

Prioritization Tool for Surveillance and Maintenance Investment in Excess Facilities

User's Manual

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Contents

Introduction.....	4
Excel Template for the Decision Support Tool	4
Sheet 1: Criteria Chart	5
Sheet 2: Pair-Wise Comparison of Risk Criteria	6
Sheet 3: Pair-Wise Comparison of S&M Activities	9
Sheet 4: Facility Evaluation Scale	10
Sheet 5: Facility Evaluation	12
Sheet 6: S&M Final Prioritization	13
Sheet 7: S&M Final Prioritization Chart	15
Sheet 8 & 9: Risk Criteria, and S&M Criteria Definitions	15
Sheet 10: Random Index Chart (RI)	18
Bibliography	19
Appendix A: Pair-Wise Comparison Formulas	20
Appendix B. Consistency Ratio.....	21

Figures

Figure 1: Relationship between green tabs	5
Figure 2. Criteria Chart Sheet.	6
Figure 3: Pair-Wise Comparison Scale.....	6
Figure 4: Pair-Wise Comparison of Risk Criteria.....	7
Figure 5. Number of Criteria.	7
Figure 6: Example of pair-wise comparison with low CR value.....	8
Figure 7: Pair-Wise Comparison of Sub-Criteria	9
Figure 8: Pair-Wise Comparison of S&M Criteria	10
Figure 9: Facility Evaluation Scale.....	11
Figure 10. Facility Evaluation Sheet.....	12
Figure 11: S&M Check List.....	13
Figure 12 . Score Table.....	14
Figure 13: S&M Actions Ranked	14
Figure 14: Final Ranked S&M Activities	15
Figure 15: Risk Criteria Definitions	16
Figure 16: S&M Criteria Definitions.....	17
Figure 17: Random Consistency Index Chart.....	18
Figure 18: Current formula used in pair-wise comparison tables.....	20
Figure 19: Normalized Weight Formula in Excel.....	20
Figure 20: Consistency Ratio (CR) Value	21

Introduction

The Department of Energy (DOE) currently faces a difficult task in the disposition of the numerous excess or to-be excessed facilities owned by the Department. Many of these facilities are in various physical conditions and contain potentially hazardous nuclear, chemical, radiological or industrial materials left behind as a byproduct of nuclear weapons production, nuclear powered naval vessels and commercial nuclear energy production. During the last period of a facility's life cycle, it is important that surveillance and maintenance (S&M) be adequate to maintain the facility within an appropriate safety envelope. Inadequate investment in maintenance can cause facilities to deteriorate to the point they are unsafe for human entry. Too often this can mean tremendous increases to cost during deactivation and decommissioning (D&D). However, experiences often show that once buildings have been declared excess and enter the transition phase (as defined in DOE G 430.1-5 Transition Implementation Guide), maintenance budgets are drastically reduced. This is justified by the desire to not spend money "on a building that is being torn down."

The objective of this tool is to provide the U.S. Department of Energy (DOE) Environmental Management (EM) federal project directors and their contractors with a decision support tool to aid in prioritizing S&M investment across a site's excess facilities so that the limited budget available can be used most effectively. The analytical hierarchy process (AHP), a multi-criteria decision making method developed by Dr. Thomas Saaty in the 1970's, was used to derive the weight of importance of a defined list of risk-based criteria and typical S&M activities. The tool allows users to select the evaluation criteria most important to them, and then allows them to evaluate those criteria to determine an overall score for each facility. A pair-wise comparison technique is used to evaluate the criteria defined by the user and 5-point scale is used to evaluate the facilities against the criteria.

Excel Template for the Prioritization Tool

An excel template was developed with the purpose of facilitating the implementation of the AHP methodology to prioritize S&M investment. The excel template contains the following ten sheets:

1. Criteria Chart
2. Pair-Wise Comparison of Risk Criteria
3. Pair-Wise Comparison of S&M Criteria
4. Facility Evaluation Scale
5. Facilities Evaluation
6. S&M Final Prioritization
7. S&M Final Prioritization Chart
8. Risk Criteria Definitions
9. S&M Criteria Definitions
10. Consistency Ratio Chart

Tabs Color Coding

Green Tabs: Sheets which require input from the user

Red Tabs: Sheets which contain information and do not require input from the user

