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February 15, 2005

Mr. Michael A. Parker
Director
Chemical Materials Agency
5183 Blackhawk Road
Edgewood Area
Aberdeen Proving Ground, MD 21010-5424

Re: Review and Assessment of the Bechtel National, Inc., Proposal for the Design and Operation of the Chemical Agent Destruction Pilot Plant at Pueblo, Colorado

Dear Mr. Parker:

As requested by the Department of Defense (DOD) and the Program Manager, Assembled Chemical Weapons Alternatives (PMACWA), the National Research Council (NRC) of the National Academies established a committee — the Committee to Review and Assess the Proposals for Design and Operation of Chemical Agent Destruction Pilot Plants, called the CAPP Committee — to review and assess the proposals submitted by Bechtel National, Inc., for the design and operation of the Pueblo Chemical Agent Destruction Pilot Plant (PCAPP) in Pueblo, Colorado, and the Blue Grass Chemical Agent Destruction Pilot Plant (BGCAPP) in Richmond, Kentucky (see Attachment A for the statement of task). The committee's assessment considers the proposed design provided by Bechtel National, an alternative suggested by Mitretek, and the desirability of technically viable alternative configurations developed by the committee itself with respect to cost and schedule.[1] This letter report, the first of two reports, addresses only the Pueblo Chemical Agent Destruction Pilot Plant.

This study was initiated on January 10, 2005, and was to be completed within 30 days. In view of the short study schedule and the nature of the task, this report does not refer extensively to or rely on detailed evidence from published sources to support the committee's assessment. Rather, this assessment reflects primarily the consensus views and judgments of the committee members, based on their substantial project and program management experience (see

[1] The cost refers to the life-cycle costs, including the construction, operation, and closure of the plant. The schedule refers to the 2012 treaty date in the Chemical Weapons Convention for the destruction of agent signed January 13, 1993.

Attachment B). To guarantee a breadth of perspectives, the committee was constituted by the NRC to include senior executives, engineers, and researchers with extensive and diverse experience in industry, government, and academia.

The Pueblo stockpile consists entirely of mustard-filled 105-mm cartridges, 155-mm projectiles, and 4.2-in. mortars. The Army prepared a request for proposal (RFP) for the PCAPP that called for disassembly of these munitions followed by the use of hydrolysis technology to treat both agent and energetics. On-site biotreatment was planned for all waste streams generated during the primary hydrolysis processes.

Recently several efforts have been made to identify alternative design configurations and life-cycle cost options with the aim of reducing the costs for the Pueblo facility. These efforts are described in the following reports:

- *Independent Evaluation of Pueblo Chemical Agent Destruction Pilot Plant (PCAPP) Process Alternatives*, Mitretek Report MTR 2004-17, December 2004;[2]
- *Pueblo Chemical Agent Destruction Pilot Plant*, Department of Defense Office of the Inspector General Report No. D-2005-009, November 1, 2004; and
- *Analysis of Impacts of Off-Site Disposal Options for the Pueblo Chemical Agent Destruction Pilot Plant (PCAPP), Final Report*, FOCIS Associates, Inc., July 25, 2003.

In addition, a recently completed NRC report — *Interim Design Assessment for the Pueblo Chemical Agent Destruction Pilot Plant* (NRC, 2005) — provided an in-depth analysis of the main unit processes and the issues regarding performance that may be encountered for each of these.

The committee used all of the above resources during its assessment of the Bechtel National proposal (Bechtel, undated).

STUDY SCOPE

Figure 1-1 depicts the major components of the PCAPP design as proposed by Bechtel National. Previous attempts to reduce the cost of the Pueblo facility, such as those described

[2] The Mitretek report (2004) contains proprietary information that qualified under Subsection 15(b)(3) of the Federal Advisory Committee Act, 5 U.S.C. App., as amended by the Federal Advisory Committee Act Amendments of 1997, PL 105-153, December 17, 1997, 111 Stat., 2689. The National Research Council has determined that to release this information to the public would disclose information described in 5 U.S.C. 552(b). The CAPP Committee was granted access to this document under an arrangement that recognized the restricted status of the document.

