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| | | | | 241-C-104 Preferred Waste | | | | |
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| JA Tuck 22 Mar. 2001<br>Signature of EDT Originator — Date | KE Carpenter 3/26/01<br>Authorized Representative for Receiving Organization — Date | W.E. Bryan 3/23/01<br>Design Authority/ Cognizant Manager — Date | Ctrl No. ____<br>☐ Approved<br>☐ Approved w/comments<br>☐ Disapproved w/comments |

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# Decision Document for Single-Shell Tank 241-C-104 Preferred Waste Retrieval Technology

*Keith E. Carpenter*

CH2M-Hill Hanford Group, Inc., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Abstract: This supporting document is the decision paper for selection of the preferred technology for Project W-523, Tank 241-C-104 waste retrieval system. This document completes the decision management process prescribed in the decision plan RPP-6878, in accordance with HNF-IP-0842, Volume IV, Section 2.7.

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**Approved for Public Release**

# DECISION DOCUMENT FOR SINGLE-SHELL TANK 241-C-104 PREFERRED WASTE RETRIEVAL TECHNOLOGY

## 1.0 STATEMENT OF THE ISSUE

The subject decision was to determine the preferred technology for retrieval of high-level waste from Tank 241-C-104 and subsequent transfer to a selected double-shell staging tank to support waste feed delivery. The selected technology is also intended to demonstrate the ability to retrieve bulk sludge and heel waste from similar Single-Shell Tanks. Decision management requirements, and the decision making process, are prescribed in tank farms procedures (CHG 2000). This document concludes the decision process outlined in Defigh-Price (2000) and related documents (DeWeese 1999; Bogen et al 1999; Davis et al 2000), by documenting the technology decision. The decision responsibilities are also updated.

## 2.0 DATE OF SELECTION

The date of selection will be the date on which the decision maker approves this document.

## 3.0 DECISION MAKER

The decision maker is the SST Closure Project Manager (R. E. Raymond). The decision maker has the authority to make the technology decision by declaring (via signature on this document) the preferred alternative. The decision maker elected to convene a Decision Support Board to assist in the decision process, as allowed by procedure (CHG 2000).

## 4.0 DECISION ACTION OFFICER

The decision action officer is the Tank C-104 Retrieval Project Manager (K. E. Carpenter). The decision action officer is responsible for documenting the decision-making process, and managing resources necessary to implement the decision plan for the preferred 241-C-104 waste retrieval technology (CHG 2000).

## 5.0 ALTERNATIVE SELECTED

The selected alternative is Alternative 6, an "In-Tank Vehicle (ITV) and Articulated Mast, with Interchangeable Tools for Both." This and the other alternatives considered are described in Section 6.1, below. The feasibility of Alternative 6 needs to be evaluated during conceptual design, as it requires additional equipment and risers as compared with Alternatives 1 through 3 (carried through preconceptual design).

The Decision Support Board concluded with a scoring exercise to evaluate and compare the technology alternatives. The results of this process are documented in tables attached to this report, and indicated Alternative 6 is clearly preferred. The most important decision criteria appeared to be the need to maximize waste retrieval; system reliability, availability, and maintainability (RAM); flexibility; and applicability to other tanks, while at the same time minimizing life cycle cost (LCC). Alternative 6 scored well against these criteria as well as providing a good value in terms of most of the other criteria considered. The Decision Support

Board also noted that Alternative 6 builds on previous experience at the Oak Ridge, West Valley, and Hanford DOE sites, and presents opportunities for system optimization during cold testing.

It was apparent that Alternatives 4 and 8 are close second and third choices, respectively. These two alternatives are also physically similar to Alternative 6. This should be considered during conceptual design. The ideal technology for C-104 retrieval may be close to Alternative 6 but with some elements of the other alternatives.

The path forward recommended by the Decision Support Board is to reflect Alternative 6 in conceptual design. The feasibility and cost of the additional mast system needs to be evaluated, and its functions and requirements need to be defined. Alternative 6 should also be reflected in the cold test work plan, and ongoing crawler development activities redirected as appropriate. In addition, acquisition of any useful existing equipment from other DOE sites should be initiated.

## 6.0 DECISION CRITERIA

Decision criteria are used to draw comparisons among alternatives as to their relative ability to address the objectives of Project W-523. The primary objective of Project W-523 is to provide a waste retrieval system for Tank C-104 and meet the limit of technology retrieval milestone (TPA M-45-03F). The project must consider retrieval needs for similar SSTs while addressing specific C-104 goals. These goals include minimizing residual waste content and demonstrating confined sluicing and robotic technologies, with the ability to improve on the past-practice sluicing baseline. A related objective of the project is to integrate the selected retrieval technology with viable leak detection, monitoring, and mitigation (LDMM) strategies. Additional objectives of Project W-523 include minimizing environmental impacts, satisfying applicable regulatory requirements, and protecting the health and safety of workers and the general public. Therefore, the decision criteria for this technology decision are:

a. Minimize impacts on the facility authorization basis
b. Minimize worker risks
c. Minimize potential leak loss
d. Minimize addition of water to tanks
e. Minimize secondary waste (e.g., solid waste)
f. Maximize waste retrieval
g. Maximize system reliability, availability, and maintainability (RAM)
h. Minimize Project W-523 life cycle cost (LCC)
i. Maximize applicability to future retrieval actions

### 6.1 Alternatives for the Technology Decision

The following retrieval alternatives were identified to support the technology decision:

