IMPACT OF THE CRITERIA OF CANDIDATE REPOSITORIES AND OF ENVIRONMENTAL REGULATIONS ON THE TREATMENT AND DISPOSAL CHOICES OF INTEC MIXED WASTES

Jila Banaee

INEEL, Bechtel BWXT Idaho, LLC

P.O. Box 1625, Idaho Falls, ID, 83415-3625
Phone: 208-526-7463, Fax: 208-526-4017, E-mail: jb6@inel.gov

ABSTRACT

A study is being conducted at the Idaho National Engineering and Environmental Laboratory (INEEL) to evaluate various treatment alternatives and disposal options for the mixed wastes currently stored at the Idaho Nuclear Technology and Engineering Center (INTEC). The wastes were generated from spent nuclear fuel (SNF) reprocessing, calcination, and related and unrelated on-going decontamination activities. These wastes include three principal streams: high-level waste (HLW), "sodium-bearing waste" (SBW), and the "newly generated liquid waste" (NGLW). The proposed treatment alternatives are expected to convert the wastes into stable waste forms that are suitable for permanent disposal.

The treatment and disposal options considered in this study are those included in the Draft INEEL High Level Waste and Facilities Disposition Environmental Impact Statement (Draft Idaho HLW & FD EIS). In particular, three separation and three non-separation options are considered.

The study identifies the currently applicable and the proposed regulatory requirements for the treatment and disposal of the various wastes stored at INTEC. The study also includes a comprehensive survey of the waste acceptance criteria (WAC) for the various candidate repositories. The implications of the identified regulatory requirements and of the WAC for the various candidate repositories on the treatment and disposal needs of the INTEC wastes and on their qualification needs (e.g. classification confirmation, reclassification, and exclusions such as delisting) are identified. It is shown that the treatment options under consideration will result in a majority of waste forms that meet the applicable regulatory requirements and that satisfy the WAC of the repositories identified as most suitable for them. However, a few exceptions are noted. For the latter, a path forward based on exclusions (e.g., delisting and/or reclassification) is proposed.

INTRODUCTION

The State of Idaho Settlement Agreement and other applicable agreements contain commitments for the treatment and disposal of HLW and SBW, and for their transfer out of Idaho. In order to meet these commitments, the U.S. Department of Energy (DOE) is conducting a study at the INEEL to evaluate various treatment and disposal options for the wastes currently stored at the INTEC. The INTEC wastes are considered mixed wastes because they contain both Resource Conservation and Recovery Act (RCRA) hazardous chemicals and radionuclides. The wastes fall into three categories. These are HLW, SBW and NGLW. The HLW resulted from the reprocessing of SNF at the INTEC. The SBW was generated from the decontamination of facilities associated with reprocessing, HLW calcination, and related laboratory activities. The HLW and part of the SBW (HLW/SBW blend) have been converted into a solid form, called calcine. The remaining liquid SBW has been stored in tanks at the INTEC. The NGLW also includes wastes from the on-going decontamination work and miscellaneous wastes generated or received at INTEC, and which will continue to be generated in the future.

Several alternatives, including various treatment options and means to retrieve, process, store, and prepare wastes for disposal have been proposed and considered for further analysis. The alternatives consider converting the wastes into stable waste products that can be permanently disposed of. The proposed treatment options include three non-separations and three separation processes (1). In addition, other alternatives, including the continuation of the current practice of calcination and storage in stainless steel (SS) bins at the Calcined Solids Storage Facilities (CSSF); minimum processing; and a no-action alternative have been considered. These are essentially the options included in the Draft Idaho HLW & FD EIS. The waste processing alternatives and treatment options selected under

the non-separation and separation alternatives and the disposal options, including candidate repositories, for the final waste forms are described in the section on "Waste Processing Alternatives." The wastes resulting from the various treatment options are described in the following section in the context of their evaluation against applicable regulatory requirements and disposal facilities WAC. In the next section, the subject wastes are described. In the third section, the regulatory drivers, including Agreements and the applicable regulations are identified. In the fourth section, the mechanisms for excluding treated mixed waste from RCRA regulations are presented. In the fifth section, radiological reclassification issues are discussed. The final section summarizes the conclusions of this study.

DESCRIPTION OF PRINCIPAL WASTES STREAMS

The HLW was generated directly from the chemical processing of SNF at INTEC. The waste contains a combination of highly radioactive short-lived radionuclides [Cesium-137 (Cs-137) and Strontium-90 (Sr-90)] and long-lived isotopes [TRU, Technetium-99 (Tc-99), Iodine-129 (I-129), and Carbon-14 (C-14). The liquid HLW, originally stored in INTEC Tank Farm tanks, was calcined for storage in solid form in the CSSF. The existing volume of the HLW calcine is 4,200 m^3.

The SBW originated from decontamination activities that were primarily associated with reprocessing and calcination. Currently, about 5,044m^3 of SBW is stored in the INTEC Tank Farm tanks. The SBW is so named because it contains sodium (from sodium hydroxide). In addition, it contains a number of dissolved radioactive and hazardous constituents in a nitric acid solution. Based on the types of isotopes and their activities, the SBW meets the definition of TRU waste.

The NGLW consist of, but is not limited to, miscellaneous decontamination liquid wastes from INTEC operations that are not associated with HLW management, waste generated during the processing of HLW and SBW, leachate from treating contaminated high-efficiency particulate air filters, and wastes from other INEEL sources (2). For the purpose of this study, it is presumed that the NGLW will undergo volume reduction, followed by further treatment. It is suggested that once concentrated, NGLW will have radiological and chemical characteristics similar to those of the SBW (2). Consequently, the concentrated NGLW could possibly be classified as mixed TRU wastes. Presently, the estimated volumes of the NGLW generated and projected to be generated through 2035 are 1,262 m^3.

All of these radioactive wastes, HLW, SBW and NGLW, are considered mixed wastes because of their RCRA characteristic and their listed chemical components, as defined in 40 Code of Federal Regulations (CFR) Part 261, Subparts C and D.

AGREEMENTS AND REGULATORY REQUIREMENTS

The applicable environmental regulations and agreements constitute the drivers and the source for defining the performance requirements and schedules for the treatment and disposal of the INTEC wastes. The drivers can be classified into three principal groups. These are (i) the Settlement Agreement and the Consent Order between the State of Idaho and other parties, (ii) EPA (RCRA) regulations, and (iii) the Atomic Energy Act (AEA)-based requirements as implemented and administered by DOE [and implied Department of Transportation (DOT) regulations]. The implications of each of these drivers are identified in turn, below.

The State of Idaho Settlement Agreement (3) contains several commitments for the treatment and disposal of the HLW and SBW, and their transfer out of Idaho. Under the terms of the Settlement Agreement, DOE is committed to meet the following milestones (the first of which was met by DOE in February 1998):

- Complete calcination of all remaining non-sodium bearing liquid HLW by June 30, 1998 (done).
- Commence negotiating a plan and schedule with the State of Idaho for calcined waste treatment by December 31, 1999 (started).
- Begin calcination of liquid SBW by June 2001 (started).
- Complete calcination of all SBW by December 31, 2012.
- Accelerate efforts to evaluate alternatives for the treatment of calcined waste in order to put it into a form suitable for transport to a permanent repository or interim storage facility outside Idaho.

- Treat all HLW currently at the INEEL so that it is ready to be moved out of Idaho for disposal by the year 2035.

The Consent Order and its Revised versions (4, 5, 6) mandates requirements that are compatible with those of the Settlement Agreement. In addition, it requires that all SBW be removed from five of the eleven non-compliant storage tanks by June 30, 2003 and from all other remaining tanks by December 31, 2012. However, meeting these requirements could be made difficult by another mandate of the Consent Order which requires that DOE decide by June 1, 2000 whether to upgrade the calciner at the INTEC New Waste Calcination Facility (NWCF) to comply with the EPA emissions and permitting requirements to operate, or to suspend the calciner operation. If the new operating requirements are not met, the calciner would be shut down and the calcination milestones could be missed if a timely restart is not achieved. The intricate details of the issues surrounding the continued operation of the calciner can be found in reference (7).

The INTEC RCRA waste contents include characteristic and listed chemicals. The characteristic components consist of corrosive chemicals, heavy metals, and others, known as the underlying hazardous constituents (UHCs). All of the chemicals are subject to the federal RCRA land disposal restrictions (LDR) regulations prior to land disposal, as adopted and enforced by the State of Idaho. The LDR requires hazardous waste to be treated before being land disposed. The treatment standards for hazardous wastes, as designated by their Hazardous Waste Numbers (HWNs) and the UHCs are identified in 40 CFR 268.40 and 40 CFR 268.48. The applicable LDR standards are determined at the point of generation of the waste. For INTEC wastes, the point of origin is the Tank Farm tanks. The hazardous chemicals, the associated HWNs, and the LDR treatment standards, identified in 40 CFR 268, for the wastes in the Tank Farm tanks are presented in Tables I and II, based on reported and historical data (8, 9, 10). Since there are uncertainties regarding the contents, a full characterization study must be conducted, in accordance with RCRA requirements. The study would determine all the "regulated constituents" at the point of generation. The chemicals that are listed in Table I only for the characteristic of ignitability, including Acetone, Cyclohexane, Cyclohexanone, Ethyl acetate, Methanol, Methyl isobutyl ketone, and Xylenes have not been assigned with any HWNs (10). These chemicals, though still subject to LDR (hence their inclusion in Table I) have been mixed with water or other wastes prior to storage in the tanks, and they lost their characteristic of ignitability (10). It follows, based on the provisions of 40 CFR 261.3(a)(2)(iii), that these chemicals would no longer require a HWN. The list of the potential UHCs shown in Table II is preliminary and subject to change. Further process waste evaluation at the point of generation and further sampling and analysis are needed to identify possible additional UHCs and to confirm the preliminary entries.

