Ron Bhada is currently Associate Dean of Engineering and director of the Waste-management Education and Research Consortium (WERC). WERC is a consortium of three universities, a minority college, Sandia National Laboratories and Los Alamos National Laboratory established to increase the nation's resources that can address issues related to environmental management. Ron joined NMSU in 1988 and served as department head and professor of chemical engineering until 1992 when he was promoted to associate dean. Prior to joining the NMSU faculty, Ron worked for 29 years at a major energy system company involved in environmental management.

THE WASTE-MANAGEMENT EDUCATION AND RESEARCH CONSORTIUM

Ron Bhada
Waste-management and Research Consortium
New Mexico State University
Box 30001 - Dept. 3805
Las Cruces, NM 88003

INTRODUCTION

Efficient and safe management of nuclear, hazardous and solid waste is a critical multidisciplinary issue that requires an integrated collaborative effort among multiple organizations with diverse expertise and experience. In 1990, the Department of Energy (DOE) approved a cooperative agreement for the Waste-management Education and Research Consortium (WERC), a five-year model program. The consortium includes members from New Mexico State University (NMSU), University of New Mexico, New Mexico Institute of Mining and Technology, Navajo Community College, Los Alamos National Laboratory, and Sandia National Laboratories. WERC's operational organization is presented in Figure 1.

The model program was assigned the mission of demonstrating that a university and national laboratory partnership can effectively expand the nation's capability to address the issues related to management of all types of waste via education and technology development. The program provides a national resource of education and research related to waste-management: it develops and transfers new technologies, increases human expertise and sensitivity to waste-related issues, trains future experts in environmental disciplines, creates advanced technologies and promotes their application, and encourages universities, national laboratories and private industry to work together to solve some of our nation's waste problems.

The formative years have demonstrated conclusively that the partnership of universities, national laboratories and industry developed by WERC is an effective tool for education, technology development and technology transfer, with the education process playing a critical role in technology transfer. A 1992 study by Oak Ridge Assoc. Univ./Pacific Northwest Laboratory indi-

