managers, have become functionally obsolete, unsafe, and, in some cases, inoperable.[1] For example, neither the clinical center's fire safety or emergency electrical power distribution systems meet current codes and standards.

In 1987, NIH initiated the Clinical Center Complex Infrastructure Modernization and Improvement Program to address known deficiencies in the clinical center's utility infrastructure systems. In response to NIH's initial proposal to upgrade the clinical center and other laboratory facilities, the House Committee on Appropriations, in July 1990, requested that the Secretary of Health and Human Services conduct a review of these needs in cooperation with other federal agencies. The U.S. Army Corps of Engineers agreed to assess NIH's facilities revitalization program regarding the (1) extent of the problems, (2) probable cost of the work, and (3) timetable for accomplishing the work.

In a November 1991 report, the Army Corps of Engineers' review committee stated that it unquestionably substantiated the extent of the overall problems identified in NIH's Facilities Revitalization Program. Specifically, the review committee found that

[1]For more information about building obsolescence, see the Building Research Board's report entitled The Fourth Dimension in Building: Strategies for Minimizing Obsolescence (June 1993).

"The Clinical Center Complex is in serious need of major corrective action to resolve its facilities deficiencies. The Review Committee agrees that the utility systems within the Clinical Center Complex have deteriorated beyond reasonable repair. The systems are no longer reliable, they violate codes and regulations, are difficult and costly to maintain, the capacities of the systems have been exceeded, and they do not provide adequate flexibility for modification or upgrade."

The review committee further stated that the limited space between the clinical center's ceilings and floors constrains the ability to install and service HVAC equipment and duct work, electrical power lines, and other utilities. In comparison with the clinical center's floor-to-floor height of 12 feet, the Department of Veterans Affairs and the Army Corps of Engineers require a minimum 18-foot floor-to-floor height in new and upgraded hospitals. The additional 6 feet provides more space between a ceiling and the floor above for installing and servicing utilities. According to NIH facilities managers, demand on the clinical center's HVAC systems exceeds capacity by 50 percent, resulting in the marginal operation of laboratory fume hoods, degradation of indoor air quality, and cross contamination of air between laboratories.

The Army Corps of Engineers' review committee recommended that NIH construct a new clinical center complex as the best long-term technical solution among four alternatives evaluated for addressing the clinical center's problems. The Corps of Engineers estimated that construction of a new clinical center would cost $1.43 billion and take 14-1/2 years to complete. NIH adopted the review committee's recommendation; its Buildings and Facilities Plan issued in August 1992 included a new clinical center complex estimated to cost $1.6 billion and take 11-1/2 years to complete.[2]

National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST) has laboratory campuses at Boulder, Colorado, and Gaithersburg, Maryland. In a March 1992 report, NIST proposed the implementation of two separate 10-year plans to upgrade its laboratory facilities to a condition necessary to fulfill its mission.

NIST's first plan addresses the technical obsolescence of environmental systems controls and the reliability of power supplies that limit its ability to provide the exacting measurements of a national reference laboratory.

[2]This cost estimate includes funds for relocating personnel necessary to clear a site for the new clinical center and demolishing the existing clinical center.

NIST's laboratory buildings were state-of-the-art structures when they were constructed at Boulder in the mid-1950s and at Gaithersburg in the early 1960s. However, the combination of (1) advancing age, which requires substantial maintenance and repair to retain originally designed capabilities, and (2) rapidly advancing technology has made these facilities inadequate for many types of advanced research essential to its mission. NIST cited the need for improved temperature, humidity, air cleanliness, and vibration controls for its advanced research that employs such sensitive instruments as optical, electron, and tunneling microscopes.

NIST proposed a $540 million, 10-year effort to upgrade its laboratory facilities. NIST plans to renovate seven existing laboratory buildings and construct the equivalent of two new laboratory buildings with advanced systems to control temperature, humidity, air cleanliness, and vibrations. NIST also plans to improve the reliability of electrical power supplies and, at Boulder, construct a central plant to provide steam and chilled water. The Congress appropriated $110 million in fiscal year 1993 for design and initial construction activities.[3]

NIST's second plan addresses improvements to remedy major safety and systems capacity problems. In particular, NIST would improve fire safety and electrical power systems at both its Gaithersburg and Boulder campuses. In addition, NIST plans to repair the structural deterioration of building foundations and expand the chilled water plant at the Gaithersburg campus. The NIST safety and systems capacity plan is estimated to cost about $98 million, including $4 million that the Congress has already appropriated.

Three Agencies Have Reported Facilities as a Material Management Weakness

EPA, in its FIA reports for 1989-92, cited as a material management weakness deteriorating laboratory buildings and facilities among its Office of Research and Development's research laboratories and field stations. According to EPA, these laboratory facilities are in various states of disrepair, resulting not only in health, safety, and environmental compliance violations but also in significant delays in EPA's research requirements. EPA stated that its science program is vulnerable if its research facilities do not meet the laboratory standards for the regulated community. To address this material weakness, EPA initiated a master planning process in fiscal year 1991 to identify and prioritize projects for funding through its building and facilities appropriation. The Congress

[3]The appropriation included funding not to exceed $5 million for design and $105 million for construction of new research facilities.

also raised the threshold allowing EPA to make repairs and minor improvements using R&D program funds from $25,000 to $75,000.

In its 1992 FIA report, DOE also cited deteriorating facilities as a material management weakness, noting that the average age of its 25,000 nonnuclear-related buildings, utilities, and other structures is 32 years. DOE stated that a departmentwide program is needed to plan for, acquire, maintain, modernize, replace, and/or dispose of its facilities' infrastructure. For example, DOE plans to develop an infrastructure replacement program to systematically replace facilities needed for its mission and dispose of unneeded or unjustified facilities that have exceeded their useful lives. In addition, DOE program offices have begun to collect maintenance and repair data from operations and maintenance contractors for their laboratories in response to a capital assets management process initiated in March 1992.