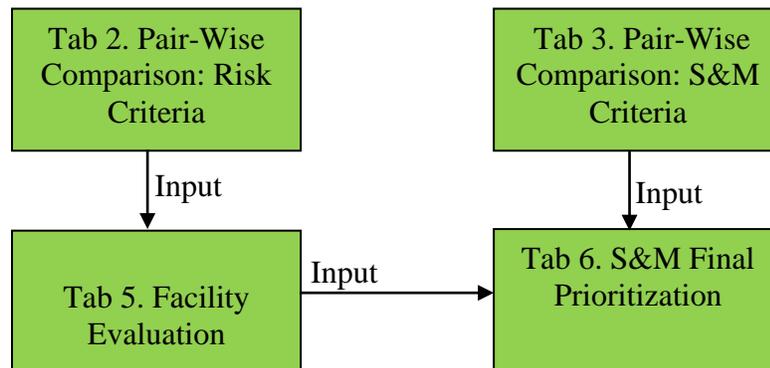


Figure 1: Relationship between green tabs

The relationship between the green tabs is shown in Figure 1. The normalized weight calculated in the pair-wise comparison of the risk criteria are used in the Facility Evaluation tab. The normalized weights of the S&M criteria are used in the final S&M prioritization along with the results from the Facility Evaluation tab.

Tables Color Coding

Gray Cells: Cells in the tables which contain formulas are protected and DO NOT require input from the user

White Cells: Cells in the tables require input from the user

Protected Sheets

Sheets containing formulas were protected to prevent changes which can affect the results of the calculations. If the tables need to be updated then unprotect the sheet using the password **fiuarc2009**. The sheets may be locked again after the necessary changes are made.

Sheet 1: Criteria Chart

The first sheet in the excel template displays the risk criteria and the S&M criteria (Figure 2). These criteria were identified by a group of subject matter experts. The risk criteria are used to prioritize the facilities based on risk. The S&M criteria are a list of general S&M activities performed to excess facilities. The S&M criteria were included in this decision tool because it would not only consider how risky the facility is currently, but also how important are the specific maintenance it requires. This method will avoid overspending too much money on higher risk facilities' non critical maintenance, and will pay attention to those facilities of less risk but with maintenance that is critical for preventing it of becoming higher risk in the future. The criteria developed by the subject

matter experts are used in the following two sheets to determine their weight of importance.

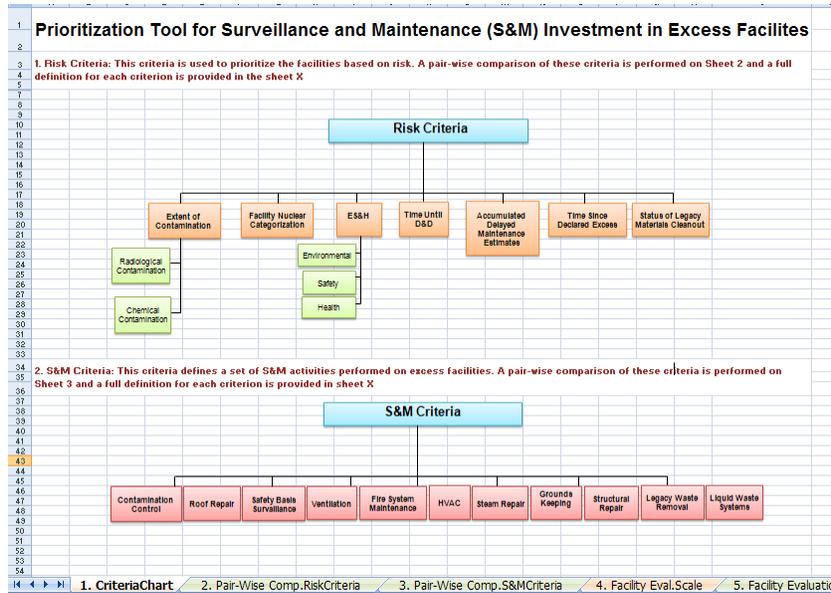


Figure 2. Criteria Chart Sheet.

Sheet 2: Pair-Wise Comparison of Risk Criteria

The second sheet, Pair-Wise Comparisons Risk Criteria, is used to calculate the weight of importance of the risk criteria and its sub criteria. The results will be used in the evaluation of the facilities in sheet 5. The sheet contains three sets of tables and a comparison scale.

The first table contains at the top a 9-point comparison scale to be used in the pair-wise comparison (Figure 3).

Pair-Wise Comparison Scale			
1	1	if two criteria are EQUALLY IMPORTANT	
2	3	if Criterion on row is SLIGHTLY MORE important than criterion on column	1/3
3	5	if Criterion on row is MODERATELY MORE important than criterion on column	1/5
4	7	if Criterion on row is STRONGLY MORE important than criterion on column	1/7
5	9	if Criterion on row is EXTREMELY MORE important than criterion on column	1/9
6	2,4,6,8	Intermediate values	1/2,1/4,1/6,1/8
7			Intermediate values

Figure 3: Pair-Wise Comparison Scale

In the second table “Pair-Wise Comparison of Risk Criteria” (Figure 4), the risk criteria from worksheet one are evaluated relative each other.

