Note to the Public:

The Panel welcomes public comment on this draft of the report. The public comment periods during the Jackson meeting will be from 1:00-2:00 pm MST and 7:00 pm- 9:00 pm MST on December 5. The meeting will be in the Grand Room at the Snow King Resort, 400 East Snow King Ave., Jackson, WY. The two-day meeting will be open to the public and will take place from 8:00 am- 9:00 pm, December 5 and 8:00 am- 11:30 am, December 6.

If you wish to provide written comments prior to the meeting, please fax them to Francesca McCann (Fax 202-586-6279) by **noon EST on Friday, December 1**. If you wish to email them (francesca.mccann@hq.doe.gov), please do so by **noon EST, Monday, December 4.** The Panel appreciates your contribution to the report.

FINAL DRAFT FOR PUBLIC AND PANEL REVIEW
[Distributed on November 28, 2000]

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REPORT OF THE SECRETARY OF ENERGY ADVISORY BOARD'S PANEL ON EMERGING TECHNOLOGICAL ALTERNATIVES TO INCINERATION

December 2000

Secretary of Energy Advisory Board
U.S. Department of Energy

Secretary of Energy Advisory Board
Panel on Emerging Technological Alternatives to Incineration

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LIST OF ACRONYMS

AEA	Atomic Energy Act
AMWTP	Advanced Mixed Waste Treatment Project
CBD	Commerce Business Daily
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DOE	United States Department of Energy
DOT	United States Department of Transportation
EM	United States Department of Energy's Environmental Management
EPA	United States Environmental Protection Agency
ES&H	Environmental, Safety and Health
FACA	Federal Advisory Committee Act
FFCAct	Federal Facility Compliance Act of 1992
HEPA	High-Efficiency Particulate Air
HWFP	Hazardous Waste Facility Permit
IDC	Item Description Code
INEEL	Idaho National Environmental Engineering Laboratory
LDR	Land Disposal Restrictions
MOU	Memorandum of Understanding
PCB	Polychlorinated biphenyl
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RDD&D	Research, Development, Demonstration and Deployment
RFI	Request For Information
SAR	Safety Analysis Report
SARP	Safety Analysis for Packaging
SDA	Subsurface Disposal Area
SEAB	Secretary of Energy Advisory Board
SWB	Standard Waste Box
TDOP	Ten Drum Overpack
TMFA	DOE's Transuranic and Mixed Waste Focus Area
TRU	Transuranic Waste
TRUPACT II	Transuranic Package Transporter Model 2
TSA	Transuranic Storage Area
TSCA	Toxic Substances Control Act
USNRC	United States Nuclear Regulatory Commission
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria
WETO	DOE's Western Environmental Technology Office
WIPP	Waste Isolation Pilot Plant

REPORT OF THE SECRETARY OF ENERGY ADVISORY BOARD'S PANEL ON EMERGING TECHNOLOGICAL ALTERNATIVES TO INCINERATION

I. Statement of the Problem

A. The Panel's Charge and Approach

The Blue Ribbon Panel on Emerging Technological Alternatives to Incineration is a task force of the Secretary of Energy Advisory Board (SEAB). The Panel was created following a dispute over the proposed construction of an incinerator for treatment of radioactive mixed waste at the Idaho National Engineering and Environmental Laboratory (INEEL), which resulted in the Department of Energy's April 2000 commitment to appoint a "blue ribbon" panel of independent scientific experts that would explore technological alternatives to incineration that might become available for use at DOE facilities nationwide.[1]

1. Secretary of Energy Advisory Board Terms of Reference

More details on the Panel's mission appear in the Terms of Reference subsequently established by the SEAB, based on the Settlement Agreement:

> The SEAB Panel . . . will evaluate and recommend emerging nonincineration technologies for treatment and disposal of mixed waste on which the Assistant Secretary of Environmental Management's Office of Science and Technology should focus efforts for development, testing, permitting and deployment. The Panel will evaluate technologies to treat low-level, alpha low-level and transuranic wastes containing polychlorinated biphenyls (PCBs) and hazardous constituents, including the up to 14,000 cubic meters of such wastes that the DOE had planned to incinerate in the Advanced Mixed Waste Treatment Facility (AMWTF) at INEEL. The Panel will also evaluate whether these technologies could be implemented in a way that would allow the department to comply with all the legal requirements, including those contained in the Settlement Agreement and Consent Order signed by the State of Idaho, DOE and the Navy in October 1995. That agreement requires the Department to remove 65,000 cubic meters of waste at the INEEL from Idaho by the end of 2018.[2, 3]

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1 Settlement Agreement: Keep Yellowstone Nuclear Free v. Richardson, et al.; No 99 CV 1042J (D. Wyo.).

2 Terms of Reference are in Appendix I.

3 While the Panel's charge is to address non-incineration technologies for treating the 65,000 cubic meters of above-ground waste at INEEL, we also acknowledge that other DOE facilities have unique waste forms that must be treated. For example, TRU and fission-product contaminated kerosene from the PUREX process at the Savannah River Plant (`570 cubic meters) and Hanford must also be treated.

2. The Panel's History and Procedures

The Panel consisted of nine members, appointed by the Secretary of Energy (five members), the Governors of Idaho and Wyoming (one member each), and public interest groups (two members). Biographical summaries appear in Appendix II.

The Panel held five formal meetings (Table 1). As required by the Federal Advisory Committee Act (FACA) all meetings were open to the public and the Panel sought public comments at each meeting. Briefings to the Panel at these meetings covered applicable regulations, inventory and characteristics of the waste, technology state-of-the-art and DOE plans for research and development on alternatives to incineration. In addition, the Panel issued a Request for Information (RFI) through the Commerce Business Daily (CBD) to solicit a broad range of industry and other views on mixed waste treatment options[4]. A sub-panel, consisting of five Panel members, initially reviewed the responses to the RFI and reported their findings to the full Panel. The sub-panel received technical assistance from three independent reviewers and a DOE review team.

Table 1. Blue Ribbon Panel Meetings

Meeting Number	Location	Date	Purpose
I.	Washington, DC	June 22, 2000	1. Task Definition 2. Planning and Procedures
II.	Idaho Falls, ID Jackson, WY	August 22-24, 2000	1. Regulatory briefing & discussion 2. Waste inventory /characterization 3. Technology options 4. Hear public comments
III.	Washington, DC	September 27, 2000	1. Discuss DOE R&D Plans 2. Discuss Final Report Structure
IV.	Denver, CO	October 11, 2000	1. Further review DOE R&D Plans 2. Discuss responses to RFI 3. Review drafts of Final Report
V.	Jackson, WY	December 5-6, 2000	1. Complete Final Report 2. Hear public comments

In addition to the Panel meetings, five full-panel conference calls and four sub-panel conference calls were held to prepare, discuss and organize materials for the formal meetings.

B. Overview of the Issues

As early as the 1970's, the scientific community recognized that the release to the environment of waste streams containing persistent organic compounds such as polychlorinated biphenyls (PCBs) posed unacceptable hazards to humans and to ecological systems. One approach for treating PCB

4 CBD announcement of RFI and list of responders appear in Appendix III.

contaminated wastes has been incineration. It turns out, however, that incineration of PCBs can lead to the formation of compounds such as dioxins and furans that are even more toxic, although these emissions can be minimized by proper design and control of the incineration facilities. On the other hand, no such solution exists for radioactive wastes. The U. S. Government's choice for disposal of transuranic radioactive waste (TRU) has been deep underground at the Waste Isolation Pilot Plant (WIPP) in New Mexico.