NASA, in its FIA reports for 1989-91, cited inadequate maintenance funding for its laboratories and other facilities as a material management weakness. Our December 1990 report also stated that many NASA facilities had not been adequately maintained and were in degraded condition.[4] We noted, however, that NASA's Facilities Maintenance Management Branch, formed in 1987, was working with NASA's laboratories and other facilities to define total maintenance needs and assess facilities' conditions. Since 1990 NASA has increased maintenance and repair funding, enabling it to meet the Building Research Board's minimum guideline that 2 percent of a facility's current replacement value be used for maintenance and repairs. As a result, NASA stopped identifying facilities maintenance as a management weakness in 1992. In addition, in response to a growing list of needed repairs and renovations identified during NASA's wind tunnel revitalization program, the Associate Administrator for Aeronautics and Space Technology initiated a 5-year program to augment maintenance and instrumentation funding at three laboratories with $15 million of R&D funds in fiscal year 1991 that rose to $30 million in fiscal year 1993.

[4]NASA Maintenance: Stronger Commitment Needed to Curb Facility Deterioration (GAO/NSIAD-91-34, Dec. 14, 1990).

Laboratory Facilities Have Limited Agencies' Productivity and Scientific Capabilities

The federal laboratory facilities managers and researchers we interviewed stated that aging federal laboratories have reduced scientific productivity primarily because many HVAC and other systems can no longer meet their designed capacities; are more apt to break down; and, in some cases, have posed health hazards to researchers. In addition, laboratories' expanding missions and researchers' needs for performing advanced R&D have increased capacity and reliability requirements for such utilities as electrical power, ventilation, and air conditioning. The facilities managers and researchers cited various instances in which a facility's problems disrupted R&D programs or reduced confidence in the reproducibility of experimental results, causing researchers, in many instances, to repeat experiments. However, they stated that their laboratories generally have avoided a prolonged shutdown of R&D programs by successfully engineering around emergencies. Furthermore, some agencies cited the need for advanced laboratory facilities to improve (1) health and safety conditions, particularly for biochemical research; (2) temperature, humidity, air cleanliness, and vibration controls; and/or (3) flexibility to respond to new research programs and scientists' needs.

Scientific Productivity Is Reduced

Federal facilities managers and researchers stated that aging laboratory facilities have reduced scientific productivity and cited many instances in which productivity was substantially reduced because of (1) inadequate ventilating systems that have caused respiratory problems among researchers or contaminated laboratory samples with microorganisms or particles; (2) delays and disruptions in making facilities repairs that limited researchers' access to equipment or facilities needed to perform R&D; (3) researchers' inability to control experimental conditions that reduced confidence in the reliability of the research results; (4) power outages and other systems malfunctions that disrupted experiments; and (5) inadequate ventilating capacity, which limited researchers' access to fume hoods.

Agency and laboratory facilities managers and researchers provided the following examples of reduced scientific productivity at federal laboratories because of facilities limitations.

- BARC's bioscience building (building 011A) is experiencing ventilation problems that have caused respiratory problems among researchers and specifically have led to the closing of two laboratories within the building and the relocation of five researchers since December 1991. The building, completed in 1972, has 78,000 gross square feet of laboratory and office space. A recent engineering analysis of the building found several fundamental and interrelated problems, including the following: (1) the air conditioning system recirculates air through the corridors; (2) the building's air system tends to distribute rather than contain fumes and/or smoke; (3) the building's outside air intakes are too close to its exhaust stacks, hence exhausted air may be recirculated into the laboratory; and (4) area exhaust capacity in the building's laboratories and the venting of fumes from stored chemicals are inadequate or nonexistent. The design of the bioscience building's HVAC system does not conform with ARS' requirement that its laboratories have at least eight air exchanges per hour with no recirculation of the air. This requirement is derived from the American Society of Heating, Refrigerating, and Air Conditioning Engineers standards for laboratories.[1] In response to the health problems, BARC has given higher priority to renovating the bioscience building's HVAC system within its modernization program by requesting design funding for fiscal year 1995 to be followed by a renovation funding request in fiscal year 1996.

- At EPA's Gulf Breeze facility, the Marine Environment Assessment Laboratory's newly renovated ventilating system had inadequate air-handling capacity, enabling mold and fungus to grow in the duct work. Some researchers experienced severe allergic reactions to the microorganisms, and research samples were contaminated by spores entering the laboratory through the ventilating system. Researchers were relocated to temporary space for 9 months while the ventilating system was upgraded. However, a research manager estimated that researchers in his branch lost 6 months to 1 year on their research projects because of the disruption and the minimal facilities available in the temporary space.
- At BARC, several researchers told us that drafty window frames have caused laboratory rooms to be too cold, too hot, and/or too humid. In some cases, researchers' inability to control temperature and humidity caused inaccurate research results or equipment failure. For example, researchers' inability to control humidity affected an experiment designed to measure the food intake of rats because the food absorbed excessive moisture, leading to inaccurate data.
- Electrical power outages have interrupted, and sometimes even ruined, scientific experiments. BARC researchers cited several examples of the effect of power failures and inadequate emergency backup equipment, including outages that (1) destroyed controlled experiments investigating animals' feeding patterns and (2) lasted sufficiently long enough in one

[1] These standards recommend that the ventilation system for chemical and biological laboratories discharge all exhaust air to the outdoors without recirculating it. The standards also provide a table for determining the minimum number of air changes per hour, depending on the specific research performed.

case to raise the temperature in an ultra-low temperature freezer to the point where 62 cell lines were lost, wiping out one researcher's work conducted over a 2-year period. Similarly, the work of over 200 NIH scientists was virtually halted for 1 week when an old circuit breaker malfunctioned. NIST experiences approximately 20 to 30 power outages each year that, although typically lasting less than a second, have caused computer systems to shut down, resulting in the loss of irretrievable data for long-term experiments, and damaged lasers and other sensitive electronic equipment.