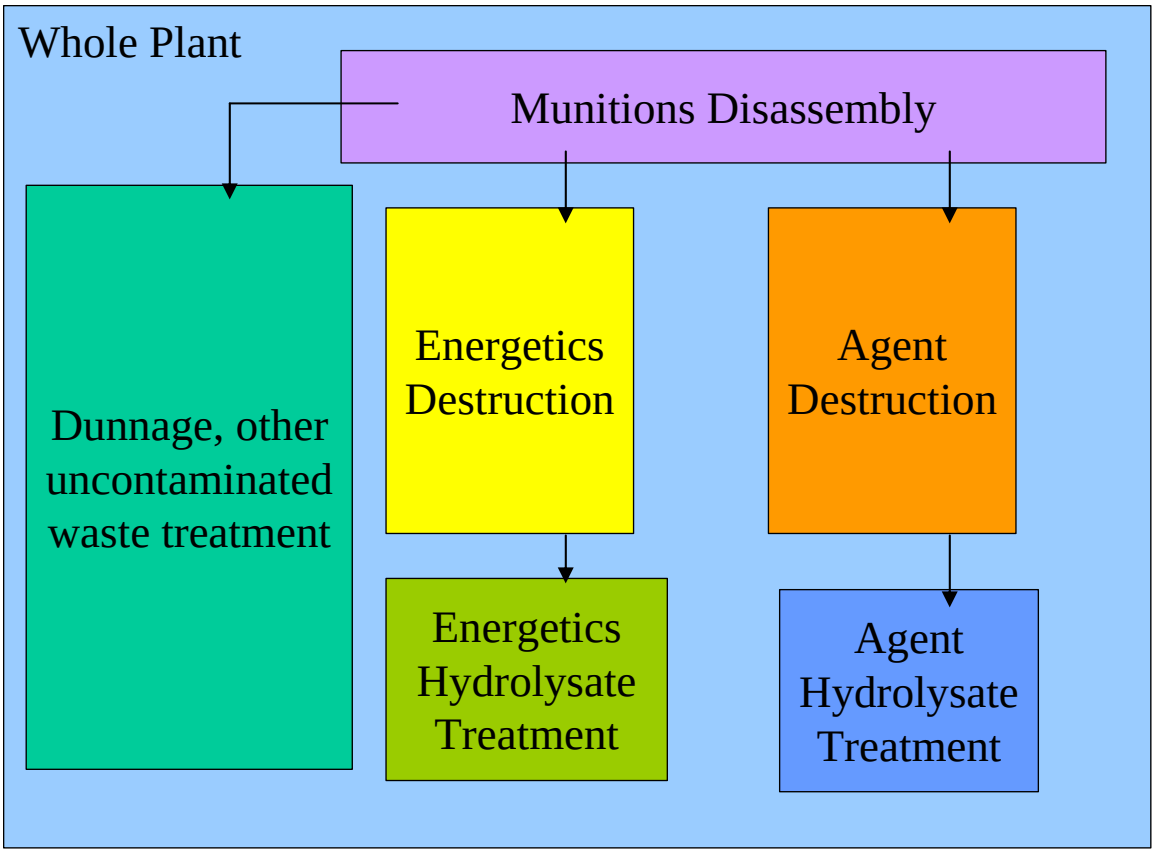

Figure 1-1 Simplified design concept for Pueblo Chemical Agent Destruction Pilot Plant as proposed by Bechtel National.

in the Mitretek study mentioned above, have addressed discrete changes to operations or equipment within the major design components.

The committee focused on the major systems in the Bechtel design and on the integration of these systems. Because of time constraints, it did not perform a detailed technical engineering evaluation of the unit operations, but instead assessed these in terms of potentially viable alternative configurations and their impact on cost and schedule issues. Discrete changes to the operations or equipment in the Bechtel National design can provide only modest reductions in cost or schedule. In the Bechtel design, munitions disassembly is the rate-limiting step.

The committee developed seven design alternatives to the Bechtel proposal that could result in more substantial cost and/or schedule savings by modifying some of the design constraints originally required in the RFP. All of the alternatives proposed by the committee are considered to be technically feasible and utilize technologies that either are proven or present a lower risk than those in Bechtel National's proposed design. The set of alternative configurations developed by the committee is illustrative and certainly not exhaustive.

