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CERCLA and RCRA Considerations in D&D Safety Analyses

J.C. Laul, ESH-3, Los Alamos National Laboratory
MS K489, P. O. Box 1663, Los Alamos, NM 87545
505-665-9791, jclaul@lanl.gov

Abstract

CERCLA and RCRA play an important role in D&D activities in LLW or TRU waste that contains hazardous chemicals (RCRA component). Authorization basis or safety analysis is required prior to initiating D&D of a nuclear or a radiological facility. DOE-EM-STD-5502-94 provides guidelines for hazard categorization and subsequent level (graded approach) of safety analysis for a facility disposition for which the guidelines are provided in DOE-STD-1120-98.

1.0 Regulatory Protocols

Cleanup, decontamination and decommissioning (D&D), and remediation of a hazardous or contaminated site fall under the purview of CERCLA (Comprehensive Environmental Response, Compensation and Liability Act of 1980 or Superfund; 40 CFR 300, 302, 305, and 306). CERCLA encompasses other federal regulatory requirements such as CAA (Clean Air Act), CWA (Clean water Act), SDWA (Safe Drinking Water Act), RCRA (Resource Conservation Recovery Act), TSCA (Toxic Substance Control Act), and SARAH Title III/EPCRA (Emergency Planning and Community Right to Know Act). RCRA stipulates certain rules for dealing with hazardous waste or LLW and TRU waste mixed with hazardous chemicals (RCRA component). Before D&D or remediation is undertaken at a site, EPA's protocol under CERCLA requires that certain steps be followed:

a) Preliminary Assessment/Site Investigation (PA/SI) – Initial site evaluation is performed to evaluate whether there has been a release or there is a threat of a release to the environment.
b) Remedial Investigation (RI) – RI is performed to determine the nature of a release, leaching (TCLP tests), migration rate, etc. RI is also used to evaluate various technologies.
c) Feasibility Study (FS) – The FS is performed to select a technology- (ies) and other viable tests, including TCLP, in order to substantiate the selected approach.
d) National Environmental Policy Act (NEPA) Compliance – NEPA applies if it is a federal facility. NEPA requires a record of decision.
e) Record of Decision (ROD). The ROD is the final step before any remedial action can begin. The ROD contains the input and results from the above steps, the remedial action selected, basis for selection, consequences, risks involved, cost considerations, etc.

DOE issues the ROD for its facilities with the concurrence of the EPA and the host State. Per DOE policy, clean up or D&D actions are implemented as CERCLA non-time critical removal actions, unless the circumstances make it inappropriate.

For non-DOE sites, EPA issues the ROD to private-sector Superfund sites. In cases, where the ROD specifies controlling the hazards in place rather removing them (e.g., a radium site in Denver), air or groundwater monitoring for radionuclides and RCRA elements can provide an indication if the stabilization process for radium-contaminated soil is working under CERCLA.

RCRA (40 CFR 260-280)

RCRA focuses on hazardous waste and TSD (treatment, storage, and disposal) facilities and is mostly managed by individual States. RCRA requires that hazardous and mixed wastes follow certain rules, which are as follow:

a) Cradle-to-grave concept;
b) Mixture rule; If a hazardous waste is mixed with a non-hazardous waste, the total is considered hazardous waste;
c) Derived-from rule; If a waste is generated by a TSD facility, it is considered hazardous unless exempt;
d) Contained-in rule; If a waste contains listed or characteristic waste, it is still a hazardous waste;
e) Listed waste (F, K, U, P); F indicates nonspecific source, K a specific source, U a toxic commercial chemical, and P an acute toxic commercial chemical; and
f) Characteristic waste; It exhibits the following characteristics: (CRIT)
    - Corrosivity– If waste's pH is ≤ 2 but ≥ 12.5 range
    - Reactivity - If it reacts with water
    - Ignitability – If it is ignitable
    - Toxicity – If it contains contaminants above established limits. It is measured by TCLP test.

