

An Overview of Tool for Response Action Cost Estimating (TRACE)

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788



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An Overview of Tool for Response Action Cost Estimating (TRACE) - 12407

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ABSTRACT

Tools and techniques that provide improved performance and reduced costs are important to government programs, particularly in current times. An opportunity for improvement was identified for preparation of cost estimates used to support the evaluation of response action alternatives. As a result, CH2M HILL Plateau Remediation Company has developed Tool for Response Action Cost Estimating (TRACE). TRACE is a multi-page Microsoft Excel® workbook developed to introduce efficiencies into the timely and consistent production of cost estimates for response action alternatives. This tool combines costs derived from extensive site-specific runs of commercially available remediation cost models with site-specific and estimator-researched and derived costs, providing the best estimating sources available. TRACE also provides for common quantity and key parameter links across multiple alternatives, maximizing ease of updating estimates and performing sensitivity analyses, and ensuring consistency.

INTRODUCTION

Issues with past cost estimates for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) feasibility studies at Hanford prompted the creation of TRACE:

- Difficult to complete cost estimates on schedule due to a labor intensive cost generation and documentation system, key inputs provided very late in document development, and last minute project changes to remedial technologies and process options
- Regarded by the customer as appearing to be: difficult to explain and defend, unrelated to recent actual costs, and inconsistent between estimates.

TRACE calculates capital and operations and management (O&M) costs for each alternative, as both life-cycle non-discounted and present value costs. Standardized unit costs are based on a combination of the commercially-available Remedial Action Cost Estimating and Risk (RACER™) cost model runs and actual Hanford costs from completed response actions, detailed post-feasibility study (FS) and (EE/CA) estimates, and contractor quotes and bids. Project-specific user-supplied costs are easily entered and automatically flagged for quality assurance (QA) checks. Key quantities, percentages, and project information are entered once, and then linked through capital and O&M cost spreadsheets to generate costs for each remedial alternative. TRACE modular design facilitates: alternative cost development, modification of cost elements,

comparisons between multiple alternatives, itemization of up to 60 site specific costs for each alternative, and cost sensitivity analyses.

TRACE was developed, documented, and implemented to be an improved and more responsive cost estimating tool, meeting project needs.

METHOD

TRACE was developed as an MS Excel workbook, documented by a series of Environmental Calculation Files (ECFs) that were independently validated and verified, checked against specific project and actual cost cases, and approved before implementation. Cost estimating methodologies and guidance from Association for the Advancement of Cost Engineering (AACE) EPA, DOE and CH2M HILL Plateau Remediation Company were followed in the development of TRACE. The TRACE master workbook is version-controlled, with documented updates following CHPRC procedures. Project cost estimates are initiated with the latest TRACE master workbook. The TRACE worksheets are locked, except for designated user entry fields and designated fields for comments and references. Changes to standard unit costs, or additions of new user-defined cost items generate automatic flags that prompt review checks and approval signoffs.

TRACE Spreadsheets

The TRACE workbook has five sets of five spreadsheets each, each set for a response action alternative, and six general spreadsheets used to generate the cost estimates and report results for all alternatives. Figure 1 provides an overview of the content in the various spreadsheets and shows general and example-specific flow of information between the spreadsheets

[Note to WMS – this figure will be updated, enhanced and possibly split into two figures for the FINAL Version].

