WASTE MANAGEMENT AND ENVIRONMENTAL COMPLIANCE ASPECTS OF A MAJOR REMEDIAL ACTION PROGRAM*

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ABSTRACT

The Formerly Utilized Sites Remedial Action Program (FUSRAP) is one of four major programs undertaken by the U.S. Department of Energy (DOE) to remediate various sites where radiological contamination remained from programs conducted during the nation's early years of research and development in atomic energy. The remedial actions at the 33 sites that are currently in FUSRAP could generate an estimated total volume of about 1.6 million cubic meters of radioactive waste, roughly equivalent to the total volume of low-level waste that has been disposed of at all the commercial disposal sites in the United States so far. The success of the program depends not only on remediating these sites but also on finding a disposal location for the wastes generated. Waste disposal is currently estimated to represent about one-third of the total estimated $2.1 billion cost for the entire program over its total duration.

Waste management aspects within the program are diverse. The sites range in size from small areas used only for storage operations to large-scale decommissioned industrial facilities where uranium processing and other operations were carried out in the past. Currently, four sites are on the National Priorities List for remediation.

Remedial actions at FUSRAP sites have to satisfy the requirements of both the National Environmental Policy Act and the Comprehensive Environmental Response, Compensation and Liability Act, as amended. In addition, a number of federal, state, and local laws as well as Executive Orders and DOE Orders may be applicable or relevant to each site. Several key issues currently face the program, including the mixed waste issue, both from the environmental compliance (with Resource Conservation and Recovery Act) and the disposal technology perspectives.

BACKGROUND

The Formerly Utilized Sites Remedial Action Program (FUSRAP) was initiated in 1974 by the Atomic Energy Commission (AEC), the predecessor of the U.S. Department of Energy (DOE). The mandate of the program is to identify, evaluate, and, if necessary, decontaminate (to meet current applicable standards) the sites or apply controls at the sites that were previously used by the AEC or its predecessor, the Manhattan Engineer District (MED). The program objectives include the disposal or stabilization of the waste and certification of the remediated sites for use without radiological restrictions. All work conducted under FUSRAP must be in accordance with all applicable federal, state, and local laws, as well as other requirements. FUSRAP is one of four such DOE remedial action programs dealing with unacceptable radiological conditions at various sites. The other programs are Grand Junction Remedial Action Program, Uranium Mill Tailings Remedial Action Program, and Surplus Facilities Management Program (SFMP). The MED and the AEC conducted several programs during the 1940s and 1950s that involved research, development, processing, and production of uranium and thorium, and the storage of residues. Most of this work was conducted in various facilities across the United States. These facilities were decommissioned at the completion of the contracts and decontaminated to meet the health and safety guidelines in use at that time. However, with the emergence of more stringent health and safety standards, it became necessary to assess the need for and to conduct remedial action at many of these sites. In addition, from more recent radiological surveys, it was recognized that several private properties adjacent to many of these sites showed contamination originating from processing operations carried out for MED/AEC and required remediation. These properties are called vicinity properties.

Most of the FUSRAP sites are primarily contaminated with uranium-238 and decay products (thorium-234, uranium-234, thorium-230, and radium-226) and thorium-232 and decay products (radium-228, thorium-228, and radium-224). However, the program also includes sites used in the Los Alamos plutonium development program and a fallout area due to the first atomic bomb test at the White Sands Proving Grounds. Some sites were added to FUSRAP by

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the U.S. Congress through legislative action in 1984 and 1985.

The current tentative completion date for the program is year 2010. The total estimated cost of the program is $2.14 billion of which about one-third represents the cost of waste disposal. The program is managed by the Former Sites Restoration Division at DOE-Oak Ridge for the Office of Environmental Restoration and Waste Management (EM) at DOE-Headquarters. Bechtel National, Inc., serves as the Project Management Contractor, and Argonne National Laboratory serves as the Environmental Compliance Contractor.