1. Past Practice Hydraulic Sluicing, with Enhancements

2. In-Tank Vehicle (ITV) with On-Board Slurry Nozzle and On-Board Transfer Pump, operated together or separately

3. ITV with On-Board Transfer Pump and Mast Mounted Sluicing Nozzle

4. ITV with On-Board Sluicing Nozzle and Mast with Stationary Transfer Pump

5. Articulated Mast with Interchangeable Slurry Nozzle and Transfer Pump

6. ITV and Articulated Mast, with Interchangeable Tools for Both

7. Two ITVs with Interchangeable Tools

8. Two ITVs and an Articulated Mast, with Interchangeable Tools for All

9. Deferral of Technology Decision

The above alternatives address the selection of in-tank retrieval hardware. All of the alternatives would require additional equipment to complete the retrieval system, including pumps, pits, and transfer piping outside the tank. This balance-of-process equipment is discussed in the referenced documents and its design and selection will involve additional technology selections outside the scope of this decision document.

The "in-tank vehicle" (ITV) featured in most of the above alternatives would provide a mobile platform for selected retrieval equipment, as well as direct mechanical action to help break up the waste and mobilize it. The ITV is envisioned as utilizing existing crawler technology, with the necessary support system to deploy it in the tank. In cases where two ITVs are used, the vehicles may be of the same design or different designs.

The "articulated mast" is a yet-to-be refined design concept, envisioned as a simple device utilizing existing technologies. It may be as simple as an adjustable-elevation transfer pump or eductor, or it may be more complex with multiple tools and capabilities. However, it is not envisioned as a system as complex as a long-reach utility arm or manipulator. The specific technology for the mast would be determined based on a feasibility assessment, performed as a separate effort.

Alternatives 1, 2, and 3 were proposed in the original decision plan (Defigh-Price 2000), and were carried though preconceptual design (Crass 2000a). These have been supplemented with six additional options as listed above.

Alternative 1 was defined as a conventional sluicing process similar to the WRSS system installed by Project W-320, but with the addition of a heel pump and other possible enhancements as required to meet current performance criteria. Alternative 1 would only be pursued if it can be demonstrated that the past practice sluicing process is sufficiently modified or enhanced to meet the requirements in the TPA and gain regulator acceptance. The current regulatory climate does not favor global sluicing-based retrieval options used in the past. This alternative was eliminated from serious consideration before the final decision was made.

In the case of Alternative 2, the ITV would provide a platform for both a sluicing nozzle and a transfer pump. Waste would be dislodged by high-pressure spray from the sluicing nozzle, while the resulting slurry would be scavenged by the on-board pump. Alternatives 3, 4, and 6 separate one of these components from the ITV, simplifying the design of the ITV and its support system.

Alternative 3 would utilize a stationary, remote sluicing nozzle separate from the crawler (which provides a platform for the pump only).

In the case of Alternative 4, the ITV would provide a mobile platform for the sluicing nozzle to locally dislodge and slurry the waste as it maneuvers around the tank. It would use a separate transfer pump located to retrieve the waste as it is mobilized by the on-board sluicer and drains (or is pushed) toward the center of the tank. This concept would take advantage of the "dished" design of the tank floor. Oak Ridge National Laboratory heel retrieval utilized a fixed pump with ITV for waste retrieval. This approach is also being planned for utilization at the Savannah River Site for final heel retrieval in Tank 19. Alternative 6 is similar to Alternative 4, but provides additional capabilities for both the ITV and the central pump mast.

Alternatives 5, 7, and 8 are additional combinations of the above technologies. Alternative 8 represents the greatest hardware complexity of all the alternatives presented. With three independent retrieval systems, it also offers the greatest versatility, with two ITVs and a mast that can be operated separately or in various "cooperative" combinations. Experience at other sites has shown that a combination of two or more retrieval systems provides greater flexibility and availability for operation. Since operation is a major cost of retrieval, the added hardware complexity and capital cost are not necessarily a disadvantage.

Alternative 9 provides a general "deferred decision" or "no action" option to allow consideration of additional technologies, perhaps not considered or not available at the time of the AGA (Bogen et al 1999). This assumes that, given more time, new technologies would likely be evaluated and shown more appropriate for Tank C-104 waste retrieval. The current regulatory climate and a Tri-Party Agreement milestone do not favor this option, but it was provided as a reference because it is within the realm of possibilities. This alternative was eliminated from final consideration after discussion by the decision support board.

## 7.0 KEY DECISION CONSIDERATIONS

### 7.1 Assumptions

A set of enabling assumptions was used to develop the Project W-523 technical baseline. The assumptions are discussed in the project technical baseline documents, including the project functions and requirements (Leonard 2000), preliminary engineering report (Crass 2000a), and project definition criteria (Crass 2000b). The following list is selected from this baseline to include only those assumptions that are associated with the preferred retrieval technology decision. Most of the assumptions will need to be validated based on a requirements set to be developed for the preferred technology.

1. Liquid (supernatant, water, or both) addition to Tank C-104 will be authorized in sufficient amounts to support Tank C-104 retrieval, regardless of the retrieval technology selected.

2. There will be viable leak detection, monitoring, and mitigation (LDMM) strategies to support Tank C-104 retrieval, regardless of the retrieval technology selected.

