Executive Summary

Background and Purpose

The Department of Energy is one of the lead agencies with responsibility to help create and maintain the scientific and technological infrastructure that supports the nation's security and environmental integrity. Today it is one of the nation's largest sponsors of basic and applied research and development. In September 1997, the Department published the *U.S. Department of Energy Strategic Plan.* The plan was built on the four business lines—National Security, Energy Resources, Environmental Quality and Science. The Department has initiated a comprehensive effort to improve the planning and management of the large, complex research and development enterprise that supports the business line missions. This approach is based upon developing and managing business line research and development portfolios.

The Department's five volume R&D Portfolio provides, for the first time, a complete and comprehensive picture of the Department's research and development investment. The relative size and relationship of the four portfolios is illustrated in Figure ES-1. Historically research and development planning and management were conducted at the program or lower level. This approach resulted in overlaps, missed opportunities for collaboration and integration, and difficulty in identifying research gaps. The portfolio approach provides a comprehensive look at the entire research and development investment, in the context of the Department's missions and strategic objectives. This comprehensive picture provides the basis for analyzing, planning, and budgeting the research that will be needed in the future.

This volume is the first step in Environmental Quality (EQ) portfolio planning and management. It provides a baseline description of Fiscal Year 1999-2001 investments and combines selected R&D activities from four separate programs into an integrated portfolio. The portfolio is not organized by program, nor is it a comprehensive accounting of every program's activities. The portfolio does provide an accurate picture of the Department's investment in Environmental Quality R&D and is consistent with the President's budget.

Though it will identify some of the major issues and challenges of the future, this portfolio is not intended to be a planning document; it provides only a limited discussion of future investment plans. The longer-term view of the portfolio will be developed in the next phase of the process. A more complete discussion of the portfolio approach and management process is described in Volume I.