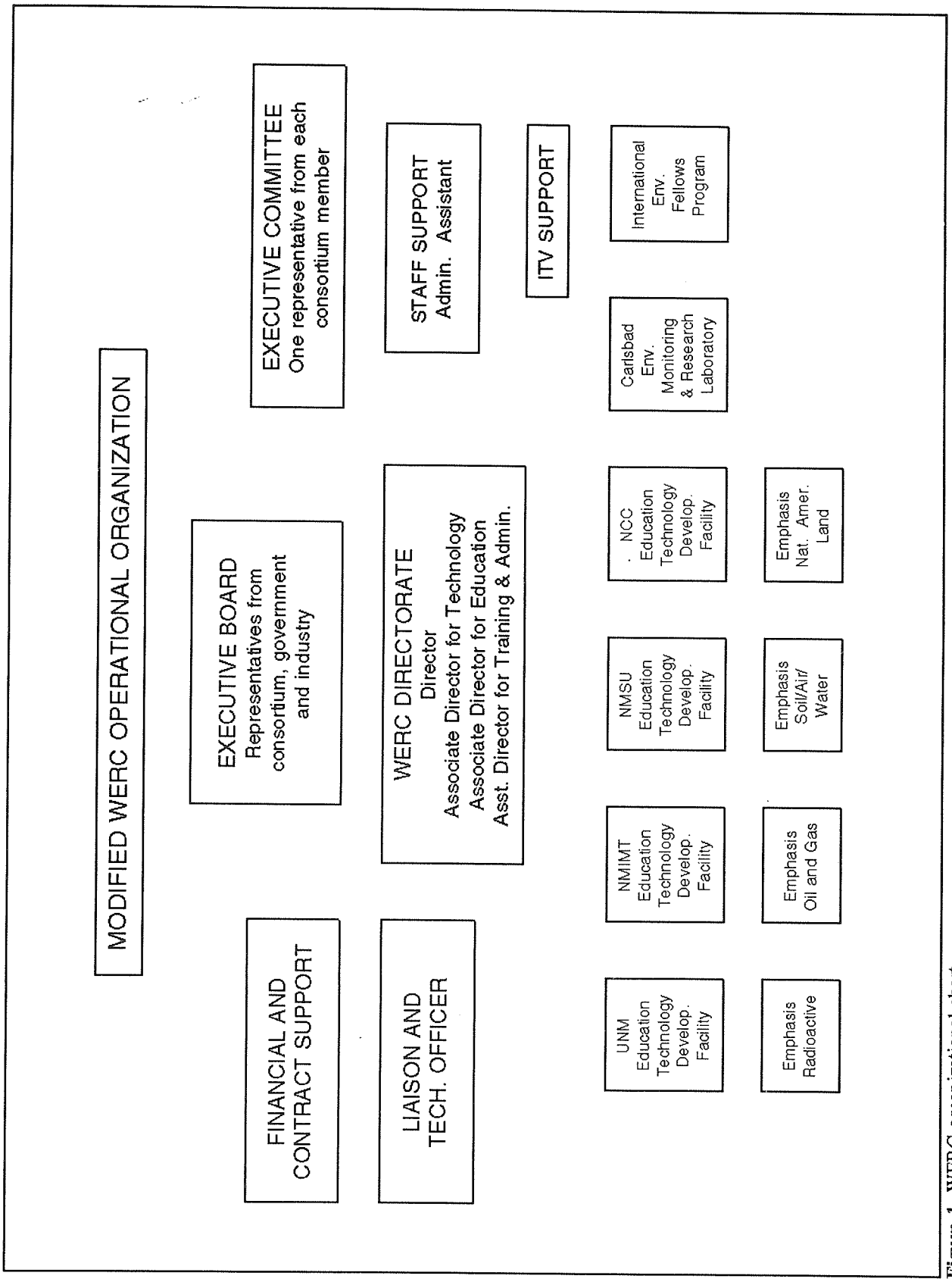

Figure 1. WERC organizational chart.

cated that there will be a 45% increase in manpower needs from 1993-1997, with a corresponding budget increase of 49%-87%. Training and education needs are at a critical level for environmentally trained engineers, project managers, technicians, hydrogeologists, environmental scientists, and risk assessment managers. There also is a critical need for students to participate in internships providing them with practical experience in their field.

The WERC program is available to over 30,000 students in academic institutions with a minority population of 25%-95%. The very high minority population of New Mexico and of the academic institutions of WERC makes the continuation of WERC a national priority.

Education

In its first years, WERC has successfully developed the infrastructure and the activities for education and retraining which are proving to be significant factors for technology transfer. Significant accomplishments have included:

- Providing undergraduate and graduate options and degrees in environmental engineering and management to over 500 students annually.
- Developing associate degree programs at Carlsbad and at the Navajo Community College especially aimed at retraining technicians working at DOE and industry sites.
- Producing an intensive state-of-the-art video conference series for retraining and technology transfer to over 8,000 professionals at national laboratories, industry, and federal agencies.
- Developing capstone courses on environmental process design with technology being transferred among universities internationally.
- Initiating educational programs aimed at making pre-college students aware of the most up-to-date technology.
- Starting an Environmental Fellows Program to provide graduate-level technology information to emerging leaders from government and industry.
- Launching a two-year Solid Waste Management degree program specifically for Native American students.

These initiatives have been critical to the technology-transfer effort, including direct state-of-the-art technology transfer as over 100 WERC graduates have entered the work force annually (Figure 2).

STUDENT PLACEMENT SUMMARY

Placement	Percent
DOE & DOE Facilities	40
Other Government Facilities	20
Industry	22
Graduate School	8
Total	**100**

Figure 2. Student placement chart.

More than 2,000 students and professionals are enrolled in WERC educational programs with over 300 students receiving scholarships (Figure 3). Figure 4 depicts student growth over the past three years, while Figure 5 shows that 464 New Mexico residents enrolled in the WERC program. Students come from cities and towns throughout the state. Undergraduate, graduate, and associate degree programs are offered through the program. An International Fellows program provides opportunities for foreign students.

The teleconference system reaches locales throughout New Mexico and the Americas. A satellite/fiber optic TV system has been established throughout New Mexico and the ITV courses are received by over 500 students at sites shown in Figure 6. The Teleconference Series presents state-of-the-art updates on environmental issues monthly and the series has participation from about 85 organizations in the U.S. as shown in Figure 7.

