US Department of Energy's Environmental Management of Legacy Waste: Successes and Challenges - 9515

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ABSTRACT

Since 1989 the U.S. Department of Energy's (DOE) Office of Environmental Management (EM) has assumed primary responsibility for cleanup and removal or stabilization and containment, of the radioactive and chemical waste legacy of five decades of nuclear weapons production at over 100 sites in 34 states. Following the end of the Cold War in 1989, waste remediation became a high priority, and DOE entered into a series of tri-party agreements (TPA) with the Environmental Protection Agency (EPA) and various states, charting an ambitious and optimistic cleanup program, long before it had a detailed understanding of the magnitude of this legacy. DOE's *Baseline Environmental Management Report* (1995-96), charting a $250+ billion dollar cleanup requiring 75 years, painted a daunting picture of huge volumes and radio-activity of thigh level, transuranic, low level and mixed wastes, in solid and liquid form, in buildings, containers, lagoons, and tanks, including large scale contamination of soil, ground, and surface waters. Over its 20 year lifetime, EM has explored different approaches to setting priorities, including human health risk and operational risk. In 1997 DOE's *Linking Legacies* clarified how different aspects of the nuclear weapons cycle, particularly isotope separations, contributed to the waste inventory. By the mid-nineties DOE had already fallen behind many of the TPA milestones, incurring distrust from EPA, states, tribes, and site neighbors. At this time the Consortium for Risk Evaluation with Stakeholder Participation (CRESP), a multi-disciplinary, multi-university group, began working with EM on improving DOE's involvement of stakeholders in characterizing hazards, setting priorities, and considering remediation options. In 2008 CRESP undertook a review of EM's 20 year history, preparing a report on *Progress and Pathways* towards closure of sites. This paper reviews some of CRESP's findings, for example, that Tribes, regulators and other stakeholders around the largest sites (Hanford, Savannah River, Idaho National Laboratory), perceived little progress towards cleanup, partly because DOE still struggles with effective ways to make its plans transparent, and partly because metrics used by EM as part of its congressional budget process, do not provide a clear picture of either accomplishments or challenges. However, EM has actually made substantial progress in cleaning up and closing many smaller contaminated sites including Formerly Used Sites (under FUSRAP) and Uranium Mill Tailings Sites (under UMTCRA). The most high profile success was the complete decommissioning, demolition, and cleanup of the Rocky Flats plutonium production plant, deemed nearly impossible a decade earlier. Closure of that site allowed transfer of most of the 10 square mile property to the Department of Interior as a wildlife refuge, while a core area with residual contamination was transferred to DOE's Office of Legacy Management (LM), protected by a combination of engineered and institutional controls. DOE and its regulators, tribal neighbors and stakeholders at a variety of sites continue to wrestle with how goals and achievements in waste treatment and/or other clean-up, should be related to compatible future land uses, including those that incorporate the wildlife and recreational value of the large buffer areas at some sites. As EM sites have been "closed" and transferred to LM, EM now focuses budget, technology, and management, on the most vexing challenges, such as the leaking, sludge-filled, single-walled underground tanks at Hanford. Although DOE has achieved a remarkable worker safety record, many of the anticipated remediation tasks are risky for workers, particularly for contract workers. Finally, the inter-relationships between waste management, spent nuclear fuel transportation safety, nuclear security, and the future of atomic energy, Similarly, relationships among DOE sites, repositories such as the Waste Isolation Pilot Plant and Yucca Mountain, and related transportation issues must be clarified so that as wastes are treated or vitrified, they can be transferred to secure interim or

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INTRODUCTION

Since 1989 the U.S. Department of Energy's (DOE) Office of Environmental Management (EM) has assumed primary responsibility for cleanup and removal or stabilization and containment, of the radioactive and chemical waste legacy of five decades of nuclear weapons production on more than 100 sites in 34 states[1]. Some of these are small sites are near densely populated areas and others are large and remote with both contaminated central areas and uncontaminated buffers of ecological importance[2]. For more than 40 years following World War II, tensions between the United States and the Soviet Union waxed and waned, with rising tensions stimulating feverish investment and acceleration of the arms race. Worker safety and environmental protection were secondary to development, production, and testing, as each nation amassed its nuclear deterrence arsenal. The decline of the Soviet Union removed the sense of urgency signaling the end of the Cold War, and a 1989 FBI raid on the Rocky Flats plutonium plant near Denver, pointed out the flagrant violation of environmental regulations[3].