Based on RCRA regulations in 40 CFR 262.3(a)(2)(iv), the "mixture rule," and 40 CFR 262.3(c)(2)(i), the "derived from rule," the products resulting from treatment of the INTEC listed wastes would be considered listed wastes. When such wastes are to be land disposed, they must be disposed of at a RCRA-regulated Subtitle C facility. Indeed, the treatment products would continue to be regulated as mixed wastes under the RCRA Subtitle C program even after they meet the applicable LDR requirements, unless excluded from hazardous waste regulations. The mechanisms for obtaining such exclusions are identified and presented in the fourth section.

The principal DOE requirement is compliance with DOE Order 435.1 on "Radioactive Waste Management," (11) and by implication, compliance with DOE Order 460.1A on "Packaging and Transportation Safety" and DOE Order 460.2 on "Departmental Materials Transportation and Packaging Management." These, in turn, imply compliance with applicable DOT regulations.

Several facilities have been evaluated as potential sites for the disposal of the final products from the treatment and conditioning of INTEC wastes. The products must meet the criteria of the facilities for acceptance and disposal.

Table I. Assigned Tank Farm listed HWNs and chemicals, and LDR treatment standards.

HWNs	Chemical Name	LDR Non-Wastewater Standard
F005	Benzene	10 mg/kg
F005	Carbon disulfide	4.8 mg/L TCLP
F001 F002	Carbon tetrachloride	6.0 mg/kg
U134	Hydrogen fluoride	ADGAS fb NEUTR or NEUTR[1]
F005	Pyridine	16 mg/kg
F002	Tetrachloroethylene	6.0 mg/kg
F005	Toluene	10 mg/kg
F001 F002	1,1,1-trichloroethane	6.0 mg/kg
F001 F002	Trichloroethylene	6.0 mg/kg
N/A[2]	Acetone	160 mg/kg
N/A	Cyclohexane	CMBST[3]
N/A	Cyclohexanone	CMBST (alternate standard: 0.75 mg/L TCLP)
N/A	Ethyl acetate	33 mg/kg
N/A	Methanol	CMBST
N/A	Methyl isobutyl ketone	33 mg/kg
N/A	Xylenes	30 mg/kg

[1] ADGAS fb NEUTR: Venting of compressed gases into an absorbing or reacting media, followed by, neutralization.
[2] Not Applicable. These are the chemicals that were listed only for the characteristics of ignitability. But they lost the characteristic of ignitability because of mixing with water and other solid waste. Therefor, they would no longer carry the listed HWN (see the text for further discussion on this matter).
[3] CMBST – High temperature organic destruction technologies such as combustion.

These WAC are discussed in the seventh section, in conjunction with the evaluation of the WAC compliance of the waste forms from the proposed options.

In addition to all the drivers discussed in this section, the wastes must be managed in a way that meets the enforceable requirements and intent of the INEEL Site Treatment Plan developed in accordance with the Federal Facilities Compliance Act (FFCA). Finally, it is noteworthy that the management of the wastes is subject to a number of other state, regional, and local laws and regulations, including those of the jurisdictions through which the wastes may be transported.

MECHANISMS FOR EXCLUDING MIXED WASTES FROM RCRA REGULATIONS

Currently, among the candidate disposal facilities considered in this study, only the Waste Isolation Pilot Plant (WIPP), the Hanford site, and the Envirocare are authorized to accept certain RCRA-regulated waste (treated to applicable treatment requirements) originating from outside their respective states. The remaining candidate sites are not RCRA-regulated Subtitle C facilities. Consequently, the final products resulting from the treatment of INTEC wastes to LDR standards must not contain any RCRA wastes in order to be disposed of at these latter facilities. This section describes the avenues for allowing the disposal of the final wastes as non-hazardous wastes once they meet the RCRA LDR requirements. These avenues include EPA delisting, the use of the EPA proposed Hazardous Waste Identification Rule (HWIR), the EPA proposed Mixed Waste Storage and Disposal Rule, and of the DOE regulatory reform proposals, if the latter three are approved. Another mechanism evaluated but later eliminated for consideration in this study is the EPA's Project XL (eXcellence and leadership). This is a national pilot program which tests innovative strategies designed to achieve better and more cost-effective environmental results than conventional regulatory approaches would achieve. The requirements to participate in the Project XL are that the applicants develop proposals with alternative innovative and cost-effective environmental management strategies to improve public health and the environmental protection. The alternative strategies must: 1) produce superior environmental results beyond those that would have been achieved under the current and reasonably expected future regulations, 2) produce benefits such as cost-savings, 3) incorporate stakeholders involvement, 4) are feasible, 5) achieve innovation and pollution prevention, 6) produce lessons that are transferable to other facilities, and 7)

Table II. Assigned Tank Farm characteristics HWNs, preliminary UHCs, chemicals responsible for these assignments, and applicable LDR treatment standards.

HWNs	Chemical Name	LDR Non-Wastewater Standard
D002 D002- Mixed HLW	Corrosivity (pH)	DEACT and meet UTS for UHC HLVIT for mixed HLW
N/A[1] (underlying D002)	Fluoride[1]	-----[2]
N/A (underlying D002)	Nickel	11 mg/L TCLP
D004 D004-Mixed HLW	Arsenic	5.0 mg/L TCLP HLVIT[3]
D005 D005-Mixed HLW	Barium	21 mg/L TCLP HLVIT
D006 D006-Mixed HLW	Cadmium	0.11 mg/L TCLP HLVIT
D007 D007-Mixed HLW	Chromium	0.60 mg/L TCLP HLVIT
D008 D008-Mixed HLW	Lead	0.75 mg/L TCLP HLVIT
D009 D009-Mixed HLW	Mercury[4] Mercury[6] Mercury[7]	IMERC; or RMERC[5] 0.20 mg/L TCLP 0.025 mg/L TCLP HLVIT
D010 D010-Mixed HLW	Selenium[1]	5.7 mg/L TCLP HLVIT
D011 D0011-Mixed HLW	Silver	0.14 mg/L TCLP HLVIT
UHC	Antimony	1.15 mg/L TCLP
UHC	Beryllium	1.22 mg/L TCLP
N/A UHC	Vanadium[1] Thallium	1.6 mg/L TCLP 0.20 mg/L TCLP
N/A	Zinc[1]	4.3 mg/L TCLP
D019	Carbon tetrachloride	6.0 mg/kg and meet UTS for UHC
D021	Chlorobenzene	6.0 mg/kg and meet UTS for UHC
D022	Chloroform	6.0 mg/kg and meet UTS for UHC
D026	Cresol-mixed sorbers	11.2 mg/kg and meet UTS for UHC
D028	1,2-dichloroethane	6.0 mg/kg and meet UTS for UHC
D032	Hexahlorobenzene	10 mg/kg and meet UTS for UHC
D034	Hexachloroethane	30 mg/kg and meet UTS for UHC
D035	Methy ethyl ketone	36 mg/kg and meet UTS for UHC
D036	Nitobenzene	14 mg/kg and meet UTS for UHC
D038	Pyridine	16 mg/kg and meet UTS for UHC
D039	Tetrachloroethylene	6.0 mg/kg and meet UTS for UHC
D040	Trichloroethylene	6.0 mg/kg and meet UTS for UHC
UHC	Phenol	6.2 mg/kg
UHC	Ethyl benzene	10 mg/kg
UHC	Chloroform	6 mg/kg
UHC	Methylene chloride	30 mg/kg
UHC	Isobutyl alcohol	170 mg/kg
UHC	Naphthalene	5.6 mg/kg
UHC UHC	*o*-Nitrophenol *p*-Nitrophenol	13 mg/kg 29 mg/kg

[1] Not an UHC in characteristic wastes.
[2] No specific treatment standard finalized for this constituent.
[3] HLVIT – Vitrification of mixed HLW.
[4] High-Mercury (≥ 260 mg/kg total mercury) that also contains organics.
[5] IMERC and RMERC - IMERC: Incineration of wastes containing mercury and organics; and RMERC: Retorting or roasting in a thermal processing unit.
[6] Low-mercury (<260 mg/kg total mercury) and residues from RMERC.
[7] Low mercury (<260 mg/kg total mercury) that are not residues from RMERC.

establish accountability through agreed upon monitoring, reporting, and evaluation processes. Under the current DOE's proposed plans for the treatment of the INTEC wastes, the Project XL does not seem to offer a viable approach for excluding the wastes from the RCRA Subtitle C regulation.

The wastes excluded from the RCRA Subtitle C regulations, however, would be radioactive and would still need to be managed in accordance with the applicable federal, state, and local regulations (e.g., DOE, DOT, etc.).

Delisting Approach

Delisting is a method by which a waste bearing a listed HWN can be excluded from the hazardous waste regulations under the RCRA Subtitle C program. To exclude, or delist, a listed waste, a delisting petition must be submitted to the authorized delisting agency. Then, the agency determines if the waste is eligible for delisting. There are three types of delisting or exclusion: a standard exclusion, a conditional exclusion, and an upfront exclusion. Procedures and guidance for petitioning to delist a listed waste can be found in 40CFR 260.20 and 260.22 and references 12 and 13.