In addition, research animals and plants were lost in some instances because of HVAC malfunctions. For example, a thermostat malfunction in an NIH laboratory caused temperatures to rise above 90 degrees Fahrenheit, resulting in the death of 421 laboratory rats. Similarly, an HVAC failure at an Army laboratory resulted in the death of over 1,000 laboratory animals, while a boiler failure in a BARC greenhouse ruined a major plant disease experiment.

- NIH has imposed a moratorium on adding fume hoods in the clinical center's laboratories because the demands on the ventilating systems have exceeded the available capacity. According to NIH officials, the capacity of the building's ventilation systems is deficient by 50 percent, posing a potential safety risk that air between laboratories and public spaces in the clinical center might be cross-contaminated. Although the clinical center's ventilating systems originally were designed to support 180 fume hoods, more than 226 fume hoods currently are in use. NIH officials told us that as a result fume hoods currently are operating at only 25 to 40 percent of their designed capacity because of the demands on and age of the ventilating systems. Currently, NIH scientists cannot add a fume hood in a clinical center laboratory without correspondingly reducing use elsewhere. To expand their research programs, scientists would either have to perform research in another building where fume hoods are available or wait until a fume hood became available.

NIH building engineers also told us that preparing space in the clinical center for such new diagnostic and treatment equipment as positron emission tomography scanners and other large and heavy advanced research equipment sometimes has taken years. The time needed to prepare this space has delayed important clinical studies and has severely inhibited researchers' ability to perform various types of advanced research, according to NIH research managers. For example, development of a medical technologies area within the clinical center is nearly impossible because of limited utility capacities. As a result, needed diagnostic scanning equipment has been stored in a warehouse until additional utilities can be added.

Obsolete Facilities Have Limited Scientific Capabilities at Some Federal Laboratories

Facilities managers at some of the laboratories we visited stated that their scientists' ability to perform advanced R&D has been constrained in certain cases by obsolete laboratory facilities. In addition, NASA is developing a national facilities plan for world-class aeronautics and space facilities.

NIH's research capabilities are limited because it cannot provide adequate laboratory facilities for performing research in some new medical fields, particularly ones that require such biocontainment systems as the use of negative air pressure and specialized rooms. For example, the Chief of the Nuclear Medicine Department stated that (1) protocols are limited because only four rooms in the clinical center have the specialized facilities needed to segregate out radioactive gases given to patients, (2) research projects are canceled 75 percent of the time if they must wait for space to be prepared for needed equipment, and (3) using outside laboratories to perform nuclear research is very difficult because of stringent regulatory requirements and concerns that hazardous radioactive materials might contaminate the outside laboratories.

NIH facilities managers also stated that many of the utility systems in the clinical center and other buildings are functionally obsolete, citing as an example that the Bethesda campus's electrical power supplies are outmoded and inadequate. According to the facilities managers, NIH needs to increase both electrical power capacity and reliability. In addition, NIH needs to provide proper grounding and install uninterrupted power supply systems and equipment to provide "clean" power because modern medical instruments and equipment are sensitive to harmonic distortions.

NIST performs R&D to provide the measurements, calibrations, and quality assurance techniques that underpin U.S. commerce and technological progress and help U.S. industry develop advanced technologies. However, in a March 1992 report, NIST stated that it cannot provide some U.S. manufacturers with such services as state-of-the-art calibrations needed to maintain production-line quality controls on a par with Japanese and European competitors because it lacks high-quality environmental systems controls to allow precision measurements under predictable, stable conditions. In a 1991 study for NIST, Smith, Hinchman & Grylls Associates, Inc., found that 42 percent of the laboratories at Gaithersburg and 59 percent of the laboratories at Boulder failed to meet system performance levels required by current scientific and engineering programs.

As an example of its facilities' shortcomings, NIST cited its need for laboratory space with precise temperature control for an advanced coordinate-measuring machine because the length of metal parts is sensitive to temperature changes—one of NIST's recent calibration tests operates completely under computer control because even the operator's body heat in the room when measurements are taken can degrade the accuracy of final results. NIST has begun to replace the temperature control system, designed 30 years ago with vacuum tube technology, with substantially more reliable temperature control technology that uses semiconductors.

NIST also cited as an example the semiconductor industry's need for standard reference materials to ensure the quality of high-purity solvents and high-purity water used in fabricating the microscopic dimensions of integrated circuits. NIST cannot provide these reference materials; however, Japan's National Institute for Environmental Science already has clean-room facilities with the capabilities required for such ultra-high-purity analyses. This laboratory, as well as national standards laboratories in Switzerland and Canada, have special inorganic chemistry facilities featuring plastic walls, ceilings, floors, and furniture that enable them to outpace NIST's ability to detect low levels of such important metallic elements as iron, nickel, and copper by a factor of 100.

In November 1992, NASA's Administrator initiated a task force to develop a national facility plan for world-class aeronautics and space facilities that meets the needs of U.S. industry and federal agencies. This study, which will assess DOD's and NASA's mission requirements through the year 2023, will (1) determine where U.S. facilities do not meet national aerospace needs, (2) define new facilities required to make U.S. capabilities world-class, (3) define where the consolidation and phase-out of existing facilities are appropriate, and (4) develop a long-term national plan for world-class facility acquisition and shared usage. The task force is expected to issue its final report in the spring of 1994.