The committee did not restrict itself to the design constraints specified in the RFP, although it recognizes the implications of some of the committee-generated alternatives in terms of public, permitting, political, and legal considerations. Instead, the committee developed and

evaluated alternative configurations that could reduce cost and/or positively impact schedule based on an analysis and judgment of technical considerations.

The committee proceeded as follows:

- It reviewed the DOD-provided Bechtel National proposal for the design of the PCAPP, as well as the three documents listed above.
- It heard presentations by the DOD sponsor and held discussions with representatives of Mitretek Systems, whose independent evaluation of PCAPP design alternatives is presented in the Mitretek report cited above.
- It identified the factors that it would use to evaluate the Bechtel proposal. After discussion, the committee identified those items in the design that might reduce cost and schedule.
- Based on these items, it developed technically viable alternative design configurations to the Bechtel proposal and possible combinations of alternatives that might reduce the cost and schedule of PCAPP.

ASSESSMENT FACTORS FOR ALTERNATIVE CONFIGURATIONS

To assess the alternative configurations developed by the committee and the alternative proposed by Mitretek, the committee selected factors consistent with the overall programmatic goal of safe and expeditious disposal of the chemical weapons stockpile:

- **Technical Feasibility and Operational Risk:** Evaluation of this factor included assessing whether the technology is in commercial use or is under development following completion of detailed engineering design.
- **Integration of the Unit Operations and Availability of Equipment:** Evaluation of this factor included assessing whether a unit operation or alternative configuration could be easily integrated into the overall system and if it would impact the plant's throughput.
- **Permitting and Public Acceptance:** Evaluation of this factor included assessing whether a suggested alternative configuration might encounter barriers to obtaining permits and to the public acceptance of the modification. [3]
- **Plant Closure:** Evaluation of this factor included assessing whether the proposed/suggested course of action would increase or reduce the cost of plant closure.
- **Safety:** Evaluation of this factor included assessing whether the alternative configuration would increase or decrease the safety of the plant's operational staff and the general

[3] The committee notes that changes in permits or laws are required and it recognizes that these processes are fraught with uncertainty and would likely lengthen the time to completion. Therefore, further consideration of any alternative requiring a permit change, new permit, or change in law or regulation should first include detailed discussion with all agencies and stakeholders involved. The committee also notes that when it discussed processing at another site where necessary, it was not able to estimate the additional costs or schedule impacts of processing at these sites. Therefore, the cost savings and schedule impacts estimated in this report should be adjusted for such increases.

public when compared with the risk associated with the storage of agent and the activities involving the destruction of the agent in Bechtel National's design.

Considering all of these factors in their totality, the committee will then make their assessment regarding cost and schedule for PCAPP:

- **Life-Cycle Cost:** The life-cycle cost includes the construction, operation, and closure of the Pueblo plant. Evaluation of this factor included assessing whether a change to the Bechtel design would increase or reduce the total life-cycle cost.
- **Impact on Schedule for Agent Destruction:** Evaluation of this factor included an assessment of the impact that changes to the Bechtel design would have on meeting the 2012 Chemical Weapons Convention treaty date for destruction of agent.

RATING THE ALTERNATIVE CONFIGURATIONS

The committee rated its alternative configurations using the Bechtel design proposal as a baseline. Each of these alternatives was assessed in terms of the factors listed above and each was given a rating of (+) more advantageous, (0) no significant change from the Bechtel proposal, or (–) negative impact. These judgments were based on the committee's joint experience and do not necessarily represent a quantitative assessment of the various criteria. However, where a (+) assessment has been made, the committee's opinion is that the impact is significant enough to merit the attention of the DOD.

CONCLUSIONS

As stated above, the committee used the information contained in the original proposal by Bechtel National as well as several studies that evaluate the proposal and possible alternatives as a basis for the committee's evaluation. It did not limit its analysis to the specific alternatives developed in those reports. Rather, it used its expertise and judgment to select areas with potentially the most impact on Pueblo plant life-cycle costs and on the schedule for agent destruction. The committee looked at reducing the number of munitions disassembly lines from three to two and found that this approach had little cost advantage, but led to a definitive increase in time to completion.

