Fig. 1. A map of the 109 sites the DOE expects will require long-term stewardship.

Long-Term Stewardship—Part II

Analysis and Planning

The U.S. Department of Energy analyzed sites that might need stewardship by first identifying sites where the DOE has remediation, waste management, or nuclear materials and facility stabilization responsibilities. The DOE then included in its analysis sites that have been (or will be) transferred to the department for long-term care. This resulted in the DOE's analyzing 144 sites in 31 states and one U.S. territory. Of these 144 sites, 109 are expected to required some degree of long-term stewardship based on completed or planned cleanup strategies (see Figs.1 and 2). Most cleanup plans have already received some level of regulatory approval. The sites expected to require DOE stewardship range from small sites (approximately the size of a football field) with limited contamination, such as the General Atomics site in California, to large and complex ones such as the Nevada Test Site (NTS), which is larger than the state of Rhode Island.

Part II in a two-part series on the issues in the DOE's long-term stewardship program to ensure that site remediation work will remain protective for future generations. Part I, which focused on the nature of the long-term stewardship problem, appeared in the July/August 2000 issue of Radwaste Solutions*.*

Nature and Extent of Stewardship Activities

The nature and extent of anticipated long-term stewardship activities at the 109 sites will vary based on the amount and type of residual contamination, the anticipated future site uses, and other factors (e.g., proximity to a river and floodplain). To understand how stewardship activities can vary across sites, the DOE analyzed the level of stewardship (e.g., active or passive) as well as the types of activities likely to be needed.

LEVEL OF STEWARDSHIP—ACTIVE AND PASSIVE

Of the 109 sites currently expected to require stewardship, 103 are expected to require *active* stewardship. Active stewardship ranges from detection monitoring on a continuous or periodically recurring basis to enforcing access and use restrictions. Sites expected to require active stewardship vary in size and complexity.

The DOE is expected to rely solely on *passive* stewardship at only 6 of the 109 sites. Passive stewardship requires less oversight and care. Enduring obligations may include permanent markers or public records to convey information on previous uses or residual contamination. Sites where the DOE plans to rely on passive controls include General Atomics and General Electric in California, where excavation and removal of contamination occurred to levels allowing for industrial use and where the U.S. Nuclear Regulatory Commission has released the site without radiological restrictions but where the DOE will need to maintain records of previous activities or residual contamination.

Long-term stewardship by the DOE is not currently anticipated at 35 sites, most of which were remediated under the Formerly Utilized Sites Remedial Action Program (FUSRAP). However, a record of the extent of cleanup will need to be maintained at a central DOE or federal archiving facility.

The number of sites where the DOE has stewardship responsibility may increase over time. Additional sites may be identified and added to the DOE's responsibility under existing or new laws. The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 directs the DOE to stabilize, dispose of, and control uranium mill tailings at inactive mill sites. Sites included under Title I of UMTRCA are those that operated prior to 1978 and where all uranium was produced for sale to the federal government. Title II of UMTRCA includes privately owned sites that were operating under an NRC license in 1978 when the act was signed. Title II gave the NRC the responsibility for transferring these sites to the DOE, to another federal agency, or to a state for long-term care after their licenses are terminated.

According to the Nuclear Waste Policy Act (NWPA), low-level radioactive waste (LLRW) disposal sites (with privately held licenses) can be transferred to the DOE upon termination of the site license (NWPA, Subtitle D, Sec. 151(b)). The DOE is authorized to take title of these sites if the NRC determines the transfer to be desirable, of no cost to the government, and necessary to protect human health and the environment. The NWPA also states that if LLRW is the result of a licensed activity to recover zirconium, hafnium, and rare earth metals from source material, the DOE shall assume title and custody of the site if requested by the site owner (NWPA, Sec. 151(c)). For example, in 1994, the secretary of energy assumed title to the Amax site in West Virginia under this section.

Conversely, some sites may be removed from the DOE's long-term stewardship responsibility, or sites may require stewardship for only a finite period. As contaminants decay, or if standards become less restrictive, the number of sites and the level of long-term stewardship required will decrease. In addition, some sites may require long-term stewardship, but not by the DOE. For example, at the request of the state of North Dakota, the DOE revoked the UMTRCA designation of the Belfield and Bowman, N.D., sites. As a result of the revocation, effective May 18, 1998, the sites will no longer require remediation under UMTRCA, and the state of North Dakota will be responsible for any long-term stewardship required at the sites.

Although statutory and regulatory requirements provide guidelines for a blueprint for long-term stewardship, it is not clear that existing requirements anticipate the measures that may be needed in the future for long-term stewardship.

Stewardship by Media Type: Water, Soil, Engineered Units, and Facilities

The nature and extent of stewardship will vary depending on which media are contaminated. To better understanding the magnitude of the challenges, the DOE identified for each site four categories of media that will likely remain contaminated: soil, water, engineered units, and facilities.