Table 2. Panel Conference Calls

Conference Call Date	Participants
August 2, 2000	Full Panel
August 18, 2000	Full Panel
September 22, 2000	Sub-panel
October 2, 2000	Sub-panel
October 10, 2000	Sub-panel
November 1, 2000	Sub-panel
November 6, 2000	Full Panel w/ Independent Reviewers & Public
November 20, 2000	Full Panel & Public
November 27, 2000	Full Panel & Public

The disposal of mixed transuranic (TRU) waste – containing radioactive material, PCBs, and other hazardous constituents – poses a unique problem, and existing regulations were not designed specifically to address such wastes. For example, the removal of PCB's from mixed TRU waste requires some sort of treatment that might involve an overall risk to society higher than the risk of sending the untreated waste to a facility such as WIPP. In any event, treatment of mixed TRU waste might be required for several reasons related either to long-term stability or to safe transportation to the disposal site, such as removal or immobilization of liquids. Also, it might be necessary to remove volatile organic compounds and to minimize the radiolytic generation of hydrogen (from the interaction of alpha particles emitted by the radionuclides with organic compounds) in order to eliminate the potential for explosion of gases emanating from the waste.

The nature of the technologies to be utilized for the waste treatment depends on their purpose. For example, volatile and semi-volatile organic compounds can be separated from the mixed waste relatively easily – e.g., by evaporation at moderate temperatures, or by extraction under vacuum – and these compounds can be destroyed subsequently by oxidation to yield mostly carbon dioxide and water. PCBs are chemically very stable and are not volatile under ambient temperature conditions, so that their destruction is more difficult, requiring strong chemical or thermal treatment before or after separation from the waste stream; no suitable "mild" treatment exists. At the same time, it is necessary to insure that the radioactive material eventually remains in the solid waste stream, so that it can be safely disposed of. An assessment of technologies for waste treatment should take into account, among others, the overall risks and costs involved with handling and disposing of all the effluents, including but not limited to front-end handling, aqueous waste treatment, primary treatment, and off-gas treatment.

Incineration involves high temperatures, an open flame, and a large volume of gaseous effluents. A wide array of technological alternatives to incineration exists, although no single one may be suitable for treatment of all types of mixed waste: a combination of steps or a set of several technologies might be required to treat the multiplicity of mixed waste. Some of these alternative technologies might also require high temperatures, but are nevertheless clearly distinct from incineration: they might operate, for example, under reducing conditions, rather than under oxidizing conditions in an open flame, avoiding the generation of dioxins and furans from PCBs. Also, many alternative technologies generate small amounts of gaseous effluents consisting of volatile organic compounds. Once separated from the waste, these effluents can be oxidized, for example, by contact with a ceramic catalyst at high temperatures, in the presence of oxygen, so that only carbon dioxide and water are released to the atmosphere.

C. Characteristics of the "Mixed Wastes" at Issue in this Report

For purposes of this report, "mixed waste" means waste that contains both hazardous waste and radioactive material that is subject to the requirements of the Resource Conservation and Recovery Act (RCRA) and the Atomic Energy Act (AEA), which apply to generation of waste and to wastes already stored. In some cases, this waste is also contaminated with PCBs, which are regulated under the Toxic Substances Control Act (TSCA). EPA and the States enforce the requirements imposed by RCRA and TSCA. DOE sites that store, treat, or dispose of mixed waste are regulated under RCRA, TSCA, and the AEA. In addition, mixed waste buried in the ground at DOE facilities is subject to section 120(a)(2) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. The term "mixed waste" is used frequently in this report as a generic term for all the contaminated radioactive wastes under consideration by the Panel, although strictly speaking radioactive waste containing only PCBs (which are not regulated under RCRA as "hazardous") is not "mixed waste" under the prevailing technical definition.

Hazardous and radioactive wastes pose difficult challenges to DOE as owner and to EPA and States as regulators of these sites. DOE must manage, treat, and dispose of these mixed wastes in an environmentally sound and cost-effective manner to ensure public health and safety.
[DO WE NEED THIS PARAGRAPH?]

1. Origin, Forms and Status of the Stored Mixed Wastes at INEEL

DOE currently stores approximately 65,000 cubic meters of radioactive waste at the Transuranic Storage Area (TSA) at the Radioactive Waste Management Complex (RWMC) at the INEEL. Most of this waste resulted from nuclear weapons production operations at the Rocky Flats Plant in Colorado and was transported to the INEEL before the current definition of transuranic (TRU) waste was established (prior to 1982). This waste is managed as TRU waste, although not all of it meets the current definition. Approximately 95 percent of this waste is classified as "mixed waste." Some contains polychlorinated biphenyls (PCBs), which are regulated under the Toxic Substances Control Act (TSCA). It should be emphasized that at this time we do not know precisely what is in all 65,000 cubic meters of waste, since not all has been characterized (e.g., pre-1973 drums, comprising 18% of the total above-ground stored volume). In addition, a small volume of the waste may contain mercury, a metal that vaporizes at low temperatures and is particularly difficult for off-gas systems to manage.

Of the 65,000 cubic meters, approximately 52,000 cubic meters (80 percent) is in wooden boxes and metal drums that were stacked on an asphalt pad and covered with tarps, plywood, and then soil to form an earthen-covered berm. The earthen-covered berm is enclosed within a metal building called the Transuranic Storage Area Retrieval Enclosure (TSA-RE), a RCRA interim status facility.

Approximately 13,000 cubic meters of the waste (the other 20 percent) is stored in adjacent RCRA-permitted facilities at the RWMC.

A portion of these 65,000 cubic meters needs to be treated by alternatives to incineration.[5] Without treatment, this waste does not currently meet requirements for shipment to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico or other regulatory requirements for waste disposal and transportation, which are reviewed in subsection C below. Initial planning for the Advanced Mixed Waste Treatment Project (AMWTP) incorporated the assumption that 78% of the waste would require incineration in order to meet these requirements. This included all non-debris and combustible debris (typically paper, rags, plastic and rubber). Improved understanding of the waste has resulted in successively lower estimates, and by early 1997 the AMWTP contractor had determined that only non-debris waste should be incinerated. As a result, the amount to be treated was reduced to 22% of the total.

In 1996, waste designated for disposal at WIPP was exempted from the RCRA Land Disposal Restrictions (LDR), further reducing the quantity of waste to be treated. Only a fraction of many of the waste streams will now require treatment. The current estimate is approximately 1,500 cubic meters (or about 2%), based on review of the envelope of waste comprising the full 65,000 cubic meters, published information about the waste, anecdotal evidence, and subsequent analysis or examination of the wastes. The actual volume requiring treatment will be determined only after individualized analysis of each container, which must be completed before any waste is shipped or treated.

These wastes will be received for inspection, characterization and then shipment or processing. Receipt is in wood boxes, bins or 55-gallon drums (which are generally lined with a high density polyethylene liner). Sometimes the waste is contained in a plastic bag alone or in a smaller container (such as a one gallon polyethylene container) that has been placed in a 55-gallon drum. Where the condition of the 55-gallon drum is suspect, it will be placed in an 83-gallon overpack drum to prevent the spread of contamination.

2. Other Mixed Wastes at INEEL

The Panel has focused upon the waste requirements defined in its mandate. During our deliberations, however, we heard much about another large quantity of waste on the INEEL site that arrived between 1952 and 1970, in addition to the 65,000 cubic meters addressed in the panel's charter. This additional waste is buried in pits and trenches on an 88-acre disposal area.

The volume of this waste has been estimated at 63,000 cubic meters and at up to 186,000 cubic meters in various published accounts. These very large differences appear to be caused principally by uncertainties about the volumes of contaminated soil in the neighborhood of the buried waste, which can only be determined by detailed testing and mapping of the actual conditions of the pits and

5 Waste streams potentially requiring treatment are identified in Appendix IV.

trenches. However, the precise volumes are not the important issue. Whether the additional amounts are comparable to the 65,000 cubic meters at the Transuranic Storage Area, or two or three or more times greater, the fact remains that volumes of waste of the same general kind and at least equal magnitude to that under consideration by the Panel remain on the INEEL site. This waste is buried under conditions that are much less contained and much less predictable than the waste in the Panel charter, and the Panel urges that increased emphasis be given to this in some ways more worrisome quantity of waste. It must be immediately and seriously addressed by the Department.