Several Agencies Are Assessing R&D Facilities' Funding Needs and Missions

In recent years, the eight federal agencies have improved management oversight of their laboratory facilities to address the growing need to maintain, repair, and upgrade aging buildings. However, the eight agencies cited a total backlog of at least $3.8 billion in needed repairs for their laboratories, and facilities managers at six of the eight agencies told us that funding to renovate existing laboratory facilities or construct new ones is either inadequate or only slightly adequate.

Laboratory Facilities Management

The eight federal agencies have strengthened their management of laboratory facilities through several initiatives designed to improve facilities planning and provide a basis for justifying increased funding to maintain, repair, or upgrade their laboratory facilities. For example, both ARS and NOAA have conducted facility condition surveys to identify and prioritize their laboratories' repair and replacement needs, and NIH and EPA are updating their laboratories' master site plans for future development.[1]

As part of its modernization plan initiated in 1985, ARS has completed comprehensive assessments of maintenance and repair needs at about 15 major laboratories and used in-house personnel to assess needs at its other laboratories. ARS' estimate of its backlog of needed repairs grew from about $350 million in 1985 to $700 million in 1993 primarily as a result of these assessments, which provided better information about needed repairs, and cost growth for making repairs.

NOAA became concerned about the deteriorating condition of its laboratories and other facilities about 4 years ago. Because maintenance and repair competed with R&D programs for limited funds, NOAA's laboratories repaired or replaced HVAC equipment, roofs, and other facilities almost entirely on an emergency basis without a plan for repairing and maintaining them in an acceptable condition. As part of its capital improvements program initiated in 1990, NOAA has completed comprehensive assessments at 15 laboratories. In addition, the Congress established a construction account for NOAA in fiscal year 1992. Although most of the $94.5 million appropriated in fiscal year 1993 is designated for Weather Service modernization projects, a line item in the account is designated for facilities maintenance.

NIH is updating its site master plans for the potential future expansion of its facilities to meet the R&D mission needs of its laboratories in Bethesda and Poolesville, Maryland. In particular, the Bethesda plan, which was last

[1]NIH is conducting facility condition assessments as part of its master planning process.

updated more than 20 years ago, is addressing space constraints and local community concerns about traffic and parking. In its 1991 evaluation of NIH's plans to renovate the clinical center complex and several other laboratory buildings, the Army Corps of Engineers recommended that NIH accelerate its master planning process, stating that the absence of a quality, up-to-date plan definitely hinders the ability of the NIH engineering staff to develop sound and reasonable strategies for future facility use and expansion.

EPA is updating its site master plans for each of its laboratories. The Gulf Breeze laboratory, which initially conducted R&D on the effects of pesticides on aquatic organisms, has expanded its mission substantially since EPA acquired the site in 1970. Correspondingly, the laboratory has grown from 14 buildings to 42 buildings, including 3 laboratory buildings, several small houses built when it was a yellow fever quarantine station, and leased trailers. The draft Gulf Breeze master plan proposes to consolidate offices and support services in a few larger buildings. For example, the computer center, currently housed in a trailer, would be moved to a central administration building. Several small buildings and temporary trailers would be eliminated, reducing maintenance and repair expenses.

Funding for Maintenance and Repair

Facilities managers for most of the eight federal agencies stated that funding for maintaining laboratory facilities was moderately adequate; however, facilities managers for four agencies said that funding for repairing laboratory facilities was only slightly adequate or inadequate. Facilities managers for the Navy, Geological Survey (USGS), and NASA's Offices of Aeronautics and Space Technology and Space Science said that the adequacy of funding for laboratory maintenance and repair was moderate to great. In contrast, NIH, NOAA, Air Force, Army, and NASA's Office of Space Flight managers told us that funding for both laboratory maintenance and repair was inadequate or slightly adequate. EPA and NIST officials stated that laboratory maintenance funding was moderately adequate, but funding for laboratory repairs was inadequate or only slightly adequate. DOE managers said that maintenance funding was moderately adequate, while repair funding was between slightly and moderately adequate. In general, federal laboratories are responsible for maintenance and minor repairs, paying for these expenses with R&D program funds; major repair projects generally are submitted to a central facilities organization within an agency for approval and funding prioritization.

Both NOAA and EPA officials stated that a repair request typically must reach a critical stage before it is funded. In particular, NOAA facilities managers stated that maintenance and repair funding of $2.9 million per year is inadequate to bring the condition of NOAA's laboratory facilities up to an acceptable level within a reasonable period of time, especially with an increasing backlog of maintenance and repair projects that currently exceeds $38 million. EPA facilities managers similarly noted that a recent survey of field offices identified $120 million in needed repairs and improvements for EPA's laboratory facilities, while only $12.1 million was appropriated for such expenses in fiscal year 1993.

Routine Maintenance and Repair

The National Research Council's Building Research Board, in its report Committing to the Cost of Ownership: Maintenance and Repair of Public Buildings, noted that the underfunding of maintenance and repairs of public buildings is a widespread and persistent problem. The Board recommended that 2 to 4 percent of the current replacement value for a substantial inventory of facilities (excluding land and major associated infrastructure) be allocated each year for routine maintenance and repair. The Board further stated that this funding level (1) should be used as an absolute minimum value in the absence of specific information upon which to base the maintenance and repair budget and (2) excludes funds for operations, alterations, and the reduction of any backlog of repairs. According to the Board's Director, this recommended guideline is intended to encourage government agencies to develop a maintenance and repair program on the basis of the appropriate service life of roofs, HVAC systems, and other building components. Whether a facility is at the high or low end of the 2- to 4-percent range primarily depends on the (1) age of buildings and utility systems; (2) level of use of the buildings, which affects utility systems requirements; (3) type of construction—permanent versus temporary; (4) climate; and (5) structure of the maintenance organization. For example, hospitals and R&D laboratories have a substantially greater level of use of a building's ventilation, electrical power, and other utility systems than office buildings because of the former's greater functional needs and concerns about health and safety, reliability, and adaptability. Accordingly, a greater proportion of hospitals' and R&D laboratories' current replacement value would generally be spent on maintenance and repair than on office buildings.