In 1989, the Department of Energy (DOE) established the Office of Environmental Management, entrusting it with responsibility for characterization and remediation of the Cold War legacy of nuclear and chemical waste [4]. Quite suddenly, environmental management replaced weapons production as top priority at many DOE sites.

Probably DOE's most important first task was to inventory the nuclear and chemical waste at each DOE site. However, while this task was ongoing, state and federal regulatory agencies became concerned with the hitherto unappreciated amount of nuclear waste, while lacking details on the nature of the waste or the magnitude of the task. To show good faith, DOE negotiated a series of tri-party agreements (TPAs) with the U.S. Environmental Protection Agency (EPA), and various states. The TPAs acknowledged DOE's responsibility for "cleanup". The TPA's loosely defined the cleanup goals (often to residential standards), and set milestones and timetables. Within the first few years of EM's existence it quickly became clear that the TPA goals and timetables were unrealistic, and as EM's cleanup accomplishments fell behind negotiated timetables, the EPA, states, tribes, and the public interpreted this in various ways, reflecting lack of trust of DOE and questioning of its actual commitment.

The new administration in 1993 ushered in an era of change for DOE, with transparency and declassification proceeding rapidly. The new Assistant Secretary of EM, Thomas Grumbly, recognizing the growing distrust among stakeholders requested the National Academy of Science to investigate how DOE could gain public confidence while planning and implementing remediation of the nuclear waste legacy. The 1994 National Research Council *Building Consensus* report [5] encouraged DOE to engage outside academic assistance and consultation in building a stakeholder program. Several organizations participated, including the Consortium for Risk Evaluation with Stakeholder Participation (CRESP), a multi-university, multi-disciplinary consortium (see www.cresp.org).

DOE's *Baseline Environmental Management Report* (1995-96) [6] painted a daunting picture of huge volumes and quantities of radio-activity of transuranic, high level, low level and mixed wastes, in solid and liquid form, in buildings, containers, landfills, lagoons, and tanks, including large scale contamination of soil, ground, and surface waters at sites in 34 states. It provided timetables for various remediation alternatives, and estimated a total complex wide cost of well over $200 billion dollars spread out over 75 years. BEMR and subsequent reports used a waste classification nomenclature evolved from the Atomic Energy Act (1954) and the Nuclear Waste Policy Act (1982), which was not based on risk and only partly on radioactivity. Over its 20 year lifetime, EM has explored different approaches to setting priorities, and has improved its communication with an dinvolvement of stakeholders, particularly around its largest sites.

In 1997 DOE's *Linking Legacies* [4] clarified how different aspects of the nuclear weapons cycle, particularly isotope separations, contributed to the waste inventory. CRESP began working with EM on

improving DOE's involvement of stakeholders in characterizing hazards, setting priorities, considering remediation options, changing one way communication into dialogue and building trust. The report contained information on the missions and functions of each of the country's nuclear weapons facilities, on the inventories of waste and materials remaining at these facilities, as well as on the extent and characteristics of contamination in and around these facilities. The Department's goal was to link two legacies nuclear weapons production and nuclear waste generation.
In 2008 CRESP undertook a review of EM, preparing a report on DOE's *Progress and Pathways* towards closure of sites [3]. This paper reviews some major findings of our report which emphasizes the progress that has been achieved since 1997 in eliminating, reducing, treating and/or safely containing the DOE's legacy waste streams. It identifies the challenges that have arisen or been recognized, as DOE struggles to develop sustainable environmental cleanup solutions. These include the technological challenges of extracting, separating and vitrifying high level tank waste; disposition of calcine and other wastes incidental to reprocessing; and the reliance on ultimate waste disposition in geologic repositories such as the Waste Isolation Pilot Plant (WIPP) and Yucca Mountain).

METHODS

CRESP undertook its *Progress and Pathways* study through a combination of general and site specific document review, literature search, examination of published budget proposals, and interviews with several of the former Assistant Secretaries of DOE-EM: Tom Grumbly, Carolyn Hontoon, Jesse Roberson, and James Rispoli. Albert Alm was deceased. CRESP benefited from having been involved closely at a number of sites and having participated actively in a risk-based endstate review of all DOE sites in the 2002-2004 period.