Pair-Wise Comparison of Risk Criteria										
8										
9										
10	Enter Number of Criteria :	7								
11										
12	Risk Criteria	Extent of Contamination	Facility Nuclear Categorization	ES&H	Time Until D&D	Delayed Maintenance	Time Since Declared Excess	Status of Leg. Mat. Clenaout		Normalized Weight
13	Extent of Contamination	1.0	7.0	0.1	8.0	9.0	8.0	2.0		0.202
14	Facility Nuclear Categorization	0.1	1.0	0.1	9.0	9.0	9.0	2.0		0.141
15	ES&H	7.0	7.0	1.0	9.0	9.0	9.0	9.0		0.445
16	Time Until D&D	0.1	0.1	0.1	1.0	0.3	1.0	0.1		0.022
17	Delayed Maintenance	0.1	0.1	0.1	3.0	1.0	0.3	0.1		0.029
18	Time Since Declared Excess	0.1	0.1	0.1	1.0	3.0	1.0	0.1		0.031
19	Status of Leg. Mat. Clenaout	0.5	0.5	0.1	9.0	9.0	9.0	1.0		0.130
20										
21										
22										

Figure 4: Pair-Wise Comparison of Risk Criteria

Refer to Sheet 8 for a definition of each criterion and follow these steps to complete the Pair-Wise Comparison of Risk Criteria table:

1. Determine the risk criteria to be used in the evaluation. The model defaults to the risk criteria developed in the first tab, but users may add or delete criteria as needed. If more than ten criteria are needed some adjustments to the formulas may be needed. (Refer to Appendix A for a detailed explanation of the formulas). In addition, the Facility Evaluation Scale needs to be updated every time you add or delete criteria. (Refer to Sheet 4: Facility Evaluation Scale)
2. Check the number of criteria shown in red at the top of the pair-wise comparison table (Figure 5) and make sure it is the right number of criteria in the table. This number is updated every time a criterion is added or deleted. The reason for this is that the number is included in the formula to calculate the normalized weight.

Pair-Wise Comparison Scale										
1	1	If two criteria are EQUALLY IMPORTANT								
2	3	if Criterion on column is SLIGHTLY MORE important than criterion on row				1/3	if Criterion on column is SLIGHTLY LESS important than criterion on row			
3	5	if Criterion on column is MODERATELY MORE important than criterion on row				1/5	if Criterion on column is MODERATELY LESS important than criterion on row			
4	7	if Criterion on column is STRONGLY MORE important than criterion on row				1/7	if Criterion on column is STRONGLY LESS important than criterion on row			
5	9	if Criterion on column is EXTREMELY MORE important than criterion on row				1/9	if Criterion on column is EXTREMELY LESS important than criterion on row			
6	2,4,6,8	Intermediate values				1/2,1/4,1/6,1/8	Intermediate values			
7										
8										
9										
10	Enter Number of Criteria :	7								
11										
12	Risk Criteria	Extent of Contamination	Facility Nuclear Categorization	ES&H	Time Until D&D	Delayed Maintenance	Time Since Declared Excess	Status of Leg. Mat. Clenaout		Normalized Weight
13	Extent of Contamination	1.0	7.0	0.1	8.0	9.0	8.0	2.0		0.202

Figure 5. Number of Criteria.

3. Determine the relative importance of each criterion vs. the others. Begin by comparing the first criterion in the blue row versus all of the criteria in the blue column. For example, if Extent of Contamination is strongly more important than the Facility Nuclear Categorization, then enter 7 in the empty cell that connects these two criteria. The gray section in the pair wise comparison table contains formulas that automatically calculate the reciprocal of the values entered in the

white section. For example, if you entered 7 in the comparison between Extent of Contamination vs. Facility Nuclear Categorization, then 1/7 is automatically calculated in the cell comparing Facility Nuclear Categorization vs. Extent of Contamination. Continue with the next criteria in the blue column until all of the criteria have been compared.

4. After completing the pair-wise comparison, check your consistency by reading the consistency ratio and making sure the number is not greater than 0.3, if a larger number is obtained you must go back to the pair-wise comparison table and re-evaluate the numbers you entered. (For a detailed explanation of the formulas read Appendix B).

For example, the pair-wise comparison shown below in Figure 6 received a CR value of 0.4 which means it must be re-evaluated. To do so, go back and re-evaluate the comparisons. In this case, ES&H received the highest scores when compared to the rest; however, it has a 1 when compared to Time Until D&D. The inconsistency here is that Time Until D&D is less important than the rest of the criteria.

