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Application of Risk Management Practices to NNSA Tritium Readiness Subprogram

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Abstract

The National Nuclear Security Administration (NNSA), Office of Stockpile Technology (NNSA/NA-123) chartered a risk assessment of the Tritium Readiness (TR) Subprogram to identify risks and to develop handling strategies with specific action items that could be scheduled and tracked to completion in order to minimize program failures. This assessment was performed by a team of subject matter experts (SMEs) comprised of representatives from various organizations participating in the TR Subprogram. The process was coordinated by Savannah River Site, Systems Engineering (SRS/SE) with support from Subprogram Team.

The Risk Management Process steps performed during this risk assessment were: Planning, Identification, Grading, Handling, and Impact Determination. All of the information captured during the risk assessment was recorded in a database. The team provided estimates for the cost and schedule impacts of implementing the recommended handling strategies and facilitated the risk based cost contingency analysis. The application of the Risk Management Practices to the NNSA Tritium Readiness Subprogram resulted in:

- The quarterly review and update of the Risk Management Database to include an evaluation of all existing risks and the identification/evaluation of any potential new risks.
- The risk status and handling strategy action item tracking mechanism that has visibility and buy-in throughout the Tritium Readiness Subprogram to ensure that approved actions are completed as scheduled and that risk reduction is being achieved.
- The generation of a risk-based cost contingency estimate that may be used by the Tritium Readiness Subprogram Manager in establishing future year program budgets.

1.0 BACKGROUND

One of NNSA's missions is to provide tritium to the US nuclear stockpile. The purpose of the Tritium Readiness Subprogram of the Readiness Program is to establish a system that can ensure that the inventory is maintained by producing new tritium to replace that tritium lost to radioactive decay and consumption. The Tritium Production System being established by this subprogram will produce tritium by irradiating the NNSA-designed Tritium Producing Burnable Absorber Rods (TPBARs) in reactors operated by the Tennessee Valley Authority (TVA), an independent government agency. These TPBARs will be manufactured commercially. After irradiation, the radioactive TPBARs will be removed from the reactors and transported to a new Tritium Extraction Facility (TEF) at the Savannah River Site (SRS). There the tritium will be removed from the rods using a special vacuum-thermal process.

An assessment of NNSA Tritium Readiness Subprogram risks were conducted as part of the risk management process adopted by the NNSA. The goal of this overall assessment was to identify risks to the NNSA Tritium Subprogram and to develop handling strategies with specific action items that could be scheduled and tracked to completion in order to minimize program failures. The issues and assumptions developed during the assessment planning stage were considered during several meetings by a team (hereafter referred to as Team) comprised of individuals representing Pacific Northwest National Laboratory (PNNL), WesDyne, Kansas City Plant (KCP), NNSA, NAC, Tennessee Valley Authority (TVA), and Savannah River Site (SRS) in identifying risks.

2.0 RISK ASSESSMENT PROCESS

The methodology employed for the risk assessment was based on current NNSA risk management methodology (see References 1 thru 3) and also included elements of the risk management process as it is currently being taught within NNSA in the "Systems Thinking" training program. This process also follows the guidance provided in Appendix B, *Risk Analysis & Management*, of Reference 2.

Process steps performed during this risk assessment were limited to the following elements:

- Planning,
- Identification,
- Grading,
- Handling, and
- Impact Determination to include cost contingency for residual risks and handling strategies.

All of the information captured during the risk assessment was recorded in a database.

2.1 Planning

Risk management planning provides an approach for screening an activity for potential risks and for preparing a plan to assess and manage these events throughout the life cycle of the activity. The following items in planning were addressed during this risk assessment: 1). Selection of assessable elements, and 2). Calibration of likelihood and consequence definitions used to grade risks. The Team developed criteria against which to judge the likelihood that a risk might or could be made to occur (respectively). Criteria were also developed to judge the magnitude of risk consequences. These criteria are provided in Appendix A.

2.2 Identification

Identification is an organized approach for determining which events may affect the program and for documenting the characteristics of the events that may happen with a basis as to why these events are considered risks. Using brainstorming, the list of issues and assumptions created during the risk assessment kickoff meetings, and the information gathered during the vendor/supplier interviews, the Team identified and documented risks by creating statements of event that included:

- The *baseline* – the normal situation for the element containing the risk (e.g. – assumptions, design basis).
- The *event* – some other incident, occurrence, circumstance, etc., that may happen that is different from the normal situation.
- The *impact* – a statement of what affect or result the event will or could have on the normal situation (including performance, cost, and schedule impacts).

