WM2008 Conference, February 24-28, 2008, Phoenix, AZ
Abstract #8350

Long-Term Surveillance and Maintenance at Rocky Flats: Early Experiences and Lessons Learned

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ABSTRACT

The U.S. Department of Energy's (DOE's) Rocky Flats Site was established in 1951 as part of the United States' nationwide nuclear weapons complex to manufacture nuclear weapons components. In 1992 weapons production halted, and the Rocky Flats mission changed to include environmental investigations, cleanup, and site closure. In October 2005, DOE and its contractor completed an accelerated 10-year, $7 billion cleanup of chemical and radiological contamination left from nearly 50 years of production. The cleanup required the decommissioning, decontamination, demolition, and removal of more than 800 structures; removal of more than 500,000 cubic meters of low-level radioactive waste; and remediation of more than 360 potentially contaminated environmental sites.

The final remedy for the site was selected in September 2006 and included institutional controls, physical controls, and continued monitoring for the former industrial portion of the site. The remainder of the site, which served as a buffer zone surrounding the former industrial area, was transferred to the U.S. Fish and Wildlife Service in July 2007 for a national wildlife refuge.

DOE's Office of Legacy Management is responsible for the long-term surveillance and maintenance of Rocky Flats, which includes remedy implementation activities and general site maintenance. Several factors have complicated the transition from closure to post-closure at Rocky Flats. The early experiences associated with the two years since the physical cleanup and closure work were completed have led to several valuable lessons learned.

INTRODUCTION

Due to historical releases of hazardous substances, including plutonium, depleted uranium, organic chemicals, and hazardous waste constituents, the U.S. Department of Energy's (DOE's) Rocky Flats Plant was listed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List in 1989. DOE completed cleanup and closure in October 2005 under the July 1996 Rocky Flats Cleanup Agreement (RFCA) [1]. The RFCA approach involved an accelerated 10-year, $7 billion cleanup of chemical and radiological contamination left from nearly 50 years of production. The cleanup required the

decommissioning, decontamination, demolition, and removal of more than 800 structures; removal of more than 500,000 cubic meters of low-level radioactive waste; and remediation of more than 360 contaminated and potentially contaminated environmental sites. (Refer to the DOE website at www.lm.doe.gov for additional information on the Rocky Flats Site's cleanup and closure.) Figures 1 and 2 present 2001 and 2007 aerial photographs of Rocky Flats, respectively.

After completion of the physical cleanup and closure work, referred to as "post-closure," the Rocky Flats property was configured into two CERCLA Operable Units (OUs). The Central OU consolidates all areas of Rocky Flats that have remaining hazardous substance contamination and require additional remedial actions. The Peripheral OU surrounds the Central OU and includes the other generally unaffected portions of Rocky Flats that served as a buffer zone surrounding the former industrial area. Figure 3 presents the locations of the Central and Peripheral OUs at Rocky Flats.

Under the September 2006 Corrective Action Decision/Record of Decision (CAD/ROD), signed by DOE, the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE) [2], the final remedy is no action for the Peripheral OU, and institutional controls, physical controls, and continued monitoring for the 1,309 acres that comprise the Central OU.

The low levels of contamination remaining in the Central OU do not pose an unacceptable risk to human health or the environment for the wildlife refuge land use; however, the remedy does not allow for unlimited use and unrestricted exposure in the Central OU. Therefore, periodic review is required under CERCLA at least every five years (known as the "CERCLA five-year review") to determine whether the Central OU remedial actions remain protective of human health and the environment.

Most of the land in the Peripheral OU was transferred to the U.S. Department of the Interior in July 2007 to establish the Rocky Flats National Wildlife Refuge, under the jurisdiction and control of the U.S. Fish and Wildlife Service (USFWS) [3]. (The USFWS website at www.fws.gov provides additional information on the establishment of the wildlife refuge.) The remaining portions of the Peripheral OU, on which third-party mineral rights holders are currently conducting permitted surface mining operations, will also become part of the refuge under USFWS when the land is reclaimed in accordance with the mining permits. Under the Rocky Flats National Wildlife Refuge Act of 2001 (Public Law 107-107, Subtitle F, 16 USC 668dd) (Refuge Act), the United States will continue ownership of the Rocky Flats property in perpetuity.

