r

LBNL/PUB-5461

Lawrence Berkeley National Laboratory
Strategic Facilities Plan

October 2000

Prepared for the U.S. Department of Energy under Contract No. DE-AC03-76SF00098

Strategic Facilities Plan
Lawrence Berkeley National Laboratory

Prepared for the
Office of Science
U.S. Department of Energy

October 2000
Berkeley, California 94720

Ernest Orlando Lawrence Berkeley National Laboratory

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

Contents

NOTE: This October 2000 edition is substantially the same as the September 2000 edition. The October edition incorporates additional Information Technology text. This can be found in the Information Technologies Infrastructure section on page 10, General Purpose Equipment (GPE) section on page 15 and in Appendix B where subitems have been added in the Operating funding and GPE budgets. A new Networking Facilities subsection has been added in the Operating funding section of Appendix B. This addition increases the overall Operating funding needs identified. There are otherwise no changes to the overall budget figures in Appendix B. A map showing the location of each of the proposed new buildings has been added as Appendix C. Minor edits have also been made in preparing the October 2000 edition.

Strategic Facilities Plan
Lawrence Berkeley National Laboratory

Executive Summary

Lawrence Berkeley National Laboratory (Berkeley Lab) has prepared this Strategic Facilities Plan in order to prioritize and guide infrastructure and facility developments to advance the physical and multidisciplinary sciences that have been a key to the nation's prosperity. Modern, effective and efficient physical infrastructure is critical to maintaining the capabilities of the multiprogram laboratories. These laboratories have a tradition of providing first-of-a-kind enabling discoveries and technologies that drive national advances and advantages.

The Berkeley Lab *Strategic Facilities Plan* has been prepared to sustain Berkeley Lab's contributions to the DOE's mission. This 10-year Strategic Facilities Plan was prepared for the Department of Energy's (DOE's) Office of Science as part of its "Laboratories of the 21st Century" initiative. The *Plan* describes:

(1) the scientific mission of this Laboratory,

(2) the facilities and infrastructure changes needed to support the planned research mission and

(3) the operational and performance issues that must be addressed to meet the modernization goals described in this Plan.

This Plan identifies existing and anticipated infrastructure deficiencies, and it proposes actions that can be taken to address these deficiencies before they can have any impact upon the science that is at the core of our mission. Current roles and anticipated changes call for strategic investments in the renewal of the scientific and support infrastructure that is essential for Berkeley Lab to meet its mission and program obligations.

As Berkeley Lab is the oldest of the DOE National Laboratories, portions of its infrastructure and a number of facilities are candidates for renovation and replacement at this time. The physical plant must be modernized so that it appropriately supports the science of today and the coming decades and ensures that the infrastructure is not a barrier to achieving programmatic goals.

Laboratory Mission and Role

The Lawrence Berkeley National Laboratory is a multiprogram national research facility and an integral element of the Department of Energy's National Laboratory System. Berkeley Lab's programs, all unclassified, support DOE's mission to maintain "a secure and reliable energy system that is environmentally and economically sustainable" and to ensure "continued United States leadership in science and technology," as stated in DOE's *Strategic Plan*. These programs also support the Comprehensive National Energy Strategy to "work internationally on global issues," to "improve the efficiency of the energy system," and to "expand future energy choices through wise investments in basic science and new technologies."

Berkeley Lab's principal role for DOE is fundamental science; for example, developing powerful experimental and computational systems for exploring properties of matter, deepening our understanding of molecular interactions and synthesis, and gaining insights into biological molecules, cells, and tissues.

Berkeley Lab is a major contributor of research on energy resources, including the earth's structure and energy reservoirs, fusion, combustion of fuels, and keys to efficient energy storage and use. In addition, Berkeley Lab is extensively involved in environmental research, including subsurface contaminant transport, bioremediation and indoor air quality.

User facilities at Berkeley Lab include the Advanced Light Source, National Energy Re-

search Scientific Computing Center, National Center for Electron Microscopy, 88-Inch Cyclotron, Gammasphere, Biomedical Isotope Facility and National Tritium Labeling Facility. Our multidisciplinary research environment and unique location adjacent to the University of California at Berkeley and the heart of the Bay Area, in a technology-intensive region serve to strengthen partnerships with universities, industry, and government laboratories (see Figure 1).

Berkeley Lab's principal, contributing and specialized participating roles conform to DOE's *Strategic Laboratory Missions Plan* and the laboratory profile reports that distinguish each of the national laboratories. Berkeley Lab's mission statement, as stated in its FY 2001–2005 *Institutional Plan*, articulates four distinct Laboratory goals that support the DOE mission:

- To perform leading multidisciplinary research in the energy sciences, general sciences, biosciences, and computing sciences in a manner that ensures employee and public safety and protection of the environment.
- To develop and operate unique national experimental facilities for qualified investigators.
- To educate and train future generations of scientists and engineers to promote national science and education goals.
- To transfer knowledge and technological innovations and to foster productive relationships among Berkeley Lab's research programs, universities, and industry in order to promote national economic competitiveness.

Up to the 10-year planning horizon, Berkeley Lab's mission will be sustained in fundamental research, energy resources and environmental quality (see Appendix A). Berkeley Lab does not anticipate major growth in programmatic activity, outside of DOE mission initiatives. On the other hand, advances in the Laboratory's scientific programs and the emerging developments in DOE program areas are expected to sustain key trends, such as: a growing population of users at the Advanced Light Source and other user facilities; more powerful computational capabilities integrated with science applications; increased scale of new bioscience programs in functional

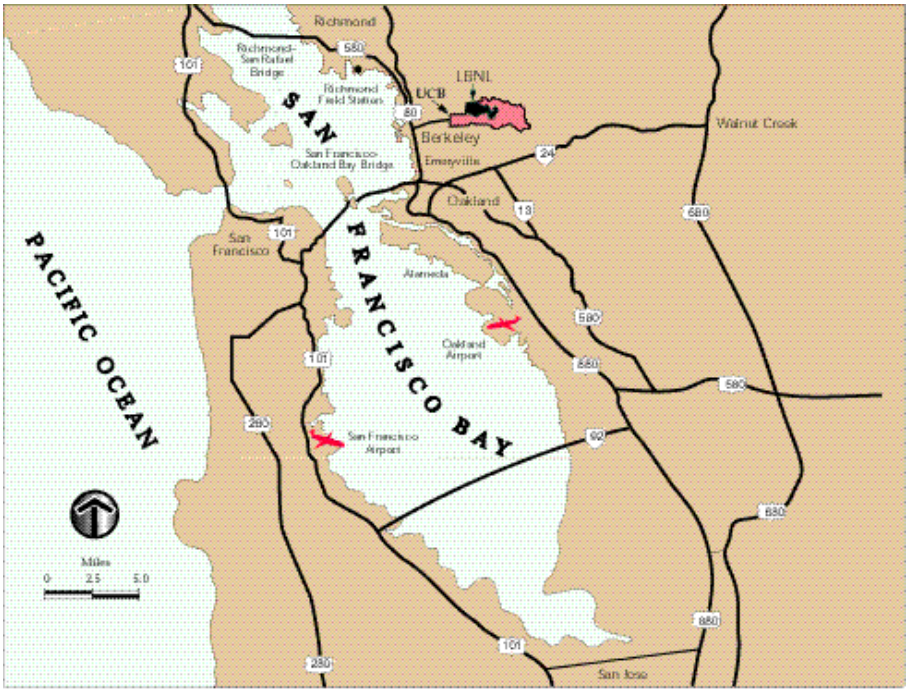


Figure 1: Regional Map, Lawrence Berkeley National Laboratory

Figure 1. Regional Map, Lawrence Berkeley National Laboratory

genomics and structural biology; and a new understanding of the universe, matter and energy through advances in astrophysics, detectors, and accelerator science. In addition, energy and environmental issues will reaffirm the research focus on inertial fusion energy science, carbon sequestration, and reliability-of-electric-power and energy-efficiency research as the nation addresses its energy supply problems.

Both the current roles and the anticipated changes—especially in growth of nano-scale science, advanced instrumentation, computation, and the new biology—call for strategic investments and renewal of scientific and support infrastructure that is essential for Berkeley Lab to meet its current and anticipated mission and program obligations.

Major new scientific instrumentation and experimental programs are not included in the scope of this plan. Such facilities as, for example, a new accelerator for high energy or nuclear physics, a major test accelerator for inertial fusion energy, and a major new fourth generation synchrotron radiation source offer the prospect for significant scientific and economic benefit consistent with Berkeley Lab's current research expertise. Because of their size and uniqueness, such significant initiatives are planned and advanced through national and international scientific forums. The Laboratory has and will continue to advance new, novel and innovative accelerators, x ray sources, and other instrumentation through its ongoing programs.

Some program growth and redirection may occur in selected areas, such as additional operations to accommodate the expanding user communities, current and anticipated national initiatives such as those in nanoscience and computing and, potentially, other areas. However, the strategic facility investments called for in this plan are essential and valuable to Berkeley Lab and to DOE programs under level operating cost conditions, adjusted for inflation.

Infrastructure Vision, Goals and Objectives

The infrastructure for the DOE National Laboratory system supports some of the most productive scientific institutions in the nation. Berkeley Lab is a renowned and preferred research location. Yet the continued reliance on an aged and decaying physical plant impedes research, reduces productivity, and makes recruitment and retention of our top-quality scientists and engineers much more difficult.

As indicated in the *Strategic Plan of the Office of Science*, a key objective for this Laboratory is to "provide leading research facilities and instrumentation to expand the frontiers of the natural sciences." Berkeley Lab's infrastructure planning and management efforts are directed towards sustaining the Office of Science mission and its strategic objective. This will require that several facilities be upgraded and renovated to conform to modern standards, and the replacement of a few structures that can no longer be economically upgraded.

The sections that follow describe facilities investments that must be made to sustain Berkeley Lab's contributions to the strategic plans of DOE and the Office of Science. In addition, the Laboratory's Strategic Facility Plan supports DOE's planning objective "for achieving laboratories of the 21st century."

The principal goals of the *Strategic Facilities Plan* are to:

- Provide laboratories, offices and infrastructure systems appropriate to Berkeley Lab's research roles for DOE.
- Support the growing user community at Berkeley Lab's scientific facilities.
- Provide an environment that is safe, efficient, and enabling for staff, guests, and the community.

Consistent with these goals, Berkeley Lab has adopted the following infrastructure planning objectives:

- *Mission*: Anticipate the changes in Berkeley Lab's technological capabilities that will be required to meet programmatic and mission direction in order to accommodate Berkeley Lab's long-term mission for the next 20 to 30 years.
- *Quality and Value*: Continuously improve the quality, uniqueness and value of this world-class scientific research facility to Berkeley Lab's stakeholders (the research and academic communities, institutional researchers, the Federal government, Congress and the general public) so that both current and future research expectations are fully realized.
- *Working Environment*: Provide facilities and a campus that is a "preferred" working environment for the caliber of scientists and engineers that we need to attract and retain.
- *Security:* Provide visiting scientists access and the opportunity to collaborate with Laboratory researchers while protecting security and assets.
- *Flexibility and Versatility:* Building and interior construction will respect the dynamic changes in scientific programs. Interior space/layout will be adaptable for new program work, and office space will require only minimal modifications to accommodate program changes and staff relocation.
- *Durability and Longevity:* We will strive to use materials and construction technologies that yield structures capable of providing 50+ useful years of research use without a major renovation.
- *Environmental Safety and Health:* Building materials, design and construction should provide a safe working environment for the occupants as well as a model of environmentally sustainable design and materials of construction.
- *Sustainability:* Incorporate environmentally sound and energy-saving design, materials and utilities that will use state-of-the-art technology where appropriate.
- *Cost:* Ensure that the proposed investments yield a significantly high rate of return and help minimize operating and maintenance costs.