This information was entered into a database that was used throughout the rest of the process to capture the assessment details and provide a vehicle for reporting the results.

2.3 Grading

Grading is the process of evaluating the likelihood that the risk event will occur, assessing the range of possible outcomes (consequences), and combining these two elements to establish a risk level. These grading results may then be used to prioritize risks. Using the definitions for likelihood and consequence defined in Tables A-1 and A-2 in Appendix A), the team evaluated all identified risks and determined a risk level of *High*, *Moderate*, or *Low* for each event. Risk levels were determined by simply plotting the likelihood and consequence values for each risk on the matrix shown in Figure A-1 in Appendix A.

2.4 Handling

For risks, handling involves the identification of specific responsive actions to the risk and an assessment of the effectiveness of that handling strategy. Risk handling strategies are developed with the purpose of eliminating or at least reducing the likelihood and/or consequences of an identified risk. Assessing the effectiveness of the handling strategy is accomplished by identifying and grading any residual risk that may remain after the implementation of the prescribed handling strategy.

For risks, the Team assigned one of four handling strategies, *Avoid, Transfer, Mitigate,* or *Accept* (as shown in Figure A-2 in Appendix A) to each of the risk items. In order to maximize risk reduction, the Team made a concerted effort not to assign a handling strategy of *Accept* to *High* or *Moderate* risks. As noted above, the common objective is to select a handling strategy that will either maximize risk reduction or, where possible, eliminate the risk altogether.

Handling strategies that do not completely eliminate risk (i.e. – *Mitigate* or *Accept*) result in residual risk that must be reevaluated in a manner similar to the evaluation of the original risk. For each of these residual risks, the Team graded residual risk levels using the same process described above under **Grading**.

2.5 Impact Determination

Risk impact determination is an evaluation of cost and schedule impact of the risks on the program. It includes not only the cost and schedule impacts of implementing risk handling strategies, but also the residual risk cost and schedule impacts. To facilitate this process, the Team provided estimates for the cost and schedule impacts of implementing the recommended handling strategies. In addition, the Team provided estimates for cost and schedule impacts of the residual risks (best, most likely, and worst case) to facilitate the generation of a risk-based cost contingency estimate that may be used by the Tritium Readiness Subprogram Manager in establishing future year program budgets.

3.0 RESULTS OF THE ANALYSIS

3.1 Initial Findings

The Team identified a total of ninety-four (94) risks events. As of January 2006, the Team dispositioned forty-one (41) events as '*combined with others'*, '*deleted',* and '*resolved'* resulting in fifty-three (53) "Active" risk events. These fifty-three (53) active risk events are documented on the Risk Assessment Forms. The initial assessment of fifty (50) out of 53 active events designated twenty-one (21) *High*, twenty-two (22) *Moderate* and 7 *Low* level risks. An initial formal assessment was not completed by the Team on the three events because they were long-term programmatic type events.

The Team evaluated these active risks and provided handling strategies. The assessment provided impact of these active risks on the TRP in light of the various risk handling strategies (accept, avoid, mitigate) and the assigned "post-handling" residual risk level. These handling strategies when implemented would result in residual risks with seven (7) *High*, sixteen (16) *Moderate* and twenty (20) *Low* level risks. This assessment also provided a cost contingency analysis using "Crystal Ball®" software.

3.2 Analysis of Handling Strategy Effectiveness

The handling strategies recommended by the Team for the forty-eight active risks are tabulated as shown at right in Table 3.2-1.

Table 3.2-1 Handling Strategies

Avoid	4
Transfer	0
Mitigate	31
Accept	13

The risk handling strategies resulted in reduction in the risk levels as shown in the Table 3.2-2.

Table 3.2-2 - Impact of Risk Handling Strategies

	Initial Risk Level	Residual Risk Level
High	21	7
Moderate	22	16
Low	7	20

4.3 Analysis of Cost and Schedule Impact

Risks may have cost and schedule impacts to the program in two ways:

1) Impacts of implementing handling strategies, and/or

2) Impacts of residual risks.

In the case of handling strategies, the normal process is to simply sum the total of all risk handling strategy implementation cost estimates provided by the Team during the assessment and then factor those additional costs into program budgets as appropriate. The rationale for this process is the assumption that handling strategies for risks have not previously been factored into existing program budgets, and for these strategies to be successful, they must be funded and scheduled in revised program plans.

