Making the Impossible Possible

Closing Rocky Flats—Ahead of Schedule and under Budget

By Ed Bodey

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To a large percentage of the 2.5 million inhabitants of the nearby Denver-Boulder metropolitan area, the words "Rocky Flats" in the mid-1990s evoked images of environmental crimes, rampant plutonium contamination, and secretive government agencies.

Today, people living in surrounding communities are beginning to think of Rocky Flats in much the same way as residents did prior to 1950: a beautiful, high-prairie mesa at the foot of the Rocky Mountains, teeming with wildlife, rare vegetation, and majestic views of both the Front Range of the Rocky Mountains to the west and the high plains to the east.

Above: *Workers demolish Rocky Flats Building 371 in July 2004, the last of the five major plutonium-contaminated facilities at the site. Building 371 contained processes to recover plutonium from scrap and residues and was meant to replace the aging Building 771. Preparing the facility for demolition presented enormous challenges, especially in decontaminating the facility's massive plutonium storage vault and 12 highly contaminated process canyons. Building 371 once stored the site's entire inventory of weapons-usable special nuclear materials.*

The transformation is the result of a dramatically successful, 10-year effort by the U.S. Department of Energy, the U.S. Environmental Protection Agency (EPA), the state of Colorado, local communities, and Kaiser-Hill Co. LLC and its thousands of employees to accomplish what U.S. Sen. Wayne Allard described as "making the impossible possible."

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of thousands of cubic meters of radioactive waste, the demolition of more than 800 structures, and remediation of hundreds of acres of soil, Rocky Flats, at least where the weapons component plant used to sit, is flat once again. It looks pretty much the same as it did when Denver's well-heeled citizens traveled across Rocky Flats to visit the El Dorado Springs Resort during the early years of the 20th century.

Forty Years of Production

The DOE's Rocky Flats Environmental Technology Site was a former nuclear weapons component production facility located approximately 15 miles northeast of Denver, Colo., where production activities started in 1952. The site consisted of more than 800 facilities and structures on a 275-acre industrial area surrounded by 6000 acres of buffer zone.

Rocky Flats produced plutonium "triggers" for the U.S. weapons program (enriched uranium triggers were also produced during the early years of production). Some officials estimate that virtually all nuclear weapons in the current U.S. arsenal contain triggers produced at Rocky Flats.

In 1989, almost all activities involving nuclear component production were suspended due to safety and environmental concerns. Forty years of production contaminated a large number of facilities and a significant amount of soil, ground, and surface water with a variety of materials, including plutonium, uranium, beryllium, asbestos, heavy metals, and chlorinated solvents. The site was placed on the EPA's National Priorities List (also known as the Superfund list) in 1989. In 1992, the nuclear weapons production role at Rocky Flats officially ended when then President George H.W. Bush terminated the Trident-II missile program.

In 1995, Kaiser-Hill LLC, a joint venture between Kaiser Group Holdings and CH2M Hill, plus a team of subcontractors that included Westinghouse, Washington Group International, and BNFL, was awarded a first-of-its-kind performance-based contract. The focus of work was to reduce some of the urgent health and safety risks at the site and begin cleanup activities. Unlike previous contracting models, the performance-based system rewarded contractors only when measurable, predefined tasks were completed, for example, repackaging a set number of plutonium containers or venting hydrogen from a predefined number of drums.

The early focus on urgent risks played center stage against a backdrop of other problems. The volume of waste, extent of contamination, and viable options for removing it from Rocky Flats led the DOE to estimate that closure of the site would take 70 years and cost $36 billion.

The Kaiser-Hill team made significant progress toward stabilizing special nuclear materials, cleaning up environmental contamination, decontaminating and demolishing buildings, and shipping radioactive and hazardous waste offsite for disposal. At the same time, Kaiser-Hill developed a series of planning models followed by more specific project plans that suggested that cleanup could be achieved decades sooner and for billions of dollars less.

Based on past performance and Kaiser-Hill's detailed and aggressive plan, the DOE awarded Kaiser-Hill a contract in January 2000 to complete the cleanup and close Rocky Flats by December 2006 at a cost of $3.96 billion.