3. The following SST and DST infrastructure will be available to support C-104 retrieval with minimal upgrades:
   - Electrical power distribution system and other utilities (as needed)
   - Sluicing system transfer piping
   - DST receiver tank and systems
   - Contaminated equipment removal systems

4. The tank farms Authorization Basis (AB) can be amended, if necessary, to support Tank C-104 retrieval regardless of the retrieval technology selected.

5. Physical properties of the waste heel and tank liner in Tank C-104 are similar to C-106.

6. Capability for cold-testing demonstration of full-scale hardware will be available.

7. Debris and failed equipment will be left behind.

### 7.2 Risks

There are risks associated with three basic areas of the project: (1) validity of design assumptions, (2) achievement of design performance requirements; and (3) the occurrence of unplanned events or unexpected conditions. The first set of risks will be managed by validating the assumptions on an ongoing basis as the project develops.

The alternatives based on an ITV represent a technology demonstration of a prototypical system. The challenges of operating a prototypical system inside a waste tank can be overcome by sound engineering using proven technologies and rigorous testing. The system design concept will be based on past development and testing activities on similar prototypes. However, since the system is prototypical in nature, some uncertainties exist that may limit its success. The project plans to identify and actively manage these risks through a number of activities including additional analysis and testing in a simulated tank environment. Specific uncertainties include the following:

- ITV performance and RAM
- Retrieval efficiency
- LDMM strategies
- Cold test surrogate
- Waste and surrogate waste properties and volumes
- Tank integrity
- Tank access and deployment
- In-tank hardware and debris
- In-tank viewing and lighting
- Process control and monitoring
- Hose (umbilical) management
- Transfer line plugging

Although Tank C-104 retrieval is considered a "demonstration," the selected technology will utilize, to the maximum extent practical, a mature technology with a history of commercial use, including recent technology demonstrations using simulated Hanford tank wastes (Berglin et al

1998). Vehicle-based technologies have also been previously used in commercial applications, including environmental remediation and cleaning of nuclear fuel pools and containments, storage tanks, wastewater systems, and other hazardous or difficult-to-access areas. This experience base has been well documented, and can be utilized to minimize the risks associated with a vehicle-based retrieval technology.

## 8.0 ALTERNATIVES REJECTED

Of nine alternatives presented in Sec. 6.1, Alternatives 1 and 9 were not considered in the final selection process for reasons explained in the text. The results of the decision process are discussed in Sec. 5.0, and summarized in attached Table 9.

## 9.0 REFERENCES

Berglin, E. J., B. K. Hatchell, and J. A. Yount, 1998, *Hanford Tanks Initiative Fiscal Year 1997 Retrieval Technology Demonstrations*, HNF-SD-HTI-RPT-001, SGN Eurisys Services Corporation, Richland, Washington.

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Leonard, M. W., 2000, *Functions and Requirements for the Tank 241-C-104 Waste Retrieval System (Project W-523)*, RPP-6525, CH2M-Hill Hanford Group, Inc., Richland, Washington.

WDOE and ORP, 2000, *Conclusion Agreement on Negotiation of Requirements Governing the Near Term Retrieval of Wastes from the Department of Energy's Single-Shell Tanks (Negotiations Pursuant to Milestone M-45-00A)*, HFFACO Agreement Change Number M-45-00-01A, State of Washington, Department of Ecology, Kennewick, Washington, and U. S. Department of Energy, Office of River Protection, Richland, Washington.

# ATTACHMENTS

COMPLETED DECISION DATA SHEETS AND SCORING MATRICES

## EXPLANATION OF ATTACHED TABLES

The attached tables provided a means of documenting the decision process to select a preferred waste retrieval technology for Tank C-104. These tables are adapted from data sheets and scoring matrices in the original decision plan, RPP-6878 (Defigh-Price 2000), and modified as necessary to reflect the revised decision criteria and alternatives in this document. The technology selection was facilitated by a prescribed decision process, conducted in a 2-day Retrieval Technology Decision Workshop. Twelve participants, from various parts of the U. S. Dept. of Energy complex (including the Hanford site, other sites, and national laboratories), completed a scoring exercise at the conclusion of the workshop to formalize the decision process.

The decision process for the preferred technology selection can be summarized as follows:

1. Applicable information about the retrieval technology alternatives was reviewed.

2. A weight factor was assigned to each of the nine decision criteria in Section 6.0 of this document. The total sum of the weight factors was required to be 100. The weight factors and their justifications were recorded as shown on attached Table 1 (results from all participants were combined and averaged). The "Justification/Remarks" column on Table 1 is a compilation of bases for the weight factors, provided by the twelve participants during the decision process.

3. Each of the alternatives considered (Section 6.1 of this document) was rated against the nine decision criteria. The raw scores and their justification were recorded, as shown on attached Tables 2 through 8 (results from all participants were combined and averaged). The "Justification/ Remarks" columns on Tables 2 through 8 are a compilation of bases for the raw scores provided by the twelve participants in the decision process. Alternatives 1 and 9 were not considered (see Sec. 6.1). For each criterion the score was required to be no less than a minimum of 0.1 (worst case, least desirable, or lowest confidence), and no more than a maximum of 0.9 (best case, most desirable, or highest confidence). However, the scores among the six alternatives were not required to span the entire range from 0.1 to 0.9 for a given criterion.