For risks, there are also the cost and schedule impacts associated with residual risk – a forecast of the risk that remains after the successful implementation of a handling strategy. It is not appropriate to simply sum the residual risk costs since not all, nor perhaps will any, of the residual risks materialize. To address the uncertainty in these potential residual risk cost impacts, a technique is employed that uses residual risk cost distributions based on the Team's estimates of Best Case, Most Likely, and Worst Case cost impacts for each residual risk. These distributions are then combined with the residual risk likelihoods for each of the residual risks in a Monte Carlo simulation to derive a cumulative distribution that defines a forecast of residual risk-based cost contingency for the program.

The results of this risk contingency analysis show that the program should keep a reserve of approximately $32.52M for an 80% confidence that the program will be able to address the potential (probabilistic) cost impacts for currently identified residual risks that may materialize. Also, based on the individual contribution of each risk to the total (mean) contingency number is used to determine the ranking of the risks. This ranking and their percent contribution is listed in the following table:

Table 4.4 - Risk Ranking Based on Mean Contingency Contribution

Ranking	Risk ID	Title	Mean Contingency $K	Mean-Total Contingency $K	%
1	40	Equipment Design Change	6,181.11	22,284	27.74
2	38	Impacts of Costing Factors Outside Program's Control	3,329.46	22,284	14.94
3	77	Yield Impacts Production Success	2,259.09	22,284	10.14
4	8	Loss of Vendor A as a Long-Term Supplier	2,162.99	22,284	9.71
5	33	Equipment Consolidation Process Design	1,746.17	22,284	7.84
6	4	Loss of Vendor B as a Long-Term Supplier	1,523.00	22,284	6.83
7	23	Loss of Testing Capability	800.46	22,284	3.59
8	48	Unable to Reduce Uncertainties to Meet Program Needs	520.48	22,284	2.34
9	41	Equipment Performance impact	506.85	22,284	2.27
10	92	Excessive impurities in Materials	493.01	22,284	2.21

Total Cost Contingency	
Percentiles	**Contingency ($K)**
60%	**22,470**
80%	**32,511**

4.0 CONCLUSIONS AND RECOMMENDATIONS

The Team identified a total of ninety-four (94) risks events. As of January 2006, the Team dispositioned forty-one (41) events as 'combined with others', 'deleted', and 'resolved' resulting in fifty-three (53) "Active" risks events. These fifty-three (53) active risk events are documented on the Risk Assessment Forms similar to one shown in Appendix C. The initial assessment of fifty (50) out of 53 active events designated twenty-one (21) High, twenty-two (22) Moderate and 7 Low level risks. An initial formal assessment was not completed by the Team on the three events because they were long-term programmatic type events.

As requested by NNSA, the Team evaluated risks and provided recommended handling strategies. These handling strategies were evaluated, prioritized, turned into actionable tasks for risk reduction. The Team made the following recommendations:

1. The risk point of contact (POC) should prioritize each risk, develop an action plan complete with implementation cost and schedule estimates, and make a recommendation to NNSA for a path forward.
2. If required, task plans and budgets should be updated to reflect the new scopes of work.
3. The Risk Management Database should be reviewed and updated quarterly to reflect decisions that have been made and work that has been completed.
4. The program quarterly review should include an evaluation of all existing risks and the identification/evaluation of any potential new risks. New risks should be added to the database and assigned to a responsible POC.
5. A handling strategy action item tracking mechanism that has visibility and buy-in throughout the Tritium Readiness Subprogram must be established to ensure that approved actions are completed as scheduled and that risk reduction is being achieved.

6. Based upon the results of the risk contingency analysis, it is recommended that the program should keep a reserve of approximately $32.52M for an 80% confidence that the program will be able to bear the potential costs associated with the risks. To fund this contingency in annual budget a contingency utilization plan should be developed.

6.0 REFERENCES

1. *NA-12 Risk Management Process Description.* NA12-PD-03-0002, Revision 0, U.S. DOE Defense Programs Office, Washington, DC 20585 (September 17, 2003).
2. *Systems Engineering Methodology Guidance Manual*. NNSA NA12-02-00034, Revision D1, U.S. DOE Defense Programs Office, Washington, DC 20585 (October 15, 2002).
3. *Systems Engineering Methodology Guidance Manual*. WSRC Manual WSRC-IM-98-00033, Revision 10 Savannah River Site, Aiken, SC 29808 (February 26, 2004).

