Savannah River Site
Salt Processing Project

Down Selection Decision Analysis Summary Report, Revision 0

June 2001

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ACRONYMS

Cs	Cesium
CSSX	Caustic-Side Solvent Extraction
CST	Crystalline Silicotitanate Non-Elutable Ion Exchange
DF	Decontamination factor
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOE-EM	U.S. Department of Energy-Headquarters, Office of Environmental Management
DOE-SR	U.S. Department of Energy-Savannah River Operations Office
DWPF	Defense Waste Processing Facility
EM-1	Office of the Assistant Secretary
EM-20	Office of Integration and Disposition
EM-40	Office of Project Completion
EM-50	Office of Science and Technology
HLW	High level waste
INEEL	Idaho National Engineering and Environmental Laboratory
INMM	International Nuclear Materials Management
IPE	Independent Peer Evaluation
ITP	In-Tank Precipitation
MAUT	Multi-attribute utility theory
MST	Monosodium Titanate
NAS	National Academy of Science
NRC	National Research Council
ORNL	Oak Ridge National Laboratory
Pu	Plutonium
R&D	Research and development
SC	Safety Class
SME	Subject matter experts
SPP	Salt Processing Project
Sr	Strontium
SRTC	Savannah River Technology Center
SS	Safety significant
SSC	Structures, systems, and components
STTP	Small Tank Tetraphenylborate Precipitation
TAT	Technical Advisory Team
TFA	Tanks Focus Area
TWG	Technical Working Group
VE	Value Earned
WSRC	Westinghouse Savannah River Company

1.0. INTRODUCTION

1.1. BACKGROUND

This report summarizes actions taken by the U.S. Department of Energy's Tanks Focus Area (TFA) to support the DOE Salt Processing Project's (SPP) Technical Working Group (TWG) in selection of a technology to separate radioactive and non-radioactive elements in Savannah River Site (SRS) high-level waste (HLW). This technology will enable SRS to remove HLW from its tanks and convert it into a solid waste form suitable for disposal. This mission, required for compliance with the SRS Site Treatment Plan and Federal Facilities Agreement, converts the HLW sludge by incorporating long- and short-lived radioisotopes into borosilicate glass. This process, called vitrification produces a solid waste form acceptable for disposal in the national HLW repository. For the process to be economically feasible, SRS must limit the volume of HLW glass produced by separately processing the radioactive salts, which can then be disposed on site as low-level waste at far less expense.

In the 1980s, SRS developed a salt treatment process, called In-Tank Precipitation (ITP), and demonstrated it in moderate and full scale with actual SRS waste. During radioactive startup in 1995, ITP produced benzene in quantities significantly higher than predicted. Westinghouse Savannah River Company (WSRC), the operating contractor, initiated laboratory and facility tests to determine the cause of escalated benzene generation and to manage it safely. In August 1996, the Defense Nuclear Facilities Safety Board (DNFSB, an independent oversight board for DOE) recommended that the ITP facility suspend operations until the process of benzene generation, retention, and release were better understood. WSRC evaluated these processes from August 1996 through March 1998, and in January 1998, advised Department of Energy-Savannah River Operations Office (DOE-SR) that the existing system configuration could not cost effectively meet safety and production requirements for the ITP facility. In February 1998, the DOE Assistant Secretary for Environmental Management (EM-1) approved a DOE-SR plan to suspend startup-related activities and conduct a systems engineering study of alternatives to ITP.

1.2. PREVIOUS WORK PERFORMED TO SUPPORT TECHNOLOGY SELECTION

1.2.1. SYSTEMS ENGINEERING STUDY

The Systems Engineering Team chartered by WSRC evaluated potential cesium removal technologies in terms of process engineering, chemistry, waste processing, science, safety and regulatory engineering, operations, and systems engineering and interface controls. Members of the Systems Engineering Team also provided perspectives from industry, international radioactive waste disposal programs, and other DOE facilities that have large

radioactive waste disposal programs. The Savannah River Technology Center (SRTC) and other DOE national laboratories – including Oak Ridge National Laboratory and Argonne National Laboratory – provided research and development support. Several universities also provided needed expertise in specific areas. The Systems Engineering Team performed extensive evaluation of the problem and performance requirements and, from this, identified over 140 technologies that had some potential to address the problem.

The systems engineering study[1] evaluated over 140 technologies and reduced the list of candidates to four alternative cesium removal processes: Crystalline Silicotitanate Non-Elutable Ion Exchange (CST), Caustic-Side Solvent Extraction (CSSX), Small Tank Tetraphenylborate Precipitation (STTP), and direct grouting (eliminated by DOE-SR in subsequent evaluation). During this study, the System Engineering Team performed several key aspects of the technology decision process, including definition of requirements for the SPP. Table 1-1 lists the Key Functional Requirements for the technology evaluated. These requirements constituted a viability screening-process; any technology that could not meet these requirements was disqualified from further consideration. Section 2.1 provides a description of the SPP decision process and how the systems engineering study work fits in.

1.2.2. INDEPENDENT TECHNICAL REVIEWS AND OVERSIGHT

As research and development on the three technology alternatives progressed, DOE conducted independent evaluations to make sure that their technical maturity was adequate to support selection. DOE chartered both an independent review by its experts, in the form of an Independent Peer Evaluation (IPE), and a study by the National Academy of Sciences (NAS). The IPE and NAS expressed concerns that significant technical uncertainties would remain unresolved at the time scheduled (1999) for selection between the alternatives. The NAS recommended that DOE postpone selection of an alternative until research and development resolved critical technical issues.

These recommendations[2,3] prompted the DOE Under Secretary and Assistant Secretary for Environmental Management to direct additional research and development on each alternative to reduce the technical uncertainty prior to down-selection. DOE-SR also withheld a Draft Supplemental Environmental Impact Statement for Defense Waste Processing Facility[4] and a solicitation for a design/construct contractor.

In March 2000, DOE requested the TFA to manage the SPP technology development program for the TWG and to support a technology selection by EM-1 in June 2001.[5] TFA was requested to review and revise the SPP technology roadmaps, prepare a comprehensive research and development program plan for the three candidate cesium-removal technologies as well as the alpha- and strontium-removal processes that are part of the overall SPP. In addition, TFA was requested to develop down-selection criteria. The technology roadmaps, R&D Program Plan,[6] and selection criteria were approved by the TWG in FY 2000.

Table 1-1. Key Functional Requirements

Area	Functions
Hazard Assessment Document	Provide a facility that meets the requirements of a non-reactor nuclear hazard category 2 and low chemical hazard category.
Interface Streams	
DWPF Recycle	Support tank farm space management and the evaporator strategy for addressing DWPF recycle.
DWPF Glass	Provide a Cs-containing product that supports glass waste form requirements relative to durability, crystallization temperature, sodium content, and viscosity.
Salt Waste Processing Facility Feed	Provide a Decontaminated Salt Solution (DSS) product that meets Waste Acceptance Criteria relative to producing a non-hazardous saltstone waste form suitable for disposal as low-level solid waste at the SRS.
Tank 49H	Support Tank Farm space management strategy to recover Tank 49H for HLW storage.
Tank 50H	Support Tank Farm space management strategy to recover Tank 50H for HLW storage.
New Waste Form	Comply with DOE-RW* HLW repository requirements. (*Office of Civilian Radioactive Waste Management Program)
Nominal Decontamination Factor (DF)	
Strontium DF	Provide a strontium DSS concentration of ≤40 nCi/g, which equals to a nominal DF = 5 (overall average).
Alpha DF	Provide an alpha DSS concentration of ≤18 nCi/g, which equals to a nominal DF = 12 (overall average).
Cesium DF	Provide a cesium DSS concentration that enables conversion to a solid low-level waste form suitable for near-surface disposal at the SRS. •For processes that remove cesium, cesium-137 ≤45 nCi/g is required to enable processing in the existing Saltstone Production Facility and disposal in the existing Saltstone Disposal Facility, which equals a nominal DF = 8000 (overall average).
Schedule	
HLW Storage	Support Tank Farm space management strategy to support site missions (timely startup of new process by 2010).
Federal Facility Agreement	Support readiness for closure of all waste tanks by 2028.
Saltstone Treatment Plant	Support readiness for closure of old style tanks by 2020, and an average glass-canister production rate of 200 canisters per year.

The TWG used the decision process described in Section 2.0 to develop down-selection criteria with support of the TFA and SPP Technical Advisory Team (TAT) in evaluating the three remaining alternatives. This report documents the development of the criteria for technology down selection.

2.0. DECISION PROCESS DESCRIPTION

2.1. KEY PERSONNEL

DOE assembled a group of its own personnel, contractors and consultants with extensive experience in radioactive waste processing to support technology evaluation and selection.[7] Figure 2.1 shows the organization that DOE assembled. The TWG members were Kenneth Lang (EM-40), Kurt Gerdes (EM-50), Kenneth Picha (EM-20) and William Spader (DOE-SR). Kenneth Lang was established as day-to-day lead for operation of the TWG. DOE also established the TAT who provided senior-level and subject matter expertise to assure that all operations and implementation issues were identified. TFA also utilized the Technical Advisory Group, their senior consultants with expertise in HLW pretreatment and operations. TFA received input from these subject matter experts (SME) and incorporated it into the revised Research and Development (R&D) Program Plan.[8] The goal of the R&D Program Plan was to obtain resolution of issues on a schedule that supported down-selection among the alternatives by June 2001.

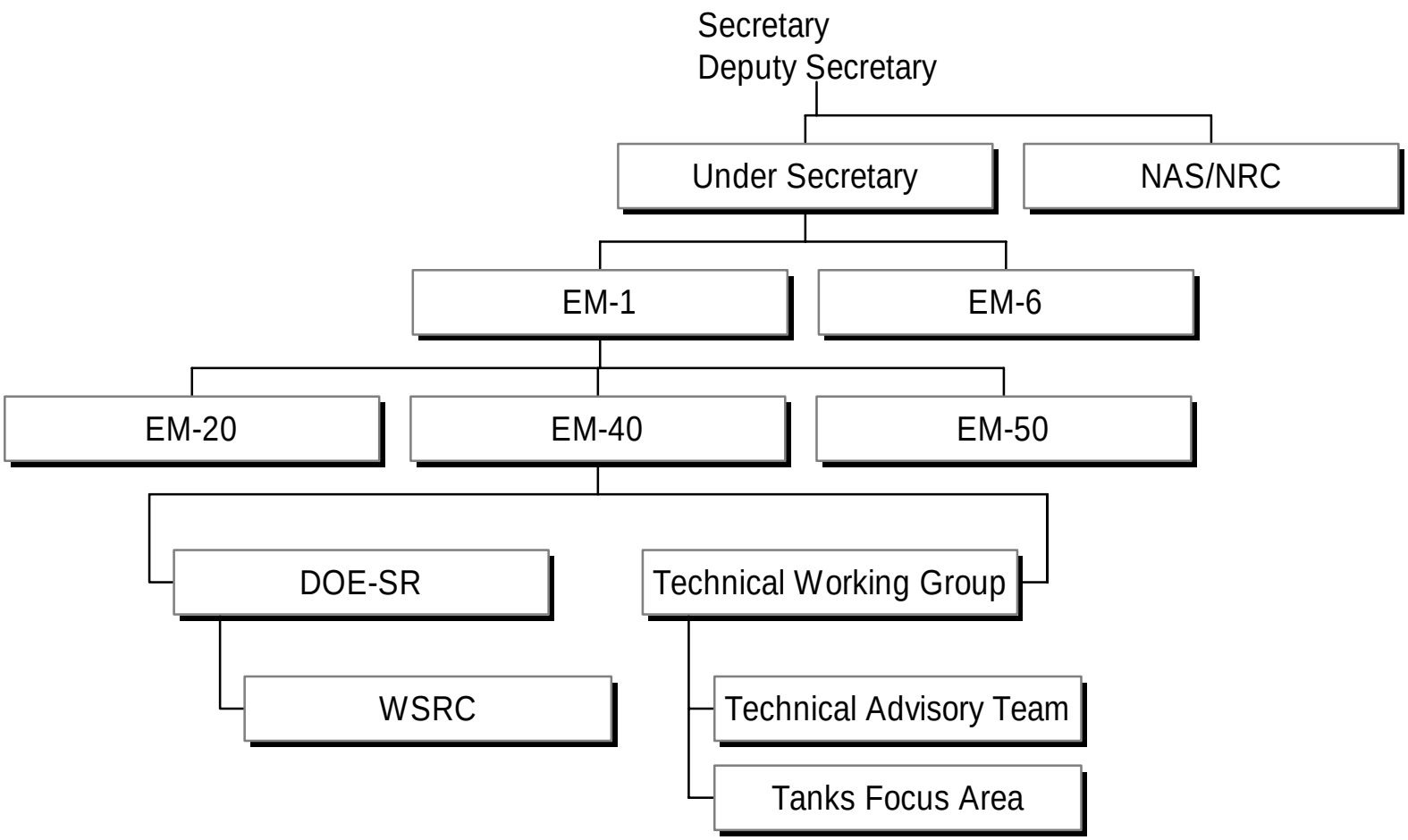
DOE and DOE-SR management maintained overall responsibilities for oversight and decision making including:

- Approval of criteria
- Re-evaluation of technologies with new and updated data packages
- Formal request for new studies
- Evaluation of activities to accelerate key R&D activities
- Monitoring progress through quarterly updates as R&D programs and engineering data packages mature.

The TWG was responsible for managing the technology development of treatment alternatives through:

- Approval of the SRS SPP R&D Program Plan
- Development of technology roadmaps
- Establishing down-selection criteria and weights
- Providing project integration
- Ensuring project execution and technical oversight
- Providing briefings to DNSFB
- Facilitating public involvement with open conferences, including a vendor forum, and
- Prompt, on-going reporting to DOE management on project progress.

Figure 2-1. Management Structure for Savannah River Site High Level Waste SPP Technology Development and Selection



The TFA was responsible for:

- Evaluating technical issues to be resolved and revising technology roadmaps
- Evaluating the three cesium removal processes
- Proposing the criteria to be used for potential down-selection during the R&D phase
- Preparing the new R&D Program Plan
- Endorsing new R&D work scope, and recommending approval to TWG
- Monitoring progress of the R&D activities
- Serving as a technical resource for the TWG with specific emphasis on R&D
- Convening and facilitating meetings, teleconferences, conferences, workshops, and providing briefings/presentations and program updates.

The TAT was responsible for:

- Assessing the results of the R&D program data in terms of the design, construction and operation of production scale facilities
- Providing an engineering maturity baseline for each of the alternatives, including a review of the pre-conceptual design as well as the identification of key scale up issues
- Assisting the TWG in the development of down-selection criteria, ensuring that the criteria address the engineering aspects of the project
- Serving as a technical resource for the TWG with expertise in implementation of treatment technologies.

The Action Plan[7] has scheduled certain activities that must be fulfilled by the TFA. Table 2-1 identifies the leaders and support teams for the technology areas for which the Action Plan required additional evaluation.

In this report, the Salt Processing Team (Team) refers to a collective of members of the TWG, TAT, TFA (including the SPP system leads) and key WSRC personnel. This Team met quarterly from April 2000 through June 2001 to review the status of R&D activities, evaluate the effects of new data on the scoring process, and adjust the program as needed. In May 2001, this Team collected all the SPP R&D results and engineering data to the TWG in a final scoring using the criteria, factors, relationships, and data detailed below. The TWG made the final scoring using input from TFA, TAT and other experts (e.g., National Research Council[2,3,5]). Based on this final scoring and other key input, the TWG recommended a preferred alternative to DOE management who will make the final technology selection.

The complexity of the evaluation of the salt processing technology alternatives required a well-defined decision process that would be transparent and credible to DOE management and interested stakeholders. Section 2.0 provides a concise, conceptual overview of the process (i.e., what was done and why). Section 3.0 presents specific analyses performed to assure resolution of issues. Section 4.0 presents the conclusions and recommendations of the decision analysis described in Section 3.0.

Table 2-1. Tanks Focus Area Salt Processing Project Research and Development Participants

Harry D. Harmon, Manager, Pacific Northwest National Laboratory
Steve Schlahta, Deputy Manager, Pacific Northwest National Laboratory

Technology Alternative	System Lead	Participating Laboratories
Alpha and Sr Removal	Sam Fink Savannah River Technology Center	Savannah River Technology Center Pacific Northwest National Laboratory University of South Carolina Texas A&M University Princeton University
CST Non-Elutable Ion Exchange	Dennis Wester Pacific Northwest National Laboratory	Sandia National Laboratories Pacific Northwest National Laboratory Savannah River Technology Center Oak Ridge National Laboratory Texas A&M University
Small Tank TPB Precipitation	Joe Walker Oak Ridge National Laboratory	Oak Ridge National Laboratory Savannah River Technology Center University of Georgia Georgia Institute of Technology University of Florida Illinois Institute of Technology
Caustic Side Solvent Extraction	Major Thompson Savannah River Technology Center	Argonne National Laboratory Oak Ridge National Laboratory Savannah River Technology Center

2.2. DECISION APPROACH

The salt processing technology selection is typical of evaluations that must be done to support DOE's mission. It is complex; it involves multiple objectives and qualitative and quantitative factors with varying levels of importance. It also involves multiple decision-makers or stakeholders whose opinion may impact implementation after selection. To steer the decision process through these multiple factors and interests, the Team adopted a uniform decision process and supporting evaluation methods. This decision process is documented in a draft guidebook called "A Guidebook for Decision Analysis Methods Developed for the Department of Energy INMM Program", in March 2001.[9] The chosen decision analysis tool was the Idaho National Engineering and Environmental Laboratory's (INEEL) *Quick Compare* computer program. This software combines a uniform decision process and a systematic decision analysis method that provides the following benefits:

- A structured way to approach complex problems;
- A rational basis for decisions;
- Consistency in decision making with other DOE-EM programs;
- Objectivity and transparency of the process;
- A sequenced approach that allows a decision to be made at the lowest level of complexity that provides adequate technical justification; and
- Documentation of criteria and weights (values) used in making the decision.

The decision analysis process is a seven-step process and is illustrated in Figure 2-2. The design of the decision analysis approach must be based on the scope and availability of resources. Additionally, the depth of the decision analysis is based on five factors:

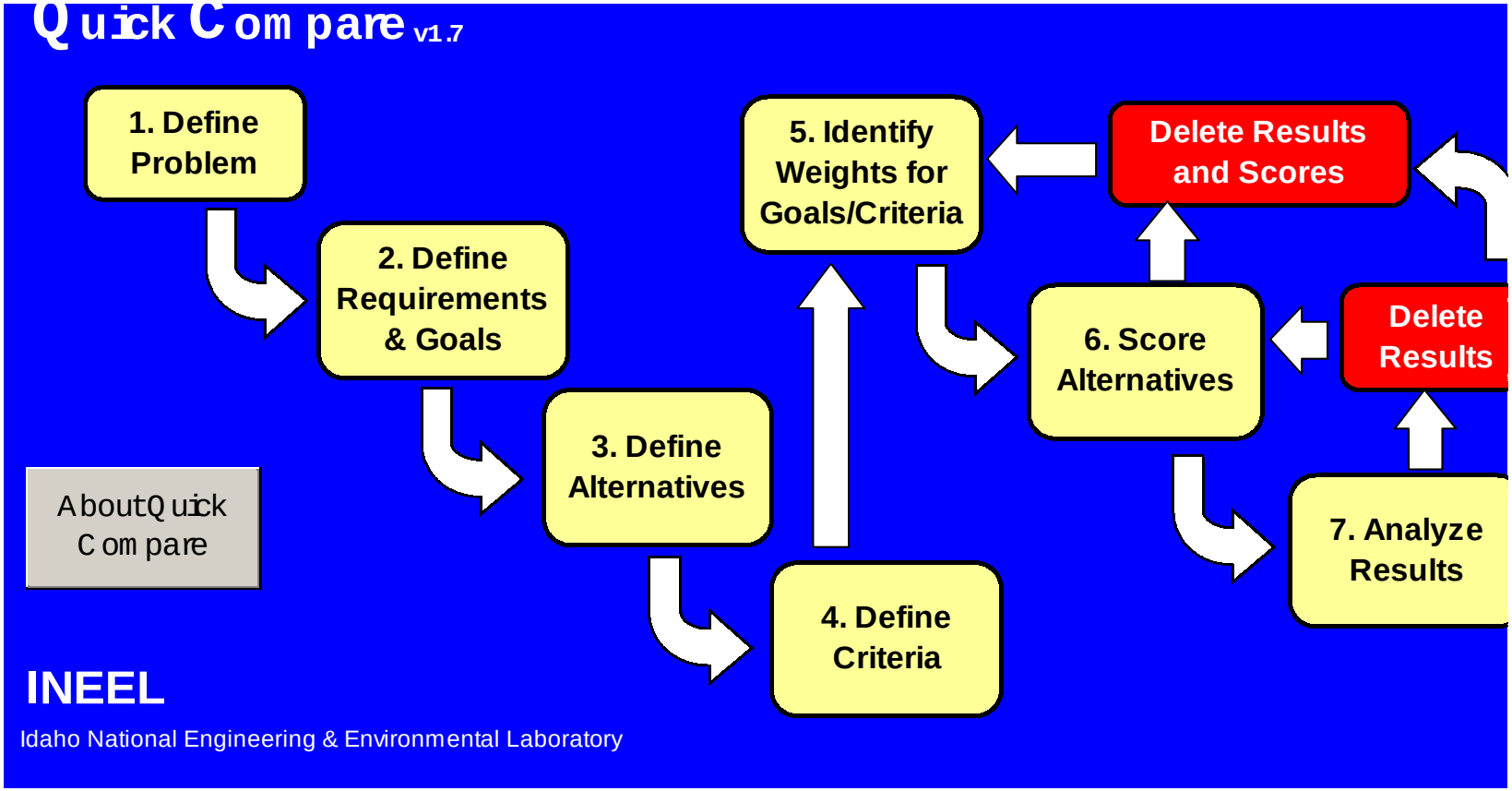
1. The level of visibility (very high for SPP),
2. Time available to perform the analysis,
3. Resources that can be committed,
4. The decision evaluation method used, and
5. The level of technical information needed to support the decision.

Based on the nature of the decision, complexity of input, need for quantitative basis of decision, and the desire for transparency of method to reviewers, the team chose INEEL's modified multi-attribute utility analysis.

2.3. DEFINITION OF GOALS

Once the systems engineering study[1] adequately defined the problem, technology requirements, and a specified number of alternatives, the SPP decision process focused its analysis on three levels: (1) identification of goals that the selected technology should

Figure 2-2. Decision Analysis Tool



achieve, (2) selection of criteria representing a measure of the technology's effectiveness at achieving the goal, and (3) scoring and weighting the criteria for each technology alternative.

These three levels define, at successively greater detail, what key issues the SPP Team should consider during evaluation of the alternatives. Goals describe what the outcome will be if the technology performs successfully. Due to their general nature, goals do not provide an explicit measure of their individual merit nor do they indicate how well each technology would perform in meeting them. The goals serve as the guiding light toward which all actions in the project should move. The goals also provide a conceptual framework within which tradeoffs between competing issues can be evaluated. Criteria represents the next level of detail and are developed from the goals. The criteria are the specific project performance issues that provide a definable measure of how effectively a given alternative will satisfy a particular goal. Several criteria were required to describe how effectively a given alternative addressed some goals, but the SPP Team spent significant effort to assure that each criterion was unique. For each criterion, the SPP Team defined measures that would reflect the effectiveness of each alternative in achieving the stated goals.

In the initial goal and criteria development (April 2000), the SPP Team identified 11 possible goals and, by June 2000 the Team refined this list to six goals. Office of Project Completion (EM-40) approved the criteria in August 2000. Sections 3.2 and 3.3 provide the goals and criteria for the SPP technology down-selection analysis. Section 3.4 describes the process for evaluating the three alternatives against the criteria.

2.4. CRITERIA DEFINITION

Working from the goals, the SPP team identified criteria that the technology that would measure how to achieve the project goals. In the initial development session, the entire Team developed a candidate criteria list. After the candidate criteria were identified, the Team ran a series of test scoring and data analyses based on the perceptions of each of the technology's performance by the SME on the SPP Team. The goals of the trial scoring were to:

(1) Determine if the alternatives could be discriminated by a simple SME evaluation;
(2) Determine if the criteria discriminated effectively, individually, and as a whole; and
(3) Evaluate if any criteria were redundant and modify to remove redundancy.

The following sections describe the subsequent iterations of the process to make a more defensible technology recommendation. Section 3.0 presents the analysis of these evaluations and their impacts on the technology down-selection process.

2.5. EVALUATION OF TRADEOFFS AND SENSITIVITY

Many approaches exist for decision analysis of alternatives, but the effort and the level of detail must be appropriate for the decision. If the decision is made too early, the analysis will lack adequate data to make it defensible. Figure 2-3 shows a graded approach to evaluation that identifies the potential exit points at each stage of evaluation. INEEL's decision guidebook[9] provides some decision readiness checks. Because the approach is graded, the evaluations shown in Figure 2-3 generally require more time and money as the project proceeds down the chart. As the SPP proceeded the remaining uncertainties indicated that a full analysis would be required to support the desired June 2001 down-selection.

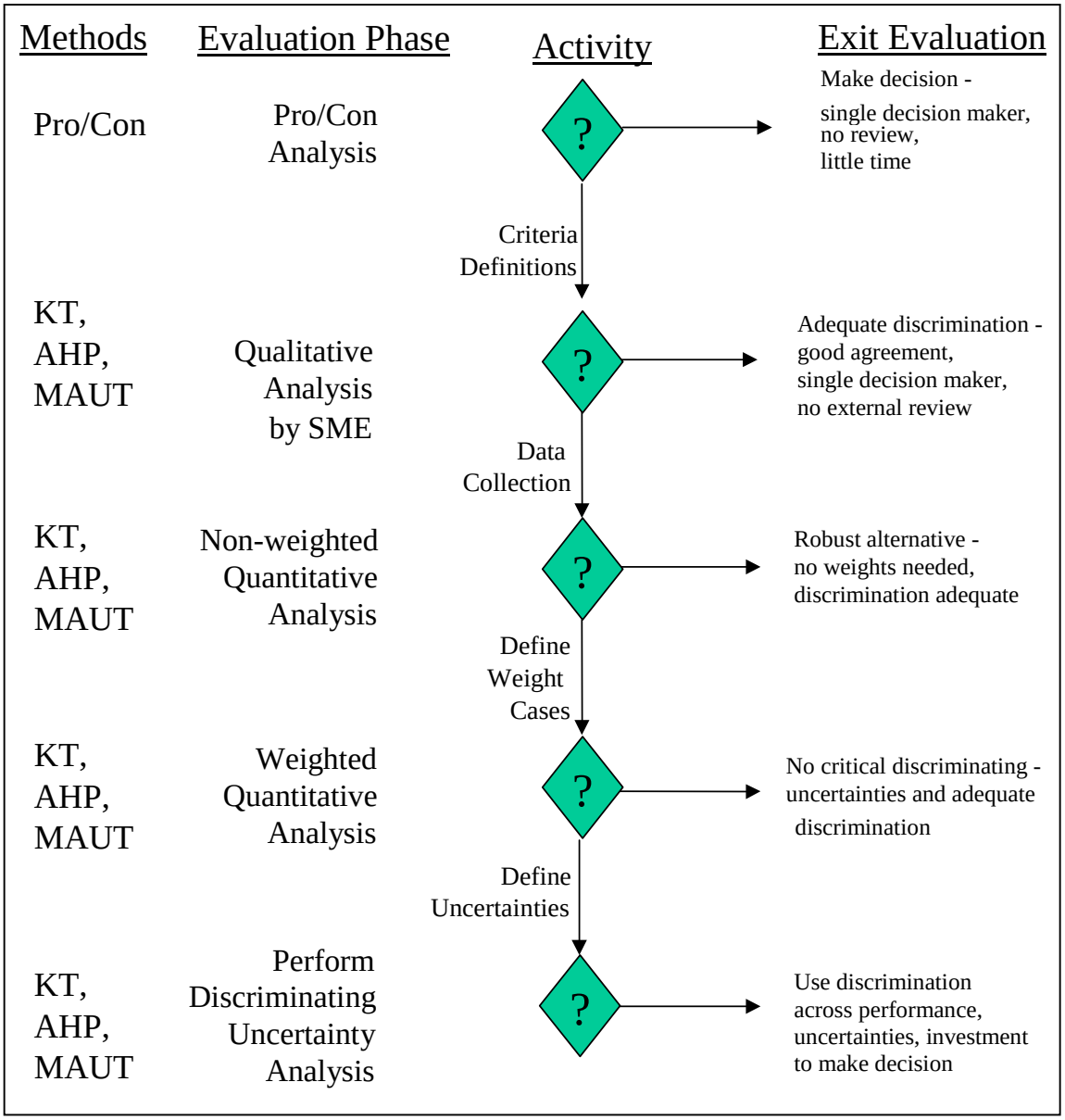
2.5.1. QUALITATIVE ANALYSIS

The SPP Team performed a qualitative analysis to:

- Evaluate the alternatives across all criteria to determine if they could be discriminated by expert opinion, and
- Identify specific areas of agreement and/or disagreement.

The individual SPP Team scored each identified criterion for the three alternatives on a scale of poor, neutral, or good using a scale of 1 to 5. The qualitative scores did not identify a clearly-preferred technology. The SPP Team subsequently identified data that, if provided, would reduce the uncertainity in how they scored the criteria. The TWG considered the technical input and scores from the TFA and TAT in determining a final TWG score for each technology. With the identification of quantitative data that would allow scoring of the criteria, the analysis moved into a quantitative phase. In quantitative analysis, the data (instead of expert opinion) become the common basis for scoring the criteria. After the SPP Team defined the criteria and quantitative data to score them, they conducted another trial scoring based on their best prediction of what the data results would be. This was done to test the adequacy of the criteria (and associated data) to discriminate among alternatives. After this detailed look at criteria and supporting data, the SMEs took an overall look at the criteria, alternatives, and data to discern if any discriminating factors were omitted in the evaluation. Their analyses were included in the Team records and data needed to develop the discriminating factors were identified in the R&D Program Plan.[8]

Figure 2-3. Decision Analysis Process



Key: KT = Kepner-Tregoe Analysis
AHP = Analytical Heirarchy Process
MAUT = Multiple Attribute Utility Theory

2.5.2 DATA PLAN AND COLLECTION

From the qualitative evaluation and recommendations, the SPP Team and TFA compiled a data collection plan that:

(1) defined the selection criteria,
(2) described the factors that would be used to score the criteria,
(3) described, in detail, the data that constitute critical measures, and
(4) made assignments for data collection.

The purpose of the data collection was to provide objective evidence of each technology's performance for each of the evaluation criteria. Team members collected data from previous work including systems engineering, laboratory research and development, and engineering modeling tools. During the 12 months that the decision analysis proceeded, the Team reviewed data as it became available and altered definitions where appropriate (e.g., to exclude non-discriminating data or eliminate redundancies in "critical measures" that addressed more than one criterion). "Critical measures" were the data sets derived from the data packages used as input to scoring. For example, the cost data package consisted of a significant volume of data, but the Total Project Cost and the Life Cycle Cost were extracted as "critical measures" for the scoring. Section 3.0 describes, in greater detail, how the selection criteria evolved during this decision analysis process.