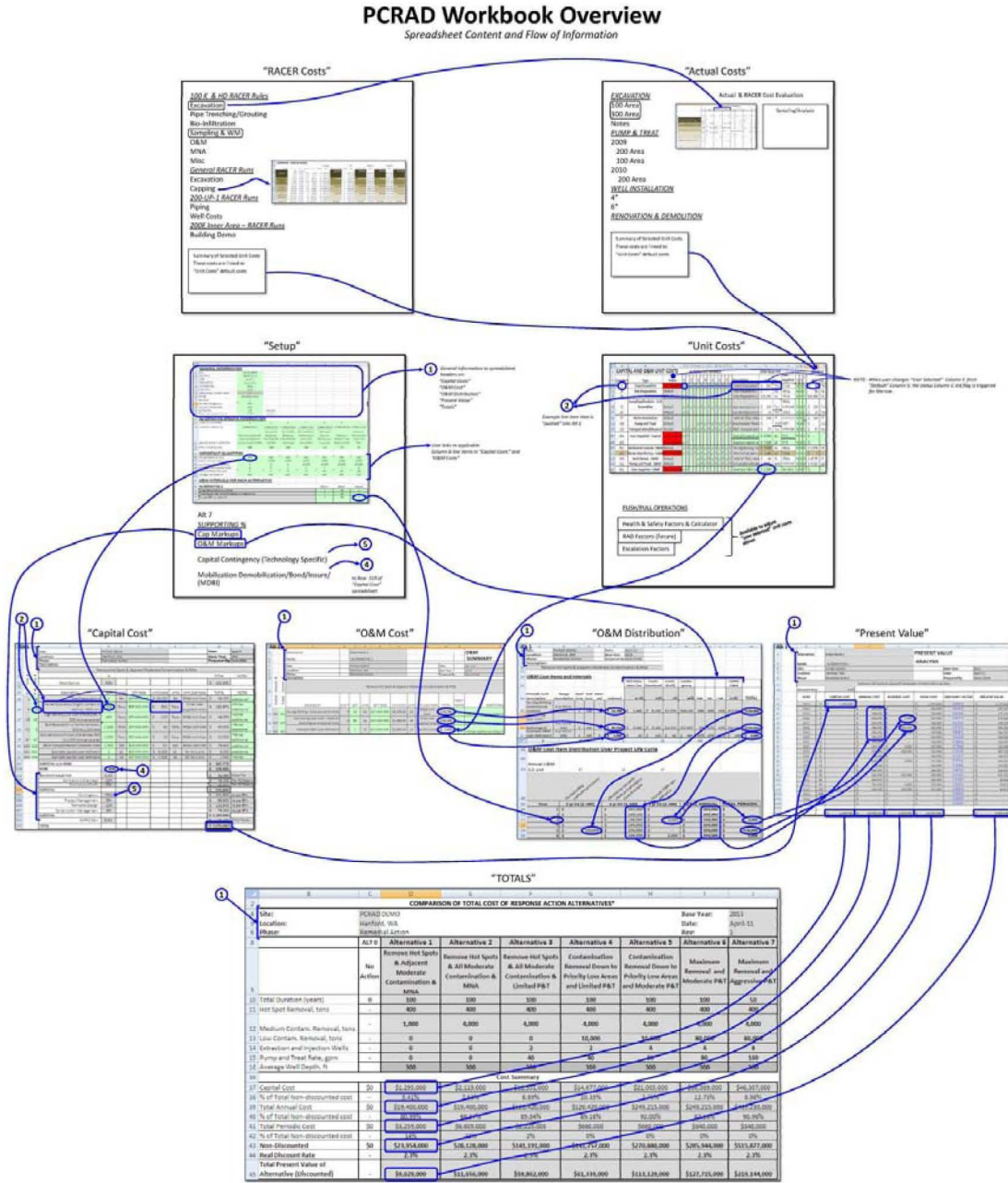


Figure 1 TRACE Workbook Overview

The following provides an overview of the TRACE workbook spreadsheets:

1. **General Spreadsheets 1 & 2: “Actual Costs” and “RACER Costs”** – These two spreadsheets hold cost results that form the basis for the standardized line item unit costs in the “Unit Costs” spreadsheet. Both of these were locked after review/validation, and only updated with new information on a periodic basis:

