Sensitivity Analysis of the Methodology for Estimating The Costs of Long-term Treatment of Mine Drainage

Prepared for:

U.S. Office of Surface Mining
Pittsburgh, Pennsylvania 15220

Disclaimer

This document presents the sensitivity analysis of the methodology for estimating the costs of treatment of mine drainage. The cost methodology was developed by Tetra Tech EM Inc. under this contract. The cost information in this report is for illustrative purpose only and may not represent the true cost of treatment. This document does not represent U.S. Office of Surface Mining official guidance or policy for the design or approval of mine drainage treatment systems.

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Contract No.:	143868-CT99-12063
OSM Contracting Officer:	Ms. Kathy Oberle
Telephone:	(412) 937-2838
Prepared by:	Tetra Tech EM Inc.
Tetra Tech Program Manager:	Arthur Glazer
Telephone:	(703) 390-0623

1.0 INTRODUCTION

Under the Contract No. 143868-CT99-12063, Tetra Tech EM Inc. (Tetra Tech) was tasked to assess the relationship among economic variables and time, specific technical variables , and their effect on determinations of long-term treatment costs of mine drainage.

2.0 APPROACH

Tetra Tech, with recommendation from the Office of Surface Mining (OSM), selected a number of economic and technical variables for the analysis. Further, a mining site in Pennsylvania and a mining site in West Virginia were selected for the case studies.

2.1 Economic Variables:

- Tetra Tech analyzed the impact of three economic factors on the long-term treatment costs of mine drainage - nominal rate of return, real rate of return, and inflation rate. The range of values used for this analysis for each of these rates are presented in Table 1.

- Tetra Tech also calculated the net present value (NPV) multipliers for long-term treatment costs of mine drainage based on various net discount rates (real rates of return) and selected years ranging from one year to 100 years. The NPV multipliers are used to calculate the net present value of estimated treatment costs based on various net discount rates and time frames. The NPV multipliers calculated for this analysis are presented in Table 2; Figure 1 is a graphical presentation of Table 2.

- The NPV multipliers were then used to calculate the total NPV costs for the two selected sites, to demonstrate how the net discount rates and time frames impact the estimated costs.

2.2 Technical Variables:

- The sensitivity analysis of the technical variables was conducted based on costs associated with select treatment activities as recommended by OSM. The activities OSM recommended were the costs to perform maintenance and the replacement of active treatment systems and source control measures. These activities were selected because there is not a standard approach used in the coal ming industry to estimate the future costs to perform these activities. The approach typically used is based on “engineering judgement” on a facility-by-facility basis.

- Tetra Tech then calculated the impacts of costs for the maintenance and replacement of active treatment systems and source control measures on total costs using the approach presented in the cost methodology (developed by Tetra Tech under this contract). In the cost methodology, the costs for maintenance and replacement of active treatment systems and sources control measures are estimates based on a percentage of the total initial capital cost for each system. For this analysis, the percentages used were varied from 1% to 15% of the total capital cost to determine how the impacts of these treatment activities on the total long-term treatment costs will

vary.

2.3 Characteristics of the Selected Sites:

In selecting the two sites for the case studies, Tetra Tech considered the following factors:

a.. For the sensitivity analysis of the technical variables, coal refuse pile facilities were considered the most reasonable type of facility because the potential area to be capped is more definitive than the potential area to be capped at surface and underground mining facilities. This approach provides more accurate estimates of the actual long-term treatment costs.

b. For the two facilities selected, the data provided by OSM was sufficiently complete to allow for a more comprehensive and accurate analysis.

The following table summarizes the characteristics of the two sites, based on select parameters for this analysis.

Parameter	Mining Site in West Virginia	Mining Site in Pennsylvania
Type of operation	Coal refuse facility	Coal refuse facility
Status of operation	Active	Active
Disturbed area to be capped	58 acres	0.9 acres
Source control measures	Capping of the disturbed area, storm water diversion channels, and sedimentation ponds.	Capping of the disturbed area, storm water diversion channels, and sedimentation ponds.
Source control status	The cap has not been constructed, however diversion channels and sedimentation ponds are partly constructed.	The cap has not been constructed, however diversion channels and sedimentation ponds are partly constructed.
Active treatment system	Hydrated lime neutralization with the maximum capacity of 0.4 MGD.	Pebble quicklime neutralization with the maximum capacity of 5 MGD
Status of active treatment system	In place and operating	In place and operating

3.0 RESULTS

3.1 Sensitivity of the Economic Variables

This section presents the results of the analysis of the relationship among the economic variables and long-term costs for the treatment of mine drainage.