Risk Criteria	Extent of Contamination	Facility Nuclear Categorization	ES&H	Time Until D&D	Delayed Maintenance	Time Since Declared Excess	Status of Leg. Mat. Clenaout
Extent of Contamination	1.0	7.0	0.1	8.0	9.0	8.0	2.0
Facility Nuclear Categorization	0.1	1.0	0.1	3.0	7.0	3.0	2.0
ES&H	7.0	7.0	1.0	1.0	9.0	9.0	9.0
Time Until D&D	0.1	0.3	1.0	1.0	0.3	1.0	0.2
Delayed Maintenance	0.1	0.1	0.1	3.0	1.0	0.3	0.2
Time Since Declared Excess	0.1	0.3	0.1	1.0	3.0	1.0	0.1
Status of Leg. Mat. Clenaout	0.5	0.5	0.1	5.0	5.0	7.0	1.0

Figure 6: Example of pair-wise comparison with low CR value

5. Review the final scores in the Normalized Weight column; these numbers were normalized to add up to 1. The risk criteria with the highest weight should represent the criteria with the highest importance.

The last two tables on this sheet are the sub-criteria of Extent of Contamination and EH&S. Follow the same steps mentioned previously to do the pair-wise comparison of these sub-criteria (Figure 7).

Pair-Wise Comparison of Sub-Criteria For Extent of Contamination

31				
32				
33	Enter Number of Sub criteria under Extent of Contamination :	2		
34				
35	Extent of Contamination	Radiological Contamination	Chemical Contamination	Normalized Weight
36	Radiological Contamination	1.0	1.0	0.50
37	Chemical Contamination	1.0	1.0	0.50
38	sum	2.0	2.0	1.00
39				
40	Consistency Check			
41	Lambda max	2.00		
42	CI	0.00		
43	RI	0.00		
44	Consistency Ratio	#DIV/0!		
45				

Pair-Wise Comparison of Sub-Criteria For ES&H

46					
47					
48	Enter Number of Sub criteria under ES&H:	3			
49					
50	ES&H	Environment	Safety	Health	Normalized Weight
51	Environment	1.0	0.1	0.1	0.067
52	Safety	7.0	1.0	1.0	0.47
53	Health	7.0	1.0	1.0	0.47
54	sum	15.0	2.1	2.1	1.0
55					
56	Consistency Check				
57	Lambda max	3.00			
58	CI	0.00			
59	RI	0.58			
60	Consistency Ratio	0.00			
61					
62					

Figure 7: Pair-Wise Comparison of Sub-Criteria

Sheet 3: Pair-Wise Comparison of S&M Activities

This sheet is used to calculate the weight of importance of the S&M activities. The results will be used in the sixth sheet when the S&M requirements for each facility are identified.

This sheet also contains at the top a 9-point scale to be used in the pair-wise comparison. The criteria in the column are compared against the criteria on the row following the same steps previously mentioned for the comparison of the risk criteria. Refer to sheet 9 for a definition of each S&M criterion and follow these steps to complete the pair-wise comparison table:

1. Determine the S&M criteria to be used in the evaluation. The model defaults to the S&M criteria developed in the first tab, but users may add or delete criteria as needed. (Refer to Appendix A for a detailed explanation of the formulas)
2. Check the number of criteria shown in red at the top of the pair-wise comparison table and make sure it is the right number of criteria in the table. This number is updated every time a criterion is added or deleted. The reason for this is that the number is included in the formula to calculate the normalized weight.
3. Determine the relative importance of each criterion vs. the others. Begin by comparing the first criterion in the blue row versus all of the criteria in the blue column. For example, if you entered 3 in the comparison between Contamination Control vs. Roof Repair, then the reciprocal of 3 is automatically calculated in the

cell comparing Roof Repair vs. Contamination Control. Continue with the next criteria in the blue column until all of the criteria have been compared.

4. After completing the pair-wise comparison, check your consistency by reading the consistency ratio and making sure the number is not greater than 0.3, if a larger number is obtained you must go back to the pair-wise comparison table and re-evaluate the numbers you entered. (For a detailed explanation of the formulas read Appendix B).
5. Review the final scores in the Normalized Weight column; these numbers were normalized to add up to 1. The S&M criteria with the highest weight should represent the criteria with the highest importance.