2.5.3. DATA NORMALIZATION AND SCORING

The advancement of scoring methods from qualitative to quantiative meant that all subsequent phases of evaluation shifted from perceptive qualitative scoring to scoring with quantitiative data. In order to perform such quantitative analyses, the SPP Team developed relationships to criterion scores in a clear, understandable manner. The SPP Team used a modified multi-attribute utility theory (MAUT) for this conversion. MAUT was appropriate because the technology alternative analysis required consideration of multiple attributes of the process needed (and the technology that would be selected) and the information was very disparate in nature. This disparatity required that the score be correlated to some standard scale so that the alternatives could be compared equitably across all criteria.

For salt processing, the SPP Team selected a scale of 1 to 5 to provide a utility score for each alternative's criterion. The five point scale retained two signficant figures, representing the increased precision in moving from perceptive qualitative opinion to quantitative data packages. The final link between quantitative data and assigning the score was developing a scale (discussed in Section 3.4) that converted the data to a score. The function can be linear or non-linear, each type is described below.

The simplest function is one where the score is calculated based on a linear function. As the value increases, a higher score is given proportionately for the change in value. If a linear equation does not describe how the data should be converted to a normalized score, then a non-linear function can be used. A non-linear function is used when a small change in value

is either significantly better or worse than a linear function might calculate. For example, finishing a task a year early is good, on time is good, but late is a significant problem. In this example, finishing early may be a little better in score than finishing on time but finishing late gets a very low score. Two alternatives that finish one or two years late, respectively, may receive nearly the same low score since once the date is missed, all the problems associated with this are realized.

The utility score uses a 0 to 1 scale as does the weighting. To convert the normalized score to a utility score the following equation is used:

$$\mathbf{u = 0.25(A) - 0.25}$$

Where: A is the score between 1 to 5. From this equation, a score of 1 would be equal to a 0 in utility score and a 5 would be equal to a 1 in utility score. A 2 is worth 0.25, a 3 worth 0.5, and a 4 worth 0.75 in utility score. These values are now on the same scale as the weights (see Section 2.5.4) and can be multiplied by each other without one element affecting the overall score more than the other.

The summary utility score is calculated by multiplying the individual utility "u", by the criterion weight, "w". The summation of all the products make up the total utility score.

$$\textbf{Criteria (1-11)} \ \Sigma \ (\mathbf{u} \times \mathbf{w})$$

The importance of this normalization phase was to define the rule used to convert the quantitative data to a comparable score and follow the rule in subsequent evaluations. This step's purpose is to take perception and subjectivity out of the alternative comparison data at the level of each individual criterion. The relative importance of the criteria is the subject of the weighting phase of the evaluation and is discussed next.

2.5.4. WEIGHTING ANALYSIS

The SPP Team used quantitative analysis to discuss and evaluate tradeoffs that could change the outcome of technology selection. For decisions like the SPP (that involve multiple attributes) the selection is sensitive to not only the score assigned for each criterion, but also the relative importance of each criterion to the whole. The SPP Team evaluated this issue by performing a number of weighting scenarios in which individual subgroups (TAT, TWG, TFA) assigned weights in accordance with the importance they perceived each criterion should have. The overall Team then performed sensitivity analyses to evaluate the effects of weighting. In these analyses, the weight of each criterion was varied progressively from 0.01 to 1.0 (the weights of the others were reduced proportionally) and the relative scores were calculated. The resultant weighting sensitivity charts (see Appendix C for an example) identified the relative ranking of the alternatives. If the same alternatives remained highest ranked for all weighting scenarios, the criterion was seen as insensitive to weighting. Conversely, if a minor change in weighting caused the relative rank of alternatives to reverse, the analysis showed the evaluation to be highly sensitive to weighting. The TWG was

assigned the responsibility of assigning final weights by EM-40 to each criterion (using input from TFA, TAT, and SME.)

The Team also evaluated weighting sensitivity from a technology perspective. Ideally, one technology would be ranked highest under all weighting sets. As stated previously, none of the three alternatives was clearly superior across all weighting sets. When no technology is clearly superior, those that always plot in the top one or two spots are preferrable to those that are best in some criteria but worst on a majority of others. If a clear leader had emerged in this phase of evaluation (e.g., two of the alternatives failed), the team could have made a recommendation at that point. However, no technology emerged as clearly superior and significant uncertainities remained (especially with criteria for which performance with real waste was an issue) so the evaluation continued.

2.5.5. SENSITIVITY ANALYSIS

The SPP Team performed sensitivity analysis to supplement and fine-tune the quantitative analyses. The goal of the sensitivity analysis was to identify the issues in scoring and/or weighting that might affect the outcome of technology selection. By default, this analysis identified robust as well as sensitive factors (e.g., numerical rounding). This analysis indicated that the outcome would be more sensitive to scores than to weights and that the outcome for Criteria 1, 3, 4 and 5 could be affected by rounding errors. Thus, efforts between January and June 2001 were focused on scoring-related issues; the Team carried two significant figures throughout the scoring analysis. The TWG used all these analyses in making the final decisions and providing a recommendation to EM-1.

3.0. ANALYSIS

3.1. SCOPE OF THE DECISION ANALYSIS

As discussed in previous sections, the SPP Team comprised the expertise of numerous organizations, including DOE senior management, national laboratories, and contractors, as well as universities and private industry. The sections below identify the results of the SPP Team during the evaluation process, including:

- Defining goals,
- Establishing and defining selection criteria,
- Identifying the data needed to support selection,
- Defining the methods for data normalization and scoring,
- Evaluating appropriate weighting of the criteria, and
- Evaluating tradeoffs and sensitivities inherent in this decision.

3.2. GOALS OF THE SALT PROCESSING PROJECT

At an initial goal and criteria development meeting in April 2000, the SPP Team identified a comprehensive list of goals that, if met, would determine that the SPP was successful. At the initial meeting, the TWG approved 11 goals that comprehensively covered what was to be achieved. These eleven goals were:

- Meet Schedule Agreements
- Available Cost/Availability of Key Components, Chemicals, And Suppliers
- Minimize Cost
- Process Technology Must Work As Intended
- Minimize Environmental Impacts
- Achieve Stakeholder Buy-In
- Minimize Use Of Single-Shell Tanks
- Minimize Impact to the High-Level Waste System Interfaces
- Maximize Process Attainment/Flexibility
- Maximize Process Simplicity, and
- Maximize Flexibility Of Recovery From Upset Conditions.

As the Team refined its decision process, they critiqued these goals in a June 2000 meeting. This critique identified overlap, redundancies, and similarities in the original list of eleven goals. Based on this critique the TWG identified six goals that appeared to be clear, unique, and inclusive for the project. They were:

- Meet schedule
- Minimize cost
- Minimize technical risk
- Minimize environmental, safety, and health (ES&H) risks
- Minimize impact to interfaces (with DWPF), and
- Maximize process flexibility.

These six goals proved effective in enabling the identification of discriminating criteria and "critical measures" for scoring the criteria. Most significantly, the goals remained stable throughout the decision process even though the criteria and data derived from them evolved as the Team gained knowledge about the alternatives. The stability of the goals demonstrated the understanding of the problem, and the adherence of the Team to the defined decision process.

3.3. SELECTION CRITERIA

After identifying the goals, the SPP Team analyzed the technology alternatives and defined criteria that reflected how well each technology achieved the project goals. The initial step was to derive as many potential discriminating criteria as necessary to quantify performance of the technologies against the goal. After the Team compiled a comprehensive list of criteria, the TWG conducted a series of trial scorings, sensitivity analyses and weightings to confirm the efficacy of the criteria.

The Team evaluated the effectiveness of the initial criteria based on the following factors:

- Differentiation between alternatives
- Relationship to goals or values of DOE and other stakeholders
- Measurable or estimable
- Reasonably independent of each other, and
- Well understood by all decision makers.

From these analyses (discussed in detail in Section 3.4), the Team identified criteria that were not effective discriminators, were redundant, and could be more effectively combined with another criterion.

In this evaluation, the Team operated under the premise that having a few tangible, effectively discriminating criteria was preferred to a large number of marginally discriminating criteria. The primary method of refinement of the criteria was, "Reverse

Direction Criteria Development" as described by Baker.[9] This analysis identified criteria that, although seemingly significant in discriminating between alternatives, did not provide any discrimination in the test analyses. From these analyses, the Team also defined the criteria and factors that would provide meaningful measures of the effectiveness of each technology alternative in meeting the goals. In performing these analyses the Team consistently worked toward the goal of fewer, more effectively discriminating criteria. These analyses took the criteria through the evolution summarized in Table 3-1.

The sections below define the criteria; identify the critical measures that reflect the capability of each technology to meet the SPP goals, and the protocol to score each criterion. Table 3-2 summarizes the final criteria and the definition that the TWG used in scoring the technology alternatives. EM-40 had approved these final criteria and definitions in August 2000. Appendix A contains the data used to score the eleven criteria for each technology.

3.3.1. CRITERION 1 - SCHEDULE RISKS

One of the requirements for each of the SPP alternatives is that high-risk technology issues related to its implementation be resolved in time to make the technology down-selection in June 2001 (a milestone required to support operational objectives). Input from the SPP System Leads into the R&D Plan included resolution of all high-risk issues for each of the technologies to meet this date. To enable scoring, technology risk was defined by the magnitude of the error that would result if an incorrect decision was made because the technical uncertainty(ies) were not resolved prior to technology down-selection. The potential impact resulting from an errant technology decision ranged from total disqualification of the facility (viability), significant changes in facility size (footprint), or optimization of the facility operation. Table 3-3 shows the class of impact and scheduled date for resolution for each technical uncertainty associated with each technology.

One specific analysis made for this scoring was the risk "waterfall" chart created from these data in Table 3-3. Figure 3-1 shows the decrease in technical uncertainty following the resolution of issues over time (assuming that the outcome is favorable for a technology). The chart shows that the uncertainties associated with CST were relatively low initially and were projected to decrease steadily as research progressed through 2000. For both CSSX and CST, all high-risk issues were projected to be resolved in the first quarter of 2001, but resolution of CSSX issues would occur in a major step based on resolution of issues related to real waste test performance in March 2001. Although the initial technical uncertainty was low with STTP, the major issue (catalytic decomposition of sodium tetraphenylborate to benzene) was not planned for resolution until completion of simulant and real waste testing

Table 3-1. Evolution of Selection Criteria for Salt Treatment Technology

Criterion From April* Atlanta Meeting	Criterion At End of April Atlanta Meeting	Criterion Beginning June Aiken Meeting	Criterion At End Of June Aiken Meeting	Comment From June Meeting
1. Schedule Risk	1. Schedule Risk	1. Schedule Risk	1. Schedule Risk	
2. Project Reduction Potential	2. Project Reduction Potential	2. Project Reduction Potential	2. Project Reduction Potential	
3. Life cycle costs through D&D	3. Life cycle costs through D&D	3. Life cycle costs through D&D	3. Life cycle costs through D&D	3. Include total project cost, annual operations cost, life cycle cost
4. Total Project Cost and Funding	4. Non-discriminating factor			4. Included in LCC (#3)
5. Technical Maturity	5. Technical Maturity	5. Technical Maturity	5. Technical Maturity	5. Evaluate Process Chemistry under this
6. Potential Contractor Confidentiality Issues	6. Non-discriminating factor			
7. Implementation Confidence	7. Implementation Confidence	7. Implementation Confidence	7. Implementation Confidence	7. Limit to equipment
8. Minimizing Environmental Impacts	8. Minimizing Environmental Impacts	8. Minimizing Environmental Impacts	8. Minimizing Environmental Impacts	8. Add number of saltstone vaults; and secondary waste generation
9. Industry (commercial) Experience in Technology	9. Non-discriminating factor			
10. Cost of modifying interface systems	10. Cost of modifying interface systems	10. Cost of modifying interface systems	10. Impacts of interface to DWPF	10. Analyze impacts to DWPF as risk to canister production
11. Process Simplicity to interfacing systems	11. Process Simplicity to interfacing systems	11. Process Simplicity to interfacing systems	11. Process Simplicity to interfacing systems	
12. Number of saltstone vaults needed	12. Number of saltstone vaults needed	12. Number of saltstone vaults needed		12. Combine with Minimize Environmental Impacts (#8)
13. Levels of safety control mitigation	13. Levels of safety control mitigation	13. Levels of safety control mitigation	13. Levels of safety control mitigation	
14. Maximize process flexibility in throughput	14. Maximize process flexibility in throughput	14. Maximize process flexibility in throughput	14. Maximize process flexibility in throughput	
15. Maximize process simplicity (Operability)	15. Maximize process simplicity (Operability)	15. Maximize process simplicity (Operability)	15. Maximize process simplicity (Operability)	
16. Availability of key components from suppliers	16. Availability of key components from suppliers	16. Availability of key components from suppliers		16. Combine with Implementation confidence (# 7)
17. D&D Closure of New Facilities	17. Non-discriminating factor			
18. Turndown Process Capability	18. Non-discriminating factor			
19. Leveraging Potential for Complex-wide Applicability (tie breaker)	19. Non-discriminating factor			
Maximum Annual Peak Project Cost	20 Non-discriminating factor			

Key

Identified, but not discriminating	
Identified, potentially discriminating, but redundant	
A identified, defined, discriminating criterion	

* All dates are in the Year 2000

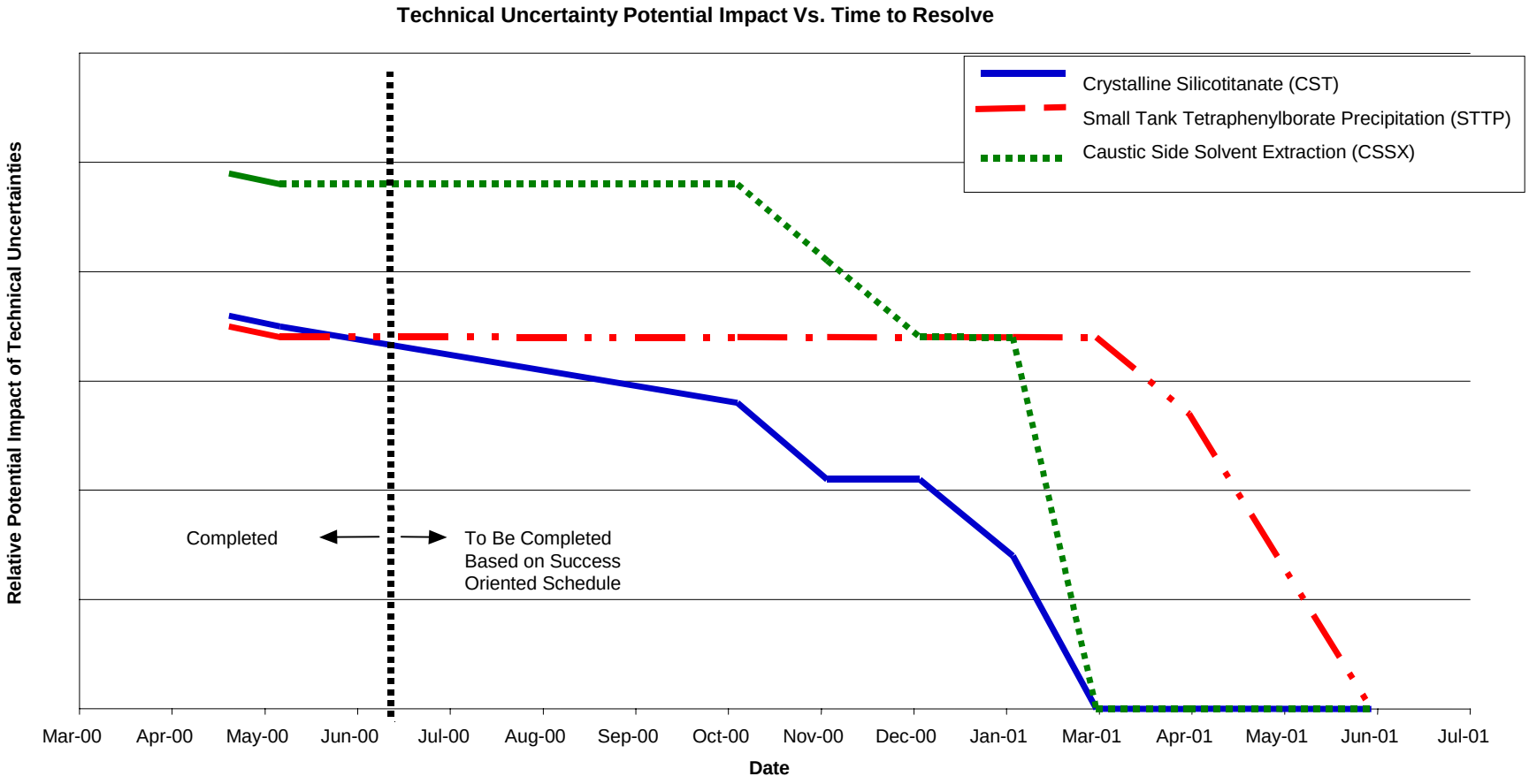
Table 3-2. Down-Selection Criteria and Definition for the Salt Processing Project

Criterion	Definition
1. Schedule Risk	Risk to the overall SRS high-level radioactive waste program schedule due to high risk technology issues not being resolved in time to support down-selection by June 2001. This includes programmatic schedule risks.
2. Project Reduction Potential	Potential that cost savings in the total project cost can be identified (generally due to flowsheet or equipment arrangement changes that would allow facility footprint reductions).
3. Life Cycle Costs Through Decontamination & Decommissioning	Total costs to complete all salt processing (including HLW system costs). The focus on life cycle costs, but the separate components of total project costs and operating costs are examined for key differences.
4. Technical Maturity	The overall maturity of the process flowsheets (including the required strontium and actinide removal steps). EM-50 stages of maturity are applied to each unit operation and the results are averaged.
5. Implementation Confidence	Amount of relevant process experience (large-scale demonstration or deployment) in the DOE complex and industry for the key equipment used for each cesium removal process. This criterion includes commercial availability of key components and chemicals.
6. Environmental Impacts	Comparative assessment of environmental impacts from secondary waste streams, airborne emissions, and liquid effluents. This criterion also includes the number of Saltstone vaults for each process.
7. Impacts of Interfaces at DWPF	Cost of implementing the changes (physical modifications) to the interfacing systems and the loss of canister production caused by outages for equipment installation or transfer-line tie-ins.
8. Process Simplicity of System Interfaces	The simplicity of interfacing the alternative cesium-removal process with other high-level waste systems. The simplicity is measured by the number of process unit operations needed for the interfaces times a difficulty factor for each interface unit operation.
9. Levels of Safety Control Mitigation	Number and type (e.g., passive, active, administrative, preventive, and mitigative) of controls required to maintain the facility in a safe configuration and to protect the worker, public and environment.
10. Process Flexibility in Throughput	Capability to operate the process at a higher or lower throughput (turn-up or turn-down) based on the equipment in the current pre-conceptual design.
11. Process Simplicity (Operability)	Simplicity of the process as indicated by the number of pieces of equipment (in both the non-radioactive areas or the remotely operated area) and the number of jumpers (piping connectors) required inside the remotely operated area.

Table 3-3. Key Technical Uncertainties and Potential Impacts (viability, footprint, or optimization)

Option	Technical Uncertainty	Potential Impact	Original Date	Current Date
Crystalline Silicotitanate (CST)	MST Pu Removal Performance	Optimization	Jun-00	
	MST/Filtration	Footprint	Mar-01	
	Resin Stability (Thermal)	Footprint	Dec-00	Mar-01
	Resin Stability (Chemical)	Footprint	Mar-01	
	Resin Handling and Sampling	Footprint	Feb-01	
	Gas Generation (Radiolytic)	Footprint	Nov-00	Jan-01
Caustic Side Solvent Extraction (CSSX)	MST Pu Removal Performance	Optimization	Jun-00	
	MST/Filtration	Footprint	Mar-01	Apr-01
	Radiolytic Stability	Footprint	Mar-01	
	Chemical Stability	Footprint	Jan-01	Apr-01
	Real Waste Performance	Viability	Mar-01	Apr-01
	Flowsheet Solvent System Proof-of-Concept	Footprint	Dec-00	
Small Tank Tetraphenylborate Precipitation (STTP)	MST Pu Removal Performance	Optimization	Jun-00	
	MST/Filtration	None	Mar-00	
	Reactor/Vessel Foaming	Footprint	Jun-01	Apr-01
	Catalytic Product Decomposition (Simulant)	Footprint	Apr-01	Mar-01
	Catalytic Product Decomposition (Real Waste)	Viability	Jun-01	Apr-01

Figure 3-1. Risk Waterfall Chart



in April through June 2001. Overall, Figure 3-1 shows that if the R&D results were favorable for each candidate technology, all major issues would be resolved prior to technology down-selection in June 2001.

This criterion also considered overall programmatic risk for each technology. The programmatic schedule uncertainty was documented by WSRC in Reference 10 and the schedule risk information is summarized in Appendix A.

3.3.2. CRITERION 2 - PROJECT REDUCTION POTENTIAL

The Team rated the technologies for their potential for reduction in the total SPP project cost. Cost savings were generally identified from flow-sheet or equipment changes that would reduce the pretreatment facility footprint. This evaluation was limited to trade studies that were identified (completed, in progress, or planned) at the time of the evaluation

During quarterly update meetings, the System Leads of each technology alternative identified engineering options that, if feasible, could reduce costs significantly. WSRC took the action to identify any value engineering studies in progress or planned for each process. WSRC identified the value engineering studies summarized below for the SPP technologies and rated the impact of various activities to incorporate into the SPP construction process.

Table 3-4. Description of Actions for Project Cost Reduction

Description of Action	Impact	Plausibility	Comments
Applicable to all three processes			
Move decontaminated salt storage facility outside Building 221-J	Large	High	Because the decontaminated salt solution requires little shielding and the structural requirements will be less stringent, 221-J could have a smaller footprint.
Evaluate number and size of the decontaminated salt storage tanks	Moderate	High	The footprint of 221-J could be reduced if there were more tanks, closely packed.
Studies applicable to alpha sorption (CST and CSSX)			
Co-precipitate strontium and alpha with strontium and magnesium oxide	Large	Moderate	The size of the filtration equipment could be reduced considerably.
Flocculate the monosodium titanate and sludge particles and filter	Moderate	High	The presumed increased filtration rate would somewhat reduce the size of the filtration equipment.

Table 3-4. Description of Actions for Project Cost Reduction (Continued)

Description of Action	Impact	Plausibility	Comments
Studies applicable to alpha sorption (CST and CSSX) (Continued)			
Flocculate, settle solids and decant the clear liquid	Moderate	Moderate	Since particle removal efficiency of > 99% is required to meet alpha limits, this option would likely require a polishing filter between the decanting tank and the feed tank.
Flocculate and centrifuge liquid	Moderate	Moderate	Separate the solids with a centrifuge.
Studies applicable to CSSX			
Reduce the number of extraction stages	Small	Moderate	Cesium may extract efficiently enough to use less than 15 stages.
Reduce the number of strip stages	Small	Moderate	Cesium may strip efficiently enough to use less than 15 stages.
Eliminate the kerosene still	Moderate	High	Potentially avoid increased concentration of extractant and modifier by distilling ISOPAR®.
Eliminate the scrub stages	Small	Moderate	R&D results suggest that this unit operation may be necessary.
Studies applicable to CST			
Use a moving bed column design	Moderate	High	This would reduce the number and length of the ion exchange columns (engineering study underway).
Use a pulsed column (counter-current ion exchange)	Moderate	Moderate	This would reduce the number and length of ion exchange columns (engineering study underway).
Use four (each) 8-foot fixed bed columns rather than three (each) 16 foot columns	Moderate	High	This reduces the height of 222-J (engineering study underway).
Reduce the volume of the guard column	Small	Moderate	This allows two of four columns to be much smaller and stacked.
Studies applicable to STTP			
Move the Fresh Waste Day Tank outside into an underground structure	Moderate	Low	This could reduce the building footprint, but require that some rearrangement be made.
Reduce reactor size	Moderate	High	The two stirred tank reactors could be smaller, especially if the strontium/alpha sorption rates could be increased.
Eliminate the organic evaporator	Moderate	High	The organic waste stream may be sufficiently decontaminated by one stage of distillation and a water strip.

The Team established a relationship that used the product of the value of the action (large, medium or small impact) and its plausibility (probability of occurrence: high, medium or low) to score the alternatives on this criterion. Table 3-5 summarizes the point value assigned for each class of impact and probability.

Table 3-5. Point Values for Reducing Project Cost

Characteristics of the Action	**Point Value**
Impact of the Action	
Large Impact	100
Medium Impact	10
Small Impact	1
Plausibility of the Action	
High Probability	0.75
Moderate Probability	0.25
Low Probability	0.10

Table 3-6 summarizes the types of project reduction actions possible for each of the technologies and the value of each action. It also shows the total point value for each of the alternatives. The Team converted these point values to utility scores using the relationship defined in Section 3.4 (Table 3-15).

Table 3-6. Reduction Actions Point Value Summary

Impact and Probability of Action	**Point Value of Action**	**Number for CST**	**Number for CSSX**	**Number for STTP**
Large, High	75			
Large, Moderate	25	1	1	
Medium, High	7.5	2	2	2
Medium, Moderate	2.5		1	
Medium, Low	1.0			1
Small, High	0.75			
Small, Moderate	0.25		3	
Small, Low	0.1			
Total Value* from Scores		**40**	**43.25**	**16**

*Number of actions multiplied by point value.

3.3.3. CRITERION 3 – LIFE-CYCLE COSTS THROUGH DECONTAMINATION AND DECOMMISSIONING

The Team also considered total costs to complete all salt processing activities (including associated HLW system costs). They focused on life-cycle costs, but separate components of total project cost and operating cost were evaluated for key factors. Life-cycle cost estimates for the three alternatives are shown in Table 3-7. These cost estimates were updated in May 2001 to support the final down selection (see Appendix A).

Table 3-7. Preliminary Life Cycle and Project Costs

Costs	**CST**	**CSSX**	**STTP**
Total Project Cost	$1.35 B	$1.60 B	$1.30 B
Operating Cost	$1.11 B	$1.49 B	$1.38 B
Life Cycle Cost	$2.46 B	$3.14 B	$2.68 B

3.3.4. CRITERION 4 - TECHNICAL MATURITY

The Team considered this criterion to be the overall technical maturity of the process flow sheets (including the required strontium and actinide removal steps). Technical maturity required an analysis more extensive than that for Criteria 1 through 3. A technology gap in any of the unit operations could impact the site's ability to implement the technology. Accordingly, the SPP Team evaluated each unit operation for each technology alternative. The Office of Science and Technology (EM-50) stages of technology development formed the basis for scoring technology maturity. Table 3-8 shows the DOE EM-50 stages of technology maturity and the scoring scale that the Team used to assign a maturity score to each of the unit operations.

After performing detailed analyses for each unit operation, the ratings were averaged for all unit operations in each "subprocess". Finally, the Team averaged the scores for all "subprocesses" that made up the flowsheet for a given technology alternative. This process was very careful to exclude factors related to interface of the operation with the DWPF (scored under Criterion 7).

3.3.5. CRITERION 5 - IMPLEMENTATION CONFIDENCE

The SPP Team identified "confidence in implementation" of a technology alternative as another important criterion in selection. Confidence was evaluated as the amount of relevant process experience (large-scale demonstration or deployment) in the DOE complex and industry for the key equipment used for each cesium-removal process. The Team used two

Table 3-8. DOE EM-50 Stages of Development

Score	Stage	Title	Activities
1	1	Basic Research	Fundamental scientific research, build knowledge, develop theories and analytical models, laboratory experiments, proof of principle
	2	Applied Research	Laboratory experiments, linked or needs, define materials requirements and design concepts, define cost requirements
2	3	Exploratory Development	Show technical feasibility, laboratory-scale prototyping, estimate costs, identify functional performance requirements
3	4	Advanced Development	Proof of design, full-scale laboratory tests, preliminary field test, develop technical specifications, hot cell tests with real waste
4	5	Engineering Development	Full-scale design, prototype and pilot-scale test, reliability testing
5	6	Demonstration	Full-scale operations with actual waste, prove economic viability
	7	Deployment	Proven technology, in-service treating actual waste cost-effectively

components for this criterion: confidence in the baseline equipment process and availability of key chemicals used in the process. Table 3-9 summarizes the basis for scoring the confidence in the baseline equipment.

Table 3-9. Implementation Confidence Scale

Score	Large-Scale Demonstration or Deployment in:
1	None of the below
2	Chemical industry
3	Foreign commercial reprocessing or waste treatment
4	SRS or other DOE reprocessing or waste treatment at different scale or waste disposition
5	Other DOE reprocessing or waste treatment at similar scale or waste composition
5	SRS reprocessing or waste treatment at similar scale or waste composition

Table 3-10 summarizes the information provided by the Team about the implementation confidence of the equipment in each technology alternative.

Table 3-10. Implementation Confidence in the Equipment

Process	Objective Evidence
CST	SRS, Hanford, West Valley Demonstration Project, and ORNL experience with non-elutable ion exchange; ORNL columns smaller than SPP pre-conceptual design
CSSX	SRS 221-F Canyon, 25-cm centrifugal contactors in first-cycle Purex waste
STTP	SRS small-scale two-stage precipitation in plutonium facilities (plutonium trifluoride and plutonium oxalate)

3.3.6. CRITERION 6 - ENVIRONMENTAL IMPACTS

Environmental impacts from operation of the selected process will be reflected in emissions (radioactive and chemical), secondary waste, liquid effluents, and quantity of saltstone generated. The emissions analysis included both building stack emissions and chemical emissions from the cold chemical feeds.

Discussions among the TWG and SPP Team indicated that the generation of 73,000 gallons of benzene per year was the greatest potential impact from any of the technologies. Participants also lowered the CSSX score because a larger volume of secondary waste was identified than previously believed. The CST process does not have significant releases of benzene or organic secondary waste.

3.3.7. CRITERION 7 - IMPACTS OF INTERFACES AT DWPF

As indicated in Section 3.3.5, Criterion 5, the TWG perceived impacts from technology interfaces on the DWPF as an issue of enough significance to qualify as a separate criterion. The Team evaluated these impacts in terms of the cost to implement the changes (physical modifications) to the interfacing systems and the loss of canister production caused by outages for equipment installation or transfer tie-ins. The TWG and SPP Team found the length of time (in the life-cycle project schedule) needed to tie the new pretreatment process to DWPF as a significant discriminator. Table 3-11 summarizes the impact of the interface issues to DWPF production.

Table 3-11. Example of Impact in Interfaces to DWPF

Process	**Reduced DWPF Production, Canisters**	**Cost in Millions**
CST	50-100	$36
CSSX	33	$36
STTP	4	$11

Table 3-11 shows STTP to have minimal impact, CSSX greater impact, and CST a larger impact to DWPF canister production.

3.3.8. CRITERION 8 - PROCESS SIMPLICITY OF SYSTEM INTERFACES

The Team also evaluated the simplicity for each of the processes to interface with the HLW systems. They measured simplicity by the number of process unit operations needed for the interface multiplied by the difficulty factor for each interface operation.

As in "Technical Maturity" addressed above, this criterion required analysis at the unit operation level to produce a score. The scoring protocol included the following steps:

1. Identify the steps that represent added process complexity,
2. Tally the number of parameters applicable to each interface unit operation,
3. Total the difficulty factor for all unique interface unit operations, and
4. Compare the total for each flowsheet and convert to a 1 to 5 score.