FUSRAP SITES

Currently 33 sites in 13 states are included in FUSRAP; most of these sites require some form of remedial action, and one has been included for radiological monitoring. The sites are added to the FUSRAP list after evaluations based on several factors, such as radiological surveys, health and safety assessments, review of DOE authority for the sites, and legislative actions. Of the 33 sites currently in the program, 28 were included in the program by DOE under the authority of the Atomic Energy Act of 1954. Five sites were added to the list by U.S. Congress in 1984 and 1985. Some 300 additional sites may undergo evaluation by DOE for possible inclusion in the program in the future. The FUSRAP sites list is frequently revised; for example, since July 1990, one new site -- Baker and Williams Warehouses in New York, N.Y. -- has been added to the program, and two sites -- Niagara Falls Storage Site (NFSS) in Lewiston, N.Y., and New Brunswick Laboratory (NBL) Site in New Brunswick, N.J. -- have been transferred into the program from SFMP. In addition to the 33 FUSRAP sites, approximately 300 privately owned vicinity properties required remediation; to date, remedial work has been completed at about two-thirds of these properties.

Four of the FUSRAP sites -- Wayne, Maywood in New Jersey, Shpack Landfill in Massachusetts, and the St. Louis Airport Site and Associated Properties in Missouri --are on the National Priorities List (NPL) of the U.S. Environmental Protection Agency (EPA). The St. Louis Airport Site and Associated Properties on NPL include three locations -- St. Louis Airport Site (SLAPS), SLAPS Vicinity Properties, and Latty Avenue Properties, but are considered as one site by the EPA. The sites on the NPL have the highest priority and are on a mandatory remediation schedule. Remedial action has been completed at 9 of the 33 FUSRAP sites (see Table I). These sites are: Acid/Pueblo Canyon, N.M.; Bayo Canyon, N.M.; Chupadera Mesa, N.M. (a fallout area from the first atomic bomb test mentioned earlier, and where it has been determined that no remedial action is necessary); Kellex/Pierpont, N.J.; Niagara Falls Storage Site Vicinity Properties, N.Y.; Middlesex Municipal Landfill, N.J.; National Guard Armory, Chicago, Ill.; University of California (Berkeley), Calif.; and University of Chicago, Ill.

From a program perspective, FUSRAP sites are categorized into four groups: New York sites, New Jersey sites, Missouri sites, and other sites. The major sites in the program are the New York, New Jersey, and Missouri sites; other sites are generally smaller, and, at present, activities are in progress at only some of these sites. The sites in New York include Colonie Site, Ashland 1, Ashland 2, Linde Air Products Site, and the Seaway Landfill Site (the last four are collectively known as the Tonawanda site). The four sites in New Jersey are Wayne, Maywood, Middlesex, and New Brunswick Laboratory Site. In Missouri, the main sites include St. Louis Airport Site, Latty Avenue Properties including Hazelwood Site, and St. Louis Downtown Site. The vicinity properties are considered a part of the remedial action at the main site from a programmatic point of view, even though the St. Louis Airport Site Vicinity Properties were shown as a separate site in the past and have been retained as such for listing purposes.

Of the other sites, remedial action or site characterization activities are currently in progress (or planned in the near future) at the following sites: Elza Gate, Tenn.; Albany Research Center, Ore.; Aliquippa Forge, Penn.; Ventron, Mass.; and Baker and Williams Warehouses, N.Y.

WASTE VOLUMES AND CHARACTERISTICS

The current estimate of the total volume of waste that will be generated from remedial actions at the sites on the FUSRAP list is 1.6 million cubic meters. A site-basis breakdown of the waste volumes is shown in Table I (note: waste volume estimates are frequently revised as site-specific characterization data become available). Most of the waste already generated from remedial actions or that will be generated during future actions is expected to be nonmixed waste, i.e., it is only radioactive. However, there are a few exceptions where mixed waste (radioactively and chemically hazardous) is present. At present it is estimated that mixed waste is present at the following sites: Albany Research Center (900 m^3), Elza Gate Site (530 m^3), Niagara Falls Storage Site (235 m^3), Colonie Site (1,629 m^3), and St. Louis Downtown Site (volume remains to be estimated). For illustration purposes, a breakdown of the mixed waste volume data for Colonie Site shows that radioactively contaminated electroplating waste accounts for the bulk (1,398 m^3) of the mixed waste, followed by radioactively contaminated waste oil (199 m^3) (1). Contaminated phenols, benzenes, acids, and aqueous alkali account for the remainder of the total volume. In addition, some radioactively contaminated soils buried at the Colonie Site show lead contamination and the quantity of these soils has not been estimated as yet.