This waste has been known to be a problem for many years, and the Panel is aware that DOE has a continuing program that attempts to deal with it. DOE is working with EPA Region X and the Idaho Department of Environmental Quality to develop and implement a remedy for the buried waste under the INEEL CERCLA cleanup program. A Record of Decision identifying the remedy is scheduled to be issued in December 2002.

However, no viable cleanup plan has yet been implemented. It is generally agreed that some of these wastes are not properly contained. In fact, they are leaching from pits and trenches, and may pose a substantial threat to the Snake River Plain aquifer underlying the site. This aquifer is one of the largest underground water bodies in America, and any threat to it carries with it legitimate cause for concern. In the public comment periods of the Panel's meetings, this buried waste emerged repeatedly as a matter of utmost concern to the citizenry. In light of these facts, the Panel wishes to note that the problem is serious, and to urge that the Department of Energy put increased emphasis on adequately defining the subsurface phenomena involved, and as quickly as possible to put in place comprehensive plans that will assure that cleanup occurs before significant crises can develop.

D. Why do Mixed Wastes Require Treatment?

Wastes must be treated for two principal reasons: (a) to meet transportation requirements and (b) to meet Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (WAC). Elements of these two overlapping sets of requirements are specified by regulations or set by permits. Transportation requirements restrict the shipment of materials that would create a hazard during transit. The WIPP WAC restrict the amount and nature of waste components that can be accepted. Three INEEL waste components can trigger a need for treatment: potential hydrogen generators, volatile organic compounds (VOCs), and polychlorinated biphenyls (PCBs).

The Nuclear Regulatory Commission has imposed a flammable gas (e.g., hydrogen, methane, etc.) concentration limit on contact-handled transuranic waste transported using the Transuranic Package Transporter, Model II (TRUPACT-II). This limit is set at the lower explosive limit of 5% by volume for hydrogen in air. To meet this limit, hydrogen generation rates are limited by the WIPP WAC and by the TRUPACT II (shipping container) specifications. Hydrogen can be produced by the action of alpha particles on water or organic materials and the restriction calls for evaluation of steady-state hydrogen release rates for every container.

Physical and chemical characteristics of the wastes are described in Table 3.

Table 3: Description of Major Waste Types

Major Waste Types	Waste Type	Description
Solidified aqueous sludge	Inorganic Homogeneous Sludge	Generated by liquid waste treatment operations. The liquids were treated with base (sodium hydroxide) to precipitate the radioactive and chemical contaminants (e,g., iron, magnesium, plutonium and americium). The resultant precipitate was filtered and solidified by adding Portland Cement or diatomite. *NB*. Sometimes other items (e.g., gloves) were also added.
Solidified organic sludge	Organic Homogeneous Sludge	Oil and chlorinated solvents generated from the machining and degreasing of plutonium metal. These organic liquid wastes were mixed with a synthetic calcium silicate to form a grease or paste like material. An absorbent (e.g., Oil Dri) may have been added to remove any free liquid.
Solidified aqueous waste	Inorganic Homogeneous Sludge	Generated by liquid treatment operations. Aqueous wastes were received from numerous sources and the radioactive and chemical contaminants removed by a variety of methods (e.g., precipitation, flocculation and evaporation). The resulting slurry was then filtered to leave a moist sludge that was dried, and a sorbent or cement added.
Solidified Inorganic Sludge	Inorganic Homogeneous Sludge	Sludge generated from the waste treatment of, for example, shower water, acid and base. Portland cement was added to solidify the aqueous waste.
Cemented sludge	Organic Homogeneous Sludge	Organic sludge generated, for example, from a plutonium recovery incinerator. It may consist of fly ash with a damp, paste like consistency. Portland cement may have been added to remove liquids.
Light metal	Metal Debris	Various light metal items that were routinely used during plutonium operations (e.g., iron, copper, brass, aluminum, stainless steel, wire, cable and tools) that have been contaminated with acids, bases and flammable solvents.
Filters	Inorganic Debris or Heterogeneous Debris	Various filters used in plutonium operations (e.g., HEPA, Ful-Flo) and contaminated with particulates, acids, bases and solvents.
Evaporator salts	Inorganic Homogeneous Sludge	Consists of a salt residue generated from the concentration and drying of liquid waste from aqueous waste treatment operations in solar evaporation ponds.
Glass	Inorganic Homogeneous Sludge	Various glass items (e.g., bottles, vials) used during routine plutonium operations. Also whole or ground up raschig rings.

VOCs are limited by transportation requirements, which are aimed to avoid fire hazards during shipping, and VOCs must be measured in the headspace of every container.

PCB disposal is restricted by WIPP WAC to concentrations below 50 parts-per-million. The PCB concentration must be verified by records or by sampling and analysis.

Transportation requirements and WIPP WAC are evidence-based rather than process-based. That is, packages can only be certified for shipment or disposal based on their contents, and not on the fact that the contents have undergone a particular treatment or set of treatments.

The wastes that may be transported to and accepted at the WIPP facility are controlled by a variety of requirements, including but not limited to:

- New Mexico Hazardous Waste Act (incorporating 40 CFR)
- WIPP Hazardous Waste Facility Permit (HWFP)
- TRUPACT II (shipping container) Safety Analysis Report For Packaging (SARP)
- Department of Transportation Regulations (49 CFR)
- WIPP Safety Analysis Report (SAR)
- WIPP Waste Acceptance Criteria (WAC)

These sources provide the criteria (summarized below in Table 4) for transportation to, and management, storage and disposal of TRU mixed waste to the WIPP facility.

At INEEL, the AMWTF will process stored mixed transuranic waste and mixed low-level waste in preparation for disposal in New Mexico at WIPP or another appropriate facility. The process will include waste retrieval, characterization, sorting, size reduction, repackaging, sorption, supercompaction, certification, and loading of the waste for shipment. Waste that does not meet the applicable disposal requirements will remain in storage at INEEL until appropriate processing is available.

One recurring issue for the Panel was the option of transporting the INEEL mixed wastes without further treatment, either to WIPP or a commercial disposal site. As indicated earlier, this is not possible under today's regulations; for example, WIPP will not accept wastes with PCB concentrations of 50 ppm or greater. Those regulations could change over the period of the DOE/Idaho agreement; indeed, applications now pending before the EPA seek amendments to WIPP's WAC that would affect the treatment required in order to ship INEEL mixed wastes to WIPP. If EPA concurs, DOE would need also to petition the State of New Mexico for a change to the Criteria. Any such regulatory changes would require extensive consultations with interested parties and states, and no amendments in the WIPP Criteria are possible without the consent of the State of New Mexico. Accordingly, while the Panel recognizes that waste disposal regulations can evolve and will influence any long-term RD&D strategy, the Panel's recommendations do not assume amendments to the current regime.

II. Criteria for Evaluating Technological Alternatives to Incineration

The Panel adopted seven criteria for evaluating alternatives to incineration, and included them in an August 2000 Request for Information:

1. Environmental, Safety and Health (ES&H) Risk Considerations. The safety of the system, potential ES&H risks and the difficulty in designing and constructing a system to meet the

safety and environmental health requirements in radioactive service with special emphasis on upset conditions.

2. Stakeholder and Regulatory Interests. The degree to which there may be resistance or delays in implementing the technology or system due to either public concerns or regulatory requirements.

3. Functional and Technical Performance. The technical performance of the treatment process to include destruction efficiency, volume reduction capability, secondary waste generation, robustness and flexibility of the system, final waste form performance and capability to be shipped.

4. Operational Reliability. The reliability and availability of the treatment process, its complexity, and the potential exposure to maintenance workers.