DOE's Office of Legacy Management (DOE-LM) is responsible for the long-term surveillance and maintenance of Rocky Flats, which includes implementing the remedy, conducting environmental monitoring, and applying best land management practices for the Central OU and exercising jurisdiction and control of the Peripheral OU lands that have not yet been transferred to USFWS.

Fig. 1. Aerial photograph of Rocky Flats (2001), looking toward the northwest

Fig. 2. Aerial photograph of Rocky Flats (June 2007), looking toward the northwest

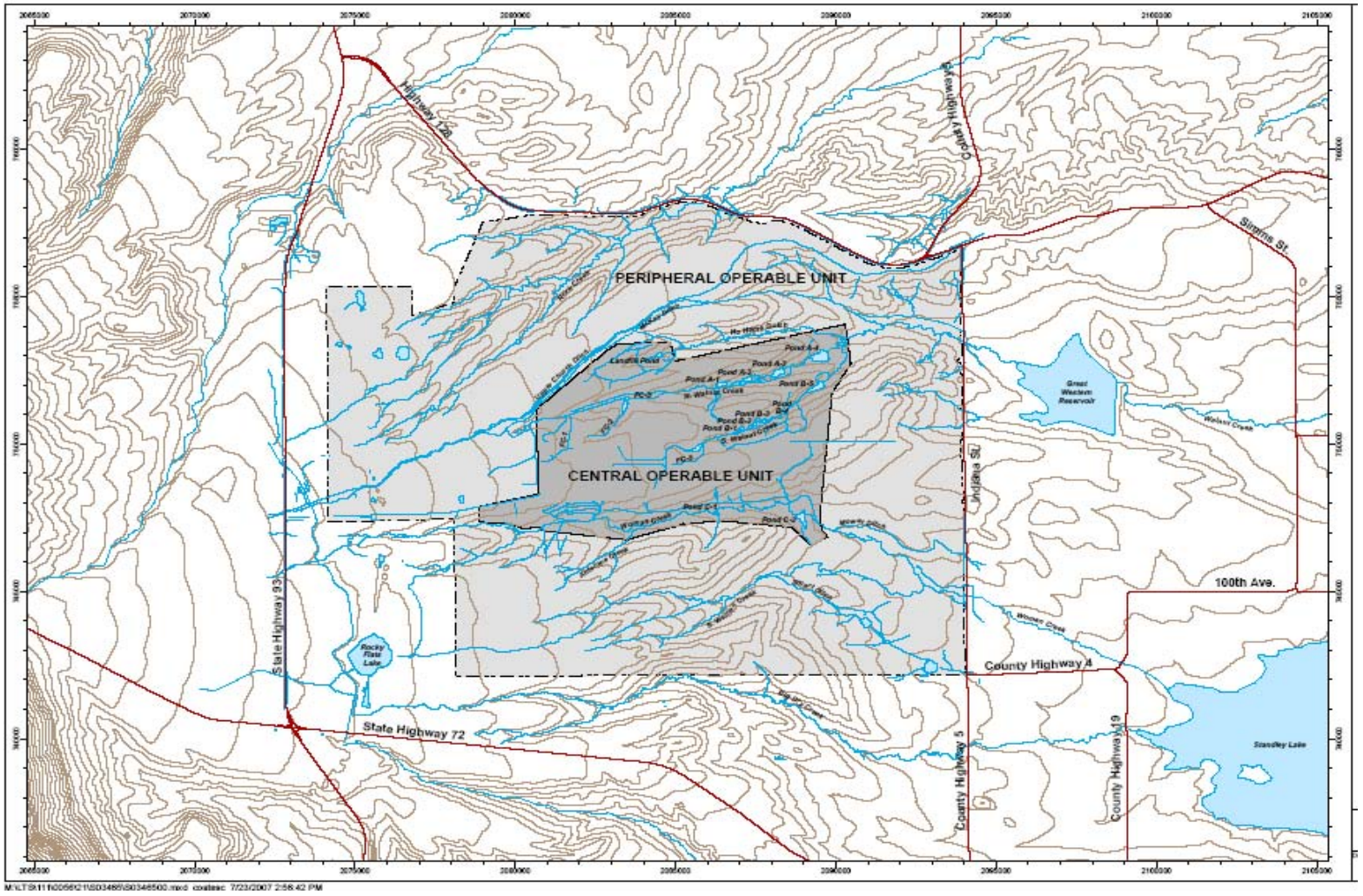

Fig. 3. Location of the Central and Peripheral OUs at Rocky Flats

During the almost two years since the physical cleanup and closure work were completed at Rocky Flats, several factors have complicated the transition from cleanup and closure to a post-closure project – some anticipated, others unexpected. Several factors to consider when planning for post-closure are discussed below.

LESSONS IN TRANSITIONING FROM CLOSURE TO POST-CLOSURE AT ROCKY FLATS

A site's transition from cleanup and closure to post-closure can vary depending on the complexity of the site, the physical work completed during cleanup and closure, and the post-closure surveillance and maintenance requirements. This paper describes some of the lessons from the transition experience at Rocky Flats that may provide useful information for other sites that are in the post-closure planning phase.

Shift to Small Organization

Sites should anticipate and plan for additional staff needs in the first one to three years (or longer, depending on the complexity and condition of the site) before achieving the smaller staff levels needed for long-term monitoring and maintenance. This may require a "virtual office" matrix organization to handle the wide variety of tasks that come early in the post-closure period to develop the administrative, organizational, and technical regime needed for successful conduct of post-closure activities.

In addition, staff should be selected with the following criteria in mind:

- Good historical knowledge of the site;
- Expertise in a variety of technical and regulatory compliance areas relevant to the site;
- Flexibility to easily respond to changing conditions and requirements, including those that might be peripheral to primary area of expertise; and
- Ability to form working relationships with team members that are not located at the site.

Under the closure contract, Rocky Flats had thousands of staff and hundreds of subcontractors; each employee had a small slice of the action. Many resources were available to handle unanticipated activities. All support staff were located on site or within 5 miles of the site. After closure, the remaining 12- to 14-person administrative/technical staff were relocated in an office building approximately 15 miles from the Rocky Flats access gate, with technical and administrative support staff rounding out a matrix organization in other locations across the country.