Delisting petitions are waste stream specific. The INTEC wastes could be delisted prior to or after final treatment. For the NGLW, a standard exclusion could be an option for obtaining delisting. This exclusion is typically used for waste that is currently generated and will be generated in the future. A "one-time" standard exclusion or conditional exclusion could be an option for delisting the HLW calcine and the SBW. The "one-time" standard exclusion is used for discrete volumes of wastes, typically generated in the past. However, using either a "one-time" exclusion or a conditional exclusion to delist the calcine could be very difficult. This is because it could be impractical to perform characterization study on the calcine that would be adequate for the delisting purposes. An alternative option that seems to be more practical than the others is to use an upfront exclusion. This type of conditional exclusion is used for future waste forms. The upfront exclusion may be granted based on the evaluation of the characteristics of the untreated waste, process description, and data from bench scale or pilot scale treatment system. The options identified in this study must be evaluated for cost effectiveness, timeliness and practicality in a subsequent study. The future study will require negotiation with the appropriate regulatory agencies. The delisting petitions, if granted by the Division of Environmental Quality in Idaho, would require approval of the waste-receiving states and of all other states through which the waste is transported. Hence, a delisted waste in Idaho may still be considered a RCRA hazardous waste when it crosses into other states.

Hazardous Waste Identification Rule

EPA proposed the HWIR to amend the RCRA hazardous waste regulations (14). This rule would allow mixed waste containing listed hazardous constituents below the HWIR exit levels to become eligible for self-implementing exemption from the RCRA Subtitle C regulations. Such wastes would be disposed as radioactive wastes only. Application of the self-implementing exemption would require notifying the state regulatory agency, complying with sampling and analysis requirements, and meeting administrative requirements. The self-implementing nature of the proposed HWIR proposal would enable some listed wastes to leave the RCRA regulatory management system without having to be formally "delisted." The proposed HWIR is scheduled to be finalized on April 30, 2001.

Mixed Waste Storage and Disposal Rule

EPA issued the proposed Mixed Waste Storage and Disposal Rule that aims to reduce dual regulations of mixed LLW, which is subject to RCRA and AEA. The proposal would exempt certain mixed LLW from RCRA storage, manifesting, and disposal requirements if specific conditions are met (15). The exemption does not apply to RCRA hazardous waste mixed with HLW or TRU waste. The conditions for exemption are to ensure the waste meet the applicable LDR requirements, to notify the disposal facility of the exempt status of the waste before shipment to the disposal facility, and to comply with the Nuclear Regulatory Commission (NRC) transportation requirements 10 CFR 71. In addition to these, for RCRA-exempted mixed wastes, DOE facilities must comply with the DOT and 10 CFR 20 requirements to claim the exemption. The exempt waste must be disposed of at facilities licensed by NRC or Agreement State.

DOE Regulatory Reform Proposals

DOE submitted two regulatory reform proposals for consideration by EPA during the development of the HWIR in July and October 1995 (14, 16). In the proposals, DOE suggested that EPA allow vitrified mixed waste (mixed HLW and mixed LLW) and immobilized mixed low-level debris to be excluded from RCRA regulations, after treatment, provided the treatment process satisfied regulatory controls (16). The department stated that after meeting the applicable treatment standards, continuing to manage the hazardous components of vitrified waste or immobilized debris under subtitle C of RCRA is unlikely to provide additional protection for human health and the environment beyond that required by the AEA. The department believes that the AEA requirements would also provide adequate protection of human health and the environment from these wastes. EPA has not made any decisions with regards to the DOE proposals. This is due to the concern expressed by the states hosting DOE facilities over losing oversight enforcement authority for RCRA-exempted radioactive waste once it exits RCRA Subtitle C jurisdiction, and over DOE self-regulation and possible mismanagement of the waste (14). However, EPA proposed the Mixed Waste Storage and Disposal Rule that is aimed to provide some flexibility for mixed LLW. This is because of EPA's view that joint regulations of mixed waste under RCRA and AEA may be, at times, redundant (17).

WASTE RECLASSIFICATION ISSUES

Some of the proposed treatment options involve separation processes that will generate waste stream fractions referred to as high-activity waste (HAW), low-activity waste (LAW) and waste with significant TRU components. The separation processes begin with dissolving the HLW calcine and mixing it with the liquid waste streams (SBW and NGLW). This is followed by fractionation of the resulting liquid wastes into HAW, LAW, and TRU portions. It is proposed that the LAW be transported to a LLW disposal facility and that the TRU fraction be disposed of at WIPP, after meeting the applicable requirements. The HAW portion would be shipped to a HLW geologic repository, when available. The HAW does not require reclassification since it is considered HLW. In contrast, the LAW and waste containing TRU radionuclides would require reclassification as LLW and TRU waste, respectively. This is because the HLW would be separated into the TRU and LAW fractions, and hence these fractions would legally remain classified as HLW pending "waste incidental to reprocessing" (WIR) determination by DOE, using either "citation" or "evaluation" process. All of these wastes, including the HAW stream, will need to be subjected to evaluation, classification confirmation, or reclassification approval and the concurrence of the competent and applicable government authorities.

WASTE PROCESSING ALTERNATIVES

The INTEC wastes are to be treated and converted into stable products that are suitable for permanent disposal. Three separation and three non-separation treatment options have been proposed. These options are described in this section. The description below focuses on the primary waste streams. The secondary or intermediate waste streams such as spent ion exchange (IX) media, spent filters, etc., and their treatment and disposal options are beyond the scope of this study. Some of the treatment options addressed below are shown to meet the schedule requirements derived from the various agreements. These are explicitly identified. Other options may or may not meet these schedule requirements and would require further study the outcome of which depends on decisions by DOE that are yet to be made. Such cases are beyond the scope of this study. Several facilities have been proposed for the disposal of the final waste products. These disposal facilities are identified under each option.

Non-Separation Alternative

In Non-separation Alternative, three treatment options have been considered. These are designated the Early Vitrification Option (EVO), the Hot Isostatic Pressed Waste Option (HIPWO), and the Direct Cement Waste Option (DCWO), respectively. Figure 1 presents simplified process flow diagrams for these options. Starting with the HLW calcine, the SBW, and the NGLW, these options would generate three distinct HLW forms: glass, glass-ceramic, and hydroceramic (pozzolan cement) waste. The wastes would have to be road-ready for shipment to a HLW geologic repository by the year 2035. All the options are designed to meet the Settlement Agreement requirement to have the HLW road-ready for transport out of Idaho by 2035, and to complete calcining the SBW by 2012 (except for EVO). The liquid SBW/NGLW would be calcined in the Maximum Achievable Control

Technologies (MACT) upgraded NWCF. In all the options, mercury from the off-gas scrubbing system would be extracted, amalgamated, and disposed of as LLW at an approved facility.

Early vitrification option (EVO). In this option (Figure 1), it is planned to retrieve the liquid SBW and NGLW from the tanks and to send them directly to a vitrification facility, bypassing calcination. The liquid wastes (SBW and NGLW) and the solid HLW calcine would be treated in separate vitrification operations. All the wastes would be mixed with glass forming materials to produce a stable borosilicate glass. The vitrified wastes to be derived from the liquid (SBW and NGLW) would be qualified as remote-handled TRU (RH-TRU). It is proposed that the glass produced from vitrifying the liquid wastes be poured into standard WIPP RH-TRU waste containers for disposal. The waste would be temporarily stored at the INEEL, until disposal at WIPP. The glass from vitrifying the HLW calcine would be suitable for disposal at a HLW geologic repository. The HLW glass would be poured into SS canisters and stored at INEEL until transported to a repository. This option would not allow DOE to complete calcination of the SBW by 2012. However, it is designed to meet the Settlement Agreement requirement to have the HLW road-ready for disposal by 2035.

Hot Isostatic Pressed Waste Option (HIPWO). In the HIPWO (Figure 1), the liquid wastes (SBW and NGLW) would be calcined and subsequently immobilized along with the HLW calcine, using the HIP process. In this process, the calcined wastes would be mixed with glass forming materials and other additives (silica and titanium powder). The mixture would be placed in special canisters and subjected to high temperature and pressure to produce a glass-ceramic waste form. The HIP waste would be stored, road-ready, on-site awaiting disposal at a HLW geologic repository.

Direct Cement Waste Option (DCWO). In this option (Figure 1), the SBW and NGLW would be calcined. All the calcined wastes, including existing HLW, would be mixed with grout forming materials (clay, blast furnace slag, caustic soda and water) and would be placed into SS canisters. The grout would be cured at elevated temperature and pressure to produce a cementitious or a hydroceramic waste. The final waste form would be stored, road-ready, on-site awaiting disposal at a HLW geologic repository.

Separation Alternative

The Separation Alternative begins with dissolving and filtering the wastes into two main streams: one with dissolved waste material and the other containing undissolved solids (UDS). The waste with dissolved material would go through separation steps that would generate up to three different waste streams designated as HAW, LAW, and TRU waste. It is planned for the HAW to be immobilized and ultimately disposed of at a HLW geologic repository, and for the LAW to be solidified, and disposed of at a near-surface LLW facility at the INEEL or at an approved off-site facility. The TRU waste stream would be converted into a solid form that would be suitable for disposal at the WIPP. Separating the wastes into major streams reduces the amount of waste that has to be shipped to a HLW geologic repository, thereby saving disposal costs, needed disposal space, and reducing the risks associated with transportation of radioactive wastes. The issues on characteristics and classification of the waste streams resulting from the separations would vary with the type of the separation process used. These issues are also discussed in this section. The UDS would be stabilized for temporary storage on-site prior to further treatment (if necessary) and ultimate disposal.

Mercury in the separation feed stream is also extracted, treated, and disposed of as LLW. Any mercury passage in the LAW and subsequently in the LAW grout, if determined to be above the LDR limit, must be treated to meet the LDR standard prior to land disposal. The scrub solution from LAW and HAW off-gas treatment is recycled back into to the LAW and HAW separation feed streams, followed by mercury extraction.