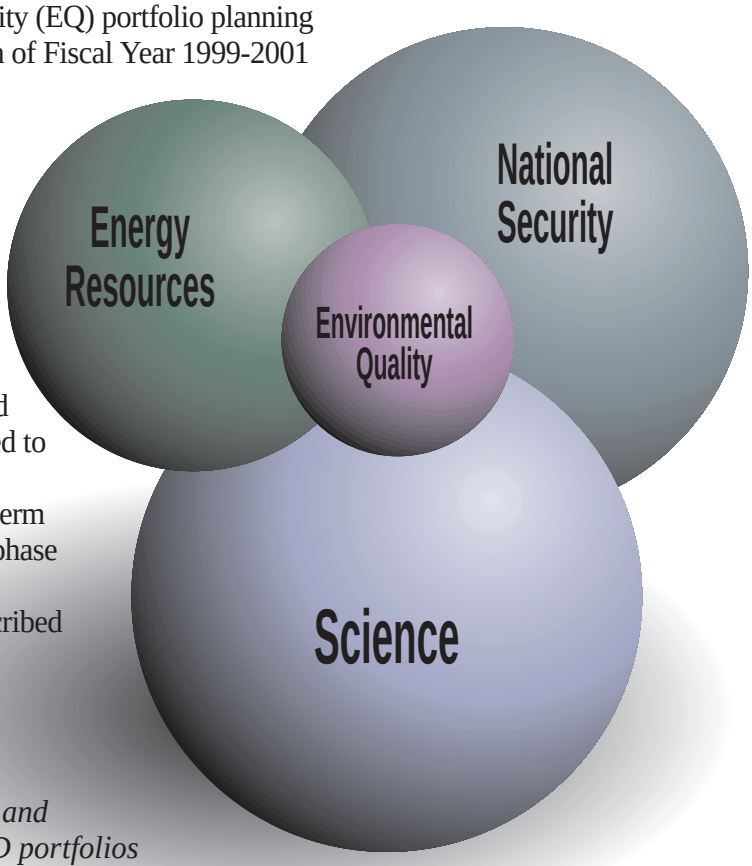
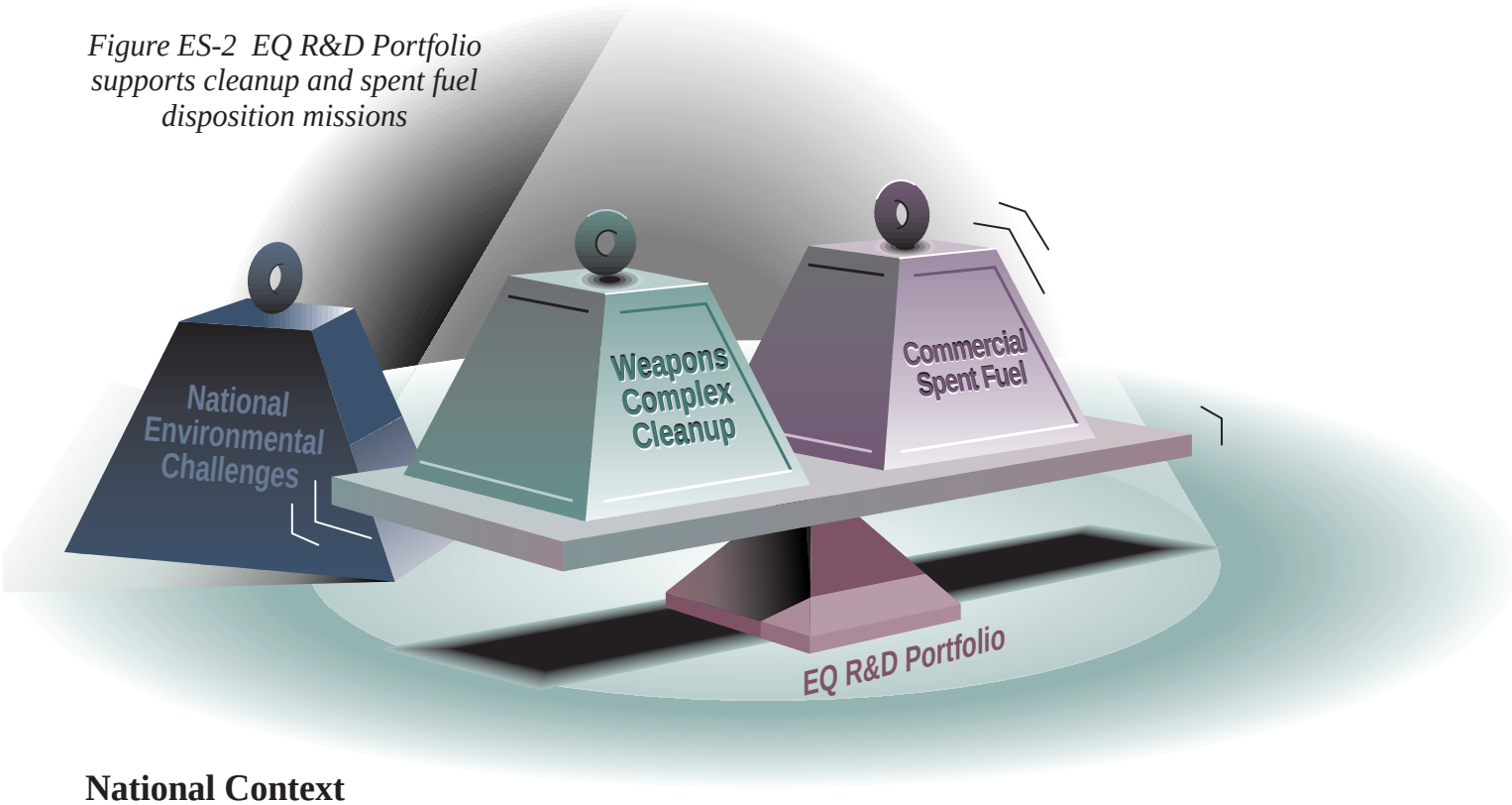


Figure ES-1 Relative size and relationship of the four DOE R&D portfolios

Figure ES-2 EQ R&D Portfolio supports cleanup and spent fuel disposition missions



National Context

The Environmental Quality business line encompasses three primary areas of responsibility:

- Reduce the environmental, safety and health risks and threats from the Department's facilities and materials.
- Safely and permanently dispose of civilian spent nuclear fuel and defense related radioactive waste.
- Provide the technologies and institutions to solve domestic and international environmental problems.