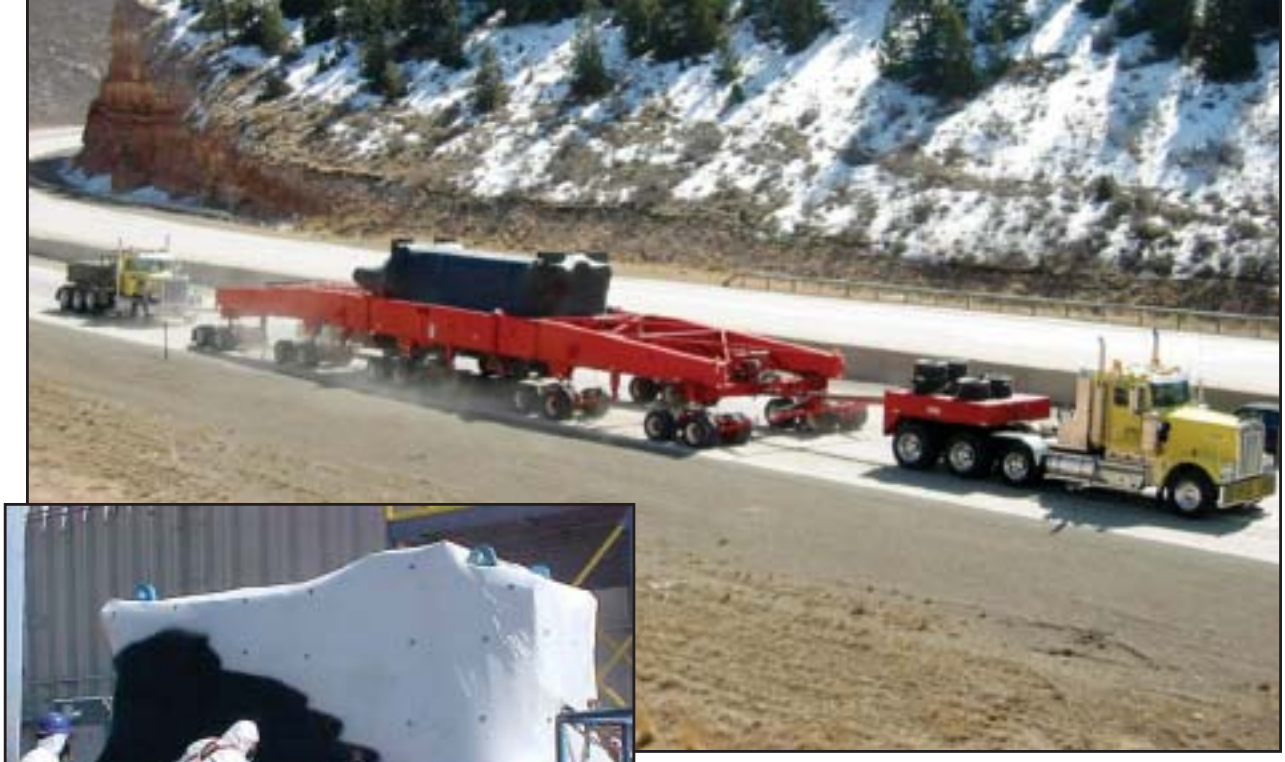
Few believed the deadline could be met. In a 2001 report titled "Nuclear Cleanup: Progress Made at Rocky Flats, but Closure by 2006 Is Unlikely, and Costs May Increase," the Government Accountability Office raised serious doubts, citing technical difficulties with a plutonium stabilization system, the massive quantity of radioactive waste needed to be shipped offsite, and the vast extent of contamination cleanup required to achieve closure.

The Challenges in 1995

More than 20 000 kilograms of plutonium and enriched uranium had to be treated, packaged, and shipped offsite for disposal. Much of this material had been improperly packaged for extended storage when operations were shut down for what was to be an extended duration in 1989 (plutonium weapons component operations would never restart). More than 30 000 liters of plutonium-contaminated solutions containing more than 700 kg of plutonium were stored in tanks and miles of process piping. Because of the age of some of the facilities, the integrity of tanks and piping was deteriorating. Furthermore, due to radiolysis—the molecular decomposition of a substance as a result of radiation—dangerous levels of hydrogen were being generated in these same tanks and pipes.