5. Pre- and Post-Treatment Requirements. The pre-treatment and post-treatment requirements of the waste, and the requirements for treating the effluents from the process.

6. Economic Viability. The total life cycle cost of the system, the cost per unit volume of waste treated, the market for the technology, and the potential that the technology will be commercially available to treat the waste.

7. Maturity. The level of development of the technology, field experience with the technology in radioactive service, and whether the technology will be available in the time frame required.

In its application of the criteria, particularly those bearing on ES&H, the panel placed special emphasis on performance under potential “upset conditions.”

Although meeting all applicable ES&H regulations is an essential criterion for any technology, the Panel believes that an even more stringent standard should be applied during the evaluation process. Specifically, a technology should be highly favored if it can demonstrably meet such regulations by very large margins, affording much higher degrees of protection and much higher confidence in that protection. The crucial words here are "demonstrably" and "large margins", because only then can both the technical community and the larger public have strong confidence in the proposed technology. We have tried to apply this philosophy throughout our evaluations.

Table 4: Comparison of Disposal and Transportation Requirements

WAC Section	Requirement	Transportation	Disposal SAR	Disposal RCRA
3.3.2	Fissile Material Quantity	Pu-239 limits for 55-gallon drums, pipe components, SWBs, and TDOPs (including 2 times the measurement error).	PU-239 limits for 55-gallon drums, SWBs, and TDOPs (including 2 times the measurement error)	No requirements
3.3.3	TRU Alpha Activity Concentration	Dewatered, soiled or solidified transuranic and tritium-contaminated materials and wastes.	> 100 nCi/g	No requirements > 100 nCi/g is part of the TRU waste definition in the HWFP
3.3.4	Pu-239 Equivalent Activity	No requirements	PE-Ci limits for 55-gallon drums, SWBs, and TDOPs.	No requirements
3.3.5	Radiation Dose Rate	Surface dose rate $\leq$ 200 mrem/hr	Surface dose rate $\leq$ 200 mrem/hr	No requirements Surface dose rate $\leq$ 200 mrem/hr is part of the definition in the HWFP
3.4.1	Liquid	< 1% by volume of the payload container	< 1% by volume of the payload container	< 1% by volume of the payload container
3.4.2	Sealed Containers	Sealed containers > 4L prohibited	No requirements	Sealed containers > 4L prohibited
3.5.1	Pyrophoric Materials	Pyrophoric radioactive materials < 1% by weight	Pyrophoric radioactive materials < 1% by weight	Non-radionuclide pyrophoric materials are prohibited
3.5.2	Hazardous Waste	No requirements	No requirements	EPA hazardous waste numbers not listed in the HWFP are prohibited.
3.5.3	Chemical Compatibility	Chemical constituents shall confirm to the allowable chemical lists in the TRUPACT-II SARP.	Wastes containing chemicals that would cause adverse reactions with other payload containers are prohibited.	Wastes incompatible with backfill, seal and panel closure materials, container and packaging materials, shipping container materials, or other wastes are prohibited.
3.5.4	Explosives, Corrosives, and Compressed Gasses	Explosives, corrosives, and compressed gasses are prohibited	Explosives, corrosives, and compressed gasses are prohibited.	Explosives, corrosives, and compressed gases are prohibited.
3.5.5	Headspace Gas VOC Concentration	Flammable VOCs	No requirements	Headspace gas must be reported using sampling and analysis
3.5.6	PCBs	No Requirements	There is a bounding requirement	PCB concentration $\geq$ 50 ppm are prohibited
3.6.2	Decay Heat	Decay heat of each payload containers $\leq$ limit in the TRUPACT-II SARP.	No requirements	No requirements
3.6.3	Test Category Waste	Steady-state hydrogen gas generation release rate shall not exceed the limit specified in the TRUPACT-II SARP.	No requirements	No requirements
3.6.4	Flammable VOCs	Equal to or less than 500 ppm in the headspace of any payload container	No requirements	No requirements

Note: SWB = Standard Waste Box
TDOP = Ten Drum Overpack

III. Overview of the Technological Alternatives

Many parties have brought to the Panel a broad array of technological alternatives to incineration. We have reviewed a large number of options at very different stages of development. From the perspective of research, development, demonstration and deployment (RDD&D), the challenge is to apply inevitably constrained resources productively without prematurely narrowing the field of potential candidates. The panel's aim is to help DOE assemble an RDD&D technology portfolio that is diverse in both technology characteristics and levels of maturity; to that end, we have identified what we think are the most promising of the relatively mature and the still emerging options. We also seek to narrow the field in a productive way. Some elements of the portfolio should be ready for comparison testing on an aggressive schedule over the next several years, while others will need substantially more time (while still being potentially available in time to meet DOE's commitments to the State of Idaho).

A. Description of the Alternatives

1. Thermal Treatment without Incineration

Thermal treatment of hazardous waste involves use of high temperature as the primary means to change the chemical, physical, or biological character and/or composition of the waste in the absence of air or oxygen and without a flame. High temperatures volatize and decompose organic compounds and break their chemical bonds to form organic fragments that may require subsequent oxidization or reduction. If the decomposition products are allowed to cool in an inert environment, the products are typically carbon, and a gas containing CO, H_2, HCl, CH_4, and low molecular weight hydrocarbons (e.g., syngas). If sufficient oxygen is present, the oxygen will combine with the organic fragments to form CO_2, and H_2O. A reducing environment implies the presence of a material with a high affinity for oxygen (e.g., hydrogen or aluminum) and the absence of free oxygen. The reductant reacts with the organic fragments to produce carbon, H_2, CH_4, HCl, or Al_2O_3 (depending on the environment and stability of the compounds at the process temperature) and low molecular weight hydrocarbons from the reduction of straight-chained and aromatic hydrocarbons.

Incineration, by contrast, involves use of fuel (usually natural gas or fuel oil) with air or oxygen to produce a flame for the destruction and oxidation of the organic waste material. Typically, a secondary combustion chamber with a flame is also required to complete oxidation of any organic material escaping in gases from the main combustion chamber. Incinerators require high volumes of air and extreme turbulence to insure adequate mixing of the waste and vapors with air, and adequate time to complete the oxidation. Because of gases from the combustion of the fuel and the excess air, incinerators generate large volumes of off-gases requiring treatment before release.

Thermal treatment processes not involving incineration include plasma arc melters, DC-arc melters, metal melters, steam reformers, molten salt oxidation, and supercritical water oxidation, each of which operates under different thermal and environmental conditions.

Plasma or DC-arc melters may be operated in at least three modes: an oxidation mode in which sufficient oxygen is supplied to oxidize the organic material; a pyrolysis mode (e.g., an oxygen deficient atmosphere); or a steam-reforming mode. In the steam-reforming mode, steam provides both hydrogen and oxygen to react with the high temperature decomposition products.

Metal melters operate in a reducing mode in which the molten metal (such as iron or aluminum) has a high affinity for oxygen.

Steam reformers operate at lower temperatures than melters and interact steam directly with heated waste materials in the absence of free oxygen; steam provides a source of both hydrogen and oxygen to produce a combustible gas mixture of CO, H_2, CO_2, H_2O, CH_4, HCl and low molecular weight hydrocarbons.

In molten salt systems, organic waste and oxygen are injected into a hot molten salt bath that provide the thermal energy to break the chemical bonds of the organic material, and a medium that enables intimate contact between the oxygen and the organic fragments.

Supercritical water oxidation is a thermal process in which high temperature and high pressure are used to generate a supercritical state of water. Supercritical water readily dissolves organic material and stimulates rapid reaction between the organic material and the oxygen to produce CO_2 and H_2O. This reaction is similar to, but much more rapid, than the non-critical chemical processes described next.