The current Environmental Quality portfolio is focused on supporting the first two areas, as depicted in Figure ES-2. The Science and Energy Resources R&D Portfolios partially support the third.

The principal program offices that support the Environmental Quality business line are Environmental Management, the Office of Civilian Radioactive Waste Management, the Office of Nuclear Energy, and the Office of Fissile Materials Disposition. The business line is also supported by the Office of Science through investments in basic and applied research.

Drivers

Cost, Technical Complexity, and Regulatory

The cost, duration, scope and complexity of the Department's environmental cleanup task were documented in *Accelerating Cleanup: Paths to Closure.* The cleanup program baseline encompasses over 350 cleanup projects with a life-cycle cost estimated at $168 billion (constant FY 1999 dollars). The life-cycle cleanup cost is based on providing solutions to:

- Three million cubic meters of buried radioactive and hazardous waste, 75 million cubic meters of contaminated soil, and 475 billion gallons of contaminated groundwater.
- 20,000 nuclear weapons production facilities contaminated with radioactive materials, hazardous chemicals, asbestos, and lead.
- Millions of gallons of high activity radioactive waste stored in large underground tanks; many of which have exceeded their design life, including some which have deteriorated, and leaked.
- 165,000 cubic meters of mixed waste located at facilities across the country.
- 150,000 metric tons heavy metal of reprocessed spent nuclear fuel currently in interim storage awaiting final disposition.
- An additional 80,000 metric tons heavy metal spent nuclear fuel is projected by 2035, requiring processing and disposition.
- Large quantities of fissile material residues and other processing intermediates in production lines or stored in a condition unsuitable to ensure long-term safety.

Many sites have entered into agreements with state regulatory agencies and the Federal Environmental Protection Agency. These agreements establish enforceable cleanup schedules and milestones and thus drive decision-making. The agreements are based on the numerous regulations associated with hazardous materials, radioactive material disposition, environmental protection, and pollution prevention.

Strategic Goal and Objectives

The *U.S. Department of Energy Strategic Plan* (September 1997) states that the Environmental Quality strategic goal is to "aggressively clean up the environmental legacy of nuclear weapons and civilian nuclear research and development programs, minimize future waste generation, safely manage nuclear materials, and permanently dispose of the Nation's radioactive waste." The seven objectives shown in Table ES-1, were established in the Strategic Plan to support this goal. These objectives describe *what* must be accomplished to achieve the Environmental Quality strategic goal, but do not prescribe *how* to perform the tasks. The functions necessary to fulfill the objectives have been identified and organized by waste type and activity to define the structure of the Environmental Quality R&D portfolio, depicted in Figure ES-3.

Table ES-1 Environmental Quality Strategic Objectives

1. Reduce the most serious risks
2. Cleanup as many sites as possible by 2006
3. Dispose of waste generated and make high-level wastes disposal ready
4. Prevent future pollution
5. Dispose of high-level radioactive waste and spent nuclear fuel
6. Reduce life-cycle costs of cleanup
7. Maximize the reuse of land and control risks

Portfolio Framework

The Environmental Quality R&D portfolio is best described by the functional relationship depicted in Figure ES-3. The portfolio is organized under three major portfolio elements: management of waste and materials; disposition of waste and materials; and, enhance future land use. Beneath the major portfolio elements are the seven major investment or problem areas. The bottom tier represents thirty six individual investments. These investments are discussed in detail in Chapters 3 through 9.