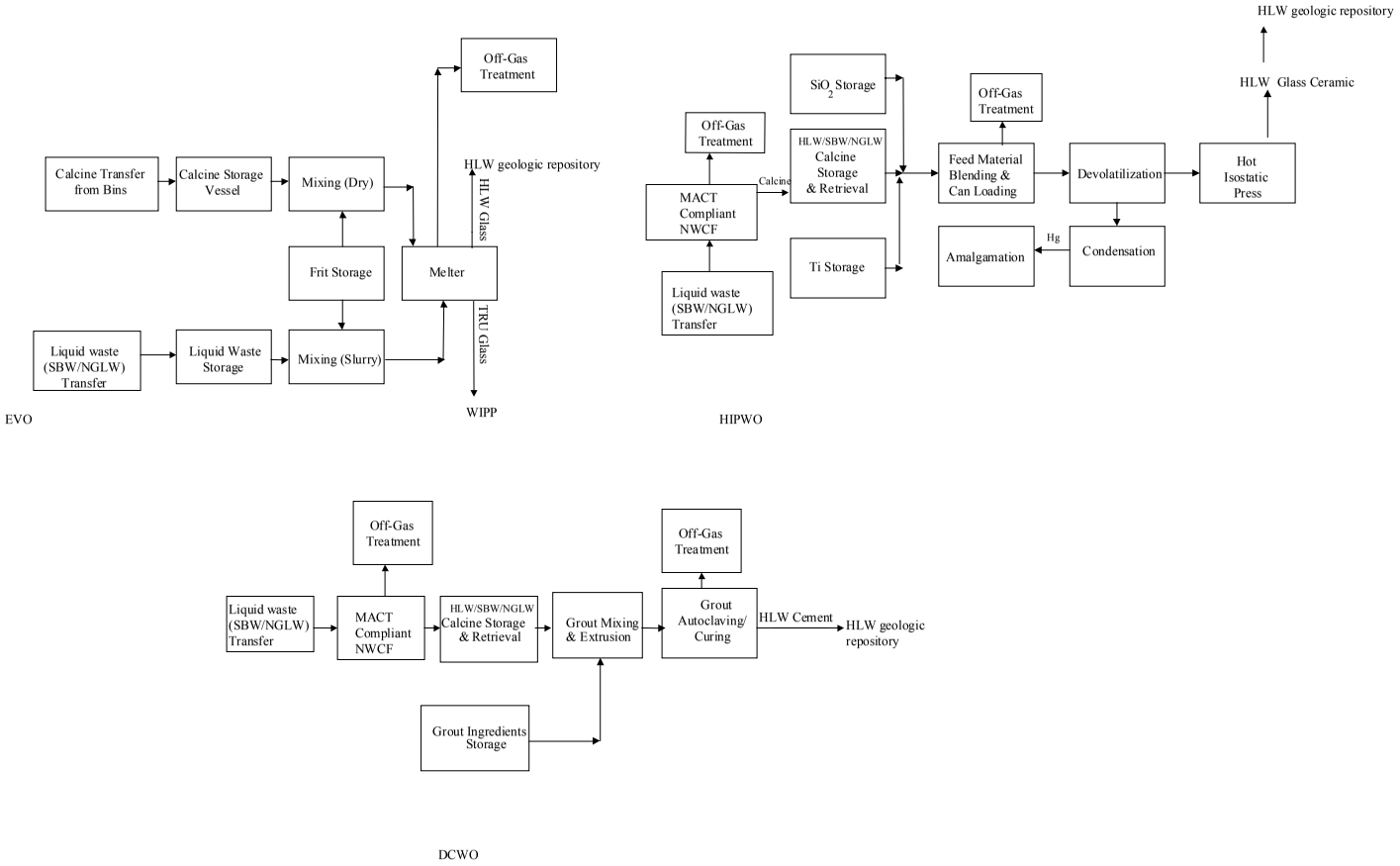

Fig. 1. Process flow diagrams for the non-separation options.

Three separation options have been selected. These are the Full Separation Option (FSO), the Planning Basis Option (PBO), and the Transuranic Separation Option (TSO). Each of these is described below, and their simplified process flow diagrams are shown in Figure 2.

Full Separation Option (FSO). In this option (Figure 2), the stored HLW calcine would be retrieved, dissolved, and separated into HAW and LAW. The liquid SBW and NGLW would be subject to the same separation process. The separation method would remove Cs, Sr, and TRU components from the process waste streams. The liquid SBW and NGLW would be processed through ion exchange columns, known as AMP-PAN (see below), to separate the highly radioactive Cs from the waste streams. The effluent from the IX columns would be fed to a TRU Extraction unit (TRUEX) to separate the TRU components. The effluent from the TRUEX process would be sent to a Sr Extraction (SREX) process to separate Sr from the waste streams. The Cs, Sr, and TRU components would make up the radionuclide composition of the HAW, including most of the radioactivity and long-lived nuclides from the HLW; SBW; and NGLW.

The HAW, along with the UDS would be vitrified and stored on-site (road-ready) until shipped to a HLW geologic repository for disposal. The process waste stream remaining after separation of the highly radioactive nuclides is called the LAW. Based on the composition and concentrations of the radionuclides in the LAW, the waste would meet the definition of NRC Class A LLW. It is planned for the LAW to be solidified into a grout form and to be sent to a near-surface LLW disposal facility. Managing the LAW as NRC LLW would require reclassification of the waste.

Several potential disposal locations are considered for the Class A grout: a new INEEL LLW disposal facility, the INTEC empty Tank Farm tanks, SS bin sets (following the removal of the calcine), and an off-site LLW (DOE or commercial) disposal facility. Two location options are proposed by DOE for vitrifying the HAW: the INEEL and the Hanford Site. In the first option, the HAW would be vitrified at the INEEL and stored on-site prior to shipment to a HLW geologic repository. In the second, the HAW generated in separation operations would be dried, packaged, and transported to the Hanford Site for vitrification. Following vitrification, the waste would be returned to the INEEL for interim storage while awaiting shipment to a geologic repository.

Crystalline silicotitanate (CST) and ammonium molybdophosphate (AMP) immobilized on polyacrylonitrile (PAN), (AMP-PAN), are two type of Cs IX media being evaluated at the INEEL for Cs removal. The AMP is known to have higher Cs selectivity and adsorption capacity than CST. When AMP loses its effectiveness, it would be removed, dissolved, and vitrified along with the HAW fraction for disposal. The low activity PAN would be grouted using the LAW grouting system prior to disposal. Cs absorption on the CST is irreversible, hence the media would become a waste that would need to be treated and disposed of.

Under the FSO, DOE would comply with the Settlement Agreement requirement to have the HLW road-ready by 2035. In order to satisfy the requirement in the revised Consent Order to remove all the SBW by the end of 2012, a Cs Ion Exchange/TRU (CsIX/TRU) Grout sub-option has been proposed (Figure 2). This sub-option involves removing the UDS from the SBW and NGLW, and feeding the effluent containing the dissolved material to a CsIX/TRU separation unit where Cs would be absorbed by the IX columns (CST), thus separated from the TRU and Sr components. The Cs absorption on the IX media is irreversible. The media would be stabilized and stored awaiting final treatment and disposal. Vitrification is considered an option for treatment of the Cs-loaded IX media prior to disposal. The remaining SBW/NGLW effluent with the TRU and Sr components, and any mercury present, would be grouted and sent to the WIPP for disposal as contact-handled TRU (CH-TRU) waste. The filtered UDS would be dried for safe storage to be ultimately disposed of at the WIPP as RH-TRU waste. With the CsIXs/TRU sub-option, the HLW calcine would still need to be treated for ultimate disposal.

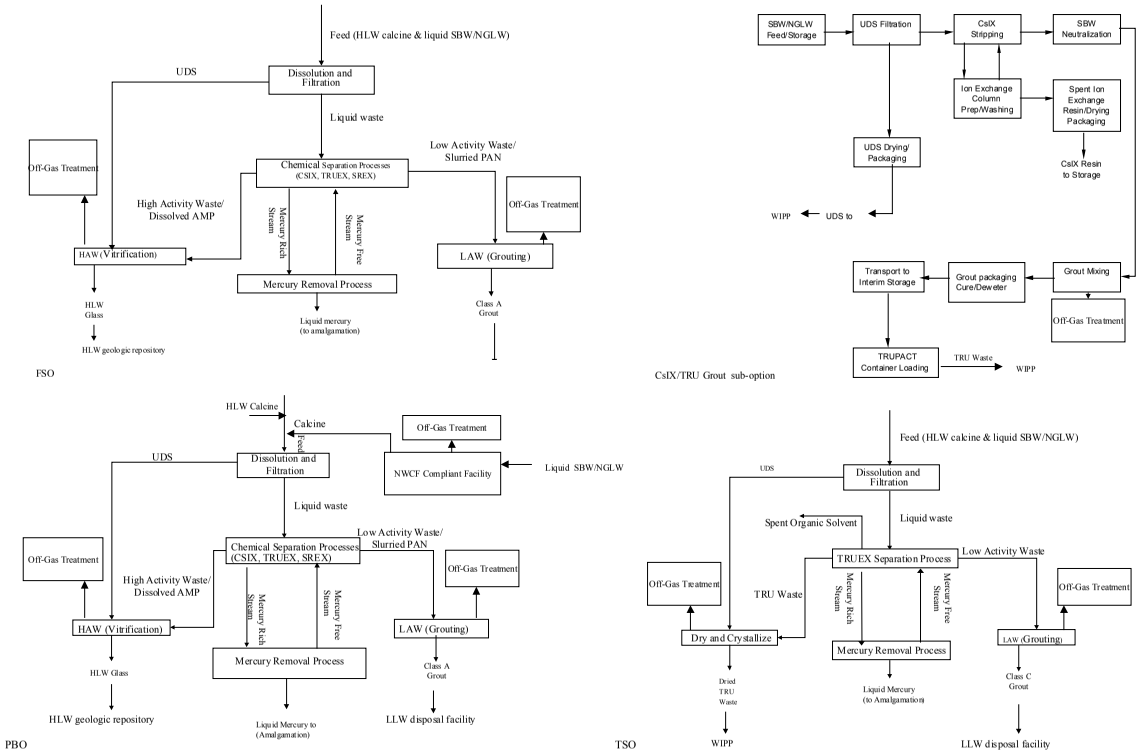

Fig. 2. Process flow diagrams for the separation options.