The committee considers that, given the complexity of the equipment, the prototypical nature of some equipment and systems and the history of the program, it is impossible to predict the actual schedule and cost of the project. After reviewing this proposal and the supplementary analyses, the committee believes that the BPT proposal for the PCAPP is viable given the RFP specifications that were stipulated for design criteria for the facility. The committee found little opportunity for reducing cost or improving schedule in the Bechtel National design unless major changes were made to the RFP requirements.

Finding. There is no opportunity for significant cost or schedule reductions unless the constraints imposed upon the original request for proposal are relaxed.

The committee identified seven alternatives to the Bechtel proposed design that could offer opportunities for positive impacts on cost and schedule for the Pueblo facility, but that require relaxation of some of the original DOD RFP requirements. Most of these alternatives also involve issues with respect to permitting and community acceptance but seem worthy of further evaluation since they all seem technically feasible. The committee appreciates that there are challenges associated with DOD continued efforts to balance cost savings with meeting existing statutory requirements and previous agreements with the public. The alternatives are as follows:

- Changing the processing and disposal of secondary wastes to eliminate one major processing unit;
- Changing the handling of all uncontaminated energetics by using an existing facility for destruction. Transport of uncontaminated energetic materials is an accepted practice in the United States;
- Using currently available nonstockpile technology to handle leakers and reject munitions in parallel with disposing of all other munitions in the main processing line, thereby saving processing time;
- Disposing of agent hydrolysate at an existing treatment, storage, and disposal facility (TSDF);
- Disposing of energetics hydrolysate at an existing TSDF;
- Shipping assembled munitions (except leakers), less the propellant to an existing demilitarization facility; and
- Shipping munitions (except leakers) with or without bursters-in-place to an existing demilitarization facility.

The committee believes that all of these alternative configurations are technically feasible and that they would decrease cost and in some cases have a positive effect on the schedule. However, all of the options listed above could require some changes in the current permitting documents and might face some public opposition. The last option, while saving a large amount of capital, would require significant changes in existing statutes and would likely raise public acceptance concerns at Pueblo and at the receiving site that could negatively affect both cost and schedule if this option were pursued and then ultimately rejected. That same option would also require a careful evaluation of the risks associated with the shipment of the munitions and of any additional risks to the workers and the public at the site receiving the munitions.

Sincerely,

Peter B. Lederman, *Chair*
Committee to Review and Assess the Proposals for
Design and Operation of the Chemical Agent
Destruction Pilot Plant

Attachments:
A – Statement of Task
B – Committee Membership—Roster and Biographies
C – References
D – Assessment (proprietary; not available to the public)
E – Acknowledgment of Reviewers

ATTACHMENT A

Statement of Task

In response to the request by the Department of Defense and the Program Manager, Assembled Chemical Weapons Alternatives, the National Research Council (NRC) established the Committee to Review and Assess the Proposals for Design and Operation of Designated Chemical Agent Destruction Pilot Plants (CAPP Committee). Those appointed to the expert committee (see Appendix B) included members from various NRC committees familiar with the destruction of chemical munitions. Following is the statement of task for this review:

> The NRC will establish an ad hoc Committee to Review and Assess the Proposals for Design and Operation of Designated Chemical Agent Destruction Pilot Plants (CAPP Committee). This new committee will receive, review, and assess the proposals submitted by Bechtel National, Inc. for the Pueblo Chemical Agent Destruction Pilot Plant in Pueblo, Colorado and the Blue Grass Chemical Agent Destruction Pilot Plant in Richmond, Kentucky to consider the desirability of alternate configurations with respect to cost and schedule. The committee will provide a review to the Army of these proposals to advise them in their procurement decisions regarding award of the task order.