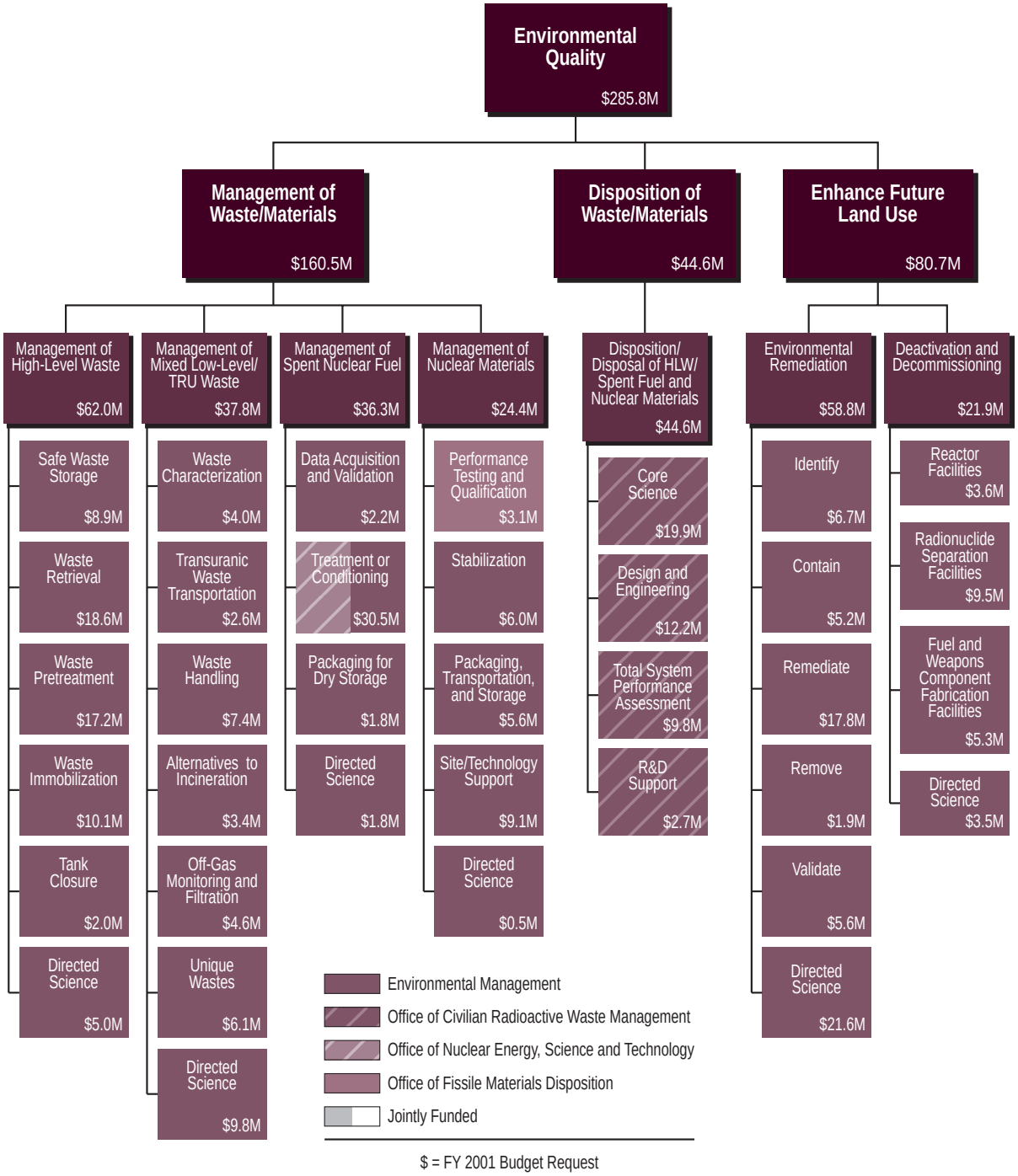


Figure ES-3 Environmental Quality R&D Portfolio

Portfolio Summary Trends

The overall Environmental Quality research and development funding decreased slightly in the FY 2001 request, and represents approximately four percent of the total business line. The major thrust remains investments in the high-risk, high-cost, and long-term problems associated with cleanup of the DOE complex and safe and permanent disposal of civilian spent nuclear fuel.

During FY 2001, efforts will focus on improving the balance of investments in the portfolio by transitioning basic research results into the applied research and development phase to address the Department's mid- and long-term cleanup needs.

Also, added emphasis will be placed in FY 2001 on developing long-term stewardship activities related to more reliable and cost-effective characterization and monitoring technologies and approaches. Long-term stewardship will ensure human health and the environment are protected after cleanup is completed, sites are closed, waste is emplaced for disposal, and/or facilities are stabilized for long periods awaiting possible further remediation.