- The larger the rate of return, either in real or nominal terms, the smaller the difference in discounted treatment costs, particularly for longer treatment periods, such as 50 years (see Table 2) . For example, for a one percent real rate of return, the difference in the NPV multiplier between 50 years and 100 years is a factor of 23.83 (63.03 minus 39.20). For a five percent real rate of return, the difference in the multiplier is a factor of only 1.59 (19.85 minus 18.26).

- The real rate of return has a more significant impact on the NPV than the projected time frame for operating the system. For example, as shown in Table 3, Figure 2, and Figure 3 for the mining site in West Virgina, a 2% real rate of return requires approximately $24.1 million (M) be set aside up front for 50 years of operation, $26.1 M for 75 years, and $27.4 M for 100 years. Using a 6% real rate of return requires approximately $19.7 M be set aside for 50 years, $19.9 M for 75 years, and $19.9 M for 100 years.

- Mine operators with a lower amount of funds to set aside up front will need to select financial options that will give a higher real rate of return. For example in Table 3, using a 75-year time frame, an operator must allocate approximately $30.1 M for a 1% real rate of return. On the other hand, only approximately $18 M is required for a 10% real rate of return.

- The same trends have been observed for the mine site in Pennsylvania. The analysis for that facility is presented in Table 4, Figure 4, and Figure 5.

3.2 Results of Technical Variables Sensitivity

This section presents the results of the analysis of the relationship among the technical variables and long-term operating costs for the treatment of mine drainage.

- The costs for system maintenance and replacement correlate linearly with the total net present value of the lifetime operating cost. The higher the total capital costs for the construction and installation of active treatment systems and source control measures, the more they will increase the total NPV of the lifetime operating costs.

- For source control measures, the total NPV of the lifetime operating costs will increase significantly for sites with a complex design of capping as part of the source control measures.

- In the case of the mine site in West Virginia, the total lifetime operating cost of the source control measures is more dominant than the lifetime operating cost for the active treatment systems. Based on information provided by OSM, the facility is planning to cap the *entire 58*

acres of disturbed area with a 2-foot layer of compacted clay, 6-inch layer of limestone, and 1.5-foot layer of top soil. The estimated total cost to construct the cap is approximately $11M (Table 5). As shown in Table 6, system maintenance and replacement for source control measures varies significantly from $131K for a 1% factor to $1.9M for a 15% factor. In Figure 6, the total NPV of the lifetime operating cost varies from $4.7M for a 1% factor to $70.8M for a 15% factor.

While for the mine site in Pennsylvania, the total lifetime operating cost of the active treatment system is more dominant than the lifetime operating cost for the source control measures. Based on information provided by OSM, the design estimated capping of *an area of 0.9 acres* with a 1-foot of top soil layer and lime addition of 6 tons per acre. The total cost to construct the cap is approximately $57K of the total estimated $175K for source control measures (Table 7). As shown in Table 8, system maintenance and replacement for source control measures varies from $2.1K for a 1% factor to $31K for a 15% factor. In Figure 6, the total NPV of the lifetime operating cost varies from $90K for a 1% factor to $1.4M for a 15% factor.

SENSITIVITY ANALYSIS OF THE METHODOLOGY FOR ESTIMATING THE COSTS OF TREATMENT OF MINE DRAINAGE

TABLE 1
IATION OF NOMINAL DISCOUNT RATE BASED ON DIFFERENT INFLATION AND NET DISCOUNT RA

	Inflation Rate								
Net Discount Rate (i)	**1%**	**2%**	**3%**	**4%**	**5%**	**6%**	**7%**	**8%**	**9%**
1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
2%	3%	4%	5%	6%	7%	8%	9%	10%	11%
3%	4%	5%	6%	7%	8%	9%	10%	11%	12%
4%	5%	6%	7%	8%	9%	10%	11%	12%	13%
5%	6%	7%	8%	9%	10%	11%	12%	13%	14%
6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
7%	8%	9%	10%	11%	12%	13%	14%	15%	16%
8%	9%	10%	11%	12%	13%	14%	15%	16%	17%
9%	10%	11%	12%	13%	14%	15%	16%	17%	18%
10%	11%	12%	13%	14%	15%	16%	17%	18%	19%