RESULTS AND DISCUSSION

Table I summarizes the location and status of some of the major DOE sites, including those closed and transferred to LM. The accelerated closure of sites such as Rocky Flats and Fernald advocated by Assistant Secretary Alm, and the closure of small sites advocated by Assistant Secretary Roberson, allowed EM to focus budget, technology, and management, on the most vexing challenges, such as the leaking, sludge-filled, single-walled underground tanks at Hanford. The Hanford situation is complicated by DOE's plans for complete "closure" of the entire 580 square mile site, while SRS and Oak Ridge have ongoing missions planned.

The congressionally mandated *Baseline Environmental Management Report* (DOE 1995-1996)[7] provided a site-by-site summary of the environmental cleanup requirements as well as projected life-cycle costs, proposed activities and schedules for accomplishing cleanup, taking into account future land use, funding, scheduling and technology development, but not competing demands.

Table 1. Department of Energy sites considered in Self Assessment for the Risk-based End-states in 2002-2004 with estimated EM completion date as of 2004 (updated from Burger et al. 2004 [8]

LTS Site	State	Regulating Law	EM Mission Completion Date	Continuing Mission
Amchitka Island	Alaska	AEA,RCRA	2006	No
Argonne National Laboratory East	Illinois	RCRA	2003	Yes
Argonne National Laboratory West	Idaho	CERCLA	2001	Yes
Astabula	Ohio	AEA/RCRA		No
Brookhaven National Laboratory	New York	AEA, CERCLA, RCRA	2005	Yes
Central Nevada Test Area	Nevada	AEA,RCRA	2012	No
Columbus-Battelle	Ohio	AEA		No
Energy Technology Center	California	AEA		No
Fernald	Ohio	CERCLA/RCRA		No
Gasbuggy Site	New Mexico	AEA,RCRA	2014	No
General Electric Vallecitos		AEA	2014	No
Gnome-Coach Site	New Mexico	AEA	2014	No
Hanford Site	Washington	CERCLA, RCRA (TRIPARTY) AEA	2035	No
Idaho National Laboratory (INL or INEEL)	Idaho	CERCLA, AEA, RCRA		Yes
Kansas City Plant	Missouri	AEA, CERCLA, RCRA	2006	Yes
Laboratory for Energy Related Health Research	California	CERLCA	2005	No
Lawrence Berkeley National Laboratory	California	AEA,CERCLA	2006	Yes
Lawrence Livermore National Laboratory - Main Site	California	AEA, CERCLA	2007	Yes
Lawrence Livermore National Laboratory - Site 300	California	AEA, CERCLA	2008	No

Los Alamos National Laboratory	New Mexico	AEA, RCRA	2015	Yes
Moab	Utah	AEA/CERCLA		No
Mound (Miamisburg)	Ohio	CERCLA	2006	No
Nevada Test Site	Nevada	AEA, RCRA	2027	Yes
Oak Ridge Reservation	Tennessee	CERCLA, RCRA, AEA,	2013	Yes
Paducah Gaseous Diffusion Plant	Kentucky	CERCLA, RCRA	2010	Yes
Pantex Plant	Texas	CERCLA, RCRA	2017	Yes
Portsmouth Gaseous Diffusion Plant	Ohio	RCRA,CERLCA, AEA	2019	Yes
Project Shoal Area	Nevada	AEA	2008	No
Rio Blanco Site	Colorado	AEA/RCRA	2009	No
Rocky Flats	Colorado	CERCLA (FFA) RCRA,AEA	2007	No
Rulison Site	Colorado	AEA/RCRA	2011	No
Salmon Site	MS	AEA/RCRA	2010	No
Sandia National Laboratories – NM	New Mexico	RCRA	2006	Yes
Savannah River Site	South Carolina	CERCLA, RCRA (FFCA) and AEA	2047	Yes
Separation Process Research Unit	New York	AEA/RCRA	2014	No
Stanford Linear Accelator (SLAC)	California	CERCLA	2006	Yes
Weldon Springs	Missouri	CERCLA		No
West Valley	New York	AEA	2112	No

The Legacy transcends waste per se, including contaminated environmental media, surplus materials, and "materials in inventory (see Table II).

