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The following are the prepared comments for Dr. Ernest Moniz's Opening Plenary Presentation at Containment 2001, the International Containment and Remediation Technology Conference, which took place on 10-13 June 2001 in Orlando, Florida.

It is a pleasure to talk to you about the theme of the Conference: ***"Advancing containment science for solutions to groundwater and soil contamination."*** As you know, the theme for last year's DOE Budget Request was "Strength Through Science." As a fellow scientist, I am glad to see the emphasis on science.

My comments this morning will revolve around the purpose of this Conference – to help transition scientific accomplishments at several federal agencies and their technical contractors and universities to solve the enduring problem of contaminated water and soil resulting from past practices.

But first let me step back and say something about the size and scope of our mission as I viewed it from my former DOE post. DOE's Environmental Management (EM) program is responsible for managing and cleaning up the environmental legacy of the nation's nuclear weapons program. It is probably the largest, most complex and most ambitious program of its kind ever undertaken:

- DOE is responsible for remediation of an estimated 1.7 trillion gallons of contaminated groundwater, an amount equal to about four times the daily U.S. water consumption

- DOE is responsible for remediation of some 40 million cubic meters of contaminated soil and debris, enough to fill about 17 professional sports stadiums

- DOE is responsible for the storage, treatment, and disposal of radioactive and hazardous waste, including over 160,000 cubic meters that are currently in storage and over 100 million gallons of liquid, high-level radioactive waste

- DOE is also responsible for deactivation and decommissioning of about 4,000 facilities that are no longer needed to support the Department's mission

- The Department must also provide long-term care and monitoring, that is, stewardship, for potentially hundreds of years following cleanup.

DOE is responsible for the cleanup of 113 geographic sites located in 30 states and one territory. Altogether, these sites encompass an area of over two million acres – equal to the size of Rhode Island and Delaware combined. Despite the complexity and size of the challenge, DOE has made substantial progress over the past decade in cleaning up the nuclear weapons complex. At the beginning of FY 2000, the Department had finished active cleanup at 69 of the 113 sites, leaving a remainder of 44 to be completed.

DOE's goal is to complete cleanup at an additional 22 geographic sites by the end of FY 2006. At the sites remaining after this date, which includes some of the largest ones, DOE will continue treatment for the remaining legacy waste streams, and manage legacy nuclear materials. To protect human health and the environment, long-term stewardship activities will be implemented upon completion of active cleanup at these sites.

The challenging job of managing DOE facilities and treating wastes is carried out in the field, in much the same manner that NASA, DOD and EPA operate – by keeping promises to the public, getting work done safely, and providing for long-term stewardship of those sites where contamination will persist for long periods of time. A major challenge to all of you and your management is the application of the best science and technology to remedy problems. When all of your ongoing work is done, the government will still have to provide long-term stewardship to insure that sites remain safe long after the cleanup is completed.

It is in this area of long-term stewardship that DOE, through the environmental research and development, and deployment activities of the past decade, has made the most significant and exciting progress. During this period, the very face of environmental clean-up activities has transitioned from simply "reacting to a problem" to a situation of "strategically working toward a desirable environmental end state." We have transitioned from responding with a limited set of available solutions – things like excavation or pump and treat – to creatively applying a broad range of technologies from a science-based toolbox. The value of this transition is that the process encourages DOE and its stakeholders to agree on the where we are going – "the end state." – and then "roadmapping" the path to get there. This paradigm simplifies the selection and implementation of a diverse set of technologies to reach our goals.

By many objective measures – things like numbers of new technologies used, reduced costs, improved performance and the like, our environmental technology development process has been a tremendous success. But one of the most exciting legacies of the past decade is general shift toward technically-based decisions and matching the technologies to problems to meet our long-term goals.

Thus, this talk about the past and future of DOE environmental technology development efforts will emphasize the themes of diversity, creativity, and strategic planning. This talk is particularly relevant to this conference, "Containment 2001," because many critical science and technology issues related to stabilization and containment must be addressed to achieve DOE's long-term commitments to best preserve and transition its valuable public lands.