Water includes groundwater, surface water, and sediments. Groundwater at approximately 100 sites is expected to require long-term stewardship. The types of stewardship activities will range from future use restrictions to continuous pumping. In some cases (for instance, the South Valley Superfund Site in New Mexico), the DOE must supply alternate sources of drinking water to local residents. In other cases, such as many former uranium mill sites, background levels of contaminants are high and/or the natural quality of the aquifer is poor due to brine; however, mining and milling activities resulted in elevated levels of uranium in the groundwater. At those mill sites where groundwater cleanup is neither feasible nor warranted (for example, Ambrosia Lake in New Mexico), monitored natural attenuation processes will be relied on to reduce contaminant levels. No active groundwater remediation will be performed. At some mill sites where groundwater is contaminated (e.g., Durango, Colo.), the DOE is proposing monitored natural attenuation as the most appropriate rem-

FIG. 2. Residual contaminants and anticipated stewardship by site and media.

State	Site Name	Soil					Water					Engineered Units						Facilities				
		VOCs	Metals	Rads	PCBs	Steward	VOCs	Metals	Rads	PCBs	Steward	Haz	MW	LLW	San/SW	TRU	Steward	VOCs	Metals	Rads	PCBs	Steward
Alaska	Amchitka Island	●		●		A			●		A						N					N
Arizona	Monument Valley			●		P			●		A						N					N
	Tuba City			●		P			●		A			●			A					N
California	Energy Technology Engineering Center	●			●	P	●		●		A	●					A		●	●		A
	General Atomics		●	●		P					N						N			●		N
	General Electric Vallecitos Nuclear Center					N					N						N			●		P
	Laboratory for Energy Related Health Research			●		A					N						N			●		P
	Lawrence Berkeley Laboratory	●	●			A	●		●		A						N			●	●	P
	Lawrence Livermore National Laboratory - Main Site	●		●		A	●		●		A			●			A			●		P
	Lawrence Livermore National Laboratory - Site 300	●			●	A	●		●		A		●				A					P
	Sandia National Laboratories/ California	●				P	●				A				●		A					N
	Stanford Linear Accelerator Center	●			●	A	●			●	A						N					N
Colorado	Burro Canyon Disposal Site					N					N			●			A					N
	Cheney Cell			●		P			●		A			●			A					N
	Cotter, Canon City					N			●		A			●			A					N
	Durango			●		P		●	●		A			●			A					N
	Estes Gulch			●		P			●		P			●			A					N
	Grand Junction Office			●		P			●		A						N			●		P
	Gunnison Mill Site			●		P			●		A			●			A					N
	PEC/A, Durita					N			●		A			●			A					N
	Maybell Mill Site			●		P		●	●		P	●		●			A					N
	Naturita Site			●		P		●	●		A						N					N
	New Rifle Site			●		P		●	●		A						N					N
	Old Rifle Site			●		P		●	●		A						N					N
	Project Rio Blanco Site			●		A			●		A						N					N
	Project Rulison			●		A			●		A						N					N
	Rocky Flats Environmental Technology Site	●	●	●		A	●		●		A	●		●	●		A		●	●		P
	Slick Rock/ Old North Continent			●		P		●	●		A						N					N
	Slick Rock/ Union Carbide			●		P			●		A						N					N
	UMETCO, Maybell					N			●		A			●			A					N
	UMETCO, Uravan					N			●		A			●			A					N
Florida	Pinellas Plant					N	●				A						N					N
Idaho	Argonne National Laboratory - West		●	●		A		●	●		A						N			●		P
	Idaho National Engineering and Environmental Laboratory	●	●	●		A	●	●	●		A	●	●	●		●	A	●	●	●		A
	Lowman			●		P					A			●			A					N
Illinois	Argonne National Laboratory - East	●	●	●	●	A	●	●	●	●	A			●	●		A		●	●		P
	Fermi National Accelerator Laboratory				●	P					N						N					N
	Site A/Plot M, Palos Forest Preserve		●	●		A		●	●		A						N					N
Iowa	Ames Laboratory			●		A	●		●		A						N			●		P
Kentucky	Maxey Flats Disposal Site	●	●	●		A	●	●	●		A						N					N
	Paducah Gaseous Diffusion Plant	●		●	●	A	●		●	●	A	●		●	●	●	A	●	●	●	●	P
Mississippi	Salmon Test Site	●		●		P			●		A						N					N
Missouri	Kansas City Plant	●			●	A	●				A						N					N
	Weldon Spring Site Remedial Action Project			●		P	●		●		A		●				A					N
Nebraska	Hallam Nuclear Power Facility					N		●	●		A						N			●		A
Nevada	Central Nevada Test Site	●				P			●		A						N					N
	Nevada Test Site			●		A			●		A		●	●			A			●		A
	Project Shoal Test			●		P			●		A						N					N
New Jersey	Princeton Plasma Physics Laboratory	●				P	●				A						N					N
New Mexico	Ambrosia Lake			●		P			●		P			●			A					N
	Area Bluewater					N			●	●	A	●		●			A					N
	Bayo Canyon			●		P					N						N					N
	Homestake, Grants					N			●		A			●			A					N
	Los Alamos National Laboratory	●	●	●		A			●		A		●				A	●	●	●		P
	Lovelace Respiratory Research Institute			●		P	●				A						N					N
	Project Gas Buggy			●		P			●		A						N					N
	Project Gnome-Coach Test Area			●		P			●		A						N					N