MANAGEMENT AND CONTRACTS

Each Assistant Secretary brought to EM a vision and a responsibility. The responsibility was imposed by congress, regulators, and stakeholder expectations. The vision established priorities for accomplishing cleanup within the available budget of approximately $6 billion per year. However, each secretary encountered obstacles to cleanup, because much of the waste was inadequately contained, and maintenance of status quo, to prevent leakage, took priority over actual cleanup or volume reduction for nuclear material and facilities stabilization. This dilemma has been likened to a mortgage, where in the early years large expenditures cover the interest with only slight reduction in principal. Indeed the BEMR is about paying down the "Cold War Mortgage" of legacy waste.[6] The "interest" in this case involved maintaining physical integrity of storage tanks, interdicting ground water plumes, and other activities required to fulfill the common priority of preventing human exposure, mainly meaning offsite exposure. Assistant Secretary Grumbly was impressed with risk as a determinant of where to make major investments in remediation. His successor, Al Alm brought to EM a somewhat radical vision of accelerated cleanup, planning to achieve cleanup and closure within 10 years. Although this vision was not fulfilled, it did lead to remarkable progress in achieving closure of several of the most consequential sites (Rocky Flat and Fernald), as well as progress towards closure of UMTRA and FUSRAP sites.

Table II Four major legacy "Elements" from *Linking Legacies* [4]

EM assumed responsibility for four major legacy "elements"

- ***Waste****, including high-level, transuranic, low-level, and hazardous waste, byproduct material as defined under Section 11e(2) of the Atomic Energy Act of 1954, as amended, and other waste;*
- ***Contaminated environmental media****, which include soils, groundwater, surface water, sediments,debris, and other materials;*
- ***Surplus facilities*** *once used for nuclear weapons production that are no longer needed and are slated to be deactivated and decommissioned; and*
- ***Materials in Inventory****, which includes all materials not used in the past year and not expected to be used in the upcoming year.*

NOTE: DOE uses the term "hazardous" to refer to non-radioactive toxic chemicals. In discussions of risk, the term "hazard" or "hazardous material" would apply to both toxic and radioactive materials. The present report uses the DOE definition of "hazardous" = "toxic".

Contract Structures

During the Bombs Race (1942-1945) and the Arms Race (1946-1989), the development, production, testing of nuclear weapons was conducted at a network of sites (referred to as the "Nuclear Complex"), each of which was operated for DOE by a Maintenance and Operations Contractor with comprehensive responsibility for all activities on a site. In some cases secondary contractors were brought in as team members to make construction and infrastructure and/or security more efficient. In the mid-1990s, spurred by a new congressional mandate to "corporatize" operations, new DOE contracts were let for Maintenance and Integration, in which the large primary contractor's responsibility was restricted to integating the work of many subcontracors. The illusion of privatization was intended to reduce costs by allowing more specialized contractors to perform work, but did not achieve this objective at the Major Sites (i.e. Hanford, SRS), since new teams with limited institutional memory had to spend valuable time integrating new subcontractors. The additional tier(s) of subcontractors distanced DOE offices from the actual work and made it more difficult to provide oversight, particularly with regard to worker safety.[9] At Paducah, for example, the primary contractor found it difficult to find construction contractors to bid on the paving contract for a new storage pad for the uranium hexafluoride cylinders.

SITE CLOSURE AND LEGACY MANAGEMENT

Site closure for DOE refers to completion of the EM mission and transfer of the site to another agency, usually DOE-LM. In Rocky Flats, the core area with residual contamination was transferred to OLM while the larger peripheral area was transferred to USFWS as a wildlife preserve. CERCLA requires that DOE complete an Institutional Controls Plan. Whenever "the physical remedy does not allow for full, unrestricted use or when hazardous materials are left on site. The plan is a legally enforceable CERCLA document and part of the remedy for the site (a requirement of the U.S. EPA)." These plans include the maintenance of any ongoing remedies such as ground water remediation, leachate management, leak detection, environmental monitoring, as well as maintenance of security and information. Long-term management also includes plans for ongoing community involvement, for example the Fernald Community Involvement Plan “explains in detail how the public will continue to participate in the future of the Fernald site.”[10]

Perceptions of Progress
At Hanford and Idaho, Tribes, regulators and other stakeholders perceived little progress towards cleanup, partly because DOE still struggles with effective ways to make its plans transparent, partly because metrics used by EM as part of its congressional budget process, do not provide a clear picture of either EM accomplishments or its major challenges. But mainly the technological complexities have resulted in stalemates regarding high level waste management, or remediation of underground plumes.