The mission drivers and facilities identified in this Plan advance DOE missions and Office of Science programs—principally, the Offices of Basic Energy Sciences, Biological and Environmental Research, High Energy and Nuclear Physics, Advanced Scientific Computing Research, and Fusion Energy Science. In addition, technology advancements made by Berkeley Lab support the Energy Efficiency and Renewable Energy programs, the Office of Civilian Radioactive Waste Management, and other elements of DOE. The potential new construction included in this report supports the DOE *Strategic Plan*, the *Science Portfolio*, and the *Strategic Plan of the Office of Science*.

Facility and Infrastructure Issues

Berkeley Lab's 82-hectare (200-acre) main site is immediately adjacent to the University of California at Berkeley (UC Berkeley). The main site encompasses 1.7 million gross square feet (mgsf). In 2000, there are 112 buildings of conventional construction and 108 trailers and other structures at the main site. Additional space on the UC Berkeley campus totals 90,000 gross square feet (gsf); and 210,000 gsf are in leased buildings in the cities of Berkeley, Oakland, and Walnut Creek (see Figure 2).

Berkeley Lab's role for DOE has changed since the first Manhattan project and 184-Inch Cyclotron facilities were constructed in the early

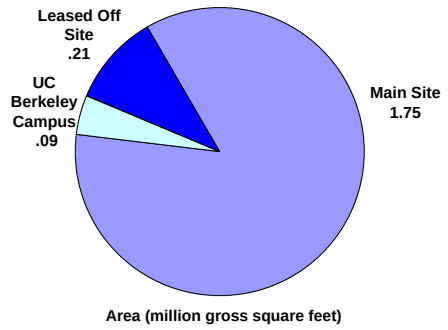


Figure 2. Laboratory Space Distribution

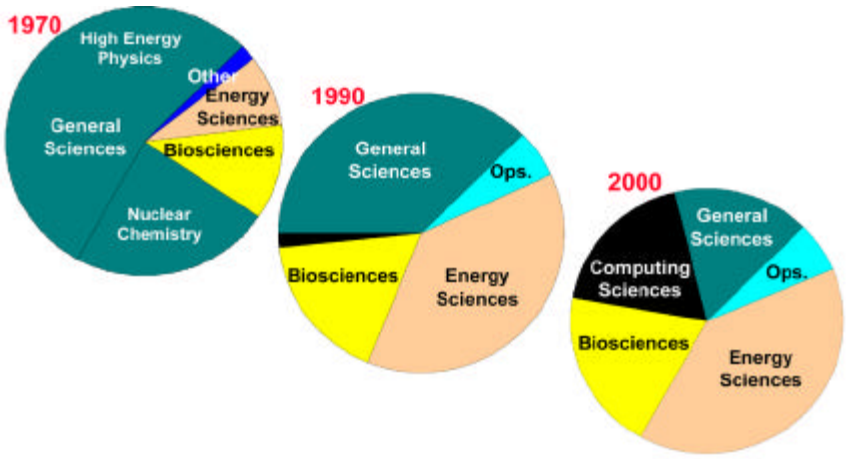


Figure 3. Change in Berkeley Lab Programmatic Areas

1940s. The challenge to Berkeley Lab in achieving its current multiprogram Office of Science mission is that more than 70 percent (or 1.2 mgsf, of Berkeley Lab's total current space 1.7 mgsf) was constructed prior to 1970, when the Laboratory was a single-purpose Atomic Energy Commission facility. The evolution of the Laboratory is given in Figure 3.

Some of the main site buildings are no longer appropriate for the current research program and most of these buildings are reaching the end of their service life. (The age distribution of Berkeley Lab buildings is given in Figure 4.) Indeed, many of the most serious facilities problems stem from the continued use of temporary Manhattan Project single-wall buildings served by 1940s utilities, structural and design systems. These facilities do not have the mechanical systems (e.g. air handling, heating, cooling, and plumbing) and electrical systems necessary to effectively or efficiently conduct current research. Many of these systems are vital to providing adequate cleanliness, fume removal, treatment, power, gas handling, and other operations necessary for experimental programs. In other instances, the buildings are not structurally satisfactory, and some are condemned or have occupancy limitations. In many cases, the

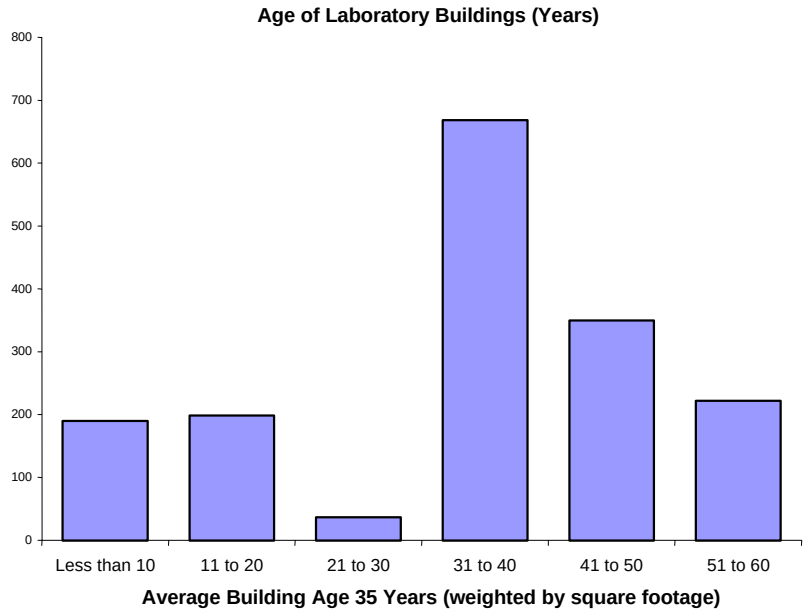


Figure 4. Age of Laboratory Buildings, Modulars, and Trailers

buildings were intended for temporary occupancy or for specialized functions that are no longer being conducted. Use of unsatisfactory space is costly and requires reliance on administrative controls to ensure that operational safety requirements continue to be attained.

The most significant facility no longer serving DOE programs is the Bevatron, which encompasses 10 percent of Berkeley Lab's space and occupies a central location that should serve priority DOE missions, including programmatic projects described in Appendix A.

Except for the Bevatron accelerator, all offices, laboratories, and support facilities at Berkeley Lab that can be occupied are 100-percent utilized.

The total replacement value of Berkeley Lab's facilities is $1,038M, as reported in the Facilities Information Management System (FIMS), and the value of the equipment in the facilities is $470M. On an annual basis, Berkeley Lab invests $5M in non-capital projects in the buildings. The DOE Office of High Energy Physics provides $3.5M for General Plant Projects. The Multiprogram Energy Laboratory-Facilities Support (MEL-FS) Program provided an average of $4M over the past seven years. Collectively, these resources provide a 1.2-percent annual investment rate—or a turnover time of 83 years, excluding additional program construction funds.

Approximately 331,000 square feet of Berkeley Lab's space at the main site is substandard and in need of replacement (Figure 5). Existing research missions need this space, and much of it remains in use pending replacement.

If maintained well and updated where required, the vast majority—some 81%-of Berkeley Lab's main site space can continue to serve the research mission. For example, 89% of computer space, 97% of wet lab space, and 84% of dry lab space are rated as adequate or functional in 2000. Still, Berkeley Lab must continue to upgrade facilities that are rated as "minor or major rehab needed," rather than "adequate," to ensure that they continue to meet researcher needs as well as all applicable health, safety, environmental, and performance standards. Moreover, as space is at a premium capabilities must be increased in order to reduce overcrowding. Evaluation of building condition and usability is based on categories utilized in FIMS.

Planning Assumptions

DOE-derived operating funding will grow by no more than the rate of inflation for the period 2002 through 2012, with the exception of new program-sponsored initiatives such as those in nanoscience and computing.

New programmatic initiatives that require major new experimental/user facilities or site development are not emphasized in this Strategic Facilities Plan. These large projects will be assessed and developed in other planning forums.

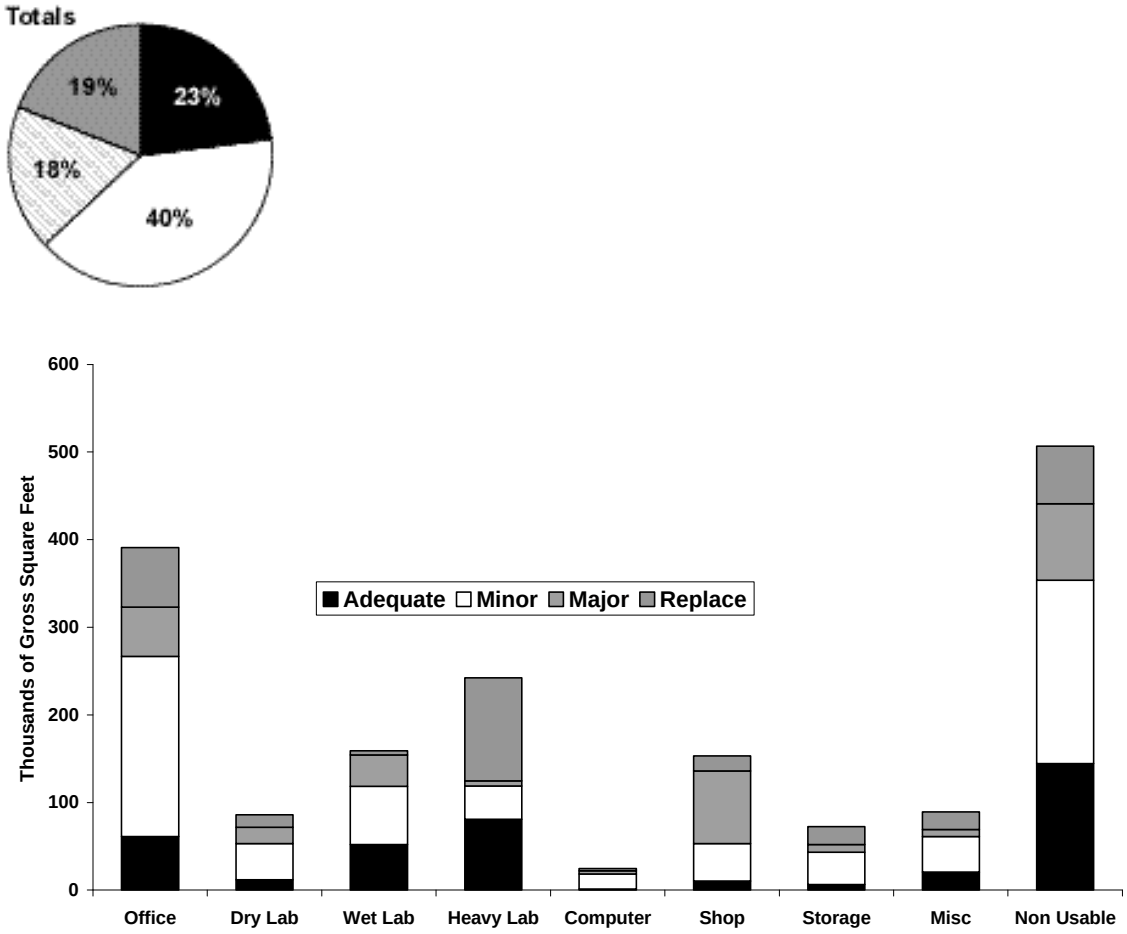
Most of the development of Berkeley Lab facilities and programs will occur on the main site. Facilities and programs will be located offsite only if this is more suitable.