The characteristics of the waste differ for different sites based on its origin (ore), its type (contaminated soil or residues), and the nature of the past processing operations. Preliminary information on radiological conditions at most of the FUSRAP sites is known through preliminary radiological surveys or characterization activities conducted at the sites. For illustration purposes, the characteristics of the waste at two sites are briefly described here.

At the Seaway Site, about 4,600 m^3 of ore residues from past operations carried out at the Linde Air Products Plant in Tonawanda, N.Y., was deposited in four areas (Area A, 10 acres; Area B, 0.5 acre; Area C, 1.5 acres; and Area D, 0.5 acre). Area A is covered with a thin (0-3 m) layer of refuse, Areas B and C are covered with about 12 m of refuse, and Area D is partially covered by berm materials and partially by refuse up to 3 m. In Area A, concentrations of Ra-226 range from 1 to 51 pCi/g (average 10 pCi/g), and concentrations of U-238 range from 2 to 63 pCi/g (average 22 pCi/g). In Areas B and C, the concentrations for Ra-226 range from 1 to 93 pCi/g (average 18 pCi/g) and for U-238 from 2 to 102 pCi/g (average 27 pCi/g). According to preliminary information available on Area D, the average concentrations of Ra-226 and U-238 are 2.4 pCi/g and 8.4 pCi/g, respectively.

At the Elza Gate site in Oak Ridge, Tenn., contamination exists on the five concrete pads to different levels and in several isolated patches of soil. Contamination also exists in soil beneath the pads. Estimated average concentrations for U-238, Ra-226, Th-232, and Th-230 for the concrete pads are 884, 18, 6, and 336 pCi/g, respectively. Estimated average concentrations in surface and subsurface contaminated soils (except a hot spot) for the same radionuclides are 6.6, 3.3, 1.6, and 4.8 pCi/g. However, for the hot spot, the highest measured concentrations for U-238, Ra-226, Th-232, and Th-230 are 12,000, 12,000, 82, and 15,000 pCi/g.

RELEVANT WASTE MANAGEMENT TECHNOLOGIES

In general, solid waste management technologies are the most relevant technologies to most FUSRAP sites except in some cases where surface water or groundwater contamination may exist or where liquid wastes may be generated from decontamination activities. For surface water and groundwater, various technologies such as precipitation, filtration, oxidation/reduction, reverse osmosis, and chemical extraction can be employed. Various pump and treat technologies can be employed for groundwater remediation, and dewatering technologies can be employed for sludges. For soils, the relevant technologies include soil washing, chemical detoxification, thermal destruction, and vitrification. For decontamination of equipment and structures, the technologies that can be used include vacuuming, solvent wiping, foam/emulsion application, steam washing,

TABLE I

FUSRAP Waste Volume Estimates for Nonmixed Waste

Site	Estimated Volume (m^3)
Acid/Pueblo Canyon, Los Alamos, N.M.	298
Albany Research Center, Albany, Ore.	2,729
Ashland #1, Tonawanda, N.Y.	64,222
Bayo Canyon, Los Alamos, N.M.	1,162
Chupadera Mesa (White Sands Missile Range), N.M.	0
DuPont and Company, Deepwater, N.J.	6,323
W.R. Grace and Company, Curtis Bay, Md.	27,524
Kellex/Pierpont, Jersey City, N.J.	209
Niagara Falls Storage Site, Lewiston, N.Y.	156,733
NFSS Vicinity Properties, Lewiston, N.Y.	38,228
St. Louis Downtown Site, St. Louis, Mo.	188,079
Middlesex Municipal Landfill, Middlesex, N.J.	[a]
Middlesex Sampling Plant, Middlesex, N.J.	67,586
National Guard Armory, Chicago, Ill.	15
Palos Park Forest Preserve, Cook County, Ill.	[b]
Seaway Industrial Park, Tonawanda, N.Y.	89,452
Shpack Landfill, Norton, Mass.	305
Aliquippa Forge, Aliquippa, Penn.	29
Ventron Corporation, Beverly, Mass.	5,352
Linde Air Products, Tonawanda, N.Y.	20,490
University of California, Berkeley, Calif.	23
University of Chicago, Chicago, Ill.	34
Ashland #2, Tonawanda, N.Y.	14,832
SLAPS Vicinity Properties, St. Louis, Mo.	145,265
Wayne Interim Storage Site, Wayne, N.J.	83.336
Maywood Interim Storage Site, Maywood, N.J.	301,997
Colonie Interim Storage Site, Colonie, N.Y.	10.857
Latty Ave. Properties, Hazelwood, Mo.	161,320
General Motors, Adrian, Mich.	153
Seymour Specialty Wire, Seymour, Conn.	19
Elza Gate, Oak Ridge, Tenn.	6,804
NBL Site, New Brunswick, N.J.	3,440
Baker and Williams Warehouses, New York, N.Y.	21
St. Louis Airport Site, St. Louis, Mo.	191,138
Total	1,587,975