Success Stories
Complex-wide, however, DOE has actually made substantial progress in cleaning up and closing many smaller contaminated sites including many of the 46 Formerly Used Sites (under FUSRAP) and Uranium Mill Tailings Sites (under UMTCRA). Table I, as well as closure of sites such as Fernald and Rocky Flats.

Rocky Flats
The most high profile success was the complete decommissioning, demolition, and cleanup of the Rocky Flats plutonium production plant, deemed nearly impossible a decade earlier. Jesse Roberson, manager of Rocky Flats (1996-1999) made closure a top priority, advancing the proposed closure date from 2015 to 2006. Major obstacles to safe cleanup included storage of plutonium in a variety of containers in a variety of places. Closure of that site allowed transfer of most of the 10 square mile property to the Department of Interior as a wildlife refuge, while a core area with residual contamination was transferred to DOE’s Office of Legacy Management (LM), protected by a combination of engineered and institutional controls.

Formerly Utilized Sites Remedial Action Program (FUSRAP)

The Atomic Energy Commission (AEC) established the Formerly Utilized Sites Remedial Action Program (FUSRAP) in 1974, “to identify, investigate, and take appropriate cleanup action at sites where work was performed in support of the Manhattan Engineer District (MED) and early AEC programs.”[11] These activities included uranium ore storage and processing, uranium metal machining, accelerator sites, and fuel element fabrication. The FUSRAP program identified 46 sites that were eligible for cleanup, and 25 cleanup and closures were by 1997, at which point the remaining responsibility was transferred to the Army Corps of Engineers [12]. Some of these sites have already been released for unrestricted use, although DOE/LM retains responsibility for the historical information and responding to inquiries. Other sites with residual contamination or storage cells are subject to long-term institutional controls.

UMTRCA Sites

Congress passed the Uranium Mill Tailings Radiation Control Act (UMTRCA) in 1978 (Public Law 95-604). Many of these were private mining or milling sites operating under active NRC licenses when UMTRCA was passed. Long-term custody of the site is the responsibility of either the federal government or the host state, at the option of the state. About 30 sites were subject to remediation under this act. Many of these sites have long-term radioactive waste storage cells, while others may have continuing mining operations. DOE retains responsibility for long-term surveillance “to ensure that the disposal cell systems continue to prevent release of contaminants to the environment.” This includes annual inspections and maintenance. Disposal cells are typically designed “to be effective for 1,000 years, to the extent reasonably achievable” [13].

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CHALLENGES REMAINING

Environmental management at DOE sites is far from complete. Indeed, with the exception of Rocky Flats, the impression is that low-hanging fruit has been picked. On the other hand, these closures represent, in many cases, real reduction of future exposure and health risks. The challenges are both technical and social.

The HLW remaining in the tanks at Hanford, Savannah River and Idaho is present in several different forms including as supernatant, aqueous salt solution, saltcake and sludge, and for those tanks from which the liquids and sludges have been removed, a residual material remains that is difficult to remove or characterize. Only West Valley and Idaho have processed the waste sufficiently so that the only major issues remaining concern tank residuals. Savannah River has made progress with sludge processing into a vitrified waste form (glass logs) but is still faced with salt solution and aqueous stream management and processing. Also, at SRS, tank capacity has become a critical factor.

Hanford

Probably the most serious challenge that remains on the DOE complex is the high-level waste in the Hanford tanks. In an effort to reduce leakage, many of the tanks have been successfully dewatered, resulting in solid and semi-solid heterogeneous sludges and slurries that defy characterization or control. These buried, one-shelled tanks have leaked or may leak, and transfer of the residual material (even if uncharacterized) to more secure containment, will require adding liquid as well as physical agitation. In addition to HLW, highly toxic constituents such as dimethylmercury[18], have been identified in some tanks. Attempts to transfer material from leaking to secure tanks has resulted in contamination, and jeopardized worker safety.