Berkeley Lab will continue to perform highly collaborative multidisciplinary research that brings to bear the power of the physical sciences, computing, engineering, and life sciences on problems of national importance. Research changes in this planning period will require new and renovated facilities with diverse capabilities (e.g., wet labs and computer facilities) that are collocated so that they provide effective support for collaborative research projects.

The direction of research at Berkeley Lab will continue to evolve within the general scientific framework that exists today. During this planning period, we anticipate further strengthening of life sciences programs, including structural biology and genomics; increased emphasis on computing, both as a research tool and as a subject of research itself; continued growth in the nanosciences and related materials research; and increased attention to energy and environmental sciences. Berkeley Lab will continue to be a national resource for detector arrays, accelerator design, and the fabrication of complex and specialized accelerator components.

Advances in electronic communication, remote experiment control capabilities, and remote visualization will require state-of-the-art facilities for electronic conferencing employing both individual workstations and groups.

Berkeley Lab user facilities will serve an ever-broader national community. These unique facilities will require additional support, both for themselves and for associated facilities that will



Adequate – No modernization/rehabilitation needed. **Minor** – Minor modernization/rehabilitation needed.
Major – Major modernization/rehabilitation needed. **Replace** – Replacement needed.

Figure 5. Use and Condition of Laboratory Space

have direct electronic connections to experimental and fabrication facilities.

Research tools and practices will continue to evolve. Efficient laboratory operations require facilities that can be adapted quickly and cost-effectively as requirements change. Buildings and the support infrastructure must be updated so that they can efficiently match the pace of modifications required by modern scientific technology and practice.

Research buildings that are fundamentally sound but which were constructed prior to the development of modern standards will need to be renovated and upgraded.

A few facilities, generally structures built as temporary facilities when construction materials were in short supply during WW II and in the early Cold War period, must be

- modernized and rehabilitated, or
- replaced with new modern facilities when they cannot be cost-effectively upgraded

in order to meet the research requirements brought about by changes in research technologies and practices.

An increasing concern with environmental considerations will require additional onsite materials storage and handling capabilities.

Plan for Modernization

Site

Berkeley Lab strives to meet the operational requirements of a first-class research facility while also respecting the natural environment. The undeveloped areas of the site are generally maintained consistent with principals that utilize native and naturalized plant communities. The undeveloped areas are also maintained as a fuel break, affording important protection to the Laboratory and the surrounding community from wildland fire risks.

The developed portions of the Laboratory were established during WW II and the Cold War. During these times site planning guidelines were generally respected, but pressing needs did not allow for full implementation of site planning principles. Today, the Laboratory is working to locate staff and facilities in related sciences to common areas in order to further improve communication, interaction and efficiency. The Laboratory is focusing efforts to ensure that guests and facility users can easily access the Laboratory and that they feel comfortable conducting their work here. The Laboratory is also working to make improvements that further improve relations with local communities and stakeholders.

The following are planning concepts to modernize the site:

- Meet programming needs and vision of the scientific community.
  - Provide infrastructure to enable future growth and expansion
  - Provide physical surroundings that reflect the value of the scientific research
  - Create environments that foster the highest level of scientific thinking
  - Adopt a planning process that is responsive to new developments within the scientific disciplines
- Develop Laboratory “Town Center” and a sense of community:
  - Create distinctive public space for community gatherings
  - Cluster public functions, such as administrative buildings, library, conference center, etc.
  - Focus on pedestrian and public-transit-based circulation hubs
  - Encourage Berkeley Lab community to interact in various ways
- Commit to sustainable design and development. Develop green design practices.
  - Preserve the natural beauty of the laboratory site
  - Encourage the development of a pedestrian-friendly site. Link pedestrian circulation to transit and building entrances
- Promote “quality of life”
  - Provide physical surroundings that contribute to productive and informed employees
  - Focus on interior working space that highly integrates components of the natural environment and light, with exterior vistas of hillsides and landscaped areas. Quality space contributes to quality work.
  - Unify and strengthen the visual streetscape of the site, making the laboratory site both safe and friendly.

Existing Facilities – Demolitions

Twenty-seven percent of the Lab’s space on the main site is located in two closed accelerator complexes and in buildings constructed during or immediately after WW II. Demolition of the abandoned Bevatron is necessary so that this large area of Berkeley Lab can be used productively. Other WW II era buildings, which provide minimal support for modern science, will be demolished as part of projects to construct replacement buildings. These other structures are typically light-frame and do not contain structural elements that have acquired induced radiation. However, the Bevatron requires attention as a separate project. The Bevatron comprises 164,100 gsf of Laboratory space, about 10 percent of the space on the main site. Since it ceased operation in 1992, the Bevatron has been largely abandoned by the Department of Energy, with no source of funds for its decontamination and demolition.

A key element of the *Strategic Facilities Plan* is the demolition of the Bevatron facility. This complex is at the very heart of the Laboratory and the need for usable space in this area is pressing. Indeed, this site can be used productively for mission-critical facilities that must be available to meet the computing infrastructure needs of the 21st century. The cost of the project is dependent on the potential for recycling components of this facility and the extent of environmental cleanup that may be required (see Appendix A).

Existing Facilities – Rehabilitation Projects

Berkeley Lab has an effective maintenance program that works to allow researchers to use building space and all other assets for the maximum number of years. Most Berkeley Lab buildings remain usable; however, there are a few highly critical buildings that require rehabilitation, because their basic systems are not capable of meeting the requirements of modern science. These buildings are fundamentally sound; renovation to incorporate modern utilities and to address current codes will extend their useful lives for many more decades—at a fraction of the cost of new construction. One potential project, Buildings 77/77A, is currently in review and is not discussed in this plan. All other rehabilitation projects are summarized in the sections that follow.

Building 90 HVAC Upgrade

In Building 90, average interior temperatures from May through September range from 74 to 80 degrees F, and peak daytime temperatures can rise to 90-plus degrees on many days. Occupants are uncomfortable on hot days and are sometimes sent home. Some computers have overheated.

This project will provide an evaporative cooling system for Building 90, reducing supply air temperatures during periods when the building's inlet air temperature exceeds 75 degrees F. At an estimate TEC of $700K, this is an extremely economical alternative to a mechanical refrigeration system estimated to cost in excess of $3M. It will reduce peak temperatures from 95 to 78 degrees F, improving comfort and productivity while decreasing lost time and expensive downtime caused by equipment overheating.

Improve Office Quality and Utilization in Building 50

Offices on the second and third floors of Building 50 were designed in an era when space was not at a premium. They are generally too large or inefficiently configured to support current functions. They also lack the modern lighting, ventilation/cooling, and space-efficient furniture that comprise the quality office required to attract and retain high-level research staff in the physics and computational sciences.

This project, with a conceptual estimate of approximately $4.0M, would reconfigure approximately 26,000 gsf of offices. Resizing offices from their current size to approximately 120 square feet will create approximately 40 additional offices. The lighting and HVAC systems will be completely revamped to meet the expectations of today's scientific staff.

Rehabilitation and Modernization of the 71 Complex

The Office of Science requires advanced accelerator front ends and ion sources for new and upgraded accelerators for High Energy and Nuclear Physics, and for other Science programs. This project provides sufficient space for that needs and addresses other general scientific needs as well. This project will renovate currently unusable space and consolidate the Ion Beam Technology Program.

Building 71

The scope of the project includes removal of the SuperHILAC and its support systems, leveling of floor sections and modernization of the utilities. This project has an estimated cost of $4.0M.

Building 74 Rehabilitation

Building 74 was originally constructed as an animal holding facility. As animal studies have been replaced with laboratory techniques that reduce the need for animals, four alteration projects have been completed over the past 40 years. Today more than 75% of this building has been converted from animal holding to research laboratory functions.

While most of the space within Building 74 has been converted to uses other than those for which the building was designed, Building 74's mechanical, electrical, structural, and architectural infrastructure systems have not been correspondingly upgraded.

The proposed project will correct HVAC, electrical, and structural problems. The estimated cost of this GPP project is $4.9M.

Building 62 – Upgrade of Building Operating Systems.

At 56,314 gsf, Building 62 is one of Berkeley Lab's largest multipurpose laboratory facilities. Building 62 urgently needs a comprehensive upgrade of its infrastructure systems to support current and future research demand for wet chemistry laboratories and clean rooms, and to provide for the health and safety of building occupants.

Building 62

- This project will replace aged wooden fumehoods, install a new centralized exhaust system, and install a modern acid waste neutralization system.
- To obtain constant air temperature and pressure conditions in the laboratories and provide for clean room capability, the project will modify the building heating, ventilation, and air conditioning (HVAC) system and install variable air volume controls in the laboratories.
- The existing low-conductivity water (LCW) system will be expanded and upgraded to meet existing demand and furnish ample LCW for the new wet chemistry labs.
- The estimated cost of this project is $4.9M.

Existing Facilities – Environmental Remediation

Berkeley Lab is completing a site survey to comprehensively identify any contaminated areas. Working with DOE, Berkeley Lab will prepare and adopt a remediation plan in the near future.

Information Technologies Infrastructure

To meet expanding information technology needs, four programmatic line item projects are proposed (see Appendix A), an increase in funding for GPE projects is requested (see GPE section) and a significant laboratory operations budget initiative is proposed (see next section).

Networking Facilities Needs

The vision of network support for Berkeley Lab in the next ten years calls for substantially enhanced performance parameters and capabilities. Networking will move beyond "transport" to include a broad range of services. Increases in performance demand has been readily measured at 100% per year over the past several years, and over a ten-year extrapolation translates to a conservative growth factor of 1,000. Whereas LBNL is now deploying 100-Mbps to 1-Gbps switched infrastructure today, growth to equivalent performance levels of 100 Gbps to 1 Tbps over a ten-year timeframe can be anticipated. Additionally, it can be expected that the range of components and

systems that will be "network smart" will increase dramatically, resulting in the need to attach end-systems numbering in the hundreds of thousands to millions for a laboratory facility such as Berkeley Lab.

Beyond simple extrapolation of performance and connectivity, it can be expected that network services capability will be greatly expanded. The network will become the "research infrastructure backbone" interconnecting scientific resources and researchers on a global basis. Researchers will work in a "virtual laboratory:" their geographic location will be largely irrelevant. Research activities will include remote interactions involving massive distributed computing resources, experimental facilities, support services, and communications systems. The impact on laboratory infrastructure will be significant. Substantial wireless technology will be necessary to support the anticipated conversion to that technology and the anticipated significant growth in end-systems connected to LBLnet. High-end performance networks will remain "wired" and will probably require significant upgrade of fiber-optic facilities. The computers, storage, and network equipment required to implement this laboratory computing initiative is expected to cost in the neighborhood of $40M. Ongoing costs of $600K per year for network maintenance and improvements are anticipated.

Utilities

The utilities systems have been maintained and most are in reasonably good condition. However, weak points in a utility system must be addressed in order for the entire system to operate reliably. Two Line Item Projects are proposed to address utility reliability and performance issues. These are modest but critical projects.