Equation:

Nominal Discount Rate = Net Discount Rate (i) + Inflation Rate

Terminology:

Nominal Discount Rate = Nominal Rate of Return (For example, interest from a bank)

Net Discount Rate = Real Rate of Return (Rate of return after inflation)

SENSITIVITY ANALYSIS OF THE METHODOLOGY FOR ESTIMATING THE COSTS OF TREATMENT OF MINE DRAINAGE

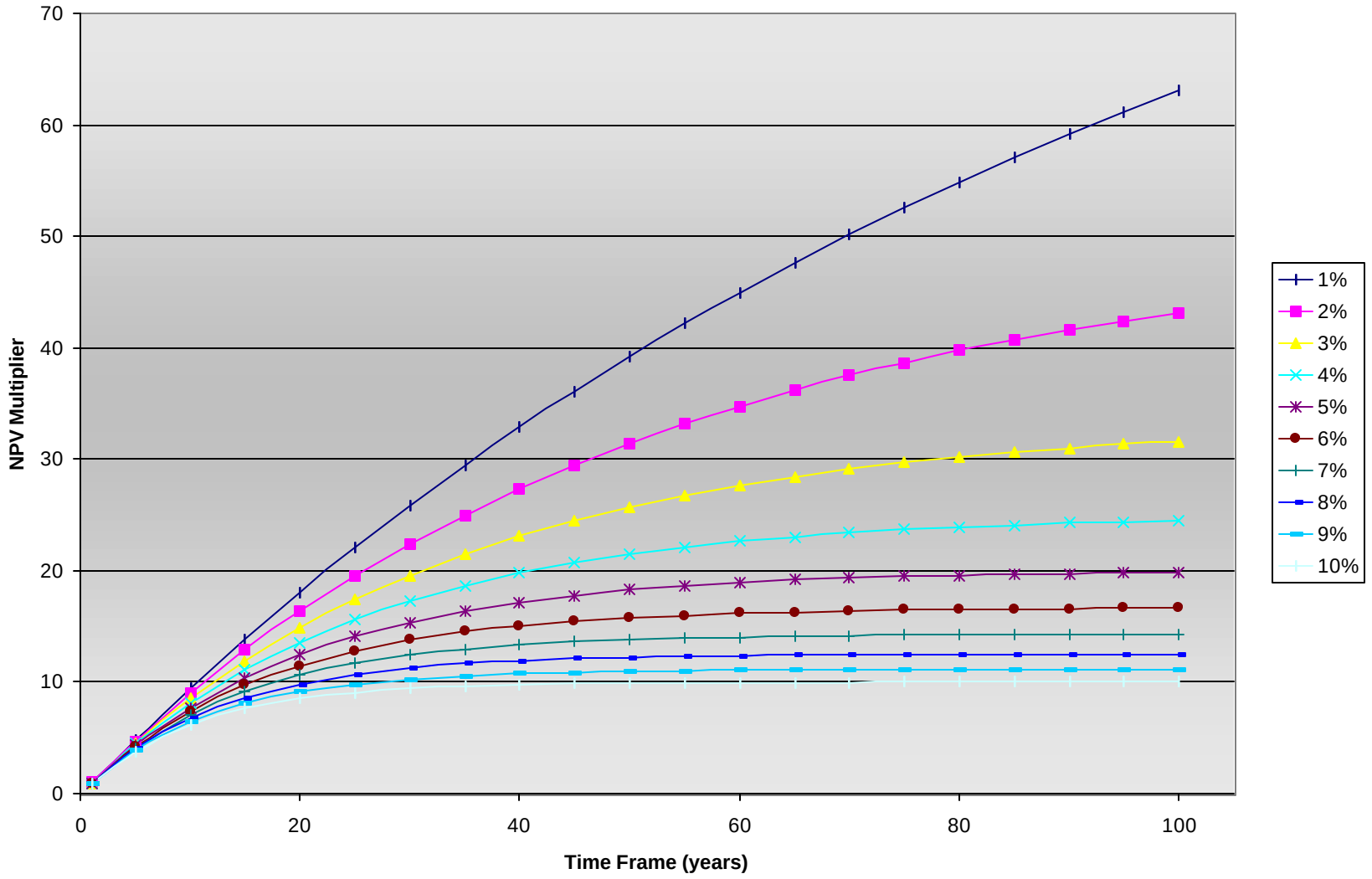
TABLE 2 NET PRESENT VALUE (NPV) MULTIPLIERS