2. Chemical Oxidation (Aqueous Based)

Chemical oxidation uses chemical oxidants other than oxygen or air as the primary means to destroy or detoxify hazardous materials. Moderate increases in temperature can be used to accelerate the rates of the organic destruction reactions, but the temperature alone is not sufficient to break the chemical bonds. Chemical oxidation processes use strong oxidants in an aqueous, acidic solution. Examples of strong inorganic oxidants are nitric acid, Ag^{2+}, Ce^{4+}, Fe^{3+}, and ammonium

peroxydisulfate [$(NH_4)_2S_2O_8$]. The organics are typically converted to H_2O, CO_2, HCl, and mineral salts. Because the reactions are strongly surface area dependent, solids and some liquids require significant size reduction and/or mixing for adequate oxidation to occur, whereas soluble organics are more easily oxidized. Because the reactions take place at low temperature and in a liquid state, the times required for the reactions are much longer than for thermal systems, and there is typically more secondary waste generated by the oxidizing agents.

3. Dehalogenation

Dehalogenation refers to chemical reactions in which halogens (chlorine, bromine, iodine) are removed from the molecular structure of organic compounds and replaced by other molecules to form non-hazardous or less hazardous products. For example, the solvated electron process is used to replace chlorine in PCBs with hydrogen. Byproducts from treating PCBs include petroleum hydrocarbons, sodium chloride, and sodium amide.

4. Separation

Three types of separation processes are used for removal of organic material from a waste matrix: soil washing, solvent extraction and thermal desorption.

Soil washing uses an aqueous solution and detergent to remove organic material from the surface of soil particles and to separate fine particulates (which contain most of the organic contaminants in the porous fines) from the coarse soil. Soil washing does not destroy the organic material but produces three products: a wastewater stream, a sludge of contaminated fine particulates, and soil that may contain regulated levels of heavy metals and radionuclides.

Solvent extraction uses a solvent to remove soluble contaminants from the waste (not unlike dry cleaning). A subsequent step removes the contaminants from the solvent, which can be re-used, leaving the liquid organic contaminant to be treated by other means. A special case of solvent extraction uses supercritical carbon dioxide to remove organics from the waste.

Thermal desorption uses heat, and sometimes a vacuum, to volatilize organic contaminants from a solid waste. Volatile and semi-volatile organic contaminants are condensed and collected in an offgas system for subsequent treatment by other means. In some cases, heat and vacuum can pyrolyze non-volatile organic material (plastics, wood, PVC, etc.) to produce volatilized organics and an ash that remains in the desorber.

5. Biological Treatment

Biological treatment (or biodegradation) refers to the processing of organic waste material using microorganisms such as bacteria and fungi. Aerobic degradation is performed by microorganisms which require oxygen for growth. Aerobic process residues are usually CO_2, H_2O, salts and biomass sludge (dead cell material). Anaerobic degradation is carried out in the absence of oxygen and yields CH_4, CO_2, and biomass. Since the contaminants must be available to the microorganisms, contaminants that are not water-soluble (e.g., solids and immiscible organics) are more difficult to treat. Chlorinated organics are difficult to treat because their degradation does not benefit the bacteria. Nonetheless, some bacteria do degrade chlorinated organics in the course of metabolizing other, more easily degraded compounds.

B. Evaluation of the Alternatives

The choice of technologies depends on the purpose of the treatment. As indicated above in Section I-C, this purpose consists of removal of potential hydrogen generators, VOCs, and/or PCBs from the waste stream. In addition, the expectation is that ignitable and corrosive streams that carry the D001 and D002 EPA hazardous waste codes, respectively, can be treated by mixing the waste with suitable additives.

Destruction of the unwanted components can be accomplished either before or after separation from the main waste stream. In general, technologies that satisfy all the treatment needs simultaneously are preferable. In any case, it is important to assess the fate of the radioactive components to insure that they remain in the solid waste stream to be buried. This, in turn, requires actual tests with authentic mixed waste.

Each treatment option creates its own waste streams, some of which are potentially hazardous and thus may require additional remedial strategies that themselves form an important part of any life-cycle comparison of the risks and costs of the technological alternatives. Thus, it is important to evaluate not only the efficiency of the main treatment itself, but also the additional steps necessary to deal with the required pretreatment of the waste as well as the secondary waste streams and their treatment.

The Panel evaluated the technological alternatives described above (Section III-A) utilizing the published criteria from Section II of this report. Most – but not all– technologies were brought to the panel in response to the RFI described in Section I-A-2. The Panel's intent was not to endorse or reject specific commercial applications, but rather to focus on categories of technologies, identifying those that are appear most promising for near-term application and for longer-term developmental funding. We have grouped the technological alternatives in three categories for discussion below: (1) those that clearly appear promising and should have highest priority for funding; (2) potentially promising technologies for which important unresolved issues remain; and (3) technologies to which the Panel accords lowest priority.

1. Most Promising Technologies

The most promising technologies are relatively mature, so that there are fewer issues regarding their capabilities to treat DOE waste in question; they are generally robust (e.g., can treat a variety of waste types with a minimal pre-treatment), they have minimal secondary wastes that can be successfully treated, and they appear to pose less risk to the workers, public and the environment.

a. Steam Reforming

Steam reforming coupled with volatilization directly from waste drums is a very promising technology to remove and destroy organic components in the waste stream. It is a robust, mature technology, applicable to a wide variety of waste streams and requiring little or no pretreatment. It operates in a reducing environment (i.e. in the absence of oxygen), producing an off-gas stream consisting of organic effluents (syngas), carbon dioxide and water vapor. This gaseous stream requires treatment to decompose the organic effluents (e.g., oxidation by a high-temperature ceramic catalyst), but the emissions to the environment can be measured and controlled and are likely to be minor. The low temperature should allow the plutonium and most other radionuclides and heavy metals to be retained in the ash, which can be sent to a disposal site.

There is also a steam reforming technology that utilizes a fluidized bed. This technology requires considerable pretreatment of the waste stream (shredding). Furthermore, levitation of a heterogeneous mixture to produce the fluidized bed is likely to pose significant problems, an unresolved issue that places this particular technology in Category 2 rather than Category 1.

b. Thermal/Vacuum Desorption

This separation process removes volatile and semi-volatile organics from the inorganic portion of the waste stream and pyrolzes non-volatile organics in an oxygen-starved atmosphere to produce organic vapors and a residual ash. The volatilized organics may be treated by some other means: oxidized in a high-temperature ceramic catalyst or absorbed onto a carbon bed or condensed back to a liquid for subsequent destruction, or possibly treatment at an existing commercial facility. The low gas flow and low temperature minimizes particulate carryover into the off-gas system and should allow the plutonium and most other radionuclides and heavy metals to be retained in the desorbed solids and ash, which can be sent to a disposal site. Thus, the emissions to the environment can be measured and controlled and are likely to be minor. Little or no pretreatment is required for a wide variety of wastes. This technology should be rather safe, effective and reliable.

c. DC-Arc Melter

This is a process with very high destruction efficiencies. It is very robust, can treat any waste or medium with minimal or no pretreatment, and produces a stable waste form. The DC-Arc melter uses carbon electrodes to strike an arc to a bath of molten slag. Use of consumable carbon electrodes that are continuously inserted into the reaction chamber eliminates the need for electrode replacement or maintenance or the need for a torch gas. The high temperatures produced by the arc convert the organic waste into light organics and primary elements in a steam-reforming or reducing atmosphere. The combustible syngas is cleaned in the off-gas system and oxidized to CO_2 and H_2O in ceramic bed oxidizers. The potential for air pollution is low due to the use of electrical heating in the absence of free oxygen and the low amount of off-gas. The inorganic portion of the waste is retained in a stable, leach-resistant slag, which may be necessary for a mixed non-TRU waste that will be disposed of in a RCRA-regulated landfill.

d. Plasma Torch

Plasma torch systems are similar to DC-Arc systems in that an arc is struck between a copper electrode and either a bath of molten slag or another electrode of opposite polarity. As with DC-Arc systems, the plasma torch system has a very high destruction efficiency, is very robust, and can treat any waste or medium with minimal or no pre-treatment. The inorganic portion of the waste is retained in a stable, leach-resistant slag, which may be necessary for mixed non-TRU waste that will be disposed of in a RCRA-regulated landfill. However, the water-cooled copper torch must be replaced periodically to prevent burn-through at the attachment point of the arc and a subsequent steam explosion due to rapid heating of the released cooling water. The air pollution control system is somewhat larger than for the DC-Arc due to the need for an arc-stabilizing torch gas.