4. The weight factors and weighted raw scores were tabulated, as shown on attached Table 9. Weighted raw scores were obtained by multiplying the averaged raw scores (from Tables 2 through 8) by the weight factors for the corresponding decision criteria (Table 1). The weighted raw scores were totaled for each alternative (see last column on Table 9). The results were sorted in Table 9 in decreasing order of magnitude of weight factor (columns) and weighted raw score totals (rows).

5. The preferred technology was selected based on the "weighted raw score totals" in the last column of Table 9, where the highest value represents the most desirable alternative.

Table 1. Decision Criteria Weight Factors Rationale

| Decision Criteria | | W.F. | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 6 | Cost and schedule impacts; cost a factor for major AB changes; need to think 'out of the box'; AB will be changed or challenged as necessary; AB can be modified or revised; not a good discriminator for these concepts. |
| b. | Minimize worker risks | 11 | A 'must'; safety is key; #1 priority; regulatory driver & contract requirement from design to D&D; implied; minimal worker risks will be met or approach is not acceptable; secondary; order of business; ALARA will be used; not a good discriminator for these concepts. |
| c. | Minimize potential leak loss | 7 | Ecology concern; significant aspect in shareholders' eyes; not likely to differentiate choices; related to 'a', 'b', & 'd'; political; additional curies not significant; sound tank; not as important as equipment development; covered in AB; not a good discriminator for these concepts. |
| d. | Minimize water addition to tank | 9 | Adds treatment & part of cost; limited double-shell tank space; evaporator can compensate; significant aspect in DST & SST programs; DST space saving; keep SST mission going forward; not likely to differentiate choices (except sluicing); related to 'c'; sound tank; not as important as equipment development; not a good discriminator for these concepts. |
| e. | Minimize secondary waste (e. g., solid waste) | 5 | Adds to cost; longterm significance; design goal; waste disposal minimal cost impact should be a factor; not likely to differentiate choices; secondary waste is of secondary importance; onsite disposal available; sound tank; not as important as equipment development; not a big deal given benefit of retrieval; not a good discriminator for these concepts. |
| f. | Maximize waste retrieval | 19 | Primary function; the job we are trying to accomplish; TPA driver; a 'must'; main requirement & reason for project; critical success factor & key objective for this project; supports TPA and tank closure; design goal; regulatory requirement; allows good discrimination between concepts. |
| g. | Maximize system reliability, availability, and maintainability (RAM) | 15 | This is the key to success in the tank; allows good discrimination between concepts; system needs to work with minimal maintenance; cost and safety factor; critical success factor for project; critical for effective remote operations; design goal; if it works at C-104 it will work for other tanks with minor modifications. |
| h. | Minimize project life-cycle cost (LCC) | 14 | Crucial to future SST retrieval; too high a cost results in delay of retrieval; necessary for Hanford's credibility; cost must be considered; significant negative impact to ORP and CHG if cost not reasonable; first tank can cost more in the interest of working the longer term costs; not as important as getting a system that will be used in other tanks; reasonable weight to cost but performance to dominate. |
| i. | Maximize applicability to future retrieval actions | 14 | Key objective; must be adaptable to future; retrieval is more than Tank C-104; must think of big picture; emphasis on demonstration aspect of milestone; regulatory driver; critical success factor for project; work the class of tank over the future; important to maximize future benefit; design goal; with >140 tanks to be retrieved, likely any [effective] option will be useful on additional tanks. |
| **Total** | | **100** | |

Table 2. Raw Score Justification - Alternative 2 (Vehicle [ITV] with Slurry Nozzle and Pump)

| Decision Criteria | | Raw Score | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 0.67 | Minimal tank impact; one vehicle therefore one tank entry point; HTI previous work shows little issue; one riser needed; no impact to AB or average AB changes; AB to be modified for all alternatives; AB needs revision (raw score range 0.3 - 0.9). |
| b. | Minimize worker risks | 0.58 | Fewer parts therefore less maintenance & worker exposure; single deployment system; one vehicle therefore one tank entry point; least number of breaks in containment; complexity of equipment and hose management; hands-on maintenance; no backup capability means more production pressure on repair, maintenance, & testing; since vehicle operates submerged and waste transfer line is near the vehicle enclosure the radiation exposure for maintenance may be high; vehicle maintenance increases risk; high probability of exposure due to maintenance (raw score range 0.4 - 0.7). |
| c. | Minimize potential leak loss | 0.65 | Pump & nozzle together; localized sluicing at vehicle; no need for lots of water addition; no significant potential for creating leaks; minimum leak potential; single system minimizes piping connections; pumping out water as soon as put in will reduce leak risk; all alternatives have same probability; less operational flexibility (raw score range 0.4 - 0.9). |
| d. | Minimize water addition to tank | 0.62 | Pump & nozzle together; uses confined sluicing concept; localized addition & immediate removal; local addition & pumping should minimize water; no need for lots of water addition; average decontamination needs expected; minimum water addition; less "blast & suck" flexibility; requires more raw water for flushing; will require a lot of water (raw score range 0.3 - 0.9). |
| e. | Minimize secondary waste (e. g., solid waste) | 0.66 | Lowest of all options; least amount of solid waste; smaller amount of hardware; one system equals minimum waste; single system minimizes hardware & disposal cost; average secondary waste; only one system to get contaminated or be disposed of and little other waste generation; can leave vehicle in tank; less waste to dispose of; more maintenance; may be hard to clean with spray ring (raw score range 0.5 - 0.9). |
| f. | Maximize waste retrieval | 0.54 | Can go after heel with "focus"; should be adequate for most non-heel waste; will have good waste recovery; should be able to reach all areas of tank; will do okay but not great; works like carpet cleaner; inefficient waste retrieval especially toward end; will not be effective for heel retrieval; no redundancy or flexibility; one system is less flexible (raw score range 0.2 - 0.8). |
| g. | Maximize system RAM | 0.51 | The system can be very reliable; average RAM; slightly more complex than Alt. 3 & 4; complex equipment; many working & moving parts on one platform; maintenance problem; no backup; single system must be relied on to be operational; system down with one failure; with only one component any downtime for maintenance has high impact on availability; reliability & availability are low; high maintenance; no redundancy (raw score range 0.3 - 0.7). |
| h. | Minimize project LCC | 0.59 | Lowest capital cost; one simple vehicle; cost for one system is less than for multiple systems; single system is cheaper option; system failures & downtime impact schedule & productivity due to no alternate system; cost of downtime is high; high operating cost due to duration; higher operating cost to retrieve heel; longer operations to get heel may drive costs up; large vehicle price tag (raw score range 0.3 - 0.8). |
| i. | Maximize applicability to future retrieval actions | 0.56 | Mobile design; system can be relocated; minimal riser needs; can be used in all tanks; would be applicable; useful but not readily adaptable to all conditions; this system may not be the best for either bulk or heel retrieval; may not represent best technology for all types of waste; minimal or limited flexibility; lacks flexibility; least flexible to deal with different conditions (raw score range 0.2 - 0.9). |