Net Discount Rate (i)	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Time (n - year)										
1	0.99	0.98	0.97	0.96	0.95	0.94	0.94	0.93	0.92	0.91
5	4.85	4.71	4.58	4.45	4.33	4.21	4.10	3.99	3.89	3.79
10	9.47	8.98	8.53	8.11	7.72	7.36	7.02	6.71	6.42	6.15
15	13.87	12.85	11.94	11.12	10.38	9.71	9.11	8.56	8.06	7.61
20	18.05	16.35	14.88	13.59	12.46	11.47	10.60	9.82	9.13	8.51
25	22.02	19.52	17.41	15.62	14.09	12.78	11.65	10.68	9.82	9.08
30	25.81	22.40	19.60	17.29	15.37	13.77	12.41	11.26	10.27	9.43
35	29.41	25.00	21.49	18.67	16.38	14.50	12.95	11.66	10.57	9.65
40	32.84	27.36	23.12	19.79	17.16	15.05	13.33	11.93	10.76	9.78
45	36.10	29.49	24.52	20.72	17.78	15.46	13.61	12.11	10.88	9.86
50	39.20	31.42	25.73	21.48	18.26	15.76	13.80	12.23	10.96	9.92
55	42.15	33.18	26.78	22.11	18.63	15.99	13.94	12.32	11.01	9.95
60	44.96	34.76	27.68	22.62	18.93	16.16	14.04	12.38	11.05	9.97
65	47.63	36.20	28.45	23.05	19.16	16.29	14.11	12.42	11.07	9.98
70	50.17	37.50	29.12	23.40	19.34	16.39	14.16	12.44	11.09	9.99
75	52.59	38.68	29.70	23.68	19.49	16.46	14.20	12.46	11.09	9.99
80	54.89	39.75	30.20	23.92	19.60	16.51	14.22	12.47	11.10	10.00
85	57.08	40.71	30.63	24.11	19.68	16.55	14.24	12.48	11.10	10.00
90	59.16	41.59	31.00	24.27	19.75	16.58	14.25	12.49	11.11	10.00
95	61.14	42.38	31.32	24.40	19.81	16.60	14.26	12.49	11.11	10.00
100	63.03	43.10	31.60	24.51	19.85	16.62	14.27	12.50	11.11	10.00

Equation:

$$NPVMultiplier = \frac{1-(1+i)^{-n}}{i}$$

FIGURE 1 NET PRESENT VALUE MULTIPLIERS



SENSITIVITY ANALYSIS OF THE METHODOLOGY FOR ESTIMATING THE COSTS OF TREATMENT OF MINE DRAINAGE FROM A MINE IN WEST VIRGINIA