KEY:
A=Active Stewardship by DOE
MW=Mixed Waste
Rads=Radionuclides
San/SW=Sanitary/Solid Waste
N=No Stewardship by DOE
PCBs=Polychlorinated Biphenyls
LLW=Low Level Waste
TRU=Transuranic
VOCs=Volatile Organic Compounds
P=Passive Stewardship by DOE
Haz=Hazardous Waste
Steward=Anticipated Stewardship Requirements

FIG. 2. Residual contaminants (continued)

State	Site Name	Soil					Water					Engineered Units						Facilities			
		VOCs	Metals	Rads	PCBs	Steward	VOCs	Metals	Rads	PCBs	Steward	Haz	MW	LLW	San/SW	TRU	Steward	VOCs	Metals	Rads	PCBs
New Mexico (cont)	Quivera, Ambrosia Lake					N			●		A			●			A				
	Sandia National Laboratories/New Mexico		●	●	●	P	●	●	●		A	●	●				A				
	Shiprock			●		P		●	●		A			●			A				
	SOHIO, L-Bar					N			●		A			●			A				
	South Valley Superfund Site	●				P	●				A						N				
	UNC, Church Rock					N			●		A			●			A				
	Waste Isolation Pilot Plant			●		P			●		A					●	A				
New York	Brookhaven National Laboratory	●		●		A	●	●	●		A	●		●	●		A			●	
	Separations Process Research Unit			●		P					N						N			●	
	West Valley Demonstration Project			●		P			●		P			●			P			●	
Ohio	Ashtabula	●		●		P	●		●		A						N				
	Fernald Environmental Management Project			●		P			●		A	●	●	●			A			●	
	Mound Plant	●	●	●		P	●	●	●		A						N			●	
	Piqua Nuclear Power Facility					N					N						N		●	●	
	Portsmouth Gaseous Diffusion Plant	●	●	●	●	A	●	●	●		A	●		●	●		A		●	●	●
Oregon	Lakeview			●		P		●	●		A			●			A				
Pennsylvania	Burrell					N			●		A			●			A				
	Canonsburg			●		P			●		A			●			A				
Puerto Rico	Center for Energy and Environmental Research					N					N						N			●	
South Carolina	Savannah River Site	●	●	●	●	A	●	●	●		A	●		●	●		A	●	●	●	●
South Dakota	Edgemont Vicinity Properties					N					N			●			A				
Tennessee	Oak Ridge Associated Universities					N	●				P						A				
	Oak Ridge Reservation	●	●	●	●	A	●	●	●	●	A	●	●	●	●		A		●	●	●
Texas	Chevron, Panna Maria					N			●		A			●			A				
	Conoco, Conquista					N			●		A			●			A				
	Exxon, Ray Point					N			●		A			●			A				
	Falls City			●		P		●	●		A			●			A				
	Pantex Plant	●	●	●		P	●	●			A				●		A			●	
Utah	Atlas, Moab					N			●		A			●			A				
	EFN, White Mesa					N			●		A			●			A				
	Green River			●		P		●	●		A			●			A				
	Mexican Hat			●		P		●	●		A			●			A				
	Monticello Millsite & Vicinity Properties		●	●		A		●	●		A			●			A				
	Plateau, Shootaring					N			●		A			●			A				
	Rio Algom, Lisbon Valley					N			●		A			●			A				
	Salt Lake City			●		P		●	●		A						N				
	Salt Lake City, Clive					N			●		A			●			A				
Washington	Dawn, Ford					N			●		A			●			A				
	Hanford Site	●	●	●		A	●		●		A		●	●		●	A		●	●	
	WNI, Sherwood					N			●		A			●			A				
West Virginia	Amax					N		●	●		A			●			A				
Wyoming	ANC, Gas Hills					N			●		A			●			A				
	Exxon, Highlands					N					A			●			A				
	Kennecott, Sweetwater					N			●		A			●			A				
	Pathfinder, Lucky Mac					N			●		A			●			A				
	Pathfinder, Shirley Basin					N			●		A			●			A				
	Petrotomics, Shirley Basin					N			●		A			●			A				
	Riverton			●		P		●	●		A						N				
	Spook					P		●	●		P			●			A				
	UMETCO, Gas Hills					N			●		A			●			A				
	Union Pacific, Bear Creek					N			●		A			●			A				
	WNI, Split Rock					N			●		A			●			A				
Total		26	17	60	11		28	29	88	5		12	9	61	9	4		4	11	20	5

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P=Passive Stewardship by DOE
Haz=Hazardous Waste

edy. In addition, contaminated surface waters (including sediments) also may require attention and long-term care.