Pair wise comparison of S&M performed to facilities awaiting D&D														
of S&M Activities: II														
S&M Activities	Contamination Control	Roof Repair	Safety Basis Surveillance	Ventilation	Fire System Maintenance	HVAC	Steam Repair	Grounds Keeping	Structural Repair	Legacy Waste Removal	Liquid Waste systems			Normalized Weight
Contamination Control	1.0	3.0	0.1	1.0	1.0	9.0	3.0	9.0	3.0	7.0	3.0			0.094
Roof Repair	0.3	1.0	0.1	0.2	1.0	9.0	0.1	9.0	7.0	7.0	4.0			0.081
Safety Basis Surveillance	9.0	9.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0			0.362
Ventilation	1.0	5.0	0.1	1.0	5.0	9.0	5.0	9.0	4.0	7.0	4.0			0.133

Figure 8: Pair-Wise Comparison of S&M Criteria

Sheet 4: Facility Evaluation Scale

The fourth sheet, Facility Evaluation Scale, contains a scale from 1–5 to evaluate each facility against all of the risk criteria developed in tab one and evaluated in tab 2. Each criterion has a specific definition for each scale number (Figure 9).

If additional risk criteria are added in the Pair-Wise Comparison of Risk Criteria tab, then the Facility Evaluation Scale also needs to be updated using the 5 point scale provided.

For each new criterion, provide a brief description of the characteristics of a facility under each scale number. Begin with 5 = very high risk, 4 = high risk, 3 = moderate risk, 2 = low risk, and 0 = no risk. The characteristics may be qualitative or quantitative.

Criteria	5 - Very High	4 - High	3 - Moderate	2 - Low	1 - None
Radiological Contamination	Facility has known or suspected radiological contamination to the degree that significant contamination control efforts must be considered during S&M .	Facility has known or suspected radiological contamination to the degree that moderate contamination control efforts must be considered during S&M.	Facility has a limited extent of known radiological contamination or there is reason to suspect the presence of radiological contamination based on known building processes (e.g. spill records or building postings indicate isolated portions of the facility would require special measures due to radiological contamination during S&M, or known building processes included some minor wet chemistry functions). Moderate to low contamination control efforts must be considered during S&M	Facility has no known radiological contamination based on building history.	Facility characterization confidence is high that no radiological contamination is present.
Chemical Contamination	Facility has known or suspected chemical contamination to the degree that significant contamination control must be considered during S&M	Facility has known or suspected chemical contamination to the degree that moderate contamination control efforts must be considered during S&M or is subject to site-specific regulatory agreement due to presence of chemical contamination.	Facility has a limited extent of known chemical contamination or there is reason to suspect the presence of chemical contamination based on known building processes (e.g. spill records or building postings indicate isolated portions of the facility would require special measures due to chemical contamination during S&M, or known building processes included some minor wet chemistry functions).	Facility has not been characterized, but has no known chemical contamination based on building history.	Facility characterization confidence is high that no chemical contamination is present.
Facility Nuclear categorization	CAT-2	CAT-3	Radiological High Risk	Radiological Low Risk	This Facility is not RAD facility
Environmental	Extensive contamination or facility deterioration could cause a very high negative impact on the environment.	Extensive contamination or facility deterioration could cause a moderate to high negative impact on the environment.	Limited contamination or facility deterioration that could cause a moderate impact on the environment	Some contamination or facility deterioration with low potential impact on environment	No unusual environmental concerns.
Safety	Extensive facility deterioration with very high potential impact on the safety of personnel.	Extensive facility deterioration with moderate to high potential impact on the safety of personnel.	Limited facility deterioration with some moderate potential impact on the safety of personnel.	Some facility deterioration with limited potential impact on the safety of personnel.	No unusual safety concerns.
Health	Extensive contamination with very high potential impact on the health of workers and/or general population.	Extensive contamination with moderate to high potential impact on the health of workers and/or general population.	Limited contamination with moderate potential impact on the health of workers and/or general population.	Some contamination with limited potential impact on the health of workers and/or general population.	No unusual health concerns.
Time Until D&D	16 years or more	11 - 15 years	6 - 10 years	2- 5 years	<= 1 year
Accumulated Delayed Maintenance Estimates (ADME)	ADME > \$1.5M	\$1M <= ADME < \$1 .5M	\$500 K <= ADME < \$1 M	\$100 K <= ADME < \$500K	ADME < \$100 K
Time Since Declared Excess	16 years or more	11 - 15 years	6 - 10 years	2- 5 years	<= 1 year or has not been declared excess
Status of Legacy Materials Cleanout	Large inventory of legacy waste with significant effort required to remove.	Large inventory of legacy waste with moderate effort required to remove	Medium to low inventory of legacy waste with moderate effort required to remove.	Small inventory of legacy waste with little effort required to remove	There is currently no legacy waste in the facility.

Figure 9: Facility Evaluation Scale

Sheet 5: Facility Evaluation

The Facility Evaluation Table is used to evaluate the facilities against the risk criteria and to calculate a score to rank them. The table is set up to evaluate a total of 50 facilities. By placing your mouse over each number in the scale above the red line you will see a box with the same definition provided on the previous sheet. The weight shown on the yellow row are the results obtained from the pair-wise comparison on sheet 2. The weight shown under the sub-criteria Radiological, Chemical, Environmental, Health and Safety is calculated by multiplying the Normalized weight of the sub-criterion times the normalized weight of its parent criterion (Figure 10).