Sitewide Water Distribution Upgrade, Phase 1

This project will correct serious performance deficiencies in the high-pressure water system to assure an ample water supply under normal operating conditions as well as during fire and earthquake emergencies. Cast iron pipe will be replaced, cathodic protection installed, and pressure reducing and isolation valves replaced. This project includes construction of a 200,000-gallon fire water storage tank on the eastern edge of Berkeley Lab. Under the *Wildland Fire Risk Management Plan*, the eastern edge of Berkeley Lab is maintained as a critical fuel-break protecting Berkeley Lab assets from the periodic and dangerous Diablo-wind-driven wildland fires that occur in the East Bay Hills. The service road to the tank site will be upgraded and fire hydrants installed so that mutual-aid fire suppression forces can safely fight any flame front approaching Berkeley Lab. The estimated cost is $8.3M.

Rehabilitation of Site Mechanical Utilities, Phase 2

Berkeley Lab's infrastructure piping systems for natural gas, low-conductivity water (LCW), compressed air, and storm drainage serve over 100 buildings and facilities, including two major user facilities and four national user facilities. Corrosive soil conditions have caused leaks and failures in underground sections of these piping systems, resulting in excessive maintenance costs and the potential for serious disruptions of mission-critical research and hazards to life safety.

By replacing some parts of these systems and installing cathodic protection for other parts, Rehabilitation of Site Mechanical Utilities, Phase 2 will economically prevent failures and arrest deterioration due to corrosion. This will extend system life and assure system performance and integrity during normal operations as well as during fire and earthquake emergencies. The estimated cost is $8.2M.

New Construction

General purpose facilities infrastructure is required to meet the needs of Berkeley Lab's scientific programs and to conduct operational and administrative support. This support includes the operations function; general engineering support; general computing support infrastructure; service needs for personnel, including environmental, health, and safety resources; property protection and emergency services; transportation services; cafeteria and conference services; and other infrastructure needs. The following buildings (and a summary of utility system needs) are important elements of the *Strategic Facilities Plan*.

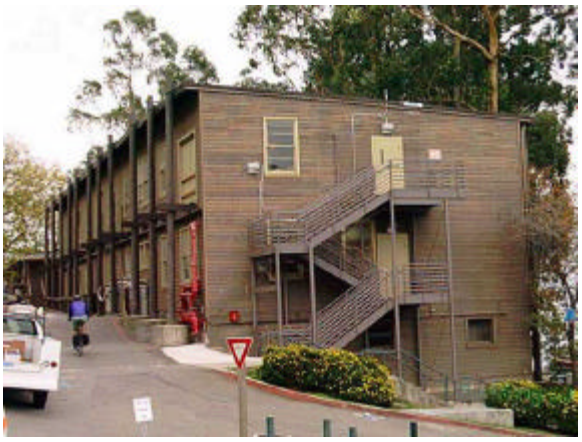
Operations Building

Upgrading and consolidating operations functions, which are primarily associated with the Facilities Department, will improve Berkeley Lab efficiency and conditions. An Operations Building is a high priority and is vital for the continuity of facilities services and to address the inefficiencies in the existing distribution of facilities services. The building will allow consolidation of existing services and replace aged temporary trailers. Important Berkeley Lab support functions to be located in the building include: facilities management, administration, planning, architecture and engineering, inspection, project management, management information systems, estimating, site services, and other support activities.

The Operations Building will save annual operating costs through productivity gains, functional efficiency, energy conservation, reduced onsite travel, and reduced maintenance costs. This building will result in a net gain of needed shop space through relocation of administrative functions from shop areas to more efficient office space. The facility will relieve crowded conditions, especially in shop areas. The Laboratory's emergency preparedness will also be improved by relocating the Facility Department's Emergency Operations Center from the shop area to the new building. In addition, the appropriate space and physical safeguards will be provided for record management and storage. The Operations Building will be located between Buildings 75 and 76. The 25,000 gsf facility has an estimated cost of $13M.

Administrative Services Building (Replace Building 29)

Building 29 and its four associated trailers (see Table I) contain 15,600 gsf of office and dry lab space. Building 29 was constructed in the 1940s and has been condemned and vacated. This building is not structurally sound and is subject to collapse. The four trailers are also in very poor



Building 29

Table I. Building 29 and Associated Structures—Conditions

Facility	Staff	Area (gsf)	Date Built	Mech. Systems	Electric. Systems	Struct. Systems
Building 29	—	10,600	1947	U	U	C
Building 29 Trailers	15	5,000	1978	U	U	C
Total	15	15,600				

U = Unsatisfactory for current research and support activities, substandard systems
A = Acceptable systems for current research and support activities, systems meet standards
C = Condemned, not suitable for occupancy

condition. An Administrative Services Building to replace these condemned structures will bring a variety of essential administrative support functions to a central area, where these services can be efficiently managed and easily accessed by all staff and guest researchers. This new building will house some of the current occupants of the Building 29 trailers and key Laboratory administrative functions that are now scattered across the site. These include the Laboratory's Education Center, the Technology Transfer and Patent Departments, and the library. This project will demolish the old structures and construct a 31,000 gsf building at this site. The estimated cost is $24M.

Engineering Support Facility

Engineering support requires additional space to address demands for assembly space. An effective solution is to construct a 19,000 gsf addition to Berkeley Lab's primary engineering support center. All research divisions use these engineering services. This addition will add dry laboratory, computer, and office space to Building 77A. The Building 77 complex contains the Laboratory's primary assembly and engineering research spaces. This addition will allow consolidation of all primary engineering functions at a single site, improving coordination, efficiency, and research support. The estimated cost is $14.5M.

Replace Building 25 (Seismic Stability)

Building 25 is actually an assembly of building additions surrounding a core building constructed during World War II. This 28,000 gsf dry lab and office building does not meet seismic safety standards and would not be usable after a significant earthquake. This building is located at the very center of Berkeley Lab and continues to be central to much of the research work performed at Berkeley Lab. This project will demolish the existing building and construct a new 25,000 gsf office and support services building at this site. This building will allow approximately half of the Operations personnel who are currently housed in off-site leased space to return to the main site. This building will improve overall service quality while also reducing lease costs. The estimated cost is $19M.

Environment, Health, and Safety (EH&S) Support Facility

A significant need is to consolidate most EH&S staff at a single location. These staff are currently located at a number of sites, including Buildings 90, 75, and 85, some of which are a mile distant from each other. This project will demolish a modest 3,500 gsf trailer, which makes inefficient use of a prime building site, and will construct a 21,000 gsf office building that will make good use of this site. The estimated cost is $15.5M.

Training Center and Auditorium

A multipurpose training facility is needed to address a pressing need to ensure that staff are fully able to safely, securely, and efficiently meet their work responsibilities. A 14,000 gsf facility will accommodate training programs, including employee orientation; environment, health, and safety training; division and department certification and training sessions; and DOE teleconference training sessions. The facility will also be an employee education (degree and certificate) center. This facility will incorporate a large assembly hall (auditorium) capable of accommodating 450 persons, two moderate-scale training rooms capable of accommodating 100 and 150 persons, and four "break-out" rooms each accommodating 20 to 30 persons. The estimated cost is $16M.

Site Support Service Facility

The Facilities Department requires a building to house, service, and outfit Facilities Department equipment, maintenance supplies, and associated staff. A common yard area will ensure that regular facilities functions can be safely performed and efficiently managed. Staff located in Buildings 76 and 31 will be consolidated at this site. The estimated cost is $9.5M.

Replace Building 73

Building 73 is a 4,200 gsf wood frame structure that was constructed in 1961 to shelter a specific instrument, and which has met its scientific

objectives. The mission required that this building be constructed using nonferrous material; therefore, this building will not have a traditional service life and is not readily adaptable for other uses. Building 73 is sited in a unique location that is accessible both from Berkeley Lab's roads and the public road system. Site planning and functional needs analysis indicate that a 19,000 gsf replacement building designed to serve Berkeley Lab's visitors and student population would make effective use of the site and address Laboratory research support needs. The facility will provide approximately 13,000 gsf of office and laboratory space and 6,000 gsf of seminar space and short-term housing for graduate students and post-docs. This facility will serve the current scientific mission and allow the Laboratory to build new and stronger relationships with the next generation of scientists. The estimated cost is $14M.

Resources Needs Summary

Multiprogram Energy Laboratory Facilities Support (MEL-FS)

Historically, MEL-FS funding at LBNL has been an average $3.8M per year. Over the period of FY96-FY01, the funding level has been only slightly above this average level, at $4.2M per year. The profile of funding has been irregular and broad, ranging from $9.3M in FY93 to $2.4M in FY96 to no new starts in FY94, FY95, FY97, and FY00. Figure 6 provides more detail.

While LBNL's funding trend has increased slightly in actual dollars, we have been alarmed by the overall trend of the size of this DOE program. The MEL-FS budget has been cut almost in half over the last 8 years. The MEL-FS program is the only available strategic capital renewal program in the Office of Science for non-programmatic infrastructure. Funding levels should be restored (corrected for inflation) in order to achieve the infrastructure renewal needed at the multiprogram labs.

General Plant Projects (GPP)

As illustrated in Figure 7, GPP funds have been relatively flat ($3.355M to $3.5M[1] in actual dollars) at LBNL since 1993. However, relative to 1993, in FY2001 the purchasing power of these funds will have dropped to about $2.6M due to inflation alone.

GPP funding is extremely valuable to the Laboratory. Typically, it is the only source of funds available to address short-term capital improvement needs. LBNL has turned to GPP to address ES&H and security needs, as well as key infrastructure needs such as additional labs and offices at our National User Facilities, and upgrades to support the study transgenic rats. There are presently 46 active GPP requests, totaling $26M, in LBNL's Project Call Database. At present funding levels, we will be able to begin work on a maximum of only four projects during FY01.

The relatively flat GPP funding for Berkeley Lab projects has created a serious backlog of infrastructure projects. These GPP infrastructure projects are required to protect the Laboratory's assets (fire alarm system rehabilitation, radio communications upgrade), provide much needed support for our National User Facilities (electrical power upgrade and new LCW cooling tower for the ALS), upgrade outdated and non-compliant systems (electrical transformers, emergency generators), install energy saving devices (VFDs and controls), and provide additional or appropriate quality space for research activities (relieve 50 and 90 complex overcrowding, cooling for the 90 complex, new clean rooms).

An increase in funding to $5.5M per year, for at least the next five years, would allow us to address the most critical needs over that time period. Without this increase, these projects would require 10+ years to complete and the schedule for

[1]The FY2000 GPP allocation of $3.5M is used in this comparison even though it was necessary to convert $530K to operating funds for the completion of the Oakland Scientific Facility.

completion of the *Strategic Facilities Plan* would be negatively impacted.

General Purpose Equipment (GPE)

GPE funding has also been historically flat at LBNL, ranging from $1.87M in FY93 to $1.95M[2] for the last several years. Figure 8 illustrates the actual allocations and purchasing power of those allocations adjusted for inflation only.
GPE requests each of the last three years have been approximately $8M per year for computer/networking equipment and another $7-8M per year for non-computer related items. Because many of LBNL's administrative functions were operating on obsolete systems that are no longer supported by vendors, computer-related purchases have received approximately 75% of the available funds each year. The limited funding has severely restricted our ability to implement a full range of modern multi-site conferencing facilities, and upgrade certain infrastructure items, including our hillwide radio network and general purpose maintenance and fabrication shops. There are 29 unfunded computer/network related projects, totaling $8.1M, and 39 unfunded general equipment requests, totaling $9.3M, in the Project Call Database. While some reuse of computer/networking equipment can occur, equipment required to complete the addition or modernization of the facilities covered in this plan, as well as that required to provide for substantially enhanced support in terms of performance parameters, is expected to cause a $750K (average) increase in GPE requests for the next five years and a continuing increase of $350K (average) per year thereafter. This increase will supplement existing funding for increased bandwidth (to 100 Gbps, or even 1 Tbps, in a "network smart" system), site-wide network infrastructure upgrades including new fiber and conduits, shared video-conferencing facilities, and digital libraries/services.