Planning Basis Option (PBO). The PBO (Figure 2) is identical to the FSO, except that the liquid SBW and NGLW would not be directly subjected to separation processes. Instead, the liquid wastes would be calcined in the MACT compliant NWCF prior to being dissolved and separated. This option is designed to satisfy the requirements in the Settlement Agreement and the revised Consent Order.

Transuranic Separation Option (TSO). In this option (Figure 2), the SBW and NGLW would not be calcined. Instead, they would be directly fed to a separation system (TRUEX) to remove the TRU elements from the process streams. The HLW calcine would be retrieved, dissolved, and subjected to the same separation process. The UDS would be filtered out. The waste containing the TRU elements is designated as TRU waste and the remaining process stream would be considered LAW. The TRU waste stream would contain most of the long-lived radionuclides of the HLW, SBW, and NGLW. It is planned for the TRU waste to be dried, solidified, and placed in temporary storage prior to shipment to the WIPP. Since the TRU waste is derived from HLW, it would have to be reclassified before disposal at WIPP. The LAW is expected to contain Cs and Sr components with higher concentrations than in the FSO. These nuclide concentrations are similar to those of the NRC Class C LLW definition. The UDS would be dried and prepared for disposal at WIPP.

DOE has selected three potential disposal options: a new INEEL LLW disposal facility, the INTEC empty Tank Farm tanks, and SS bin sets at CSSF. As in the FSO, the LAW would be solidified into a grout and sent to a near-surface LLW disposal facility. Like the TRU waste, the LAW must be reclassified and delisted prior to disposal at a LLW facility. Mercury, resulting from the process, would be treated for disposal at an approved LLW facility or shipped with the TRU waste to WIPP for disposal. The TSO would enable DOE to cease use of five of the eleven tanks by 2003, as mandated by the revised Consent Order.

In addition to the alternatives described above, others, including a minimum processing, the continued current operations (CCO) of calcination and storage in SS bins at the CSSF, and a no-action alternative have been considered. Under the minimum processing (Figure 3), the HLW calcine would be retrieved and transported to an on-site packaging facility where it would be placed into shipping containers. The containerized wastes would then be shipped to the Hanford Site where the waste would be dissolved and separated into HAW and LAW streams and vitrified. The vitrified HAW would be packaged for shipment to the INEEL where it would be stored until transported to a geologic repository for disposal. The vitrified LAW would be packaged and shipped either to the INEEL or to an off-site facility for disposal. The SBW and the NGLW would be processed using a CsIX/TRU Grout treatment process to remove Cs as discussed under the FSO. Under the minimum processing option, DOE would meet the requirement to have the HLW road-ready by 2035. Using the CsIX/TRU Grout process would allow the tanks containing the SBW to be taken out of service by 2012.

Under the no-action alternative, it is assumed that the NWCF would not undergo upgrades to comply with the EPA MACT Rule for air emissions and permitting, and no liquid SBW or NGLW would be calcined. The SBW will be evaporated to enable DOE to cease the use of non-compliant tanks by June 30, 2003. The SBW inventory in the Tank Farm would no longer be calcined and the SBW would remain in storage indefinitely. The HLW would also remain in storage at the CSSF indefinitely. The NGLW would continue to be processed to reduce the volume.

In the CCO (Figure 3), the NWCF would be upgraded to comply with the MACT requirements. Calcination of the SBW and the NGLW would continue. The calcined wastes would be stored at the CSSF, along with the calcined HLW, and would remain in storage indefinitely. The NWCF would be shut down after all the SBW has been calcined. In the interim, the SBW will be evaporated to enable DOE to cease the use of non-compliant tanks by June 30, 2003. New or existing permitted tanks would be required to store the evaporated wastes prior to further processing. The further processing could potentially include separating the NGLW into TRU waste and LAW portion through an IX process. The TRU waste fraction would be sent to WIPP and the LAW would be converted into a grout to be shipped to a LLW disposal facility. Under this alternative, it is assumed that the upgraded NWCF would calcine the SBW from 2011 through 2014.

A summary of the processing alternatives with their final waste products, volumes, and disposal locations is shown in Table III.

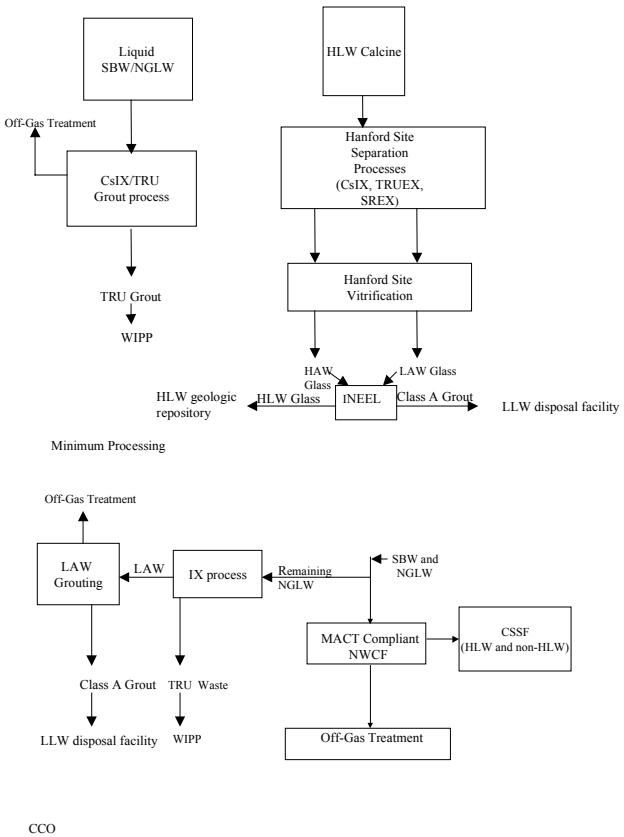

Fig. 3. Process flow diagrams for the Minimum Processing and CCO.

REGULATORY ANALYSIS OF THE WASTES AND CRITERIA OF CANDIDATE REPOSITORIES

This section is broken down into three major subsections (HLW, TRU waste, and LLW) representing the classification of the final waste products from the treatment options, discussed above. The analysis focuses on the primary waste streams. In this study, the determination of the classification of the waste products is based on three considerations: waste origin, the projected composition and estimated concentrations of the radionuclides, and the application of DOE Order 435.1 concerning the WIR concept.

Several potential locations have been considered for the disposal of the final waste products resulting from the proposed treatment options. These include a future HLW geologic repository at the Yucca Mountain Site or a second HLW repository, the WIPP, and a DOE or a commercial site for LLW disposal. The DOE Sites evaluated include a new INEEL LLW disposal facility, the NTS LLW disposal facility, and the Hanford Site LLW disposal facility. Commercial disposal sites considered are the Barnwell Waste Management Facility in South Carolina, the US Ecology Facility in Washington, and the Envirocare Facility in Utah.

High-Level Waste

The treatment options are expected to generate three HLW forms: glass, glass-ceramic, and cementitious waste. These wastes require disposal at a HLW geologic repository. Currently, the Yucca Mountain is designated as the

Table III. Summary of processing alternatives with their final waste products, volumes, and disposal locations.

Waste Processing Alternatives	Primary Waste Products Suitable for disposal	Waste Classification	Waste Volume (m^3)	Disposal Location
EVO	HLW Glass TRU Glass	HLW TRU	8,500 360	HLW geologic repository WIPP
HIPWO	HLW Ceramic	HLW	3,400	HLW geologic repository
DCWO	HLW Cement	HLW	13,000	HLW geologic repository
FSO	HAW Glass LAW Grout	HLW LLW Class A	470 27,000	HLW geologic repository LLW disposal facility
CsIX/TRU sub-option	HLW Glass TRU Grout	HLW CH-TRU	8,216 7,650	HLW geologic repository WIPP
PBO	HAW Glass LAW Grout	HLW Class A LLW	470 30,000	HLW geologic repository LLW disposal facility
TSO	TRU Solids LAW Grout	RH-TRU waste Class C LLW	220 22,700	WIPP LLW disposal facility
CCO[1]	TRU solids from NGLW LAW Grout from NGLW	RH-TRU waste Class A LLW	Not available Not available Untreated calcine remains at the INEEL	WIPP LLW disposal facility
Minimum Processing	HAW Glass LAW Glass TRU Grout from mixed SBW/NGLW	HLW LLW CH-TRU	730 14,400 7,500	HLW geologic repository LLW disposal facility WIPP
No-Action[2]	None[2]	———	Untreated waste remains at the INEEL	———

[1] In the CCO, the SBW and part of NGLW would be calcined as schedule allows and stored in CSSF indefinitely along with the existing HLW calcine. The remaining NGLW could potentially be separated into TRU and LAW for disposal. Currently, no data are available for the waste volumes destined for disposal.