To add more than 50 facilities simply select and drag the formula in the score and rank column down.

Risk Criteria	Ext. of Cont. Rad.	Ext. of Cont. Chem.	Fac. Nuclear Cat.	ES&H: Env.	ES&H: Safety	ES&H: Health	Time Until D&D	Delayed Maint.	Time Since Excess	Legacy Clean.
Weight	0.10	0.10	0.14	0.03	0.21	0.21	0.02	0.03	0.02	0.13
Very High	5	5	5	5	5	5	5	5	5	5
High	4	4	4	4	4	4	4	4	4	4
Moderate	3	3	3	3	3	3	3	3	3	3
Low	2	2	2	2	2	2	2	2	2	2
None	1	1	1	1	1	1	1	1	1	1
Facility	Score	Rank								
3517	3.89	2								
2026	3.33	4								
3026C/D	3.92	1								
4501/4505	3.11	5								
7710	1.78	8								
2000	3.83	3								
3550	2.49	7								
2011	1.66	9								
2009	1.28	10								
3503	2.78	6								

Figure 10. Facility Evaluation Sheet.

Steps to evaluate the facilities against the risk criteria:

1. Enter the names of the facilities in the “Facility” column.
2. For each facility, enter the number that best describes the facility under each criterion.
3. The total score and the rank of each facility are automatically calculated in the last two columns of this table; this number will determine the importance of each facility based on risk.

For example, figure 10 shows that after entering all the scores for each facility, facility 3026C/D ranked number 1 followed by 3517 and 2000 in third place.

Sheet 6: S&M Final Prioritization

This worksheet contains three tables. The first table is the S&M Checklist (Figure 11). This S&M Checklist is used to identify and prioritize the S&M actions required by each facility. The S&M Check List table displays in the gray column the names of the facilities entered in the Facility Evaluation sheet and in the blue row the S&M criteria ranked according to the results from tab 3. The facility names are automatically displayed in the order in which you entered them.

		S&M Check List										
S&M Criteria		Safety Basis Surveillance	Ventilation	Contamination Control	Steam Repair	Roof Repair	Fire System Maintenance	Liquid Waste Systems	Structural Repair	Legacy Waste Removal	HVAC	Grounds Keeping
Facilities	3517	X	X	X	X		X	X		X	X	
	2026	X	X	X			X	X		X	X	X
	3026C/D	X	X	X		X			X	X		
	4501/4505		X	X			X		X	X		
	7710		X				X			X		X
	2000		X	X		X	X		X			X
	3550						X		X			X
	2011											X
	2009		X									
	3503			X	X	X	X		X			

Figure 11: S&M Check List

Follow these steps to complete the S&M Check List:

1. Read the name of the first facility in the Facility Column
2. Mark the empty cells to the right with an “X” to identify each S&M activity the facility requires.

For example, facility 3517 requires safety basis surveillance, ventilation maintenance, contamination control, steam repair, fire system maintenance, liquid waste systems maintenance, legacy waste removal, HVAC maintenance, and grounds keeping (Figure 11).

The Score Board Table below the S&M Check List (Figure 12) calculates the final score of the S&M activities by adding the product of the final score of the facility times the weight of importance of the S&M activity it requires. Facility S&M Criteria with the highest values are the highest priority sites.

The numbers in the yellow row are the weight of importance of the S&M activity calculated in the pair-wise comparison in sheet 3. The score numbers in red are the score the facilities received in the “Facility Evaluation” sheet. The calculations are automatically entered in each cell, and the table provides the final score used to prioritize the S&M actions across all of the facilities.

Score Board													
		Safety Basis Surveillance	Ventilation	Contamination Control	Steam Repair	Roof Repair	Fire System Maintenance	Liquid Waste Systems	Structural Repair	Legacy Waste Removal	HVAC	Grounds Keeping	
29	Score	Facility	0.362	0.133	0.094	0.085	0.081	0.070	0.069	0.047	0.031	0.019	0.010
30	3.89	3517	1.40957	0.51665	0.36742	0.33149	0	0.27343	0.2685	0	0.11945	0.07341	0
31	3.33	2026	1.20737	0.44253	0.31471	0	0	0.23421	0.22998	0	0.10232	0.06288	0.03205
32	3.92	3026C/D	1.41814	0.51979	0.36965	0	0.31586	0	0	0.18245	0.12018	0	0
33	3.11	4501/4505	0	0.41222	0.29315	0	0	0.21817	0	0	0.09531	0.05857	0
34	1.78	7710	0	0.23571	0	0	0	0.12475	0	0	0	0.03349	0.01707
35	0.00		0	0	0	0	0	0	0	0	0	0	0

Figure 12 . Score Table

Finally, the S&M Actions Ranked table at the bottom of this sheet (Figure 13) shows the rank number for all of the S&M actions required by the facilities based on the score calculated on the Score Table. This sheet is populated automatically when you complete the S&M Check List.