As shown in table III.1, ARS and NASA spent at least 2 percent of their laboratory facilities' current replacement value on routine maintenance and repair in fiscal year 1992. The other six agencies spent a lower percentage, ranging from 0.29 percent for NIST facilities to 1.82 percent for DOE facilities.

Table III.1: Routine Maintenance and Repair as a Percentage of the Current Replacement Value of Federal Laboratories

Dollars in thousands

Agency	FY 1992 funding for routine maintenance and repair	Current replacement value	Percent
USDA			
ARS	$ 35,960[a]	$ 1,684,070	2.14
Commerce			
NIST	4,031	1,376,049	.29
NOAA	1,179	b	b
DOD			
Air Force	10,067	1,648,311	.61
Army[c]	14,550	1,574,777	.92
Navy[d]	9,900	607,752	1.63
DOE	528,443	28,978,293	1.82
EPA[e]	7,747	471,415	1.64
Health and Human Services			
NIH	32,354	1,797,084	1.80
Interior			
USGS	3,748	404,000	.93
NASA[f]	111,298	4,716,910	2.36
Total	**$759,277**	**$43,258,661**	**1.76**

[a]ARS' data include some modernization program funding for renovating facilities.

[b]Data not available.

[c]Data for six Army laboratories were not available.

[d]The Navy provided data only for the Naval Research Laboratory.

[e]Data for R&D laboratories only.

[f]Data for three NASA laboratories were not available.

Source: Federal agencies listed in table.

Facilities managers at ARS, EPA, NASA, NIH, and NOAA told us that the 2- to 4-percent guideline is about right for their laboratory facilities. Some of these managers noted, however, that the 4-percent guideline is more appropriate for their laboratory facilities. In contrast, NIST facilities managers said that this level could be somewhat high for maintenance and repair at NIST during the period when the major renovations in its capital improvement facilities project are taking place. DOD and DOE facilities managers stated that using a percentage of the current replacement value was not appropriate for estimating routine maintenance and repair funding primarily because it does not (1) differentiate between types of facilities—laboratories generally have substantially greater utility infrastructure needs than office space—and (2) account for added maintenance and repair needs associated with older facilities. The DOD and DOE managers noted that data obtained through condition assessments of and actual experience at facilities would be more accurate.

Backlog of Laboratory Facilities' Repairs

The total backlog of laboratory repairs reported by seven federal agencies ranged from $3.8 billion to $4.5 billion. (See table III.2.) This backlog, which represents about 10 percent of the current replacement value of the laboratory facilities, is about five times greater than the agencies' funding for laboratories' routine maintenance and repairs in fiscal year 1992. DOE, which has the most and the oldest laboratory space among the eight agencies, reported the largest backlog of repairs. However, ARS reported a proportionately greater problem; the agency reported a $700 million backlog, while spending only $36 million for routine maintenance and repair in fiscal year 1992. According to ARS facilities managers, even though funding for routine maintenance and repair is about 2 percent of the current replacement value of ARS' facilities, it is inadequate for addressing ARS' facilities needs because of their age and the extent of the repair backlog.

Table III.2: Repair Backlog by Agency

Dollars in millions

Agency	Backlog
USDA	
ARS	$ 700
Commerce	
NIST	94
NOAA	38
DOD	
Air Force	39
Army	350
Navy	33[a]
AFRRI	3
DOE	1,400 - 2,100
EPA	120[b]
Health and Human Services	
NIH	330
Interior	
USGS	16
NASA	718
Total	**$3,841 - $4,541**