- a. **“Actual Costs”** – This spreadsheet holds actual project costs for specific response action activities that had been documented with associated quantities and project parameters/site specifics. The actual costs are adjusted for comparability with other similar actual costs and with RACER generated costs for the same response action activity. Selected actual costs, which show a range around the standardized unit costs, and the standardized unit costs are linked to the “Unit Costs” spreadsheet. Summary information used in developing standardized line item unit costs is also presented.
 - b. **“RACER Costs”** – This spreadsheet holds RACER modeled costs for specific response action activities and associated quantities and project parameters/site specifics. The RACER costs were either run to match standardized unit cost assumptions or adjusted for comparability with similar actual costs. Selected RACER costs, which show a range around the standardized unit costs, and standardized unit costs derived only from RACER costs are linked to the “Unit Costs” spreadsheet. In some cases RACER costs are linked to the “Actual Costs” spreadsheet to supplement the actual costs.
2. **General Spreadsheets 3 & 4: “Setup” and “Unit Costs”** – These two spreadsheets are the heart of the TRACE workbook, taking key information in from the “RACER Costs” and “Actual Costs” spreadsheets and feeding estimating parameters and their associated unit costs to the alternative specific costing spreadsheets (e.g., capital cost, O&M). Both of these spreadsheets collect and display consolidated information for up to five response action alternatives, providing centralized locations for building and reviewing cost estimates.
- a. **“Setup”** – This spreadsheet contains the following information that is entered by the estimator to describe and define the cost estimate:
 - General information – site name, location, base year, and other key information that is linked automatically to all of the alternative-specific spreadsheets.
 - Alternative Specific Information – alternative name and description, discount rate, response action duration, mobilization/demobilization and contingency percentages, and user inputs specific to the response action alternative. This information feeds into alternative-specific “Capital Cost” and “O&M Distribution” spreadsheets.
 - “Important Quantities” - This matrix provides a centralized location for user-provided quantities for each response action alternative. This is particularly useful where quantities are used multiple times and/or are subject to change, and to compare key quantities between the different response actions. This also streamlines sensitivity analyses for the range of values used. The important quantities must be linked by the estimator into response action alternative-specific quantities in the “Capital Cost” and “O&M Cost” spreadsheets. The important quantities are subsequently

linked into the “Totals” spreadsheet – these rows can be hidden or displayed as desired for the project.

- O & M Intervals for Each alternative – A matrix is provided for each response action alternative that links from O&M and periodic cost line items in the “O&M Cost” spreadsheet. The entries for input are: start year, stop year, and occurrence interval in years for each O&M item for each alternative identified. This information links to the alternative-specific O&M Distribution spreadsheet.
- b. **“Unit Costs”** – This spreadsheet contains the following information:
- Numbered cost line items with separate standardized and user-defined matrices for capital costs and for O&M/periodic costs. The standardized cost line items have default unit costs that users can accept or override, and display supporting cost information compiled from the Actual Costs and RACER Costs spreadsheets. The line item descriptions, unit cost, units, and unit cost notes are linked to the alternative-specific “Capital Cost” or “O&M Cost” spreadsheets, depending on the line item cost type.
 - Each cost line item, whether standardized or user-defined, has two columns each for project specific alternatives 1 to 5:
 - The green “push” column – A user-entered “y” sends (pushes) the line item into the alternative-specific “Capital Cost” spreadsheet or “O&M Cost” spreadsheet, depending on the item type.
 - The gray “pull” column – This column gets populated from the “Capital Cost” spreadsheet or “O&M Cost” spreadsheet, corresponding to the item type. After a cost line item is “pulled” into one of those spreadsheets, by typing the line item number into the alternative-specific “Capital Cost” spreadsheet, a “y” is automatically entered in the gray column in the “Unit Cost” spreadsheet for the specific line item and alternative. Note that this column is locked in the “Unit Costs” spreadsheet.
 - There are two separate matrices for each alternative with intermediate logic and values supporting “Push” and “Pull” operations
 - A section of the spreadsheet is dedicated to health and safety factors, providing a calculation methodology for factoring cost line items based on health and safety levels and showing a range of results using different levels of assumptions for health and safety Levels A, B, C, and D. A blank set of factors is reserved for calculation results based on different levels of protection, which are to be defined, for dealing with different levels of radioactive wastes. These factors are available to scale default unit costs to account for different health and safety protection levels and conditions than assumed.