The smaller organization has advantages and disadvantages. A small organization means that all staff necessary to participate in a decision could be consulted quickly, and issues can be discussed and resolved with input from a relatively small group. However, this also means that available staff can be easily overloaded when unexpected or unplanned work is required, or

when collateral duties take additional time. As part of the smaller group, staff members have had to become generalists as well as technical specialists. Senior staff with historical site knowledge eased the transition because there was no technical learning curve. In addition, the availability of subcontractors with historical site knowledge was helpful for specialized activities such as the CERCLA five-year review.

Although pre-closure planning identified expected staffing requirements for the anticipated post-closure activities, the actual staffing requirements were higher for a variety of reasons. For example, ground water treatment systems needed intensive maintenance shortly after closure, including media replacement at the Mound Site Plume Treatment System and excavation and repair or replacement of damaged plumbing components of the Solar Ponds Plume Treatment System. Also, a substantial amount of time and energy went into the transfer of the Peripheral OU to USFWS for the wildlife refuge, including a resurvey of the site boundary, transfer and/or closeout of easements, and coordination of ongoing operations with USFWS.

Staffing plans developed during pre-closure planning were based on predictions of staff levels needed to operate and maintain Rocky Flats in a stabilized and fully transitioned condition. However, transition proved to require a significant ramping up effort to actually get to the envisioned steady-state post-closure workload. Some of the items that impacted the workload during the early post-closure period at Rocky Flats are described and discussed in more detail below.

New Regulatory Requirements

Sites approaching final remedial decisions need to consider whether regulatory agreements may tend to expand the scope of work or level of effort needed to meet additional or expanded requirements beyond what is anticipated during development of remedial alternatives. Ideally, regulatory agreements should be drafted and released for public review at the same time as the Proposed Plan, so that procedures and implementation details are well known prior to the CAD/ROD. Sites should also consider that milestones for deliverables, such as periodic CERCLA reviews, scheduled shortly after the CAD/ROD may compete for resources needed to complete the procedures to implement the remedy.