7.0 APPENDIXES

Appendix A Risk Grading Guidelines

Appendix B Risk-Based Cost Contingency Analysis

Appendix C Risk Assessment Forms

APPENDIX A – Risk Grading Guidelines

Tables A-1 and A-2 shown below and on the following page were used by the Team to define the likelihood and consequence of each risk identified during the assessment process. These definitions were used to evaluate both the initial and residual risk levels. Risk levels (*High*, *Moderate*, or *Low*) were determined using the matrix shown in Figure A-1. Handling strategies for each of the risks were selected from the four strategies shown in Figure A-2.

Table A-1 Guidelines for Assigning Risk Likelihood

Likelihood of Occurrence (L)	**Criteria**[1]
Non-Credible[2]	Determined (through formal probability calculations) to have a probability of occurrence of ≤ 10^{-6} (or other non-credible probability defined for the activity)
Very Unlikely	• Will not likely occur anytime in the life cycle of the Tritium Readiness Subprogram; or • Estimated recurrence interval > 20 years (or perceived life of program); or • Estimated recurrence frequency < 1 (i.e., event not expected to recur); or • 0% < Likelihood of single event occurrence < 15%.
Unlikely	• Will not likely occur in the life cycle of the Tritium Readiness Subprogram; or • 10 years < Estimated recurrence interval ≤ 20 years; or • 1 ≤ Estimated recurrence frequency < 2 (i.e., event expected to recur but not more than once); or • 15% ≤ Likelihood of single event occurrence < 45%.
Likely	• May occur sometime during the life cycle of the Tritium Readiness Subprogram; or • 5 years < Estimated recurrence interval ≤ 10 years; or • 2 ≤ Estimated recurrence frequency < 5 (i.e., event expected to recur from 2 to 4 times); or • 45% ≤ Likelihood of single event occurrence < 75%.
Very Likely	• Will likely occur sometime during the life cycle of the Tritium Readiness Subprogram; or • Estimated recurrence interval ≤ 5 years; or • Estimated recurrence frequency ≥ 5 (i.e., event expected to recur more than five times); or • 75% ≤ Likelihood of single event occurrence < 100%.

[1] All likelihood ranges are strictly qualitative – no numeric precision is implied.
[2] This category is normally reserved for the evaluation of residual risks associated with *Crisis* consequences.

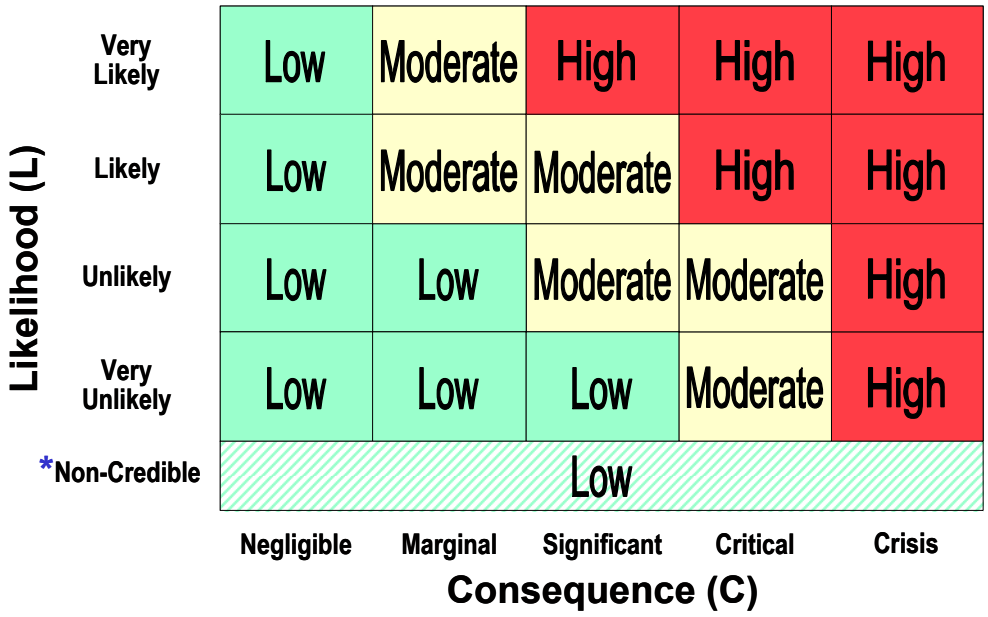
Table A-2 Guidelines for Assigning Risk Consequences3