Soil includes release sites, burn pits, burial grounds, and areas contaminated from underground utilities, tanks, or surrounding buildings. Stewardship of contaminated soil is anticipated at 71 sites. At some sites, soil stewardship is driven by subsurface rather than surface contamination. At the "Nevada Offsites" (former nuclear test sites in Alaska, Colorado, Nevada, New Mexico, and Mississippi), extensive subsurface contamination exists from conducting underground nuclear tests. Because no cost-effective technology yet exists to remediate these types of subsurface contamination, they will continue to pose hazards over the long term. Stewardship activities will be required to prevent people from intruding into these areas in the future.

▲ *The "cocooned" C Reactor at the Hanford site. The C Reactor Interim Safe Storage project was completed in 1998. The final Safe Storage Enclosure represents only 19 percent of the original reactor footprint. This project reduces surveillance and maintenance entries to once every five years. All of the reactors at the Hanford Site will be placed in a similar interim safe storage mode for 75 years to allow the radioactive contamination to decay to safer levels, and the DOE will then consider options for their final disposition. During the interim safe storage phase, the DOE will be conducting technology demonstration projects to test at least 20 new technologies and approaches that may provide safer, less expensive, and more efficient ways to decommission aging nuclear facilities.*

Engineered units include radioactive, hazardous, and sanitary landfills; vaults; and tank farms with man-made containment systems. Engineered units at 70 sites are expected to require some level of stewardship activity. These include units such as the Environmental Restoration Disposal Facility and the high-level waste tanks at the Hanford Site. Engineered units generally contain large volumes of waste and contamination and include areas where the most highly contaminated wastes have been consolidated for permanent disposal or long-term retrievable storage. Engineered units will require active stewardship activities such as leachate collection, cap maintenance, erosion control, and access restriction. Data on the size and number of all the engineered units that will remain on DOE sites were not readily available for this analysis. Some sites, however, provided the precise number and size of engineered units that will remain onsite, with most sites containing only one or two units at closure.

While cleanup at the Hanford Site as a whole is not expected to be complete until 2046, cleanup of portions of the site is already complete, and stewardship is under way.

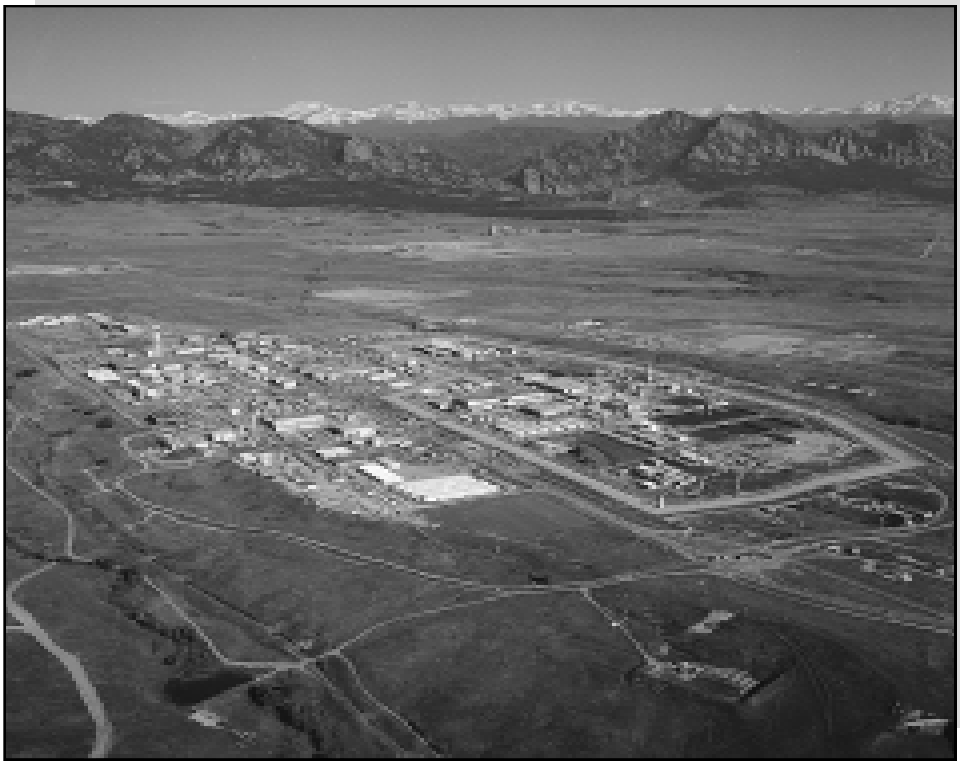
Facilities include entombed reactors, canyons, and other buildings with residual contamination, as well as remaining infrastructure. Contaminated facilities will remain at as many as 32 sites. Many of the currently contaminated buildings across the complex will be fully demolished and will require stewardship for only an interim phase prior to decontamination and demolition.