ATTACHMENT B

Committee Membership—Roster and Biographies

COMMITTEE TO REVIEW AND ASSESS THE PROPOSALS FOR CHEMICAL AGENT DESTRUCTION PILOT PLANTS

PETER B. LEDERMAN, *Chair,* New Jersey Institute of Technology (Retired), New Providence, New Jersey
CHARLES I. McGINNIS, *Vice Chair,* U.S. Army (Retired), Charlottesville, Virginia
RICHARD J. AYEN, Waste Management, Inc., (Retired), Jamestown, Rhode Island
ROBERT A. BEAUDET, University of Southern California, Los Angeles
RUTH M. DOHERTY, Naval Surface Warfare Center, Indian Head, Maryland
WILLARD C. GEKLER, PLG, Inc. Los Alamitos, California
MARTIN GOLLIN, Carmagen Engineering, Inc., St. Davids, Pennsylvania
DAVID S. KOSSON, Vanderbilt University School of Engineering, Nashville, Tennessee
JAMES F. MATHIS, Exxon Corporation (Retired), Franklin, New Jersey
CHANDRA M. ROY, Exponent Failure Analysis Associates, Inc., Irvine, California
OTIS A. SHELTON, Praxair, Inc., Danbury, Connecticut

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WILLIAM E. CAMPBELL, Manager, Program Operations
JAMES C. MYSKA, Research Associate
DETRA BODRICK-SHORTER, Senior Program Assistant

BIOGRAPHIES OF COMMITTEE MEMBERS

Peter B. Lederman, *Chair,* who holds a Ph.D. in chemical engineering from the University of Michigan, recently retired as executive director of the Hazardous Substance Management Research Center and as executive director of the Office of Intellectual Property, New Jersey Institute of Technology. He continues to teach environmental management, policy and site remediation at the institute. He is active as a consultant and is the principle of Peter Lederman & Associates. Dr. Lederman has more than 50 years of broad experience in all facets of environmental management, control, and policy development; considerable experience in hazardous substance treatment and management, as well as in process design and development in the petrochemical industry; and more than 18 years of experience as an educator. He has industrial experience as a process designer and managed the development of new processes through full-scale plant demonstrations. He is well known for his work as a professor in chemical process design. He led his company's safety program in the early 1980s. Dr. Lederman is a registered professional engineer, registered professional planner, certified hazardous material manager and a diplomat in environmental engineering. Dr. Lederman has also worked at the

federal (Environmental Protection Agency) and in environmental protection organizations at the state levels with particular emphasis on environmental policy. A National Associate of the National Academies, he has substantial expertise in chemical engineering, hazardous waste treatment, and educational and corporate leadership.

Charles I. McGinnis, *Vice Chair,* who holds an M.Engr. in civil engineering from Texas A&M University, retired from the U.S. Army as a major general. He was a former director of civil works for the U.S. Army Corps of Engineers, and more recently served in senior positions at the Construction Industry Institute in Austin, Texas. General McGinnis has also served as the director of engineering and construction for the Panama Canal Company and later as vice president of the company and lieutenant governor of the Canal Zone. As director of civil works for the U.S. Army Corps of Engineers, he was responsible for a $3 billion per year planning, design, construction, operation, and maintenance program of water-resource-oriented public works on a nationwide basis. He has considerable experience with engineering and construction. He is a registered professional engineer in Texas and Missouri.

Richard J. Ayen is current chair of the National Research Council (NRC) Committee on Review and Assessment of the Army Non-Stockpile Chemical Demilitarization Program: Workplace Monitoring and a former member of the NRC Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons (I and II). Dr. Ayen received his Ph.D. in chemical engineering from the University of Illinois. Now retired, he had served as director of technology for Waste Management, Inc. and managed all aspects of the company's Clemson Technical Center, including treatability studies and technology demonstrations for the treatment of hazardous and radioactive waste. His experience includes 20 years at Stauffer Chemical Company, where he was manager of the process development department at Stauffer's Eastern Research Center. Dr. Ayen has published extensively in his fields of interest. He has extensive experience in the evaluation and development of new technologies for the treatment of hazardous, radioactive, industrial, and municipal waste.