- A section of the spreadsheet is dedicated to Engineering News Record Construction Cost Index (ENR CCI) factors dating from 1995 to recent. These factors are used to convert past costs into current costs.
3. **Alternative-Specific Spreadsheets 1 & 2: “Capital Cost” and “O&M Cost”.**
There are five of each of these spreadsheets in the workbook identified as Alternatives 1 to 5, as needed for the project. These spreadsheets are where the capital and O&M costs are respectively assembled for each alternative, based on push/pull operations for all standardized and user-selected cost line items.
- a. **“Capital Cost”** – This spreadsheet receives the alternative-specific pushed and pulled unit cost line items, with the “Pull” numbers overriding “Push” numbers when both are listed for a line item. Capital costs are summed in the spreadsheet and markups from the “Setup” spreadsheet are applied to give a total capital cost for each alternative. The alternative-specific total capital cost is linked into the alternative-specific present value “PV Cost” spreadsheet.
 - b. **“O&M Cost”** – This spreadsheet receives the alternative-specific pushed and pulled unit cost line items, with the “Pull” numbers overriding “Push” numbers when both are listed for a line item. Since this spreadsheet contains line items with different time intervals, these costs are not summed. The cost line items are linked into the “Setup” spreadsheet for user entry of time interval information, and the costs from alternative-specific “O&M Cost” spreadsheet are linked into “O&M Distribution” spreadsheet.
4. **Alternative-Specific Spreadsheets 3, 4 & 5: “Capital Cost Distribution”, “O&M Distribution” and “Present Value”.** There are five of each of these spreadsheets in the workbook, identified as Alternatives 1 to 5, as needed for the project. These spreadsheets are where the costs get allocated to sites within each alternative (if any), distributed over time and then totaled.
- a. **“Capital Cost Distribution”** – The site numbers in the “Capital Cost” spreadsheet for each line capital cost line item are used to group the capital costs into site-specific capital costs. Site 0 begins the sequence and is the designation reserved for assigning costs that can get distributed among Sites 1 through 95 for an alternative; e.g., mobilization/demobilization costs, site preparation costs.
 - b. **“O&M Distribution”** – The alternative-specific O&M and periodic cost line items are listed in this spreadsheet along with the line-item specific interval information. Markups from “Setup” are applied to each line item. Then, in a separate matrix, the costs for each marked up line item are distributed over the specific years of occurrence, from 1 up to 200. For individual sites, Row 117 links the site number from Column R of the O&M Cost spreadsheet. The individual site annual and periodic costs are summed for each year from 1 to 200 in separate cost arrays for each site.

- c. **“Present Value”** – The alternative-specific “PV” spreadsheet receives all values from the corresponding “Capital Cost” and “O&M Distribution” spreadsheets (for all sites), summing by the year-specific distribution and displaying an overall cost distribution over 1 up to 200 years in separate columns for capital, O&M and periodic costs. Each column is totaled individually to provide the total non-discounted cost. Each row from the three columns is then totaled to show total costs in each year from 1 up to 200. A separate column displays year-specific discount factors that are calculated using the discount rate percent that is transferred in from the “Setup” spreadsheet. A final column shows the calculated year-by-year present value, which is then totaled to give a single overall present value cost for the alternative. The “PV” spreadsheet results are then transferred to the “Totals” spreadsheet.