If a RCRA component is mixed with low-level waste (LLW) or TRU waste, the product is defined as mixed LLW or mixed TRU waste. Both the host State and EPA have jurisdiction over DOE's RCRA hazardous and mixed waste.

2.0 D&D at DOE Sites

As many DOE sites gear towards D&D, considerable amounts of wastes (LLW, TRU, mixed LLW and mixed TRU) will be generated during decontamination and demolition activities. RCRA and CERCLA play an important role if LLW or TRU waste is mixed with chemical hazardous (RCRA) components. Pure LLW and TRU wastes are exempt from RCRA and CERCLA under the Atomic Energy Act of 1954. For long term storage, pure LLW can be shipped to Nevada Test Site (NTS), and pure TRU waste can be shipped to WIPP (Waste Isolation Pilot Project), Carlsbad, NM, in accordance with the waste acceptance criteria at these sites.

If RCRA waste is a mixed LLW or mixed TRU waste, then its disposal is not straight forward and is restricted to land disposal (HSWA 1984; 40 CFR Part 268). There is a considerable amount of mixed waste at various DOE sites, waiting to be disposed.

- One option is to process the mixed waste and remove the RCRA component (VOC, toxic metals) using the best available technologies. A drawback is that this operation can be very costly and time consuming.
- Other option is for DOE to work out some RCRA permit Agreements with the State and EPA, where shipping of mixed waste to NTS and WIPP is acceptable. The State of New Mexico has recently issued a RCRA permit to WIPP to receive shipment of mixed TRU waste.
- Some flexibility in DOE Orders or requirements can expedite D&D work without compromising risk and safety during the D&D operations.

As stated earlier, RCRA is managed mostly by the individual States and CERCLA is managed by the EPA, and both have jurisdiction over DOE's mixed waste. For D&D operations, waste generation, handling, management, and disposal are important issues at DOE sites, from both the regulatory

compliance and safety analysis perspectives. Safety Management Programs and integrated safety management systems (ISMS) encompass both the regulatory compliance and safety analysis features.

3.0 Facility Disposition Phases

DOE-STD-1120-98, *Integration of Environment, Safety, and Health into Facility Disposition Activities*, lists five scenarios in Figure 1. These scenarios include deactivation, decommissioning, and long-term surveillance and maintenance (S&M). Scenario 1 is an ideal case, where facility disposition activities begin with deactivation immediately following operations (e.g., removal of the radiological and chemical inventories). Decommissioning activities follow deactivation and entail removing contamination and residual hazardous substances and reuse or dismantling of facility systems and physical structures. Both D&D activities may also include routine S&M tasks as part of the overall project activities.