Investigation and cleanup activities at Rocky Flats were conducted under three successive federal facility agreements and compliance orders, beginning in 1986 and culminating with RFCA. Cleanup, closure, and selection of the final remedy were accomplished in accordance with RFCA.

In March 2007, DOE, EPA, and CDPHE entered into the Rocky Flats Legacy Management Agreement (RFLMA). RFLMA establishes the regulatory framework for implementing the final remedy for Rocky Flats and ensuring it remains protective of human health and the environment. RFLMA modifies and supersedes RFCA, but carries on the DOE, EPA, and CDPHE consultative process and public participation approach that were essential to the success of RFCA. While the regulatory framework is important in detailing the legal framework, administrative responsibilities, and enforcement provisions related to implementing the remedy, it is most

important for planning, identifying, and allocating the resources to conduct the "scope of work" requirements of the agreement.

RFLMA had to be negotiated, released for public review and comment, modified as needed, and approved in a timely manner to ensure work performance met expectations. Although negotiations first began in 2005, a public comment draft RFLMA was not released until December 15, 2006, and RFLMA was not signed until almost six months after the CAD/ROD.

While many aspects of the work that would be regulated under RFLMA were expected and well understood continuations of activities conducted in the period after physical completion of cleanup and closure in late 2005, such as ground water and surface water monitoring, other aspects were in a developmental stage. The legacy management requirements are contained in RFLMA. Notable items in this regard were:

- Residual subsurface contamination - Several contaminated building basements and slabs, portions of process waste piping, and buried materials remain in the Central OU below 6 feet from the surface. RFLMA requires inspection for significant erosion annually and following major precipitation events to evaluate whether the erosion is in proximity to the contaminated subsurface features. The first required annual inspection was conducted in March 2007. Monitoring includes visual observation (and measurements, if necessary) of precursor evidence of significant erosion (cracks, rills, slumping, subsidence, sediment deposition, and so forth). Major precipitation events are defined as 1 inch of rain or significant snowmelt runoff over a 24-hour period.
- Physical controls - Required physical controls are signs posted at intervals around and at designated access points to the Central OU that must be legible from 25 feet. Physical controls also protect engineered elements, such as landfill covers, ground water treatment systems, and monitoring equipment. The condition of signs and other physical controls must be inspected and maintained on a quarterly basis. While not required by the remedy, a four-strand fence was constructed to delineate the Central OU boundary within the wildlife refuge, and the fence is used to mount the required signs. Thus, inherent in the maintenance of legible signs is inspection and repair of the fencing.
- Institutional controls - Administrative procedures are required to control all site modification, maintenance, or other excavation activities to prevent violation of the land use restrictions imposed by institutional controls. Also, the Central OU must be inspected at least annually to determine the effectiveness of the institutional controls and for any evidence of violations of those controls. All soil-disturbing activities are prohibited except in accordance with pre-approved procedures and an approved Erosion Control Plan.
- Operational monitoring and biological condition monitoring - Although not required by the CAD/ROD, DOE agreed to include in RFLMA several activities that were of interest to the regulators and the community. These included conducting ground water monitoring at boundary wells in the Peripheral OU, sampling terminal ponds prior to discharging impounded surface water from the Central OU into the stream reaches in the Peripheral OU, and inspecting for adverse biological conditions such as unexpected mortality or morbidity.

In order to organize and properly carry out these activities on a routine basis, processes and procedures had to be developed, staff with the requisite knowledge and expertise needed to be retained, and regulator approval of the Erosion Control Plan had to be obtained. A new Site Operations Guide (SOG), which is a nonenforceable procedures manual, was prepared to contain the processes and procedures used by staff in performing legacy management work. A Regulatory Contact Record process was also developed to document the consultative process toward decision making and the regulatory approval to conduct activities that are subject to institutional control restrictions, such as work requiring soil disturbance. RFLMA provided details regarding what work was required, while other documents, such as the SOG, provided details regarding how to perform the work.