5. General Spreadsheets 5 & 6: “Site-Summary” and “Totals”

- a. **“Site-Summary”** – This spreadsheet presents the site specific costs listed below for each site evaluated within an alternative, and calculates the total of each cost for all sites which represents the totals for each alternative. Inputs to this spreadsheet are from links to other spreadsheets; such as, the Setup, Site Capital Cost Distribution, and O&M Cost Distribution spreadsheets and include the Capital, Annual, and Periodic Costs from each. The total costs for each alternative in this spreadsheet can be compared to the costs calculated in the “Totals” spreadsheet the two sets of costs are calculated independently, and when all capital and O&M cost line items in an alternative are assigned site numbers, the two sets of total Alternative costs will match.
 - Capital costs and discounted capital costs
 - Annual costs and discounted annual costs
 - Periodic costs and discounted periodic costs
 - Total non-discounted costs
 - Total discounted (PV) costs
- b. **“Totals”** – This spreadsheet presents the summary of results obtained from the other spreadsheets for each of the seven alternatives:
 - General site and alternative-specific description and duration are linked from the “Setup” spreadsheet.
 - Important quantities for each alternative are presented from the “Setup” spreadsheet.
 - Separate totals are presented from “Present Value” spreadsheet for each alternative for:
 - Capital cost

- Annual O&M cost
- Periodic cost
- Non-discounted cost
- Present value cost

TRACE Environmental Calculation Files (ECFs)

More detailed steps, calculation approaches, and equations/basis for each TRACE spreadsheet are presented in the ECF's *[ref #'s to be added]*. Each ECF consists of the following:

1. Purpose
2. Background
3. Methodology
4. Assumptions and Inputs
5. Software Applications
6. Calculation
7. Results/Conclusions
8. References

RESULTS AND DISCUSSION

TRACE has proven to significantly enhance response action cost estimating:

- **Transparency** –Generates alternative cost spreadsheets that are uniformly formatted to clearly and consistently present cost items, cost descriptions, quantities, and unit cost references. All standardized unit costs are fully referenced from their sources.
- **Relevancy** –Uses standardized unit costs based on a combination of RACER cost model runs and actual Hanford costs from completed response actions, detailed post-FS and EE/CA estimates, and contractor quotes and bids.
- **Speed** – Allows cost estimates to be generated and reviewed significantly faster than the previous system. Generally, for well-scoped and planned alternatives, initial cost estimates are completed with a 20% to 50% time reduction. Similarly, cost estimate modifications are completed with a 50% to 90% time reduction.
- **Consistency** –Allows for consistent application of costs, from a master list of unit costs, throughout all alternatives in a cost estimate and between estimates. Project supplied unit costs can also be entered into the master list further assuring consistent use.

- **Flexibility** – Provides for quick unit cost master list updates and supplements to reflect new information or alternative-specific conditions. Key quantities for each alternative are entered once, and are systematically linked to their respective capital and O&M cost spreadsheets, allowing quick changes and cost sensitivity analyses.
- **Defensibility** – Facilitates use of unit costs and linking these costs to multiple remedial alternatives for a single cost estimate. When a standardized default cost is changed, an automatic flag is displayed indicating the need for a review and an appropriate reference.
- **Usefulness** – Calculates capital and O&M costs as both life-cycle non-discounted and present value costs.
- **Cost effectiveness** – TRACE has paid for itself based on the savings of three cost estimates and the significant reduction of time needed for system maintenance due to its modular design.

The structured input of key project general information and scope quantities facilitates setup, review, and project discussions (see Figure 2).

[Note to WMS – this figure to be updated]