2. Potentially Promising Technologies with Unresolved Issues

From the RFI and other sources, the Panel identified a number of technologies that may contribute to solving the INEEL waste treatment problem. However, potentially significant issues need to be addressed before final decisions are made about integrating these technologies into DOE's research and development program. These technologies are generally less mature than those in the first category, are less robust, or have questionable ability to safely treat DOE waste. These technologies include mediated electrochemical oxidation, reverse polymerization (microwave), supercritical water oxidation, solvated electron dehalogenation, and iron chloride catalyzed oxidation.

For each of these potentially viable alternatives, the Panel's views are summarized below.

a. Mediated Electrochemical Oxidation

Positive characteristics include low temperature, low off-gas, and an apparent ability to treat diverse waste streams. The Panel's concerns center on 1) recovery/reuse of the anolyte solution; 2) amount of pre-treatment; and 3) corrosion and erosion of the system components.

Mediated electrochemical oxidation relies on an oxidizing element (e.g., silver or, cerium) to destroy organic compounds. Metals, including plutonium and americium, may be dissolved in the anolyte solution. Recovery of the oxidizing element from the anolyte and reuse back in the process is critical for economic operation. It is not clear if recovery/reuse is possible or economically viable in the presence of radionuclides. Also, to reduce process retention times and increase solubility of organic constituents, waste streams are fed to the system as liquids or slurry. This may require significant waste pre-treatment. Other issues include the ability to adequately treat PCBs, and the highly corrosive nature of the process and related safety concerns.

b. Reverse Polymerization (Microwave)

This technology may have promise for the treatment of INEEL wastes, but it has been applied only to limited waste streams (medical waste and tires). Research and development is needed to determine its efficacy for treating radioactive and transuranic wastes. Other potential unknowns and concerns include this technology's ability to treat PCBs, amount of pre-treatment, nature of the effluents, including the level of off-gas treatment required, and radionuclide accumulation in carbon precipitated on the walls of the treatment chamber (this char could present significant decontamination and worker safety issues).

Positive attributes include low off-gas and low system operating temperature and pressure.

c. Supercritical Water Oxidation

At supercritical pressure and temperature conditions, water can dissolve organic constituents. This is a relatively mature technology with a long history of development for specific applications. Positive attributes of the supercritical water oxidation system include very low off-gas, high destruction efficiencies for organics, and effluents that are relatively easy to manage, including brine, filtered solids and salts.

On the other hand, the high pressure (and the difficulty in injecting particulate-laden erosive slurries into the process) and corrosiveness of the system present significant safety concerns. Moreover, the waste stream feed must be in a liquid or slurry form, which requires substantial pre-treatment of wastes; proponents anticipate using a bulk feed system, but key details are lacking on its design and development.

d. Solvated Electron Dehalogenation

In this technology, solvated electrons, created in a mixture of anhydrous ammonia, sodium metal, and waste, remove halogens (primarily chlorine) from organic molecules. This is a relatively mature and simple technology that operates at low temperature with low off-gas and good destruction efficiencies for chlorinated compounds.

Potential concerns with the solvated electron technology include: 1) the management of treatment residues, including further treatment of non-chlorinated organics to meet WIPP acceptance criteria; 2) the amount of pre-treatment needed to maximize exposure of the chlorinated compounds to the electron solution; and 3) the process's ability to treat the diversity of INEEL wastes (waste pH and moisture content appear to be important); and 4) safety associated with the handling sodium and anhydrous ammonia and the high system pressure (100 psi) in a radioactive environment.

e. Iron Chloride Catalyzed Oxidation

Iron chloride oxidation uses iron ions in an acidic solution to oxidize organic constituents. The process operates at low temperature and produces low gas emissions. The solution is extremely corrosive, allowing it to destroy a variety of organic compounds. However, handling an extremely corrosive solution under high pressure is also a serious safety concern with respect to leaks. The process is also relatively immature and complex and generates excessive secondary wastes. It appears that significant pretreatment/sizing (to form a liquid/slurry) would be necessary, along with further characterization of INEEL wastes; also, additional treatment of waste residues may be necessary to produce an acceptable final waste form. There are questions regarding this technology's ability to treat PCBs adequately. Such issues still exist after considerable DOE funding of this technology.

3. Lowest Priority Technologies

In its review, the Panel was impressed by the number and variety of treatment processes submitted for consideration in response to the RFI. Given constrained R&D resources, The Panel felt compelled to adopt a winnowing process to yield a manageable number of candidates for further testing and development. Most of the treatment options submitted to the Panel clearly have promise for some forms of waste treatment, but our charge compels a focus on very specific applications.

The Panel concluded that technologies not recommended in this report for further development and testing were qualitatively less promising, across the full range of characteristics necessary to deal with the INEEL wastes. Several of these technologies were not applicable to the DOE wastes in question, others had serious safety issues, and others were so immature or had so little information available that an informed evaluation was impossible. In reviewing candidates for near-term testing, the Panel sought convincing evidence of technological maturity; where the issue was eligibility for further development, our focus was promise of superiority in simplicity, efficiency and economics.

The technologies examined by the panel and placed in this third category include molten aluminum, solvent extraction, high temperature hyperbaric chamber, silent discharge plasma, soil washing with a chelating agent, treatment with sodium in mineral oil followed by chemical oxidation with peroxydisulfate, and biological treatment.

4. Conclusions and Recommendations

In the Panel's judgment, the result of this evaluation is a varied and robust set of technologies that deserve a place in DOE's RDD&D program. The Panel's recommendations also include basic scientific work that should broaden the base of technologies further. The nation should emerge with improved and feasible solutions to a costly dilemma.

The Panel recommends that DOE seriously consider technologies identified in the most promising category as alternatives for an incinerator at the AMWTP. Tests of these should be conducted on both surrogates and actual wastes to prove their applicability. These tests should include total system evaluations including pre- and post-treatment requirements and should seek to identify performance under potential upset conditions.

The Panel also notes that no single technology may by itself be adequate to meet the desired environmental health and safety standards and achieve the desired destruction of hazardous and PCB waste. Robust solutions are likely to require combinations of several technologies. One problem is that some of the most promising technologies yield secondary wastes that require further treatment. For example, steam reforming generates a combustible gas that may require subsequent thermal oxidation using a catalytic reactor to accomplish destruction without incineration. Dehalogenation can very effectively destroy PCBs, but it leaves non-halogenated hydrocarbons and many of the VOCs untouched; the treated wastes still contain enough of these materials so that shipment or disposal may not be possible without further treatments. For wastes being sent to a burial site, further treatments of the hazardous inorganic chemicals (e.g., stabilization) may be needed to provide a product that meets land disposal requirements. Greater stabilization of the final waste may be required for mixed waste burial sites than for TRU wastes disposed of at WIPP.

The Panel also recommends that DOE consider technologies that are presently deemed less mature for further development and testing with the aim of either advancing them to readiness for deployment or eliminating them from further consideration.