An increase to $3.5M in GPE funding would permit us to support this important information technology expansion/upgrade, allow us to respond to developing needs and address the $15M backlog.

Real Property Maintenance

As modernization efforts proceed to meet the current and future research needs at LBNL it is expected that maintenance and operations costs will also rise. Currently we have been doing a good job of maintaining the existing old facilities with the funding provided. However, as expectations rise, the frequency and severity of complaints are expected to increase as the mismatch between obsolete and modern facilities increases. Additionally, as more modern buildings are provided with more sophisticated mechanical and electrical systems, it is expected that the associated maintenance costs will rise. Maintenance costs are therefore expected to increase as projected due to either aging facilities during rising expectations or modernized facilities with more sophisticated services.

The latest projections indicate that the approximately $1.5M annually budgeted from operating funds may need to be increased to approximately $2.0M in order to complete priority planned-maintenance projects and keep potential backlog growth under control.

Demolition/Removal of Contaminated and Non-Contaminated Facilities

The Bevalac Accelerator complex has been closed for nearly a decade. This large facility needs to be demolished and the site used for productive scientific pursuits. The project is not an EM candidate, because the environmental risks are minimal; but this complex is a DOE legacy that requires near-term attention. A specific demolition project is proposed. This project will allow for proper management of all materials with induced radiation and for all possible recycling of materials.

While there are other aged buildings that also require demolition, these are typically small and

[2] The FY2000 GPE allocation of $1.95M is used in this comparison even though it was necessary to convert $800K to operating funds.

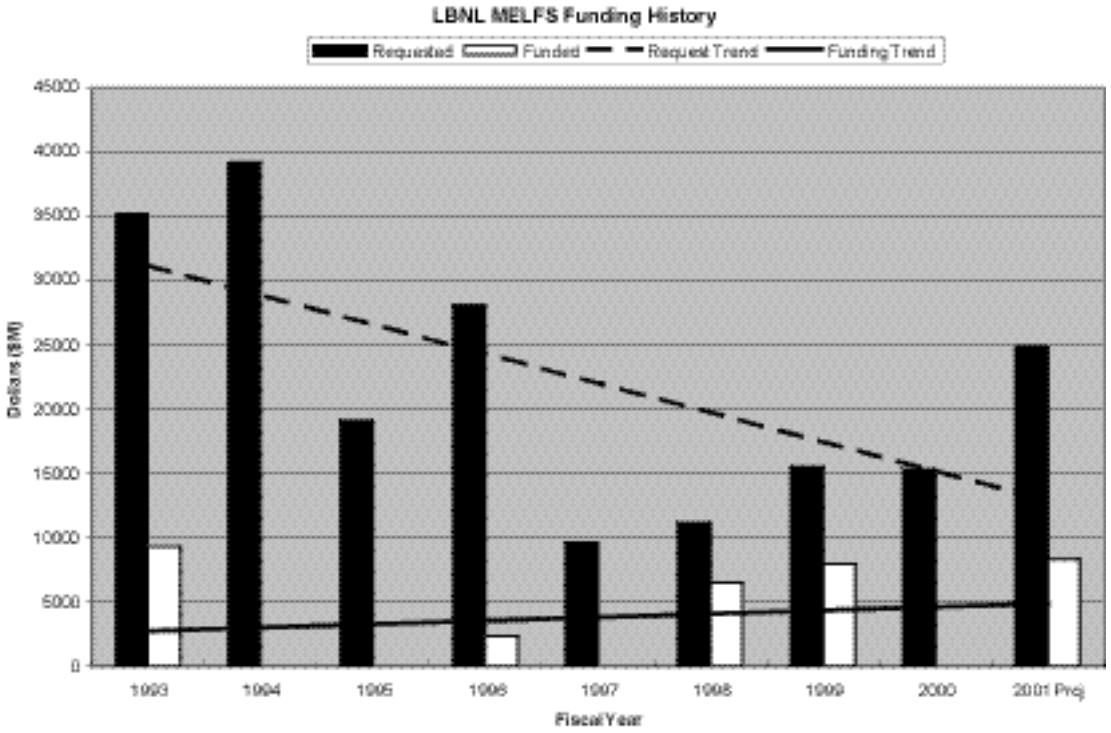


Figure 6

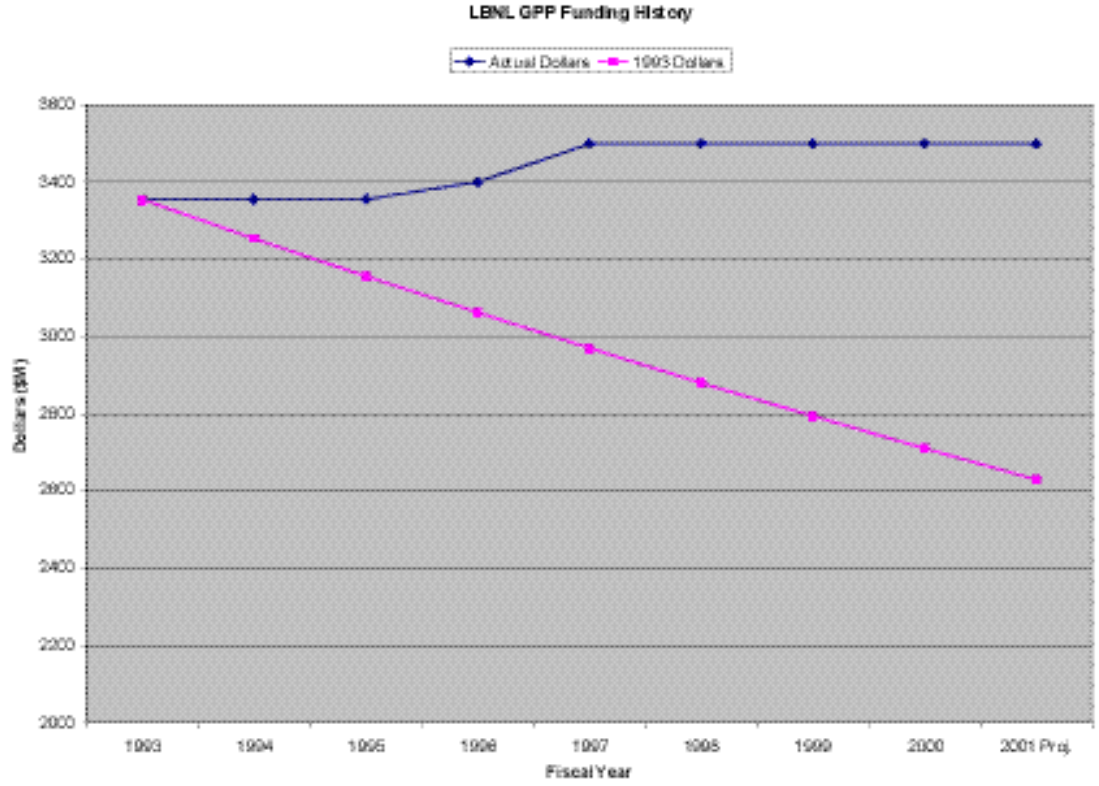


Figure 7

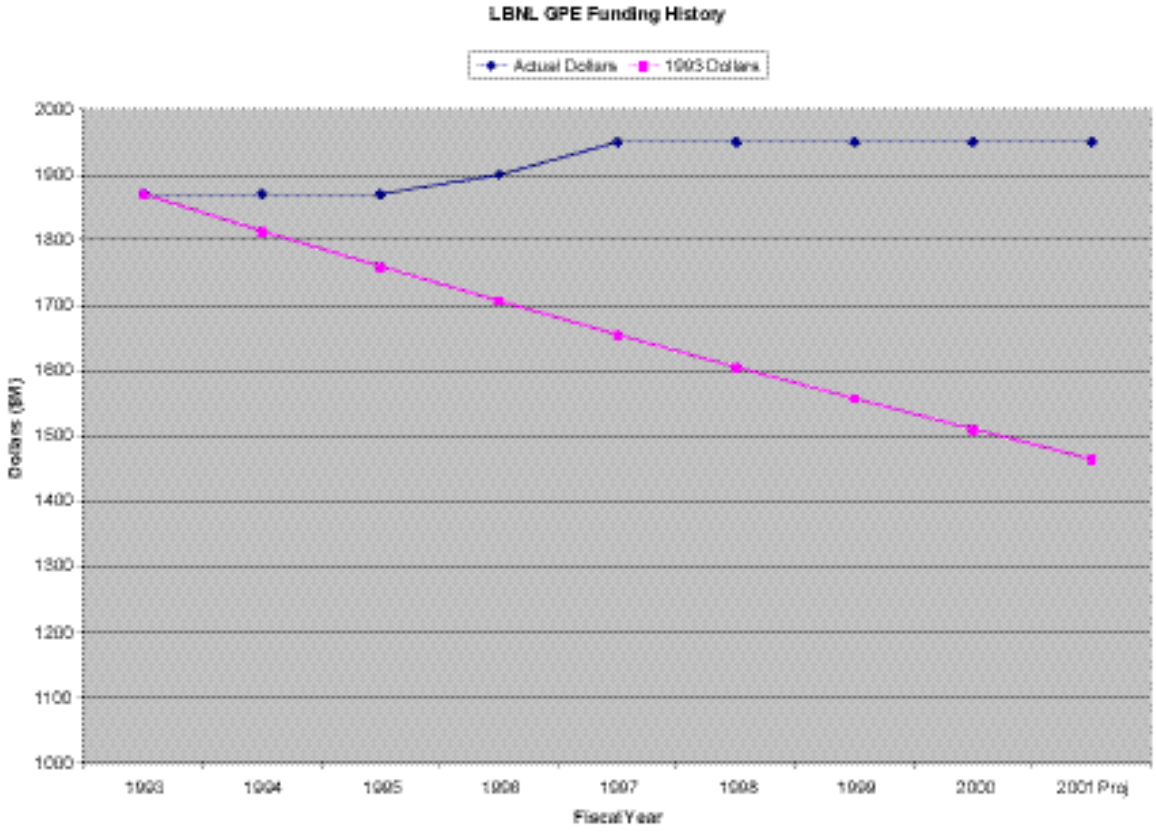


Figure 8

light frame structures that can be demolished as part of a new construction project.

Operating Funding

For budget purposes, the "non-cap" base level at LBNL has remained at approximately $2.9M for the past five years. Annually, $800K is reserved for emergencies, laboratory initiated relocations, and ES&H corrections, leaving $2.1M for requested projects. This provides very little opportunity to address the 137 requests, totaling $25M, that are currently unfunded in the Project Call Database. Among projects on the backlog are wildland fire management and seismic upgrades, both of which can be only partially funded each year; replacements of outdated electrical and mechanical systems that are outside of GPE scope; and numerous projects to improve the utilization or quality of our office and laboratory space, a significant problem due to the aging and overcrowding of our buildings.