During the time RFLMA was being finalized and the SOG was being developed, DOE was also required to conduct the second CERCLA five-year review for Rocky Flats, which was triggered by completion of the first review in 2002. The review was conducted by a team of DOE, EPA, CDPHE, USFWS, and S.M. Stoller (DOE's LM contractor) staff. The review report was submitted to EPA for approval to meet an August 1, 2007, RFLMA milestone. EPA approved the second five-year review report in September 2007 [4]. The purpose of the CERCLA five-year review is to determine whether the remedy remains protective of human health and the environment. Although the CAD/ROD had only recently been signed, a major focus of the review was to determine whether the RFLMA legacy management requirements, which are designed to ensure continuing protectiveness, were being implemented. This provided an additional sense of urgency to make sure the processes and procedures were in place and working as intended.

In addition, RFLMA required the following items be included in the review:

- Review of the continuing effectiveness of institutional controls, and whether additional response action could be taken, considering such things as advances in technology and the availability of funds that would reduce the need to rely on institutional controls; and

- A determination whether the remedy components, including requirements for monitoring, maintenance, and inspections; institutional controls; and reporting, will be continued, modified, or discontinued.

While the review was satisfactorily completed, it meant additional resources were needed to complete the effort. Following so soon after the CAD/ROD and coming at a time when RFLMA processes and procedures were still under development meant that fairly limited performance data were available. Triggering the five-year review from the CAD/ROD date would perhaps have been better; however, EPA was constrained by their five-year policy and guidance [5].

Additional Security Needs

When planning for post-closure activities, consider potential security concerns and, if need be, investigate subcontracting with an independent security company. Security concerns after closure may be more due to public perception than fact, but are no less important.

At the beginning of the post-closure period at Rocky Flats, DOE determined that there would be no need for site security or surveillance patrols, given that very little remained on site that required protection. Ground water wells and passive treatment systems were locked and only two storage shed-type buildings remained for storing tools, supplies, and ATVs. Automated surface water monitoring stations were considered the only items that might be attractive to vandals.

However, in the early months after closure, it became apparent that an after-hours security patrol would be beneficial for two reasons: 1) to alleviate community concern that the area was accessible, and 2) to discourage trespassers such as the ATV riders who crashed through the Rocky Flats boundary fence late one night. The patrol consists of a single unarmed subcontract patrol officer in a marked patrol vehicle whose primary mission is visibility. The officer spends a significant percentage of time parked in highly visible areas on busy roads on the perimeter of the Rocky Flats property so that the public is aware of a continuing security presence. Since transfer of land to USFWS for the wildlife refuge, which has not yet opened to the public, the officer also spends significant time informing potential visitors that the refuge is not yet open. The patrol has been effective in discouraging casual access by the public. The patrols will likely be reduced in the future when USFWS exercises more active management of the wildlife refuge.

IT Transfer

The information technology (IT) transfer team should include personnel familiar with the anticipated day-to-day operations of a similar site post-closure, in addition to IT professionals and the organizations that currently "own" the software, hardware, and individual database files. The type, content, and format of electronic information to be transitioned, as well as the systems to make that information available, should be thoroughly explored. The team should consider what will be needed to manage a site in post-closure and in what format, and not only what databases exist that need to be maintained as records. The timeliness of the information transfer is also important.

At Rocky Flats, the IT transfer turned out to be a several-year process. While much of the electronic information (databases, systems, and individual files) needed to maintain and operate Rocky Flats during post-closure was transferred, the process has proven to be problematic.

Insufficient resources were invested to determine the format and compile electronic information for subsequent use for long-term maintenance and operations. For example, updating the Geographic Information System (GIS) to include final closure condition coordinates delayed final transfer of the GIS hardware until almost two years after closure. Much of the work to compile, organize, summarize, and bring online needed electronic information was left until post-closure, adding unanticipated scope and straining available resources.

Sufficiency of Closeout Information

Establishing and, on an as-needed basis, meeting with a working group composed of personnel directly involved in the closure of a site, especially those performing the field work, can help make information on the remaining physical conditions more readily available for post-closure

activity planning and implementation. Complex sites approaching closure should establish such a team during the transition planning, and use them as a possible information resource as unanticipated activities or conditions warrant.