More than 800 structures totaling more than 3 million square feet (including more than 1.3 million ft^2 contaminated with plutonium and uranium) needed to be safely decontaminated and demolished. There were more than 1450 gloveboxes and hundreds of tanks requiring decon-

The last of Rocky Flats' 1457 plutonium process gloveboxes is removed from Building 371. Gloveboxes were central to operations at Rocky Flats, containing the processing equipment for the wide variety of plutonium handling operations at the site. Most of the gloveboxes were significantly contaminated due to years of use and were planned to be disposed of as transuranic waste. Workers developed innovative liquid decontamination agents that successfully cleaned a large number of boxes to levels acceptable for shipment as low-level radioactive waste. This innovation reduced the amount of waste sent to the Waste Isolation Pilot Plant in New Mexico and significantly reduced the extent of size-reduction (cutting the gloveboxes into pieces to fit into approved waste containers), a hazardous activity. Many gloveboxes were shipped intact as surface-contaminated object, low-level radioactive waste.



Rather than manually size-reducing large pieces of contaminated equipment to fit into approved waste containers, Kaiser-Hill worked with a vendor to develop a polyurea spray-on coating that served as the U.S. Department of Transportation–approved waste packaging for transportation. The innovation resulted in significantly reduced worker exposure to hazards. The largest item shipped from Rocky Flats was a 150-ton Sutton press (above).

tamination, dismantlement, and shipment offsite. Many of the facilities contained other health hazards like beryllium and asbestos.

In addition, about 450 000 cubic meters of radioactive waste had to be characterized, packaged, and shipped offsite. The scope of environmental remediation consisted of 360 individual sites that required investigation to determine whether remediation was required and included large areas of plutonium-contaminated soil, underground trenches containing hazardous and radioactive materials, and contaminated groundwater plumes.

Internally, the workforce was demoralized because trigger production would never resume at Rocky Flats. Cleaning up and closing down meant not just the end of careers, but also the end of the noble work they believed helped the United States win the Cold War. Externally, the relationship with other stakeholders, especially local communities and regulators, lacked trust due to years of secrecy, misconceptions about offsite health risks, and missed regulatory milestones.

Progress to Date

Closure of the Rocky Flats site is imminent, more than a year ahead of the December 2006 deadline and at a saving of more than $500 million. The site's last major plutonium-contaminated facility, Building 371, has been demolished, along with the 800 other structures that composed what was once a small city employing as many as 8000 people. The end state is consistent with the closure contract final vision. All structures have been demolished; all contaminated sites are cleaned to levels agreed to by regulators and citizens; all radioactive waste shipped; and all manmade structures, including roads, parking lots, and sidewalks (except for structures with a continuing function, such as passive groundwater treatment systems), have been removed. Water leaving the site in two creeks meets state water quality standards.

The accompanying table quantifies most of the activities required to close Rocky Flats. Some of these activities were accomplished in unique ways.

Key Closure Activities

Plutonium stabilization and processing	1895 containers
Plutonium residue processing and packaging	106 000 kg
Total radioactive and non-radioactive facilities	802
Grossly contaminated plutonium facilities	7 (1 079 363 ft^2)
Glovebox removal	1457
Pit (or trigger) shipment	100 percent of inventory*
EU parts destined for Oak Ridge	100 percent of inventory*
EU parts destined for other DOE sites	100 percent of inventory*
Pu parts destined for LANL	100 percent of inventory*
Pu parts destined for Savannah River Site	100 percent of inventory*
Pu metals and oxides	100 percent of inventory*
Low-level radioactive waste shipment	511 180 m^3
Low-level mixed radioactive waste shipment	48 288 m^3
TRU/TRUM shipment	15 011 m^3
Environmental remediation sites	360

*Quantity is classified information

What Brought It All Together?

Partnering with State and Federal Regulators

A key factor in Rocky Flats' success was the strong ties and open lines of communication that developed early on among Kaiser-Hill, the DOE, the state of Colorado, and federal regulators. The parties developed a common vision of the site in terms of the final end state based on foreseeable land use and then crafted a regulatory agreement that resulted in alignment on plans for decommissioning the nuclear facilities and on plans and designs for remediating environmental contamination. As trust was established and maintained, other important features of the agreement were developed. For example, one key feature was the annual establishment of enforceable milestones rather than the use of multiyear milestones. Selecting annual milestones acknowledged that the project and the environment in which it operates are in a constant state of change: new cleanup technologies emerge, new characterization information becomes available, changes in environmental regulations occur, and, sometimes, there are sudden changes to cleanup priorities due to changing human health or environmental risks. Another key feature was the eventual use of the contractors' project performance measurement system—earned value—to determine progress against the cleanup agreement.