The parameters used as indicators of process complexity were as follows:

- Requires significant modifications at DWPF or Saltstone Processing Facility,
- Involves processing/handling of a multiphase stream,
- Represents a new product transfer line not in the previous ITP baseline, and
- Adds a previously undemonstrated unit operation.

3.3.9. CRITERION 9 - LEVELS OF SAFETY CONTROL MITIGATION

Safety of operations is the foremost concern for DOE. Accordingly, the TWG and SPP Team established a criterion for safety of operations. The Team evaluated safety control mitigation by the number and type (e.g., passive, active, administrative, preventative, and mitigative) of controls required to maintain the facility in a safe configuration, and to protect the workers, public, and the environment. Safety of operation of facilities designed from the technology alternatives was evaluated for both safety class and safety significant issues.

WSRC evaluated all safety controls (Structures, Systems, and Components [SSCs] or Administrative Controls) that perform Safety Class (SC) or Safety Significant (SS) functions.[11]

SC controls address functions for which the consequence of uncontrolled operation could expose the public to hazardous material. Technically, the classification of SC is applied to SSCs required to ensure that any credible event should not exceed the Offsite Evaluation Guidelines to an individual member of the public. The report[11] details the protocols and assumptions used in these determinations.

SS controls address potential hazards that pose a risk of significant harm to workers regardless of their location. The analysis identified these hazards and the safety functions needed to protect the workers from them (including SS Controls and/or Administrative Controls). The list of SSCs did not consider standard industrial hazards for which national consensus codes and standards exist to guide safe design and operation. The listing of SS Controls did encompass equipment required to monitor, detect, or prevent a nuclear criticality accident.

Together, these controls function to maintain the facility within a safe configuration and to protect the worker and the environment. Table 3-12 details the safety controls inherent with implementing each of the alternatives.

The TWG and SPP Team also noted whether a given safety control was administrative or integral to the implementation of the alternative. Administrative controls were considered to be of greater detriment to a technology than others are because they relied on organizations, personnel, and procedures to implement them. A potential discriminator would be the recovery of off-normal conditions identified late in the R&D process. This factor and the data required to support its evaluation were considered in the final technology scoring.

Table 3-12. Safety Controls

A **Technology Identification**	**B** **SC Control Scoring Number**		**C** **SS Control Scoring Number**		**D** **Total Scoring Number***	
	Number	**Average**	**Number**	**Average**	**Number**	**Average**
STTP	18 (4)	3.500	20 (10)	3.48	38 (14)	6.98
CST	16 (4)	3.65	19 (10)	3.463	35 (14)	7.09
CSSX	16 (4)	3.613	19 (10)	3.463	35 (14)	7.08

*Sum of Columns B and C.

3.3.10. CRITERION 10 - PROCESS FLEXIBILITY IN THROUGHPUT

Implementation of the alternative selected for SPP will introduce uncertainties in the HLW treatment system. Unforeseen events can also affect this complex waste treatment system, so a capability to increase and decrease process throughput rate is desirable. The potential to increase throughput (also referred to as sprinting) was evaluated as the most important characteristic of each technology because the SPP will provide the pretreated waste to feed DWPF. The TWG and SPP Team evaluated the process flexibility potential for each of the technologies. Flexibility is defined as the capability to operate the process at a higher or lower throughput based on the equipment in the current pre-conceptual designs. Table 3-13 summarizes the initial flexibility analysis of each process to increase throughput.

Table 3-13. Summary of Technology Flexibility

Process	**Potential Throughput Increase (%)**
CST	50*
CSSX	40
STTP	20*

*Denotes potential glass requalification.

CST and CSSX both had significant potential to increase throughput, although the CST and STTP increase would potentially require glass requalification.

3.3.11. CRITERION 11 - PROCESS SIMPLICITY (OPERABILITY)

A desirable characteristic of the preferred technology alternative would be simplicity of both the equipment and operations. The TWG and the SPP Team evaluated the simplicity of each process' equipment in the shielded cell and in the cold feed/operating corridor. Jumpers were also considered as a separate category that indicated level of complexity in the remotely operated area. Table 3-14 summarizes the factors considered in evaluating process simplicity.

The scoring was based on the equipment count data as provided by WSRC at each quarterly scoring meeting. The ranking of the technologies in terms of "simplest" to "most complex" was CST, STTP, and CSSX, respectively.

Table 3-14. Summary of Process Simplicity (Example from August 2000)

	Equipment Count		
Process	**CST**	**CSSX**	**STTP**
Tanks and Equipment			
Shielded Cell	36	46*	49
Cold Feed/ Operating Corridor	12	31	19
Pumps			
Shielded Cell	35	33	33
Cold Feed/ Operating Corridor	14	43	17
Sample Pumps			
Shielded Cell	11	13	12
Cold Feed/ Operating Corridor	1	9	0
Agitators			
Shielded Cell	8	14	18
Cold Feed/ Operating Corridor	6	16	1
Jumpers			
Jumpers	238	295	263

*Centrifugal contactors are counted as six separate pieces of equipment.

3.4. RESULTS OF THE CRITERIA EVALUATION

The SPP Team proceeded in the technology evaluation stepwise process described in Section 2.4. At each quarterly progress meeting, they tested the data collected to assure its utility for scoring the technology alternatives. These trial scorings also allowed the Team to assess whether the progress of data acquisition was adequate to support technology selection, to establish protocol to normalize the data to utility scores, and to assess the sensitivity of weighting and other factors.

Table 3-15 shows the normalization protocol used to convert data (described in Section 3.3.1) to utility scores. For each of the criteria, the table defines the data needed to convert the “critical measures” for each criterion to a utility score. The table defines whether the relationship between the measures and the score are linear or non linear, what critical measure defines the top and bottom of the (1-5) utility range, and what magnitude of change constitutes a change of one point in utility score. Scoring results were shown in “consumer reports” charts. Figure 3-2 is an example of this chart for a hypothetical scoring case. This chart shows, as a color-coded circle, the merit of each criterion for each alternative.

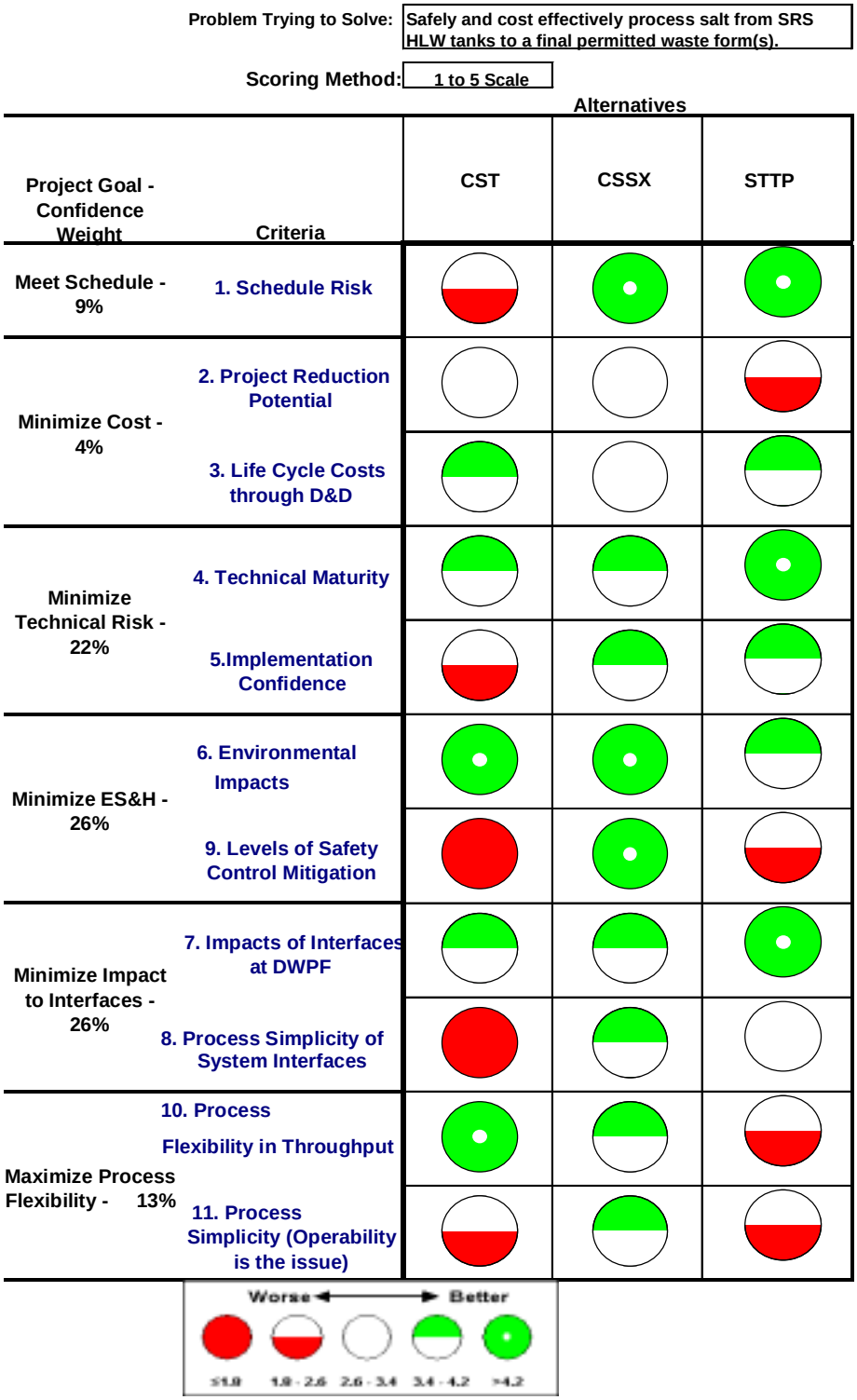
To examine the effects of weighting, the Team prepared a chart for each criterion that showed the overall score for each of the technologies as a function of relative weight. Figure 3-3 is a trial weighting sensitivity chart for Criterion 10, "Process Flexibility." If all criteria were equal, each would be weighted 0.091; and the Team generally weighted Criterion 10 somewhat less (0.025 to 0.08). Most significantly, the chart shows that as the relative weight of Criterion 10 increases (and the other criteria decrease proportionally), the score of CST increases and CSSX decreases, and that there is a crossover point. If the weighting is greater than 42%, CST scores higher than CSSX. Similar weighting analyses were conducted for all criteria and they indicated that the weighting would have to be changed by at least 0.15 to affect selection.

Combined, these analyses show that the technology selection is most sensitive to scoring and somewhat less sensitive to weighting. Finally, another sensitivity analysis indicated that the scoring would be affected by rounding. The TWG opted to carry two significant figures in the final scoring because it was supported by the quantitative data used and avoided potential problems due to rounding.

Table 3-15. Protocol for Normalizing Data

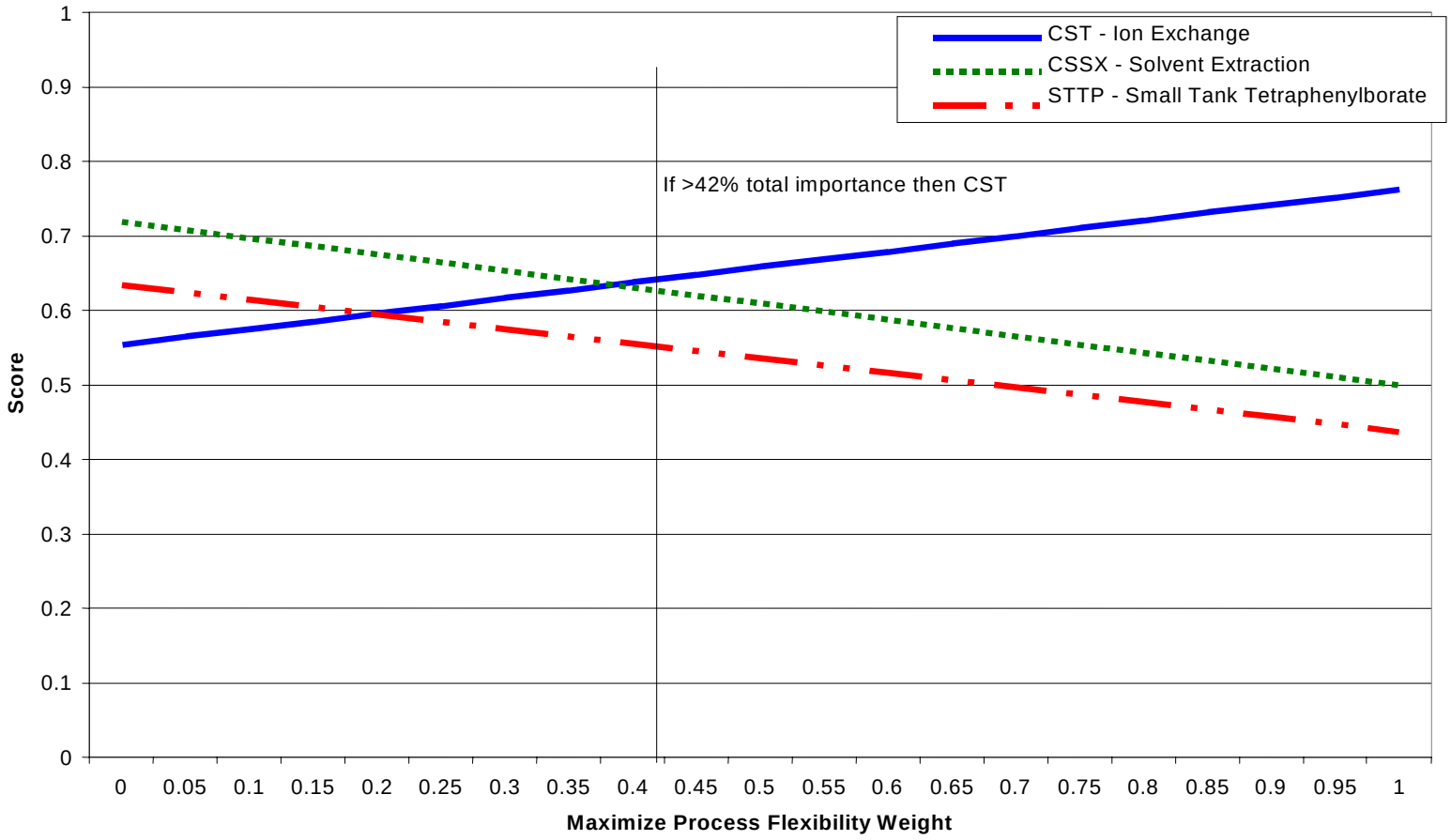
Criteria Name	Point Worth	Linear/ Non-Linear	Score Explanation 5 would be	1 would be
1. Schedule Risk	2 mo. per point	Linear	Early by two mo.	Probably late by 8 mo.
2. Project Reduction Potential	10 VE Savings points per point	Linear	Highest (43 now)	0-3 value points
3. Life Cycle Costs Through D&D	TPC - $200 M per point	Linear	$1000 K	$1800 K
	LCC - $500 M per point	Linear	$2000 K	$4000 K
4. Technical Maturity	MST or Cs Seps. Ops - 1 average stage from maturity chart per point	Linear	5 fully mature	1 concept
5. Implementation of Confidence	Equipment Maturity - 1 average stage from maturity chart per point	Linear	5 fully mature	1 concept
6. Environmental Impacts	Benzene release – point for some, scale from some to permit limit	Non-linear	No release	Permit level release
	Saltstone Vaults – point per extra vault	Linear	12 vaults	16 vaults
	Secondary Waste (gal.) – some vs. lot is bottom of scale	Non-linear	No organic to treat/ dispose	73 K gallons
9. Levels of Safety Control Mitigation	10 safety controls per point	Linear	20 safety controls	60 safety controls
7. Impacts of Interfaces at DWPF	25 lost canisters per point (1 mo. downtime)	Linear	0 Lost	100 lost or 4 mo.
	Extent of Upgrades - 25 M represents 1 point of complexity	Linear	0 upgrades	100 M upgrades
8. Process Simplicity of System Interfaces	2 complexities per point	Linear	0 complexities	8 complexities
10. Process Flexibility in Throughput	Turn Up or Down - 25% turn up capability per point	Linear	100% turn up	0% turn up
11. Process Simplicity (Operability)	50 jumpers per point	Linear	200 jumpers	400 jumpers

Figure 3-2. Example of Consumer Report Technology Scoring Summary Chart



- Green designates a good score
- Red designates a poor score
- Scoring key is located at the bottom.

Figure 3-3. Process Flexibility Sensitivity Analysis



4.0. CONCLUSIONS AND RECOMMENDATION

On May 21-23, 2001, the Team met to score the alternatives using the criteria and scoring protocol summarized. TFA System Leads reviewed the final results documented in the SPP R&D Summary Report.[12] Also, WSRC provided engineering data packages to support scoring of several criteria. The TWG requested that TFA and TAT independently score the alternatives based on their discussion of the R&D results and the data packages in the briefing books. The TWG observed these discussions and were provided the results of the TFA and TAT scores. TFA and TAT also submitted a brief written summary of the rationale or basis for their assigned scores. Also, on May 22, 2001, the TWG reviewed the R&D results, the data packages, and the TFA and TAT scores and made their final scoring for input to down selection. Based on this analysis the TWG recommended CSSX as the preferred technology for the SPP. Appendix A presents the data used in the final scoring. The final scoring results are shown in Appendix B and the supporting sensitivity analyses and weighting analyses are presented in Appendix C.

5.0 REFERENCES AND BIBLOGRAPHY

1. *Savannah River Site High Level Waste Salt Disposition Systems Engineering Team, Final Report: Recommendation Pre-Conceptual Design*, WSRC-RP-98-00170, Revision 0, October 29, 1998, Westinghouse Savannah River Company, Aiken, SC.

2. Interim Report, Milt Levenson to Ernest J. Moniz, *Alternatives for High-Level Waste Salt Processing at the Savannah River Site*, National Research Council Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site, October 14, 1999.

3. *Alternatives for High-Level Waste Salt Processing at the Savannah River Site*, National Research Council, Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site, August 2000.

4. *Supplemental Environmental Impact Statement Defense Waste Processing Facility*, DOE/EIS-0082-S, November 1994, U.S. Department of Energy.

5. Interim Report, *Evaluation of Criteria for Selecting a Salt Processing Alternative for High-Level Waste at the Savannah River Site*, National Research Council, Committee on Radionuclide Separation Processes for High Level Waste at the Savannah River Site, March 2001.

6. *Savannah River Site Salt Processing Project Research and Development Program Plan*, PNNL-13253, Revision 0, May 2000, Pacific Northwest National Laboratory, Richland, WA.

7. "Action Plan – Savannah River Site Salt Processing Project Roles and Responsibilities", April 2000, Revision 1, Excerpt from PNNL-13348, *TFA Management Plan for Savannah River Site Salt Processing Project Research and Development*, Appendix A-1, Salt Processing Project Website (http://www.srs.gov/general/srtech/spp/progplan.htm).

8. *Savannah River Site Salt Processing Project Research and Development Program Plan*, PNNL-13253, Revision 1, November 2000, Pacific Northwest National Laboratory, Richland, WA.

9. Baker, Hunter, Krupa, Murphy, et. al, *A Guidebook for Decision Analysis Methods Developed for the Department of Energy INMM Program*, March 2001, U.S. Department of Energy.

10. *Salt Waste Processing Program Risk Analysis Report (U)*, HLW-SDT-2001-00180, Revision C, June 1, 2001, Westinghouse Savannah River Company, Aiken, SC.

11. *Safety Controls and Scoring for Three Technology Options for Salt Waste Processing Facility (U)*, WSRC-TR-2000-00251, Revision 0, July 2000, Westinghouse Savannah River Company, Aiken, SC.

12. *Savannah River Site Salt Processing Project Research and Development Summary Report*, TFA-0105, Revision 0, May 2001, Pacific Northwest National Laboratory, Richland, WA.

Appendix A

SOURCE DATA USED FOR SCORING THE ELEVEN CRITERIA FOR SELECTION OF A SALT PROCESSING TECHNOLOGY

Appendix A

SOURCE DATA USED FOR SCORING THE ELEVEN CRITERIA FOR SELECTION OF A SALT PROCESSING TECHNOLOGY

This appendix documents source data as they were received from the additional data request from Westinghouse Savannah River Company, previous data requests, and other background material, which were provided in the briefing notebooks for the Salt Processing Project technology down selection Technical Working Group and Management Review Board meetings held on May 21-24, 2001. Each criterion has been listed as a separate attachment to the appendix as follows:

- Attachment A.1 – Criterion 1, Schedule Risk
- Attachment A.2 – Criterion 2, Project Reduction Potential
- Attachment A.3 – Criterion 3, Life Cycle Costs Through Decontamination and Decommissioning
- Attachment A.4 – Criterion 4, Technical Maturity
- Attachment A.5 – Criterion 5, Implementation Confidence
- Attachment A.6 – Criterion 6, Environmental Impacts
- Attachment A.7 – Criterion 7, Impacts of Interfaces at DWPF
- Attachment A.8 – Criterion 8, Process Simplicity of System Interfaces
- Attachment A.9 – Criterion 9, Levels of Safety Control Mitigation
- Attachment A.10 – Criterion 10, Process Flexibility in Throughput
- Attachment A.11 – Criterion 11, Process Simplicity (Operability)

ATTACHMENT A-1

CRITERION 1

SCHEDULE RISK

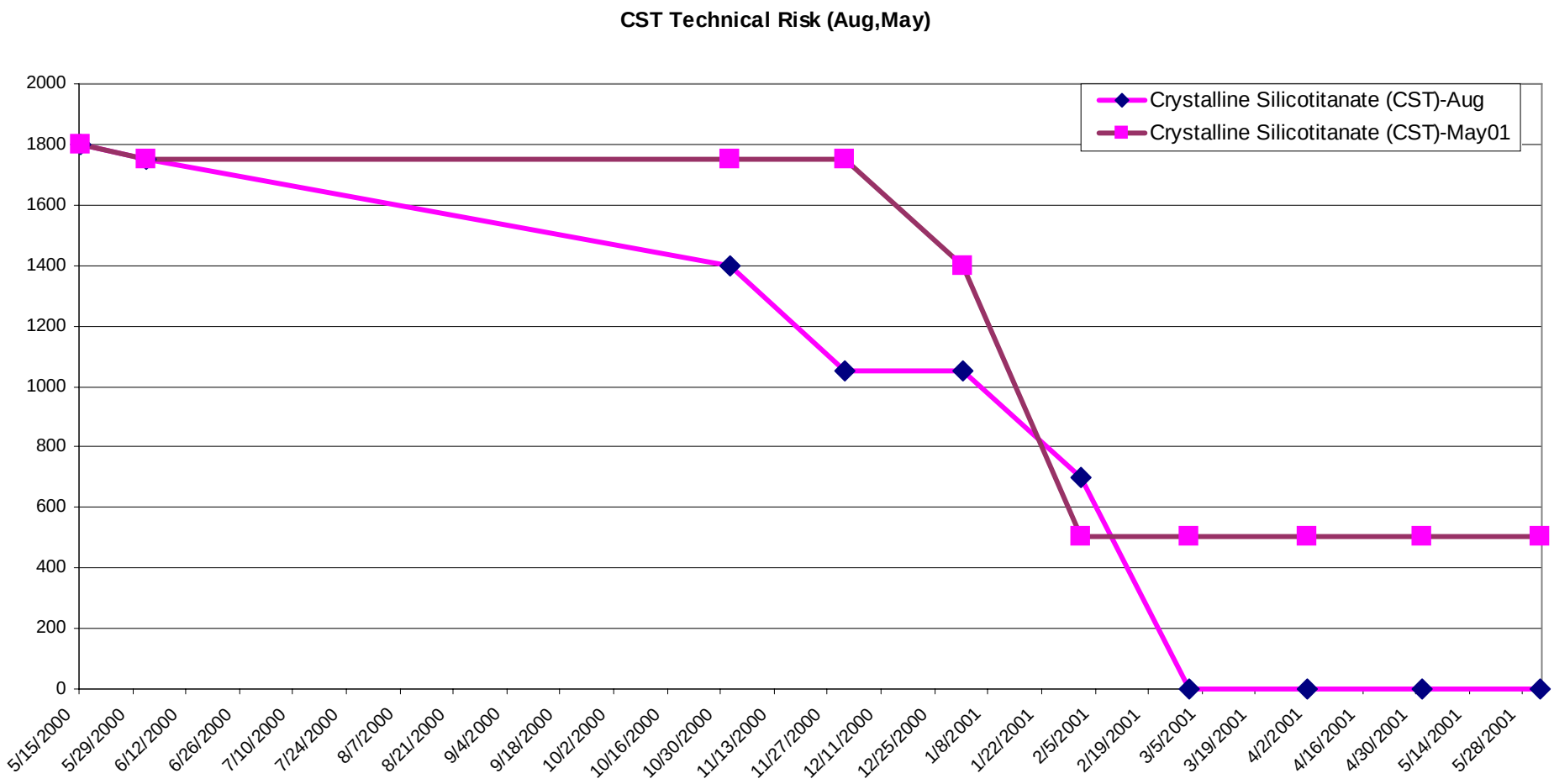
Risk to the overall project schedule: high-risk technology issues not being resolved in time to support down-selection and programmatic schedule risks.

DATE OF LATEST INPUT: 18 MAY 01

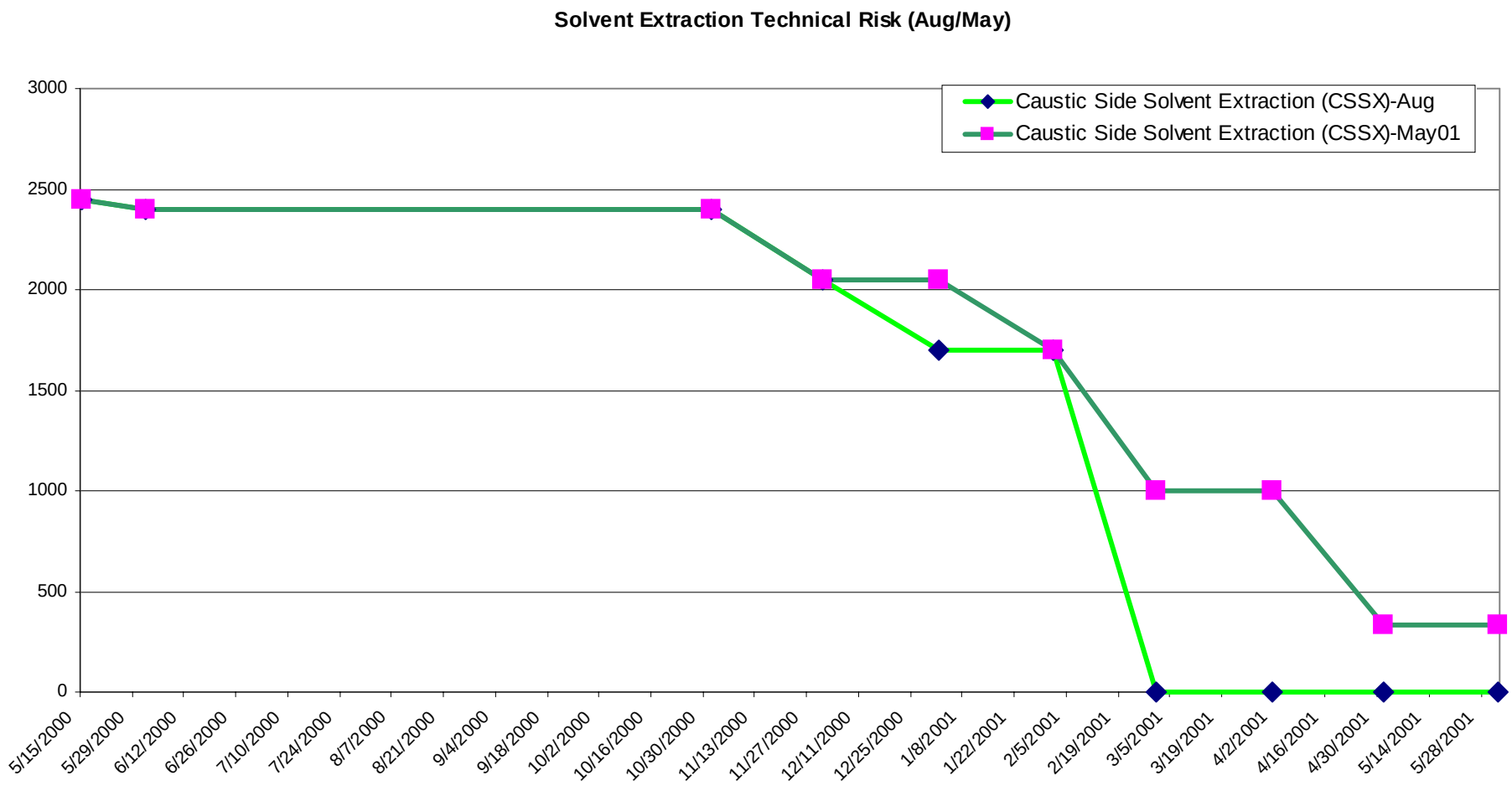
Current Assessment of Risks for Alternative Cesium Removal Process (May 2001)

Cs Removal Process	Technical Risk	Probability	Consequence (Potential Impact)	Risk
CST	MST Pu Removal Performance	Moderate	Low (Optimization)	Low
	MST/Filtration	Moderate	Moderate (Footprint)	Moderate
	Sorbent Stability	High	Moderate (Footprint)	High
	Sorbent Handling and Sampling	Low	Moderate (Footprint)	Low
	Gas Generation	Low	Moderate (Footprint)	Low
CSSX	MST Pu Removal Performance	Moderate	Low (Optimization)	Low
	MST/Filtration	Moderate	Moderate (Footprint)	Moderate
	Flowsheet Solvent System Proof-of-Concept	Low	Moderate (Footprint)	Low
	Radiolytic Stability	Low	Moderate (Footprint)	Low
	Chemical and Thermal Stability	Low	Moderate (Footprint)	Low
	Real Waste Performance	Moderate	Moderate (Footprint)	Moderate
STTP	MST Pu Removal Performance	Moderate	Low (Optimization)	Low
	MST/Filtration	Low	Low (Optimization)	Low
	Reactor/Vessel Foaming	Low	Moderate (Footprint)	Low
	Catalytic Product Decomposition	Moderate	Moderate (Footprint)	Moderate