Consequence of Occurrence (C)[4]	Criteria[5]
Negligible	• Minimal consequences; unimportant. • Some potential transfer of money (≤ $500K), but budget estimates not exceeded. • Negligible impact on program; minimal potential for schedule change; compensated by available schedule float.
Marginal	• Small reduction in Tritium Readiness Subprogram technical performance. • Moderate threat to Tritium Readiness Subprogram mission, environment, or people; may require minor facility redesign or repair, minor environmental remediation, or first aid/minor medical intervention. • Cost estimates marginally exceed planned budget (> $500K, but ≤ $1M). • Minor slip in schedule (anything less than 3 months) with some potential adjustment to milestones required. • No impact to scheduled reactor irradiation cycles.
Significant	• Significant degradation in Tritium Readiness Subprogram technical performance. • Significant threat to Tritium Readiness Subprogram mission, environment, or people; requires some facility redesign or repair, significant environmental remediation, or causes injury requiring medical treatment. • Cost estimates significantly exceed planned budget (> $1M, but ≤ $5M). • Significant slip in schedule (3 months to less than 12 months) with resulting milestones changes that may affect Tritium Readiness Subprogram mission. • Unable to provide planned quantity of TPBARs for an irradiation cycle, but able to support program at lower than planned level.
Critical	• Technical goals of Tritium Readiness Subprogram cannot be achieved. • Serious threat to Tritium Readiness Subprogram mission, environment, or people; possibly completing only portions of the mission or requiring major facility redesign or rebuilding, extensive environmental remediation, or intensive medical care for life-threatening injury. • Cost estimates seriously exceed planned budget (> $5M, but ≤ $10M). • Excessive schedule slip (12 months to ≤ 18 months) unacceptably affecting overall mission of Tritium Readiness Subprogram objectives, etc. • Unable to supply TPBARs at planned level for more than one irradiation cycle.
Crisis	• Tritium Readiness Subprogram cannot be completed. • Cost estimates unacceptably exceed planned budget (> $10M). • Catastrophic threat to program mission; possibly causing loss of mission. • Schedule slips > 18 months. • Unable to support an entire irradiation cycle.

[3] These criteria may be modified at the discretion of the current Team.

[4] Special attention must be given to first-of-a-kind risks because they are often associated with activity failure. First-of-a-kind risks should receive a *Critical* or *Crisis* consequence estimate unless there is a compelling argument for a lesser consequence value determination.

[5] Any one or more of the criteria in the five levels of consequence may apply to a single risk. The overall consequence level for the risk being evaluated must be based upon the highest level for which a criterion applies.



* Normally limited to assessing residual risks with Crisis consequences

Figure A-1. Risk Grading Matrix

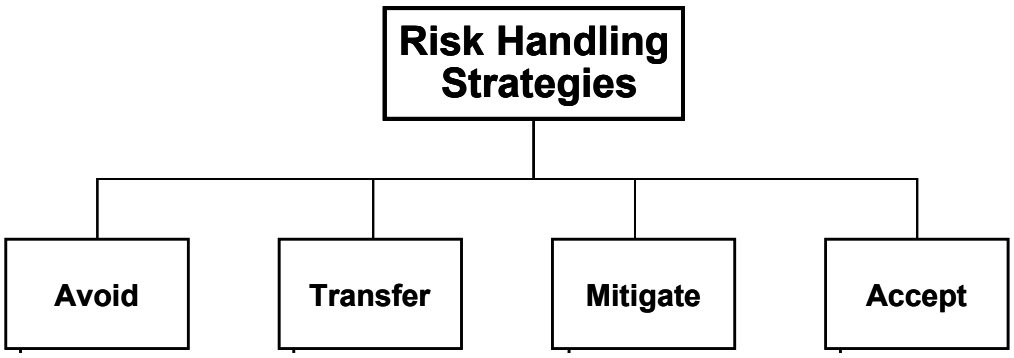


Figure A-2. Risk Handling Strategies

APPENDIX B – Residual Risk-Based Cost Contingency Analysis

This appendix provides a basis for the estimate of a residual risk-based cost contingency to the program using a methodology that is normally used to develop risk-based contingency estimates for capital projects. The Team provided a *Best Case*, *Most Likely*, and *Worst Case* cost estimate for each of the residual risks during the assessment process. These values were used to create triangular cost distribution assumptions for each of the residual risks. These assumptions were then used together with uniform distributions representing the respective likelihoods of occurrence for each residual risk in a Monte Carlo simulation to generate a cumulative curve forecast of risk-based cost contingency. The results of that simulation are shown below in Figure B-1.