We look to the science community to help address these long-term challenges in containment and monitoring. By the time this Conference adjourns, I hope we have a clear and common understanding of the highest priority containment needs and how we can benefit from good science.

I am very pleased to have been associated with the strides taken by the DOE Environmental Management Science Program. Since its inception in fiscal year 1996, EMSP has invested over $254 million in support of 316 research projects. The open, competitive approach has ensured the highest caliber of research involving 97 universities, 13 national laboratories and 20 other governmental and private laboratories. Research is being conducted in 40 states and in eight countries. DOE has also engaged the National Academy of Sciences to improve the quality of the program, and just last year the NAS completed a review of the Research Needs in Subsurface Contamination.

This approach ensures that funded proposals have scientific merit and relevance to cleanup needs across the complex; that technical problem areas are funded appropriately; and that research results are communicated to site problem holders, focus area representatives, regulators and scientists.

One of the continuing dilemmas in managing the EM science and technology program is the imbalance across the technology spectrum from basic science through to deployment. Both ends of the spectrum have ardent supporters – the imbalance indicates the "Valley of Death" continues to exist, partly due to pressure from Congress to show more deployments. EM-OST can now demonstrate a rapidly growing profile of deployments, but what if we are depleting our seed corn?

The long-term solution rests with many of you and your peers. With your encouragement and active involvement, users need to become more involved in each aspect of the OST program. Gerald Boyd has been working hard in this area to ensure end-user and regulatory buy-in. In short, more flexibility is needed so that program support is afforded to applied science and engineering development to "fill in" the Valley.

In a time of no-growth budgets, it is vital that we maintain the core components of the remediation program. It is through exchanges, such as this Conference, that funding agencies' objectives can be aligned to take the most advantage of the collective R&D funds of several agencies.

One of my proudest accomplishments while at DOE was the announcement of a $25 million program for funding for 31 new research projects aimed at our subsurface contamination problems. Researchers at 20 universities, eight DOE laboratories, and three other research institutions are conducting studies on subsurface contamination problems throughout the DOE complex.

New research projects include characterization and monitoring technologies to better understand the nature of the contaminants; the development of cost-effective, environmentally safe methods to remove these radioactive contaminants; and the study of how contaminants migrate through the soil and groundwater.

As I said at the start of my remarks, the theme for the FY2001 Budget is "Strength through Science." EM programs greatly benefit from the infusion of both basic and applied science. Basic research efforts are not just meant to help with new technology development. They also lead to new or improved processes and techniques by improving our understanding. In other words, basic science can steer us in the right direction by showing us what paths to avoid in the future.

Contamination of the subsurface environment is one of the many challenging environmental problems at DOE weapons sites. Addressing this problem requires an assessment of the risks as well as the development of reliable and economical remediation schemes. These two activities, in turn, depend on a solid understanding of the chemistry between contaminants and minerals present in the subsurface.

It is possible to make a difference. During my DOE days, I strongly supported the need to better identify vadose zone issues that lead to research on improved characterization and source control. In some cases, the source is already "out" and must be contained. That is one of the challenges that you are trying to address. And so, I can compliment all of you who contributed to the book, *Vadose Zone: Science and Technology Solutions*, a two-volume treatise on the key technical and scientific issues of vadose zone characterization, modeling, remediation, containment and long-term site management.

Since the vast majority of contamination at Energy Department sites are located in the vadose zone, it was imperative that we found out all that we could about it. We brought together the best minds currently working on these issues to find out what they knew, and just as important, what they didn't know so we could make informed decisions about where to invest future research dollars.

The science related to understanding the transport of contaminants in soil and the vadose zone is far from mature. To advance it, the Department gathered scientists and technical experts representing industry, government and academia to bring together all the disparate research that has been done on the vadose zone at a series of workshops.

The book highlights several data gaps that need to be closed in order to provide a better understanding of contaminants in the vadose zone including:

- Establishing a technical basis for taking cleanup action and setting goals at contaminated sites;

- Developing better data to understand how contaminants move through the vadose zone; and

- Developing monitoring techniques to ensure that there is no further groundwater contamination after remediation.