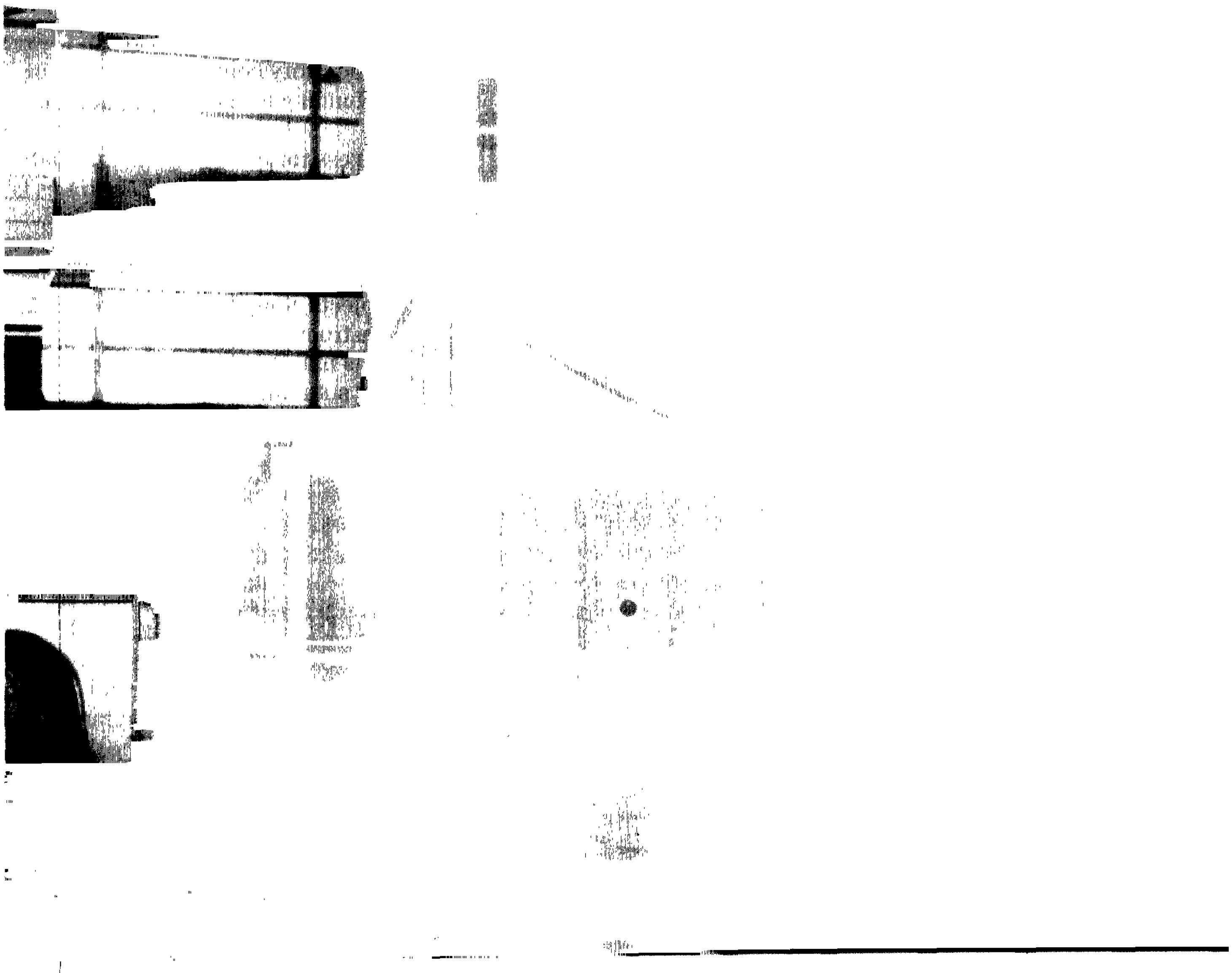
[a]The Navy provided data only for the Naval Research Laboratory.

[b]Does not include implementation of EPA's master plan, which includes repair and new construction needs.

Source: Federal agencies listed in table.

Facilities managers estimated that major repairs costing about $1 million, such as replacing a roof or an HVAC system, typically take from 3 to 5 years to implement from the time when laboratory management initially propose the repair until completion. This time involves waiting for funding to be made available, procuring contractors, and designing and making the repair. In some cases, the delay in making repairs is longer. An example is the replacement of a laboratory building's roof at Wright Laboratory located on the Wright-Patterson Air Force Base in Ohio. The roof replacement, estimated to cost $1.5 million, was delayed for 10 years because of limited funding available for repairs at Wright-Patterson. Facilities personnel installed a small structure with a pitched roof and a gutter around equipment in the laboratory to protect it from rain water leaking through the building's roof. (See center of fig. III.1.)

Figure III.1: Pitched-Roof Structure Protecting Equipment From a Roof Leak at Wright Laboratory



Source: Wright Laboratory.

Funding for Upgrading Laboratory Facilities

Facilities managers at DOD, DOE, EPA, NASA, NIH, and USGS told us that funding to renovate existing laboratory facilities or construct new ones is either inadequate or only slightly adequate. As shown previously in table I.1, construction of new laboratory space dropped from a high of

30.7 million square feet between 1953 and 1962 to 14.4 million square feet between 1983 and 1992. NIH, for example, built little new laboratory space in the past 10 years in contrast to earlier years. Similarly, EPA facilities managers told us that, in recent years, the Office of Management and Budget (OMB) has not approved any EPA laboratory construction projects; the Congress has, however, appropriated funding for new construction.

The facilities managers noted that the process for obtaining funding and either renovating existing laboratory facilities or constructing new ones is long—typically taking about 7 to 10 years from proposal to completion. While this process includes procuring services and designing and constructing the facility, a substantial portion of total time reflects the budgetary review process. Laboratory projects compete for limited funds among themselves, with other agency construction needs, and with other agencies funded in the same appropriations bill. Projects are reviewed within the agency and by OMB before being submitted to the Congress. During this process, a number of lower-priority laboratory projects will be dropped, and the amount of funding made available for a project may be reduced because of competing priorities.

In November 1989, Wright Laboratory issued a facilities modernization report that identified 28 military construction projects for funding between fiscal years 1992 and 2010 with an estimated total cost of $591 million. However, each project must be submitted to Civil Engineering, which annually develops and prioritizes Wright-Patterson Air Force Base's military construction projects. This list is submitted for review and approval to the Base Commander, then to the Office of the Secretary of the Air Force, and then to OMB for inclusion in DOD's budget. Over the past 10 years, Wright Laboratory has averaged less than one project every 2 years, and the average cost per project has been less than $7 million. Wright Laboratory facilities managers noted that laboratory projects compete at Wright-Patterson Air Force Base with housing and other quality-of-life needs for Air Force families as well as facilities for the Aeronautical Systems Center, which recently was established at Wright-Patterson.

To illustrate the problems in obtaining new laboratory space, Wright Laboratory facilities and research managers cited the construction of a major new addition to its Avionics laboratory, initially proposed around 1980 at a cost of $35 million. Wright Laboratory was advised to break the $35 million project into three construction phases to increase its funding likelihood. Phase 1, approved in fiscal year 1992, began in March 1993; phase 2 is included in DOD's 1994 budget; and phase 3 was pushed back to the fiscal year 1997 budget. Assuming that phase 3 is approved, construction of the Avionics laboratory addition will be completed about 20 years after it was initially proposed.