Robert A. Beaudet received his Ph.D. in physical chemistry from Harvard University in 1962. From 1961 to 1963, he was a U.S. Army officer and served at the Jet Propulsion Laboratory as a research scientist. He joined the faculty of the University of Southern California, Los Angeles in 1963 and has served continuously in the Department of Chemistry since that time. He also has served on Department of Defense committees that have addressed both offensive and defensive considerations regarding chemical warfare agents. Dr. Beaudet was chair of an Army Science Board committee that addressed chemical detection and trace gas analysis. He also was chair of an Air Force technical conference on chemical warfare decontamination and protection. He has served on NRC studies on chemical and biological sensor technologies and on energetic materials and technologies. Most of his career has been devoted to research in molecular structure and molecular spectroscopy. Currently, Dr. Beaudet is chair of the Committee to Assess Designs for Pueblo and Blue Grass Chemical Agent Destruction Pilot Plants. Previously, he served as a member of the Board on Army Science and Technology (BAST), as a member of the NRC Committee on Review of the Non-Stockpile Chemical Materiel Disposal Program, and as a

BAST liaison to the Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program (Stockpile Committee).

Ruth M. Doherty currently a technical adviser for the Research and Technology Department, Naval Surface Warfare Center, Indian Head, Maryland, received a Ph.D. in physical chemistry from the University of Maryland. Since 1983, she has coauthored almost 60 publications in various subjects in the physical chemistry arena, including the chemistry of underwater explosives. Over the past 6 years, Dr. Doherty has conducted more than 30 presentations in various aspects of the science and technology of explosives. She has worked extensively in the research and development of energetics materials and explosives with the Naval Surface Warfare Center for more than 15 years. She is a member of the editorial advisory board of the journal *Propellants, Explosives and Pyrotechnics.*

Willard C. Gekler graduated from the Colorado School of Mines with a B.S. in petroleum refining engineering and pursued graduate study in nuclear engineering at the University of California, Los Angeles. Mr. Gekler is currently an independent consultant working for his previous employer, ABS Consulting, Inc. His extensive experience includes membership on general NRC committees on assembled chemical weapons alternatives and on the expert panel reviewing the quantitative risk assessments and safety analyses of hazardous materials handling, storage, and waste treatment systems for the Anniston, Umatilla, Pine Bluff, Aberdeen, and Newport chemical disposal facilities. He was also project manager for development of facility design criteria for the Johnston Atoll Chemical Agent Disposal system. Mr. Gekler's expertise is in hazard evaluation, quantitative risk analyses, reliability assessment, and database development for risk and reliability. Mr. Gekler is a member of the Society for Risk Analysis, the American Institute of Chemical Engineers, the American Nuclear Society, and he is the author or coauthor of numerous publications.

Martin Gollin, an independent consultant with an association with Carmagen Engineering, Inc., and previously with ARCO Chemical Company, has more than 20 years of experience in process engineering and management of capital projects, risk assessment, process safety, loss prevention, and product development. From 1988 to 1999 he served as process design manager and principal engineer at ARCO; there he developed the design basis for a novel catalytic incinerator system and was the environmental, health, and safety manager for a $1 billion grassroots capital project in Holland. He earned a B.S. and M.S. in chemical engineering from Loughborough University of Technology.

David S. Kosson, chair and professor of the Department of Civil and Environmental Engineering and professor of chemical engineering at Vanderbilt University, has a B.S. in chemical engineering, an M.S. in chemical and biochemical engineering, and a Ph.D. in chemical and biochemical engineering from Rutgers, the State University of New Jersey. Previously, he was professor of chemical and biochemical engineering at Rutgers. Dr. Kosson has carried out research and published extensively on subsurface contaminant transport phenomena, leaching phenomena, physical, chemical, and microbial treatment processes for hazardous waste, and waste management policy. He has been a member of the NRC Committee on Alternative Chemical Demilitarization Technologies, Panel on Review and Evaluation of Alternative

Chemical Disposal Technologies, and the Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program, for which he served as chair for 2 years.

James F. Mathis, *NAE*, graduated from the University of Wisconsin with a Ph.D. in chemical engineering. Dr. Mathis was vice president of science and technology for Exxon Corporation, where he was responsible for worldwide research and development programs, and chair of the New Jersey Commission on Science and Technology until his retirement in 1997. Dr. Mathis's expertise is in research and development and chemical engineering.