[2] The No-Action Alternative would not produce a waste form that would be suitable for disposal. The 3032 m^3 of concentrated liquid TRU waste (SBW/NGLW) and 4,200 m^3 of HLW calcine would remain untreated.

only candidate site for a HLW geologic repository. However, future waste projections suggest that, in the future, the first repository will need to be expanded or a second repository constructed.

RCRA Disposal Requirements. The reported hazardous constituents in the INTEC mixed wastes to be immobilized via EVO, HIPWO, or DCWO include characteristic heavy metals (D004-D011), corrosive (D002), other D-, F-, U-coded chemicals, and UHCs (see Tables I and II). Multiple treatment methods, concentration- and technology-based methods, would apply to the wastes bearing these HWNs and UHCs at the point of generation. It would be impractical to treat the wastes using all of the LDR specified methods. In addition, because of the radioactivity of the wastes, it could be technically inappropriate to treat the wastes to the specified level or by the methods required by EPA. A "treatability variance" under 40 CFR 268.44 and a determination of an equivalent technology (DET) under 40 CFR 268.42(b) would be needed. This is to demonstrate that an alternative treatment process would provide the adequate treatment for all the hazardous constituents in the wastes.

In the case of the EVO, vitrification is the EPA specified treatment method and a BDAT for mixed HLW with D002 and D004-D011 HWNs. Other constituents require technology-based treatments other than vitrification. For example, the LDR method for Cyclohexane and Cyclohexanone is combustion and for Hydrogen Fluoride, it is neutralization or venting into an absorbing or reacting medium followed by neutralization. The wastes that are subject to the LDR technology-based treatments may also be land disposed if treated by an equivalent treatment technology approved by EPA (40 CFR 268.42(b)). Vitrification at very high temperatures (at least 1093^{o}C) could demonstrate the same level of performance as combustion or venting. Under 40 CFR 268.42(b), a petition can be submitted to EPA for using vitrification as an equivalent method to combustion and venting. For the hazardous chemicals requiring concentration-based treatments (characteristic, UHCs, and listed), a treatability variance should be sought from EPA under 40 CFR 268.44. This would be for demonstrating that the proposed vitrification option would provide adequate treatment for all of these chemicals. For the constituents that need concentration-based standards, EPA requires either a Totals Analysis Test or the Toxicity Characteristic Leaching Procedure (TCLP) for waste extract from the final treatment product to be performed to determine LDR compliance. However, due to the radiological exposure risk considerations, it could be impractical to perform the required sampling and analysis using the conventional methods. Alternate test methods that reduce or eliminate radiological exposure risk should be established. In addition, surrogate (non-radioactive) waste should be used to determine the operating and performance conditions under which the required concentration levels for hazardous constituents would be achieved. This would demonstrate that wastes produced under these operating conditions have achieved the required performance and concentration levels.

The other options, HIPWO and DCWO, are not the LDR specified treatment methods for treating mixed HLW. Based on DOE studies conducted on glass-ceramic process with minor variation from the HIPWO, EPA suggested that the glass-ceramic process is also an acceptable technology (18). The EPA's decision was announced in a notice

of a proposed action and published in a Federal Register (18) in 1992. A final EPA ruling on the glass-ceramic process has still not been issued. If the decision is finalized, a DET petition will not be needed for using the HIP technology. Under 40 CFR 268.42(b), DET would be needed for using the alternative DCWO instead of using vitrification. Like in the EVO, treatment variance would be needed for all other chemicals requiring specified technologies and concentration-based treatments.

Yucca Mountain Repository and Disposal Criteria. The 1987 amendments to the Nuclear Waste Policy Act (NWPA), "Nuclear Waste Policy Amendments Act (NWPAA)," required that DOE characterize only Yucca Mountain as potential HLW repository.

The criteria for HLW acceptance and disposal are contained in the Waste Acceptance System Requirements Document (WASRD) (19). The DOE-Office of Environmental Management (DOE-EM) has established Waste Acceptance Product Specifications (EM-WAPS) (20), describing specific technical and documentation requirements for vitrified HLW forms. Another document titled "Preliminary Plutonium Immobilization Product Specifications (PIPS)" (21) is being developed by DOE-EM and DOE Office of Fissile Materials Disposition (DOE-MD). This document addresses ceramic product specifications. The EM WAPS, PIPS, and the WASRD provide specifications for waste form, chemical composition, organic materials, radionuclides, gases, free liquids, explosiveness, pyrophoricity, combustibility, heat generation, dose rate, criticality, etc. These documents also specify that generators demonstrate compliance with these specifications via four documents: Waste Form Compliance Plan (WCP), Waste Form Qualification Report (WQR), Production Records (PR), and Storage and Shipping Records

(SSR). The specifications in these documents are used here as technical baseline requirements for the INEEL HLW acceptance to the future HLW geologic repository, and for guidance to proceed with the waste acceptance issues. The key requirements for the HLW acceptance and disposal are summarized in Table IV.

The potential repository at Yucca Mountain will not be a RCRA-regulated hazardous waste Subtitle C facility, and consequently will not accept any hazardous waste (19). INTEC mixed waste must be treated to meet the applicable RCRA requirements for disposal and must be excluded from RCRA Subtitle C regulations via delisting or other regulatory exclusion. In addition, the waste must meet all other applicable requirements for acceptance and disposal, as appropriate. The INEEL must demonstrate, along these lines, that borosilicate glass or another waste form is appropriate for long-term disposal at a HLW geologic repository.

Transuranic Waste

Some of the treatment options under separation and non-separation alternatives are expected to generate waste that would be managed as TRU waste and suitable for disposal at the WIPP. In the separation alternative, the TRU waste streams would derive from HLW processing. Consequently, reclassification would be required to ensure that such waste is no longer considered HLW and can be managed as TRU waste.

RCRA Disposal Requirements. The TRU wastes would contain RCRA chemicals exhibiting characteristics of corrosivity (D002) and toxicity (D004-D011), and would bear UHCs. The waste would also carry RCRA listed HWNs. Under the Land Withdrawal Amendments Act (LWAA), the WIPP is exempt from the LDR requirements. However, the exemption applies only to a selected number of HWNs listed in Table V (22). For TRU waste bearing other HWNs that are not in Table V, a request must be submitted to the WIPP DOE Carlsbad Area Office (CAO) to modify the WIPP RCRA Permit to allow disposal of that waste at WIPP, thus bringing it within the envelope of waste to which the LDR exemption applies. Such waste will be prohibited for disposal at WIPP until the permit modification is approved by the NMED for these HWNs. Based on the WIPP WAC (22), waste exhibiting characteristic of corrosivity, ignitability, and reactivity are not acceptable for disposal. Such waste must be treated to remove these characteristics. Two of the RCRA HWNs currently assigned to the INTEC wastes, D002 (corrosive) and U134 (hydrogen fluoride – listed waste), are not accepted at WIPP. The TRU waste must meet the applicable treatment requirements for these HWNs and not exhibit any other RCRA characteristic that is unacceptable for disposal. In addition, U-134 must be delisted. Potential alternatives to delisting could be obtaining permission from the WIPP management or addition of U134 to the WIPP Part A Permit Application.

All the RCRA HWNs in the TRU waste, regardless of the WIPP waste acceptability status, must be reported to WIPP prior to the waste shipment (22). The determination of hazardous contaminants shall be based on acceptable knowledge and/or sampling and analysis indicating that the waste is hazardous as defined in 40 CFR 261, Subparts C and D (22). It is also required that an LDR notification be transmitted to the WIPP for each shipment of mixed waste (22). The notification must contain hazardous waste characterization records and records showing types and quantities of all hazardous constituents that require LDR treatments in accordance with 40 CFR 268.

Waste Isolation Pilot Plant and Disposal Criteria. WIPP received certification from EPA and a RCRA Permit from the New Mexico Environment Department (NMED) for disposal of defense-generated TRU waste and mixed TRU waste. Waste destined for disposal at the WIPP must comply with the requirements of the Land Withdrawal Act (LAW) and its amendments (LWAA) and the WIPP WAC document. The LWA specifies that the waste must meet the definition of TRU waste, must not contain HLW or SNF, and it must be generated from atomic energy defense-related activities. LWAA exempts WIPP from LDR requirements.

Table IV. Summary of the Yucca Mountain key waste acceptance criteria.

WASTE ATTRIBUTES	REQUIREMENTS
Canistered Waste Specifications	
Waste specification	• Waste must be in solid form and placed in sealed canisters • Waste must not contain any RCRA constituents.
Waste form	• Borosilicate glass or Ceramic-glass
Specifications for Free Liquid and Gas	• No detectable amounts of free liquids • No detectable amounts of free gas other than air. • Internal gas pressure immediately after closure < 150 kPa at 25°C.
Specification for Explosiveness, Pyrophoricity, and Combustibility	• No detectable amounts of explosive, pyrophoric, or combustible materials. • Document that the canistered waste forms remain nonexplosive, nonpyrophoric, and noncombustible in the event that the temperature exceeds 400°C. • If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with the WASRD requirements.
Confinement	• Waste shall not contain or generate materials that are explosive, pyrophoric, or chemically reactive in the repository environment • Waste shall not contain or generate free liquids.
Organic Materials Specification	No detectable amounts of organic materials.
Chemical Compatibility Specification	• No waste form must cause internal corrosion of the canister. • Document interactions between the canister and its contents, including any reaction products generated within the canistered waste form, in the event that the temperature exceeds 400°C. • If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with the WASRD requirements.
Fill Height Specification	A height equivalent to at leas: • 80% of the volume of the empty canister for the West Valley Demonstration Project (WVDP) & the Savanna River Site (SRS). • 87% of the volume of the empty 4.5 m canister.
Heat Generation Specification	• < 1,500 watts per 3.0 m canister at the year of shipment or alternatively 2,540 watts per 4.5 m canister at the year of shipment. • Document heat generation projections and the range of expected variation for each waste type, indexed to the year 2015.
Specification for Maximum Dose Rates	• Maximum on-contact surface gamma dose rate < 10^5 rem/hr at shipment • Maximum neutron dose rate < of 10 rem/hr at the time of shipment. • Projections of Dose Rates • Document the expected values and the range of expected variation for both gamma and neutron dose rates indexed to the year 2015.
Subcriticality Specification	• Ensure that under normal and accident conditions, a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. • $k_{eff} < 0.90$
Drop Test Specification	Canistered wastes must withstand a 7 meter drop onto a flat, essentially unyielding surface without breaching (leak rate <1 x $l0^4$ atm-cc/sec helium).
Canister Specifications	
Canister Dimensions	• Length: 3.000 m (+0.005, -0.020 m) or alternatively 4.500 m (+0.005, -0.020 m). • Diameter: 61.0 centimeters (+1.5, -1.0 cm).