Some of the RFCA-required closeout reports for Rocky Flats have insufficient information to completely understand post-closure conditions. Thus, other documents in the Administrative Record or in the archived project files must be retrieved for needed information. Even if all documents were thorough and readily available, it would be extremely unlikely for all details of future interest to be included. Many activities performed after closure at Rocky Flats benefited from access to personnel who were involved in specific cleanup and closure projects with knowledge of exactly how and why certain things were done to close particular areas. However, this access was not readily available in most cases.

New Hydrologic Regime

Evaluations of potential hydrologic changes that can be performed during closure can prove very effective for comparison with observed post-closure conditions. Sites with water quality issues should perform detailed integrated flow and fate/transport modeling to identify potential data gaps and problem areas and issues. If possible, site-specific standards should be reassessed with the appropriate regulators, both to ensure all parties are aware of possible problem areas and to evaluate whether any regulatory modifications are appropriate or possible.

Rocky Flats underwent several years of demolition and excavation activities, including regrading and removing impervious surfaces, as part of closure. As a result, significant changes have occurred to ground water recharge, ground water seepage, surface water runoff, and water quality. The pre-closure modeling performed at Rocky Flats was helpful in assessing some of these changes. For example, the higher levels of uranium at select surface water monitoring evaluation points observed early in the post-closure period resulting from baseflow of ground water were predicted by pre-closure modeling. Due to the relatively low-permeability geologic materials and semiarid environment at Rocky Flats, hydrologic conditions will not stabilize for several years. In some cases, the site-specific standards for water quality are no longer appropriate for post-closure hydrologic conditions, although these standards are still applied.

Additionally, keeping clear records of the area-specific volumes of water used in dust suppression and other decontamination and demolition activities could prove very helpful to determine that portion of the water essentially lost to the ground and ending up as surface runoff or ground water recharge. This information may help to explain hydrologic conditions (such as elevated ground water levels, unusual changes in surface water flow rates, and so on) observed during, and up to several years after, site closure. Having access to a team of personnel involved in the closure, as described above, may also assist in evaluating unusual or unexpected hydrological conditions.

Weather Conditions

Planning for exceptional weather conditions can be difficult and costly, and generally is unnecessary. However, some consideration of weather extremes and their possible effects on

newly closed sites should be made during the closure planning process. Simple and inexpensive steps may be warranted, such as providing small stockpiles of gravel and road base for emergency road repairs that would help to reduce the ultimate cost and scale of the "final" repairs. Anticipated field projects should be prioritized and scheduled around normal seasonal conditions so that, for example, dirt road construction is not performed in what is typically the rainy season. In some cases it may also be appropriate to identify high-priority revegetation areas and provide imported water to those areas during drier periods in order to accelerate revegetation and reduce long-term erosion.

The first year after Rocky Flats closure saw very little rain, resulting in marginal revegetation growth. The second year saw record snowfalls, extended subfreezing conditions, and subsequent snowmelts, along with heavy spring rains. While these wetter conditions helped with revegetation performance, they also resulted in seeps and slumping on the Original Landfill cover installed in 2005, and revealed many areas where surface runoff caused unanticipated erosion and road damage requiring repair. The unusually severe weather also caused site access problems and significantly delayed some field projects due to mud and snow.

Simplifying Availability of Subcontract Support

During planning for transition, careful evaluation of the expected activities should be performed and decisions made as to which activities will be self-performed and which will be subcontracted. Subcontracting mechanisms should be as flexible as possible to permit quick response to unexpected conditions and changing requirements.

In the first years after transition at Rocky Flats, numerous small projects were required to respond to unplanned changes, needed repairs, or incidents such as a gate ruined by a car, snow removal after unusually heavy storms, and erosion from unusually heavy snowmelt. In the early days after transition, each small project required a separate procurement, which delayed the completion of the response to the problem, and required significant staff resources. A Statement of Work was developed and three Basic Ordering Agreement (BOA) subcontracts were awarded to cover a wide variety of tasks, from road repair to revegetation to earthmoving support. As a result, the on-site staff can initiate a task with a simple one-page work release plus a description of the work. With this mechanism in place, field work for a simple repair requiring no design or long-lead materials can be initiated very quickly, sometimes by the next day. Larger projects can also be performed with a BOA subcontract. This has significantly reduced staff time to initiate field projects and allowed quick response to situations that could have regulatory implications if not addressed quickly.