Table 3. Raw Score Justification - Alternative 3 (ITV with Pump, Mast-Mounted Nozzle)

| Decision Criteria | | Raw Score | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 0.58 | Same as HTI and W-320 (C-106); mast with nozzle done at Hanford before; no impact to AB or average AB changes; AB to be modified for all alternatives; AB requires revision; potential new risers; two risers needed (raw score range 0.3 - 0.9). |
| b. | Minimize worker risks | 0.54 | Dual deployment requires less changeout; increased complexity will increase maintenance; ITV maintenance increases worker risk; vehicle will be highly contaminated; waste transfer line close to vehicle enclosure; added system to install & maintain; two separate systems equals additional installation & open riser work; two tank entry points therefore increased risk (raw score range 0.4 - 0.7). |
| c. | Minimize potential leak loss | 0.47 | All alternatives have same probability; sluicer reach restricts operational flexibility; larger liquid volume; two systems equals more piping connections; leak potential high as spray not localized; high leak loss with nozzle shooting everywhere; nozzle sprays over large area increases probability of leak loss; use of sluicer will increase casual water in the tank; looks like past practice sluicing; higher leak potential (raw score range 0.3 - 0.8). |
| d. | Minimize water addition to tank | 0.49 | Controllability of sluicer focus; average decontamination needs expected; lots of water added with nozzle fixed; will require lots of water; use of sluicer will increase casual water in the tank; adds water (raw score range 0.3 - 0.7). |
| e. | Minimize secondary waste (e. g., solid waste) | 0.56 | No significant secondary waste generation; easier to clean than Alt. 2; slightly more solid waste than Alt. 2; two systems to dispose of; two systems requiring disposal; more secondary waste with two systems; two systems equals more hardware to dispose of; increased system hardware (raw score range 0.3 - 0.9). |
| f. | Maximize waste retrieval | 0.61 | Two systems; better than vehicle alone; appears to offer method to go to point of sludge mobilization; good potential for waste recovery; heel may be a problem; less likelihood to remove heel; system will not be good for heel retrieval; effectiveness of sluice nozzle will decrease at the tank walls; distance of nozzle from waste surface (raw score range 0.4 - 0.8). |
| g. | Maximize system RAM | 0.59 | System can be very reliable; ITV can be a little simpler than Alt. 2; mast with sluicer is simple; proven technology; backup operational capabilities possible; average RAM; two systems therefore higher availability; system will have no redundancy or flexibility; two systems to maintain; two systems more complex (raw score range 0.5 - 0.8). |
| h. | Minimize project LCC | 0.54 | Experience; lower complexity; less costly than Alt. 2 since only one tool; average LCC due to system flexibility; cost for systems will be low compared to other options; two systems with cost experience on one; same as Alt. 2 but add sluicer; downtime will be costly (raw score range 0.4 - 0.8). |
| i. | Maximize applicability to future retrieval actions | 0.55 | More applicable than single system approach; improved flexibility; lacks operational flexibility; no flexibility; not optimized for heel retrieval; limited riser availability on some other tanks (raw score range 0.4 - 0.9). |

Table 4. Raw Score Justification - Alternative 4 (ITV with Nozzle, Mast with Pump)