Plan Development and Prioritization Process

Stewardship of physical assets addresses planning for facilities development and renewal, maintenance, and space utilization.

Outline of Planning Functions

The Laboratory has developed an integrated planning approach that ensures all appropriate elements of the Laboratory community are involved in the planning of facilities and infrastructure that are important to their present and future activities.

Senior-Level Policy Guidance

The Laboratory Director, Deputy Directors and Division Directors conduct an annual strategic planning meeting and follow-up planning sessions that establish and reaffirm organizational goals

and directions. These meetings also highlight critical institutional needs and issues.

Berkeley Lab's Senior Management also discusses critical issues and plans with DOE managers. These discussions include infrastructure needs and mechanisms to address them.

Staff Planning Activities

Berkeley Lab coordinates physical planning in three primary organizations:

- Laboratory Directorate Office of Planning and Communications coordinates research activities and the overall Institutional Plan.
- Facilities Department coordinates all infrastructure and support activities, including all investment in the physical plant.
- Computing Sciences Directorate coordinates information technology resources plans.

The Office of Planning and Communications, the Facilities Department and the Computing Sciences planning staff work cooperatively throughout the year to ensure that research requirements, initiatives and other operational requirements are appropriately supported with facilities and infrastructure. These ongoing activities include:

- Reviews and updates of the Institutional Plan, Strategic Buildings Plan, Comprehensive Facilities Plan, and other planning documents (e.g., ES&H Plan, Security Plans).
- Special studies in long range planning, master planning, and future land use planning
- Ongoing space planning and needs assessment
- Unified annual project call process that invites the entire Laboratory community to identify all infrastructure needs.

In 2000, the Facilities Department and the Office of Planning and Communications convened the Laboratory's senior management and the Division Directors in a series of long range planning, master planning, and future land use planning activities.

The purpose was to affirm Berkeley Lab's 10- to 20-year scientific direction and to quantify the facilities and infrastructure needed to accommodate future scientific and support needs.

Concurrently, staff undertook an assessment of the current infrastructure, and considered its ability to accommodate future needs. Building and utility condition, suitability, flexibility, and the general ability of all assets to meet the expectations of researchers at a "Laboratory of choice" were considered.

Staff also undertook a forward-looking assessment of the physical site. Staff conducted composite constraints analyses to determine physical site development opportunities. Factors considered included:

- Managed and unmanaged areas.
- Wildland fire risks.
- Geology.
- Slope stability.
- Faults.
- Development opportunities assessments of easements and utility corridors to determine potential building sites and capacities.
- Massing studies.

To ensure that general planning needs were also fully addressed the staff considered future utility corridors, parking and circulation, visual screening and the utility of current functional planning areas.

Development of the 2002–2012 Strategic *Facilities* Plan

Building upon the base of the studies already completed or underway, the planning staff was able to identify the priority research requirements. Each of these needs was reviewed to ensure that it meets specific mission requirements; environmental, safety and health requirements; and operational and maintenance objectives, and would contribute to the work environment in a manner that enhances worker productivity and experiences. Each was also reviewed to determine if suitable space is available or could be made available at the Laboratory. When renovation or new construction projects were required, each was evaluated against a risk prioritization matrix and assessed by the Project Planning Coordinating Group, a multidivisional task force that ranks projects for senior management consideration.

Environmental and Community Considerations

All plans and projects are assessed by the National Environmental Policy Act and California Environmental Quality Act review group for appropriate environmental documentation.

Facilities Department planning staff and Office of Planning and Communications planning staff participate in the Community Relations Advisory Group (CRAG), so that community issues can be considered and appropriate communications planned and implemented.

Performance Metrics and Change Indicators

Although qualitative measures can often best describe performance; such measures are difficult to benchmark. The following quantitative performance-based metrics are suggested to address the use and condition of Laboratory assets relative to the research requirements.

Deficiency Correction Index (DCI)

$$DCI = \frac{\text{sq. ft. of replaced facilities (inc. demolition)}}{\text{sq. ft. rated "replacement needed" in FIMS}}$$

This metric provides direct assessment and benchmarking of efforts to correct the most obsolete buildings. Replacement of these structures is a paramount concern as these structures are significant ES&H problems, are exceptionally difficult research environments, and have significant negative impacts on overall site utilization rates.

Facilities Condition Index (FCI)

$$FCI = \frac{\$\text{deferred maintenance}}{\$RPV}$$

This widely-used metric provides insight into the effectiveness of the maintenance program. This metric measures the relative cost of remedying maintenance deficiencies listed in the deferred maintenance backlog and conveys condition information.

Facilities Suitability Index (FSI)

$$FSI = \frac{\text{sq.ft of suitable space}}{\text{total sq.ft. of space}}$$

This metric provides insight into the management of space. It measures the percent of space that is suitable for its current use.

Appendix A – Programmatic Research Needs

Nanoscience Center: The Molecular Foundry

Berkeley Lab facilities must be planned and expanded to address the National Nanotechnology Initiative. Current facilities lack the quality and integration of adjacent complementing facilities to meet this need (see Table II). The Molecular Foundry Building will include state-of-the-art office and materials characterization and synthesis laboratories. It will support the National Nanotechnology Initiative and enable full and efficient use of LBNL's major user facilities—ALS, NCEM, and NERSC—for investigations of nanoscale materials and structures. Location of the building adjacent to the ALS is essential to maximize interactions between collaborative users and resident scientists and to fully exploit this world-class synchrotron radiation source for nanoscience.

The Molecular Foundry Building will be a new, terraced two-story to four-story building with a total gross area of approximately 90,000 square feet and net usable area of approximately 53,000 square feet. The building will provide 16,800 square feet of new wet and dry laboratories, and approximately 215 private and shared

Table II. Existing Inadequate Facilities Adjacent to the ALS and on the site of the Proposed Molecular Foundry

Building	Staff	Area (gsf)	Date Built	Mechanical Systems	Electrical Systems	Structural Systems
Building 7	60	21,000	1943	U	U	U
Building 40	0	1,000	1947	U	U	U
Building 5	20	7,000	1943	U	U	U
Building 4	20	7,000	1943	U	U	U
Building 16,16A	10	12,100	1943	U	U	U
Building 14	20	4,200	1944	U	U	U
Trailers 7A, 7C	3	500	1977	U	U	U
Building 41	3	1,000	1998	U	U	U
Total	136	53,800				

U = Unsatisfactory for current research and support activities, substandard systems
A = Acceptable systems for current research and support activities, systems meet current standards

Figure 9. Existing Conditions and Rendering of proposed Molecular Foundry

offices and conference rooms totaling 23,500 square feet.

The building will be a state-of-the-art facility for the synthesis, processing, fabrication and in-situ characterization of novel molecules and nanoscale materials. The laboratories and offices will support multidisciplinary nanosciences research in synthetic chemistry and polymers, nanotubes and nanocrystals, ceramics, femto-second spectroscopy and diffraction, magnetic materials, scanning electron/scanning auger microscopy, detector development, analytical and surface science instrumentation, x-ray imaging, and computational infrastructure. Laser labs and labs containing vacuum systems will be incorporated into the design. The building will also contain a high bay of approximately 6,000 square feet, for an experiment buildup and staging area for experiments to be conducted at the ALS.

Biosciences Research and Support Facilities Conditions

Berkeley Lab's bioscience research advances are revealing the sequence of the genomes of key species; the structures of dozens of proteins and their complexes; the importance of environment and genetics in cancer; and the relationship between structure and function in many biological processes. Functional imaging, the development of new instrumentation and simulation tools, and other techniques are providing a basis for creating a new level of understanding of biological systems from the molecular scale to the complete organism.

With the exception of the new Genome Sciences Building, much of the existing Life Sciences and Physical Biosciences Division space was constructed between the 1940s and the 1970s, and has reached the end of its service life (see Table III). The seismic performance and infrastructure problems of Building 1 (Donner Laboratory), Building 3 (Calvin Laboratory), and Building 83 (Cell Culture Building) have resulted in the need for plans to replace these facilities. The total area of these facilities occupied by Berkeley Lab personnel is 70,350 gsf. A biosciences research replacement building would provide the laboratories for the new program in biology and will replace the existing outmoded space.

Advanced Biosciences Research Building (Replacement)

The proposed 45,000 gsf Advanced Biosciences Research Building will provide for modern, efficient, and safe conduct of biological research programs at Berkeley Lab. The facility will include approximately 40 laboratories and 130 offices for the conduct of research in structural biology, functional genomics, and biomedical research. The arrangement of laboratories and offices will integrate research in macromolecular structure, biological dynamics, computational and theoretical biology, advanced microscopics, and cell biology. The flexible laboratory space will enable research to address the genetic basis of disease; cell, molecular, and radiation biology related to cancer etiology; and cell and tissue

Table III. Biosciences Research and Support Facilities Conditions

Building	Staff	Area (gsf)	Date Built	Mechanical Systems	Electrical Systems	Structural Systems
Building 1	201	41,000	1941	A	A	U
Building 3, 3A, 3B	117	17,500	1956	U	A	U
Building 83	35	7,000	1978	A	A	U
Trailer 83A	1	550	1965	U	U	U
Total	354	66,050				

U= Unsatisfactory for current research and support activities, substandard systems
A = Acceptable systems for current research and support activities, systems meet current standards

growth and differentiation. Laboratories will conduct research on the extracellular matrix, oncogenes and tumor suppressor genes, radiation and chemical carcinogenesis, and DNA repair. A preliminary estimate places the proposed project cost at ~$50 million.

Physics Research and Support Facilities Conditions

High energy and nuclear physics programs are at the heart of Berkeley Lab's core capabilities and are providing leadership for DOE scientific programs in several areas. Despite the importance of this program, few new investments in multi-purpose physics research facilities have taken place over the past several decades. Berkeley Lab must have adequate facilities to maintain its leadership at the frontiers of core high energy and nuclear physics, including accelerator systems and ion beams for many applications. Many of the facilities supporting physics research in beams and accelerators are WW II structures or trailers. In addition to the Bevatron, the buildings that need to be replaced, listed in Table IV, total 22,900 gsf.

Accelerator Research Support Building (Replacement)

A replacement office, fabrication, and testing facility is required to advance the understanding of the properties of matter through the coming generations of accelerator systems. This building will include the offices, equipment fabrication, assembly, and testing areas needed to support new accelerator system concepts and components. The facility will address new concepts such as optical accelerators, integrated design systems, novel ion source concepts, advanced power sources, innovative magnet systems, high vacuum systems, and other advanced components.

The proposed Accelerator Research Support Building will provide the necessary modern infrastructure to efficiently and successfully address mission needs while replacing facilities that are at the end of their service life. The buildings now used for accelerator research that were constructed during the Manhattan Project and the first decade of the Atomic Energy Commission do not meet current structural or electrical and mechanical systems standards.

Bevatron Decontamination and Demolition

The Bevatron comprises 164,100 gsf of Laboratory space, about 10 percent of the space on the main site. Since it ceased operation in 1992, the Bevatron has been largely abandoned by the Department of Energy, with no source of funds for its decontamination and demolition. A key element of the *Strategic Facilities Plan* is the demolition of the Bevatron facility so that the space can be used productively for mission-critical facilities that must be available to meet the needs of the 21st century. The cost of the project is dependent on the potential for recycling components of this facility and the extent of environmental cleanup that may be required. The buildings that need to be removed are listed in Table V.