Closure Contract

The closure contract between the DOE and Kaiser-Hill was another important facet of accelerated cleanup. Under this contract, the DOE transitioned its management style from managing the contractor (as in previous contract models such as Management and Operations contracts) to managing the contract. This change was an important one because the DOE communicated what it wanted to be accomplished by the scope of work contained in the contract, and the contractor, working with regulators and the community, determined how the work would be planned and executed.

In addition, the entire scope of closure work was authorized in the contract, allowing the contractor maximum flexibility. This enabled Kaiser-Hill to accelerate out-year work into the current work year without going through a lengthy review and approval process with the DOE.

Also, the contractor could receive progress fee payments based on performance and using standard project-measurement techniques such as earned value, cost and schedule variance, and the accomplishment of various planned activities. But the fee would not be "final" until the entire scope of work—closing Rocky Flats—was accomplished.

Another important facet of the closure contract was the way in which project risks were handled. Under the Rocky Flats Closure Contract, almost all project risk that is under the control of the contractor is assumed by the contractor. Examples of these types of risk include the methods the contractor uses to perform a certain type of work. Similarly, almost all external risk is assumed by the DOE because it is out of the contractor's control. An example of this type of risk is the availability of DOE sites to receive waste. The result of this appropriate sharing of risk is that the number of project change actions was greatly diminished.

Spots of contamination from Building 771 structural concrete are sealed with an encapsulant and marked in bright colors. This allows demolition workers to easily identify pieces of concrete that will be packaged for low-level radioactive waste disposal. The remainder of the building, once called "the most dangerous building in America" by ABC News' Nightline, was decontaminated to free-release levels.

Kaiser-Hill believed that by engaging the community early on in the decision-making process, they could address concerns early in the planning stages and ultimately obtain greater community support for Rocky Flats initiatives.

Also significant in the closure contract was the way in which the DOE gave incentive to the contractor to save cost and accelerate schedule. Under the Rocky Flats contract, the DOE shared $0.30 with the contractor for every $1.00 saved up to a predetermined maximum fee. Also, the closure contract contained significant penalties for poor safety and compliance performance. These contract provisions proved to be a powerful incentive to work safely, innovatively, and cost-effectively.

Project Management

Managing the safe, accelerated cleanup of Rocky Flats could not have been possible without a commitment to develop and institute a project management culture. This approach included training staff in project management principles, selectively augmenting existing staff with experienced and expert project management and project controls staff, developing and implementing sitewide project controls and planning guidance, and developing a detailed project plan (lifecycle baseline) that encompassed the entire scope of the closure contract and integrated the cost and schedule of completing that scope. Execution to the baseline was closely measured not only by Kaiser-Hill, but also by the DOE, which had unencumbered "read only" access to the entire baseline as its current status was routinely reported through a computer program called Joshua that connected all subprojects and the central project controls community.

When the closure contract was signed in January 2000, Kaiser-Hill organized the site into subprojects that were based primarily on the location of specific facilities. For instance, the Building 771 Closure Project performed decontamination, decommissioning, and demolition of Building 771, and the 371 Closure Project focused on Building 371 and its cluster of support facilities. Crosscutting projects included the Material Stewardship Project for management of all site waste and the Site Services Project that maintained infrastructure and utilities. Each of these project organizations included dedicated project-controls and planning staff to support the execution of the project and ensure that sitewide project management guidance was being followed.

The development of the lifecycle baseline was a key step in executing the project. Contractually, the baseline was the way in which the DOE would measure project progress, particularly cost and schedule variance, as a means to support the fee-determination process.

The baseline had a number of key features:

- The Work Breakdown Structure reflected the way work would be delivered by the project organizations (rather than functional, as had been past practice).
- The baseline described how the scope of work would be accomplished for the funding levels specified by the DOE in the contract with a minimal amount of contingency in the first few years of the project.
- In addition to the contract baseline, an internal, working plan was also developed that reflected stretch goals for the project as a whole and for the individual project organizations. This working plan typically placed cost and schedule targets for all project work activities about 15 percent below the contract baseline. In this way, Kaiser-Hill was always stretching for difficult goals. In fact, the final project cost and schedule completion will more closely reflect the stretch goals set in 2000 than the contract baseline. Working toward this accelerated plan was the most important factor in achieving the closure project's substantial cost savings, due in large part to saving a year's worth of overhead and landlord costs.

A commitment was also made to develop a robust process—requests for equitable adjustment—to evaluate changes to the contract that occurred outside of the contractor's control and the cost and schedule impacts of these changes. This process was largely responsible for keeping project costs contained. In fact, the local DOE office routinely used the information contained in Kaiser-Hill's Request for Equitable Adjustment analyses to "push back" on new requirements being imposed on the site, citing the potential cost increases to the contract.