Chandra M. Roy is a managing engineer in Exponent Failure Analysis Associates, Inc., a mechanics and materials practice in Irvine, California. Dr. Roy specializes in the application of qualitative and quantitative risk assessment methodologies to engineered and business systems and processes. He also conducts consequence analysis for the release of hazardous chemicals. He has conducted source-term analysis, dispersion analysis, and fire and explosion analysis for accidental releases of airborne chemicals. Additionally, he is skilled in the analysis of failure and incident data for use in risk modeling. Dr. Roy has experience in the application of computation fluid dynamics methods to solve engineering problems. He is also familiar with a wide range of chemical processes and has experience in the operational management of the chemical process industry. He has authored or coauthored several technical publications and presented a number of papers and short courses. Dr. Roy received his Ph.D. in chemical engineering and an M.S. in nuclear engineering from the University of California, Santa Barbara; M.S. in chemical engineering from Pennsylvania State University; and a B.E. in chemical engineering from the University of Roorkee, India.

Otis A. Shelton holds an M.S. in chemical engineering from the University of Houston. He is associate director for the Safety and Environmental Services Compliance and Operational Assessments Program for Praxair, Inc., a position that he has held since 1992. In this position, Mr. Shelton is responsible for managing Praxair's assessment program that focuses on environmental, operational safety, personnel safety, industrial hygiene, emergency planning, distribution, and medical gases programs. Previously, Mr. Shelton was audit manager in Union Carbide Corporation's (UCC) Corporate Health, Safety, and Environmental Protection Audit Program. This program reviewed UCC's health, safety, and environmental compliance in the corporation's operations, worldwide. He also worked for Union Carbide for 25 years in a variety of positions in manufacturing, distribution, and financial management. He is a fellow and past member of the board of directors of the American Institute of Chemical Engineers, and he is a member of the National Society of Black Engineers National Advisory Board. He is currently serving as secretary of the American Institute of Chemical Engineers.

ATTACHMENT C

References

Bechtel. Undated. Bechtel National, Inc., Written Proposal in Response to ACWA RFP No. DAAA09-00-R-0156. Aberdeen Proving Ground, Md.: Program Manager for Assembled Chemical Weapons Alternatives.

DOD (Department of Defense). 2004. Pueblo Chemical Agent Destruction Pilot Plant, Report No. D-2005-009, November 1. Washington, D.C.: Department of Defense, Office of the Inspector General.

FOCIS (FOCIS Associates). 2003. Analysis of Impacts of Off-Site Disposal Options for the Pueblo Chemical Agent Destruction Pilot Plant (PCAPP), FOCIS Associates Aberdeen Proving Ground, Md.: Program Manager for Assembled Chemical Weapons Alternatives.

Mitretek. 2004. Independent Evaluation of Pueblo Chemical Agent Destruction Pilot Plant (PCAPP) Process Alternatives, MTR 2004-17. Falls Church, Va.: Mitretek Systems, Inc.

NRC. (National Research Council) 2005. Interim Design Assessment for the Pueblo Chemical Agent Destruction Pilot Plant. Washington, D.C. The National Academies Press.

ATTACHMENT D

Assessments

The assessments contained in this attachment are not be open to the public under Subsection 15(b)(3) of the Federal Advisory Committee Act, 5 U.S.C. App., as amended by the Federal Advisory Committee Act Amendments of 1997, PL 105-153, December 17, 1997, 111 Stat. 2689. The National Research Council has determined that to release this information to the public would disclose information described in 5 U.S.C. 552(b).

ATTACHMENT E

Acknowledgment of Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Gilbert F. Decker, Walt Disney Imagineering (Retired)
Elisabeth M. Drake, Massachusetts Institute of Technology
Stephen Drew, MMA Scientific Partners
Henry J. Hatch, US Army (Retired)
Hank C. Jenkins-Smith, George H. W. Bush School of Government and Public Service
Michael Ladisch, Purdue University
Richard S. Magee, Carmagan Engineering

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Robert Frosch, Harvard University. Appointed by the NRC, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.