| Decision Criteria | | Raw Score | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 0.58 | Not a foreseeable problem; type of work done before i.e. pump installation; no impact to AB or average AB changes necessary; AB to be modified for all alternatives; AB revision required; potential new riser (raw score range 0.3 - 0.9). |
| b. | Minimize worker risks | 0.62 | Flexible system reduces worker risk; separation of waste transfer from vehicle will help; minimal worker interface with pumping system; crawler design simplified; more complex; two systems to install & maintain; two ports or access points required in tank; ITV maintenance increases worker risk (raw score range 0.5 - 0.9). |
| c. | Minimize potential leak loss | 0.58 | Minimal use of water nozzles; pump & sluice at waste surface more localized; reduces water and appearance of past practice sluicing; lower leak loss; all alternatives have same probability; high leak potential due to fixed pump; two systems equals more piping connections; leak potential high as spray not localized (raw score range 0.3 - 0.9). |
| d. | Minimize water addition to tank | 0.56 | Minimal use of water nozzles; mobile sluicer more efficient less water; high water addition due to fixed pump; will require lots of water (raw score range 0.3 - 0.9). |
| e. | Minimize secondary waste (e. g., solid waste) | 0.58 | Little secondary waste generation; easier to clean than Alt. 2 or 3; two systems; two systems to dispose of therefore more solid waste (raw score range 0.3 - 0.9). |
| f. | Maximize waste retrieval | 0.68 | Increased sluicing control; two systems; allows aggressive local retrieval & method to push slurry to pump; better retrieval with vehicle pushing waste to pump; sluice & pump localize therefore high probability of waste retrieval; the mobility of the vehicle will help get more waste to the pump; better expected performance; lacks flexibility; heel may be a problem; may be difficult to get waste sluiced to pump (raw score range 0.4 - 0.9). |
| g. | Maximize system RAM | 0.64 | Better than average RAM; simple addition to crawler alone; two simple systems to maintain; separation of waste transfer from vehicle improves reliability and maintainability; pump-based Hanford experience; design of crawler simplified versus Alt. 2; no redundancy or flexibility (raw score range 0.5 - 0.9). |
| h. | Minimize project LCC | 0.57 | Lowest LCC; system cost is low; two simple systems; same as Alt. 2 but add pump; downtime costs will be higher (raw score range 0.4 - 0.7). |
| i. | Maximize applicability to future retrieval actions | 0.59 | Average applicability; two simple systems; improved flexibility; no flexibility for unknown conditions; may be limited by riser availability (raw score range 0.4 - 0.9). |

Table 5. Raw Score Justification - Alternative 5 (Articulated Mast with interchangeable Tools)

| Decision Criteria | | Raw Score | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 0.69 | Minimal impact; close to C-106 and interim stabilization combined; similar to past practice; similar works at Hanford done before; handled by much of existing AB; no impact to AB or average AB changes; AB to be modified for all alternatives; AB revision required (raw score range 0.5 - 0.9). |
| b. | Minimize worker risks | 0.61 | Equipment simplicity; minimal work interaction; moderate complexity therefore less maintenance than more complex alternatives; less maintenance required therefore lower risk; if tooling is reconfigured several times then exposures will be comparable to systems that have vehicles; similar works at Hanford done before; more tool changes add to worker exposure (raw score range 0.5 - 0.9). |
| c. | Minimize potential leak loss | 0.53 | Single system minimizes piping connections; medium leak loss with this system; reduces water & appearance of past-practice sluicing; all alternatives have same probability; less operational flexibility; will require more water addition than vehicle based applications; sluicing over large area; leak potential high as spray not localized (raw score range 0.3 - 0.9). |
| d. | Minimize water addition to tank | 0.48 | Addition of water above waste level; medium water added with this system; less operational flexibility in positioning & operating sluicing or pumping; will require more water addition than vehicle based applications; more water required; lots of water required (raw score range 0.3 - 0.7). |
| e. | Minimize secondary waste (e. g., solid waste) | 0.65 | Smaller number of parts & hardware; single system therefore less waste; less equipment to decommission; no ITV therefore less contaminated equipment; less contaminated equipment than for vehicle based systems; no significant secondary waste generation; spray-ring should be sufficient; one system minimizes waste (raw score range 0.4 - 0.9). |
| f. | Maximize waste retrieval | 0.33 | Limited range; one system less flexible; no flexibility for heel removal; coverage more limited; heel removal difficulties; no heel removal; no flexibility; not great retrieval; not good access to walls; lack of flexibility near perimeter of tank; not good heel retrieval (raw score range 0.1 - 0.5). |
| g. | Maximize system RAM | 0.63 | Prior design and operating experience as foundation; single system; very simple system; no ITV therefore RAM goes up; could be simpler than a vehicle & hence more reliable; based on Hanford experience; complex mechanical system; even redundant unit would have common failure modes; single system must be operable; failure mode a weakness; little redundancy; system has limited capability (raw score range 0.3 - 0.9). |
| h. | Minimize project LCC | 0.65 | Equipment simplicity; good experience available; average LCC; very simple system; simplest hardware; less expensive than a complex system; will not be cheap; system has limited capability (raw score range 0.3 - 0.9). |
| i. | Maximize applicability to future retrieval actions | 0.30 | If it works it would be applicable to all tanks; limited range; limited applicability for other tanks; may not be best option for hard heel or saltcake; less likely to get heel; in-tank obstructions a problem; less operational flexibility to deal with unexpected events; no flexibility; many tanks lack a large central riser therefore system may be relegated to one side of tank; little redundancy; little capability to deal with unknowns; one system with limited capability (raw score range 0.1 - 0.8). |