DOE's Subsurface Contaminants Focus Area and the Savannah River Technology Center (SRTC), the applied research and development lab at DOE's Savannah River Site, as well as eight DOE national labs, nine academic institutions, fourteen private companies, three government agencies and one foreign country coordinated the preparation of the text.

In their letter to me on the vadose zone book, the Defense Nuclear Facilities Safety Board called it a "most valuable resource…" and "a notable accomplishment that will be helpful in solving safety problems…." Significantly, the book is just one of the important strategic approaches implemented by DOE to transition its environmental program. Other notable examples include the environmental science and technology "roadmapping" efforts across the complex. These efforts include the vadose zone roadmap at Hanford that helped them address their near-term and long-term environmental problems associated with leaking tanks, and the complex-wide vadose zone roadmap and subsurface science initiative, coordinated by the Idaho National Engineering and Environmental Laboratory (INEEL).

The INEEL as part of its EM Lead Laboratory assignment is leading a multidisciplinary, multi-agency effort to roadmap the science and technology base required for a missing central component of environmental cleanup in the subsurface. The development of the science base and additional data acquisition capabilities (characterization) required to bound uncertainties in the fate and transport of contaminates through the vadose zone and into ground water requires in parallel, the development of significantly enhanced numerical computational capabilities. There is, therefore, a fundamental link between effective environmental cleanup and continued commitments in support of the strategic Simulation Initiative.

These important recent efforts have reached out to universities and other federal agencies to foster cooperation in a way that represents the best, and most practical, way for us to reach our shared goals. This new pragmatism is a good way to do business and is an approach that will be encouraged during the current administration. This transition and emphasis on strategically addressing science and technology needs is also evident in the planning process being implemented by the Subsurface Contaminants Focus Area. Based on the national roadmap, they are developing a high-level interpretation of the over 500 needs statements submitted by the sites to identify the underlying science and technology issues and to place bounds on what is needed – and just as importantly what is not needed – to reach necessary solutions. This will lead to a more effective selection and implementation in our technology development program.

The future direction of our program is to provide support for the logical process of matching technological solutions to problems and implementing systems of technologies to move sites to agreed end-states. In simple terms, the process might include containment, stabilization, enhanced removal or destruction of contaminants in a high-concentration source area, and documenting the performance of sustainable monitored natural attenuation processes after the source is controlled.

In addition, the DOE has fostered cooperative agreements with the Russian Academy of Sciences, other Russian Laboratories and the Ukraine Academy of Sciences to take advantage of the considerable knowledge and data generated from legacy wastes. The contamination sites they own have given us a wonderful laboratory to study fate and transport of contamination and potential sites to test containment, stabilization and remediation technologies. These cooperative agreements will assist the U.S. in accelerating development of solutions to very difficult problems. A specific example of cooperative efforts includes the containment transport and site characterization program. The goal of this program is to test and build confidence in the capabilities of DOE's contaminant transport models to predict future environmental and human impacts of radioactive contaminant releases at DOE sites. Reliable contaminant migration data from the Mayak and Tomsk sites in Russia are a unique resource for the development, calibration, and validation of U.S. models. In addition to the database resources, this program provides an opportunity to develop and refine new modeling techniques, including a semi-automated approach to integrating site characterization data, conceptual model development, and numerical modeling.

There are several important examples of successful deployment of source zone treatment. One specific and interesting example is the use of a Lawrence Livermore National Laboratory variant of steam remediation -- Dynamic Underground Stripping – for removal of residual DNAPL solvents at several DOE sites, including Savannah River Site and Paducah. This effort complements the DOE-EPA-DOD-NASA interagency DNAPL consortium that has sponsored side-by-side testing of several alternative DNAPL treatments to support future use. The work also complements international collaborations, such as deployments to clean-up former production facilities in Poland. The diversity of the DOE environmental technology development portfolio can be clearly seen by supplementing examples of large full-scale deployments with examples from the basic science studies needed to support monitored natural attenuation.