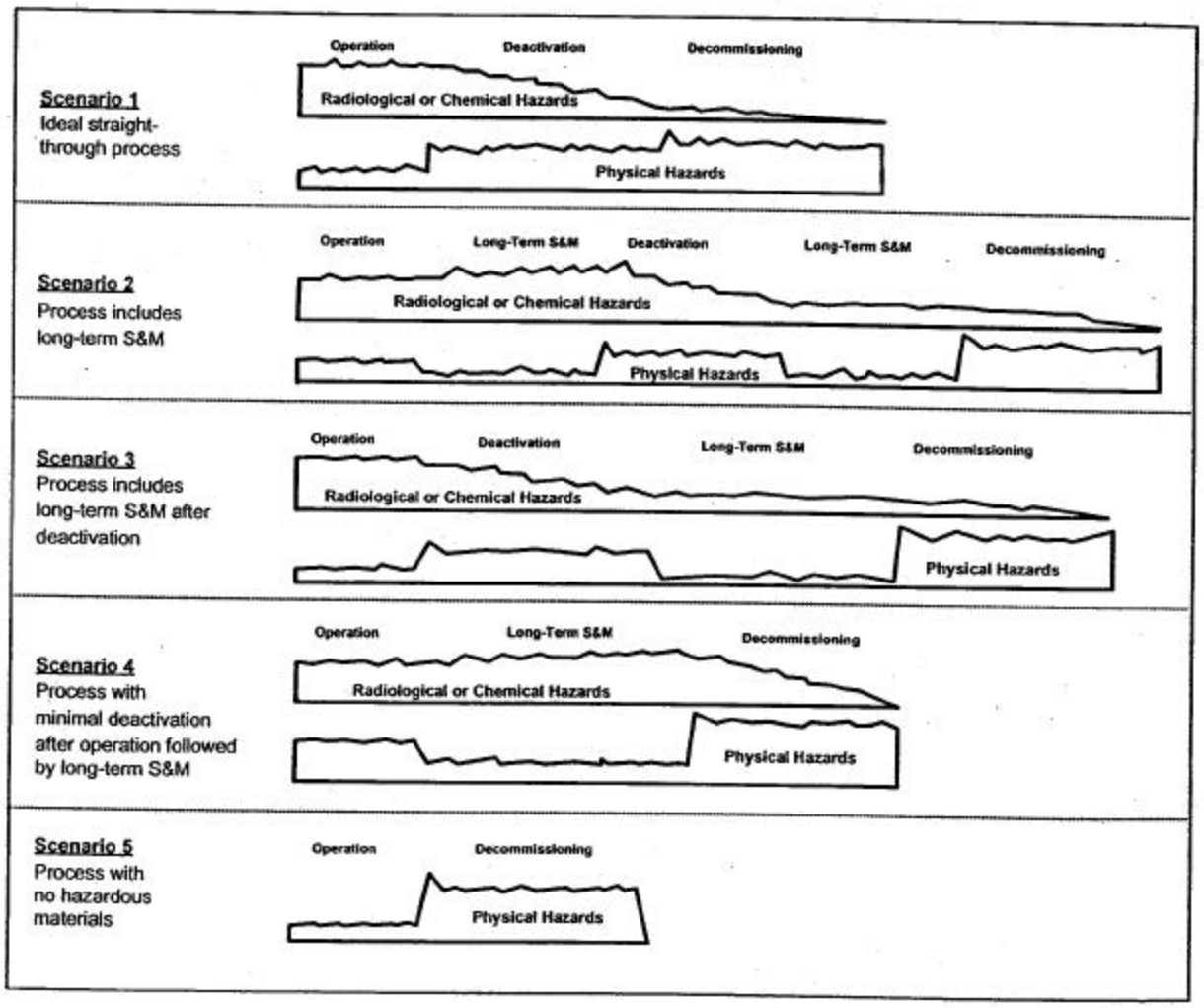

Figure 1. Facility Disposition Scenarios and Associated Hazard profiles (DOE-STD-1120-98)

However, in Scenarios 2 through 5, there is often a period of long-term S&M between the facility operation, deactivation, and decommissioning. These activities focus on monitoring and controlling any remaining radiological and/or chemical hazards or contamination and maintaining the structural integrity of the facility. The facility disposition efforts and duration generally depend on the magnitude of hazards. As radiological or chemical hazardous material inventories are removed, potential risks to the worker and public and the environment are considerably reduced. However, the potential risk to the worker increases as the result of exposure while handling and removing radiological and chemical hazardous materials. In addition, there are physical hazards involved that are similar to those in construction activities, as shown in the disposition hazard profiles in Figure 1. Overall, the ES&H aspects and regulatory impacts are important drivers in D&D activities.