The Environmental Systems Research and Analysis activities, conducted by the Idaho National Engineering and Environmental Laboratory, will continue focusing on research initiatives supporting subsurface science and long-term stewardship activities. Research activities will focus on better understanding of transport aspects of selective mass transport agents; chemistry of environmental surfaces; materials dynamics; characterization science; and computational simulation of chemical and mechanical systems. Emphasis will also continue on identifying opportunities for multi-site environmental management integration.

Regarding disposal, the Yucca Mountain Site Characterization Project is focused in FY 2001 on completing major R&D efforts to support a decision on whether to recommend the site to the President as the Nation's first repository for spent nuclear fuel and high-level radioactive waste in FY 2001.

DOE faces a number of overarching, multiple mission challenges for which the use of robotics and intelligent machines (RIM) can play a critical role. A roadmap that defines a path for RIM was developed in fiscal year 1999, and robotics activities are discussed throughout this portfolio as they apply to specific problem areas.

Portfolio Analysis

This portfolio provides the first opportunity to analyze the complete set of R&D investments supporting Environmental Quality activities. This analysis has identified five major findings, which are highlighted in the following overview of the analysis. The portfolio framework shown in Figure ES-3 correlates directly with the major problems facing the business line. **1.)** ***The portfolio is aligned with, and focused on, supporting complex-wide cleanup efforts and achieving the safe disposition of commercial spent nuclear fuel.*** This close-coupled relationship can be further illustrated by comparing R&D investments and projected life-cycle costs by problem area as shown in Figure ES-4.

[1]c. Report of the Task Force on Alternative Futures for the DOE National Laboratories; Robert Galvin, Chairman, 1995.

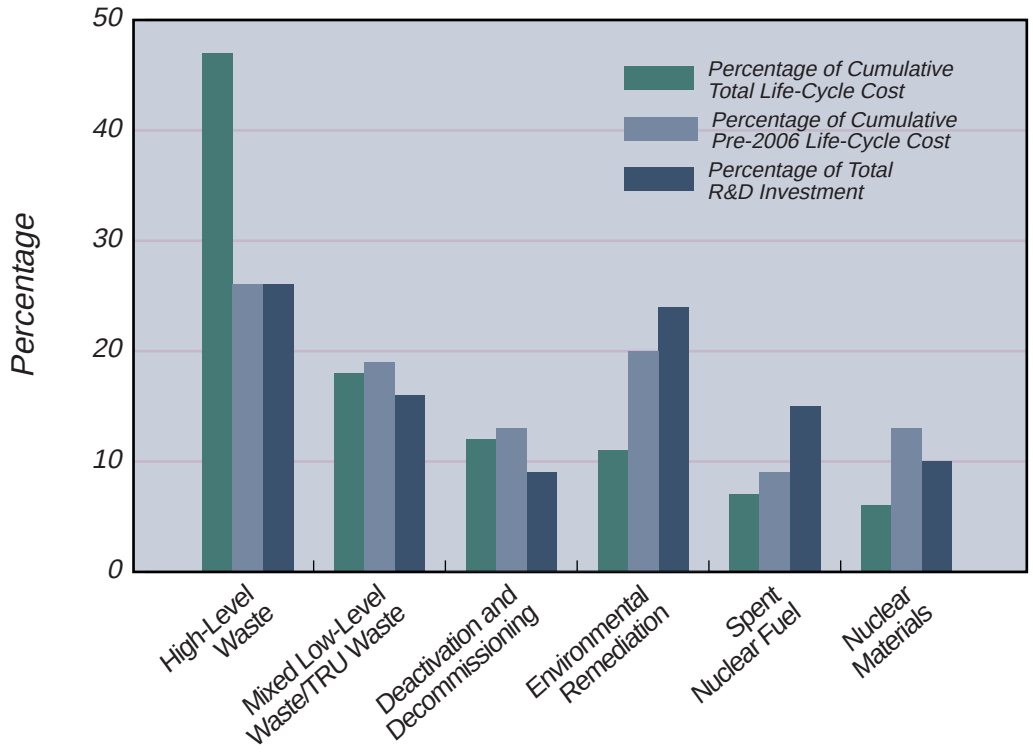


Figure ES-4 Life-cycle cost and annual R&D investment for weapons complex cleanup problem areas