Most contaminated facilities can be addressed by decontamination or demolition and disposal. Consequently, contaminated facilities typically pose less of a technical challenge for cleanup and stewardship than underground storage and disposal situations, such as HLW tanks. Nonetheless, certain contaminated facilities pose significant stewardship challenges, such as the nuclear production reactors and chemical separations facilities (reprocessing "canyons"). These facilities are very large, with extensive radionuclide contamination that is both intense and long-lived, and that could pose risks to workers conducting remediation activities. There are no specific plans as yet for the final disposition of the canyons. One option being considered is to demolish the buildings, bury them in place, and put an engineered cap on the area. Whatever the final disposition, these facilities will be in a long-term surveillance and maintenance mode until final decisions are made and probably for very long periods of time thereafter. For example, the reactors at the Hanford Site will be placed in an interim safe storage mode for 75 years to allow the radioactive contamination to decay to safer levels, and the DOE will then consider options for their final disposition. During the interim safe storage phase, the DOE will be conducting technology demonstration projects to test at least 20 new technologies and approaches that may provide safer, less expensive, and more efficient ways to decommission aging nuclear facilities.

Timing of Long-Term Stewardship Activities

The DOE has already completed cleanup and is conducting long-term stewardship at 41 of the 109 sites expected to require stewardship. Long-term stewardship is also under way at portions of many other sites where cleanup activities and other missions (e.g., nuclear weapons maintenance) continue. Figure 2 illustrates that stewardship activities will increase as cleanup is completed:

- In 1989, 126 sites were undergoing active cleanup. Of the 18 completed sites, active stewardship was ongoing at 9 sites, passive stewardship at one site, and no stewardship at 8 sites.
- In 1998, fewer than half of the 144 sites were still undergoing active cleanup. Of the 74 completed sites, active stewardship was required at 39 sites, passive stewardship at 2 sites, and no stewardship at 33 sites.
- By 2006, only 21 of the sites (15 percent) are expected to be undergoing active cleanup. Of the 123 sites where cleanup is expected to be complete, active stewardship is anticipated at 84 sites, passive stewardship at 4 sites, and no stewardship at 35 sites.
- Active cleanup is expected to be completed at all sites by 2050. By then, active stewardship is anticipated at 103 sites, passive stewardship at 6 sites, and no stewardship at 35 sites.



▲ *The Rocky Flats Environmental Technology Site. The Rocky Flats Stewardship Dialogue Planning Group is addressing stewardship needs for the site and beginning to frame the critical issues and concerns associated with stewardship there.*

The 21 sites expected to require active cleanup beyond 2006 generally are larger sites or sites with contamination requiring more complex remediation measures. All 21 sites will probably require extensive stewardship. Some stewardship activities already are taking place at portions of these sites where specific remediation goals have been met. For example, while cleanup at the Hanford Site as a whole is not expected to be complete until 2046, cleanup of portions of the site is already complete, and stewardship is under way. As other portions of these sites meet cleanup goals, stewardship will begin there as well.

The duration of stewardship depends on the persistence of site hazards as well as the technologies available for remediation. The data submitted on the duration of stewardship activities were insufficient to determine a definitive end date for stewardship; however, several sites expected stewardship to be needed for 100 years or in perpetuity.

Land Use

As noted in Part I of this article (see *Radwaste Solutions*, July/August 2000, p. 35), future land use, cleanup strategies, and long-term stewardship are interdependent. Therefore, information regarding future land use for DOE facilities is critical for developing effective cleanup strategies and long-term stewardship plans.