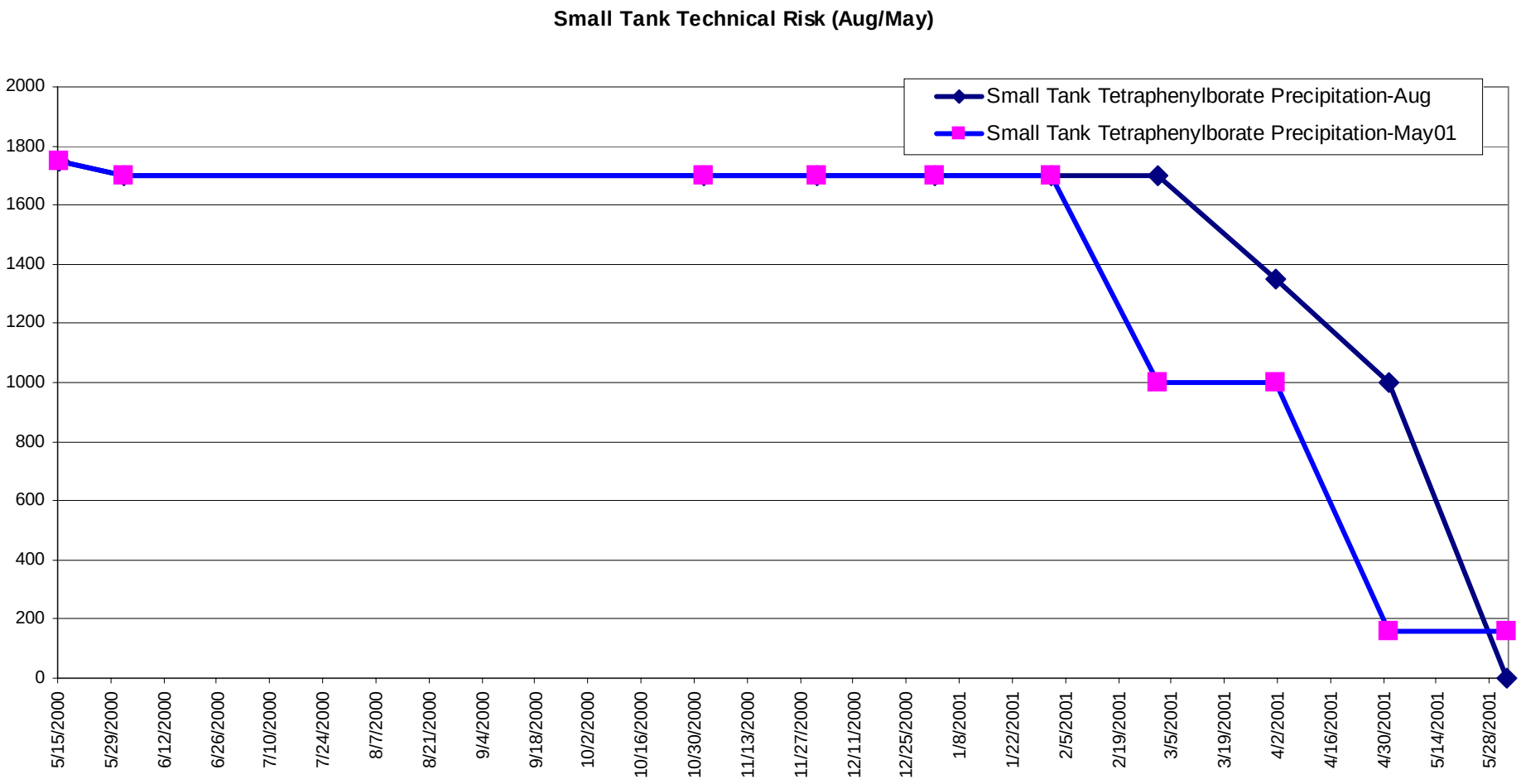
CST Comparison



CSSX Comparison



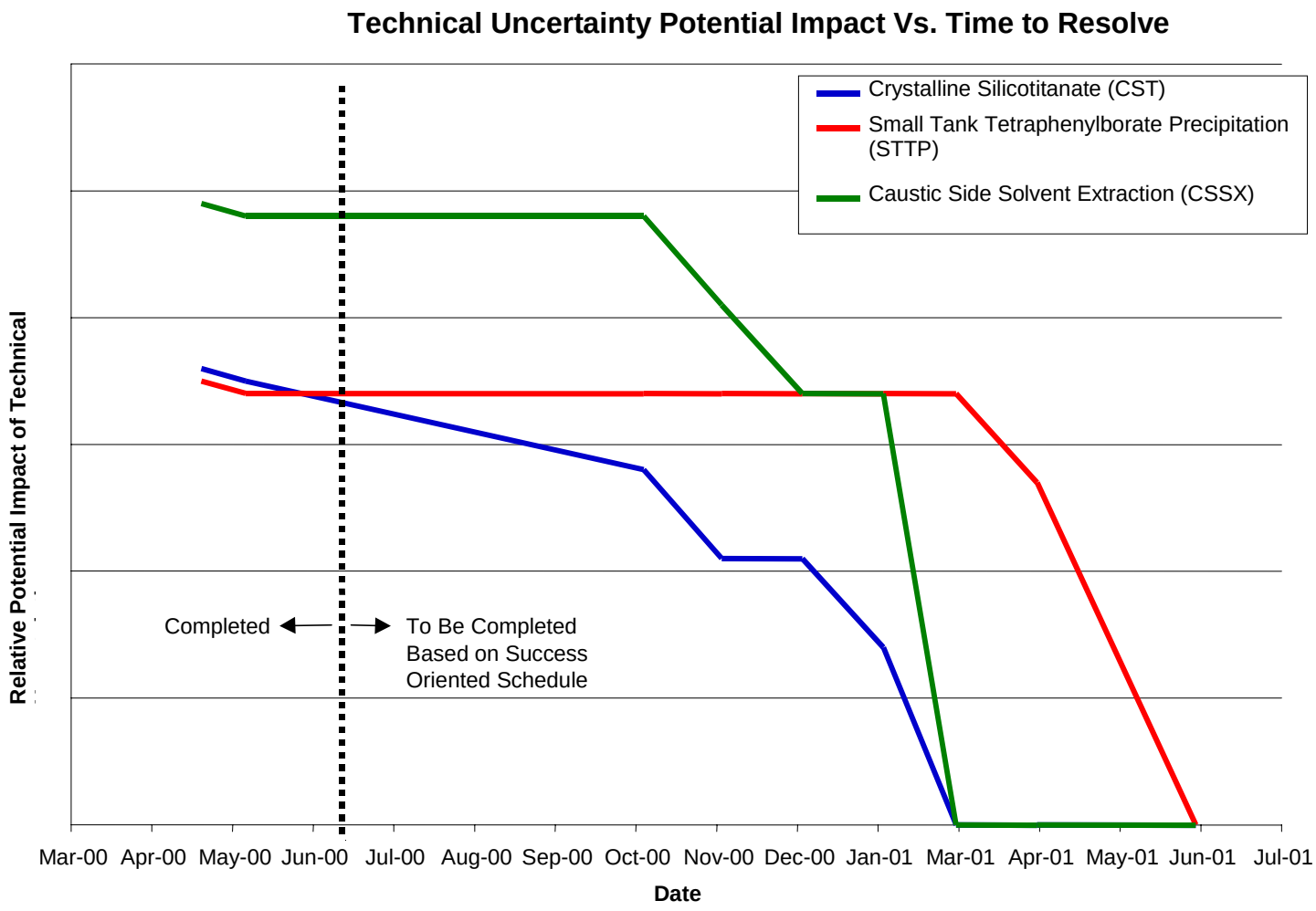
STTP Comparison



Identified Key Technical Uncertainties and Identified Potential Impacts (August 2000)

Option	Technical Uncertainty	Potential Impact	Date Resolved
Crystalline Silicotitanate	MST Pu Removal Performance	optimization	Jun-00
Crystalline Silicotitanate	MST/Filtration	footprint	Mar-01
Crystalline Silicotitanate	Resin Stability (thermal)	footprint	Dec-00
Crystalline Silicotitanate	Resin Stability (chemical)	footprint	Mar-01
Crystalline Silicotitanate	Resin Handling and Sampling	footprint	Feb-01
Crystalline Silicotitanate	Gas Generation (Radiolytic)	footprint	Nov-00
Caustic Side Solvent Extraction	MST Pu Removal Performance	optimization	Jun-00
Caustic Side Solvent Extraction	MST/Filtration	footprint	Mar-01
Caustic Side Solvent Extraction	Radiolytic Stability	footprint	Mar-01
Caustic Side Solvent Extraction	Chemical Stability	footprint	Jan-01
Caustic Side Solvent Extraction	Real Waste Performance	viability	Mar-01
Caustic Side Solvent Extraction	Flowsheet Solvent System Proof-of-Concept	footprint	Dec-00
Small Tank Tetraphenylborate Precipitation	MST Pu Removal Performance	optimization	Jun-00
Small Tank Tetraphenylborate Precipitation	MST/Filtration	none	Mar-01
Small Tank Tetraphenylborate Precipitation	Reactor/Vessel Foaming	footprint	Jun-01
Small Tank Tetraphenylborate Precipitation	Catalytic Product Decomposition (Simulant)	footprint	Apr-01
Small Tank Tetraphenylborate Precipitation	Catalytic Product Decomposition (Real Waste)	viability	Jun-01

Used Technology Roadmap for Resolution Dates Creates a Risk Waterfall Chart (August 2000)



Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Anderson 5/15/01, HLW-2001-00073

Criterion: 1. Schedule Risk

Action Criteria Description: WSRC is requested to summarize the programmatic schedule risks that will be documented in the Technical and Programmatic Risk Assessment Report.

Salt Processing Project Risk Analysis
Schedule Uncertainty

CST IX

BASELINE SCHEDULE	**C**	**P**	**F**	**Cx**	**T**	**O**
MONTHS	**8**	**9**	**20**	**51**	**13**	**165**

UNCERTAINTY SCHEDULE MONTHS	**C**	**P**	**F**	**Cx**	**T**	**O**
2. Alpha Removal						(9)
40. Spent Resin Transport						(6)
42. Resin Bed Temperature Controls						18
44. Jumper Movement for Column Operation						(3)
46. Feed (Roque) Impurities			(4)	(4)		(6)
47. Ti Glass Limits				(6)		(6)
48. CST Resin Supply						
49. DWPF Sample Station Modification						(6)
50. DOE Independent Project Review		(2)	(4)			
51. Change in Requirements & Standards			9	9		
52. Facility Tie-in				(2)		
54. Old Infrastructure						9
57. Contracting Delays Conceptual Design	4					
58. R&D Impacts Design Completion		6	(6)	(6)		
62. Foaming in DWPF Chem Cell						(3)
66. CST/Impact/DWPF						(6)
67. Gas Generation			3	3		
68. Resuspend MST			(6)			
69. Solids Deposition						
NET IMPACT	4	6	12	12		27

LEGEND
C=Conceptual Phase
P=Preliminary Phase
F=Final Phase
Cx=Construction Phase
T=Startup Phase
O=Radioactive Phase
(#) – Con Current Resolution

Project Phase 34
Life Cycle 27
Total "Most like" Schedule Impact = 61 Months

Salt Processing Project Risk Analysis
Schedule Uncertainty

CSSX

BASELINE SCHEDULE	**C**	**P**	**F**	**Cx**	**T**	**O**
MONTHS	**9**	**10**	**22**	**49**	**14**	**165**

UNCERTAINTY SCHEDULE MONTHS	**C**	**P**	**F**	**Cx**	**T**	**O**
3. Alpha Removal						(9)
70. Decomposition Products			(1)			(6)
71. Ti Glass Limits				(6)		
72. Crud/3rd Phase Formation						6
73. Feed (Rogue) Impurities			(4)	(4)		(6)
75. Extractant and Modifier Supply				(6)		(3)
77. DOE Independent Project Review		(2)	(4)			
78. Changing Requirements & Standards			9	9		
82. Old Infrastructure						9
83. Contracting Delays Conceptual Design	4					
84. R&D Impacts Design Completion		3	(6)	(6)		
90. Facility Tie-Ins				(2)		
93. MST Resuspension			(6)			
104. Waste Feed Stability						(3)
114. Decomposition Path for Organic Waste				(6)		
NET IMPACT	4	3	9	9		15

LEGEND
C=Conceptual Phase
P=Preliminary Phase
F=Final Phase
Cx=Construction Phase
T=Startup Phase
O=Radioactive Phase
(#) – Con Current Resolution

Project Phase 25.0
Life Cycle 15.0
Total "Most Likely" Schedule Impact = 40 Months

Salt Processing Project Risk Analysis
Schedule Uncertainty

SMALL TANK TPB PRECIPITATION

BASELINE SCHEDULE	**C**	**P**	**F**	**Cx**	**T**	**O**
MONTHS	**6**	**9**	**18**	**46**	**13**	**165**

UNCERTAINTY SCHEDULE MONTHS	**C**	**P**	**F**	**Cx**	**T**	**O**
13. Feed (Rogue) Impurities			(4)	(4)		(6)
16. Ti Glass Limits			(6)			
22. Fresh Precipitate Fed to Precipitate Hydrolysis						(6)
25. Stakeholder Input			(9)			
27. Organics in Recycle Stream			(1)			(6)
28. DOE Independent Project Review		(2)	(4)			
29. Changing Requirements & Standards			9	9		
30. Facility Tie-Ins				(2)		
34. Old Infrastructure						9
35. Contracting Delays Conceptual Design	4					
36. R&D Impacts Design Completion		3	(6)	(6)		
111. Decomposition Products			(1)			(6)
112. Foaming in Process Equip.						(2)
113. Decomposition Path for Organic Waste				(6)		
NET IMPACT	4	3	9	9		9

LEGEND
C=Conceptual Phase
P=Preliminary Phase
F=Final Phase
Cx=Construction Phase
T=Startup Phase
O=Radioactive Phase
(#) – Con Current Resolution

Project Phase 25
Life Cycle 9
Total "Most Likely" Schedule Impact = 34 Months

ATTACHMENT A-2

CRITERION 2

PROJECT REDUCTION POTENTIAL

Potential that cost savings in the total project cost can be identified (generally due to flowsheet or equipment arrangement changes that would allow facility footprint reductions).

DATE OF LATEST INPUT: 18 JAN 01

**Request for Revised Data Packages to Support
Salt Processing Project Down Selection,
Piccolo/Anderson dated 5/15/01, HLW-2001-00073**

Criterion: 2. Project Reduction Potential

Action Criteria Description: List any additional value engineering studies in progress or planned for each process.

Responsibility: WSRC

No change in previous information.

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Allison dated 1/18/01, HLW-2001-00012

Criterion: 2. Project Reduction Potential

Action Criteria Description: List any value engineering studies in progress or planned for each process.

Responsibility: WSRC

Studies applicable to all three processes:

- *Moving the decontaminated salt solution storage outside the 221-J Building*. Impact – Large, Plausibility – High. Since the decontaminated salt solution requires little shielding and the structural requirements will be less stringent, 221-J could have smaller footprint.
- *Evaluate number and size of the decontaminated salt storage tanks.* Impact – Moderate, Plausibility – High. The footprint of 221-J could be reduced if there were more tanks, closely packed.

Studies applicable to alpha sorption (CST and CSSX):

- *Co-precipitate Sr and alpha with Sr and MnO2.* Impact – Large, Plausibility – Medium. The size of the filtration equipment could be reduced considerably. Note: This chemistry could be used for STTP, but the impact would not be as large. It is, however, a more effective way to reduce [Np], which would allow less salt blending. Engineering study underway (high spot equipment specification). However, impact of the additional manganese salt or oxide on DWPF operation (feed preparation and glass chemistry) must be evaluated.
- *Flocculate the MST and sludge particles and filter*. Impact – Moderate, Plausibility – High. The presumed increased filtration rate would reduce the size of the filtration equipment some. The impact of the flocculent on downstream processing must be evaluated.
- *Flocculate, Settle solids and decant the clear liquid*. Impact – Moderate, Plausibility – Moderate. Since a particle removal efficiency > 99% is required to meet alpha limits, it is likely that this option would require a polishing filter between the decanting tank and feed tank.
- *Flocculate and centrifuge liquid*. Impact – Moderate, Plausibility – Moderate. Separate the solids with a centrifuge. Since a particle removal efficiency > 99% is required, it is likely that this option would require a polishing filter between the centrifuge and feed tank.

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Allison dated 1/18/01, HLW-2001-00012

Studies applicable to CSSX:

- *Reduce the number of extraction stages.* Impact – Small, Plausibility – Moderate. Cs may extraction efficiently enough to use less than 15 stages.
- *Reduce the number of strip stages.* Impact – Small, Plausibility – Moderate. Cs may strip efficiently enough to use less than 15 stages.
- *Eliminate the Kerosene Still*. Impact – Moderate, Plausibility – High. The concentration of extractant and modifier may not need to be increased by distilling ISOPAR®.
- *Eliminate the Scrub Stages*. Impact – Small, Plausibility – Moderate. R&D results suggest that this unit operation may not be needed.

Studies applicable to CST:

- *Use a Moving Bed Column Design.* Impact – Moderate, Plausibility – High. This would reduce the number and length of the ion exchange columns. Engineering study underway (high spot equipment specification).
- *Use a Pulsed Column (Counter-current Ion Exchange).* Impact – Moderate, Plausibility – Moderate. . This would reduce the number and length of the ion exchange columns. Engineering study underway (high spot equipment specification).
- *Use Four Each 8 foot fixed bed columns rather than Three Each 16 foot columns.* Impact – Moderate, Plausibility – High. This reduces the height of 222-J. Engineering study underway (high spot equipment specification).
- *Reduce the Volume of the Guard Column.* Impact – Small, Plausibility – Moderate. This allows two of four columns to be much smaller and stacked.

Studies applicable to STTP:

- *Move the Fresh Waste Day Tank Outside into an Underground Structure.* Impact – Moderate, Plausibility – Low. This could reduce the building footprint, but require that some rearrangement be made.
- *Reduce Reactor Size:* Impact - Moderate, Plausibility - High. The two stirred tank reactors could be smaller, especially if the Sr/alpha sorption rates could be increased.
- *Eliminate the Organic Evaporator:* Impact – Moderate, Plausibility – High. The organic waste stream may be sufficient decontaminated by one stage of distillation and a water strip.

Summary of Project Reduction Potential

(Data Used in August 2000)

PROCESS	REDUCTION IN LENGTH*
CST	5.5 ft (1.9%)
CSSX	5.5 ft (1.8%)
STTP	0

*** Potential Reduction Due to Alternative Alpha/Sr Sorption Process Configuration (HLW-SDT-2000-00296, Rev. 0, 8/7/00)**

ATTACHMENT A-3

CRITERION 3

LIFE CYCLE COSTS THROUGH DECONTAMINATION AND DECOMMISSIONING

Total costs to complete all salt processing (including high-level waste system costs). The focus is on life-cycle costs, but the separate components of total project cost and operating cost also are examined for key differences.

DATE OF LATEST INPUT: 18 MAY 01

SPP 2001 COST ESTIMATE VS. 1998 BASELINE

1998 Baseline	CSSX	CST IX	STTP
Project TPC Estimate			
TEC	870,996	767,460	691,059
OPC	491,384	418,491	378,722
TPC w Contractor Contingency (Constant 1998 dollars)	**1,362,380**	**1,185,951**	**1,059,781**
Estimate w Contractor Contingency (Constant 2001 dollars)	**1,462,200**	**1,272,800**	**1,147,800**
G&A/ESS Shift (Constant 2001 dollars)	**1,502,100**	**1,311,000**	**1,180,300**
HLW System Life Cycle Costs			
Life Cycle Cost			
TEC/TPC	1,502,100	1,311,000	1,180,300
O & M	1,096,860	553,858	831,841
Other	699,376	721,788	762,346
Total LCC Estimate	**3,298,336**	**2,586,645**	**2,774,487**
50% Contingency	138,882	264,234	214,081
System Impacts	399,459	335,446	834,495
Total LCC Point Estimate	**3,836,677**	**3,186,325**	**3,823,063**
Whisker	2,822,666	2,615,465	2,185,283
Upper Range	**6719,344**	**5,801,791**	**6,008,346**

2001 Project TPC Estimate	CSSX	CST IX	STTP
Project TOC Estimate			
TEC	**865,648**	**706,459**	718,760
OPC	**508,693**	**433,748**	394,563
TPC w Contractor Contingency (Constant 2001 dollars)	**1,374,341**	**1,140,207**	**1,113,323**
DOE Contingency	164,405	134,973	128,772
Project TPRA	23,200	22,900	15,500
Project Schedule Contingency	39,583	53,333	39,583
Rounding	(529)	(413)	(178)
Upper Range	**1,601,000**	**1,351,000**	**1,297,000**
Life Cycle Cost			
TEC/TPC	1,374,341	1,140,207	1,113,323
O & M	805,014	737,627	933,921
Other	436,436	89,788	441,809
HLW System Delta	300,000	229,700	-
Point Estimate Total	**2,915,791**	**2,197,322**	**2,489,053**
DOE Contingency	164,405	134,973	128,772
Project TPRA	23,200	22,900	15,500
LCC System TPRA	500	53,500	8,500
LCC Schedule Contingency	1,055,333	1,609,383	897,033
Upper Range	**4,198,813**	**4,071,412**	**3,578,442**

LIFE CYCLE COSTS JUNE 28-29, 2000 WORKSHOP*			
	CST	**CSSX**	**STTP**
TPC	**$1.2B**	**$1.4B**	**$1.1B**
Operating	**$1.1B**	**$1.6B**	**$1.4B**
Life Cycle	**$2.3B**	**$3.0B**	**$2.5B**

***Based on 1998 WSRC Report.**

LIFE CYCLE COSTS AUGUST 14-15, 2000 WORKSHOP*			
	CST	**CSSX**	**STTP**
TPC	**$1.25B**	**$1.49B**	**$1.25B**
Operating	**$1.1B**	**$1.6B**	**$1.4B**
Life Cycle	**$2.35B**	**$3.09B**	**$2.65B**

***Reflects TPC update on 7/20/00.**

Conclusion: No significant change since original estimates. This was re-iterated in pre-conceptual design packages issued January 16, 2001.

ATTACHMENT A-4

CRITERION 4

TECHNICAL MATURITY

The overall technical maturity of the process flowsheets (including the required strontium and actinide removal steps). EM-50 stages of maturity are applied to each unit operation and the results are averaged.

DATE OF LATEST INPUT: 29 JUN 00

CST TECHNICAL MATURITY

		SCORE		
UNIT OPERATIONS	**DEVELOPMENT STATUS**	**08/14-15/00**	**01/29-31/01**	**05/21-24/01**
Alpha/Strontium Removal				
Dilute Salt Solution Feed with NaOH	Demonstrated in SRS Tank Farm	5	5	5
Sorb Actinide and Strontium in Batch Reactor	ITP Demonstrations, More Real Waste Tests Needed	3	3	4
Confirm Actinide and Strontium Removal	Laboratory Methods Demonstrated, Not On-line Capability	5	5	5
Remove MST/Sludge with Cross-Flow Filter	Based on ITP Design, Further Tests Needed	3	3	4
Wash and Concentrate MST/Sludge Slurry with Cross-Flow Filter	Based on ITP Design, Further Tests Needed	3	3	3
Filter Cleaning	*Hanford Sludge Experience*	2	2	2
Alpha/Strontium Average		***3.5***	***3.5***	***3.8***
Cesium Removal				
Pre-treat CST	ORNL Experience, Laboratory Tests at SRTC, Process Nor Equipment Defined for SPP	2	3	4
Load CST into Column	Previous DOE Experience with Zeolites, Smaller Scale Work with CST	4	4	4
Load Cesium on CST Column Resin	Demonstrated in Numerous DOE Ion Exchange Operations	4	4	4
Remove Radiolytic Gases from Lead CST Column	Prototype Design Complete, Testing Underway	3	4	4
Confirm Cesium Removal from Decontaminated Salt Solution (DSS)	Laboratory Methods Demonstrated, On-Line Cesium Demonstrated	5	5	5
Remove CST Fines from DSS	Dead-End Filter Mature, Experience with Zeolites at Other DOE Sites	3	3	3
Sluice Loaded CST from Columns	Previous DOE Experience with Zeolites, Smaller Scale Work with CST	4	4	4
Reduce Size of CST	Two Vendor Tests Completed	N/A	3	3
Store Loaded CST	Need Longer Term Experiments with Real Waste	4	4	4
Cesium Removal Average		***3.6***	***3.7***	***3.9***
OVERALL AVERAGE		***3.6***	***3.7***	***3.9***

CSSX TECHNICAL MATURITY

		SCORE		
UNIT OPERATIONS	**DEVELOPMENT STATUS**	**08/14-15/00**	**01/29-31/01**	**05/21-24/01**
Alpha/Strontium Removal				
Dilute Salt Solution Feed with NaOH	Demonstrated in SRS Tank Farm	5	5	5
Sorb Actinide and Strontium in Batch Reactor	ITP Demonstration, More Real Waste Needed	3	3	4
Confirm Actinide and Strontium Removal	Laboratory Methods Demonstrated, No On-Line Capability	5	5	5
Remove MST/Sludge with Cross-Flow Filter	Based on ITP Design, Further Tests Needed	3	3	4
Wash and Concentrate MST/Sludge Slurry with Cross-Flow Filter	Based on ITP Design, Further Tests Needed	3	3	3
Filter Cleaning	*Hanford Sludge Experience*	2	2	2
Alpha/Strontium Removal Average		***3.5***	***3.5***	***3.8***
Cesium Removal				
Extract Cesium in Centrifugal Contactors	ORNL and ANL Laboratory Tests	2	3	4
Scrub Cesium-Loaded Organic Phase in Centrifugal Contactors	ORNL and ANL Laboratory Tests	2	3	4
Strip Cesium from Organic Phase in Centrifugal Contactors	ORNL and ANL Laboratory Tests	2	3	4
Confirm Cesium Removal from Decontaminated Salt Solution (DSS)	Laboratory Methods Demonstrated, On-Line Cesium Demonstrated	5	5	5
Recover Solvent from DSS with Diluent Strip in Two-Stage Centrifugal Contactor	Limited Laboratory Tests at ORNL	1	1	2
Wash Solvent	Limited Laboratory Tests at ORNL	2	2	4
Maintain Solvent Concentration	Analytical Methods Defined, Adjustment Approach Unknown	3	3	3
Cesium Removal Average		***2.4***	**2.9**	***3.7***
OVERALL AVERAGE		***2.9***	***3.2***	***3.8***

STTP TECHNICAL MATURITY

		SCORE		
UNIT OPERATIONS	**DEVELOPMENT STATUS**	**08/14-15/00**	**01/29-31/01**	**05/21-24/01**
Alpha/Strontium Removal				
Dilute Salt Solution Feed with Water	Demonstrated in SRS Tank Farm	5	5	5
Sorb Actinide and Strontium in CSTRs	Limited tests with actual waste	3	3	4
Confirm Actinide and Strontium Removal	Laboratory Methods Demonstrated, No On-Line Capability	5	5	5
Alpha/Strontium Average		***4.3***	***4.3***	***4.7***
Cesium Removal				
Precipitate Potassium and Cesium in CSTRs	ORNL 20-liter CSTR tests, Marginal Real Waste Tests	3	3	4
Concentrate Precipitate/MST Slurry with Cross-Flow Filter	ITP Full-Scale Plant Demonstrations	4	4	4
Wash Precipitate/MST Slurry	ITP Full-Scale Design, Inadequate NaTPB Recovery	3	3	3
Filter Cleaning		4	5	5
Confirm Radionuclide Removal from Decontaminated Salt Solution (DSS)	Laboratory Methods Demonstrated	5	5	5
Cesium Removal Average		***3.8***	***4.0***	***4.2***
Organic Removal				
Hydrolyze Precipitate	DWPF Non-Radioactive Commissioning Tests	4	4	4
Distill Organics	DWPF Non-Radioactive Commissioning Tests	4	4	4
Confirm Organic Destruction	Analytical Methods Established and Demonstrated	5	5	5
Organic Removal Average		***4.3***	***4.3***	***4.3***
OVERALL AVERAGE		***4.1***	***4.2***	***4.4***

ATTACHMENT A-5

CRITERION 5

IMPLEMENTATION CONFIDENCE

Amount of relevant process experience (large-scale demonstration or deployment) in the DOE complex and industry for the key equipment used for each cesium removal process. This criterion also includes commercial availability of key components and chemicals.

DATE OF LATEST INPUT: 29 JUN 00

**Request for Revised Data Packages to Support
Salt Processing Project Down Selection,
Piccolo/Anderson dated 5/15/01, HLW-2001-00073**

Criterion: 5. Implementation Confidence

Action Criteria Description: No change in equipment confidence. Please confirm prior evaluation of "Availability of Key Components/Chemicals."

Responsibility: WSRC

No change in previous information.

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Allison dated 1/18/01, HLW-2001-00012

Criterion: 5. Implementation Confidence

Action Criteria Description: Need to access availability of Key Components/Chemicals.

Responsibility: WSRC

Submittal Reference:

"Tank Focus Area (TFA) Down-Selection Criteria Data Call and Technology Development", HLW-2000-00060, June 16, 2000. Item 13. Availability of Key Components from Suppliers

Submittal Description:

There have been no substantial changes since June. However, market development for the CSSX Extractant (BobCalix) and Modifier (Cs7SBT) are underway and bid packages based on the synthesis methods will be out by 1/31/01.

There are TWO (not one) MST vendors.

IMPLEMENTATION CONFIDENCE EQUIPMENT

Process	Score	Objective Evidence
CST	5	SRS, Hanford, West Valley and ORNL Experience with Non-Elutable Ion Exchange, ORNL CST Columns smaller than SPP Pre-conceptual Design
CSSX	5	SRS 221-F Canyon, 25-cm Centrifugal Contactors in First Cycle Purex
STTP	4	SRS Small-Scale Two-Stage Precipitation in Plutonium Facilities (Plutonium Trifluoride and Plutonium Oxalate)

IMPLEMENTATION CONFIDENCE SCALE

Score	Large-Scale Demonstration or Deployment in:
1	None of the Below
2	Chemical Industry
3	Foreign Commercial Reprocessing or Waste Treatment
4	SRS or Other DOE Reprocessing or Waste Treatment at Different Scale or Waste Composition
5	Other DOE Reprocessing or Waste Treatment at Similar Scale or Waste Composition
5	SRS Reprocessing or Waste Treatment at Similar Scale or Waste Composition

ATTACHMENT A-6

CRITERION 6

ENVIRONMENTAL IMPACTS

Comparative assessment of environmental impacts from secondary waste streams, airborne emissions, and liquid effluents. This criterion also includes the number of Saltstone vaults required for each process.

DATE OF LATEST INPUT: 18 JAN 01

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Anderson dated 5/15/01, HLW-2001-00073

Criterion: 6. Environmental Impacts

Action Criteria Description: Evaluate any flowsheet/aterial balance revisions that could impact saltstone vaults, secondary waste, and environmental releases. Provide revised data.

Responsibility: WSRC

No change in previous information.

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Allison dated 1/18/01, HLW-2001-00012

Criterion: 6. Minimize Environmental Impacts

Action Criteria Description: Evaluate any flowsheet/material balance revisions that could impact releases.

Responsibility: WSRC

Submittal Reference:

"Request for Additional Data Packages to Support Salt Processing Project Technology for Down Selection", HLW-2000-00080, August 1, 2000. Item 6. Minimizing Environmental Impacts

Submittal Description:

Page 5: Emission data source information has since been updated and should reflect the values of "Preliminary Source Term and Emissions Data for Salt Processing Environmental Impact Statement", HLW-SDT-99-0161, Rev. 5, August 22, 2000, page 32, as modified by the inclusion of benzene emission abatement identified in "Request for Benzene Abatement Scoping Study for Small Tank Tetraphenylborate Precipitation", HLW-2000-00115, October 18, 2000.