Revegetation Efforts and Erosion Control

Contractual agreements with the closure contractor(s) at sites where revegetation is required should specifically address the issue of soil quality and soil compaction. More stringent requirements and oversight of initial pre-closure revegetation activities with approval or signoff steps throughout the revegetation process could help eliminate problems that will not show up until a few years down the road. The choice of erosion controls should be considered and specifically addressed in contractual agreements between DOE and the closure contractors.

Post-closure reseeding efforts should also be considered and planned for in budgeting exercises, and if the closure contract does not sufficiently address soil quality and compaction, more intensive revegetation efforts should be budgeted and planned.

At Rocky Flats, approximately 650 acres of land were disturbed during cleanup and closure activities. Revegetation activities were conducted on all these areas. However, the successful reestablishment of the vegetation during the two years since closure has varied considerably at different locations. This variability can be attributed to several factors, including poor-quality soil substrate, compacted soils, variable climatic conditions that were not conducive to vegetation establishment and growth, poor installation technique, erosion control selection, and economics.

The quality of the substrate on which vegetation will be expected to grow is of paramount importance. This factor is key to determining the type of vegetation that will establish long term, including its sustainability and density. These characteristics are important because at Rocky Flats, as at many other LM sites, erosion control and protection of soil resources is crucial to meeting regulatory standards for water quality and preventing potential off-site migration of contaminants of concern. Establishing good vegetation is often part of the remedy and serves to protect disposal cell or landfill covers, maintain required soil depths above buried infrastructure, and in general protect water quality and the land surface from erosion.

At Rocky Flats, the soil substrate remaining after closure in areas previously occupied by parking lots, roads, and buildings bore little resemblance to the original Rocky Flats Alluvium, a very coarse, cobbly, rocky substrate. At these locations, the materials that remained after the asphalt had been stripped or buildings removed were often nothing more than road base or gravel. These areas have proven successful for growing “weeds,” but not so good for the desirable species that were being seeded.

From a practical and economic standpoint it was not feasible or necessary to import topsoil or enough compost to cover the entire 650 acres needing revegetation at Rocky Flats. However, at the locations of former parking lots, roads, and some buildings, improving these poor soils during final grading and site closure efforts would have resulted in much lower costs and more successful revegetation establishment. Since Rocky Flats closure, over 75 acres of roads, parking lots, and building areas have been revegetated. These areas have been re-ripped or scarified to reduce soil compaction and have had compost, slow-release fertilizers (Biosol® or Sustane® products), and mycorrhizal inoculants added as soil amendments to help provide a more suitable soil substrate for vegetation growth.

Other issues that have come up are related to project oversight/implementation and climate. It is apparent after two years that some revegetated areas at Rocky Flats were not seeded uniformly. For example, in some areas the vegetation occurs in strips (good establishment, little establishment, good establishment, and so forth), indicating insufficient seed was placed during initial revegetation efforts. As a result, additional reseeding has been conducted in these areas. Unanticipated climate extremes were also a factor in revegetation efforts and successes. Areas that were seeded at Rocky Flats in the spring of 2005 received sufficient moisture for germination to occur and a good cover of vegetation began to establish during the first growing

season. However, much of the reseeding that was completed later in the summer of 2005 or beyond did not establish as well. Moisture conditions were limited so the seed did not have much opportunity to grow prior to the first winter after closure. In 2006, most of the Front Range and Rocky Flats experienced a drought, causing little of the seed to germinate or begin to establish. Hence, in the first year after closure Rocky Flats had minimal vegetation establishment. While this is not a factor that can be controlled, it should be anticipated and considered in planning, as noted previously.