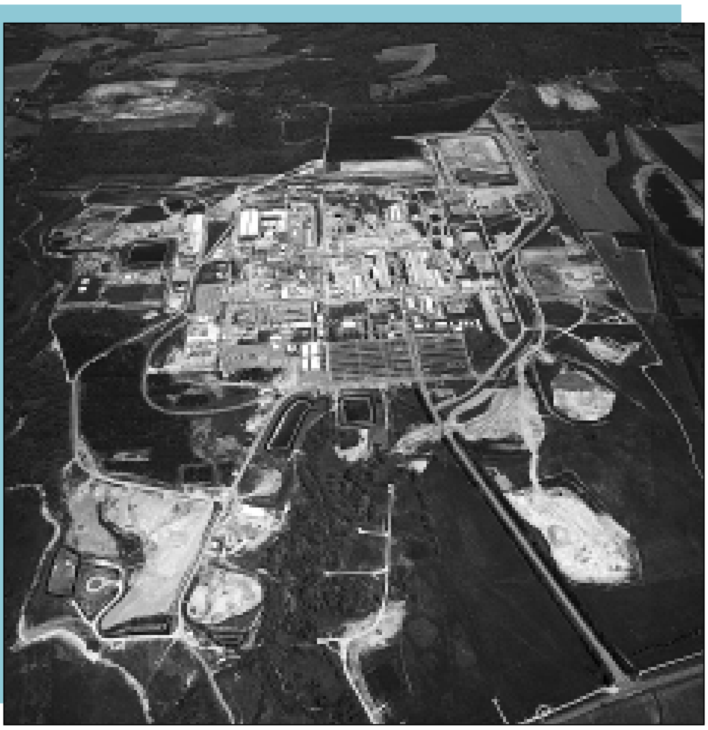
Because previous land use planning reports addressed only a limited number of sites, the DOE is seeking to improve its understanding of current and anticipated future land use to aid in site cleanup and stewardship planning. Moreover, the DOE is working with its field office personnel to develop common definitions for land use categories (e.g., industrial vs. recreational), which will allow for intersite planning and comparisons. Finally, site personnel are continuing to work with local governments and other stakeholders to develop plans for anticipated future land use that are consistent with required planning assumptions.

There are a number of reasons why decisions have not been made regarding postcleanup alternative future use of many sites. First, many sites have, or are seeking, a non–Environmental Management mission (e.g., nuclear weapons materials management or scientific research), so active DOE control of the site is expected to continue indefinitely. Second, many fundamental cleanup decisions have not been made (e.g., cleanup strategy, amount of residual contamination, and disposition of excess property); until decisions have been made on these issues, definitive future use cannot be determined.

In some cases, before determining the future use of a site, the DOE may prepare an environmental impact statement (EIS) or environmental assessment pursuant to the National Environmental Policy Act (NEPA) to analyze the potential environmental impacts of alternative uses. A number of DOE sites (e.g., Hanford, NTS, the Los Alamos National Laboratory) have already been the subject of an EIS covering land use. Land use or resource management plans have also been developed for other sites.

Current Organizational Responsibilities

Current responsibility for long-term stewardship resides with a variety of DOE offices. For most sites, when cleanup is ongoing, but where cleanup of certain por-



▲ *The Fernald Environmental Management Project. Malfunctions of various systems at the Fernald site resulted in releases of several hundred tons of uranium dust into the environment. Although remediation of contaminated soil can restore the Fernald site to an end state that serves a number of alternative land uses, residential and agricultural uses will not be considered. Institutional controls will be implemented to ensure that these restrictions are upheld.*

tions has been completed—e.g., Hanford and the Savannah River Site (SRS)—long-term stewardship is part of the overall infrastructure maintenance responsibility of the DOE operations office managing the site. For a number of sites where cleanup has been completed, personnel assigned to the Grand Junction Office (GJO) in Colorado perform a variety of long-term stewardship functions. The mission of the DOE's GJO is to assume long-term custody of certain sites where cleanup is complete and to provide a common basis for their operation, security, surveillance, monitoring, maintenance, annual reporting, and emergency response. There are currently five types of sites assigned to the GJO program for long-term surveillance and maintenance:

- UMTRCA Title I sites, which are inactive uranium milling sites where NRC licenses terminated prior to November 1978.
- UMTRCA Title II sites, which are uranium milling sites licensed as of November 1978.
- NWPA Section 151 sites that were privately owned and that contain radioactive wastes but not low-level mill tailings.
- Decontamination and decommissioning sites, including three entombed nuclear reactors (Hallam reactor in Nebraska, Piqua reactor in Ohio, and the Site A/Plot M burial site of Enrico Fermi's original "Chicago Pile" reactor in Illinois) and associated waste materials.
- Other sites, including the former Pinellas Plant in Florida, transferred to GJO in 1997.

It appears that long-term stewardship responsibilities for additional sites will be transferred to this program. For example, long-term stewardship responsibility for the Weldon Spring Site in Missouri is expected to be transferred to GJO in 2002.

The DOE's Nevada Operations Office is responsible for long-term stewardship at former nuclear explosion test sites in Alaska, Colorado, Nevada, New Mexico, and Mississippi (referred to as Nevada Offsites).