Before Update		
	Peak Rate (lb/hr)	Annual Rate (lb/yr)
Benzene	56	104,00

After Update		
	Peak Rate (lb/hr)	Annual Rate (lb/yr)
Benzene	0.56	935

Small Tank Precipitation

Building Stack

Radioactive Emissions:

Isotope	Ci/year
H-3	4.3
Sr-90	1.1 E-03
Tc-99	1.7 E-05
Ru-106	5.4 E-06
Sb-125	1.5 E-06
I-129	1.5 E-08
Cs-134	4.5 E-03
Cs-137	1.3 E+00
Total Alpha	1.3 E-03

Chemical Emissions:

Chemical Species	Peak Rate (lb/hr)	Annual Rate (lb/year)
Hg	5.4 E-4	4.8
Benzene	0.56*	935*
Particulates	See discussion	See discussion
Volatile Organics: Biphenyl	Minimal	Minimal
Phenol	Minimal	Minimal
Formic Acid	See discussion	See discussion
Triphenylboric acid	Minimal	Minimal
Biphenylboric acid	Minimal	Minimal
Phenylboric acid	Minimal	Minimal
Carbon monoxide	See discussion	See discussion
Nitrous oxides	See discussion	See discussion

*"Request for Benzene Abatement Scoping Study for Small Tank Tetraphenylborate Precipitation", HLW-2000-00115, October 18, 2000.

Cold Chemical Feeds

Chemical Emissions:

Chemical Species	Peak Rate (lb/hr)	Annual Rate (lb/year)
Hg	N/A	N/A
Particulates	See discussion	See discussion
Volatile Organics: Biphenyl	4.7	2100
Benzene	4.7	2100
Methanol	3.3	840
2-propanol	3.3	840
Formic acid	See discussion	See discussion
Carbon monoxide	See discussion	See discussion
Nitrous oxides	See discussion	See discussion

Caustic Side Solvent Extraction

Building Stack

Radioactive Emissions:

Isotope	Ci/year
H-3	15
Sr-90	2.0 E-03
Tc-99	5.4 E-05
Ru-106	1.6 E-05
Sb-125	5.9 E-06
I-129	6.6 E-07
Cs-134	1.4 E-02
Cs-137	1.4 E+00
Total Alpha	6.0 E-03

Chemical Emissions:

Chemical Species	Peak Rate (lb/hr)	Annual Rate (lb/year)
Hg	5.4E-4	4.8
Particulates	See discussion	See discussion
Volatile Organics	See discussion	See discussion
Carbon monoxide	See discussion	See discussion
Nitrous oxides	See discussion	See discussion

Cold Chemical Feeds

Chemical Emissions:

Chemical Species	Peak Rate (lb/hr)	Annual Rate (lb/year)
Hg	N/A	N/A
Particulates	See discussion	See discussion
Volatile Organics Methanol	3.3	840
2-propanol	3.3	840
Other Organics	See discussion	See discussion
Carbon monoxide	See discussion	See discussion
Nitrous oxides	See discussion	See discussion

CST Ion Exchange

Building Stack

Radioactive Emissions:

Isotope	Ci/year
H-3	18
Sr-90	4.9 E-05
Tc-99	1.6 E-06
Ru-106	4.7 E-07
Sb-125	1.6 E-07
I-129	1.6 E-09
Cs-134	2.4 E-03
Cs-137	2.4 E-01
Total Alpha	1.5 E-04

Chemical Emissions:

Chemical Species	Peak Rate (lb/hr)	Annual Rate (lb/year)
Hg	5.4E-4	4.8
Particulates	See discussion	See discussion
Volatile Organics	See discussion	See discussion
Carbon monoxide	See discussion	See discussion
Nitrous oxides	See discussion	See discussion

Cold Chemical Feeds

Chemical Emissions:

Chemical Species	Peak Rate (lb/hr)	Annual Rate (lb/year)
Hg	N/A	N/A
Particulates	See discussion	See discussion
Volatile Organics Methanol	3.3	840
2-propanol	3.3	840
Carbon monoxide	See discussion	See discussion
Nitrous oxides	See discussion	See discussion

Additional air emissions analysis, using the above data, is being performed for the SEIS by the Savannah River Technology Center (SRTC). It will allow comparison of the effects of emissions at the site boundary. The analysis will be available in early August.

Secondary Waste

Maximum annual waste generation for the Salt Disposition Alternatives[a].

	CST Ion Exchange	Direct Disposal in Grout	Small Tank TPB Precipitation w/ Salt Cell	CSSX
Radioactive liquid waste (gallons)[b]	250,000	150,000	300,000	900,000
Nonradioactive liquid waste (gallons)[d]	34,000[c]	negligible	negligible	negligible
Benzene (gallons)	negligible	negligible	73,000	negligible
Organic Solvent (gallons)	0	0	0	1,000
Transuranic waste (m^3)	0	0	0	0
Low-level waste (m^3)	71	71	71	71
Hazardous waste (m^3)	Startup - 23 Operations - 1	Startup - 23 Operations - 1	Startup - 23 Operations - 1	Startup - 23 Operations - 1
Mixed low-level waste (m^3)	1	1	1	1
Industrial waste (metric tons)	Startup - 30 Operations - 20	Startup - 30 Operations - 20	Startup - 30 Operations - 20	Startup - 30 Operations - 20
Sanitary waste (metric tons)	Startup - 62 Operations - 41	Startup - 62 Operations - 41	Startup - 62 Operations - 41	Startup - 62 Operations - 41

a. Based upon "Supplemental Data Call for Salt Disposition Alternatives SEIS", HLW-SDT-2000-00263
b. Incremental increase of aqueous waste generated during DWPF operations for return to Tank Farm verses previously reported sludge only operation of DWPF.
c. CST resin pretreatment generates a spent 1 M NaOH solution and CST fines slurry.
d. Non-radioactive industrial waste generated as process waste. Reported values do not include sanitary waste.

Process Alternative	STTP	CST	CSSX
6.44 mol/L Salt Solution from TF, Mgal	70.87	70.87	70.87
Decon. Salt Solution from SWPF, mol/L	4.7	5.6	4.9
Decon. Salt Solution from SWPF, Mgal	97.11	81.50	93.14
4.6 M Salt Solution from ETF, Mgal	2.25	2.25	2.25
Total Salt Solution to Z Area, Mgal	99.36	83.75	95.39
No. Cells needed @ 1.1 Mgal/cell	90.3=91	76.2=77	86.7=87
No. Cells available	10	10	10
New Cells needed	81	67	77
New vaults needed @ 6 cells per vault	14	12	13

ATTACHMENT A-7

CRITERION 7

IMPACTS OF INTERFACES AT THE DEFENSE WASTE PROCESSING FACILITY

Cost of implementing the changes (physical modifications) to the interfacing systems and the loss of canister production caused by outages for equipment installation or transfer line tie-ins.

DATE OF LATEST INPUT: 18 JAN 01

Request for Revised Data Packages to Support
Salt Processing Project Down Selection,
Piccolo/Anderson dated 5/15/01, HLW-2001-00073

Criterion: 7. Impact of the Interfaces at DWPF

Action Criteria Description: Review and update prior analyses of costs, lost canister production, and DWPF recycle volumes. For example, CST flowsheet has been modified by moving grinding equipment from DWPF to SWPF.

Responsibility: WSRC

There are no changes in the interfacing requirements for CSSX since the last update.

CST – The scope for the SWDF now includes facilities to grind the CST resin before it is transferred to DWPF. This resulted in a minor increase in cost (~ $2 million at the project level), but this change eliminates CST particle size control as an interface issue.

STTP – Facilities were modified to evaporate the DWPF feed stream (Precipitate Hydrolysis Aqueous – PHA). This volume reduction allows the DWPF to prepare feed within the allowable Slurry Receipt and Adjustment Tank cycle time. If this water were not removed in the SWPF, the evaporation time would be excessive.

In preparation for the Risk Assessment Workshop and Revision 3 of the BAR, major product streams for all three flowsheets were reanalyzed with this result shown in the table below. The table shows only minor difference between processes.

	STTB	**CST**	**CSSX**
Sludge Only Canisters	3109	2787	2787
Coupled Canisters	2797	3024	3117
Total Canisters	5906[1]	5811	5904
Saltstone Cells[2] (100'X100'X25')	110	94	102

[1] This planning case for STTP assumed that precipitate washing in the SWPF would be improved. However, if only
10% of the solid NaTPB is recovered in the wash step, approximately 100 more canisters would be required.
[2] Both CST and CSSX may require dilution with NaOH to preclude in-process precipitation of Gibbsite
($Al_2O_3 \bullet 3H_2O$). This may result in an increase of up to 10% in Saltstone volume for both.

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Allison dated 1/18/01, HLW-2001-00012

Criterion: 7. Impact of Interfaces at DWPF

Action Criteria Description: Review and evaluate prior analysis.

Responsibility: WSRC

Submittal Reference:

"Request for Additional Data Packages to Support Salt Processing Project Technology for Down Selection", HLW-2000-00080, August 1, 2000. Item 7. Impact of Modifying Interfacing Systems

Submittal Description:

There have been no changes to the analyses with respect to CSSX or STTP.

Paragraph 2 of the CST write up should be changed to read:

"In addition, the CST option requires an additional route for transfer of expended ion exchange media (slurry) using an additional Pump Tank (and Pump Pit). This stream will be routed through an existing spare outside wall penetration, terminated just west of 221-S. An additional tank will be required to receive the CST slurry in the existing Salt Processing Cell. CST will be blended with Sludge / Frit slurry to make melter feed. Results of technology development activities since 1998 indicate that the CST particles are too large, as-is, to be sampled representatively in this slurry. Testing in FY00 has confirmed that size-reduced CST can representatively sampled with existing sampling equipment and two types of grinders were tested and shown to accomplish the required size reduction. Homogeneous feeding to the melter of the size-reduced CST will be confirmed in future testing. Grinding facilities will be installed as in-cell equipment, probably in the Salt Waste Processing Facility. Current design shows these facilities in the DWPF, but recent studies indicate that as received CST particles cannot be suspended in a homogenous slurry. Well mixed slurry is required for blending in DWPF and this can be accomplished by sending DWPF size-reduced CST."

Summary of Impact of Interface to DWPF

Process	Reduced DWPF Production, Canisters	Cost in Millions
CST	50-100	$42.9
CSSX	33	$35.6
STTP	4	$10.6

Additional Data Call Request – Schepens to Poulson, dated 8/1/00 – Item 2

Criteria 7: Impact of Modifying Interfacing Systems

Criteria Description: Impact of implementing the changes to the interfacing systems (physical modifications)

Responsibility: WSRC

Due: 08/01/00

Transmitted: 08/01/00

Program Point of Contact: Bob Hinds

Submittal References:

1. SRS High Level Waste System Plan Rev. 11, HLW-2000-00019, 4/18/00
2. SRS HLW SD Systems Engineering Team Life Cycle Cost Estimate Bases, Assumptions, and Results, Revision 1, WSRC-RP-98-00167, 10/21/98

Small Tank Tetraphenylborate (TPB) Precipitation

The precipitate hydrolysis aqueous (PHA) resulting from the precipitation process, also containing the residual sludge and MST in it, will be transferred as a combined effluent stream from the Salt Disposition Facility through new waste transfer line to the existing DWPF Precipitate Reactor Bottoms Tank (PRBT). A cold tie-in is available at the LPPP. New process jumpers will be required to transfer the PHA to the PRBT. There are several alternatives to this routing, all of which require only new jumpers to be fabricated and installed. New construction can take place up to the LPPP tie-in concurrent with DWPF operations. Canister production may be impacted for approximately one week during execution of the tie-in. With a targeted average production rate of 200 canisters/year, this could reduce canister production by approximately 4 cans. The final tie-in could be scheduled around the normal transfers required to support DWPF operation to minimize or eliminate process interruption.

The direct cost of the modifications to connecting lines required to feed DWPF from a TPB Salt Waste Processing Facility (SWPF) was estimated to be $10.6 million (excluding contingencies and programmatic risk). This is based on the referenced cost estimate for WBS element 1.2.2.6, “Connecting Piping Lines.”

Caustic Side Solvent Extraction (CSSX)

Dilute cesium nitrate product will be routed, as for PHA above, with the same modifications required.

In addition, a route must be established for transfer of washed MST/Residual Sludge Slurry requiring an additional Pump Tank (and Pump Pit). This will be routed through an existing spare outside wall penetration terminated just west of the 221-S. A new tank will be installed in the existing Salt Processing Cell.

An outage of two months may be required to install this tank and its jumpers, complete testing, and put it in service. This could reduce canister production in the year of tie-in execution by approximately 33 canisters. There is a possibility that this work could be executed concurrent with planned melter

Additional Data Call Request – Schepens to Poulson, dated 8/1/00 – Item 2

replacement outages in FY06 and FY09 without impact on the production schedule. There is a currently an unquantified risk to the SWPF schedule, because of an indeterminate melter life, that the melter outage(s) will not occur between FY05 and FY10. This time frame represents a window of opportunity between completion of the design of the modifications necessary to accommodate the new SWPF, and the need to complete tie-ins to support start of radioactive operation.

The direct cost of the modifications to connecting lines required to feed DWPF from a CSSX SWPF, including the new pump tank and pump pit, was estimated to be $35.6 million (excluding contingencies and programmatic risk). This is based on the referenced cost estimate for WBS element 1.2.2.6, "Connecting Piping Lines," and includes modifications (i.e., addition of two tanks) in DWPF Salt Process Cell.

Crystalline Silicotitanate (CST) Ion Exchange

Washed MST/Residual Sludge will be routed through existing facilities, as for PHA above, with the same modifications required (including the addition of a new tank).

In addition, the CST option requires an additional route for transfer of expended ion exchange media (slurry) using an additional Pump Tank (and Pump Pit). This stream will be routed through an existing spare outside wall penetration, terminated just west of the 221-S. An additional tank will be required to receive the CST slurry in the existing Salt Processing Cell. CST will be blended with Sludge/Frit slurry to make melter feed. Results of technology development activities since 1998 indicate that the CST particles are too large, as-is, to sampled representatively in this slurry. There is some indication from testing that the DWPF sampling system may require modification. Further, the CST particles may be too large to be fed through the melter feed system without additional processing. This will be tested in FY01. Proposed solutions include the addition of a grinder to be installed as in-cell equipment at DWPF.

In-cell modifications to resolve feed issues may take an outage of up to three months in duration. If extensive sample system modifications are needed, the outage could be up to six months due to the hostile work environment created by contamination levels in the sample cells. This could reduce canister production by as much as 100 canisters in the year the modifications are made, depending on the ability to integrate required modifications with melter outage activities between FY05 and FY10. DWPF in-cell work to support modifications for SWPF feed would put a competing demand on the same support systems and resources required for melter replacement.

The direct cost of the modifications to connecting lines required to feed DWPF from a new CST Ion Exchange SWPF, including the new pump tank and pump pit, was estimated to be $35.9 million (excluding contingencies and programmatic risk). This is based on the referenced cost estimate for WBS element 1.2.2.6, "Connecting Piping Lines," and includes modifications (i.e., addition of two tanks) in DWPF Salt Process Cell. Please note that previously quantified risks related to (but not necessarily all-inclusive of) the modifications proposed to resolve issues associated with CST transfer and sampling were estimated to cost an additional $7 million.

ATTACHMENT A-8

CRITERION 8

PROCESS SIMPLICITY OF SYSTEM INTERFACES

The simplicity of interfacing the alternative cesium removal process with other high-level waste systems. The simplicity is measured by the number of process unit operations needed for the interfaces times a difficulty factor for each interface unit operation.

DATE OF LATEST INPUT: 29 JUN 00

DIFFICULTY FACTOR FOR HLW INTERFACE UNIT OPERATIONS

Parameters Contributing To Complexity of Interfaces:

- **Requires Significant Facility Modifications at DWPF or Saltstone**
- **Processing / Handling of a Multiphase Stream**
- **Represents a New Product Transfer Not in the Previous ITP Baseline**
- **Adds a Previously Undemonstrated Unit Operation**

CST INTERFACE UNIT OPERATIONS COMPLEXITY

UNIT OPERATIONS	COMPLEXITY PARAMETERS	NO. OF PARAMETERS
HLW Interfaces		
Transfer MST/Sludge Slurry to DWPF	Multiphase, New Product Transfer	2
Transfer Loaded CST to DWPF	Multiphase, New Product Transfer	2
Blend/Sample CST/MST/Sludge in Slurry Receipt Adjustment Tank (SRAT)	Multiphase, Undemonstrated Unit Operation	2
Blend/Sample CST/MST/Sludge/Frit in Slurry Mix Evaporator (SME)	*Included Above*	
Store/Sample Melter Feed	*Multiphase, Undemonstrated Unit Operation*	*2*
Feed CST/MST/Sludge/Frit Slurry to Melter	*Included Above*	
SUM		**8***

* TFA Update on January 24, 2001. WSRC moved size reduction of CST to Salt Waste Processing Facility.

CSSX INTERFACE UNIT OPERATIONS COMPLEXITY

UNIT OPERATIONS	COMPLEXITY PARAMETERS	NO. OF PARAMETERS
HLW Interfaces		
Transfer MST/Sludge Slurry to DWPF	Multiphase, New Product Transfer	2
Transfer Organic Waste to CIF	*None*	*0*
SUM		**2**

STTP INTERFACE UNIT OPERATIONS COMPLEXITY

UNIT OPERATIONS	COMPLEXITY PARAMETERS	NO. OF PARAMETERS
HLW Interfaces		
Transfer PHA/MST/Sludge to DWPF	Multiphase, New Product Transfer	2
Transfer Organic Waste to CIF	None	0
Transfer DSS to Saltstone	*Facility Modifications, New Product Transfer*	*2*
SUM		**4**

Interface Complexity Scoring Approach

- **Identify Parameters that Represent Added Process Complexity**
- **Tally Number of Parameters that Apply to Each Interface Unit Operation – This is the Difficulty Factor**
- **Total Difficulty Factors for all Unique Interface Unit Operations**
- **Compare Total for Each Flowsheet and Convert to 1 to 5 Score**

ATTACHMENT A-9

CRITERION 9

LEVELS OF SAFETY CONTROL MITIGATION

Number and type (e.g., passive, active, administrative, preventive, and mitigative) of controls required to maintain the facility in a safety configuration and to protect the worker, public, and environment.

DATE OF LATEST INPUT: 01 AUG 00

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Anderson dated 5/15/01, HLW-2001-00073

Criterion: 9. Levels of Safety Control Mitigation

Action Criteria Description: Verify no change in previous analysis.

Responsibility: WSRC

There have been no changes in the analysis since the last update, however more up to date information for source term is available from the Preliminary Hazards Assessment Document input memoranda.[1]

	STTB	CST[2]	CSSX
Cesium Inventory, Ci	1.30E+7	3.29E+07	8.42E+06
Offsite Dose Potential, Aggregate, rem	1.40E+14	6.49E+13	6.28E+13

The CST process accumulates larger quantities of cesium, because cesium is loaded to a high concentration on the lead column and the column about to be unloaded. Also, there is a large amount of cesium in the loaded resin hold tanks.

All three designs have comparable aggregate dose potential, because they have comparable inventories of sludge and the transuranic radionuclides in sludge drive the dose potential. This sludge is entrained in the salt feed and is concentrated in all three processes. The sludge is not removed as a separate stream in the STTB process, so there is an appreciable inventory of transuranic material in the PHA product inventory (equivalent to 2 months of operation). The other two processes accumulate somewhat less sludge, equivalent to about a month's feed.

[1] HLW-SDT-2000-00099 (Rev 0) for CST, HLW-SDT-2000-00123 (Rev 0) for STTP, HLW-SDT-00199 (Rev 1) for CSSX.

[2] The inventories for CST ans CSSX have been adjusted to account for design changes to the alpha sorbtion equipment. Other, smaller changes since the references were prepared have been ignored.

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Allison dated 1/18/01, HLW-2001-00012*

Criterion: 9. Levels of Safety Control Mitigation

Action Criteria Description: Verify no change in previous analysis.

Responsibility: WSRC

Submittal Reference:

"Request for Additional Data Packages to Support Salt Processing Project Technology for Down Selection", HLW-2000-00080, August 1, 2000. Item 9. Level of Safety Control Mitigation

Submittal Description:

There have been no changes to the previous analysis in "SAFETY CONTROLS AND SCORING FOR THREE TECHNOLOGY OPTIONS FOR SALT WASTE PROCESSING PROGRAM (U)", WSRC-TR-2000-00251.

*Criterion number corrected from original WSRC letter.

Summary of Number of Safety Controls

A Technology Identification	B SC Control Scoring Number		C SS Control Scoring Number		D Total Scoring Number = Sum of Columns B & C	
	Number	Average	Number	**Average**	**Number**	**Average**
CST Ion Exchange Process	**16 (4)**	**3.625**	**19 (10)**	**3.463**	**35 (14)**	**7.09**
Caustic-Side Solvent Extraction Process	**16 (4)**	**3.613**	**19 (10)**	**3.463**	**35 (14)**	**7.08**
Small Tank TPB Precipitation Process	**18 (4)**	**3.500**	**20 (10)**	**3.480**	**38 (14)**	**6.98**

*** Number of Administrative Controls in Parentheses.**

Additional Data Call Request – Schepens to Poulson, Dated 8/1/00 – Item 3

Criterion: 9. Levels of Safety Control Mitigation

Criteria Description: Number of active (administrative (@-2) or engineered (@-1) vs. passive (@-1) controls)

Responsibility: WSRC

Due: 8/1/00

Transmitted: 8/1/00

Program Point of Contact: Ken Rueter

Submittal References:

- WSRC-TR-2000-00251, Rev. 0, "Safety Controls and Scoping for Three Technology Options for Salt Waste Processing Facility (U)"

Other References:

See Attached.

Submittal Description:

The purpose of this report is to determine/evaluate if Safety Class (SC)/Safety Significant (SS) controls required for the three Salt Disposition Technologies provide a discriminator. Each selected control is graded and assigned a scoring number. This report documents the steps required to identify the anticipated safety controls that perform Safety Class (SC) and Safety Significant (SS) functions to maintain the facility within a safe configuration and to protect the public, the worker and the environment. The intent of this report is to make a qualitative assessment of dominant SC and SS functions for each technology under evaluation and provide a specific set of SSCs and Administrative Controls that could be credited with performing those functions. This report is not directly applicable to the identification of actual safety controls to be included in the final design without a systematic assessment of the detailed design and hazardous material inventories, rather it permits a comparison of the controls required for the different technologies.

Additional Data Call Request – Schepens to Poulson, Dated 8/1/00 – Item 3

Other References:

- Salt Waste Processing Facility Scoring Methodology For Safety Controls (U). Letter # WSMS-LIC-M-00-0070, Westinghouse Savannah River Company, Aiken, SC, July 11, 2000.
- WSRC E7 Conduct of Engineering and Technical Support Manual (U). Procedure 2.25, "Functional Classification:, Rev. 7, Westinghouse Savannah River Company, Aiken, SC, September 1999.
- Pre-Preliminary Functional Classification Report Salt Waste Processing Facility (U). WSRC-TR-99-00004, Rev. A, Westinghouse Savannah River Company, Aiken, SC, September 1999.
- Hazards Analysis For the Salt Waste Processing Facility (Small Tank Tetraphenylborate Precipitation Process) At Pre-Conceptual Design Phase (U). WSRC-TR-99-00083, Rev. A, Westinghouse Savannah River Company, Aiken, SC, April 1999.
- Bounding Analysis for Safety Controls of Salt Disposition in Technology Options (U). WSMS-SAE-M-00-0071, July 24, 2000.
- HLW Salt Disposition Systems Engineering Team, Phase III Preliminary Hazard Evaluations (U). WSRC-RP-98-00977, Rev. 1, Westinghouse Savannah River Company, Aiken, SC, September 1998.
- High Level Waste Salt Processing Caustic Side Solvent Extraction (U). Drawing X-M5-H-0053, Rev. E, Sheet 1 through 7.
- High Level Waste Salt Processing Caustic Side Solvent Extraction (U). Drawing X-PG-H-0001, Rev. C, Sheet 1 through 3.
- High Level Waste Salt Processing Small Tank TPB Precipitation (U). Drawing X-M5-J-0001, Rev. B, Sheet 1 through 6.
- High Level Waste Salt Processing Small Tank TPB Precipitation Process General Arrangement (U). Drawing X-PG-J-0001, Rev. A, Sheet 1 through 3.
- High Level Waste Salt Processing CST Ion Exchange General Arrangement (U). Drawing X-PG-H-0003, Rev. D., Sheet 1 through 3.
- High Level Waste Salt Processing CST Ion Exchange (U). Drawing X-M5-H-0056, Rev. E, Sheet 1 through 5.
- Nomm, E. Frequency of Criticality in High Level Waste Facilities (U). S-CLC-H-00380, Rev. 0, Westinghouse Savannah River Company, Aiken, SC, November 1995.
- Fire Protection Program Manual. WSRC Procedure Manual 2Q, Westinghouse Savannah River Company, Aiken, SC.

SALT DISPOSITION OPTIONS SAFETY CONTROLS STUDY

Westinghouse Safety Management Solutions LLC.

SALT DISPOSITION OPTIONS SAFETY CONTROLS STUDY

- Outline of Presentation
  - Purpose of Task
  - Inputs, methodology and approach
  - Scoring Methodology
  - Conclusions

SALT DISPOSITION OPTIONS SAFETY CONTROLS STUDY

- Task Purpose:
  - Develop a scoring methodology for Safety Controls for 3 technologies
  - Develop a preliminary list of Safety Controls for the 3 technologies at the system level (macroscopic view)
  - Assign scoring values to the list of Safety Controls

SALT DISPOSITION OPTIONS SAFETY CONTROLS STUDY

- Inputs for study:
  - Existing PPFCR for Small Tank
  - Recent Scoping Hazards Analysis (HA) based on Pre-Conceptual Design for:
    - Salt Cell
    - Caustic Side Solvent Extraction
    - CST Ion Exchange
  - Pre-Conceptual Design and Safety Strategy

SALT DISPOSITION OPTIONS
Hazards Analysis

- All alternatives process the same waste streams (source terms) but have different concentration ratios.
- CSSX & CST concentrate alpha 5X more than STTP
- CST concentrates Cs 25X STTP & CSSX
- Conservative estimates of consequences for all three exceed safety control selection criteria

SALT DISPOSITION OPTIONS
Pre-Conceptual Design Safety Strategy

- Safety Strategy for all 3 Pre-Conceptual Designs is similar
  - 3 "barriers" that will control most events
    - Flammable vapor control (O_2 control for Small Tank and LFL control for the other two)
    - Primary confinement by qualified vessels and piping
    - Secondary confinement of liquid releases in cell with leak detection and confinement of airborne releases through ventilation/filtration

SALT DISPOSITION OPTIONS Methodology

- The SRS Functional Classification Methodology (i.e., Manual E7, Procedure 2.25) was qualitatively applied to determine the preliminary safety controls based on the available HA information
  - Events that are postulated to exceed Offsite Evaluation Guidelines require Safety Controls
  - Events that are postulated to exceed Onsite Criteria require Safety Controls
  - Additional controls selected to meet requirements on minimum level of Defense-in-Depth

SALT DISPOSITION OPTIONS
Scoring Methodology

- Three characteristics selected for scoring
  - Control type
    - Engineered vs. Administrative Controls
    - Prevent vs. mitigate
    - Passive vs. active
  - Control relative complexity
  - Relative number of SSCs within a control

SALT DISPOSITION OPTIONS
Conclusions

- Number of administrative controls is the same.
- Number of Safety Class Controls is ±2
- Number of Safety Significant Controls is ±1
- Weighted scoring is well within 10%

SALT DISPOSITION OPTIONS
Conclusions

- Similar safety strategies in Pre-Conceptual Design drives a similar list of safety controls for all three technologies.
- The preliminary conclusion of the task is that the differences in Safety Controls for the 3 technologies is so small that this criterion is not a discriminator between the options.

ATTACHMENT A-10

CRITERION 10

PROCESS FLEXIBILITY IN THROUGHPUT

Capability to operate the process at a higher or lower throughput (turn-up or turn-down) based on the equipment in the current pre-conceptual designs.

DATE OF LATEST INPUT: 01 AUG 00

Request for Revised Data Packages to Support Salt Processing Project Down Selection, Piccolo/Anderson dated 5/15/01, HLW-2001-00073

Criterion: 10. Process Flexibility in Throughput

Action Criteria Description: Review and validate prior analysis, as needed, based on latest flowsheets and material balances.

Responsibility: WSRC

No change in previous information.

Request for Revised Data Packages to Support
Salt Processing Project Down Selection,
Piccolo/Anderson dated 5/15/01, HLW-2001-00073*

Criterion: 10. Maximize Process Flexibility in Throughput

Action Criteria Description: Review and validate prior analysis.

Responsibility: WSRC

Submittal Reference:

"Tank Focus Area (TFA) Down Select Criteria", HLW-SDT-2000-00253, June 23, 2000. Item 10. Maximize Process Flexibility in Throughput

Submittal Description:

There have been no changes to the previous analysis in the Criteria 10 (Item 4) submittal of 8/01/00.

*Criterion number corrected from original WSRC letter.

Summary of Maximize Process Flexibility in Throughput

Process	Potential Throughput Increase, %
CST	50*
CSSX	40
STTP	20*

*** Potential Glass Requalification**

Additional Data Call Request – Schepens to Poulson, dated 8/1/00 – Item 4

Criterion: 10. Maximize Process Flexibility in Throughput

Criteria Description: Original: Turnup and turndown capability. Revised per 7/18/00 Schepens letter: Provide a revised data package that considers higher centrifugal contactor flow-rates and provides the basis for assumptions underlying expected turn-up rates for all three processes.

Responsibility: WSRC

Due: 08/01/00

Transmitted: 08/01/00

Program Point of Contact: Joe Carter

Submittal References:

1. High Level Waste Salt Processing Caustic Side Solvent Extraction Process Flow Diagram, Rev. E, Dwg. No. XM5H0053E.
2. High Level Waste Salt Processing Small Tank TPB Precipitation Process Flow Diagram, Rev. B, Dwg. No. XM5J0001B.
3. SRS HLW SD Systems Engineering Team Final Report, WSRC-RP-98-00170, Rev. 0, 10/29/98.
4. SRS High Level Waste System Plan Rev. 11, HLW-2000-00019, 4/18/00, §8.6 Defense Waste Processing Facility.
5. Bases, Assumptions, and Results of the Flowsheet Calculations for the Short List Salt Disposition Alternatives, WSRC-RP-98-00168, Rev. 1, 10/29/98.
6. Bases, Assumptions, and Results for the Decision Phase Alternatives, WSRC-RP-99-006, 9/30/99.
7. Performance of a Multi-Stage Centrifugal Contactor, DP-841, October 1963.

Other References:

Refer to footnotes.

Submittal:

This data is a revision to the previous submittal, including references to the source documents containing the basis of the information provided. The constraint on the maximum salt processing rate is the ability of the existing four decades old infrastructure to support waste removal. The maximum sustained slat removal rate, based on logistical constraints imposed by the infrastructure of the tank farms is 6,000,000 gallons annually (an average 6.44 M [Na+]). This requires the facilities to be able to process 6,900,000 gallons yearly to

Additional Data Call Request – Schepens to Poulson, dated 8/1/00 – Item 4

work backlog accumulated during outages requires to replace DWPF melters. Factoring in an estimated 75% attainment rate make the instantaneous process rate 17.5 gpm for 6.44 M salt.[1] Waste removal infrastructure and the Saltstone facility would require significant modification to process the material at higher than the desire basis. Impacts on DWPF are discussed with each flowsheet.