[a]Middlesex Municipal Landfill waste is included in the volume for Middlesex Sampling Plant.
[b]Palos Park site has been removed from FUSRAP.
Source: Adapted from Ref. (1).

high-pressure water jetting, and abrasive blasting techniques. For example, a portable abrasive blasting system was used in a demonstration cleanup of a concrete pad at the Elza Gate site (2). Demolition of contaminated buildings and reducing to rubble are the applicable methods at some of the sites. Perhaps the most applicable technologies for FUSRAP sites, however, are the excavation, storage, and disposal technologies, because the bulk of the FUSRAP waste is contaminated soil, fill materials, and prior buried waste. While there are other innovative technologies such as paramagnetic separation, they are not yet considered cost-effective. In most cases, standard excavation techniques are sufficient, modified only in terms of worker safety concerns through wearing protective clothing and respiratory protection, as necessary. Storage methods can include standard 210L drums, above-ground engineered storage with a foundation and a protective cover, or below-ground storage. A variety of disposal options for these wastes are under consideration, but the most relevant disposal technologies involve engineered disposal in-ground or above-ground.

For mixed wastes, special technologies may be necessary, such as thermal extraction/destruction and various chemical treatment technologies. It should be noted that remedial actions and environment restoration activities at several sites may require refinements/advancements in existing technologies or development of innovative technologies. The DOE has set up an Office of Technology Development within the EM organization at DOE-Headquarters. The focus of technology development efforts is in the areas of waste minimization, site and waste characterization, and the remediation technologies.

ENVIRONMENTAL COMPLIANCE AND CLEANUP GUIDELINES

Remedial action at FUSRAP sites has to satisfy the requirements of the National Environmental Policy Act (NEPA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). NEPA, which was enacted in 1969, provides the basic national charter for the protection of the environment, and is implemented by Executive Orders 11514 and 11991 and the Council on Environmental Quality regulations of 1978. The major goal of NEPA is to restore and maintain the quality of the human environment. It requires the preparation of an environmental impact statement (EIS) for all major federal actions that *may significantly* affect the quality of the human environment. In 1980, CERCLA, commonly known as "Superfund," was enacted. CERCLA was substantially amended through the Superfund Amendments and Reauthorization Act (SARA) of 1986, which provided increased Superfund funding, set more stringent remedial action standards, and gave the EPA greater response power. CERCLA Section 104 authorized EPA to recover the cleanup costs of a hazardous site from the potentially responsible parties (PRPs). Also, SARA Title III established a new federal Community Right-to-Know Law.

Section 120(a)(1) of CERCLA, as amended, requires that federal departments and agencies must comply procedurally with CERCLA in the same manner and to the same extent as nongovernment entities. Thus, remedial action at FUSRAP sites has to satisfy the requirements of both NEPA and CERCLA.

Under CERCLA, a remedial investigation/feasibility study (RI/FS) must be prepared to support the decision-making process for evaluating remedial action alternatives. Consistent with the EPA guidance for conducting an RI/FS, a Work Plan for the site should contain a summary of information currently known about the site, present a conceptual site model that identifies potential routes of human exposure to site contaminants, identify data gaps, and summarize the process and proposed studies that will be used to fill the data gaps.