4.0 Authorization Basis or Safety Analysis

Currently, authorization basis (AB) or safety analysis (SA) is required prior to initiating D&D of a nuclear or radiological facility. A useful guidance for D&D AB is shown in *EM Hazard Baseline Documentation Process* (DOE-EM-STD-5502-94) in Figure 2, which provides guidelines for hazard classification and subsequent level (graded approach) of safety analysis. For a nuclear facility, DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with 5480.23*, is used to classify a facility as Hazard Category (HC) 1, 2 or 3, based on the assigned threshold values of radionuclides. If the radionuclide inventory exceeds thresholds of HC-2 or HC-3, then a graded Safety Analysis Report (SAR) is required per DOE Order 5480.23, *Nuclear Safety Analysis Reports*, along with other AB requirements such as technical safety requirements (TSRs, DOE Order 5480.22) and unreviewed safety questions (USQs, DOE Order 5480.21). The graded SAR or BIO (Basis of Interim Operation) is written in accordance with guidelines provided in DOE-STD-3009-94, Revision 1, *Preparation Guide for U.S. Department of Energy Non-Reactor Nuclear Facility Safety Analysis Reports.* Some DOE sites are using an enhanced BIO as a graded SAR per the guidelines of DOE-STD-3011-94, *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*.

If the radionuclides inventory is below the HC-3 threshold, then the radionuclides are compared with the reportable quantity (RQ) values in 40 CFR 302, Appendix B. If the radionuclides exceed Appendix B levels, it is classified as a radiological facility. If the radiological facility contains hazardous chemicals and their inventories exceed OSHA's 29 CFR 1910.119 or EPA's 40 CFR 355 thresholds, it requires the development of an Auditable Safety Analysis (ASA) and a Health and Safety Plan (HASP). The HASP primarily emphasizes worker safety. If the chemical inventory does not exceed or is not listed in 29 CFR 1910.119 or 40 CFR 355, the HASP shall develop the same safety ASA plan (DOE Order 5481.1B) as required for non-nuclear within a radiological facility.

If the radiological inventory does not exceed 40 CFR 302, Appendix B, a facility is classified as an industrial facility. If the chemical inventory exceeds 40 CFR 302, it follows a non-nuclear HASP. If the radiological inventory does not exceed 40 CFR 302, it follows the industrial HASP or OSHA standards, depending on the waste activities. Thus, DOE-EM-STD-5502-94 provides guidance for a radiological facility-HASP and an industrial facility-HASP and other OSHA standards, depending on the D&D or waste activities.

A compliance agreement with the host State, EPA, and DOE can provide flexibility and facilitate the D&D process without compromising risk and safety during the operations. Thus, authorization basis or safety analysis documents can benefit from the information gathered under the RCRA and CERCLA protocols and thereby assist in the hazard identification, hazard evaluation, safety analysis and subsequent accident and risk analyses, and development of TSR-required controls.