Small Tank Tetraphenylborate (TPB) Precipitation

Based on a nominal working volume of 15,000 gallons[2], the residence time for the two Continuously Stirred Tank Reactors is 9.5 hours each. The process has been demonstrated to have a mean residence time of approximately eight hours.[3] The data suggest that for the two reactor configuration, a substantially shorter holdup may be adequate. The throughput for this plant could be increased by 20%. DWPF may not be able to vitrify the quantity of precipitate hydrolysis aqueous (PHA) produced at the higher rate and still maintain full sludge oxide loading consistent with the existing glass qualification.[4] This potential throughput from process optimization would be in addition to the 33% improvement in throughput gained by incorporating the DWPF Salt Process Cell functions into the design of the TPB Salt Waste Processing Facility flowsheet.[5,6]

Caustic Side Solvent Extraction

The 25-cm centrifugal contactors have a tested capacity of 40 gpm. Capacities as high as 60 gpm have been demonstrated during testing for other processes at SRS.[7] The total flow in the extraction stages in the current flowsheet is 28.6 gpm (20.7 gpm of 5.6 M [Na+] feed, 1.3 gpm aqueous scrub, and 6.6 gpm solvent).[8] The flow through other stages is smaller. There is a potential for increase in throughput of at least 40%.

DWPF should be able to vitrify the cesium nitrate in dilute nitric acid at the higher rate. Some adjustment to oxidant in DWPF may be necessary to keep the cations in the proper oxidation state.

[1] SRS High Level Waste System Plan Rev. 11, HLW-2000-00019, 4/18/00.
[2] High Level Waste Salt Processing Small Tank TPB Precipitation Process Flow Diagram, Rev. B, Dwg. No. XM5J0001B.
[3] Bases, Assumptions, and Results for the Decision Phase Alternatives, WSRC-RP-99-0006, 9/30/00, §3.1.2.2.
[4] Bases, Assumptions, and Results for the Decision Phase Alternatives, WSRC-RP-99-0006, 9/30/00, §3.1.3.10.
[5] Bases, Assumptions, and Results for the Decision Phase Alternatives, WSRC-RP-99-0006, 9/30/00, §3.1.6.
[6] ECF-HLW-SDT-2000-0012, 5/24/2000.
[7] Performance of a Multi-Stage Centrifugal Contactor, DP-841, October 1963.
[8] High Level Waste Salt processing Caustic Side Solvent Extraction Process Flow Diagram, Rev. E, Dwg. No. XM5H0053E.

Additional Data Call Request – Schepens to Poulson, dated 8/1/00 – Item 4

CST Non-elutable Ion Exchange

The throughput of the ion exchange column is directly related to the length of the mass transfer zone, that region between 90% of the inlet cesium concentration and 1.3 ppb cesium. In the current design, that zone is 16 feet.[9] This for resin with an average distribution coefficient (800 ml/g) and the high nitrate waste. When the 2nd lag column is operated to break-through, the 1st column is near its full loading. The columns as designed can process at a much higher flow. The consequence is that the 1st bed has a lower loading when the 2nd bed reaches break-through. There would be more resin to vitrify in DWPF as a result of the change-out of the ion exchange media in the first column prior to full loading. Glasses can be made at a loading exceeding the approximate 5% CST oxide for the design basis, as much as two times that loading. Sludge loading is not reduced significantly, but there would be an increase in the volume of glass produced. Based on the ability to increase flow rate, an increase of 50% is possible, but this would likely require requalification of the glass for waste acceptance due to a revised glass formulation.[10] Glass qualification was a lengthy process requiring extensive testing prior to DWPF startup.

[9] Bases, Assumptions, and Results of the Flowsheet Calculations for the Short List Salt Disposition Alternatives, WSRC-RP-98-00168, Rev. 1, 10/29/98.
[10] Bases, Assumptions, and Results for the Decision Phase Alternatives, WSRC-RP-99-006, 9/30/99.

ATTACHMENT A-11

CRITERION 11

PROCESS SIMPLICITY (OPERABILITY)

Simplicity of the process as indicated by the number of pieces of equipment (in both the non-radioactive areas and the remotely operated area) and the number of jumpers (piping connections) required inside the remotely operated area.

DATE OF LATEST INPUT: 15 MAY 01

Summary on Process Simplicity
(May 15, 2001)

Equipment Count			
Process	**CST**	**CSSX**	**STTP**
Tanks and Equipment			
Shielded Cell	46	78* (45)**	43
Cold Feed/Operating Corridor	13	31	20
Pumps			
Shielded Cell	37	33	35
Cold Feed/Operating Corridor	16	47	17
Sample Pumps			
Shielded Cell	12	10	12
Cold Feed/Operating Corridor	1	9	0
Agitators			
Shielded Cell	11	12	15
Cold Feed/Operating Corridor	6	17	4
Jumpers			
Jumpers	262	311	263
Instruments			
Instruments	145	112	129

*Includes 40 contactor stages.
**If built as seven 6-packs.

Criterion: 11. Process Simplicity Operability

Action Criteria Description: Update equipment and jumper count based on latest preconceptual design and revised BAR.

Responsibility: WSRC

Submittal References:

Component counts, with the exception of jumpers, were provided by the Salt Process Programs Process & Controls Technology group by review of the most current Process Flow Diagrams provided by HLW Salt Waste Processing Design Engineering as of 5/10/01. Jumper quantities were extracted from the "In Cell Equipment" sections of the draft estimates developed for the pending Conceptual Design Data Report update. The jumper count varies for both the Caustic Side Solvent Extraction and CST Ion Exchange options from the last Data Call Report due to information derived from the recent R&D efforts. Instrumentation quantities were extracted from the "In-Cell" portions of the referenced flowsheets.

1. High Level Waste Salt Processing Caustic Side Solvent Extraction, Rev. F, Dwg. No. XM5H0053F
2. High Level Waste Salt Processing Small Tank TPB Precipitation, Rev. E, Dwg. No. XM5J0001E
3. High Level Waste Salt Processing CST Ion Exchange, Rev. H, Dwg. No. XM5H0056H
4. Bases, Assumptions, and Results of Flowsheet calculations for the Decision Phase Salt Disposition Alternatives, Document No. WSRC-RP-99-00006, Rev. 2.

Submittal Description:

An accounting of each of the three options is described on the following pages. Operational components for each option, (i.e. tank sizes, transfer pumps, sample pumps, agitators, etc.), are listed as well as an executive summary of the process control strategies that will be employed. Based on the current process flow diagrams, there are no complex control methodologies that need to be implemented for any of the processes. Basic Closed-Loop control will meet the majority of the needs of each facility while a small number of Advanced Regulatory Control loops (cascade, feed forward, model based control) will be employed to address certain process requirements. A need for Advanced Process Control technologies has not been identified at this point. From a Control Room Operator's perspective, none of the three options are considered complex to control or maintain within its normal ranges of operation. Additionally, based on the current reference data, the only criteria that could be employed to determine controls simplicity would be the instrumentation count for each option.

Caustic Side Solvent Extraction Option

Cold Feeds Area	Equipment	Capacity (gal)
	Process Water Tank 2 transfer pumps	25,000
	Chemical Additive Tank 2 transfer pumps 1 agitator	100
	Strip Makeup Tank 1 transfer pump 1 agitator 1 sample pump	25,000
	Scrub Makeup Tank 2 transfer pumps 1 agitator 1 sample pump	15,000
	Nitric Acid Feed Tank 2 transfer pumps	1,000
	Simulated Salt Solution Makeup Tank 2 transfer pumps	4,000
	Nitric Acid Charge Tank 50% HNO3	1
	Caustic Feed Tank 0.5 mol. 2 transfer pumps	1,000
	MST Loading Station 1 transfer pump	55
	Wash Water Hold Tank 2 transfer pumps 1 agitator	25,000
	Caustic Storage Tank 2 transfer pumps	5,000
	Caustic Makeup Tank 2 transfer pumps 1 agitator 1 sample pump	100
	ISOPAR Hold Tank 2 transfer pumps 1 agitator	5,000

	Caustic Dilution Feed Tank 1 transfer pump	15,000
	ISOPAR Makeup Tank 2 transfer pumps 1 sample pump	2,000
	Extractant Makeup Tank 2 transfer pumps 1 agitator 1 sample pump	50
	Modifier Makeup Tank 2 transfer pumps 1 agitator 1 sample pump	500
	Trioctylaine Tank 2 transfer pumps 1 agitator 1 sample pump	5
	Solvent Wash Solution Makeup Tank 1 transfer pump 1 agitator 1 sample pump	1,000
	ETF Bottoms Tank 2 transfer pumps 1 agitator	50,000
Operating Corridor	**Equipment**	**Capacity (gal)**
	MST Storage Tank 2 transfer pumps 1 agitator	400
	Oxalic Acid Feed Tank 1 transfer pump 1 agitator	200
	Filter Cleaning Caustic Tank 1 transfer pump 1 agitator	500
	Simulated Salt Solution Feed Tank 2 transfer pumps	4,000
	ISOPAR Feed Tank 2 transfer pumps	500

	Scrub Feed Tank 2 transfer pumps 1 agitator	2,500
	Strip Feed Tank 2 transfer pumps 1 agitator	4,000
	Solvent Makeup Tank 1 transfer pump 1 agitator 1 sample pump	1,000
	3 Back Pulse Tanks	

Shielded Processing Cells	**Equipment**	**Capacity (gal)**
	Alpha Sorption Tank 4 transfer pumps 1 agitator 1 sample pump	88,000
	Sludge Solids Receipt Tank 2 transfer pumps 1 agitator 1 sample pump	10,000
	Salt Solution Feed Tank 2 transfer pumps 1 agitator 1 sample pump	30,000
	Cleaning Solution Dump Tank 3 transfer pumps 1 sample pump	1,000
	2 Filters	
	Strip Effluent Stilling Tank 2 transfer pumps	500
	3 Wash Filters	
	Solvent Wash Tank 2 transfer pumps 1 agitator 1 sample pump	1,000

	Solvent Hold Tank 1 transfer pump 1 agitator 1 sample pump	1,000
	40 Extractors	
	Kerosene Still	TBD
	Kerosene Condensate Tank	TBD
	Aqueous Rafinate Stilling Tank 3 transfer pumps	500
	BA-137 Decay Tank #1 1 transfer pump 1 agitator	2,500
	BA-137 Decay Tank #2 1 transfer pump 1 agitator	2,500
	DWPF Salt Feed Tank 2 transfer pumps 1 agitator 1 sample pump	100,000
	Filter Feed Tank 4 transfer pumps 1 agitator	111,000
	Caustic Solvent Wash Tank 1.0 mol 2 transfer pumps 1 agitator 1 sample pump	1,000
	Strip Holding Tank 1 process pump	N/A (Existing LPPP Precipitate Tank)
	4 Moisture Separators	
	4 HEPA Filters	
	8 Blowers	
Low Shield Area	**Equipment**	**Capacity (gal)**
	DSS Hold Tank #1 2 transfer pumps 1 agitator 1 sample pump	100,000
	DSS Hold Tank #2 2 transfer pumps	100,000

	1 agitator 1 sample pump	
In-Cell Jumpers	Process Jumpers	158
	Process Jumpers w/ 1 MOV `	15
	3-way Process Jumpers	5
	3-way Process Jumpers w/ 2 MOV	1
	Electrical Jumpers	95
	Instrumentation Jumpers	37
Process Controls	Instruments	112
	Closed-Loop Control Algorithms	28
	Cascaded Control Algorithms	3
	Model Based Control Algorithms	1
New Pump Pit	Pump Pit Sludge Tank	10,000
In DWPF Salt Cell	MST/Sludge Tank 1 transfer pump 1 agitator 1 sample pump	10,000
	Strip Effluent Hold Tank 1 transfer hold tank 1 agitator	10,000

Small Tank TPB Option

Cold Feeds Area	**Equipment**	**Capacity (gal)**
	Process Water Tank 2 transfer pumps	80,000
	NaTPB Storage Tank 2 transfer pumps	20,000
	Anti Foam Storage Tank 1 transfer pump	600
	Caustic Storage Tank 2 transfer pumps	5,000
	Organic Waste Storage Tank 1 transfer pump	40,000

	ETF Bottoms Tank 2 transfer pumps 1 agitator	50,000
	Nitrogen Storage Facility	
	MST Drum Unloading Station 1 transfer pump	55
Operating Corridor	**Equipment**	**Capacity (gal)**
	MST Storage Tank 2 transfer pumps 1 agitator	400
	Oxalic Acid Feed Tank 1 transfer pump 1 agitator	500
	Caustic Feed Tank 1 transfer pump 1 agitator	500
	Na Feed Tank 1 transfer pumps	500
	Copper Nitrate Feed Tank 1 transfer pump	500
	Formic Acid Feed Tank 1 transfer pumps	500
	6 Back Pulse Tanks	
Shielded Processing Cells	**Equipment**	**Capacity (gal)**
	Fresh Waste Day Tank 2 transfer pumps 1 agitator	25,000
	Precipitation Tank #1 2 transfer pumps 1 agitator 1 sample pump	16,000
	Precipitation Tank #2 2 transfer pumps 1 agitator 1 sample pump	16,000

Concentrate Tank 5 transfer pumps 1 agitator 1 sample pump	10,000
Cleaning Solution Dump Tank #1 1 transfer pump 1 agitator	1,000
3 Concentrate filters	
Recycle Wash Hold Tank 1 transfer pump 1 agitator 1 sample pump	25,000
Wash Tank 5 transfer pumps 1 agitator 1 sample pump	10,000
3 Wash filters	
Cleaning Solution Dump Tank #2 1 transfer pump 1 agitator	1,000
Precipitate Reactor Feed Tank 1 transfer pump 1 agitator 1 sample pump	10,000
Precipitate Reactor Tank 1 transfer pump 1 agitator 1 sample pump	10,000
Precipitate Hydrolysis Aqueous Surge Tank 2 transfer pump 1 agitator 1 sample pump	40,000
Organic Evaporator 1 transfer pump 1 agitator 1 sample pump	1,750
Organic Evaporator Condensate 2 transfer pumps 1 agitator 1 sample pump	1,000
PR Overheads Tank	7,500

	1 transfer pump	
	Filterate Hold Tank #1 2 transfer pumps 1 agitator 1 sample pump	100,000
	Filtrate Hold Tank #2 2 transfer pumps 1 agitator 1 sample pump	100,000
	Precipitate Reactor Condenser	
	Precipitate Reactor Decanter	
	Organic Evaporator Condenser	
	Organic Evaporator Decanter	
	4 In-cell Sump Pumps	
	Salt Cell Vent Condenser	
	4 Moisture Separators	
	4 HEPA Filters	
	8 Blowers	
In-Cell Jumpers	Process Jumpers	130
	Process Jumpers w/ 1 MOV	28
	3-way Process Jumpers	3
	3-way Process Jumpers w/ 2 MOV	1
	Electrical Jumpers	53
	Instrumentation Jumpers	48
Process Controls	Instruments	129
	Closed-Loop Control Algorithms:	51
	Cascaded Control Algorithms:	2
	Model Based Control Algorithms:	0

CST Ion Exchange Option

The CST Ion Exchange option is the only one that requires the use of jumper movement to support normal operations, increasing operational complexity. The alternative to the use of jumpers requires a minimum of 32 jumpers, 16 for the MOVs (to allow maintenance), and the related 16 electrical jumpers for power and control. The use of large numbers of MOVs in a high radiation environment introduces a reliability penalty.

Cold Feeds Area	**Equipment**	**Capacity (gal)**
	Process Water Tank 2 transfer pumps	20,000
	Caustic Storage Tank 2 transfer pumps	5,000
	ETF Bottoms Tank 2 transfer pumps 1 agitator	50,000
	MST Drum Unloading Station 1 transfer pump	55

Operating Corridor	**Equipment**	**Capacity (gal)**
	MST Storage Tank 2 transfer pumps 1 agitator	400
	Oxalic Acid Feed Tank 1 transfer pump 1 agitator	200
	Filter Cleaning Caustic Tank 1 transfer pump 1 agitator	500
	Caustic Feed Tank 2 transfer pumps 1 agitator 1 sample pump	15,000
	Column Treatment Tank 2 transfer pumps 1 agitator	5,000
	Fines Hold Tank 1 transfer pump	1,000
	Column Preparation Tank	6,000
	2 Back Pulse Tanks	

Shielded Processing Cells	Equipment	Capacity (gal)
	Alpha Sorption Tank 1 transfer pump 1 agitator 1 sample pump	88,000
	Recycle Blend Tank 3 transfer pumps 1 agitator 1 sample pump	30,000
	Wash Water Hold Tank 2 transfer pumps 1 agitator 1 sample pump	25,000
	Loaded Resin Hold Tank #1 2 transfer pumps 1 sample pump	15,000
	Loaded Resin Hold Tank #2 2 transfer pumps 1 sample pump	15,000
	Product Holdup Tank #1 3 transfer pumps 1 agitator 1 sample pump	5,000
	2 filters	
	4 CST Ion Exchange Columns	
	Product Holdup Tank #2 3 transfer pumps 1 agitator 1 sample pump	5,000
	Sludge Solids Receipt Tank 3 transfer pump2 1 agitator 1 sample pump	10,000
	1 Wash Filter	
	Cleaning Solution Dump Tank 3 transfer pumps 1 agitator 1 sample pump	1,000

	DSS Hold Tank #1 2 transfer pumps 1 agitator 1 sample pump	120,000
	DSS Hold Tank #2 2 transfer pumps 1 agitator 1 sample pump	120,000
	Filter Feed Tank 3 transfer pumps 1 agitator 1 sample pump	111,000
	Caustic Hold Tank 1 transfer pump 1 agitator	15,000
	4 Column Heat Exchangers	
	4 Column Recirculation Pumps	
	1 Resin Cyclone	
	1 Resin Grinder	
	3 In-cell Sump Pumps	
	4 Moisture Separators	
	4 HEPA Filters	
	8 Blowers	
In-Cell Jumpers	Process Jumpers	151
	Process Jumpers w/ 1 MOV	13
	3-way Process Jumpers	4
	3-way Process Jumpers w/ 2 MOV	1
	Electrical Jumpers	46
	Instrumentation Jumpers	47
Process Controls	Instruments	145
	Closed-Loop Control Algorithms:	21
	Cascaded Control Algorithms:	3
	Model Based Control Algorithms:	0
New Pump Pit	Pump Pit Resin Tank 1 transfer pump	15,000

In DWPF Salt Cell	MST/Sludge Tank 1 transfer pump 1 agitator 1 sample pump	10,000
	Resin Hold Tank 1 transfer pump 1 agitator	10,000

Appendix B

FINAL SCORING ANALYSIS FOR THE SALT PROCESSING PROJECT TECHNOLOGY DOWN-SELECTION

Appendix B

FINAL SCORING ANALYSIS FOR THE SALT PROCESSING PROJECT TECHNOLOGY DOWN-SELECTION

This appendix documents the protocol that the TWG used to develop the scores for each of the technology alternatives using the 11 criteria identified in the body of this report. The TWG heard updates on the status of each technology and input from the TAT and TFA that each thought relevant to the scoring. They used the data packages for each technology provided in Appendix A of this report. They extracted from these data packages critical measures that they believed accurately reflected the performance of each technology against that criterion. The TWG had previously established normalization relationship with which they converted these critical measures to utility scores. The critical measures were converted to utility scores that are shown in the "calculated score" row of the summary tables. The TWG also allowed itself the option of over riding the calculated scores in cases where they had information that indicated that such actions were appropriate. The following charts for the TWG scoring explain the basis for scores, including where the TWG opted to over ride the calculated value. The final scoring results are summarized in the consumer report format in Table B-16.

Table B-1. Scoring Summary Matrix for Criterion 1, Schedule Risk

	Pt. Value		**CST**	**CSSX**	**STTP**	Linear Scoring Values
Initiate Design	1 point per 200 (million)	Linear	101	55	40	1 5
Calculated Score			2.0	3.4	3.8	135 0
Override scores to ? Rationale?						
						Linear Scoring Values
Schedule Uncertainty (technical and programmatic)		Linear	61	40	34	1 5
Calculated Score			3.0	4.5	5.0	87 34
Override score to ? Rationale?			2 **Requires new column design**	5 **Simulated and hot waste resembled real waste without new uncertainties**		
1. Schedule Risk	Score		**2.0**	**5.0**	**5.0**	Data Validated

Figure B-1. Schedule Risk Score

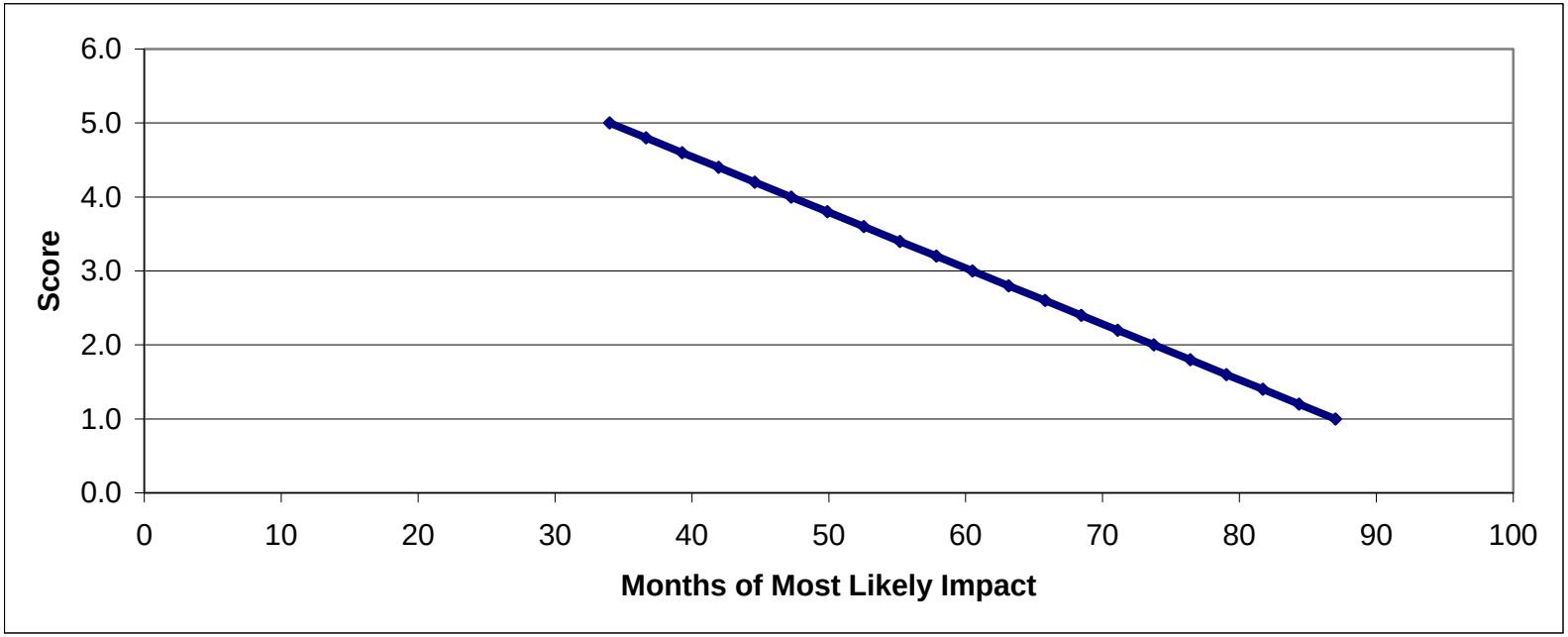


Table B-2. Scoring Summary Matrix for Criterion 2, Project Reduction Potential

	Pt. Value	CST	CSSX	STTP	Linear Scoring Values		
Project Reduction Potential		40.25	40.75	16	1	5	Sub-Weight
Calculated Score		3.0	3.0	1.8	0	80	1
Override scores to ?				2			
Rationale?				**Only penalized one point due to being optimized already**			Units Estimated savings potential (sum of prob * cons)
2. Project Reduction Potential	Score	**3.0**	**3.0**	**2.0**	Data Validated		

Figure B-2. Project Reduction Potential Scoring Relationship

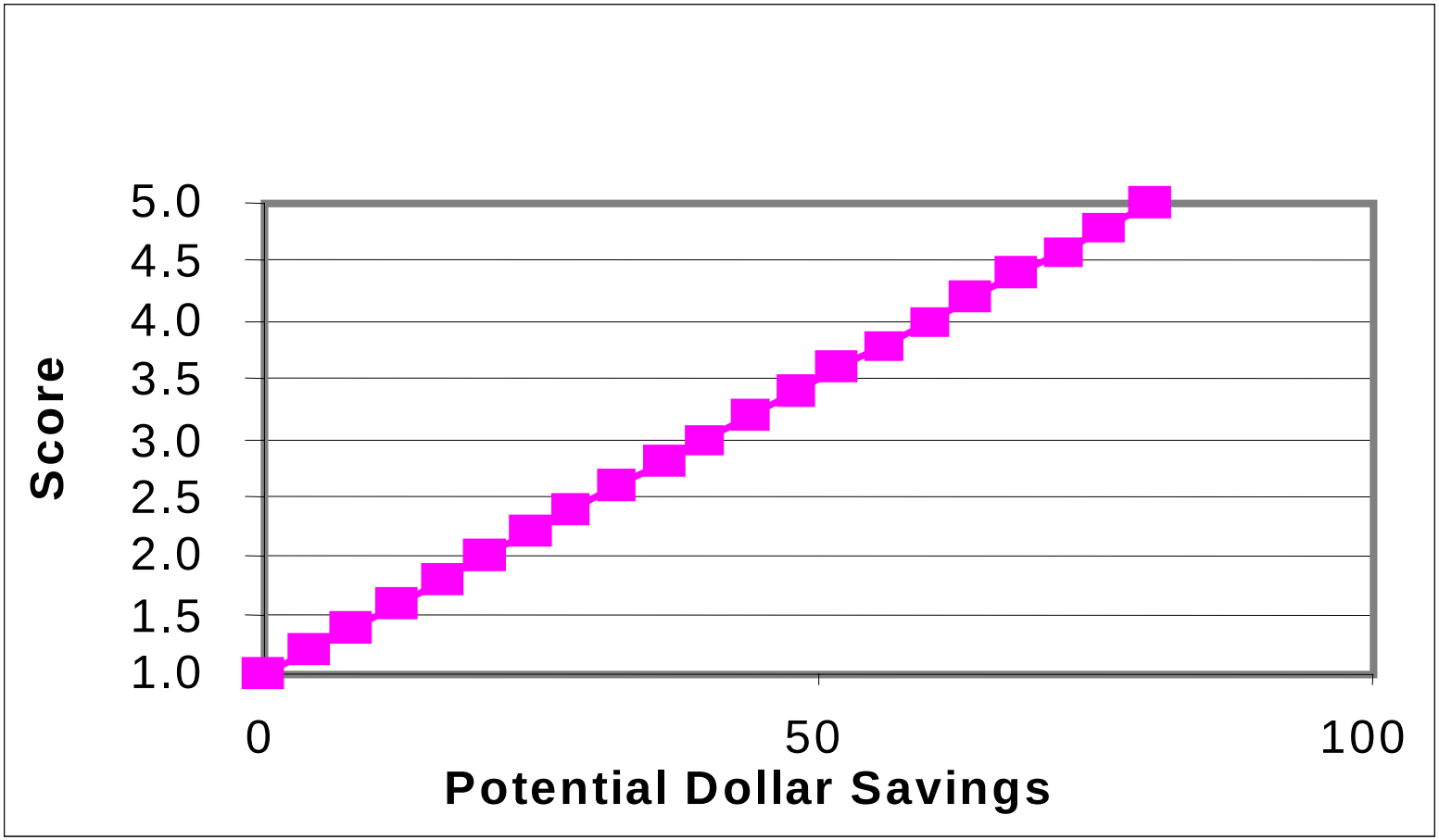


Table B-3. Scoring Summary Matrix for Criterion 3, Life Cycle Costs through D&D

	Pt. Value	CST	CSSX	STTP	Linear Scoring Values		
Total Project Cost		1351	1601	1297	1	5	Sub-Weight
Calculated Score		3.6	2.6	3.8	2000	1000	0.8
Override scores to ?							
Rationale?							Units 1999 Yr Dollars
					Linear Scoring Values		
Life Cycle Cost		2462	3144	2681	1	5	0.2
Calculated Score		**4.1**	**2.7**	**3.6**	4000	2000	
Override scores to ?							Units
Rationale?							1999 Yr Dollars
3. Life Cycle Costs through D&D	Score	**3.7**	**2.6**	**3.8**	Data Validated		