Technology Development

The university/national laboratory/industry partnership has resulted in unique solutions to technology issues. Within the three-year period from the program's commencement, some pro-

SCHOLARSHIPS AND ASSISTANTSHIPS

Type	Estimated Women and Minorities	Total
Undergraduate Scholarships	34	70
Native American Scholarships	110	110
Work Study Scholarships	10	30
Tech. Development Assistantships	30	75
Fellowships	15	30
High School Scholarships	5	6
Internships	12	20
Total	**216**	**341**

Figure 3. WERC scholarships and assistantships.

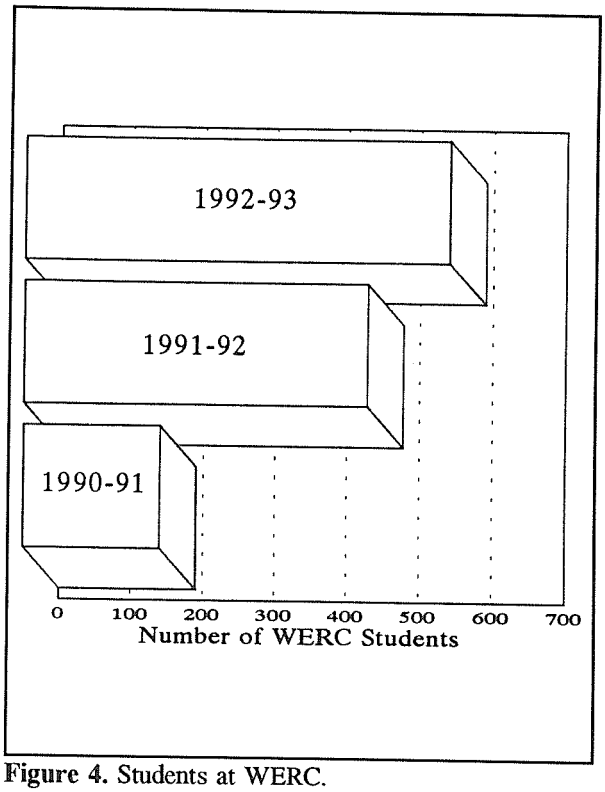

Figure 4. Students at WERC.