Table IV. Physics Research and Support Facilities Conditions

Facility	Staff	Area (gsf)	Date Built	Mechan. Systems	Electric. Systems	Struct. Systems
71 trailers	34	6,200	1968–78	U	U	U
Building 53	9	7,000	1944	U	U	U
Building 27	1	3,300	1944	U	U	U
Building 52	2	6,400	1944	U	U	U
Total	46	22,900				

U = Unsatisfactory for current research and support activities, substandard systems
A = Acceptable systems for current research and support activities, systems meet current standards

Table V. Bevatron Complex Conditions

Facility	Staff	Area (gsf)	Date Built	Mech. Systems	Electric. Systems	Struct. Systems
Building 51	35	88,000	1950	U	U	U
Building 51A	–	24,900	1950	U	U	U
Building 51B	–	44,200	1962	U	U	U
51 trailers	2	7,000	1975	U	U	U
Total	37	164,100				

U = Unsatisfactory for current research and support activities, substandard systems
A = Acceptable systems for current research and support activities, systems meet standards

The long-term optimum plan for the Bevatron site, once cleared of the existing buildings, is a computing facility to house the National Energy Research Scientific Computing Center and other Berkeley Lab facilities. Working with the Department of Energy, Berkeley Lab's goal is the decontamination and demolition of the Bevatron by 2005 so that planning and construction of the computing facility can be completed by 2010 (see Computing Facilities Conditions following).

Supercon Facility Preparation

The superconducting magnet research program (Supercon) is located in a number of buildings spread across the site. In addition, the superconducting magnet research program's cabling facility is located in Building 52, which is scheduled for demolition for the Berkeley Molecular Foundry. Supercon's fabrication and testing facilities occupy space that will be required to house general Laboratory guest and user offices. This project, with a TEC of $1M, will prepare a facility for relocation of the cabling facility and consolidate the Supercon fabrication and testing program at a single location. The cost of actual relocation is not included in this project.

Astrophysics Research Facility Needs

Berkeley Lab is advancing astrophysics through a multidisciplinary program that is studying many fundamental parameters of matter and energy. These studies include supernova observations, cosmic microwave background radiation studies, neutrino physics, dark matter searches, high-energy nuclear astrophysics, theoretical astrophysics, and geoastrophysics. Some key instrumentation and detector technologies being developed that are a part of this work are high-resistively charge-coupled device (CCD) automated telescopes, a proposed supernova astrophysics satellite probe, the KamLAND neutrino detector, and the cubic kilometer neutrino detector.

The scientific impact of this area of research is revolutionizing the understanding of matter, energy, and the universe. Berkeley Lab is now poised to gain an understanding of the forces that created the big bang and the dark energy that is accelerating the expansion of the universe; and the underlying energy density, mass density, and geometry of the universe. The effective and efficient conduct of the program will require a new facility for astrophysics, primarily for offices but with laboratories and staging areas for instrumentation development. These staging areas should provide for instrument assembly under conditions appropriate to the high sensitivity and complexity of the detector systems required. The facility will include the offices, meeting areas, and control systems for the earth-based and satellite-based programs. The 40,000 gsf building will require space and communications utility systems for modern communications and conferencing requirements.

Computing Facilities Conditions

Berkeley Lab is advancing high-performance computing as a tool for scientific discovery. A key element of DOE's program at Berkeley Lab is the National Energy Research Scientific Computing Center (NERSC), an extremely powerful computing environment incorporating high-

performance computing capability, capacity, storage resources, and computational science and engineering. The Energy Sciences Network (ESnet) is the backbone of DOE's research network, providing access to the NERSC computing environment—and to other research, experimental, and computational facilities—for scientists across the nation and by international collaboration.

Existing facilities for computing operations, equipment and research are located in the Building 50 Complex and are crowded—as measured by existing DOE and Federal office occupancy standards. To meet the immediate needs for computing infrastructure, Berkeley Lab has leased the Oakland Scientific Facility, with a planned occupancy during March-April 2001.

Computational Sciences Research Facility Needs

To meet the multiprogram needs in computational sciences research and to relieve overcrowded conditions, a centralized computational and mathematical sciences research facility is planned that will enable the joint development of algorithms and protocols for solving complex problems of scale. These algorithms include systems of equations for physical, chemical, and biological processes, and for petabyte data analysis and visualization of complex systems and peta-scale experiments. The problems to be addressed include forthcoming peta-scale efforts at the frontiers of high energy and nuclear physics; problems of global environmental data analysis and modeling; problems of molecular design and materials simulation; and data problems and analysis for structural biology, genomics, microbial cell simulation, and plasma science. The 50,000 gsf office building has an estimated cost of $25M.

Over the next ten years, the computing and networking facilities at LBNL must grow to match the growing needs of at least two major experimental facilities, as well as the general needs of Berkeley Lab scientists.

Genomics Computing Facility Needs

Genome sequencing will soon be a regular user of advanced high performance computing facilities of the teraflop class. In 10 years, comparing genomes of various species and even of individual animals within species will require machines of the order of 100 teraflops. Current trends indicate that these machines will consist of large ensembles or clusters of commercially available symmetric multiprocessors. Those multiprocessors will evolve from ones currently used for midrange scientific computing and commercial web serving. A genome computing facility housing a 10-terabyte to 100-terabyte machine will require a machine room of about 40,000 square feet and room for a staff of from 30 to 100 to operate it. Such a facility would also probably be called upon to perform biological modeling of many kinds.

Advanced Light Source Computing Needs

The Advanced Light Source at LBNL is used for experiments that range from modern materials science to protein crystallography. It will require increasing computational support over the next decade, including:

- High speed networking that allows remote experimentation.
- Computational analysis and modeling for new classes of high-throughput experiments in molecular biology and materials.
- Data management capabilities that will grow to at least the petabyte class in 10 years.

The projected computing needs for the ALS, the Production Sequencing Facility, and other Berkeley Lab scientific programs will require a local computing facility with a total capability of a few teraflops and a petabyte of storage. These figures correspond to a modern supercomputing facility today. In ten years they will constitute a midrange laboratory computing facility. However, the physical facility required will have decreased by no more than a factor of two or four from today's requirements, even though the cost of the computers will have decreased by a larger factor. Thus it is to be expected that a building of 10,000 square feet will be necessary, along with local area networking in the vicinity of 10 gigabits/second.

Computing Infrastructure Building Needs

NERSC computing resources at Berkeley Lab are expected to experience increased programmatic demands as scientific disciplines

become highly predictive quantitative enterprises, that involve analyzing petabytes of data with teraflop (and eventually petaflop) processing capacity. Associated development of software and scientific services supported by NERSC will greatly strengthen scientific understanding and prediction in all areas supported by the Office of Science. The effort will require new computing facilities, offices, and electronic communication and networking systems.

The 27,000-gsf Oakland Scientific Facility should provide adequate floor capacity for high-performance computing equipment for the foreseeable future, perhaps through 2010. At that time, a 150,000 gsf facility for computing infrastructure is planned for operation at the main site. This NERSC facility should meet the significantly increased computational capability that will be required in the future. The estimated total cost is $100M (not including computers).

Fusion Energy Science Facility Conditions

DOE's fusion energy research at Berkeley Lab focuses on accelerator systems that support the nation's inertial-confinement energy science programs. This heavy-ion fusion accelerator research advances the physics of induction acceleration, applied to producing high-current, heavy-ion beams as drivers for inertial-confinement fusion systems. Critical areas of study now address beam quality (focusability) and cost—two primary issues for the design and construction of a multi-kilojoule accelerator. Through experiments in beam physics, beam-target interaction physics, fusion target physics, and physics of the reactor chamber, such an accelerator will provide the scientific and technical data for building a full-scale fusion driver. The potential Integrated Research Experiment accelerator test system is now being assessed for promotion to a CD-0 stage. This step is needed by the nation so that the feasibility of accelerators as drivers of inertial-confinement fusion may be understood. These experimental systems are a next step beyond the single-beam and multiple-beam transport experiments already completed at Berkeley Lab. The specific cost, scope, and location will be determined at the conceptual design stage. The work also includes studies of plasma heating by various methods, and support for networking and computing for fusion energy science.

Fusion High Bay Addition

The existing component testing, assembly, and research capability in the Building 58 area lacks adequate floor space, crane coverage, and high bay area to efficiently implement the current program. In order to more efficiently advance the current experimental program and to further examine the accelerator components for injection, focusing, and the behavior of space-charge-dominated beams undergoing current amplification, a $3M addition to the Building 58A high bay is proposed.

DOE Missions in Energy and the Environment

Berkeley Lab conducts essential research for the nation's programs in Energy Efficiency and Renewable Energy. This research comprises a set of related activities aimed at national goals to reduce carbon emissions, urban and regional air pollution, and cost to consumers, as well as to enhance energy security. These programs work toward the overall goal of providing energy-efficient systems that reduce greenhouse gases and dependence on foreign oil, and enhance the reliability of electrical systems. Key elements of the program are: Building technologies research on residential and commercial buildings, geothermal energy resources, and increasing the reliability of the utility grid. Advances from Berkeley Lab technologies now in the marketplace save the nation several billion dollars in annual energy costs.

Berkeley Lab conducts a multidisciplinary program of geoscience and geological engineering research important to the safe, long-term underground storage of high-level nuclear wastes. This research includes characterization of deep geological formations, determination of the physical and chemical processes occurring in the repository rocks, analysis of hydrologic and chemical transport mechanisms, and development of predictive techniques for repository performance. In parallel with ongoing basic research sponsored by the geosciences program in

the Office of Basic Energy Sciences and the Office of Health and Environmental Research, Berkeley Lab is contributing to technology and applied development research at DOE's Yucca Mountain Project, at DOE site restoration locations nationwide, and for DOE research on carbon sequestration.

Most of the existing offices for these programs are located in Building 90. Building 90 has inadequate HVAC systems. Some offices have crowded conditions, exceeding DOE and Federal occupancy standards. A key element of the Strategic Facilities Plan is the mechanical rehabilitation of Building 90 and the replacement of trailers in the area with adequate office buildings designed to current building standards. In addition, seismic safety modifications for nonstructural building elements will be made.

Earth and Environmental Sciences Facility

To address the global and national environmental challenges of the next decade, office and laboratory facilities are needed for advanced research in carbon sequestration, global change, radioactive waste management, and other vital areas. Laboratory facilities must also be available for new research in engineered remediation of metals and radionuclides through biological methods such as immobilization of contaminants *in situ*. Offices and laboratories are needed for geological engineering research in storage of high-level nuclear wastes. This research includes characterizing geologic formation and understanding the processes occurring in rock formations, such as hydrologic and chemical transport mechanisms.

Plans for the Earth and Environmental Sciences Facility include two components: first, a research office area; and second, a laboratory, field staging area, and office complex. The research offices will house programs closely coupled to computationally intensive research, including global climate modeling, carbon sequestration modeling, computational seismology, and the development of computational models for complex transport in heterogeneous media. These offices are located in close proximity to the proposed Computational Sciences Research Facility.

The second laboratory/office complex includes staging areas for field research, including staging for specialized large mobile instrumentation in seismology, geology, and geochemistry, and for ocean science carbon sequestration studies. This component of the facility is in closer proximity to the Advanced Light Source, where important earth and environmental sciences characterization studies are conducted. The combined area of the facility is approximately 80,000 gsf, with an estimated cost of $80M.