Figure B-3. Graphic of Scoring Relationship for Total Project Cost

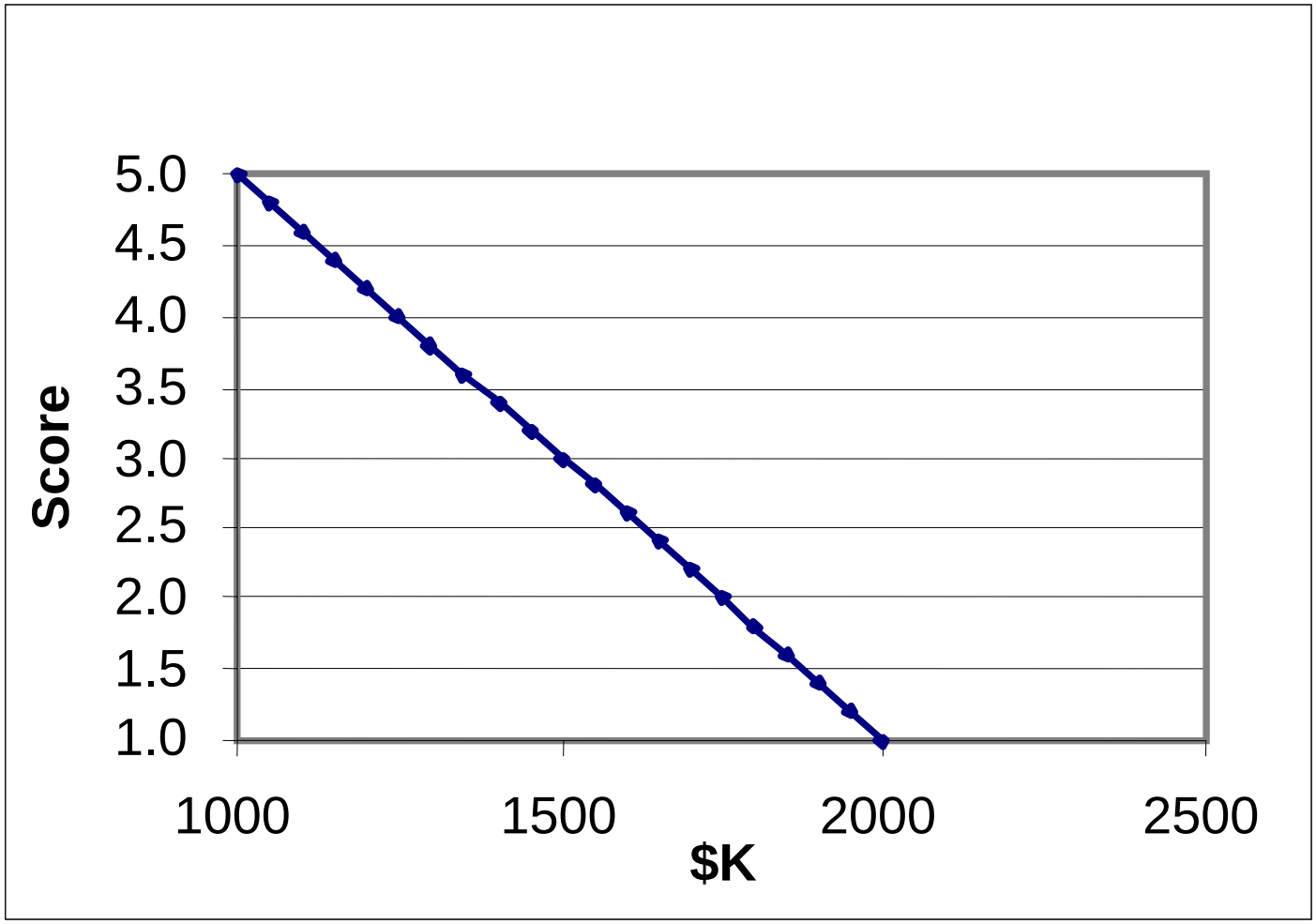


Figure B-4. Graphic of Scoring Relationship for Life Cycle Cost

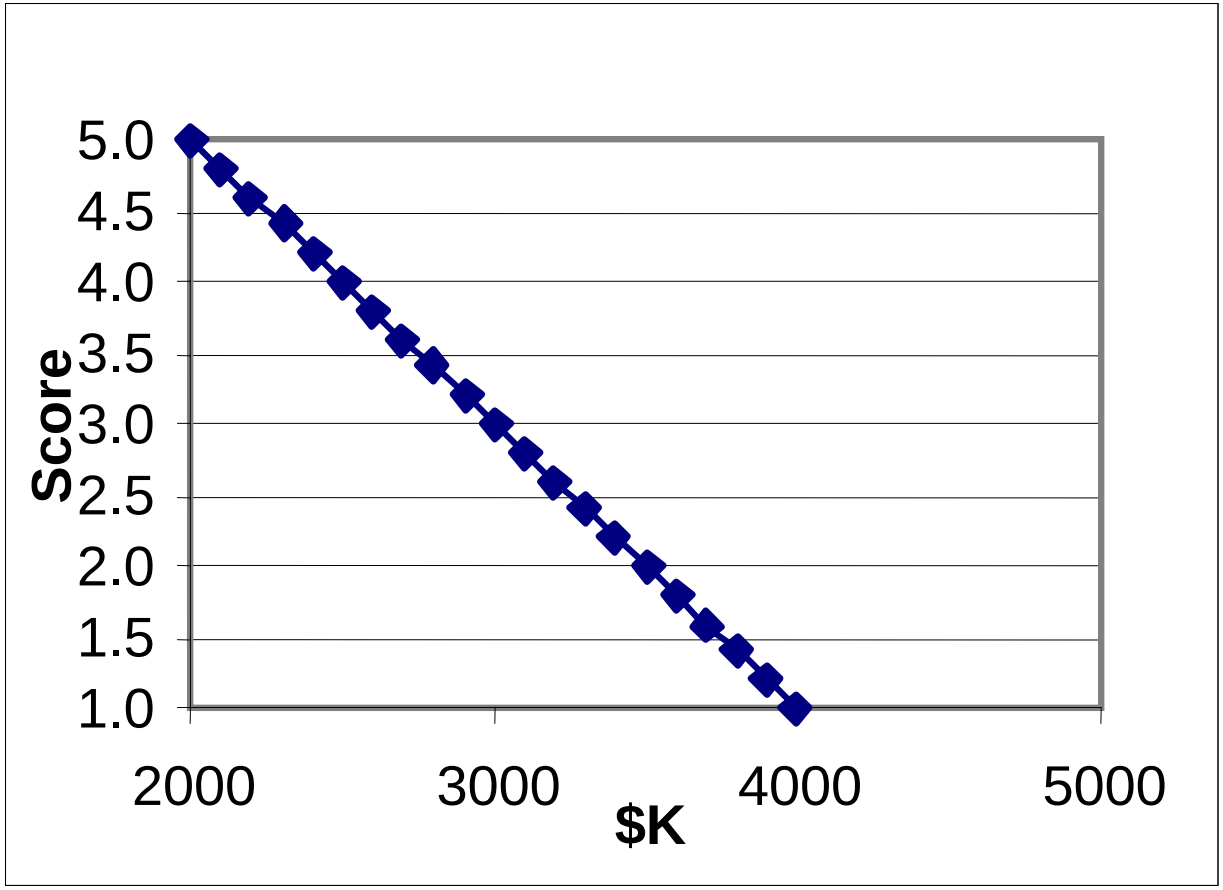


Table B-4. Scoring Summary Matrix for Criterion 4, Technical Maturity

	Pt. Value		CST	CSSX	STTP	Linear Scoring Values		
MST Maturity	One maturity stage per point	Linear	3.8	3.8	4.7	1	5	Sub-Weight
Calculated Score			3.8	3.8	4.7	1	5	
Override scores to ?								
Rationale?								Units TFA Maturity scale average
						Linear Scoring Values		
Cs Separations	One maturity stage per point	Linear	3.9	3.7	4.3	1	5	
Calculated Score			**3.9**	**3.7**	**4.3**	1	5	
Override scores to ?					4.1			Units
Rationale?								TFA Maturity scale average
4. Technical Maturity	Score		**3.9**	**3.8**	**4.4**	Data Validated		

Figure B-5. Graphic of Scoring Relationship for MST Technical Maturity

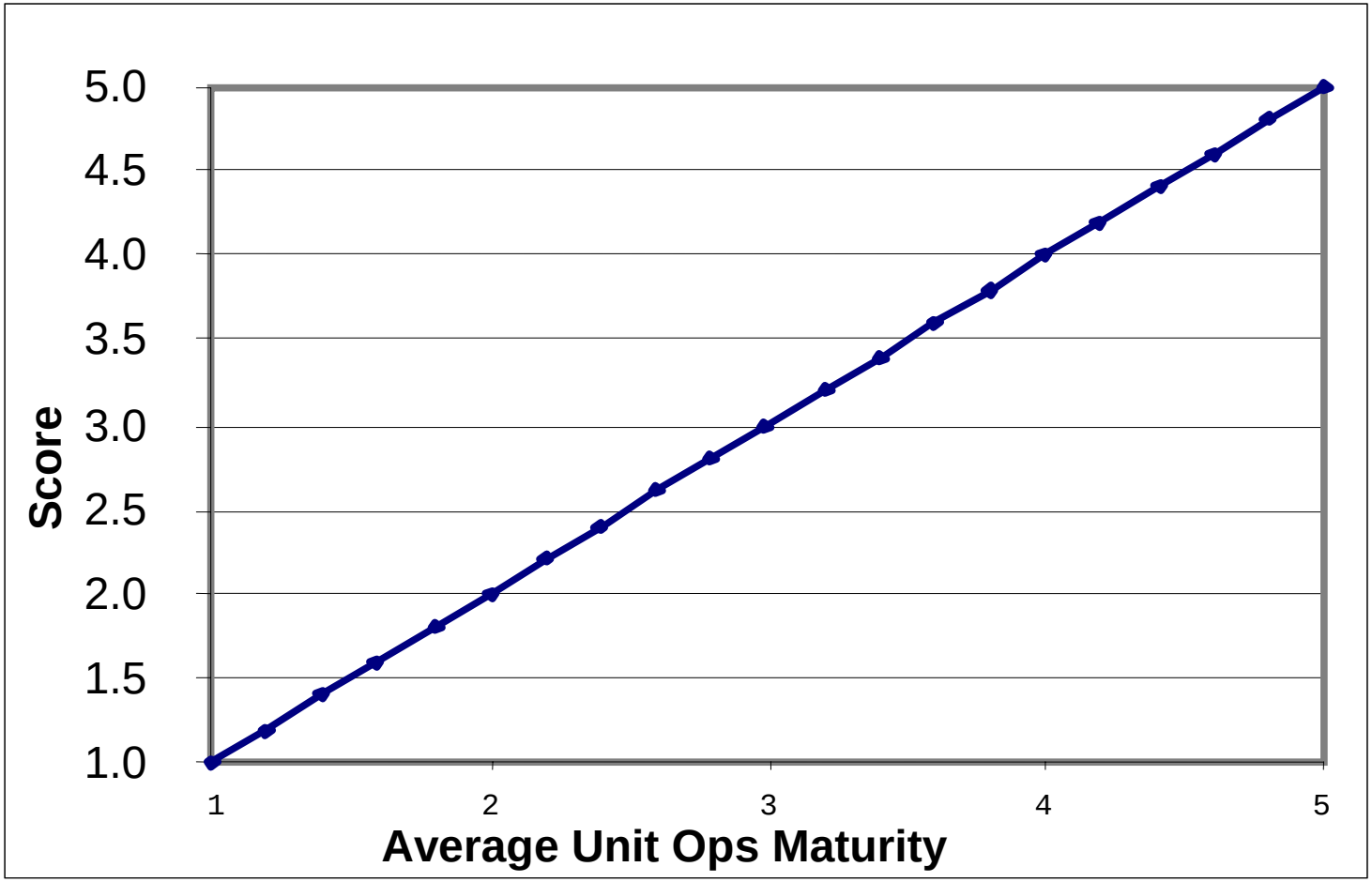


Figure B-6. Graphic of Scoring Relationship for CS Separation Technical Maturity

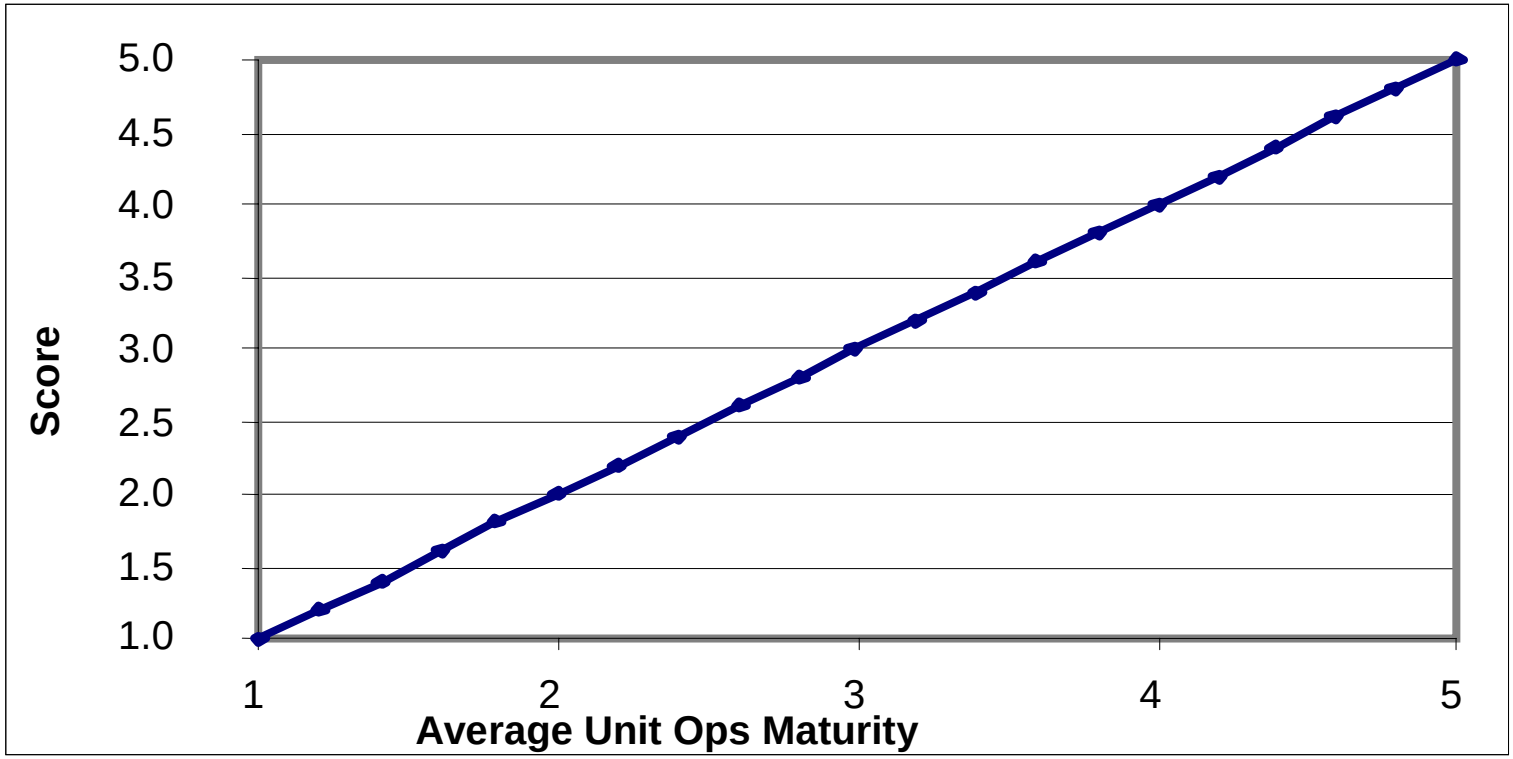


Table B-5. Scoring Summary Matrix for Criterion 5, Implementation Confidence

	Pt. Value		CST	CSSX	STTP	Linear Scoring Values		
Confidence of Implementation	One maturity stage per point	Linear	5	5	4	1	5	Sub-Weight
Calculated Score			5.0	5.0	4.0	1	5	1
Override scores to ?			2	4				
Rationale?			**No experience with equipment to unplug a loaded column and filter pumps size, new column design has little experience**	**Filter and pump size, solvent components not readily available**				Units TFA Equipment Maturity average
5. Implementation Confidence	Score		**2.0**	**4.0**	**4.0**	Data Validated		

Figure B-7. Graphic of Scoring Relationship for CS Separation Implementation Confidence

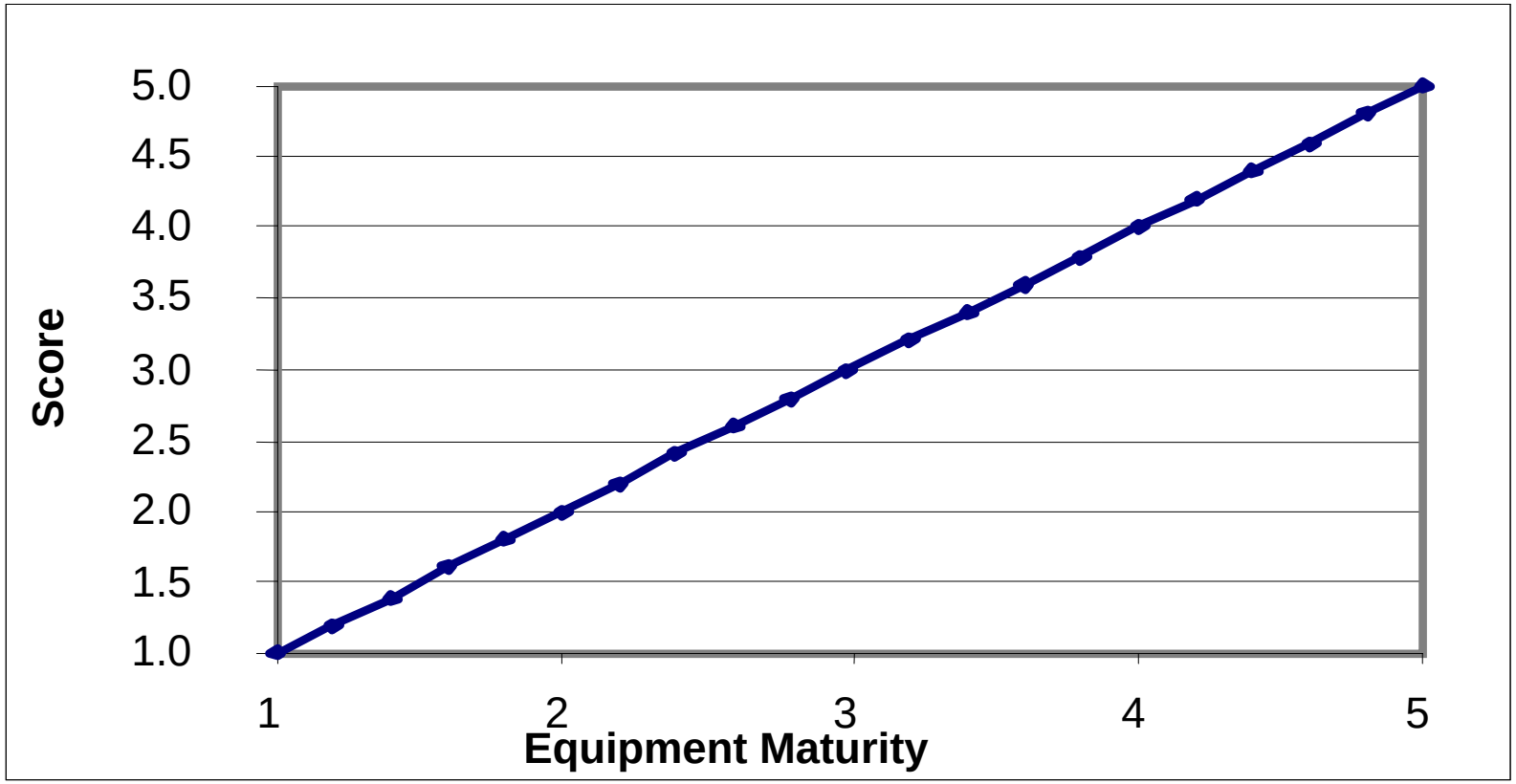


Table B-6. Scoring Summary Matrix for Criterion 6, Environmental Impacts

	Pt. Value	CST	CSSX	STTP	Non-Linear Scoring Values		
Organic Release		1660	1660	6735	1	5	Sub-Weight
Calculated Score		5.0	5.0	3.9	100000	1660	0.9
Override scores to ?							
Rationale?					50000	50000	Units Percent of allowed benzene under permit
					Non-Linear Scoring Values		Sub-Weight
Secondary Organic Waste		0	333	73000	1	5	0.1
Calculated Score		**5.0**	**4.3**	**1.0**	73000	0	
Override scores to ?					3	3.01	Units m3 of secondary organic waste
Rationale?							
6. Environmental Impacts	Score	**5.0**	**4.9**	**3.6**	Data Validated		

Figure B-8. Graphic of Scoring Relationship for Organic Releases

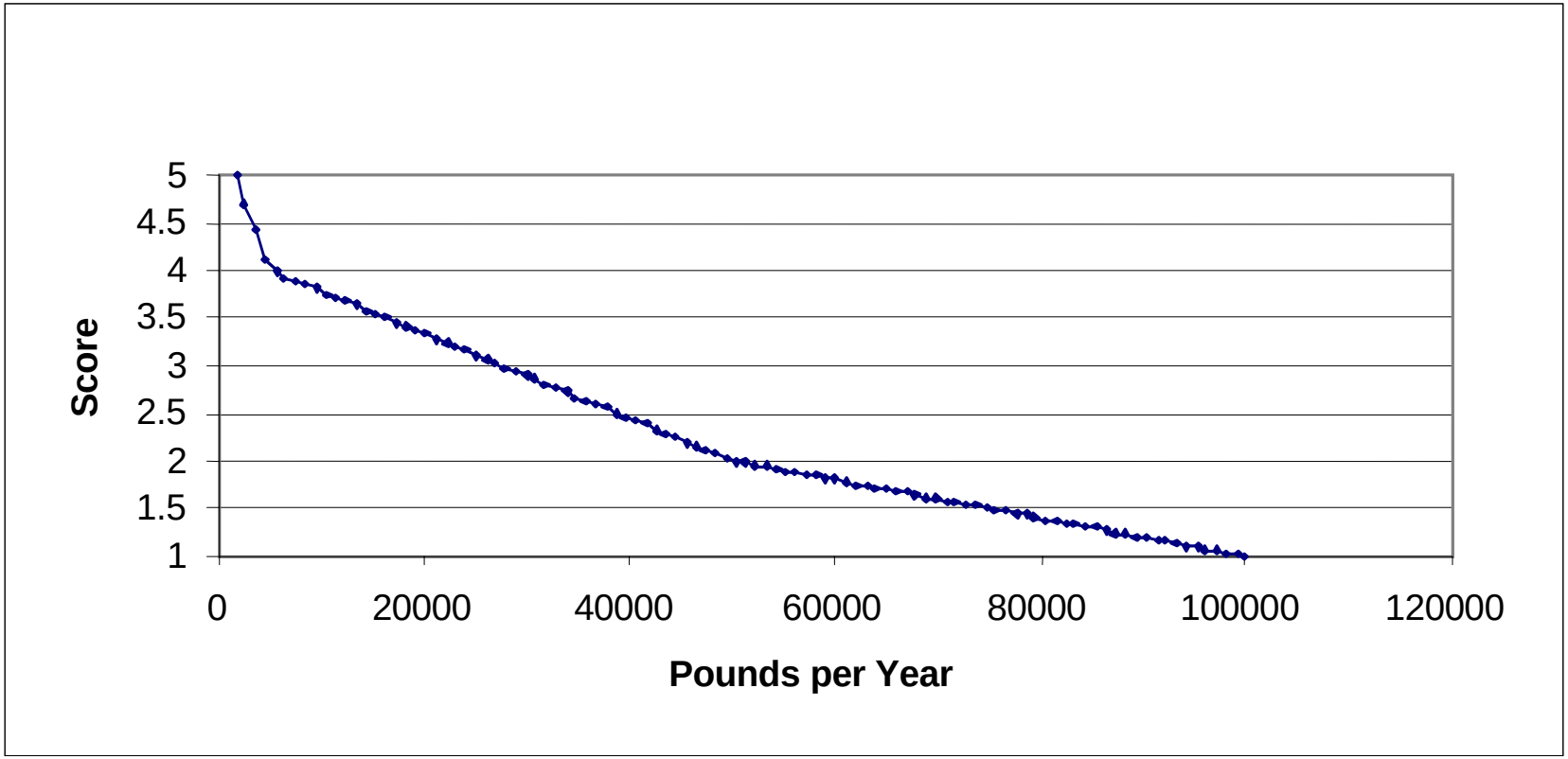


Figure B-9. Graphic of Scoring Relationship for Secondary Organic Waste

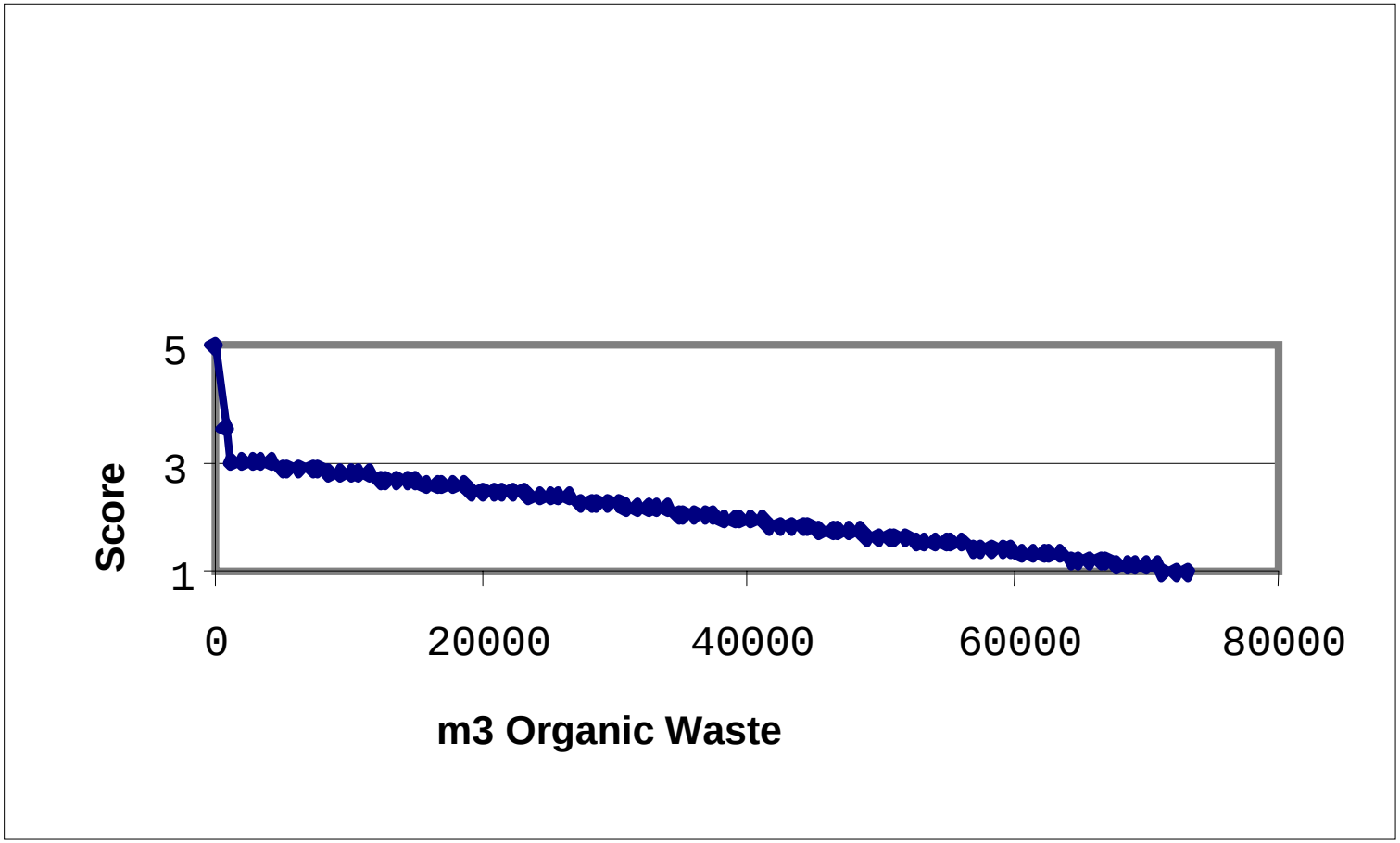


Table B-7. Scoring Summary Matrix for Criterion 7, Impact of Interfaces at DWPF

	Pt. Value		CST	CSSX	STTP	Linear Scoring Values		
Extent of Upgrades		Linear	36	36	11	1	5	Sub-Weight
Calculated Score			3.6	3.6	4.6	100	0	1
Override scores to ?								
Rationale?						**now that the complex operations were moved to the salt facility**		Units Millions of dollars upgrade to existing facilities
7. Impact of Interfaces at DWPF	Score		**3.6**	**3.6**	**4.6**	Data Validated		

Figure B-10. Graphic of Scoring Relationship for DWPF Canister Production Loss

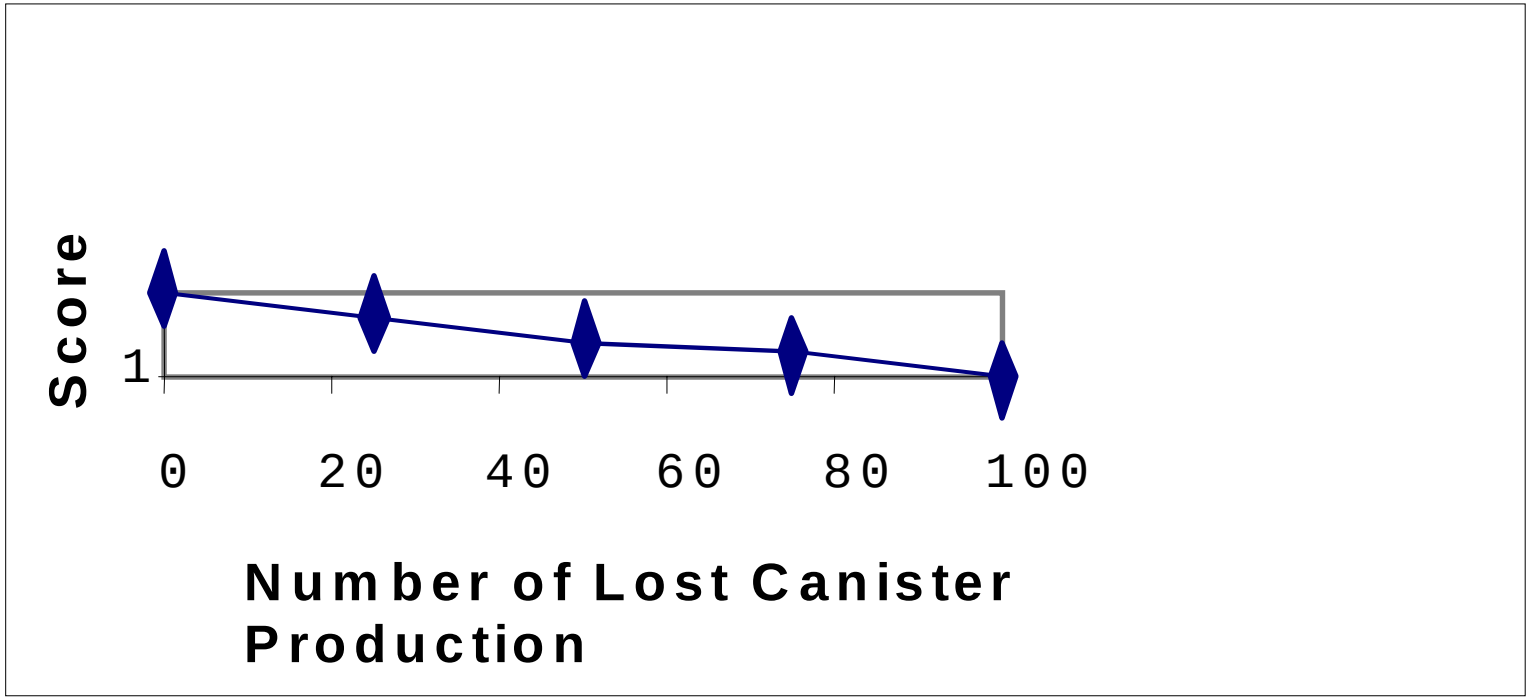


Figure B-11. Graphic of Scoring Relationship for Upgrades Required to DWPF

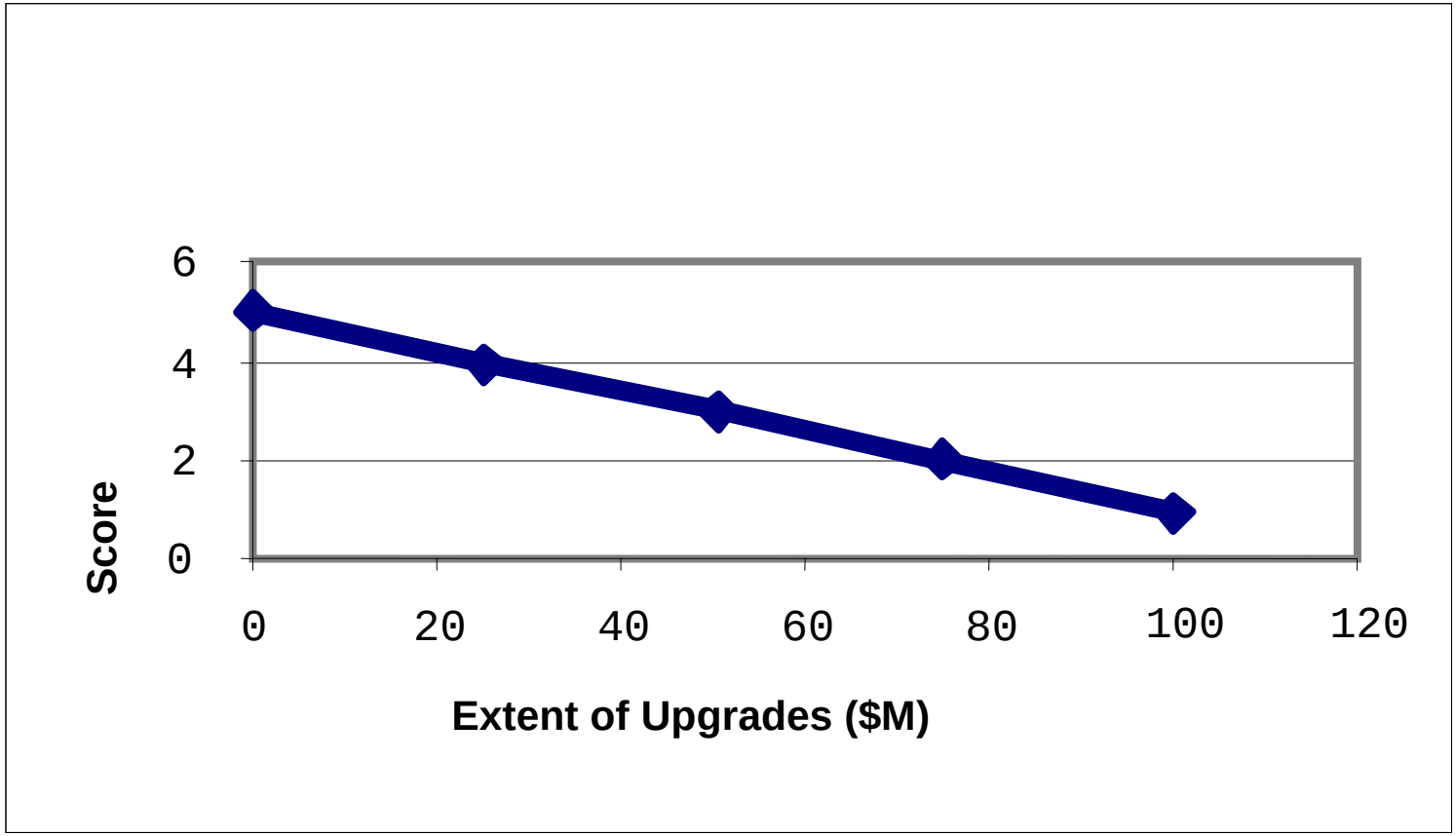


Table B-8. Scoring Summary Matrix for Criterion 8, Process Simplicity of System Interfaces