S&M Actions Ranked												
		Safety Basis Surveillance	Ventilation	Contamination Control	Steam Repair	Roof Repair	Fire System Maintenance	Liquid Waste Systems	Structural Repair	Legacy Waste Removal	HVAC	Grounds Keeping
113	3517	2	5	10	12		17	19		34	39	
114	2026	3	7	14			23	24		36	40	44
115	3026C/D	1	4	9		13			28	33		
116	4501/4505		8	16			26			37	41	
117	7710		22				32				43	46
118	2000		6	11		15	18		29			42
119	3550						30		35			45
120	2011											47
121	2009		31									
122	3503			20	21	25	27			38		
123												
124												
125												
126												
127												
128												
129												
130												
131												
132												

Figure 13: S&M Actions Ranked

For example, Figure 13 shows that the safety basis surveillance in facilities 3026C/D, 3517 and 2026 are the top three priorities.

Sheet 7: S&M Final Prioritization Chart

The final sheet in the Excel template displays S&M activities prioritized across all the facilities based on the risk of the facilities and the weight of importance of the S&M they require. As shown in Figure 14, the top three priorities are safety basis surveillance in ORNL facilities 3026C/D, 3517, and 2026.

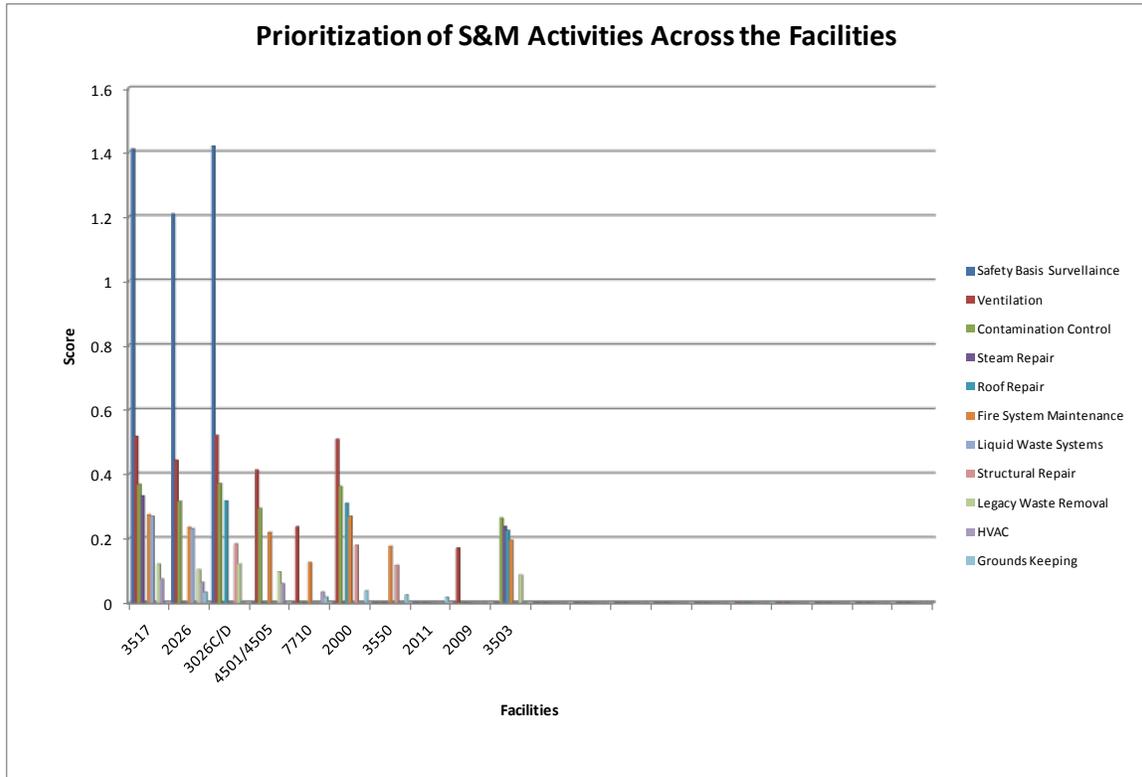


Figure 14: Final Ranked S&M Activities

Sheet 8 & 9: Risk Criteria, and S&M Criteria Definitions

These sheets contain the definitions for the criteria in order to help you evaluate them according to a standard definition. The definitions were obtained from a group of subject matter experts at ORNL (Figures 15 and 16).