2.) ***The portfolio recognizes the need for, and attempts to invest across, a full spectrum of activities ranging from basic research through technology deployment.*** The relative investment distribution across this spectrum is indicated by the blocks in each maturity stage in figure ES-5. High costs, the long-term nature of the cleanup, and the technical complexity require efforts to both reduce cost in the short term and invest for the future. Past Environmental Quality investments were focused on technology development and demonstration. The need for greater emphasis on basic science to help resolve long-term environmental issues was identified in the 1995 Galvin Report,[1] resulting in the appropriation of additional funds for this purpose by Congress in FY 1996. The Department also identified the need for increased technology deployment efforts to make sure developed technologies were more rapidly used. The current portfolio balance thus reflects the Department's renewed commitment to gain improved scientific understanding of its most difficult or intractable environmental problems, as well as to increase the deployment of new technologies needed to meet or accelerate schedules.

To invest across this spectrum requires a portfolio with participants that are diverse and distributed. The investment strategy also requires a portfolio that is leveraged. **3.)** ***The portfolio has been strengthened through the diversity of participants (universities, laboratories, site contractors, and industry), as illustrated in Figure ES-5, and the leveraging of activities with both internal and external participants.***

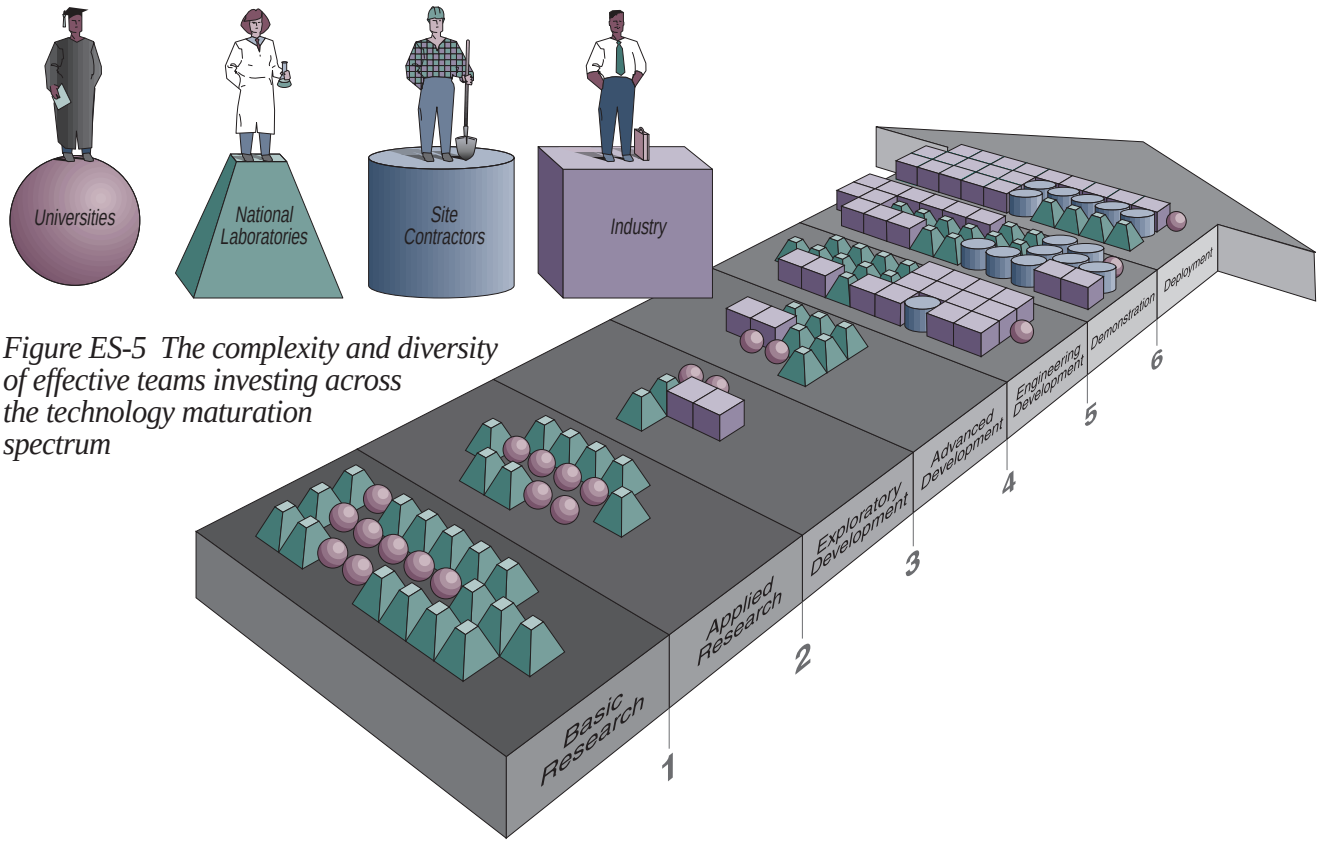


Figure ES-5 The complexity and diversity of effective teams investing across the technology maturation spectrum

The close coupled relationship, the broad spectrum of investments, and diverse participants are needed to meet the Department's environmental quality goal and objectives. **4.)** ***However, the overall Environmental Quality portfolio may be under invested to sustain achievement of existing mission objectives beyond the near term, i.e. beyond 2006***. The impacts of the under investment are currently being offset by directing funding toward basic research (relative to ongoing remediation) and the deployment of new technologies to support pre-2006 cleanup goals and commitments. Although this investment strategy should be successful in the near term, it is unlikely that this investment strategy can successfully support projected post-2006 cleanup costs and schedules.

5.) The Department should continue the portfolio planning process in order to improve the alignment of the four portfolios and make investment decisions that ensure the Department can help meet the nation's greatest challenges. The portfolio planning process has already enabled better integration within the individual portfolios. However, because there are significant interfaces and crosscutting elements, each of the business lines will contain some research activities that are relevant to other portfolios. The portfolio management process would benefit from improved coordination and a more integrated approach to these inter-portfolio activities.