	Pt. Value	CST	CSSX	STTP	Linear Scoring Values		
Number of Complexities for Interfacing System	One point for each two complexities	8	2	4	1	5	Sub-Weight
Calculated Score		1.8	4.2	3.4	10	0	1
Override scores to ?							
Rationale?		**Product transfer and what DWPF has to do to process (grinding, settling in line-slurry transfer, batch transfer, glass production slowdown (viscosity) glass durability (requalification), sampling)**	**Product transfer and what DWPF has to do to process (nitric acid)**	**Product transfer and what DWPF has to do to process (ppt hydrolysis, periodic transfer)**			Units Number of process complexities
8. Process Simplicity of System Interfaces	Score	**1.8**	**4.2**	**3.4**	Data Validated		

Figure B-12. Graphic of Scoring Relationship for Process Simplicity

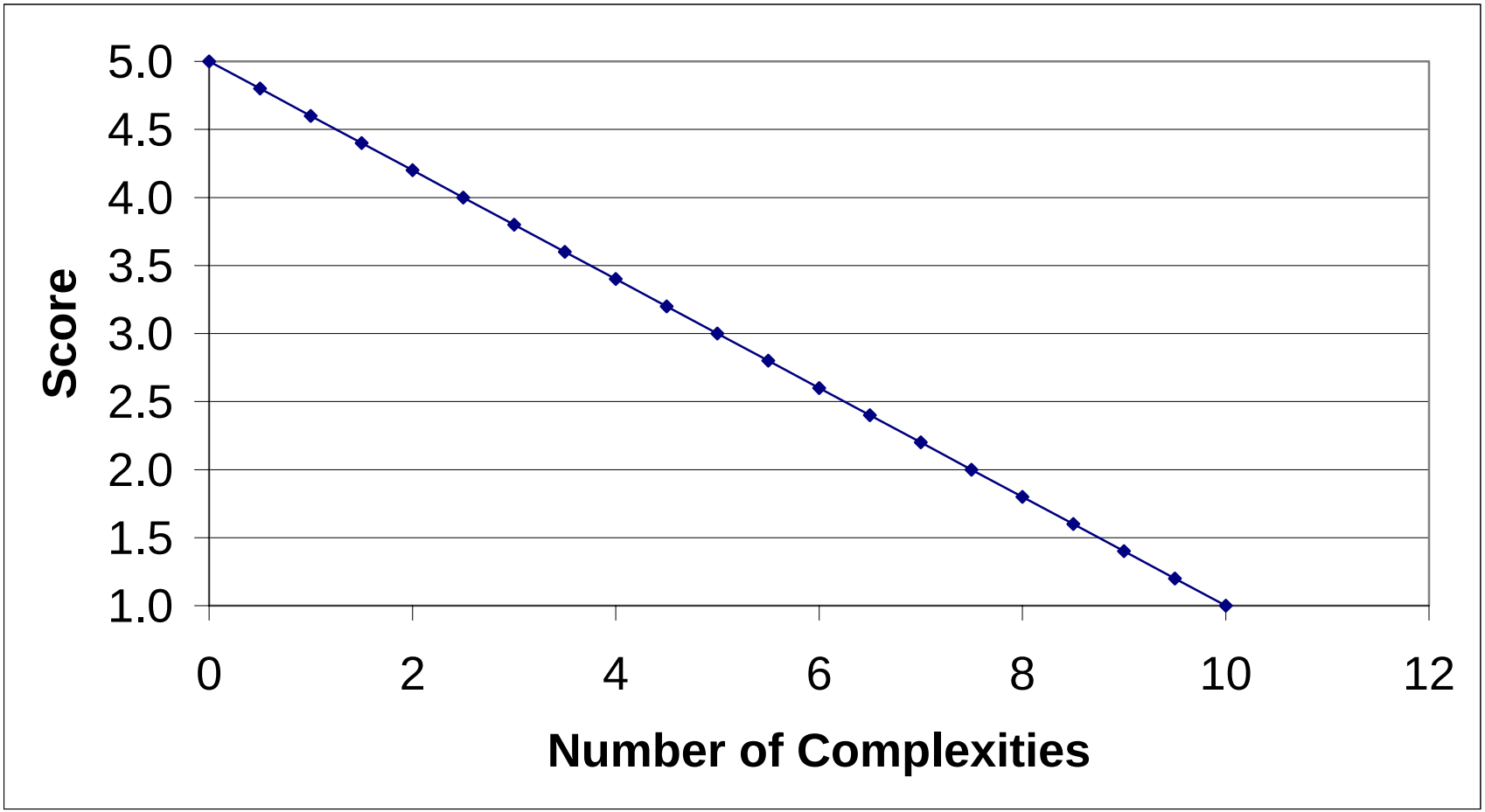


Table B-9. Scoring Summary Matrix for Criterion 9, Levels of Safety Control Mitigation

	Pt. Value		CST	CSSX	STTP	Linear Scoring Values		
Safety Controls Authorization		Linear	35	35	38	1	5	Sub-Weight
Calculated Score			4.3	4.3	3.9	60	30	1
Override scores to ?			1	4.5	2.5			
Rationale?			**Safety issues associated based on probability and consequences of loss of flow (plugging, pump, etc.) for a number of reasons (cooling)**	**Organics in process**	**Benzene safety, pressurized system (different from conventional confinement design)**			Units Number of safety controls and authoriza-tion basis
9. Levels of Safety Control Mitigation	Score		**1.0**	**4.5**	**2.5**	Data Validated		

Figure B-13. Graphic of Scoring Relationship for Levels of Safety Control

Table B-10. Scoring Summary Matrix for Criterion 10, Process Flexibility in Throughput

	Pt. Value		CST	CSSX	STTP	Linear Scoring Values		
Percent turnup available for sprinting		Linear	50%	40%	20%	1	5	Sub-Weight
Calculated Score			5.0	4.2	2.6	0%	50%	1
Override scores to ?								
Rationale?								Units Percent turnup capability
10. Process Flexibility in Throughput	Score		**5.0**	**4.2**	**2.6**	Data Validated		

Figure B-14. Graphic of Scoring Relationship for Process Flexibility in Throughput

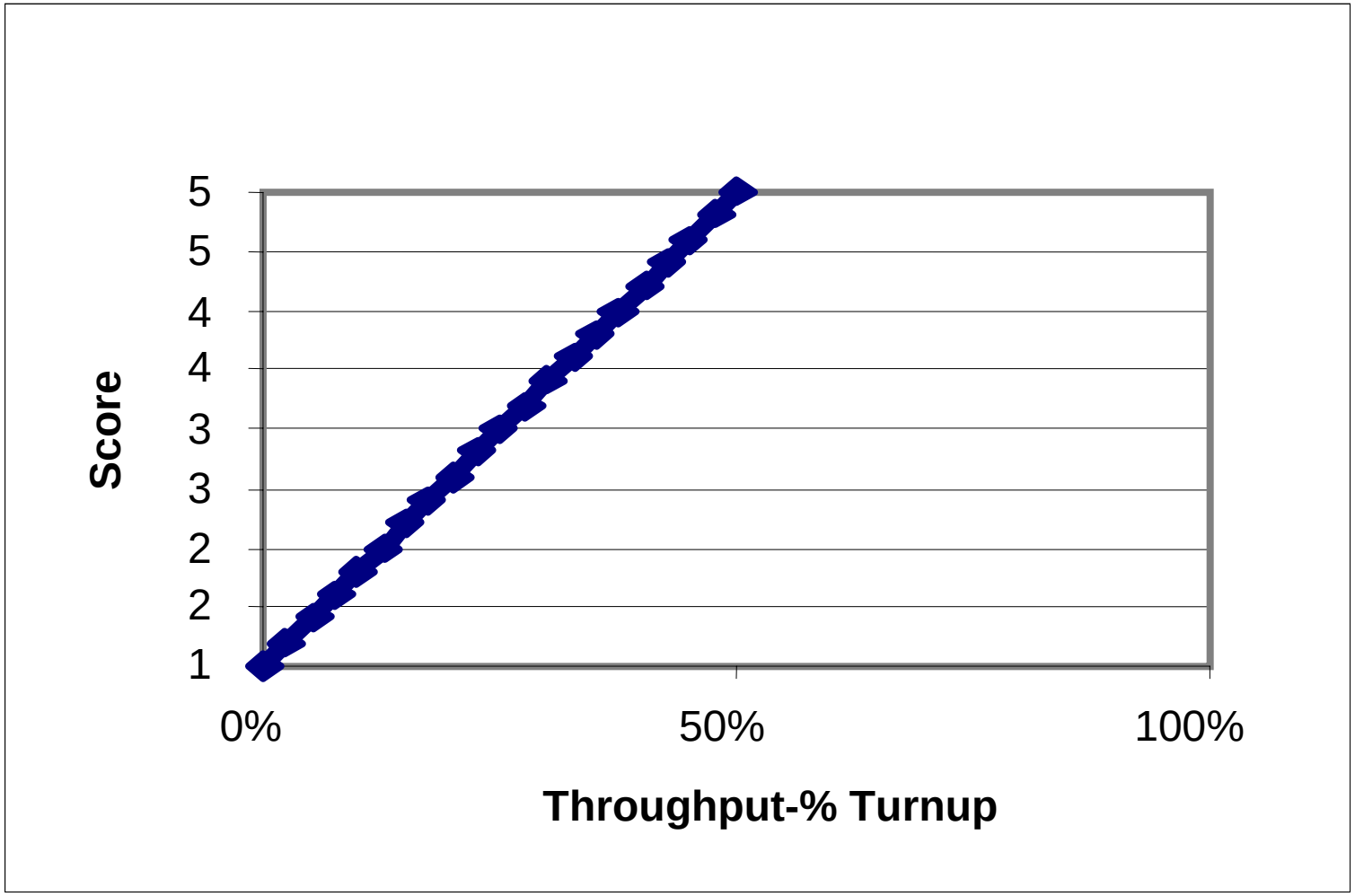


Table B-11. Scoring Summary Matrix for Criterion 11, Process Simplicity (Operability)

	Pt. Value		CST	CSSX	STTP	Linear Scoring Values		
Number Pieces of Process Equipment and Operational Complexity		Linear	262	311	263	1	5	Sub-Weight
Calculated Score			5.0	4.0	5.0	400	280	1
Override scores to ?			2	4	2			
Rationale?			**Multiple operational jumper changes in normal operations**	**10-15 years between jumper changes for motor changeout in canyon experience**	**Coupled system is complex (continuous and semi-batch coupling), inevitable to have spills and difficult to cleanup with flammable material in process**			Units Number of process jumpers
11. Process Simplicity (Operability)	Score		**2.0**	**4.0**	**2.0**	Data Validated		

Figure B-15. Graphic of Scoring Relationship to Maximize Process Operability

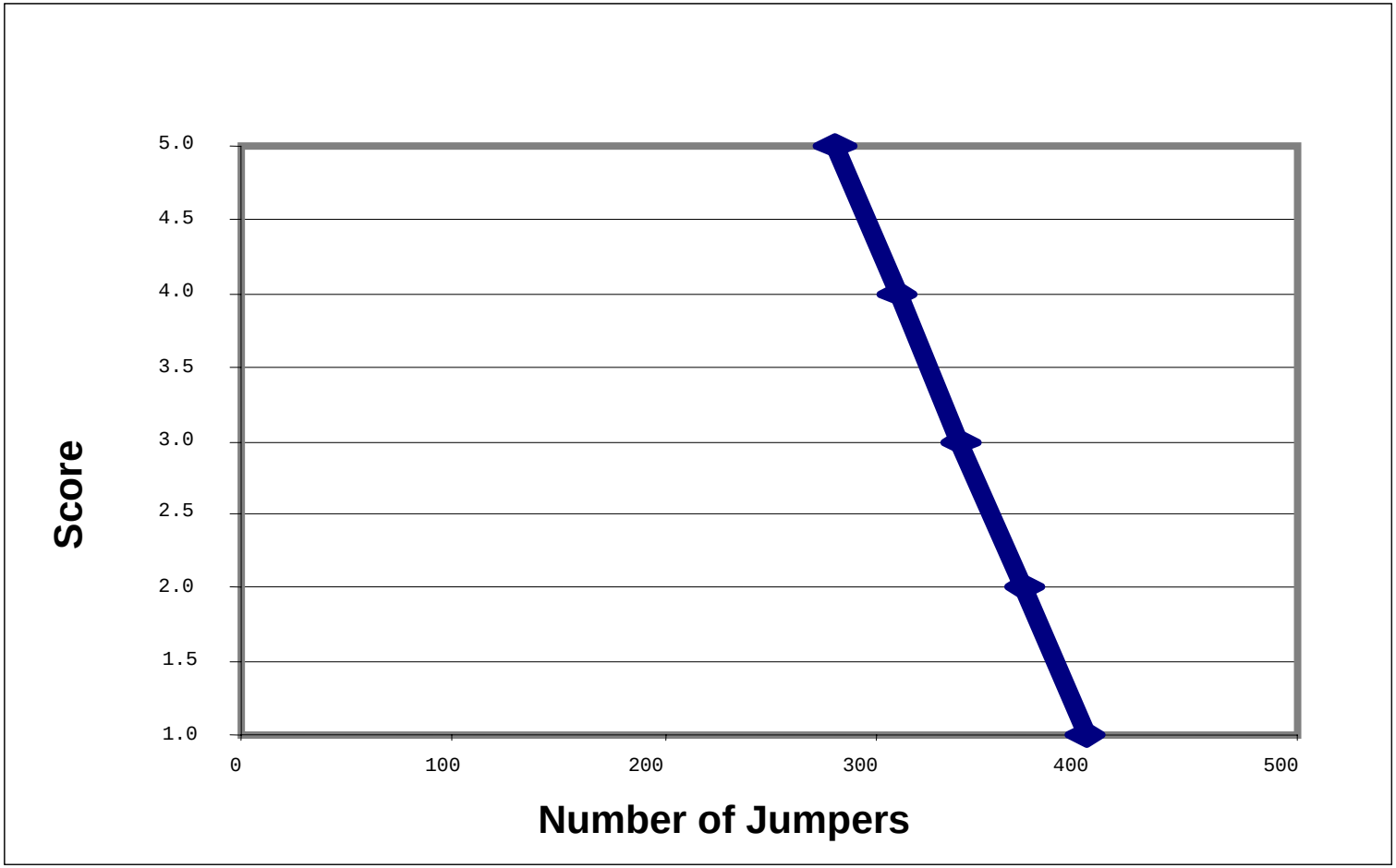


Figure B-16. Consumer Report Chart for TWG Analysis May 2001

Problem Trying to Solve: Safely and cost effectively process salt from SRS HLW tanks to a final permitted waste form(s).

Scoring 1 to 5 Scale

Alternatives

Criteria	CST Overall Score: 30%	CSSX Overall Score: 80%	STTP Overall Score: 59%
1. Schedule Risk	2.0	5.0	5.0
2. Project Reduction Potential	3.0	3.0	2.0
3. Life Cycle Costs Through D&D	3.7	2.6	3.8
4. Technical Maturity	3.9	3.8	4.4
5. Implementation Confidence	2.0	4.0	4.0
6. Environmental Impact	5.0	4.9	3.6
9. Levels of Safety Control Mitigation	1.0	4.5	2.5
7. Impacts of Interfaces at DWPF	3.6	3.6	4.6
8. Process Simplicity of System Interfaces	1.8	4.2	3.4
10. Process Flexibility in Throughput	5.0	4.2	2.6
11. Process Simplicity (Operability)	2.0	4.0	2.0

Appendix C

Scoring Sensitivity and Weighting Analyses

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Scoring Sensitivity and Weighting Analyses

As discussed in Section 2.5.4, sensitivity analyses were performed to evaluate the effects of weighting on the final scoring results. The following figures and table show how the different weighting sensitivity studies were performed for the TWG to consider.

Scoring Sensitivity

There are three aspects of sensitivity that were investigated. The utility calculation uses both the scores converted from the 1 to 5 score and the weighting of the criteria. The utility could change as the scores or the weights are varied. Three studies are presented to give perspective on the robustness or sensitivity of the preferred alternative. The sensitivity analysis will be based on the scores being varied by +-0.5 for each criterion. The graph shown in Figure C-1, shows the amount of utility score change would occur if the score was reduced or increased by the 0.5. The criteria with the largest sensitivity is Criterion 8 and 9, but even if the values were to change a full 0.5 points, the total utility score does not approach any overlapping of total scores.

Weight Sensitivity

Two types of weight sensitivity are presented. First, using the weights established by the TWG, each weight was varied from 0 to 100% where each of the weights of the other criteria are kept at the same proportion as established by the TWG. This analysis identifies where the choice could change and what the weights would need to be to change the preferred alternative. The graph shown in Figure C-2, displays the tradeoff points where the color of the bar changes as well as the weight where the tradeoff occurs. The TWG weights are shown as the diamond points. The sensitivity to these weights can be seen by the difference between the TWG weights and the tradeoff weights. The graph shows that if the weight for cost was elevated to about 0.45, the preferred alternative would be STTP.

The last sensitivity study observes the preferences for different weighting sets. This sensitivity study investigates the effects of having different values that those of the TWG. The graph in Figure C-3 shows that if cost or schedule is given a considerable amount of the total weight, the alternative STTP would be preferred. All other variations would consider CSSX as the preferred alternative. As the TWG considered the weights, an attempt should be made to avoid placing high weights to criteria with data that have low confidence of the discrimination. For instance, the cost differences between the alternatives is considered questionable due to the state of design the cost is based on (0.5% approximately). The weight cases considered are shown in Table C-1 that make up the analyses shown in Figure C-3.

Figure C-1. Scoring Sensitivity Using Three Utility Scores

Figure C-2. Weight Sensitivity Analysis

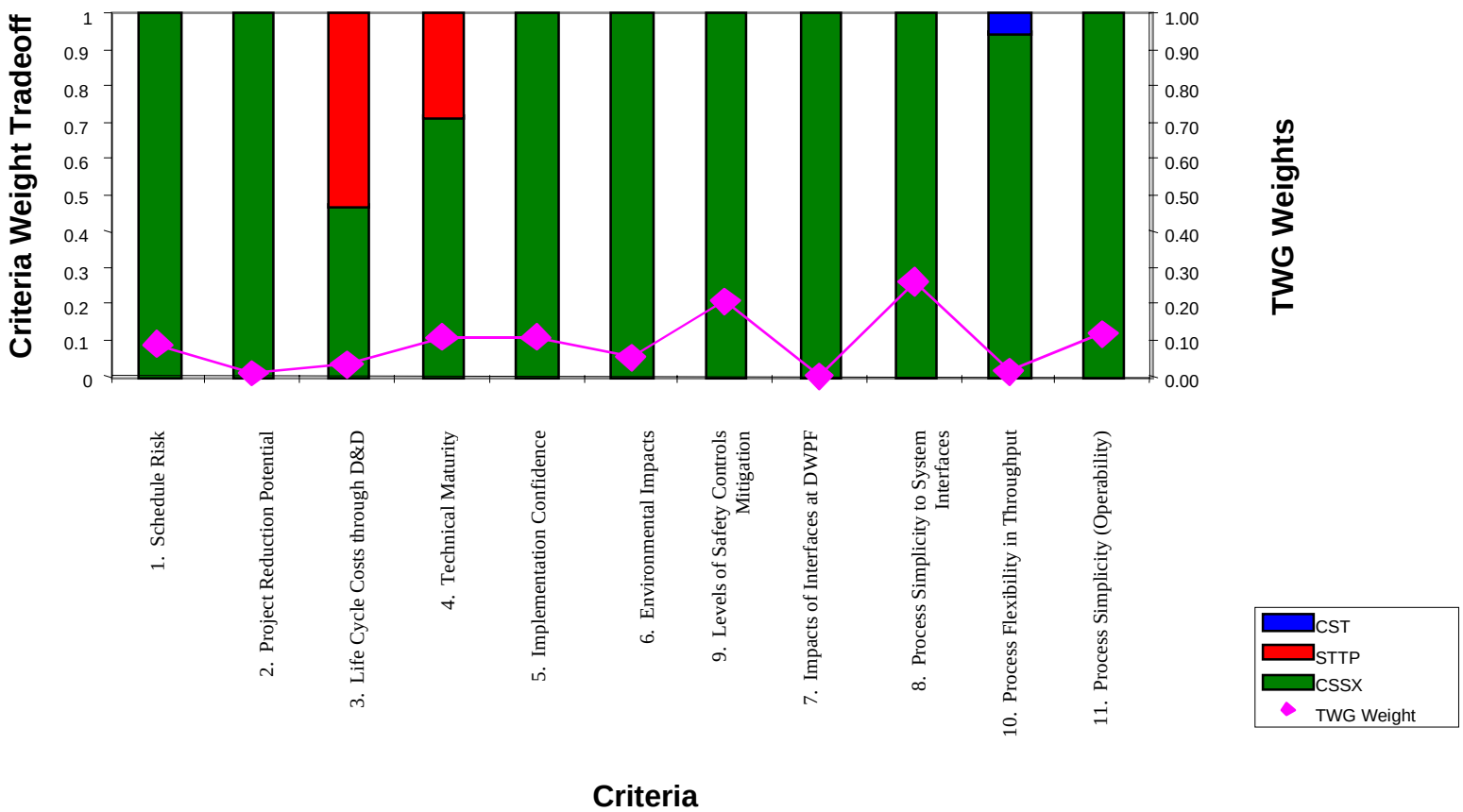

Table C-1. Weight Case Data

Project Goals	**TWG Confidence Weight**	**TWG Importance Weights**	**Potential HQ View**	**General Public Stake-holder**	**Local Stake-holder**	**Project Manager**	**Environ-mental Focus**	**Interfac-ing Facilities View**	**60% Cost**	**60% Schedule**	**60% ES&H**	**60% Technical Maturity**
Meet Schedule	9%	20%	19%	19%	12%	26%	26%	23%	20%	60%	8%	8%
Minimize Cost	4%	20%	26%	12%	6%	26%	3%	5%	60%	20%	8%	8%
Minimize Technical Risk	22%	33%	19%	19%	25%	26%	26%	23%	5%	5%	8%	60%
Minimize ES&H	26%	13%	21%	26%	30%	13%	40%	5%	5%	5%	60%	8%
Minimize Impact to Interface	26%	7%	10%	10%	11%	8%	3%	23%	5%	5%	8%	8%
Minimize Process Flexibility	13%	7%	5%	15%	11%	3%	3%	23%	5%	5%	8%	8%

Figure C-3. Weight Sensitivity Cases

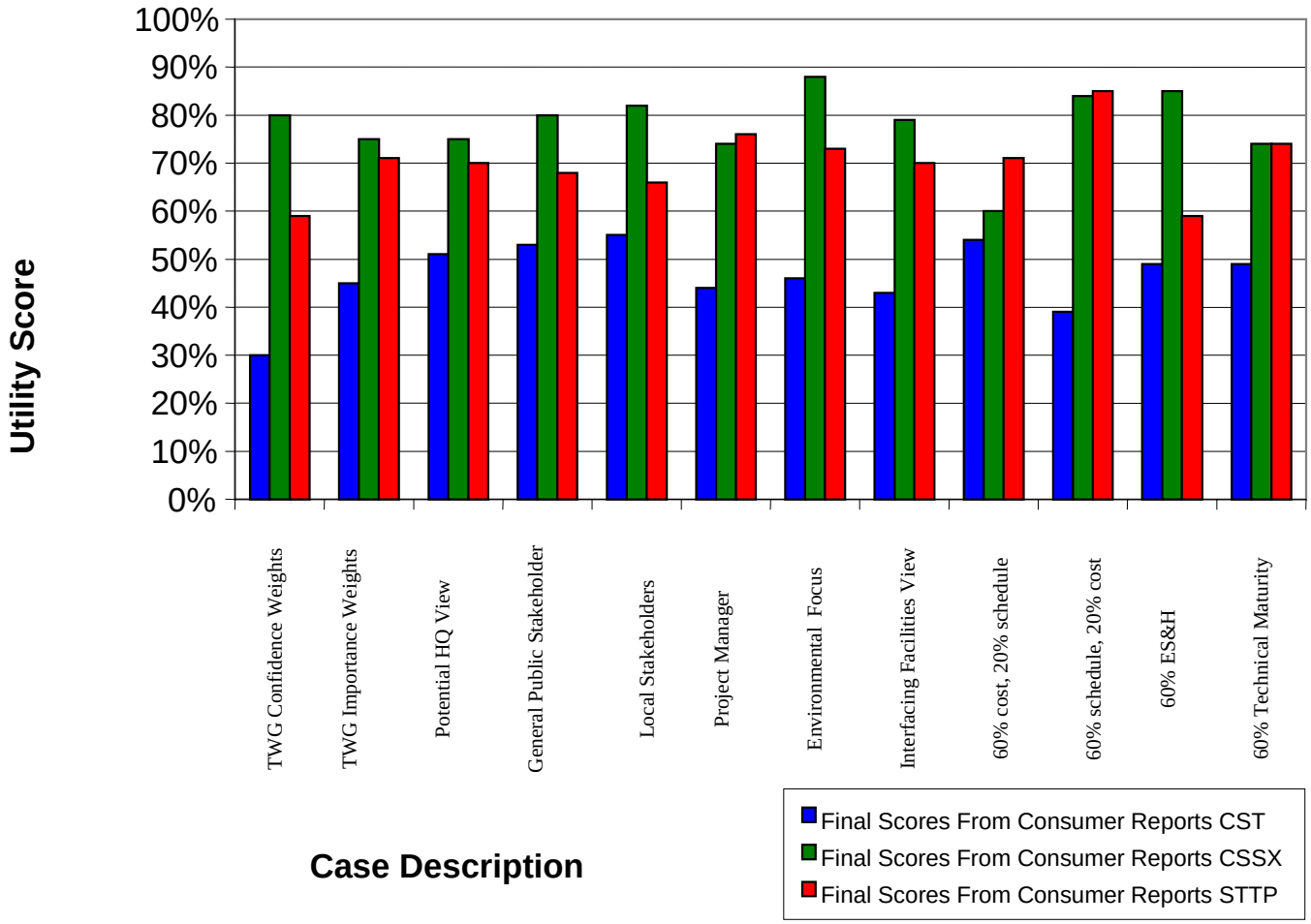

Table C-2 shows the analysis from the TWG scoring. The first data column contains the final score given a particular criterion. The second column contains the converted utility score and the TWG confidence weights are shown in the third data column. The fourth data column contains summary of the product of the utility and weight data for the alternative.

Table C-2. Utility Conversion of TWG Scores

Alternative	Criteria Name	Score from Consumer Reports	Criteria Utility Score	TWG Weight	$\sum$(Utility * Weight)
CST	1. Schedule Risk	2.0	0.250	0.087	.301
	2. Project Reduction Potential	3.0	0.503	0.009	
	3. Life Cycle Costs through D&D	3.7	0.673	0.035	
	4. Technical Maturity	3.9	0.717	0.109	
	5. Implementation Confidence	2.0	0.250	0.109	
	6. Environmental Impacts	5.0	1.000	0.052	
	9. Levels of Safety Control Mitigation	1.0	0.000	0.209	
	7. Impacts of Interfaces at DWPF	3.6	0.640	0.000	
	8. Process Simplicity of System Interfaces	1.8	0.200	0.261	
	10. Process Flexibility in Throughput	5.0	1.000	0.013	
	11. Process Simplicity (Operability is the issue)	2.0	0.250	0.117	
CSSX	1. Schedule Risk	5.0	1.000	0.087	.803
	2. Project Reduction Potential	3.0	0.509	0.009	
	3. Life Cycle Costs through D&D	2.6	0.405	0.035	
	4. Technical Maturity	3.8	0.692	0.109	
	5. Implementation Confidence	4.0	0.750	0.109	
	6. Environmental Impacts	4.9	0.983	0.052	
	9. Levels of Safety Control Mitigation	4.5	0.875	0.209	
	7. Impacts of Interfaces at DWPF	3.6	0.640	0.000	
	8. Process Simplicity of System Interfaces	4.2	0.800	0.261	
	10. Process Flexibility in Throughput	4.2	0.800	0.013	
	11. Process Simplicity (Operability is the issue)	4.0	0.750	0.117	
STTP	1. Schedule Risk	5.0	1.000	0.087	.590
	2. Project Reduction Potential	2.0	0.250	0.009	
	3. Life Cycle Costs through D&D	3.8	0.694	0.035	
	4. Technical Maturity	4.4	0.841	0.109	
	5. Implementation Confidence	4.0	0.750	0.109	
	6. Environmental Impacts	3.6	0.658	0.052	
	9. Levels of Safety Control Mitigation	2.5	0.375	0.209	
	7. Impacts of Interfaces at DWPF	4.6	0.890	0.000	
	8. Process Simplicity of System Interfaces	3.4	0.600	0.261	
	10. Process Flexibility in Throughput	2.6	0.400	0.013	
	11. Process Simplicity (Operability is the issue)	2.0	0.250	0.117	