The WIPP WAC document identifies the criteria for the safe handling, transportation, and disposal of TRU waste, as well as mixed TRU waste, including requirements for container, nuclear properties, chemical properties, and for certification and shipment. The WIPP WAC document was revised in November 1999 to incorporate the requirements of the NMED Permit.

Table V. List of RCRA hazardous waste codes acceptable at the WIPP.

F001	D008	D030
F002	D009	D032
F003	D010	D034
F004	D011	D035
F005	D018	D036
F006	D019	D037
F007	D021	D038
F009	D022	D039
D004	D026	D040
D005	D027	D043
D006	D028	P015
D007	D029	

The revised WAC addresses only criteria that are specific to CH-TRU waste. The RH-TRU waste criteria for disposal are deleted in the new WIPP WAC document because the WIPP is currently not permitted to dispose of RH-TRU. The RH-TRU criteria are being developed by the WIPP office and will be issued as a separate document. Tables VI and VII provide a summary of the key disposal criteria for CH- and RH-TRU waste. The criteria for RH-TRU waste are based on the previous version of the WIPP WAC document (23) and are preliminary at the present time. They are provided here for information only to proceed with waste acceptance issues.

Low-Level Waste

Some of the proposed waste processing alternatives would produce up to two types of LAW, designated as Class A and Class C LLW (as defined in the LLW classification system of 10 CFR 61.55). The LAW will meet the NRC Class A LLW concentration limits under the FSO and PBO and Class C LLW limits under the TSO (9). The LAW would be converted into a grout waste form to be shipped to a LLW disposal facility. Since the LAW is derived from HLW separation processes, it would need reclassification to be managed as LLW.

The LAW meets the definition of "waste incidental to reprocessing" as defined in the DOE Manual 435.1. The Manual states that some waste that is determined to be incidental to SNF reprocessing may be managed as LLW. Such waste is required to be processed to remove key radionuclides to the maximum, technically and economically feasible extent, and must be converted into a solid form at a concentration less than Class C LLW limits (11). The current plan at the INEEL is to solidify the LAW (Class A or C) into a grout form prior to disposal.

The facilities identified above for the disposal of the LAW are discussed in turn, below. Not discussed, as they are beyond the scope of this study are the empty tanks and bins.

RCRA Disposal Requirements. The LAW (Class A or C) is also a mixed waste, and therefore, it is subject to the RCRA LDR requirements prior to land disposal. The waste would also carry RCRA listed chemicals and would still considered a mixed waste, even after meeting all the LDR treatment standards. Such waste requires delisting before being managed as a LLW.

Commercial LLW Disposal Facilities and Criteria

DOE's policy is to rely on its own facilities for the disposal of its wastes, and by exemption where necessary, make limited use of commercial facilities that have been licensed by the NRC or an Agreement State (24). When an exemption is sought, the DOE requires the following minimum requirements be met (11):

Table VI. Summary of WIPP CH-TRU key waste acceptance criteria.

WASTE ATTRIBUTES	REQUIREMENTS
Container And Physical Properties	
Container Description	DOT Type A 55-gallon drums, Standard Waste Boxes (SWBs), Ten-drum overpacks (TDOP)
Container Weight	≤ 1000 lb/55-gallon drum ≤ 4000 lb/SWB ≤ 6700 lb/TDOP
Removable Surface Contamination	20 dpm/100 cm^2 for Alpha 200 dpm/100 cm^2 for Beta-Gamma
Radiological Properties	
Nuclear Critically Pu-239 FGE	≤ 200 g/55-gallon drum ≤ 325 g/SWB ≤ 325 g/TDOP < 325 g/TRUPAT-II ≤ 2,800 g/TRUPACT-II (14 55-gallon drums Pipe Overpacks)
Pu-239 Equivalent Activity (PE-Ci)	Untreated Waste ≤ 80 PE-Ci/55-gallon drum ≤ 130 PE-Ci/SWB ≤ 130 PE-Ci/TDOP ≤ 1,100 PE-Ci/55-gallon drum overpacked in a 85-gallon drum, or SWB, or TDOP ≤ 1,100 PE-Ci/SWB in a TDOP ≤ 1,800 PE-Ci/55-gallon drum containing a pip component Solidified/Vitrified Waste ≤ 1800 PE-Ci/55-gallon drum
Contact Dose Rate	≤ 200 mrem/hr @ the surface of the payload container and the TRUPACT-II ≤ 10 mrem/hr @ 2 m
Thermal Power	≤ decay heat limit for the authorized shipping category Report if > 0.1 watts/ft3 (3.5 watts/m^3) < 40 watts per TRUPACT-II
TRU Alpha Activity	> 100 nCi of alpha-emitting TRU isotopes per gram of waste
Chemical Properties	
Pyrophoric Materials	< 1% Radionuclide pyrophorics No nonradionuclide pyrophorics
Mixed Waste Hazardous Components	Limited to EPA HWNs listed in Table V
Explosives, Corrosives and Compressed Gases	No explosives, corrosive, or compressed gases
Flammable VOCs	≤ 500 ppm in container headspace
Data	
Acceptance and Shipping Data	Auditable package of data with signed Certification Statement Payload Container/Assembly Transportation Certification Documents Bill of Lading (A Uniform Hazardous Waste Manifest may be substituted.)
RCRA Data	Waste Stream Profile Form, Uniform Hazardous Waste Manifest, LDR notification

Table VII. Summary of WIPP preliminary RH-TRU key waste acceptance criteria.*

WASTE ATTRIBUTES	REQUIREMENTS
Container and Physical Properties	
Container Description	DOT Type A RH canister
Canister gross Weight	≤ 8000 lb/loaded canister
Removable Surface Contamination	≤ 20 dpm/100 cm^2 Alpha ≤ 200 dpm/100 cm^2 Beta-Gamma
Radiological Properties	
Nuclear Critically Pu-239 FGE	< 325 g/cask < 600 g/canister (may get waiver)
Pu-239 PE-Ci	≤ 1000 PE-Ci/canister
Contact Dose Rate	≤ 1000 rem/hr per canister Preapproval required if > 1000 rem/hr per canister ≤ 200 mrem/hr per cask Neutron ≤ 270 mrem/hr per canister
Thermal Power	< 300 watts per canister
TRU Alpha Activity	> 100 nCi/g of waste matrix ≤ 23 Ci/Liter
Chemical Properties	
Pyrophoric Materials	< 1% Radionuclide pyrophorics No nonradionuclide pyrophorics
Mixed Waste	Limited to EPA HWNs listed in Table V
Explosives, Corrosives and Compressed Gases	No explosives, corrosive, or compressed gases
Flammable VOCs	≤ 500 ppm in canister headspace
Data	
Acceptance Data	Auditable package of data with signed Certification Statement on file WWIS data transmitted
RCRA Data	Waste Stream Profile Form, Uniform Hazardous Waste Manifest, LDR notification
Shipping Data	RH-TRU 72-B cask payload Container Transportation Certification Documents Bill of Lading (A Uniform Hazardous Waste Manifest may be substituted.)

* The criteria for RH-TRU waste are preliminary at the present time but they provide technical guidance to proceed with the waste acceptance issues. The specific RH-TRU waste transportation and disposal requirements will be finalized after NRC approval of the RH-TRU 72-B Cask Safety Analysis Report for Packaging (SARP) and issuance of a Certification of Compliance (C of C).

- The commercial disposal facility must meet the applicable federal, state, and local requirements, and have the necessary permits, licenses, and approvals;
- Disposal of wastes at a commercial facility must be cost-effective and in the best interest of DOE;
- The commercial facility must have adequate history of operational and regulatory performance, as determined by an annual review by DOE;
- DOE wastes must be sufficiently characterized and certified to meet the facility acceptance criteria;
- Appropriate National Environmental Policy Act (NEPA) review must be completed;

- DOE-HQ must be notified of the exemption to use a commercial facility, and the Office of the Assistant Secretary for Environment, Safety, and Health must be consulted prior to the exemption being implemented;
- Host states and state compacts must be consulted before approval of the exemption.

The commercial disposal facilities evaluated in this study include the Barnwell Waste Management Facility in South Carolina, US Ecology Disposal Facility in Washington, and the Envirocare Facility in Utah.