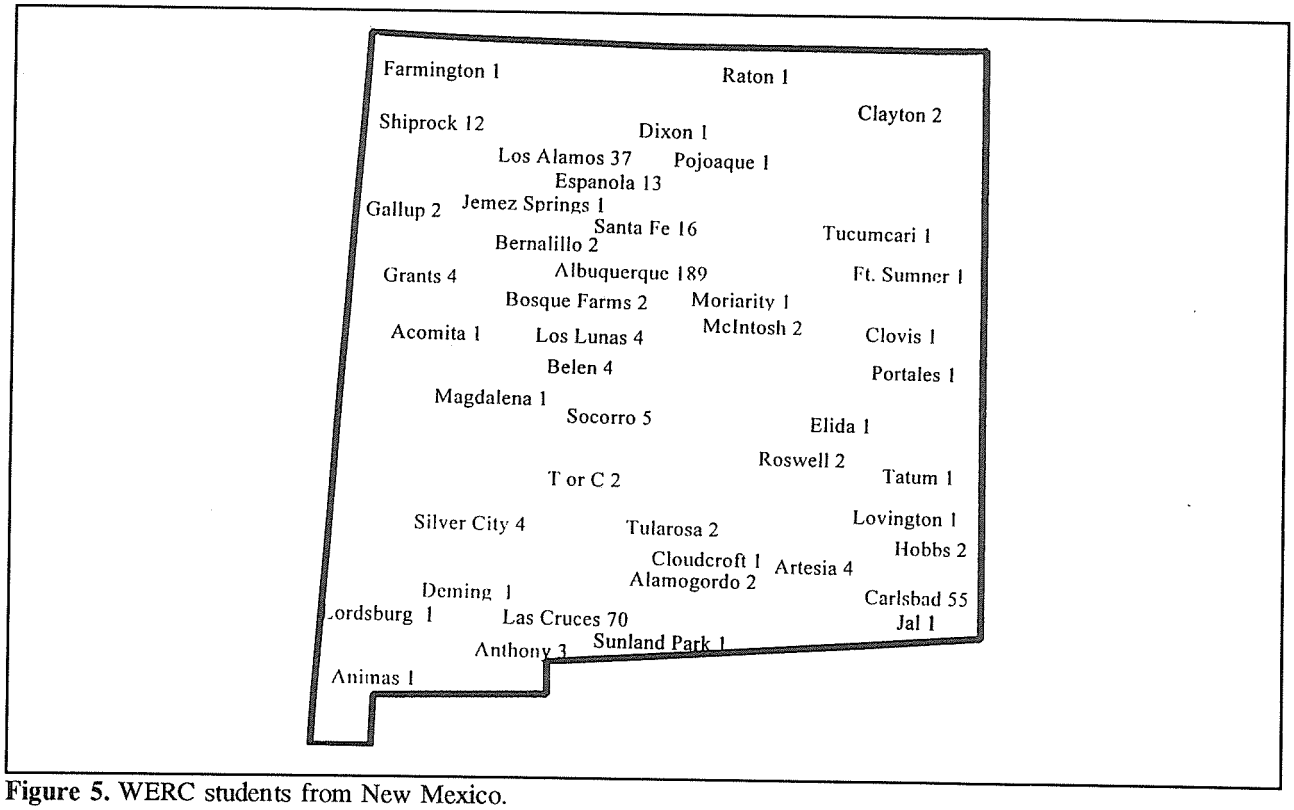

Figure 5. WERC students from New Mexico.

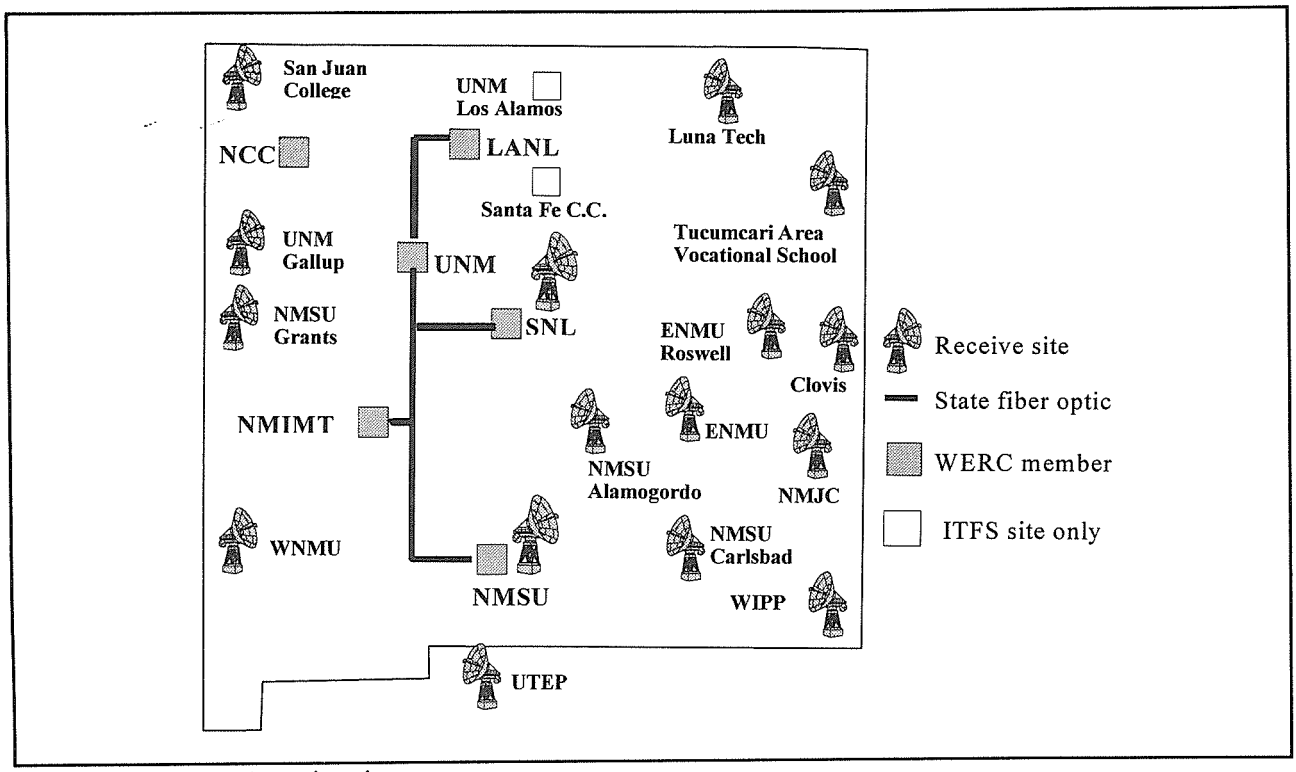

Figure 6. WERC-ITV receive sites.