Alternative Actions to Address Aging Federal Laboratory Facilities

Federal agencies are confronted with aging laboratory facilities that have a substantial backlog of repairs and, in some cases, limited research capabilities. Several federal agencies are assessing options for improving the effectiveness and efficiency of their laboratories in response to the end of the Cold War and/or funding constraints because of the budget deficit.

Realigning, Consolidating, And/or Closing Laboratories

In response to budget constraints and/or changing mission needs, several federal agencies have examined options for realigning, consolidating, and/or closing some of their laboratory facilities. Important considerations include (1) any changes to an agency's mission and the R&D capabilities needed to fulfill that mission; (2) the adequacy of funding to maintain, repair, and upgrade these laboratory facilities; and (3) potential budget savings achieved by consolidating laboratories that are not essential for fulfilling the agency's mission and/or closing inefficient older laboratories.

DOD, DOE, and USDA have taken steps to reevaluate their laboratories' missions and R&D capabilities. In response to the end of the Cold War, the Army, Navy, Air Force, and Armed Forces Radiobiology Research Institute (AFRRI) are reducing their combined laboratories from 76 to 31, according to DOD research managers. Similarly, earlier this year, DOE initiated a review of the roles, missions, and core competencies of its principal laboratories, including a review of whether to realign the mission of one of its three nuclear weapons laboratories, which together spend almost half of DOE's R&D funds. In addition, USDA is studying whether to close or consolidate some of ARS' 111 laboratories. Most of these laboratories spend less than $5 million on R&D each year; about half are colocated with university laboratories.

House bill 1432, introduced in March 1993, proposes to establish a Federal Laboratory Mission Evaluation and Coordination Committee, which in part would make recommendations on the advisability of establishing a commission to determine whether specific federal laboratories should be realigned, consolidated, or closed. One criterion that the Committee would be directed to consider is improving the efficiency and effectiveness of the overall federal laboratory system.

Upgrading Federal R&D Facilities

Several federal agencies have proposed substantial laboratory modernization programs to improve scientific productivity and/or research capabilities. The following are examples of programs that have been proposed and/or funded.

- The Congress has made available about $70 million of $205 million that ARS requested in 1988 to modernize BARC's laboratory facilities by (1) renovating many of BARC's original buildings and (2) clustering related research programs in larger laboratory buildings to encourage interactions between researchers.
- In fiscal year 1993, the Congress appropriated $110 million of NIST's proposed $540 million, 10-year-effort to upgrade laboratory facilities at its Gaithersburg and Boulder campuses. NIST plans to (1) renovate seven existing buildings, (2) construct the equivalent of two advanced technology buildings, (3) improve the reliability of electrical power supplies, and (4) at Boulder, construct a central plant to provide steam and chilled water.
- NIH has proposed construction of a new clinical center complex at an estimated cost of $1.6 billion. The new clinical center would replace the existing 38-year-old clinical center, which does not have the (1) fire protection systems required for a modern research hospital or (2) flexibility, particularly in ventilating and cooling systems, to adequately address NIH's biomedical research programs.
- A task force appointed by NASA's Administrator is expected to issue a national facility plan in the spring of 1994 for world-class aeronautics and space facilities that meet the needs of U.S. industry and federal agencies.

Providing Spending Flexibility

DOD and DOE officials suggested that their laboratories would be able to respond faster to scientists' needs for important R&D capabilities in certain instances if they were given greater authority to proceed with minor new construction without obtaining specific congressional authorization.

In November 1989, the Deputy Secretary of Defense initiated the Laboratory Demonstration Program to improve the quality, productivity, and efficiency of DOD laboratories. The Deputy Secretary proposed that legislation be drafted to address inadequate funding for R&D projects in the annual military construction bill and the need for new construction in part to modernize aging laboratory facilities and exploit new technologies. Among its recommendations, the Laboratory Demonstration Program has proposed providing laboratories with greater flexibility to upgrade facilities by increasing the threshold for (1) minor construction projects using operations and maintenance funds from $300,000 to $1 million and (2) unspecified minor construction projects using military construction funds from $1.5 million to $3 million without obtaining specific congressional authorization.

DOE has proposed to increase its General Plant Projects threshold for minor construction from $1.2 million to $2.5 million without obtaining specific congressional authorization. DOE officials noted that the $1.2 million threshold has not been increased since it was established in 1983. In contrast, they stated that construction costs have increased to the point where $1.2 million, which would pay for a 20,000-square-foot module in 1983, would pay for only an 8,300-square-foot module using inexpensive building materials in 1993.

Objectives, Scope, and Methodology

The Vice Chairman, Joint Economic Committee, U.S. Congress, expressed concern that federal research agencies may be underinvesting in maintaining, repairing, and upgrading their laboratory facilities. Citing the importance of federal R&D to economic growth and national well-being, the Vice Chairman requested that we assess the (1) condition of federal laboratory facilities, (2) effect of inadequate laboratory facilities on agencies' scientific productivity and research capabilities, and (3) funding needed to repair or upgrade these facilities.

As agreed with the Vice Chairman's office, to assess the condition of federal laboratory facilities, we obtained information from the Department of Commerce; DOD; DOE; EPA; NASA; ARS, within the Department of Agriculture; NIH, within the Department of Health and Human Services; and USGS, within the Department of the Interior. These agencies have 220 government-owned laboratory campuses that spent about $18.1 billion of the estimated $24.9 billion obligated for R&D at federal laboratories in fiscal year 1992. (See table IV.1.) In addition, ARS, EPA, NOAA, and NIH lease some of their laboratories from state governments, universities, or private companies.[1]

[1]For example, 9 of EPA's 32 laboratories and field stations and 15 of NOAA's 39 laboratories are leased facilities.