	A	B	C	D	E	F	G	H	I
7	GENERAL INFORMATION								
8				<u>UNITS</u>	<u>NOTES</u>				
9	SITE	PCRAD DEMO							
10	LOCATION	Hanford, WA							
11	DATE	April-11							
12	PREPARED BY	Kevin Klink							
13	CURRENT YEAR	2011							
14	BASE YEAR	2013							
15	DELTA (BASE - CURRENT YEAR)	2							
16	PHASE	Remedial Action							
17	REVISION	1							
18	Accuracy Range (Low)	-30%							
19	Accuracy Range (High)	50%							
20	Soil Density	1.5		tons/bcy					
21	Bank to excavated volume	1.15		ecy/bcy					
22									
23	ALTERNATIVE SPECIFIC INFORMATION								
24									
25	ALTERNATIVE NUMBER	1	2	3	4	5	6	7	
26	NAME OF ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5	ALTERNATIVE 6	ALTERNATIVE 7	
27	DESCRIPTION OF ALTERNATIVE	Remove Hot Spots & Adjacent Moderate Contamination & MNA	Remove Hot Spots & All Moderate Contamination & MNA	Remove Hot Spots & All Moderate Contamination & Limited P&T	Contamination Removal Down to Priority Low Areas and Limited P&T	Contamination Removal Down to Priority Low Areas and Moderate P&T	Maximum Removal and Moderate P&T	Maximum Removal and Aggressive P&T	
30	TOTAL DURATION (YRS)	100	100	100	100	100	100	50	
53									
54	IMPORTANT QUANTITIES								
55									
56	Hot Spot Removal, tons	400	400	400	400	400	400	400	
57	Medium Contam. Removal, tons	1,000	4,000	4,000	4,000	4,000	4,000	4,000	
58	Low Contam. Removal, tons	0	0	0	10,000	10,000	80,000	80,000	
59	Extraction and Injection Wells	0	0	2	2	4	4	8	
60	Pump and Treat Rate, gpm	0	0	40	40	80	80	160	
61	Average Well Depth, ft	300	300	300	300	300	300	300	
62	Important quantities 7								
81									

Figure 2 Selected TRACE “Setup” Worksheet Information *[to be revised]*

Side-by-side cost summaries with “site” itemization for each alternative (Figure 3) can be quickly modified by changing key parameter inputs, and provides excellent support for project sensitivity analyses and decision making meetings.

Title: 5 ALTS for 5 Plume Areas						
Purpose: WMS Paper						
Site:	TRACE EXAMPLE			Date:	November-11	
Location:	Hanford, WA			Base Year:	2014	
Phase:	Scoping			Prepared By:	K. Klink	
Description:						
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	
Site number 1						
Site name	Uranium					
Capital Cost	\$ 4,352,463	\$ 14,084,055	\$ 33,756,912	\$ 37,574,845	\$ 46,164,644	
Annual	\$ 47,918,100	\$ 79,551,200	\$ 71,365,700	\$ 92,634,000	\$ 92,068,600	
Periodic	\$ 131,108,325	\$ 37,988,300	\$ 24,451,400	\$ 30,602,700	\$ 30,825,400	
Individual Site (Non Discounted)	\$ 183,378,889	\$ 131,623,555	\$ 129,574,012	\$ 160,811,545	\$ 169,058,644	
Discounted (PV)	\$ 26,143,535	\$ 79,754,982	\$ 96,498,013	\$ 118,992,165	\$ 135,852,438	
Site number 2						
Site name	Nitrate					
Capital Cost	\$ 4,352,463	\$ 14,084,055	\$ 33,756,912	\$ 37,574,845	\$ 46,164,644	
Annual	\$ 6,432,000	\$ 28,847,200	\$ 39,685,200	\$ 50,650,500	\$ 60,513,900	
Periodic	\$ 15,304,425	\$ 17,052,700	\$ 22,022,900	\$ 28,289,300	\$ 30,825,400	
Individual Site (Non Discounted)	\$ 26,088,889	\$ 59,983,955	\$ 95,465,012	\$ 116,514,645	\$ 137,503,944	
Discounted (PV)	\$ 15,907,201	\$ 44,757,396	\$ 74,593,679	\$ 90,496,908	\$ 111,187,533	
Site number 3						
Site name	Chromium					
Capital Cost	\$ 4,352,463	\$ 14,084,055	\$ 33,756,912	\$ 37,574,845	\$ 46,164,644	
Annual	\$ 20,100,000	\$ 79,175,200	\$ 100,760,200	\$ 62,394,000	\$ 79,399,400	
Periodic	\$ 57,111,425	\$ 58,923,900	\$ 49,353,500	\$ 28,443,900	\$ 46,876,300	
Individual Site (Non Discounted)	\$ 81,563,889	\$ 152,183,155	\$ 183,870,612	\$ 128,412,745	\$ 172,440,344	
Discounted (PV)	\$ 24,388,109	\$ 76,060,831	\$ 111,799,008	\$ 96,732,944	\$ 131,423,502	
Site number 4						
Site name	I-129					
Capital Cost	\$ 2,720,290	\$ 9,286,841	\$ 9,294,091	\$ 9,287,027	\$ 9,342,630	
Annual	\$ 84,007,500	\$ 20,094,400	\$ 20,094,400	\$ 20,094,400	\$ 20,094,400	
Periodic	\$ 62,569,214	\$ 8,025,200	\$ 8,025,200	\$ 8,025,200	\$ 8,025,200	
Individual Site (Non Discounted)	\$ 149,297,003	\$ 37,406,441	\$ 37,413,691	\$ 37,406,627	\$ 37,462,230	
Discounted (PV)	\$ 12,006,270	\$ 31,527,920	\$ 31,534,692	\$ 31,528,093	\$ 31,580,029	
Site number 5						
Site name	Installed Interim Action					
Capital Cost	\$ -	\$ -	\$ -	\$ -	\$ -	
Annual	\$ 27,240,900	\$ 27,240,900	\$ 27,240,900	\$ 27,240,900	\$ 27,240,900	
Periodic	\$ 6,830,311	\$ 6,703,200	\$ 6,703,200	\$ 6,703,200	\$ 6,703,200	
Individual Site (Non Discounted)	\$ 34,071,211	\$ 33,944,100	\$ 33,944,100	\$ 33,944,100	\$ 33,944,100	
Discounted (PV)	\$ 25,435,435	\$ 25,348,260	\$ 25,348,260	\$ 25,348,260	\$ 25,348,260	
Total Capital (Non-discounted)	\$ 15,778,000	\$ 51,540,000	\$ 110,565,000	\$ 122,012,000	\$ 147,837,000	
Total Annual (Non-discounted)	\$ 185,699,000	\$ 234,909,000	\$ 259,147,000	\$ 253,014,000	\$ 279,318,000	
Total Periodic (Non-discounted)	\$ 272,924,000	\$ 128,694,000	\$ 110,557,000	\$ 102,065,000	\$ 123,256,000	
Total Non Discounted	\$ 474,401,000	\$ 415,143,000	\$ 480,269,000	\$ 477,091,000	\$ 550,411,000	
Total Discounted (Discounted)	\$ 103,881,000	\$ 257,450,000	\$ 339,774,000	\$ 363,099,000	\$ 435,392,000	