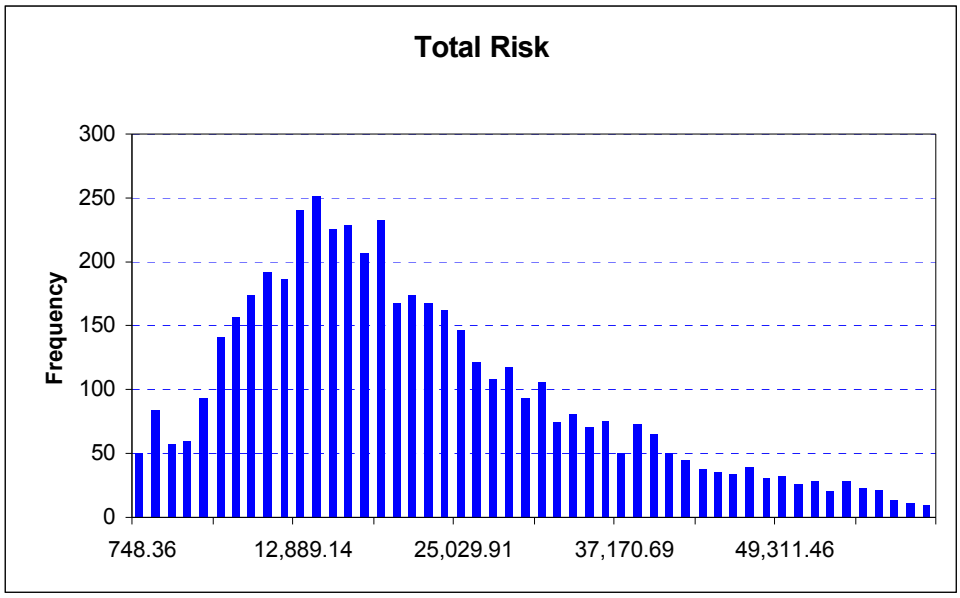


Figure B-1. Cumulative Residual Risk-Based Cost Contingency

Note: All risk-based cost numbers are in $K

Risk Ranking Based on Mean Contingency Contribution				
Risk ID	**Mean**	**Mean-Total**	**%**	**Ranking**
40	6,181.11	22,284	27.74	**1**
38	3,329.46	22,284	14.94	**2**
77	2,259.09	22,284	10.14	**3**
8	2,162.99	22,284	9.71	**4**
33	1,746.17	22,284	7.84	**5**
4	1,523.00	22,284	6.83	**6**
23	800.46	22,284	3.59	**7**
48	520.48	22,284	2.34	**8**
41	506.85	22,284	2.27	**9**
92	493.01	22,284	2.21	**10**

Cost Contingency	
Percentiles	**Total Risk**
60%	**22,470**
80%	**32,511**

The significance of this data is that it shows the program must keep a reserve of approximately $32.52M for an 80% confidence that the program will be able to address the cost impacts for currently identified residual risks that may materialize.

APPENDIX C – Risk Assessment Forms

This Appendix provides a copy of *sample* Risk Assessment Form used during the risk assessment process. These sheets are sorted by the event number (referred to elsewhere in this report as Event ID). In addition to providing information summarized elsewhere in this report, these forms provide statements and bases for the likelihood and consequence values selected by the Team. All of the information presented on these forms is contained in the NNSA TR Subprogram Risk Assessment Database.

Risk Assessment Form

ID Number: **Revision:** **Last Date Evaluated:** **Status:**

Event Title:					
Type: Risk		**Category:**			
Assess. Element:		**Title:**			
Responsible Org:			**Contact:**		**Date Identified:**
Statement of Event:					
Likelihood:		**Basis:**			
Consequence / Benefit:		**Basis:**			
Most Significant Cost Impact ($k):			**Most Significant Schedule Impact (Mos):**		
Level:		**Event Trigger:**			
Handling Strategy:		**Description:**			
Handling Strategy Action Items:					
HS Implementation Cost ($K):		**Basis:**			
HS Implementation Schedule (Mos):		**Basis:**			
Other Handling Strategies:					
Statement of Residual Risk:					
Residual Likelihood:		**Basis:**			
Residual Consequence:		**Basis:**			
Residual Risk Level:	Moderate			**Residual Impact Basis:**	
Residual Cost Impact ($K):	**Best Case**	**Most Likely**	**Worst Case**		
Residual Schedule Impact (Mos):					
Impacted Scope of Work:					
Evaluation Comments:					
Event Comments:					

BIOGRAPHY

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