It is worthwhile to cite a couple of examples of how science has played an important role in the cleanup of soil and water. The Pacific Northwest National Laboratory and Stanford University have been studying the molecular-level process governing the interaction of contaminants with iron and manganese oxides. The fact that EPA and other agencies are using the data from this research is evidence of its valuable, real world, everyday application in environments that also include containment while remediation occurs.

Until now traditional remediation strategies for mercury-contaminated soils have been expensive and site-destructive. But, with global heavy metal contamination increasing, living plants that can process heavy metals might offer efficient and ecologically sound approaches to sequestration and removal. Toward that end the University of Georgia is leading research in the use of plants and trees to clean up contaminated soil and water. Their long-term goal is to enable plant species to extract, detoxify, and sequester toxic heavy metal pollutants as an environmentally friendly alternative to physical remediation methods. The team has already engineered several plant species to extract soil and water-borne metals and the results have been encouraging. This is particularly encouraging for EM because the high cost of current pollution remediation prevents most large, existing sites from being cleaned up. Containment of contaminated soil and water allows these techniques to work.

Perhaps there is no better example of the complexity of containment and supporting sciences than at the Hanford Site, where it is important to control the very real hazards associated with wastes leaking from HLW tanks. These wastes pose a threat to human health and environment, and to the Columbia River in particular.

I know the audience understands the urgency, scale and complexity of this problem. The wastes in these tanks pose significant risks to worker safety, health and the environment for several reasons: Nature and quantity of waste -- Over 54 million gallons of highly radioactive waste are stored in the tanks. The tank wastes pose complex technical, safety, and management difficulties --including heat generation, pH, reactivity, flammability and nuclear criticality; and the composition of wastes in each tank is unique. Tank condition -- All of the 149 single-shell tanks have exceeded their 20-year design life, and 67 are registered with the State of Washington as having leaked or are suspected to have leaked high-level radioactive waste into the surrounding soils.

A word about current and potential releases to the environment -- leaking tanks have already released up to one and a half million gallons of high-level radioactive waste into the soil, threatening the Columbia River through the vadose zone and groundwater transport pathways. Monitoring data have confirmed that some contamination from earlier tank leaks has reached the groundwater. A Los Alamos National Laboratory study done for Hanford concluded that four tanks in the Hanford SX farm leaked as much as 413,000 gallons of high-level waste and some one million curies of radioactive cesium. This increased by 40 percent our previous estimates that one million gallons of the waste had leaked from the tanks.

The tanks are not the only source of contamination to the vadose zone. Decades of discharges of billions of gallons of process waters, cooling waters, and contaminated liquids to the ground and land burial of radioactive material, including over 500 pounds of plutonium, left behind significant quantities of contamination in the vadose zone and groundwater. This contamination poses a threat to the Columbia River. The vadose zone is now an object of major attention, and was a personal focus for me.

As a consequence of the tank leaks, I directed that an integrated site-wide, science-based strategy be developed to characterize the full magnitude of vadose zone contamination and how it behaves and migrates through the vadose zone and into the groundwater, the primary pathway to the Columbia River. It is critical that the efforts to address vadose zone and groundwater contamination work are fully integrated, and that the best scientific minds and tools be applied to the problem. I am gratified by the progress that has been made on this issue in the past few years, but there is still much to be done. Containment, and understanding the processes by which containment is achieved, are crucial to success.

Allow me the liberty of reiterating the mission of the Environmental Management Science Program as mandated by the Congress in 1996 because, I believe, it is still quite timely. The EMSP mission is to focus the nation's science infrastructure on critical DOE-EM issues by bridging the gap between fundamental research and needed technology deployment. The EMSP mission is probably even more important today to our success than it was 4 years ago. I want all of you to know that I am a strong supporter of your mission and your work.

In closing, I challenge all of you researchers to continue to help solve containment problems. I ask you to reach out of the laboratories and to collaborate beyond your research team with the wider scientific and research community. Site managers, project managers, regulators, and others involved in cleanup activities must engage with the scientific community in order to tap the potential of their resources. For this reason, I am especially pleased to see the large turnout and the diversity of organizations and talent represented in the audience. I wish you all a successful outcome.