Also at Hanford, DOE has encountered controversy over whether there has been adequate characterization of all areas of Hanford, not just the tanks, with particular emphasis on the Columbia River.[19] DOE has divided responsibility for Hanford between two offices: the Hanford Operations Office and the Office of River Protection.

Future Land Use

In large part the TPAs assumed that DOE would cleanup most of the contaminated land to residential standards, allowing it to be turned over to communities for unrestricted use, while a few more highly contaminated areas would be capped and converted to commercial/industrial uses. These land use assumptions preceded the technical appraisals. Working with EM, CRESP provided evidence [20,21], that DOE's site neighbors were not necessarily in favor of these options, with preference for outdoor recreational opportunities or ongoing protection as National Environmental Research Parks. Freeing DOE of "residential standards", allowed more realistic priority setting and changes the risk assessment assumptions.

Assistant Secretary Roberson (2001-2004), who as site manager for Rocky Flats had played a lead role in its accelerated closure, attempted to re-evaluate plans and priorities at most sites based on risk-based endstates[22]. Sites were required to develop maps and conceptual site models, [23] to make the nature and magnitude of hazards as well as the receptors, pathways, and barriers to exposure, more transparent. The project updates a lot of information, but also engendered skepticism on the part of stakeholders, that DOE was trying to back away from previous cleanup commitments.

DOE and its regulators, tribal neighbors and stakeholders at a variety of sites continue to wrestle with how goals and achievements in waste treatment and/or other clean-up, should be related to compatible future land uses, including those that incorporate the recreational, wildlife and cultural value of the large buffer areas which are for the most part uncontaminated.

Part of the debate at Hanford focuses on treaty rights that concern future tribal access to traditional lands for traditional purposes, and whether current contamination or future spread of contaminants will jeopardize access. [24] DOE also maintains deed restrictions at some sites, such as Riverton, WY, limiting new wells adjacent to a former uranium processing site, and limiting use of state-owned property at the site.[25]

Spent Nuclear Fuel

Spent nuclear fuel (SNF) consists of the irradiated fuel or targets containing uranium, plutonium, or thorium that is periodically removed from nuclear reactors when the density of radioactivity is no longer sufficient to sustain the nuclear reactions and produce electricity or achieve other irradiation functions. It is categorized as “material in inventory” rather than “waste”.

Spent Nuclear Fuel (SNF) is both a current issue at three DOE sites (Hanford, SRS, INL), and a long-term national discussion topic which impacts the future development of nuclear power in the United States. Plans for Yucca Mountain included storage of commercial SNF, and the failure to achieve approval for this, has been a setback for the nuclear power industry. Reprocessing of SNF, brought to a halt in the 1970s, remains a future option, allowing SNF to be converted into forms that can be re-used, since only a part of the radioactivity is utilized in the first pass through a power plant.

INTERRELATIONSHIPS AMONG SITES

The ability of DOE to safely manage and dispose of the legacy waste, including the SNF at several of its sites, will clarify whether the nation can expect to safely manage the much larger quantity of SNF accumulating at commercial sites. The inter-relationships between waste management, nuclear security, transportation safety for spent nuclear fuel will impact the future of atomic energy. Similarly, relationships among DOE nuclear sites, repositories such as the Waste Isolation Pilot Plant (WIPP) and Yucca Mountain, and related transportation issues must be clarified so that as wastes are treated or vitrified, they can be transferred to secure interim or long-term storage.

Transportation of Nuclear Materials

During the Manhattan Project, and especially during the Cold War, materials produced at one DOE site had to be transferred to another for fabrication and assembly and ultimately testing or stockpiling of nuclear weapons. This was accomplished in secret with a high level of transportation safety. Today transportation of nuclear wastes and materials has become a high profile public policy issue facing DOE. Vitrified high level waste from SRS must someday find an interim repository. Hanford is large enough to allow onsite storage of nuclear materials, but current plans call for transferring Hanford’s waste to other sites. TRU waste is destined for WIPP and much has already been transferred there.