DOE has developed and adopted an integrated approach to satisfy both CERCLA and NEPA. A single set of documentation is produced to satisfy the requirements of both laws. A summary of the integrated process and various steps in the environmental compliance process, from the site identification stage to the Record of Decision, are discussed in Refs. (3) and (4). For the full-scope integrated remedial actions, the documentation produced is Remedial Investigation/Feasibility Study -- Environmental Assessment (RI/FS-EA) or Remedial Investigation/Feasibility Study -- Environmental Impact Statement (RI/FS-EIS). For limited-scope remediation through removal actions, an Engineering Evaluation/Cost Analysis (EE/CA) report and a (NEPA) Categorical Exclusion (Cat-X) are prepared.

In addition, a number of federal laws are applicable or relevant, most notably, Resources Conservation and Recovery Act (RCRA), Clean Air Act, Clean Water Act, Toxic Substances Control Act, and Safe Drinking Water Act. As a part of remedial action planning at a FUSRAP site, a number of federal and state laws as well as Executive Orders and DOE Orders are identified as Applicable or Relevant and Appropriate Requirements (ARARs). DOE standards and requirements for radiation protection of the public and the environment are published in DOE Order 5400.5 (5). These are applicable to the cleanup of the FUSRAP sites and the management of the resulting wastes and residues. The requirements in this Order cover the topics of basic dose limits, authorized limits for allowable levels of residual radioactive material, and the requirements for control of radioactive wastes and residues.

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr (effective dose equivalent). However, it is DOE policy that all exposures be kept as low as reasonably achievable (ALARA). For airborne radon decay products, the generic guideline is that in a habitable building the concentration (including background) shall not exceed 0.03 WL.* A reasonable effort shall be made to achieve an annual average radon decay product concentration (including background) below 0.02 WL. For interim storage, Rn-222 concentrations in air above the facility surface or openings shall not exceed 100 pCi/L at any given point and shall not exceed an annual average concentration of 30 pCi/L over the facility site. At or above any location outside the facility site, the annual average concentration must not exceed 3 pCi/L. Flux rates from storage of radon producing wastes shall not exceed 20 $pCi/m^2 \cdot s$. Levels of external gamma inside a habitable structure or a site to be released for use without radiological restrictions shall not exceed the background level by more than 20μR/h and shall comply with the basic dose limit considering an appropriate use scenario for the site.

For residual radioactive materials at FUSRAP sites, generic guidelines for thorium and radium (Ra-226, Ra-228, Th-230, and Th-232) are (averaged over an area of 100 m^2): 5 pCi/g, averaged over the first 15 cm of soil below the surface, and 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface. For other radionuclides, such as uranium, the guidelines are derived on a site-specific basis based on the basic dose limit and an environmental pathways analysis. Procedures for these derivations are described in Ref. (6).

Authorized limits for surface residual radioactive material are also listed in DOE Order 5400.5. For U-natural, U-235, U-238, and associated decay products, the limits are (in dpm/100 cm^2): 5,000 α average; 15,000 α maximum; 1,000 α removable. For beta-gamma emitters (except Sr-90 and others noted in DOE Order 5400.5), the limits are (in dpm/100 cm^2): 5,000 $\beta\gamma$ average; 15,000 $\beta\gamma$ maximum; 1,000 $\beta\gamma$ removable.

WASTE MANAGEMENT/DISPOSAL AND ENVIRONMENTAL COMPLIANCE ISSUES

Waste management aspects of FUSRAP sites are quite diverse. The areal extent of contaminated sites varies greatly from larger sites in New York, New Jersey, and Missouri to smaller areas such as Elza Gate in Tennessee. The physical characteristics of many sites are also diverse. The following examples demonstrate the diversity. The Seaway Site is an operating industrial landfill. Ashland 1 is a past waste storage area, and Ashland 2 is a past waste burial site. Colonie is a decommissioned plant. Linde is an operating manufacturing plant. Albany Research Center is a laboratory facility. Elza Gate is mostly vacant but is partially occupied by a small manufacturing concern. While in most cases the contamination exists as soils or residues, in some cases, such as Colonie, contaminated equipment and buildings may require unique remedial action and waste management technologies. The vicinity properties with contamination at rooftops and in backyards add to the diversity. Location of the waste varies significantly. At Seaway, radioactive waste is located in a perched water table, and some waste is buried beneath 12 m of refuse. At Elza Gate, the concrete pads are contaminated to a depth of about 6 mm; however, contaminated soil patches exist on the property, and soil beneath some of the pads has been found to be contaminated. The radionuclides and their concentrations also vary. At the Elza Gate site, while the average concentrations across the site (except the hot spot) are <10 pCi/g for U-238, Ra-226, Th-232, and Th-230, a small "hot spot" area has concentrations in several thousand pCi/g, as noted earlier.