Table 6. Raw Score Justification - Alternative 6 (ITV and Mast, interchangeable Tools)

| Decision Criteria | | Raw Score | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 0.58 | Not a foreseeable problem; similar work at Hanford conducted; no impact to AB or average AB changes required; AB to be modified for all alternatives; AB revision required; two risers needed; complex system - likely changes (raw score range 0.3 - 0.9). |
| b. | Minimize worker risks | 0.53 | No significant difference from other concepts; minimal worker risk with flexible system; similar work at Hanford conducted; dual system reduces production schedule pressure and common mode failures; complex; more complexity that will lead to increased maintenance; complex system increases maintenance & risk; worker interaction to change tools (raw score range 0.3 - 0.8). |
| c. | Minimize potential leak loss | 0.60 | Very good for minimizing leaks; no need for lots of casual water; flexible system reduces leak potential; all alternatives have same probability; some combinations will have higher leak risk than others; less operational flexibility; two systems equals more piping connections; sluicing over large area (raw score range 0.4 - 0.9). |
| d. | Minimize water addition to tank | 0.64 | More focused material mobilization; some spray above waste; very good for minimal water addition; no need for lots of casual water; flexible system reduces water needed; cold testing will reveal minimized water strategy; lots of water (raw score range 0.3 - 0.9). |
| e. | Minimize secondary waste (e. g., solid waste) | 0.48 | No significant secondary waste generation; additional hardware; slightly more solid waste than other options; two systems; two separate systems equals more equipment to dispose of; lots of solid waste with number of tools; complex system therefore more waste (raw score range 0.3 - 0.7). |
| f. | Maximize waste retrieval | 0.85 | Likely continuity in waste retrieval during individual system downtimes; provides excellent potential for waste removal; very good job of retrieval due to flexibility; flexible system has high likelihood of waste retrieval; maximum flexibility; flexibility; flexibility to go after material; more flexibility to access waste at walls and heel; ITV can attack heel; cold testing will reveal optimum configuration & approaches; two systems multiple applications (raw score range 0.7 - 0.9). |
| g. | Maximize system RAM | 0.74 | Continuity in retrieval operations; two systems with one fairly simple allows backup; operational interaction; redundancy; either system could operate independently if the other is down; minimizes downtime; better RAM with flexibility; neither system would be a liability; two systems multiple applications; complex system requires more maintenance (raw score range 0.6 - 0.9). |
| h. | Minimize project LCC | 0.48 | Average LCC; alternate system promotes continuity in waste retrieval; payback during operations; two systems allow retrieval operations to continue; operation not as efficient [with one system down]; slightly higher upfront cost; two systems with multiple applications equals more cost; two systems equals more equipment; increased complexity increases cost (raw score range 0.2 - 0.8). |
| i. | Maximize applicability to future retrieval actions | 0.72 | Should be applicable to several tanks; tooling flexibility to address more scenarios; good flexibility to retrieve bulk & heel materials; flexibility to operate in various tank geometries; minimal riser availability on some tanks; two systems multiple applications; two systems more flexible (raw score range 0.3 - 0.9). |

Table 7. Raw Score Justification - Alternative 7 (Two ITVs, interchangeable Tools)

| Decision Criteria | | Raw Score | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 0.45 | No impact to AB or average AB changes; AB to be modified for all alternatives; AB revision required; new riser likely; would require additional or new riser; two risers needed (raw score range 0.2 - 0.9). |
| b. | Minimize worker risks | 0.39 | No significant difference compared to other concepts; complex equipment; common failure modes; will require additional riser; additional hose management system; more complexity that will lead to increased maintenance; multiple vehicles therefore more exposure; possible increased worker interaction & hands-on maintenance; two ITVs increase maintenance & risk (raw score range 0.2 - 0.7). |
| c. | Minimize potential leak loss | 0.61 | Good minimization of leak loss; increased operational flexibility to deal with leak conditions and control mobilization; no requirement for lots of casual water; flexible system reduces leak potential; all alternatives have same probability; some combinations will have higher leak risk than others; two systems equals more piping connections (raw score range 0.5 - 0.9). |
| d. | Minimize water addition to tank | 0.65 | Localized; tooling flexibility may enhance material mobilization & retrieval; efficient use of water; no requirement for lots of casual water; flexible system reduces water; more equipment resulting in added water needs for decontamination; lots of water (raw score range 0.3 - 0.9). |
| e. | Minimize secondary waste (e. g., solid waste) | 0.43 | No significant generation of secondary waste; additional hardware; more potential for solid waste; two systems; two systems to dispose of; more vehicles therefore more solid waste; more equipment to dispose of as waste (raw score range 0.3 - 0.7). |
| f. | Maximize waste retrieval | 0.79 | Flexibility to go after material; ITV can attack heel; flexibility and synergy ("cooperation"); two systems - good waste retrieval; two vehicles alternating in pitch & catch mode or with custom heel retrieval tooling gives great tank access; very good retrieval due to tank access; two systems lots of capability (raw score range 0.6 - 0.9). |
| g. | Maximize system RAM | 0.64 | Operational interaction; redundancy; two vehicles have better RAM; two systems lots of capability; systems operate independently to minimize downtime; if a common platform is used then the cost for spare parts, maintenance, & training will be decreased; common failure points; complex equipment; complexity of two crawlers; hose management difficult; two systems - more maintenance (raw score range 0.2 - 0.8). |
| h. | Minimize project LCC | 0.38 | Redundancy allows minimum cost from downtime; cost for two vehicles will not be as much as arm & vehicle; complexity & lack of simple retrieval technology option resulting in likely schedule impact & nonproductive downtime; more cost; cost of AB concerns; very costly with two crawlers; very expensive deployment with two vehicles; installation costs; highest cost due to adding risers; increased complexity increases cost; two systems equals more equipment (raw score range 0.1 - 0.7). |
| i. | Maximize applicability to future retrieval actions | 0.56 | Good flexibility; two ITVs provide enhanced operational flexibility; would be applicable to many tanks; high applicability to other tanks; not as flexible as Alt. 8; not best option for all types of waste; limited riser availability on some tanks; two-crawler option not politically, financially, technically very realistic (raw score range 0.2 - 0.9). |