Workforce Management and Incentives

In 1995, Kaiser-Hill invested a significant amount of time improving its relationship with the site's unions and salary staff. A number of initiatives were launched to support building a workforce that was completely aligned with the goal of safe, accelerated cleanup. Initially, the focus was on improving the relationships with the unions. The former collective-bargaining agreements with the unions were not particularly conducive to doing cleanup work efficiently. Concessions were made by both parties, and a new collective-bargaining agreement was crafted that eventually (a) reduced the number of union classifications, allowing more freedom of movement of union workers between work activities; (b) enabled the sharing of monetary incentives with the union that were tied directly to the same incentives in Kaiser-Hill's overall contract—achieving safe, accelerated cleanup progress while minimizing costs; (c) provided additional compensation to workers working in hazardous environments; and (d) allowed the use of on-the-spot rewards for outstanding performance and innovation by individual members. Kaiser-Hill developed an incentive program for the

salaried workforce that tied incentives directly to contributions. This annual incentive had two components. The first was a direct cash incentive; the second, and larger, component was a "credit" incentive that would be paid at the end of the project based on overall project performance at completion. The ultimate value of the credit component would be determined based on the final project cost and could range from $0.00 to $1.00 per credit granted. Both the union and salary incentive programs were effective in improving project performance and stimulating innovation, which ultimately resulted in saving hundreds of millions of dollars.

One of the most important components of workforce management at Rocky Flats was fully involving the workers in the preparation of work planning—defining scope, analyzing hazards, and implementing controls to mitigate the hazards. This collaborative effort resulted in a continuously improving safety record throughout the duration of the project, as well as cost savings and schedule acceleration.

Stakeholder Alignment

Kaiser-Hill initiated a number of programs to engage key stakeholders—local municipal governments and citizens—because they would be most affected by the decisions regarding Rocky Flats cleanup and closure. Kaiser-Hill conducted routine meetings with community members on issues and decisions facing the site. By engaging the community early on in the decision-making process, Kaiser-Hill could address concerns early in the planning stages and ultimately obtain greater community support for Rocky Flats initiatives. State and federal regulators also participated in the meetings.

Kaiser-Hill also ensured that community members had the opportunity to see work performed at the site by hosting frequent tours. Furthermore, Kaiser-Hill engaged the business community in supporting the closure efforts. The local chambers of commerce and the regional coalition of local governments were routinely informed of what was going on at Rocky Flats. As a result, they became ardent supporters of the cleanup.

Deployment of Closure Technologies

In 1997, Kaiser-Hill established a technology-deployment program to support cleanup activities. The emphasis was on integrating innovative technologies into the projects rather than performing research and development. Kaiser-Hill negotiated an agreement with the DOE whereby the DOE would share the risk of deploying technologies by sharing the cost with Kaiser-Hill. This new way of doing business has since become the model for the other closure sites.

A key aspect of Kaiser-Hill's successful technology-deployment program was the innovative atmosphere that was created. This environment allowed the workforce to innovate and deploy technologies with the recognition that sometimes the innovations and technologies would fail. The success of the technologies and innovations that did work greatly outweighed—in terms of safety, cost, and schedule project performance—the setback from technologies that did not work.

Managing a Large Workforce in Transition

Management of a workforce that is literally working itself out of a job was an ongoing challenge. This year was particularly challenging because nearly all of the 2000 remaining Kaiser-Hill employees and its subcontractors will be leaving the site by the end of the year.

In April 2003, Kaiser-Hill launched the aggressive Workforce Transition Program to assist employees whose jobs will be ending as the project draws to a close. Workers were provided a full menu of services available to them under the Workforce Transition Program to help them move to new careers, start a new business, retire, or make other choices. As part of this innovative program, Kaiser-Hill created the high-tech Career Transition Center managed by a professional outplacement firm. It offers current and former employees a wide range of services, including career counseling; an entrepreneurial resource program; a unique, internet-based, interactive career transition assistance website; and many other resources.

The program also has a job development team to work with other DOE sites and with local companies and organizations to develop partnerships and create job opportunities for the Rocky Flats workforce. The program has sponsored a number of job fairs and subcontractor forums, placed full-page newspaper advertisements highlighting the workforce's job skills, and worked with the governor's office to promote the workers to a variety of businesses. ■

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