Finally, a modest program of basic and applied research should be pursued to identify and nurture the next generation of technologies that are sure to be needed. It is important and appropriate that DOE address the completion of relatively near term waste management actions such as meeting the agreement schedule for removal of stored mixed TRU and low-level waste from Idaho. Nonetheless, as noted elsewhere in this report, there are other wastes that will need to be treated, and the total problem will not be quickly solved. New technologies will be based on new science that can only result from investments in basic and applied research.

IV. DOE's Current Plan for Developing Technological Alternatives to Incineration

A. Overview of the Evolving DOE Plan

A recent review of the DOE Environmental Quality R&D Portfolio concluded that "[t]he greatest gap identified among mixed waste technologies is the need for alternatives to incineration." Moreover, "[a]lthough there has been R&D on other technologies for destroying hazardous organics and for volume reduction, little such R&D is now under way and, more importantly, no specific technology is currently acceptable to replace incineration." The review concluded that "[j]ust as there is a gap identified with alternatives to incineration, there is an opportunity to fill that gap.

Several candidate technologies have been brought forth in the past and prioritization of those to identify most likely successors, followed by development and demonstration activities should commence."[6]

In the period following creation of the Panel, DOE has been preparing an RDD&D plan for developing and deploying safe, cost-effective and timely technological alternatives to incineration.[7] DOE has made provision for public review of all elements of this plan, and revisions are possible as that review proceeds; the Panel places particular emphasis on this issue, and subsection B below

6 "Adequacy Analysis of the Environmental Quality Research and Development Portfolio" (September 2000).
7 The complete Executive Summary of the RDD&D Plan appears in Appendix VI.

presents comments and recommendations on public involvement and other elements of the DOE plan.

The preliminary DOE plan includes the stages of development from basic science research through full-scale integrated demonstrations. The development and deployment plan would be initiated in FY 2001 by DOE's Transuranic and Mixed Waste Focus Area (TMFA) and it includes provisions for regulatory and public involvement. Regulatory issues are to be addressed by working directly with the various State and Federal agencies (e.g., the Environmental Protection Agency/EPA and State permit writers) throughout the alternatives development process. A DOE-EPA Memorandum of Understanding is already in place for this purpose. Developers would be informed of the data needed for permitting purposes, and would be notified of pending regulatory changes that may affect the future applicability of their alternative technology.

Technical issues would be addressed through a development effort involving side-by-side comparisons of emerging alternative technologies. Technologies selected for comparative study would be relatively mature. The comparative study would collect the necessary performance, design, scale-up, and permitting data for each selected technology. Testing with identical waste surrogates and/or actual wastes would ensure that each alternative technology generates comparable data.

Starting in FY 2001, the TMFA would establish facilities for the comparison tests and issue the appropriate competitive calls to initiate the testing program in FY 2002. DOE's Western Environmental Technology Office (WETO) in Butte, MT would support the majority of the comparison testing, and would be equipped with the required additional monitoring and analytical equipment in FY2001. Based on the competitive solicitation issued in 2001, three to five primary alternative treatment processes would be selected for comparison testing at WETO in FY 2002. The current strategy is to select enough processes to represent the three general classes of alternatives: thermal, aqueous based chemical oxidation, and separations.

The two-year long comparative study of mature alternatives would be supplemented with a series of basic science research efforts and with development activities to optimize the auxiliary systems required for completely integrated alternative methods. The efforts in basic science research would span three years and, at a minimum, would include studies in materials research, off-gas pollutant formation, and long-term waste form stability. Auxiliary system testing would include activities involving pretreatment, waste feed pre sizing, off-gas monitoring, and residue stabilization. Upon completion of the comparison testing in FY-2003, two to three of the better performing alternatives would be selected for integrated prototype testing, starting in early FY2005. If appropriate, the current plan is to conduct this final test phase at a single location. Integrated testing is expected to last at least two years and to culminate with deployments by 2007.

Following extended discussion at its October public meeting in Denver, the Panel asked DOE staff to provide initial estimates of budget impacts associated with the principal elements of its preliminary draft plan, which are summarized below. [CAUTION: This draft budget has not been fully reviewed internally at the Department of Energy and does not necessarily represent its views or recommendations.]

Table 5: Preliminary Analysis of Budget Impact for Draft RDD&D Plan for Alternatives to Incineration. (All values are shown in millions of dollars).

ACTIVITY	**2001**		**2002**		**2003**	**2004**	**TOTALS**	
	Original	**Panel Version**	**Original**	**Panel Version**			**Original**	**Panel Version**
TECHNICAL								
Comparison Testing and Developments								
Competed Alternatives		.25	.05				**.05**	**.25**
Surrogate Testing		.50	4.50	6.00	6.00	6.00	**16.50**	**18.50**
Actual Waste Testing				5.00	10.00	6.00	**16.00**	**21.00**
Leveraged Alternatives	1.80*	2.48		2.20	2.00	2.00	**5.80**	**8.68**
Prepare Test Facilities to Host Comparisons	.25	.50		.10			**.25**	**.60**
Specific Development for Transuranic Waste	2.10	4.11	1.70	3.00	2.50	2.00	**8.30**	**11.61**
Integrated Demonstrations						4.00	**4.00**	**4.00**
Basic Science and Applied Research **	.75	.75	3.00	3.00	8.00	8.00	**19.75**	**19.75**
Testing of Auxiliary Systems	.70	.70	.50	.80	.55	.50	**2.25**	**2.55**
REGULATORY	.10	.40	.10	.50	.50	.50	**1.20**	**1.90**
STAKEHOLDER	.05 *	.50	.05	.50	.50	.50	**1.10**	**2.00**
TOTALS	**5.75**	**10.19**	**9.90**	**21.10**	**30.05**	**29.50**	**75.2**	**90.84**

* Draft RDD&D plan is preliminary and has not been fully developed or reviewed internally
** There is a research proposal call planned for FY 2002 to solicit solutions to TRU/Mixed Waste problems

B. Evaluation

The Panel generally appreciates and supports DOE's substantial ongoing efforts to devise a strategy for developing technological alternatives to incineration. This section presents our recommendations for designing and executing that strategy. If these recommendations are followed, the Panel believes that DOE should be able to achieve results consistent with the deadline of the Idaho agreement, other regulatory requirements, and broader public interest considerations applicable to mixed waste throughout the nation.

BUDGETARY NEEDS: It is the view of the Panel that the Transuranic and Mixed Waste Focus Area (TMFA) is not now funded adequately to underwrite the testing of the technological alternatives to incineration. As an essential first step, the Panel supports the budget outlined in the preceding section, which represents a substantial increase over current allocations. Urgent needs start with proof testing of candidate technologies, using the actual materials involved. Even focusing only on the relatively mature alternatives with the most immediate promise of meeting commitments to the State of Idaho, none have had the benefit of demonstration of capability to treat the wastes at issue here. And longer-term alternatives that appear to have advantages in overall robustness or in specialized areas, and that could be applied across the DOE complex, need not only testing but extensive developmental work. The Panel also believes that more basic work on

processes should identify much-improved alternatives that could pay off handsomely down the road. Adequate funding is necessary to make all of this possible.

For materials specifically requiring treatment in lieu of incineration, there is no substitute for proof testing of each process with the actual materials to be treated. Testing of surrogate materials can create considerable useful knowledge, but only testing with actual materials will show up the inevitable surprises to be anticipated in practice. For example, some elements, notably americium, can be difficult to contain. Where there is plutonium there is americium.[8] For both, adequate confinement is crucial. Worker exposure to both is of the highest concern, and as a practical matter worker uptake of transuranics must be zero. Processes that break down very stable compounds such as PCBs are of necessity vigorous, and establishing where the transuranics go is of considerable importance to the viability of the process.

Such testing will cost in the range of several millions of dollars a year, with total costs ultimately in the range of a few tens of millions. But the costs of failure are in the hundreds of millions of dollars, and much more than dollars is at stake. In light of the attention that has now been focused on the issue, and the likelihood of continued skeptical scrutiny by the public and by the states involved, even partial success will not be good enough.