Risk Criteria Definitions

Criteria	Sub-criteria	Definition
Extent of Contamination	Radiological Contamination	Addresses extent of radiological contamination of facility and its impact on S&M. Includes the existence of facility-specific regulatory agreements related to radiological contamination.
	Chemical Contamination	Addresses extent of chemical contamination of facility and its impact on S&M. Includes measure for facility-specific environmental regulatory agreements or requirements.
Facility Nuclear Categorization		Addresses Nuclear Categorization of Facility with assumption that impact of problems at nuclear facilities create greater potential for risk.
ES&H	Environmental	Addresses the likelihood of and the extent/damage possible to the environment in the event of a release of contamination because of inadequate S&M. Examples of factors to be taken into consideration include contamination of soil, groundwater, streams, or other natural resources, as well as airborne contamination.
	Safety	Addresses the physical safety impacts on personnel created by the failure of the facility structure or infrastructure due to the lack of performance of S&M activities. These impacts are to be focused around facility personnel and those in the area and could consider materials of construction and failures of systems such as ventilation and fire detection/ suppression.
	Health	Addresses the impact on the health of workers and/ or the general population (when considering the facility location/ proximity to other operating facilities and general population centers due to the lack of proper S&M.) The considerations here are to be focused more on the body's physiological responses to exposure to the hazards rather than the more physical damage aspects to be considered in "Safety".
Time Until D&D		Addresses time between S&M and D&D at the time of the prioritization. Like the other criteria discussed, this criteria will change from year-to-year.
Accumulated Delayed Maintenance Estimates		Estimates the total cost of all facility maintenance that has been delayed/unperformed since facility became non-operational.
Time since declared excess		Addresses the time since the facility has been declared excess.
Status of Legacy Materials Cleanout		Addresses the extent of the efforts to remove legacy materials in preparation for either facility transfer to EM, the start of D&D or both.

Figure 15: Risk Criteria Definitions

S&M Criteria Definitions

Maintenance Action	Definition
Contamination Control	Actions required to prevent the spread of contamination. It includes decontamination and contamination fixing efforts.
Roof Repair	Maintenance and repair of the roof.
Safety Basis Surveillance	The surveillances required by documented safety analysis or equivalent documents.
Ventilation	Maintenance of systems designed to maintain air flow to prevent the uncontrolled release of contamination. This will include duct work, filters, and blowers.
Fire System Maintenance	Maintenance of systems designed to mitigate a fire event.
HVAC	Maintenance of heating, ventilation and air conditioning.
Steam Repair	Maintenance of systems designed to move and control steam through out the facility.
Grounds Keeping	Mowing grass, filling in animal holes, controlling weeds and other maintenances related to grounds keeping.
Structural Repair	Any maintenance related to structural repairs. Not including the roof.
Legacy Waste Removal	Efforts associated with the disposition of legacy waste in anticipation of D&D activities. Includes those items that are easily removed or require minimal effort to disconnect.
Liquid Waste Systems	Maintenance of piping, sumps and associated equipment designed to remove liquid waste from a facility.

Figure 16: S&M Criteria Definitions

Sheet 10: Random Index Chart (RI)

This sheet contains a random consistency index chart which is used in the calculation of the Consistency Index used in tabs 2 and 3 to determine the internal consistency of comparisons of the criteria ranking for both risk and S&M (Figure 17).

Table 8: Random Consistency Index (RI)															
n	1	2	3	4	5	6	7	9	10	11	12	13	14	15	
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.45	1.49	1.51	1.48	1.56	1.57	1.59	

Figure 17: Random Consistency Index Chart

This chart was provided by Dr. T. Saaty, where n equals the number of criteria. For a detailed explanation of the Consistency Index see Appendix B.

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Appendix B. Consistency Ratio

The consistency ratio (CR) value at the bottom of each pair-wise comparison table measures the consistency of the pair-wise assessment. Thomas L. Saaty, the creator of the analytical hierarchy process, gave a measure of consistency, called consistency index (CI), as deviation or degree of consistency using the following formula:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Where n = number of facilities and Lambda max = the summation of products between the normalized weights times the sum of the columns.

The consistency ratio is a comparison between the consistency index and the random consistency index, as shown in the following formula:

$$CR = \frac{CI}{RI}$$

Where RI = is the Random Consistency Index provided in tab 10.

Lambda max	16.81
CI	0.58
RI	1.51
Consistency Ratio	0.38

Figure 20: Consistency Ratio (CR) Value

According to Saaty, a score less than 0.3 is acceptable, and any CR score of more than 0.3 indicates that the pair-wise comparison must be re-evaluated for consistency.