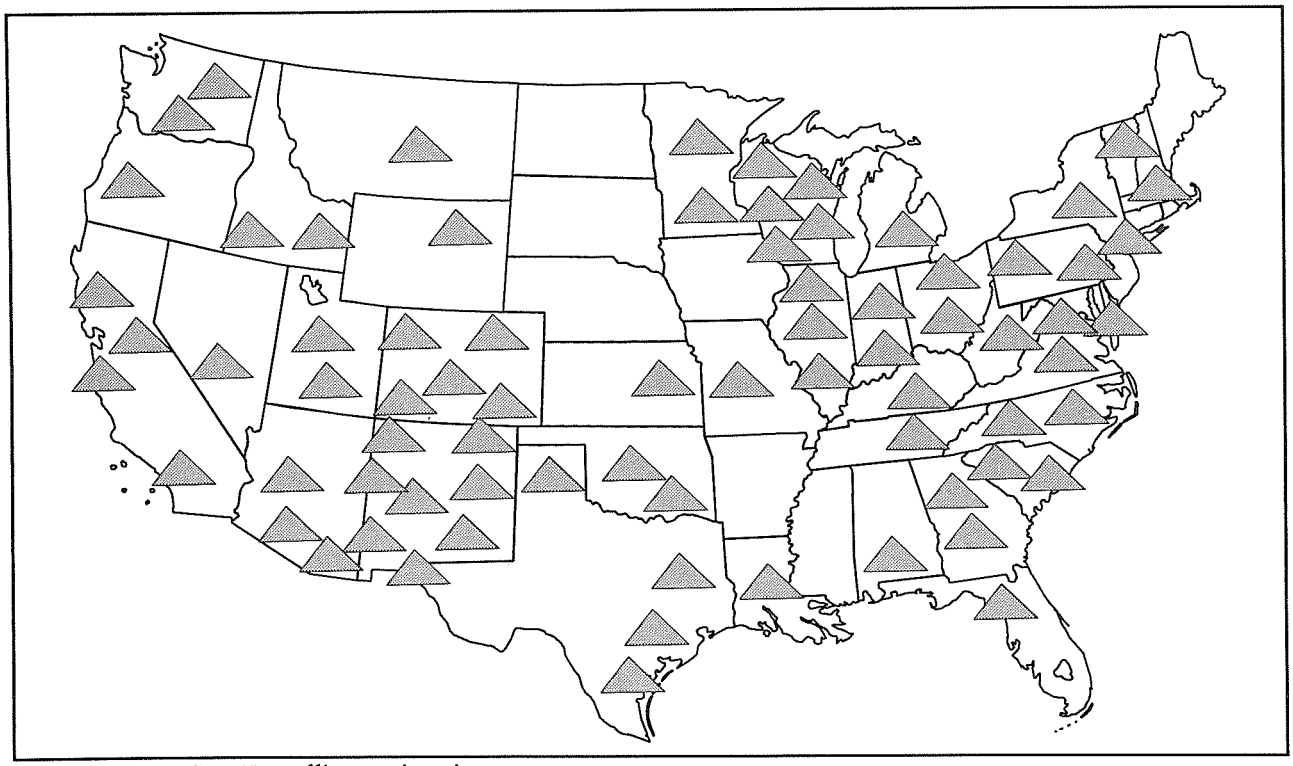

Figure 7. WERC-ITV satellite receive sites.

jects are ready for the demonstration stage to be conducted at DOE and industry sites. Further, the program has resulted in students with experience on practical development projects at the leading edge of technology, thus forming a base for technology transfer as these students flow into government and industry jobs. Several graduates occupy responsible positions and are already technology transfer agents.