Other offices perform stewardship functions following waste management activities. For example, SRS personnel are managing two underground storage tanks that had been filled with HLW and subsequently "closed" by removing and vitrifying most of the waste and filling the tank with grout. Also, the DOE's West Valley (New York) personnel are developing long-term stewardship plans for the site following completion of waste management and other cleanup tasks.

The Big Unknown—The Costs of Post-Cleanup Stewardship Activities

There are a number of long-term stewardship activities for which funding will doubtless be required. First, there are tasks required as part of direct site maintenance, including site monitoring, maintenance of the remedy, and regular (e.g., annual or five-year) review of the long-term stewardship plan to determine if changes are appropriate. Second, site security and overhead costs may include maintaining fences, gates, signs, roads, and utilities (electric, water, and sewer) for security facilities. Third, a relatively small cost is required for record keeping, including archiving records, indexing, reproduction, title and deed recording, and distribution of records.

Compared to other activities (e.g., waste management, environmental restoration, fissile materials stabilization, and security), the DOE currently spends relatively little money on long-term stewardship. As part of its cleanup program, the DOE is seeking to lower the postcleanup risks as much as possible and, as a result, the required costs for long-term stewardship site maintenance. There is little specific information available, however, on the DOE's long-term stewardship funding requirements.

The primary reason for this lack of comprehensive and specific information is that the DOE is conducting much of its current long-term stewardship responsibility as part of the larger site infrastructure support and maintenance activities associated with operations. (In a broader sense, long-term stewardship is an extension of the current funding for site infrastructure to maintain safe conditions—e.g., roof repair, repaving parking lots, radiation control. Clearly, one of the goals of cleanup, in addition to reducing risks, is to reduce the cost of maintaining safe site conditions, thereby reducing long-term stewardship costs.) Because these costs are combined with other site maintenance costs, such as site security, emergency response, and road repair, there is relatively little explicit information on long-term stewardship. Moreover, long-term stewardship costs are dwarfed by other site support costs incurred during active environmental management (i.e., environmental restoration, waste management, and nuclear materials and facilities stabilization) or other missions (e.g., Defense Programs or Nuclear Energy). The costs for long-term stewardship are more apparent when these other costs are eliminated through completion of the environmental management missions or cessation of the other missions, thereby eliminating the need for large site infrastructure support funding. Also, site personnel cannot project long-term stewardship costs until specific end states are determined for the active environmental management tasks.

Nonetheless, the DOE has recently developed a significant amount of general long-term stewardship cost information, including cost elements (i.e., What is being funded?) and responsibility for costs (i.e., Who is funding it?), as well as some useful anecdotal cost information from specific projects.

The most explicit funding for long-term stewardship is provided through the GJO. The FY 1999 budget for the Grand Junction long-term surveillance and monitoring program is $1.6 million, with life cycle costs for individual sites ranging from $4000 to $2.5 million. These costs generally include collecting groundwater samples, repairing fences, conducting minor erosion control, restricting access, and conducting periodic surface inspections. These costs do not include potentially required major site repair if a breach in site containment were to occur. The costs also do not include active pumping and treatment of contaminated groundwater as part of a long-term remediation or containment system. In the near future, however, the GJO will likely be responsible for such "pump and treat" systems at three former uranium mill tailings sites.

The DOE's Nevada Operations Office has managed long-term stewardship (mostly collecting groundwater and surface water samples near the underground test locations) at the Nevada Offsites for about 25–35 years. These activities are assumed to continue indefinitely. Annual costs range from $30 000 to $50 000 per site. The monitoring at these sites is performed by the U.S. Environmental Protection Agency, but paid for by the DOE. Experience with these sites suggests that such monitoring can be conducted at a modest cost, although its direct applicability to other DOE sites has not yet been determined.

The uncertainties associated with long-term stewardship of DOE sites include the nature of the hazards, the effectiveness of monitoring and maintenance of barriers and institutional controls, and the cost of these activities.

Planning for Long-Term Stewardship

The DOE has made significant progress in its cleanup program. Workers have completed environmental restoration of hundreds of contaminated release sites across the nation. Millions of cubic meters of waste have been disposed of, much of it in independently regulated commercial facilities. The DOE has opened and begun disposition of radioactive transuranic (i.e., plutonium-contaminated) waste at the nation's first deep geological repository, the Waste Isolation Pilot Plant in New Mexico. The enduring success of all these activities will depend on effective long-term stewardship.

Running a long-term stewardship program over the extended period of time discussed in Part I of this article is an unprecedented task with many uncertainties. No existing institution has yet acquired experience in protecting public health and the environment from hazards for such a long period of time.