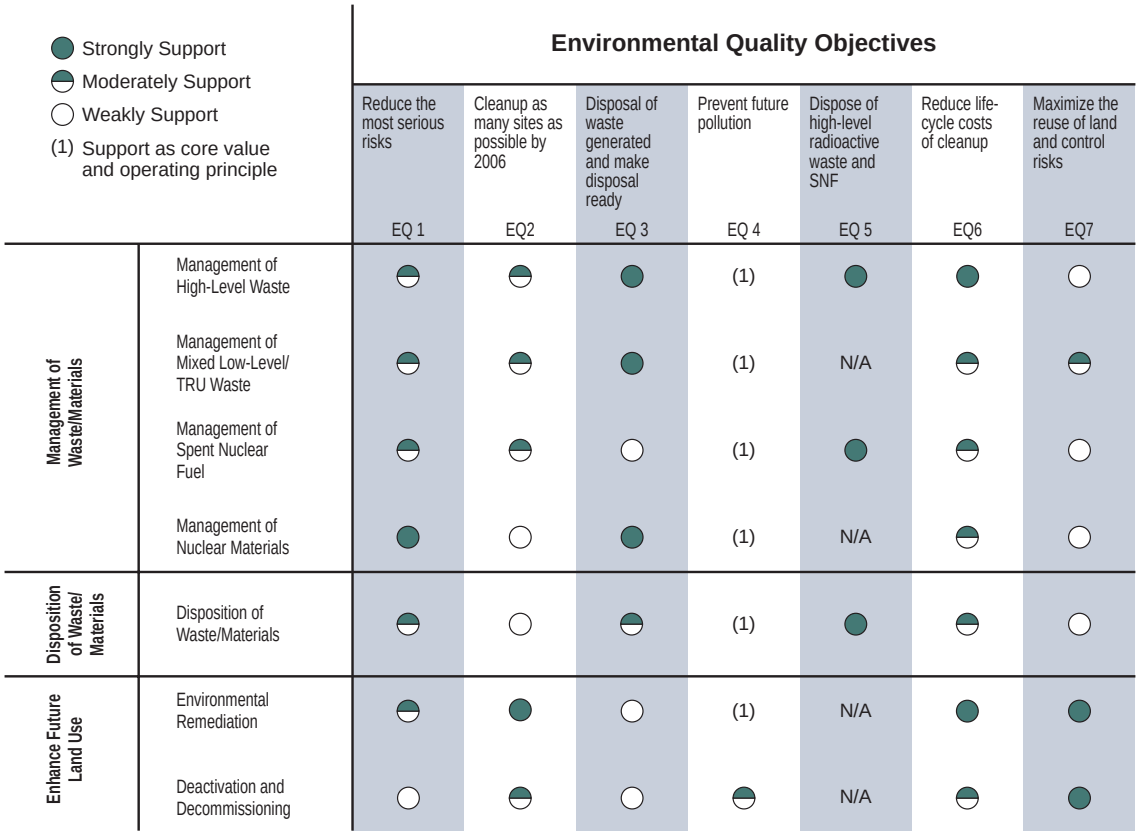


Figure ES-6 Relationship of and support by portfolio elements to strategic objectives

In addition to the major findings, the analysis also identified the relationship and level of support that each investment area of the portfolio framework provides relative to the current Environmental Quality business line strategic objectives, illustrated in Figure ES-6.

External Factors and Uncertainties

There are a number of external factors and uncertainties that impact the Environmental Quality R&D portfolio:

- The final end-states for the cleanup effort are not fully defined. Decisions regarding the disposal or disposition of some waste types and materials have not been made.
- Federal Facility Compliance Agreements drive cleanup decisions and can inhibit or even prevent the development and maturation of better or improved alternative technologies.
- The inherent nature of the cleanup effort and the proximity of some sites to the general population necessitate stakeholder participation in cleanup decisions and technology use.
- Contract reform efforts, such as shifting to management and integration contractors and privatization, impact the portfolio's investment strategy and tactics.

Federal Role

To succeed, the Department must invest in those areas of high technical risk or limited potential for private investment. While the portfolio is leveraged with private sector investment, in the long run federal funds are needed to improve problem definition, provide a core investment base, and demonstrate the technical feasibility of innovative solutions. These investments ultimately reduce financial risk and attract greater private sector participation in cleanup activities. In addition to funding the portfolio, there are a number of aspects, some unique to the Department's role in Environmental Quality, that are worth discussion. These roles are identified in Table ES-2.

Table ES-2 Federal Role in the Environmental Quality Business Line and R&D Portfolio

The Department of Energy:

- Owns the problem
- Is a Major source for R&D funding
- Is a Primary participant in the R&D portfolio (through national laboratories and site contractors)
- Owns unique facilities for conducting R&D (e.g., hot cells and canyons)
- Coordinates federal investments in Environmental Quality R&D
- Provides global leadership to environmental quality efforts
- Is a Signatory of compliance regulations and agreements
- Is a market driver due to large percentage of the total environmental cleanup market

Key Accomplishments

A number of technologies from the Environmental Quality R&D portfolio have been developed and applied to solve environmental problems and to prepare for disposition of waste and materials in a geological repository. In many cases, ongoing research and development efforts continue to enhance the effectiveness or the scope of application of these technologies. Highlights of some of these technologies are provided below.

- Instrument improvements—portable detectors and nondestructive and nonintrusive examination techniques for stored waste and materials, contaminated surfaces, and soils; chemical sniffers and non-intrusive spatial metal detector arrays.

- New robots and tele-operated vehicles to characterize and retrieve waste in high radiation, chemically hazardous, and potentially explosive environments.

- Advanced chemical separations technologies for the removal of selected metals and radionuclides have already reduced life-cycle cleanup costs by over $6 billion.

- Improved technologies for stabilization of waste and materials: macroencapsulation, microencapsulation, calcination, and ceramification. Two vitrification facilities are safely operating.

- A geologic repository for the disposal of transuranic waste is in operation. A viability assessment for the disposal of spent fuel and high-level waste has been completed.

- R&D achievements also supported the successful remediation of over 50 contaminated sites through use of innovative technologies such as chemical washing, in situ bioremediation, vapor extraction, and the treatment of nonaqueous phase liquids.