The scope of the unique technologies developed through WERC are successfully demonstrated via application at national laboratories and industrial sites. Examples include:

- Remediation of soil contaminated with plutonium using a polymer capture process has been applied at a DOE waste site.
- Mapping of radioactivity in oil fields has been applied at a DOE integrated demonstration site.
- Tensiometric barrier for vadose zone waste containment has been applied at a DOE integrated demonstration site.
- A process for non-toxic building blocks from fly ash and toxic wastes has been applied to alleviate industrial problems.
- A pipeline detection system has been applied to detect leaks from storage tanks and pipelines in the oil industry.
- Remediation of soil containing heavy metals using a heap leaching process has been applied at a DOE waste site.
- Design codes for encapsulation, brine flow and ventilation for waste burial have been applied to the Waste Isolation Pilot Plant.

Another example of new technology developed through WERC involves a series of WERC supported projects that have provided subsurface mapping of waste sites. The application of analysis and software has been demonstrated at Sandia National Laboratories and will be demonstrated next at the Idaho National Engineering Laboratory. Several procedures were integrated including ground penetrating radar, magnetic sensing, Eddy current sensing, cross-borehole tomography, ultrasonic sensing, radiographic sensing, thermal sensing, and interferometric holography. Software has been developed which uses sensing data to produce a three-dimensional subsurface map to guide remediation. These projects have been instrumental in developing a non-destructive mapping technique which is safer and more cost effective than alternate methods. Two NMSU faculty, three students, and professionals from Sandia National Laboratories, Pacific Northwest Laboratory and Stoller participated in these projects.

In the next five years, applications to DOE and other sites will result from program activity. Equally important is the practical experience that about 2,000 faculty members and students have obtained from the involvement in the technology projects and in the exchange of technology between universities, the national laboratories and industry.

Four laboratory facilities have been established to assist research and education and continue to attract industry and state participation.

- Soil-Water-Air Testing Facility
- Environmental Radioactive Measurement Laboratory
- Hobbs Oil-Water Experimental Facility
- Navajo Drylands Environmental Laboratory

A major effort called the Carlsbad Environmental Monitoring and Research Center has also started environmental monitoring in the Carlsbad, New Mexico area. The center, which reports to the director of WERC, generates experimental data using state-of-the-art techniques and conducts research on monitoring techniques. A permanent laboratory building is critical to this program.

Technology Transfer

The technology transfer function of the consortium is emphasized throughout the program. An Executive Board and an Advisory Board composed of representatives from top management of government, industry, academia and environmental organizations have been formed and are functioning for the purpose of technology transfer starting at the top level of industry and government. Major technology transfer conferences and teleconferences are held annually for industry and government. Continuous contact with government and industry is

maintained to transfer the technology development results to real applications. Over 100 technical papers have been presented and published on the various aspects of this program. Additionally, a large number of WERC students are transferring information via summer internships, co-op job programs, and permanent job placements.

WERC Strategy

WERC has proven to be an invaluable resource for the DOE and others. WERC's strategy is to utilize the excellent base started by DOE and the WERC partners and strives to reach its objectives to produce the following.

- New professionals educated in economics, law, business, engineering and science for the management of nuclear, hazardous and solid waste transferring new technologies as they enter the work force. A need for specialists will exist for at least the next three decades.
- Technologists trained or retrained on the safe handling of radioactive and hazardous waste.
- A pipeline of pre-college students informed of opportunities and technological challenges offered by the environmental field.
- Faculty and students working together with national laboratories and industry personnel using state-of-the-art technology information to resolve DOE and other site remediation issues.
- Retrained professionals and management personnel in government and industry via the interactive TV and site-intensive courses. This retraining effort will be a base for technology transfer for managerial and professional resources for several decades.
- World-class environmental monitoring laboratories, including the Carlsbad Environmental Monitoring and Research Center, that serve the real needs of DOE and communities.

The WERC program has been outstanding in its achievements to date. The program annually develops unique technological solutions and transfers information to over 2,000 students and professionals. The program has graduated over 100 students and is projected to graduate at least 100 annually. The $5 million per year initial WERC program has been leveraged by new programs of over $3 million annually. New outreach programs currently in the formation stages will further increase the new program starts to $5-$10 million annually.

As noted earlier, WERC is a model for environmental education and technology transfer, especially for minorities, since New Mexico, with its very high minority population, forms a model that other states in the U.S. will reach by the year 2020.

In 20 years of operations, the program is projected to pay back over $600 million in benefits to the U.S., a return of over 300% if the investment continues for 20 years. However, all of this is contingent on WERC continuing to be funded at about $5.5 million annually.