Although statutory and regulatory requirements provide guidelines for a blueprint for long-term stewardship, it is not clear that existing requirements anticipate the measures that may be needed in the future for long-term stewardship. Nor do they ensure the development of effective implementation strategies. The challenges ahead may be technical, economic, institutional, cultural, environmental, or of a type not yet anticipated. The uncertainties associated with long-term stewardship of DOE sites include the nature of the hazards, the effectiveness of monitoring and maintenance of barriers and institutional controls, and the cost of these activities. Other unknowns include the availability of adequate technologies, the future development of better remedial and surveillance technologies, long-term funding and other resources, and long-term management of data. These uncertainties and unknowns make it difficult to shape definitive plans for the many years that stewardship will be needed.

The long-term stewardship challenges facing the DOE also include the disposition of "materials in inventory." The DOE is responsible for managing a variety of materials resulting from the operation of large production facilities and numerous laboratories that acquired and produced enormous amounts of chemicals, metals, radioactive substances, and other materials. There are as yet no feasible disposition options for many of these materials, including both nuclear materials (e.g., uranium hexafluoride, U-233, spent nuclear fuel) and non-nuclear materials (e.g., radioactive sodium, contaminated metals). Managing these materials often involves stabilization and long-term storage until final disposition options become available. Much like the entombed reactors placed in interim storage until final disposition is pos-

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sible, these materials will require years of long-term management and control at DOE sites.

Despite these uncertainties, the DOE is carrying out its stewardship obligations and planning for future stewardship efforts. As the DOE accelerates cleanup, the need for postcleanup stewardship is also accelerated. Because stewardship is already under way at some sites and will soon be at others, the DOE needs to ensure that there is a smooth transition from cleanup to stewardship. To succeed, this planning must be done in consultation with federal agencies, Tribal Nations, state and local governments, and other stakeholders.

Personnel at DOE headquarters and many field sites are now examining future stewardship activities. In addition, states and Tribal Nations, through the State and Tribal National Working Group and local community groups and coalitions (such as the Energy Communities Alliance and the Rocky Flats Coalition of Local Governments), are working with the DOE to raise long-term stewardship issues and determine the best ways to address them. Other organizations, such as the National Academy of Sciences, the Environmental Law Institute, and Resources for the Future, are also considering stewardship issues, as are some of the national laboratories.

The Long-Term Stewardship Study

The DOE has begun planning for long-term stewardship through the process of developing the "Paths to Closure" document and "From Cleanup to Stewardship" (from which this article is taken), as well as through the accumulated experience of carrying out long-term stewardship in the field. The planning is still in its early stages; the DOE recognizes that more research and analyses are needed to ensure reliable and cost-effective stewardship at a programmatic level. The follow-on long-term stewardship study is the next step in this planning process.

The long-term stewardship study will describe the scope of the DOE's long-term stewardship responsibilities, the status of current and ongoing stewardship obligations, activities, and initiatives, and the plans for future activities; it will analyze the national issues the DOE needs to address in planning for and conducting long-term stewardship activities; and it will promote information exchange among the DOE, Tribal Nations, state and local governments, and local citizens. The study will *not* be a NEPA document or a "decision document"; it will not identify or address site-specific issues except as examples in the context of national issues; nor will it address issues specific to nuclear stockpile stewardship, other activities related to national security, or the Central Internet Database.

Development of the long-term stewardship study began with a public scoping process. Scoping includes opportunities for interested parties to learn about the goals of the study, comment on what issues or topics the study should consider, and discuss key elements of the study with DOE staff. Since there was no predetermined scope for the study, broad public input was essential. (The scoping period ended February 2, 2000.) Based on the results of the scoping process, the DOE is preparing a draft study that is anticipated to be released for public comment later in 2000. The public comment process will allow comprehensive public comment on the draft study. After the public comment period, the DOE will prepare a final study.

What Might Future Generations Question?

In 1995, the DOE published a document in which it asked, "What Might Future Generations Question?"

> A question that haunts many who are involved in the Department's environmental management program is: "What are we doing today that will prompt another generation to say, 'how could those people—scientists, policymakers, and environmental specialists—not have seen the consequences of their actions?'" . . . No one can yet know what these future questions will be, much less the correct answers. Nonetheless, part of the inheritance of the people working on this new enterprise is desired to look to the future and anticipate those questions.
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> If the intellectual giants of the Manhattan Project could not foresee all of the implications of their actions, it is particularly daunting for those involved in this new undertaking to consider what they might be missing in taking on the equally challenging task of cleaning up after the Cold War.

The question for current and future generations is "How do *we* ensure effective long-term stewardship of sites with residual waste and contamination?" The question has technical, financial, cultural, and institutional elements. We cannot today provide complete answers to it. But, as we conclude cleanup operations and dispose of waste, we will need to work together on individual community, state, and national levels to address this question.

For more information on the DOE's long-term stewardship initiatives, please log on to www.em.doe.gov/lts. ■

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