With the unexpected climatic conditions that affected the establishment of vegetation, the other erosion controls that had been installed became increasingly important to prevent potential erosion. Both water and wind erosion can be significant over short time periods, and selection of erosion controls should consider both of these erosion mechanisms. Most of the initial erosion controls that were installed at Rocky Flats during closure were either erosion blankets or hydromulch/flexible growth media-type products (Flexterra®). As closure approached, a switch was made to crimped straw where revegetation areas were flat and erosion potential was less. This choice may also have been made in an effort to reduce costs and increase the speed at which controls could be installed, given that other flat areas had previously received either erosion blankets or the Flexterra product.

During the first winter after closure (2005-2006), the high winds that Rocky Flats typically experiences in the winter months (50 to 100 mile-per-hour winds are not uncommon) blew most of the crimped straw away, stripping this protection from the exposed upper mesas and depositing several feet of straw on the downwind hillslopes and lower areas. The lack of protection on the upper areas allowed the already drought-limited soil moisture to be further reduced by the winds, adding to the stresses on vegetation establishment. In the lower areas where the straw was deposited in deep piles there is still little or no vegetation establishment two years later, because the straw is too deep to allow germination of the seed in the ground. Another problem related to the use of crimped straw was the abundant wheat that grew the first and second years from the seedheads that were present in the straw. The wheat crop further limited establishment of the seeded species by competing for resources such as nutrients and water.

Endangered Species Consultations

Sites that have Endangered Species Act (ESA) issues should consider and incorporate potential post-closure conditions, activities, and projects during the pre-closure consultation process. This would alleviate time-consuming consultations, delays, and workloads in the post-closure operating environment.

At Rocky Flats, the Preble's meadow jumping mouse (*Zapus hudsonius preblii*) is a federally listed, threatened species under the ESA. As such its habitat is protected by law and all activities that are conducted within its habitat must be discussed with USFWS under the consultation process. During cleanup and closure activities, DOE conducted a consultation with USFWS and produced a Programmatic Biological Assessment (PBA) that outlined and addressed all potential activities that might take place in the Preble's mouse habitat through completion of closure at Rocky Flats. USFWS approved the PBA and provided their biological opinion on the document,

giving approval for routine and cleanup activities to proceed in Preble's mouse habitat. During preparation of the PBA, however, little consideration was given to post-closure conditions or activities that would continue to be performed. As a result, considerable time and effort have been expended to amend the existing PBA and provide the required project notifications to USFWS.

CONCLUSIONS

The experiences at Rocky Flats and associated lessons learned could prove valuable to other sites as they prepare for closure and eventual post-closure. The lessons learned during the transition to post-closure are summarized as follows:

- Sites should anticipate and plan for additional staff needs in the first one to three years (or longer, depending on the complexity and condition of the site) before achieving the smaller staff levels needed for long-term monitoring and maintenance.

- Sites approaching final remedial decisions need to consider whether regulatory agreements may tend to increase the level of effort needed to meet additional or expanded requirements beyond what is anticipated during development of remedial alternatives.

- When planning for post-closure activities, consider potential security concerns and, if need be, investigate subcontracting with an independent security company.

- The IT transfer team should include personnel familiar with the anticipated day-to-day operations of a similar site post-closure, in addition to IT professionals and the organizations that currently "own" the software, hardware, and individual database files.

- Complex sites approaching closure should establish a working group composed of personnel directly involved in closure of the site to help make information on the remaining physical conditions more readily available for post-closure activity planning and implementation.

- Sites with water quality issues should perform integrated flow and fate/transport modeling to identify potential data gaps and problem areas and issues. If possible, site-specific standards should be reassessed with the appropriate regulators.

- The possibility of weather extremes and their effects on newly closed sites should be considered during the closure planning process. Anticipated field projects should be prioritized and scheduled around normal seasonal conditions.

- During planning for transition, careful evaluation of the expected activities should be performed and decisions made regarding the need for subcontracts. Subcontracting mechanisms should be as flexible as possible to permit quick response to unexpected conditions and changing requirements.

- As part of closure, contractual agreements covering revegetation efforts should specifically address the issue of soil quality and soil compaction. The choice of erosion controls should also be considered and specifically addressed, as well as planning for post-closure reseeding efforts.

- Sites that have ESA issues should consider and incorporate potential post-closure conditions, activities, and projects during the pre-closure consultation process.

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