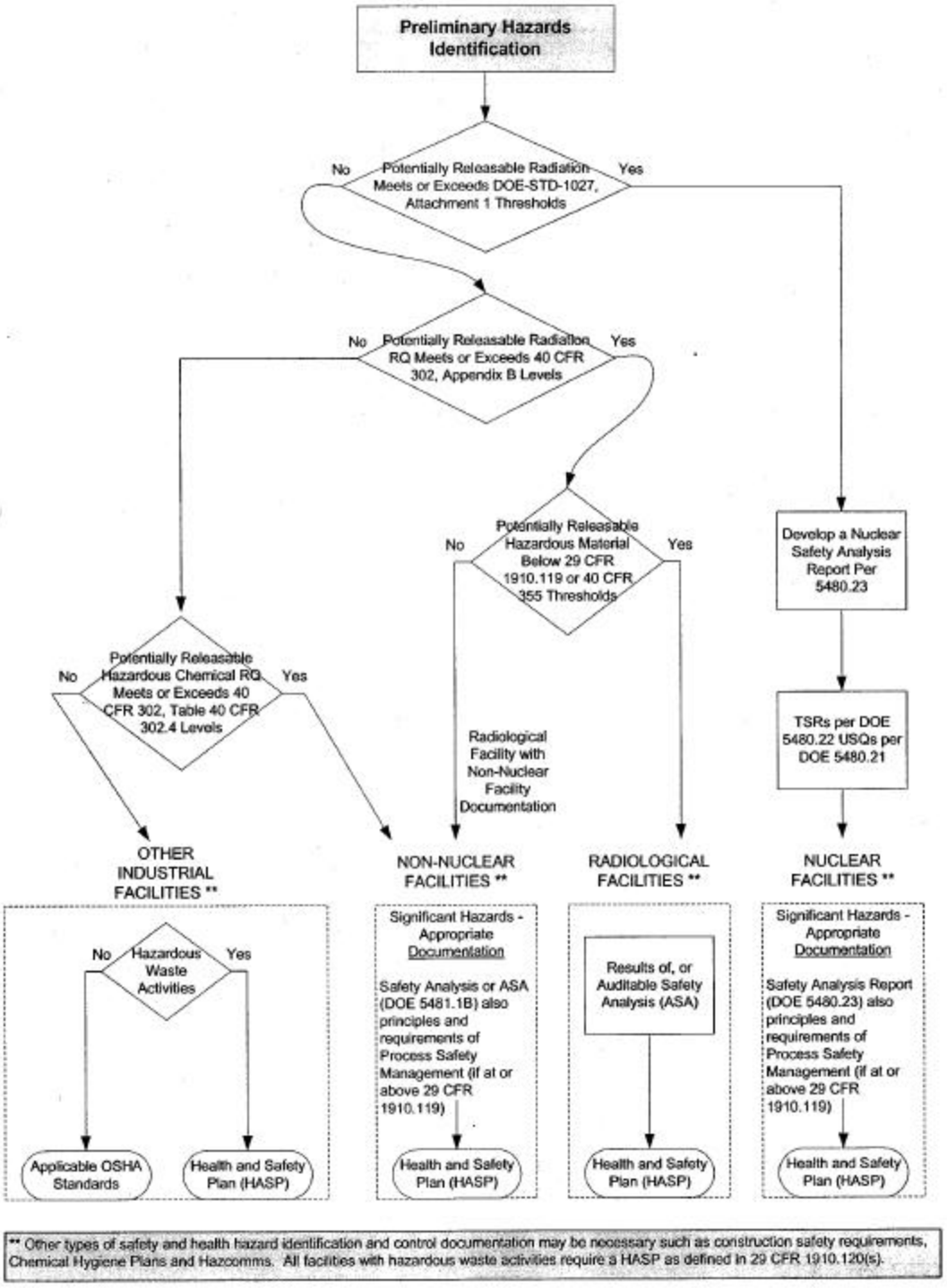

Figure 2. EM-Hazard baseline Documentation Process (DOE-EM-STD-5502-94)

5.0 Facility Disposition ES&H Documentation

DOE-STD-1120-98 provides a summary of ES&H documentation in Table 1 that provides cross-reference between the type of work performed in D&D, the type of hazard baseline document required, and the environmental permit needed. This table is useful in understanding the relationship between key requirements and their features, which are explained as follow.

Table 1. ES&H Documentation*

Type of Work	Hazard Baseline Document				Environmental Permits		
	SAR	BIO	HASP	Other	RCRA Permit	CAA Permit	CWA Permit
Deactivation of category 2 or 3 nuclear facility (Note: Use existing facility SAR or BIO if it adequately addresses deactivation hazards and work activities).	X	X			X	X	X
Deactivation of non-nuclear or radiological facility.				X	X	X	X
Long-term S&M of category 2 or 3 nuclear facility.	X	X			X	X	X
Long-term S&M of non-nuclear or radiological facility.				X	X	X	X
Decommissioning of category 2 or 3 nuclear facility (low-level residual fixed radioactivity).			X				
Decommissioning of category 2 or 3 nuclear facility (inventory is not low-level residual fixed radioactivity).			X				
Decommissioning of non-nuclear or radiological facility.			X				

* From DOE-STD-1120-98/Vol.2

Hazard Baseline Documents are : a) SAR as defined by DOE Order 5480.23 and DOE-STD-3009-94, Revision 1; b) BIO as defined by DOE Order 5480.23 and DOE-STD-3011-94; c) HASP written in accordance with 29 CFR 1910.120 or 29 CFR 1926.65; and d) Others, which may range from auditable safety analysis (ASA) as described in DOE Order 5481.1B, to a simplified hazard checklist. Although DOE Order 5481.1B has been cancelled, it may still be in contract of some DOE facility contractors.