Figure 3 TRACE Site Specific Cost Results for Five Response Action Alternatives for Five Plumes

[Note to WMS – this figure will be enhanced/revised and example explained]

REFERENCES

[NOTE TO WMS – THESE REFERENCES WILL BE AUGMENTED AND PUT IN STANDARDIZED FORMAT PER WM48-2K INSTRUCTIONS IN THE FINAL VERSION]

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- ECF-Hanford-11-0164, Environmental Calculation File TRACEV2 – Site Cost Distribution
- ECF-Hanford-11-0098, Environmental Calculation File for PCRAD V1 Overall-Overview
- ECF-Hanford-11-0099, Environmental Calculation File for PCRAD V1-Actual Costs
- ECF-Hanford-11-0100, Environmental Calculation File for PCRAD V1- RACER Costs

ECF-Hanford-11-0101, Environmental Calculation File for PCRAD V1-Calculations

ECF-Hanford-11-0102 Environmental Calculation File for PCRAD Unit Costs

ECF-Hanford-11-0103, Environmental Calculation File for PCRAD V1-Capital Cost

ECF-Hanford-11-0104, Environmental Calculation File for PCRAD V1-O&M Cost

ECF-Hanford-11-0105, Environmental Calculation File for PCRAD V1-O&M
Distribution

ECF-Hanford-11-0106, Environmental Calculation File for PCRAD V1-Present Value

ECF-Hanford-11-0107, Environmental Calculation File for PCRAD V1-Totals

Remedial Action Cost Engineering and Requirements (RACER)

DRAFT