Table IV.1: Federal Laboratories' R&D Funding

Dollars in millions

Federal agency	Number of laboratory campuses	Estimated R&D obligations for agencies' laboratories in FY 1992
USDA		
ARS	111	$653
Commerce		
NIST	2	295
NOAA	24	272
DOD		
Air Force	4	1,949
Army	21	2,083
Navy[a]	1	583
AFRRI	1	17
DOE	16	6,607
EPA	23	167
Health and Human Services		
NIH	5	1,753
Interior		
USGS	3	246
NASA	9	3,499
Total	**220[b]**	**$18,124**

[a]The Navy provided data for the Naval Research Laboratory, which primarily performs R&D, but did not provide data for its four test and evaluation laboratories.

[b]Total number of laboratories excludes satellite laboratory facilities and laboratories that the federal government leases from other organizations.

Specifically, to assess the nature and extent of deteriorating buildings and inadequate infrastructure, we obtained (1) condition studies, modernization proposals, and other laboratory facilities assessments; (2) data showing the age of laboratory buildings by 10-year periods; (3) information about major problems at facilities that occurred during the past 3 years; and (4) any of the agencies' FIA reports that identified deteriorating facilities as a material management weakness. We also visited eight laboratories, shown in table IV.2, to observe the facilities and obtain the views of laboratory facilities and research managers about the condition of laboratory facilities.

Table IV.2: Federal Laboratories Visited

Federal agency	Laboratory	Location
Commerce	NIST	Gaithersburg, Md.
	NOAA's Southeast Fisheries Center	Miami, Fla.
	NOAA's Atlantic Oceanographic and Meteorological Laboratory	Miami, Fla.
DOD/Air Force	Wright Laboratory	Wright-Patterson Air Force Base, Ohio
EPA	Environmental Research Laboratory	Gulf Breeze, Fla.
Health and Human Services	NIH	Bethesda, Md.
NASA	Lewis Research Center	Cleveland, Ohio
USDA	ARS	Beltsville, Md.

To evaluate the effects of inadequate infrastructure on agencies' scientific productivity and research capabilities, we interviewed (1) agencies' facilities managers and (2) laboratory management, scientists, facilities managers, and other personnel at the eight laboratories visited. We also obtained information about the effect of such laboratory facilities problems as electrical outages and inadequate ventilation on scientific research. In addition, we reviewed reports by the Army Corps of Engineers and architect and engineering consultants that evaluated laboratory facilities needs to perform advanced R&D.

To analyze the funding needed to repair or upgrade federal laboratory facilities, we interviewed the Director of the National Research Council's Building Research Board and reviewed the Board's report entitled Committing to the Cost of Ownership: Maintenance and Repair of Public Buildings. We then obtained data from each of the eight agencies to (1) compare agencies' funding for routine maintenance and repair of laboratory facilities with the facilities' current replacement value and (2) estimate the backlog of laboratory repairs. We also obtained the views of agencies' facilities managers about the adequacy of funding for maintaining, repairing, and renovating existing laboratory space or constructing new space. We reviewed laboratory facilities modernization studies and obtained information about any studies by agencies to realign, consolidate, or close their laboratory facilities.

Facilities managers at several agencies cited problems with maintaining, repairing, and upgrading their laboratory facilities that were beyond the scope of our assessment. For example, some managers stated that, in addition to funding limitations, their maintenance and repair programs have been constrained by (1) staffing ceilings for facilities personnel; (2) procurement requirements that lengthen the time or add to the cost associated with hiring contractors to replace major building systems, renovate existing laboratory space, or construct new facilities; and (3) procurement requirements that delay purchases of critical spare parts. In addition, EPA and NOAA officials cited problems with leased laboratory facilities—in many cases, they pay for maintenance, repairs, and renovations because of a lease's terms. Furthermore, EPA officials told us that OMB effectively has made leasing new laboratory space unrealistic by requiring that an agency set aside funding for the duration of a lease, known as "scoring," before the lease is signed.

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.

Jim Wells, Associate Director
Robert E. Allen, Jr., Assistant Director
Richard Cheston, Evaluator-in-Charge
John Johnson, Staff Evaluator

Related GAO Products

Federal Budget: Choosing Public Investment Programs (GAO/AIMD-93-25, July 23, 1993).

Department of Energy: Cleaning Up Inactive Facilities Will Be Difficult (GAO/RCED-93-149, June 25, 1993).

Navy Laboratories: Plans for Consolidation and Progress Toward Implementation (GAO/NSIAD-93-160, June 23, 1993).

Military Bases: Army's Planned Consolidation of Research, Development, Test and Evaluation (GAO/NSIAD-93-150, Apr. 29, 1993).

Transition Series: Investment (GAO/OCG-93-2TR, Dec. 1992).

Federal Buildings: Actions Needed to Prevent Further Deterioration and Obsolescence (GAO/GGD-91-57, May 13, 1991).

NASA Maintenance: Stronger Commitment Needed to Curb Facility Deterioration (GAO/NSIAD-91-34, Dec. 14, 1990).

Ordering Information

The first copy of each GAO report and testimony is free. Additional copies are $2 each. Orders should be sent to the following address, accompanied by a check or money order made out to the Superintendent of Documents, when necessary. Orders for 100 or more copies to be mailed to a single address are discounted 25 percent.

Orders by mail:

U.S. General Accounting Office
P.O. Box 6015
Gaithersburg, MD 20884-6015

or visit:

Room 1000
700 4th St. NW (corner of 4th and G Sts. NW)
U.S. General Accounting Office
Washington, DC

Orders may also be placed by calling (202) 512-6000 or by using fax number (301) 258-4066.

PRINTED ON RECYCLED PAPER

United States
General Accounting Office
Washington, D.C. 20548

Official Business
Penalty for Private Use $300

First-Class Mail
Postage & Fees Paid
GAO
Permit No. G100