Types of Work in D&D are: a) Deactivation of HC 2 or 3 nuclear facility; b) Deactivation of non-nuclear or radiological facility; c) Long-term S&M of a HC 2 or 3 nuclear facility; d) Long-term S&M of a non-nuclear or radiological facility; e) Decommissioning of a HC 2 or 3 nuclear facility (low-level residual fixed radioactivity); f) Decommissioning of a HC 2 or 3 nuclear facility (not low-level residual fixed radioactivity); and g) Decommissioning of non-nuclear or radiological facility. In the case of (f), applicable requirements of 10 CFR 830.120 and DOE Order 232.1 should be met and also an administrative TSR for inventory control should be established. In the case of (g), a HASP with an addendum of SAR/BIO information is needed to show that releasable materials have been adequately confined or that the consequences have been adequately mitigated.

Environmental Permits (RCRA, CAA, and CWA): See the discussion of RCRA in Section 2. Under CAA, airborne effluents are to be controlled in accordance with applicable National Ambient Air Quality Standards (NAAQSs) and National Emission Standards for Hazardous Air Pollutants (NESHAPs).

Under CWA, liquid discharges into surface or ground waters should be controlled in accordance with a National Pollutant Discharge Elimination System (NPDES) permit. It is to be noted that RCRA, CAA, and CWA permits may not always be required to perform work. Each permit should be considered on a case-by-case basis. However, in D&D activities, a concept of an ARAR (Applicable or Relevant and Appropriate Requirement) is always encouraged to minimize the spread of contaminants or pollutants into the environment.

6.0 Radium Site (Shattuck Site) in Denver: Stabilization Process under CERCLA

Shattuck site was evaluated for stability under CERCLA, which included evaluation of hazards (radionuclides migration), controls such as stabilization process, and its effectiveness through groundwater monitoring wells.

Radium Shattuck site (OU VIII) is located in southwest Denver in the middle of residential, commercial and industrial areas. In its early history (1920 – 1984), Shattuck Site processed radium, vanadium, molybdenum, copper, and uranium ores. Over time, Shattuck soils became highly contaminated with radium, thorium and uranium. Radionuclide concentrations in the site soils are shown in Table 2. Under CERCLA, this site was a Superfund site for clean up or remediation.

Table 2. Radionuclides- Ra-226, Thorium-230, and Uranium Concentration*

Radionuclide	Average Soil Stockpile Concentration (pCi/g)	Average Soil Monolith Concentration (pCi/g)	Elevated Soil Stockpile Concentration (pCi/g)	Elevated Soil Monolith Concentration (pCi/g)
Ra-226	63	67	470	307
Thorium-230	170	135	1400	1050
Uranium (total)	35	25	91	86

* ROD 1992.

Soil concentrations ranged (pCi/g) from: 63-470 for Ra-226; 135-1400 for Th-230; and 25-91 for mostly U-238 (EPA, Record of Decision, 1992). The TCLP results of these radionuclides, gross alphas and gross beta, and other metals such as vanadium, molybdenum, and copper (in some cases) exceeded the ARAR values (e.g., 5pCi/l for Ra-226) in groundwater (S. W. Shattuck Company, Treatability Study 1993).