Green Building: Energy Technologies Laboratory and Testbed

Berkeley Lab's work for Energy Efficiency & Renewable Energy (EERE) is carried out in buildings that were funded by other parts of DOE and intended for other purposes than research on energy efficiency. While these facilities have proved satisfactory, the overall EERE effort would benefit from consolidation into a building specifically constructed for research on energy efficiency and incorporating energy efficient and renewable technologies developed at Berkeley Lab or elsewhere with EERE funding—in effect, a "showcase" for EERE.

The building will showcase a variety of new design practices and technologies that can be replicated widely throughout the DOE laboratory system. Applying new information technology such as interoperable software tools should allow design, procurement and construction to proceed more quickly, more efficiently and with fewer errors than with conventional techniques. State-of-the-art energy simulation tools will be used to develop and implement a building design that uses less than half of the purchased energy of conventional buildings, and will supply a large fraction of the remaining needed energy with renewable systems and distributed generation sources. The design will be tuned to take advantage of the local climate and will feature daylighting and natural ventilation strategies. Building materials will be selected using life cycle assessment tools to minimize adverse impacts of materials production and use. The building will be operated and controlled with self-diagnosing environmental control systems that optimize energy performance while enhancing the quality of the indoor environment for staff. An intelligent

communications infrastructure extending to all experimental and office spaces will support intralab and interlab scientific collaboration as well as partnerships with remote collaborators from the public and private sector. Advanced controls will facilitate intelligent management of building electric loads in a manner that allows full building operation with lower peak demand than any other laboratory buildings during summer power emergencies.

The integrated building research facility would include quality laboratory facilities, instrumentation, and building systems-simulation capabilities. These will enable the development of novel systems from conceptual studies to benchtop experiments, then through prototyping to small-scale evaluation and demonstration. The facility is needed in proximity to the core of the Environmental Energy Technologies Division, and could replace substandard trailers. This 40,000 gsf building has an estimated cost of $40M.

Appendix B – Resource Needs Spreadsheet

Appendix B - Resource Needs Spreadsheet

October 2000

Resource Needs for Achieving SC Vision for 21st Century Labs

Lab: Berkeley Lab (LBNL)

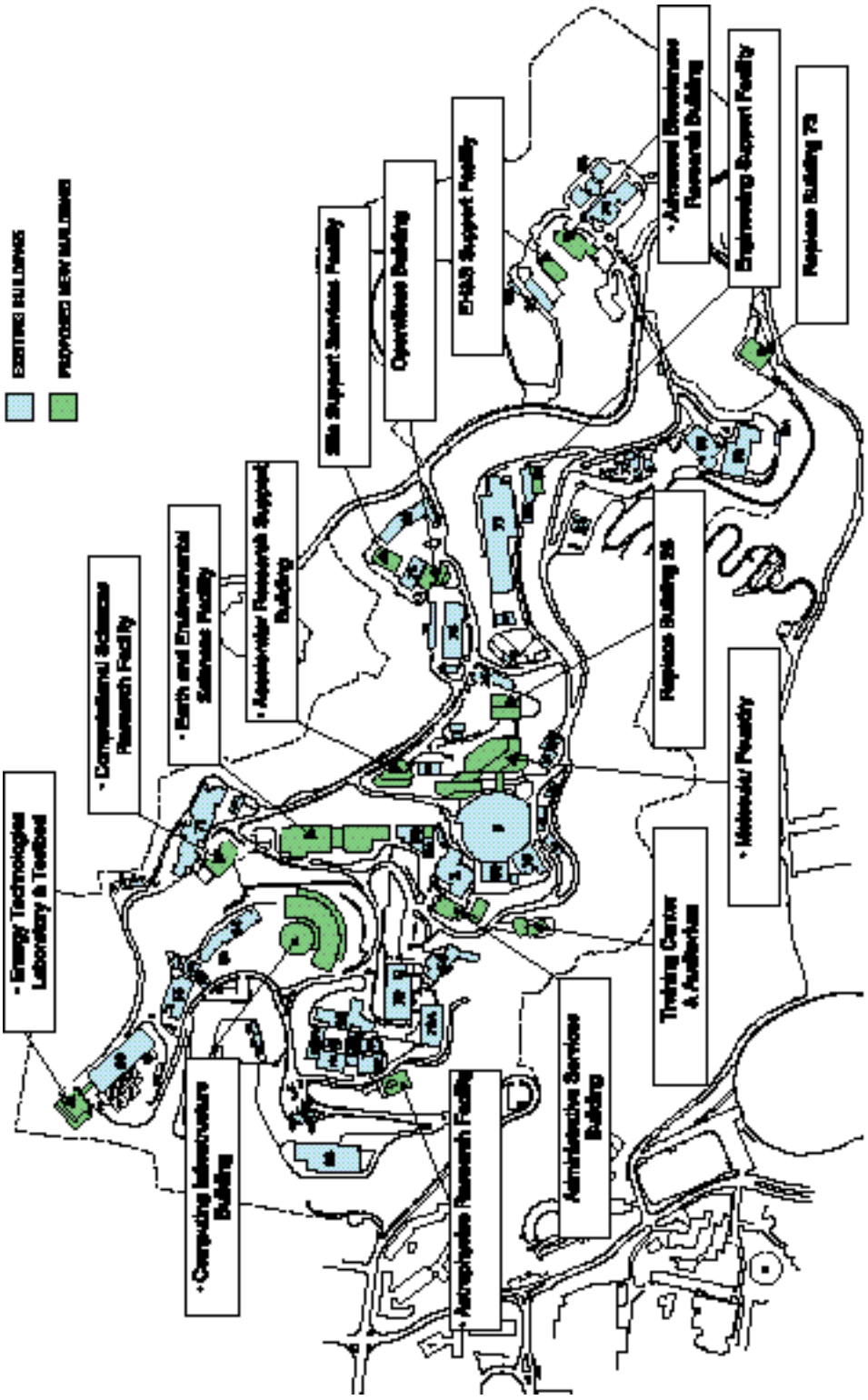
Project/Activity	Vision/Goal	TEC	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Projects Only: Simple Payback*	Projects Only: TEC $ (opt	Projects Only: Const $ (opt **
I. Select Operating Funding																
Operating Funds: Real Property Maintenance	E, M, O, W		11.7	10.7	11.2	11.5	11.9	12.2	12.6	13.0	13.4	13.8	14.1			
Percent of Replacement Plant Value (RPV) by Fiscal Year:			*1.2*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*			
Operating Funds: Needed for Removal of Retired Facilities, Prep. & Transfer to EM etc.: ***			0	0***	0	0	0	0	0	0	0	0	0			
Operating Funds: Networking Facilities Needs	M,W		0	0	40.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6			
Total Select Operating Funding: ***			11.7	10.7	51.2	12.1	12.5	12.8	13.2	13.6	14.0	14.4	14.7			
II. GPP, GPE, & GPF Funding																
GPP:																
Building 90 HVAC Upgrade	E, M, O, W	0.7	0.7													
Rehabilitation and Modernization of the Building 71 Complex	E, M, O, W	4.0	4.0													
Supercon Facility Preparation	M,W	1.0		1.0												
Improve Office Quality and Utilization in Building 50	M, O, W	4.0		4.0												
Fusion High Bay Addition	E, M, W	3.0			3.0											
Building 74 Rehabilitation	E, M, O, W	4.9				4.9										
Building 62 - Upgrade of Building Operating Systems	E, M, O, W	4.9					4.9									
Other GPP Priorities		varies	0.8	0.5	2.5	0.6	0.6	4.0	4.0	4.0	4.0	4.0	4.0			
Total GPP by Fiscal Year:			5.5	5.5	5.5	5.5	5.5	4.0	4.0	4.0	4.0	4.0	4.0			
GPE:																
Information Technology: Conferencing and Collaboration Equipment	M,W		0.3	0.2	0.3	0.2	0.3	0.1		0.1			0.1			
Information Technology: Digital Libraries and Information Management	M,W		0.2	0.2	0.2	0.1			0.1			0.1				
Information Technology: "Network Smart" Equipment Infrastructure	M, E,W		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3			
Other GPE Priorities			2.7	2.8	2.7	2.9	2.9	3.1	3.1	3.1	3.2	3.1	3.1			
Total GPE by Fiscal Year:			3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5			
LINE ITEM CONSTRUCTION:																
GPF (MEL-FS) Projects:																
Sitewide Water Distribution Upgrade, Phase 1 (FY 2001 start)	E, M, O	8.3													NA	
Operations Building	E, M, O, W	13.1	13.1											5.7	524	
Rehabilitation of Site Mechanical Utilities, Phase 2	E, M, O	9.2		9.2											NA	
Administrative Services Building	E, M, O, W	24.0		24.0											774	
Engineering Support Facility	E, M, W	14.5			14.5										763	
Replace Building 25 (Seismic Stability)	E, M, O, W	19.0				19.0									760	
Environmental, Health and Safety Support Facility	M, O, W	15.5					15.5								738	
Training Center and Auditorium	M,W	16.0						16.0							1,143	
Site Support Service Facility	E, M, O, W	9.5							9.5						790	
Replace Building 73	E, M, O, W	14.0								14.0					737	
Total GPF (MEL-FS) by Fiscal Year:			13.1	32.2	14.5	19.0	15.5	16.0	9.5	14.0	0.0	0.0	0.0			
Total GPP, GPE & GPF Line Item Funding:			22.1	41.2	23.5	28.0	24.5	23.5	17.0	21.5	7.5	7.5	7.5			
III. Program-Related Line Item Funding																
LINE ITEM CONSTRUCTION:																
Program-Related Projects:																
The Molecular Foundry	E, M, O, W	90.0	90.0												1,000	
Energy Technologies Laboratory and Testbed	E, M, W	40.0		40.0											1,000	
Bevatron Decontamination and Demolition	E, M, O, W	90.0		90.0											NA	
Advanced Biosciences Research Building	E, M, O, W	50.0			50.0										1,111	
Computational Sciences Research Facility	E, M, O, W	25.0				25.0									500	
Astrophysics Research Facility	E, M, W	40.0				40.0									1,000	
Earth & Environmental Sciences Facility	E, M, W	80.0					80.0								1,000	
Computing Infrastructure Building	E, M, O, W	100.0						100.0							667	
Accelerator Research Support Building	E, M, O, W	25.0						25.0							1,092	
Genomics Computing Facility	M, O, W	40.0								40.0					667	
Advanced Light Source Computing Facility	M, O, W	10.0									10.0				1,000	
Total Program-Related Line Item Funding:			90.0	130.0	50.0	65.0	80.0	125.0	0.0	40.0	10.0	0.0	0.0			

KEY to Vision/Goals :
E = Environmental Health & Safety
M = Mission
O = Maintenance & Operations
W = Working Environment

Footnotes:
* = Payback calculated for Operations Building. Others are being calculated. Based on experience we anticipate that all others will have simple paybacks in the 5 to 10 year range.
** = Const. $/gsf is being calculated.
*** = Note that the Bevatron D&D is considered under the Programmatic Line Item category in this analysis.

†0/13.00
†D

Appendix C — Proposed Major Construction Map – MEL-FS and Programmatic Line Item Projects



Map of major MEL-FS and Programmatic Line Item construction projects described in Berkeley Lab's *Strategic Facilities Plan*. Programmatic projects are designated with a dot (•) in the block. Three potential projects are omitted from this map as they are currently in review. These three projects are: a potential project to rehabilitate and upgrade the operating systems of Buildings 77 and 77A, the Gimmicks Computing Facility, and the Advanced Light Source Computing Facility. Note: The *Strategic Facilities Plan* references new experimental accelerator facilities and other major initiatives not shown above.