Table 8. Raw Score Justification - Alternative 8 (Two ITVs & Mast, interchangeable Tools)

| Decision Criteria | | Raw Score | Justification/Remarks (see explanation, p. 9) |
|---|---|---|---|
| a. | Minimize impacts on the facility AB | 0.40 | No impact to AB, or average AB changes; AB to be modified for all alternatives; AB revision required; potential additional riser; high likelihood of new risers & other changes; requires additional riser; two risers needed (raw score range 0.1 - 0.9). |
| b. | Minimize worker risks | 0.37 | No significant difference compared to other concepts; least production schedule pressure on work planning & execution because of continuity in retrieval using other systems; most complex choice; requires additional riser; more equipment therefore more risk; more complexity that will lead to increased maintenance; operational complexity & multiple equipment requires more worker interaction & maintenance; worst worker risk due to most systems; most maintenance & risk (raw score range 0.1 - 0.7). |
| c. | Minimize potential leak loss | 0.62 | Best overall for leak loss minimization; increased operational flexibility to deal with leak conditions and control mobilization; no requirement for lots of casual water; good capability; flexible system reduces leaks; all alternatives have same probability; some combinations will have higher leak risk than others; three systems equals more piping connections (raw score range 0.3 - 0.9). |
| d. | Minimize water addition to tank | 0.64 | Best overall for efficient water use; increased operational flexibility to deal with leak conditions and control mobilization; water addition offset by ability to recycle or evaporate; flexible system reduces water; no requirement for lots of casual water; three systems add water; added water for decontamination of more equipment; lots of water (range 0.3 - 0.9). |
| e. | Minimize secondary waste (e. g., solid waste) | 0.33 | No significant generation of secondary waste; additional hardware; more equipment to decommission; lots of equipment to clean; multiple systems; now have three systems to dispose of; worst for secondary waste generation; most waste (raw score range 0.2 - 0.7). |
| f. | Maximize waste retrieval | 0.88 | Greatest flexibility means maximum waste retrieval capability; maximum in-tank flexibility; most flexible for best waste retrieval; flexibility to go after material; ITV can attack heel; gives most flexibility & best access to deal with all waste; versatility; synergy; good capability; high likelihood of waste retrieval (raw score range 0.7 - 0.9). |
| g. | Maximize system RAM | 0.69 | Best option for continuity of retrieval progress; best RAM with two vehicles; operational interaction; gives best redundancy; greatest availability; redundancy; systems operate independently to minimize downtime; reliable due to redundancy; most redundancy; very complex; could be very unreliable due to complexity; expensive downtime if one system breaks while others deployed; high maintenance (range 0.3 - 0.9). |
| h. | Minimize project LCC | 0.27 | Cost offset by steady progress in retrieval; there should be minimal lost time for maintenance; most equipment & readiness intense option; highest cost due to adding risers; very complex system; increased complexity increases cost; worst LCC due to complexity of three systems; the added complexity of three systems will cost more up front; cost of AB concerns (raw score range 0.1 - 0.7). |
| i. | Maximize applicability to future retrieval actions | 0.65 | Ability to gain most data & experience; most applicable to other tanks; highest flexibility; this concept or a subset would have good adaptability to other tanks; too complex for other tanks; limited riser availability on some tanks (raw score range 0.1 - 0.9). |

Table 9. Decision Scoring Summary Matrix

| Decision Criteria: | f. Maximize waste retrieval | g. Maximize system RAM | h. Minimize Project W-523 LCC | i. Maximize applicability to future retrieval actions | b. Minimize worker risk | d. Minimize addition of water to tanks | c. Minimize potential leak loss | a. Minimize facility AB impacts | e. Minimize secondary waste (e.g., solid waste) | Weighted Raw Score Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| Weight Factor: | 19 | 15 | 14 | 14 | 11 | 9 | 7 | 6 | 5 | |
| Alt. 6 | 16.15 | 11.10 | 6.72 | 10.08 | 5.83 | 5.76 | 4.20 | 3.48 | 2.40 | 65.72 |
| Alt. 4 | 12.92 | 9.60 | 7.98 | 8.26 | 6.82 | 5.04 | 4.06 | 3.48 | 2.90 | 61.06 |
| Alt. 8 | 16.72 | 10.35 | 3.78 | 9.10 | 4.07 | 5.76 | 4.34 | 2.40 | 1.65 | 58.17 |
| Alt. 2 | 10.26 | 7.65 | 8.26 | 7.84 | 6.38 | 5.58 | 4.55 | 4.02 | 3.30 | 57.84 |
| Alt. 7 | 15.01 | 9.60 | 5.32 | 7.84 | 4.29 | 5.85 | 4.27 | 2.70 | 2.15 | 57.03 |
| Alt. 3 | 11.59 | 8.85 | 7.56 | 7.70 | 5.94 | 4.41 | 3.29 | 3.48 | 2.80 | 55.62 |
| Alt. 5 | 6.27 | 9.45 | 9.10 | 4.20 | 6.71 | 4.32 | 3.71 | 4.14 | 3.25 | 51.15 |