EPA and Colorado Department of Public Health & Environment (CDPHE) evaluated seven alternatives for remediation. Only two alternatives were seriously considered: a) excavate, treat and stabilize, and leave it on-site; and b) excavate, haul it away, and replace with fresh soil. The local community preferred the latter (b) option. However, based on economic and other considerations, the EPA (Region VIII) and State chose the former option (a) stabilize and leave it on-site. The site soil was diluted with fresh soil so that the average concentration of Ra-226 in the mixed soil was 25 pCi/g. Then 70% of this diluted soil was mixed with 20% cement and 10% flyash (70:20:10) for stabilization and solidification (S/S) process. No liner was used underneath or above the S/S monolith.

Groundwater monitoring wells were installed around the site. Groundwater samples were taken on a quarterly basis and analyzed for radionuclides and RCRA metals to evaluate the effectiveness of the S/S process in stabilizing the contaminants. The first three sets of the wells' monitoring results reported by the City of Denver showed that contaminants such as uranium, radium, molybdenum, and copper were still present in high concentrations as they were before the remediation began. These results suggest that the S/S process was probably not working, which had undoubtedly raised more concerns in the local community.

Based on chemistry consideration, a cement and flyash slurry mixture provides a strong and hard cement matrix in which the radionuclides and metals are encapsulated. However, it appears that there are inadequate "chemical bonds" for containment to provide a stable chemical structure for contaminants within its matrix. The cement matrix contracts and expands with changes in temperature (cold and hot), causing cracks. The analogy is similar to cement pavement in driveways. Overtime, with cold and hot weather changes (winter and summer), there is contraction and expansion. With the result, cracks and fractures develop. When water enters, it slowly permeates through the cracks/fractures and shall slowly start dissolving radionuclides and metal hydroxides. Thus, over time, the S/S remedy would not provide a long-term stability to the Shattuck site.

The convincing evidence was the groundwater monitoring results of radionuclides and RCRA metals, indicating that the S/S process was probably not working. Based on these findings, EPA and the State decided in November 1999 to abandon the S/S option and adopt the former (a) option – excavate, haul it away, and replace with fresh soil. This decision has undoubtedly made the local community extremely happy. This is a good example where the S/S process did not work under CERCLA.

7.0 References

DOE-STD-1120-98, *Integration of Environment, Safety, and Health into Facility Disposition Activities*, May 1998.

DOE-EM-STD-5502-94, *EM Hazard Baseline Documentation Process*, August 1994.

DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with 5480.23, Nuclear Safety Analysis Reports*, December 1992.

DOE-STD-3009-94, Revision 1, *Preparation Guide for U.S. Department of Energy Non-Reactor Nuclear Facility Safety Analysis Reports*. July 1994, Revision 1 (January 2000).

DOE-STD-3011-94, *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*, July 1994.

DOE Order 5480.23, *Nuclear Safety Analysis Reports*, March 1994.

DOE Order 5480.22, T*echnical Safety Requirements*, February 1992.

DOE Order 5480.21, *Unreviewed Safety Questions*, December 1991.

DOE Order 5481.1B, Ch. 1, *Safety Analysis and Review System*, May 1987.

40 CFR 302, *Designation, Reportable Quantities, and Notification*, EPA, Appendix A and Appendix B, 281-346, July 1998.

29 CFR 1910.119, *Process Safety management*, U.S. Department of Labor, 346-367, Ch. XVII, July 1998.

40 CFR 355, *Emergency Planning and Notification*, EPA, 438-453, Ch. 1, July 1998.

29 CFR 1910 and 1926, *Occupational Safety and Health Administration*, U.S. Department of Labor, July 1998.

10 CFR 830.120, *Quality Assurance requirements*

10 CFR 835, *Occupational Radiation Protection*, December 1993.

DOE Order 232.1, *Occurrence Reporting and Processing of Operations Information*, July 1997.

ROD, 1992, *Record of Decision, Denver Radium Site, Operable Unit # 8,* Denver, CO, January 1992.

Treatability Study, *Pilot-Scale Treatability Study, Denver Radium Site, Operable Unit VIII*, The S.W. Shattuck Chemical Company, Project No. 866S, July 1993.