Barnwell Waste Management Facility. This facility is not a "Compact" facility. It is authorized to accept LLW Class A, B, and C for disposal from other states, except for the State of North Carolina (24). Mixed LLW is not accepted for disposal (24). The Barnwell Waste Management Facility WAC (25) require that waste shipments for disposal at this site be in compliance with the South Carolina Department of Health and Environmental Control (DHEC) Radioactive Materials License and the DOT and NRC requirements. The key requirements for waste shipment and disposal are:

- An approval and a permit must be obtained from the Barnwell Facility before waste shipment.
- Class A, B, and C wastes must meet the requirements of 10 CFR 61.56.
- Waste must be stabilized in concrete or other stabilization agents in accordance with the requirements of the NRC Technical Position Paper on Waste Form26, 27 for demonstrating long-term (300-year) structural stability that is required by 10 CFR 61.56 for Class B and C, or other methods for which approval has been granted by the DHEC.
- Waste greater than Class C limit is not acceptable for disposal without prior written approval from the DHEC.
- Mixed LLW regulated under 40 CFR 261 and South Carolina Hazardous Waste Management Regulations is not accepted for disposal. Radioactive waste exhibiting solely hazardous characteristics as defined in 40 CFR 261, Subpart C, but that has been treated so that it no longer exhibits RCRA characteristics, will be reviewed for acceptance on a case-by-case basis. A description of the treatment process and results of the analytical tests of the final waste must be submitted to the Barnwell Facility for evaluation prior to shipment.
- Not accepted for disposal are: free liquid, explosive and pyrophoric waste, chemically explosive materials, and materials that could react violently with water or moisture or when subject to agitation.
- Wastes must be packaged and transported in accordance with the applicable DOT and NRC requirements.

US Ecology Disposal Facility. The US Ecology facility in Richland is a "Compact" facility which serves the "Northwest Compact" and the "Rocky Mountain Compact" (24). The "Northwest Compact" includes Washington, Oregon, Wyoming, Idaho, Montana, Utah, Alaska, and Hawaii; and the "Rocky Mountain Compact" consists of Nevada, Colorado, and New Mexico. The US Ecology facility accepts Class A, B, and C LLW for disposal. Mixed waste is not accepted for disposal at the facility. Because the US Ecology facility is a Compact facility, the Compact States must approve any disposal of DOE waste there (24). Under the Low-Level Radioactive Waste Policy Act (LLRWPA), the State of Washington and the others relevant Compact States can prohibit the disposal of the DOE waste at US Ecology (24) in Richland.

The US Ecology Richland Disposal Facility WAC (28) require that waste shipment and disposal be in accordance with the requirements of the Washington State Department of Health, the Washington Radioactive Materials License of the facility, the Washington State Rules and Regulations for Radiation Protection, the Washington State Dangerous Waste Regulations, and DOT and NRC regulations. These requirements are comparable to those described for the Barnwell facility, above.

Envirocare Facility. The Envirocare Facility is licensed by the State of Utah under the State Agreement with NRC to dispose of LLW and mixed LLW with very low levels of radioactivity. The Envirocare is not a "Compact" facility under the LLRWPA, and therefore can accept waste from sites throughout the country. It is the only facility currently permitted to dispose of treated mixed LLW (commercial and DOE) from other states (24). The facility accepts LLW with levels of radioactivity corresponding to Class A limits or less. Envirocare accepts a number of

listed wastes with F, P, and U HWNs that are treated to LDR specifications. Delisting would not be required for the listed HWNs currently assigned to the INTEC wastes.

DOE LLW Disposal Sites and Criteria

DOE Manual 435.1 provides a set of general criteria for treatment and disposal of LLW and mixed LLW. The requirements address waste form acceptability, waste characterization, packaging and transportation, and waste certification for shipment. In addition to these general criteria, each DOE Site has developed specific waste acceptance and disposal criteria. The sites evaluated in this study and their WAC are described in the following sub-sections.

A New INEEL LLW Disposal Facility. It is expected that the criteria of a new INEEL LLW disposal facility for waste acceptance and disposal be comparable those of the INEEL Radioactive Waste Management Complex (RWMC) (29). The RWMC disposes of CH and RH LLW generated at the INEEL. The key criteria are:

- LLW resulting from treated mixed waste must meet all the applicable LDR treatment requirements and must not exhibit any characteristic hazard. In addition, the waste must have all the necessary LDR notification and certification documentation.
- LDR treated must not bear any listed HWNs.
- Radionuclide concentrations must not exceed the Class C limits (10 CFR.61). Wastes exceeding the limits will require a case-by-case evaluation and approval prior to disposition.
- No free liquid, explosive or pyrophoric waste could be accepted.
- TRU concentrations (except for Pu-241 and Cm-242) must be <10 nCi/g
- CH LLW <500 mrem/hr at 1 meter; RH LLW is taken as >500 mrem/hr at 1 meter

Based on RWMC criteria, several issues must be resolved before the LAW or LLW could be disposed at a new INEEL facility: receive an approved delisting petition to remove the F and U codes prior to disposal, demonstrate the waste contains concentration <10 nCi/g TRU constituents, and meet all other applicable requirements.

Nevada Test Site. The NTS accepts LLW (Class A, B, or C) and mixed LLW for disposal from generators that are designated by DOE–HQ and approved by the DOE-NV (30). Presently, the site does not accept mixed waste generated out of the State of Nevada. Waste acceptance criteria for out of state mixed waste have not been developed. Currently, the INEEL is neither a designated nor an approved generator (31). DOE-NV requires that the generator develop an NTS WAC (30) compliance program for obtaining the DOE-NV approval. The WAC compliance program includes development and/or completion of certain waste acceptance documentation demonstrating waste characterization plan and quality assurance requirements for waste certification. Prior to the compliance program development, the DOE-NV Waste Management Division must be contacted to verify that waste is potentially acceptable at NTS. The NTS key waste acceptance and disposal requirements are essentially similar to those of RWMC.

Hanford Site. All non-Hanford Site waste generators must receive approval from the DOE Richland Operations Office (DOE-RL) before acceptance by and shipment of waste to the Hanford Site (32). It is required that the parties requesting approval contact their DOE Operations or Field Office Interface and request that the Field Office approach DOE-RL regarding the possible shipment of waste to the Hanford Site. DOE-RL can approve a waste stream consistent with the long-term waste management strategies for the site and meeting the acceptance criteria.

Presently, the INEEL is not an approved customer for shipping waste to Hanford for disposal (33). It would be unlikely for the INEEL grouted LAW to be acceptable for disposal at the Hanford Site. This is because at Hanford, DOE has selected vitrification as the acceptable treatment method for the LAW fraction (resulting from HLW separations) for on-site disposal (34). This technology selection was based on the evaluation of alternatives for management of HLW separation processes and the resulting waste steams, regulatory compliance requirements, costs, safety and health, and public comments (34). Irrespective of the DOE decision mentioned above, the current Hanford WAC document does not include any criteria for acceptance and disposal of LAW resulting from HLW separation processes. It defines criteria for LLW and mixed LLW acceptance and disposal at Hanford and does not require that LLW be vitrified prior to disposal.

The applicable key requirements at the Hanford WAC are comparable to those of the INEEL RWMC and NTS. Notable differences include:

- LLW fractions from the HLW separation processes must be vitrified
- LDR treated waste must not bear any U, P, and K codes
- Waste must meet the Hanford classification system (category 1 and/or 3) for the radionuclide
- Waste heat generation < 3.5 watts/m^3
- TRU content < 100 nCi/g of waste
- CH-LLW <200 mrem/hr at any point of the surface and $\leq$100 mrem/hr at 30 cm form the waste container
- RH-LLW defined as ≥200 mrem/hr at any point of the surface
- Category 3 waste can be disposed of only if the waste meets one of the following waste form stability criteria:
  - Packaging in Hanford approved HIC
  - Stabilization in concrete or other stabilization agents in accordance with the requirements in the NRC Technical Position Paper on Waste Form for demonstrating long-term (300-year) structural stability that is required by 10 CFR 61.56 for Class B and C wastes.

CONCLUSIONS

The applicable environmental regulations and agreements identified in this study constitute the drivers and the source for defining the performance requirements and schedules for the treatment and disposal of the INTEC wastes. The drivers were categorized into three principal groups. These are (i) the Settlement Agreement and the Consent Order between the State of Idaho and other parties, (ii) EPA (RCRA) regulations, and (iii) DOE orders and implied NRC and DOT regulations. In addition, the management of the wastes is subject to a number of other state, regional, and local laws and regulations, including those of the jurisdictions through which the wastes may be transported. The wastes addressed in this study are HLW, SBW, and NGLW. These wastes are "listed" mixed wastes, subject to the requirements of RCRA Subtitle C and the AEA-based requirements, as implemented and administered by DOE.

To comply with the drivers, three separation and three non-separation treatment options have been proposed. These options are expected to convert the INTEC wastes into stable waste products that would be suitable for permanent disposal. The treatment products would continue to be regulated as mixed wastes under the RCRA Subtitle C program even after they meet the applicable treatment requirements, unless excluded from hazardous waste regulations. The avenues for such exclusion and for allowing the disposal of the concerned mixed wastes as non-hazardous wastes once they meet the RCRA LDR requirements have been identified. These avenues include EPA delisting, the use of EPA proposed HWIR, the proposed Mixed Waste Storage and Disposal Rule, and DOE regulatory reform proposals, if the latter three are approved.

Some of the treatment options addressed in this study were shown to meet the schedule requirements derived from the various agreements. The schedules of the other options may require or could not be determined as they may depend on decisions by DOE that are yet to be made.

Several facilities have been evaluated as potential sites for the disposal of the final products from the treatment of INTEC wastes. The products must meet the criteria of the facilities for acceptance and disposal. The HLW and HAW will be sent to a HLW geologic repository. This course of action is acceptable without reclassifying the HAW since it is already HLW. In contrast to the HAW, the TRU and LAW portions will require reclassification and the concurrence of the competent authorities for disposal as TRU and LLW, respectively.

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