The Panel is only too aware that there is some history in Idaho of failures to deal effectively with buried waste, which might have been avoided if more adequate proof testing had been done before large commitments were made. This experience, and others, lend urgency to the Panel’s convictions about proof testing. Where, as here, good faith is in question, testing beyond that dictated by normal engineering considerations is advisable. Economies made possible by omitting prudent validation of the favored alternatives to incineration, using actual materials to be treated, would be false and supremely unwise economies.

The Panel concludes that the Transuranic and Mixed Waste Focus Area at INEEL is the logical home for this testing work. The testing program should be cognizant of and responsive to the needs of the entire DOE complex. Such testing can be expected not only to settle the issue of adequacy of process, but it should also give a real and palpable demonstration of Departmental good faith in doing all that could reasonably be asked in accomplishing what needs to be done. Put directly, proven success through properly directed testing provides the best hope of eliminating the need for incineration. For all these reasons, we believe this work should be given high priority.

This work is useful, however, only if it underlies and supports actual treatment of the waste. Successful proof testing only shows the way. The Panel is concerned that mechanisms may not yet be in place to ensure that the results of such testing form the basis for the actual treatment. There is a contract in place with BNFL, and DOE continues to emphasize privatization of the treatment process. The Panel has no comment on this, one way or the other. But the Panel does have a view on the need for organizational definition to ensure that technology with the greatest proven chance of success is in fact implemented. The very formation of the panel indicates that the situation in Idaho requires DOE to assume full responsibility for whether or not the waste treatment processes are satisfactory for the task at hand.

It is not sufficient to say that success is the responsibility of the contractor. Nothing must be allowed to get in the way of selection, testing, implementation and deployment of a technology or

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[8] Pu-241 decays with a 14-year half-life to produce Am-241.

technologies that, in this sensitive situation, will get the job done, while also demonstrating good faith to all parties with an interest in seeing that the job is getting done well. Commercial interests associated with a privatized project must not dictate the selection and testing of specific technologies; much more weight should be given to the major benefit flowing to the nation from a proven technology for this class of waste. For beyond the measures necessary to resolve the impasse that produced this Panel, there are the volumes of buried TRU waste that we addressed previously in this report, as well as other TRU waste across the complex, both from legacy and from on-going and future program and decommissioning activities. Some of this waste will need treatment.

Also in this regard, the Panel wishes to underline its strong support for increased and continuing basic scientific and developmental work over the longer term on processes to deal with mixed waste. We are aware of and applaud the Focus Area plans to deploy alternatives to incineration across the DOE complex by 2007. But the nation has what is often called “a 50 year problem,” involving both legacy and ongoing waste generation. Breakthroughs in cost, convenience and safety of processes may yet be possible, but only if they are pursued. A simple analogy may be useful: the end-all in air transport was thought to have been achieved by 1939, until proof of the jet engine changed everything. In the mixed waste area, the huge bills contemplated across the nation reinforce the importance of continued search for more and better technological alternatives.

Finally, the Panel believes strongly that its budgetary recommendations should be supported with an infusion of new federal funds rather than internal transfers from other vital efforts to solve problems associated with mixed waste, buried wastes at INEEL and elsewhere, and high-level radioactive waste. **[ALTERNATIVE: OMIT THIS PARAGRAPH AS OUTSIDE THE PANEL’S CHARGE]**

TECHNOLOGY INTEGRATION: DOE should make every reasonable effort to ensure that the Panel’s recommended alternatives are included in the comparative and integration phases of its RDD&D process. DOE’s emphasis on “near ready” or “mature” technologies should not preclude further evaluation of innovative alternatives, and the proposed RDD&D schedule almost certainly will have to be extended to allow full assessment of such technologies.

SYSTEMS APPROACH: In evaluating the most promising alternatives to incineration, the Panel urges the Department of Energy to take a systems approach, and to consider the alternative technologies (especially the air effluent containment technologies) as a system under both normal and upset conditions. For example, under upset conditions, will fire suppression systems plug HEPA filters at a time when they are most needed? In particular, the panel urges rigorous evaluation of whether the reliability and efficacy of the various effluent control systems will be sufficient to protect workers, the public, and the environment. In other words, will these systems meet appropriate standards after accounting for the probability of upset conditions as well as normal conditions? The Panel also urges DOE and other federal agencies independently to evaluate the air effluent containment systems with surrogate and alpha-emitting waste, to determine the appropriate decontamination factors.

TECHNOLOGY EVALUATION: DOE should use the Panel’s seven criteria in evaluating alternative technologies in the comparative and integration phases of the RDD&D. Primary emphasis should be on the alternative’s protection of the environment, safety, and health. Economic viability should be a lesser consideration. **[ALTERNATIVE: eliminate the final sentence of this paragraph.]**

PUBLIC INVOLVEMENT: DOE's proposal recognizes the need to develop and maintain full and meaningful public involvement throughout the RDD&D process, particularly in the evaluation and implementation of any technology for the INEEL TRU and mixed waste. Specifically, DOE should follow the example of the Army's chemical weapons disposal program by broadening stakeholder outreach beyond the agency's site-based Citizen Advisory Boards (CABs) and making sufficient, specific budgetary provision for technical assistance to committees of citizen advisors. These committees also should have a role in the peer review process that DOE uses to evaluate technology alternatives.

The Panel believes that citizen stakeholder involvement is essential for successful deployment of waste treatment technologies. Citizen stakeholders should involve people of various expertise from around the country and region. While DOE's primary focus is on appropriate treatment of waste streams and removal of treated TRU waste to the WIPP repository, the public's primary focus is on broader health, safety and environmental concerns; closer to the facility, there is added emphasis on worker health and safety and jobs. The goals of the public and DOE need not conflict.

The Panel encourages the Department in its attempts to involve the public and to include funds in its FY2001 and later budgets for that purpose. Broad-based and meaningful public involvement requires both expenditures and a carefully thought out disbursement process. The Panel endorses the proposed Spring 2001 conference on alternative technologies to incineration, and feels it is important and necessary for DOE to involve, in both the Steering Committee and the conference itself, not only the local CABs but also other persons and groups with a regional and national perspective and expertise. A third party facilitator and participation by interested companies and agencies are also recommended.

The panel's public involvement recommendations reflect these principles:

- The national conference on alternatives to incineration should be planned through a small Steering Committee, which should be charged with ensuring that major stakeholders participate.

- Organization of the conference should include a group of public representatives from all of the regions where the alternative technologies to incineration may be candidates for use at DOE sites.

- Opportunities should be provided for ongoing public participation in periodically assessing the progress of the technology developments on alternatives, e.g., the peer review process.

- State and EPA regional regulators for DOE sites should be kept informed or invited to periodically attend information reviews on the technology alternatives.

- Financial assistance should be provided to support some expenses for ongoing public participation and to engage as needed independent experts responsive to the needs of the public representatives.

- Discussions of methods to organize and continue public participation at the national level should a major topic at the spring 2001 conference.

NEXT STEPS FOR DOE AND SEAB: The Panel expects that the DOE draft Current Plan for Developing Technological Alternatives to Incineration, outlined in the previous section, will change in response to the Panel's recommendations. The Panel's recommendations for technological development should be followed without arbitrariness in the early assignment of priorities among technologies and processes. In particular, DOE should first categorize in detail the wastes that need to be treated, then link the actual wastes to processes in proposed workscopes. To simplify for emphasis: DOE must identify which processes are to treat what wastes.

DOE's early selections should be made on the basis of the Panel recommendations. The Panel is also vitally interested in the science-based portion of the DOE plan. Given the likelihood that the plan itself will change in light of this report, the full SEAB needs to follow up after the Department has had the opportunity to recast its initial proposal to reflect the Panel's findings and recommendations.