Several important issues currently face the program. These include incorporating new technologies as they are developed, decisions on developing new disposal sites, developing regulatory consensus, building public trust, and dealing with the regulatory and technical aspects of the mixed waste problem.

One of the more important developments relevant to the program has been the establishment of a new organization, the Office of Environmental Restoration and Waste Management (EM) at DOE-Headquarters in November 1989. All DOE activities related to the environmental management of nuclear-related facilities as well as the restoration and waste management activities are now consolidated under this office. The FUSRAP program is assigned under the Decontamination and Decommissioning Division of the Office of Environmental Restoration within the EM organization. Within the reorganized structure, the program can benefit from interaction with other major programs, most notably, the Research, Development, Demonstration, Testing, and Evaluation programs.(7) Significant savings in cost, accelerated cleanup schedules, and permanent remedies for cleanup and waste management are some of the key advantages that can result from a continuing interface with technology development programs.

Disposal of FUSRAP wastes is a key issue. For radioactive waste, the disposal options can include in-situ containment, existing DOE reservations, commercial disposal sites, and new disposal sites. Most FUSRAP sites have

* A Working Level (WL) is any combination of short-lived radon decay products in 1L of air that will result in the ultimate emission of 1.3×10^5 MeV of potential α energy.

small volumes, and it is possible to dispose of the material at an existing DOE facility or at a commercial facility. However, larger volumes at several of the sites necessitate development of new facilities because of geographical location, transportation cost, and sociopolitical factors. According to the current waste disposal plan, four disposal sites need to be identified and developed (one each in the states of New York, New Jersey, Missouri, and Maryland). Current design-basis volume estimates for such facilities are New York, 160,500 m^3; New Jersey, 405,000 m^3; Missouri, 504,000 m^3; and Maryland, 30,600 m^3. However, any decisions on the development of disposal sites will follow only after an extensive environmental review and analysis process. While the individual states or state compacts are developing low-level radioactive waste disposal facilities, DOE is currently not considering the use of these facilities for FUSRAP wastes because, under the provisions of the Low Level Waste Policy Act of 1980, amended in 1985, FUSRAP wastes can only be disposed of there if specifically accepted by the state or the compact. However, DOE continues to cooperate with the states to explore possibilities of joint efforts.

Interagency dialogue and agreements are important to the program success, especially for the NPL sites. DOE has used the Federal Facilities Agreement (FFA) mechanism to accomplish this. Recently, such FFAs have been concluded with EPA Region II and the state of New Jersey for the Wayne and Maywood sites. Interaction with public above and beyond that required by the laws is necessary to build public trust, and the program has already made significant efforts in this direction.

Perhaps the most important issue currently facing the program is the presence of mixed waste at some of the sites. It may be necessary to develop an approach integrating the requirements of RCRA and CERCLA both in terms of the technical elements and the administrative elements. Mixed waste presents both technical as well as programmatic challenges because of the potential penalties under RCRA. Mixed waste disposal is still an unresolved issue because of the apparently conflicting requirements for disposal of hazardous waste and radioactive waste.

CONCLUSIONS

The waste management and environmental compliance aspects of FUSRAP sites are diverse. Large volumes of waste and the lack of nearby and cost-effective disposal sites necessitate development of new disposal facilities. However, any such decisions depend on technical, environmental/regulatory, and socioeconomic factors. Mixed waste disposal presents a special problem both from a technical perspective as well as from a regulatory perspective.

The program has made significant progress with remedial action complete at 9 of the 33 sites on the list. A large number of vicinity properties have also been cleaned up. Consolidation of DOE's environmental restoration and waste management activities under one office will benefit the program in terms of interface with other programs and the development of new technologies. With remedial action initiated or in progress at several other major sites, especially those on the NPL, and with some sites presenting mixed waste problems, many challenges lie ahead.

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