Waste transportation has been an obstacle for several plans, including Yucca Mountain. The National Academy of Science assembled a Committee to review the transportation of high level radioactive waste (HLW) and spent nuclear fuel (SNF). The report, released in 2006 [26] focused on the assumption that both materials (HLW and SNF) would be channeled to Yucca Mountain from DOE sites and commercial power plants near and far (mostly far). The report concurred with DOE’s decision that for the most part rail transportation would be more economical and safer than truck transport, but noted that a planned rail spur to Yucca Mountain had met public and state opposition.

Although the Committee could identify “no fundamental technical barriers” to the safe transport of spent fuel and high-level radioactive waste in the United States. it recognized the social and institutional challenges facing large-quantity shipping programs. The committee declared that it was “unable to perform an in-depth examination of transportation security because of information constraints.” Unfortunately this vitiated a large part of the report substance because theft or terrorism are major public concerns about radioactive transport.

Whereas cask and vehicle design can be specified, route selection and assumptions about driver safety and vehicle speed are flexible. Modeling route selection has been examined in several contexts. Models invoked to demonstrate that nuclear materials can be safely transported, have been criticized [27] for using unrealistically slow truck speeds as the basis of force calculations (force being an exponential function of velocity).

DOE is required by statute to rely on private contractors for transportation, but such reliance does not assure that the private sector can achieve the high commitment to safety that the public expects. For example, Utah Governor Leavitt,[27] testified that the Private Fuel Storage company was extremely deficient in preparing a Baseline Environmental Impact Statement for the proposed interim storage site and its associated transportation corridors.

The NRC Committee concluded that “radiological health and safety risks associated with the transportation of spent fuel and high-level waste are well understood and are generally low, with the possible exception of risks from releases in extreme accidents involving very long duration, fully engulfing fires. The likelihood of such extreme accidents appears to be very small, however, and their occurrence and consequences can be reduced further through relatively simple operational controls and restrictions.”[26:4]

Both physical [28] and modeled [29] transportation events involving radioactive material have been simulated. Biwer and Chen [29] of DOE’s Argonne National Laboratory simulated a rail transportation accident of SNF in Chicago, and concluded that under their worst case, human exposure in the aftermath of the release would be equivalent to about one year exposure to background radiation.

CONCLUSIONS

Ultimately EM’s mission includes the cleanup and closure of all contaminated sites, allowing it to declare completion and transfer responsibility to LM or some other agency. For sites, such as SRS that have an ongoing mission, the EM components still require cleanup and closure. During its 20 years EM has achieved major successes in remediating and closing many sites, releasing some for unrestricted use, while those with residual contamination are under LM which assumes responsibility for maintaining the engineered and institutional controls assuring the ‘sustainable protectiveness of people and the environment”. Although Tribes, regulators and other stakeholders around the largest sites (Hanford, Savannah River, Idaho National Laboratory), perceive little progress towards cleanup, EM has actually made substantial progress in cleaning up and closing many smaller contaminated sites. The most high profile success was the complete decommissioning, demolition, and cleanup of the Rocky Flats plutonium production plant, deemed nearly impossible a decade earlier. Site concerns transcend the EM closure mission, since stakeholders are concerned about DOE’s ability to maintain its long-term commitment to legacy stewardship.

DOE and its regulators, tribal neighbors and stakeholders at a variety of sites continue to wrestle with how goals and achievements in waste treatment and/or other clean-up, should be related to compatible future land uses, including those that incorporate the recreational, wildlife, and cultural value of the large buffer areas at some key sites. As more and more EM sites have been “closed” and transferred to OLM, EM now focuses budget, technology, and management, on the most vexing challenges, such as the leaking, sludge-filled, single-walled underground tanks at Hanford.

Although DOE has achieved a remarkable worker safety record, many of the anticipated remediation tasks are risky for workers, particularly for contract workers.[9] Cleanup choices regularly involve tradeoffs between ecological disruption and more complete waste removal. And the process of decision-making on all these issues is complicated by complex, often overlapping state and federal regulatory authorities, including the fact that DOE is itself a regulator and/or trustee of some of its own environmental responsibilities [3]. Interim solutions to stabilize material and prevent leakage in the short-term are important, while permanent options must be worked out. Finally, the inter-relationships between waste management, transportation safety, nuclear security, spent nuclear fuel disposition, and the future of atomic energy must be clarified, including the identification, construction, and management of repositories, and the revisiting of nuclear fuel re-processing.

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