TABLE 3
TOTAL NET PRESENT VALUE COST FOR DIFFERENT TIME FRAMES AND NET DISCOUNT RATES

Time	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	$ 15,534,693	$ 15,531,865	$ 15,529,036	$ 15,526,490	$ 15,523,944	$ 15,521,398	$ 15,518,852	$ 15,516,306	$ 15,514,042	$ 15,511,779
5	$ 16,627,501	$ 16,587,896	$ 16,549,989	$ 16,513,779	$ 16,479,266	$ 16,446,168	$ 16,414,484	$ 16,383,932	$ 16,354,794	$ 16,326,788
10	$ 17,933,891	$ 17,795,557	$ 17,667,690	$ 17,548,876	$ 17,438,832	$ 17,336,708	$ 17,241,374	$ 17,152,829	$ 17,069,942	$ 16,992,713
15	$ 19,176,913	$ 18,889,496	$ 18,631,500	$ 18,399,812	$ 18,190,756	$ 18,002,067	$ 17,830,918	$ 17,675,894	$ 17,534,732	$ 17,406,299
20	$ 20,359,397	$ 19,880,180	$ 19,463,199	$ 19,099,118	$ 18,780,017	$ 18,499,107	$ 18,251,577	$ 18,032,054	$ 17,836,859	$ 17,662,881
25	$ 21,484,737	$ 20,777,509	$ 20,180,610	$ 19,673,952	$ 19,241,412	$ 18,870,825	$ 18,551,159	$ 18,274,208	$ 18,033,185	$ 17,822,432
30	$ 22,555,196	$ 21,590,255	$ 20,799,292	$ 20,146,380	$ 19,603,230	$ 19,148,341	$ 18,765,024	$ 18,439,134	$ 18,160,769	$ 17,921,161
35	$ 23,573,885	$ 22,326,337	$ 21,333,107	$ 20,534,506	$ 19,886,686	$ 19,355,983	$ 18,917,219	$ 18,551,441	$ 18,243,656	$ 17,982,831
40	$ 24,543,069	$ 22,993,111	$ 21,793,370	$ 20,853,607	$ 20,108,756	$ 19,511,007	$ 19,025,849	$ 18,627,822	$ 18,297,688	$ 18,021,021
45	$ 25,465,294	$ 23,597,083	$ 22,190,549	$ 21,116,130	$ 20,282,733	$ 19,626,710	$ 19,103,361	$ 18,679,874	$ 18,332,767	$ 18,044,501
50	$ 26,342,821	$ 24,143,911	$ 22,533,130	$ 21,331,693	$ 20,418,804	$ 19,713,274	$ 19,158,525	$ 18,715,235	$ 18,355,398	$ 18,059,211
55	$ 27,177,632	$ 24,639,252	$ 22,828,751	$ 21,508,782	$ 20,525,737	$ 19,778,056	$ 19,197,847	$ 18,739,281	$ 18,370,108	$ 18,068,547
60	$ 27,971,989	$ 25,087,917	$ 23,083,636	$ 21,654,471	$ 20,609,472	$ 19,826,430	$ 19,226,136	$ 18,755,689	$ 18,379,727	$ 18,074,205
65	$ 28,727,591	$ 25,494,431	$ 23,303,442	$ 21,774,134	$ 20,675,103	$ 19,862,640	$ 19,245,938	$ 18,766,721	$ 18,386,233	$ 18,077,599
70	$ 29,446,699	$ 25,862,472	$ 23,493,262	$ 21,872,580	$ 20,726,306	$ 19,889,515	$ 19,260,366	$ 18,774,359	$ 18,390,194	$ 18,079,862
75	$ 30,131,012	$ 26,196,001	$ 23,656,772	$ 21,953,487	$ 20,766,477	$ 19,909,600	$ 19,270,550	$ 18,779,734	$ 18,392,740	$ 18,081,277
80	$ 30,781,944	$ 26,497,845	$ 23,797,935	$ 22,019,966	$ 20,798,160	$ 19,924,876	$ 19,277,905	$ 18,783,129	$ 18,394,437	$ 18,082,125
85	$ 31,401,192	$ 26,771,401	$ 23,919,861	$ 22,074,564	$ 20,822,772	$ 19,935,909	$ 19,282,997	$ 18,785,392	$ 18,395,569	$ 18,082,408
90	$ 31,990,454	$ 27,018,930	$ 24,024,813	$ 22,119,544	$ 20,842,291	$ 19,944,396	$ 19,286,675	$ 18,787,089	$ 18,396,417	$ 18,082,974
95	$ 32,551,143	$ 27,243,545	$ 24,115,339	$ 22,156,319	$ 20,857,285	$ 19,950,620	$ 19,289,221	$ 18,788,221	$ 18,396,983	$ 18,082,974
100	$ 33,084,676	$ 27,446,661	$ 24,193,416	$ 22,186,589	$ 20,869,166	$ 19,955,429	$ 19,291,201	$ 18,789,070	$ 18,397,266	$ 18,083,257

Cost Information[1]:

		Active Treatment	Source Control	Total
Total Capital Cost*:		$ 342,009.49	$ 10,958,584.00	$ 11,300,593.49
Total capital cost ajdusted for engineering exxpenses and contigencies		$ -	$ 15,254,348.62	$ 15,254,348.62
Total Operating Cost:		$ 126,156.37	$ 109,586.00	
Operating Contigencies	20%	$ 25,231.27	$ 21,917.20	
Adjusted Operating Cost		$ 151,387.64	$ 131,503.20	$ 282,890.84

Equation:

Total Net Present Value Cost = Total Capital Cost Adjusted for Engineering Expenses and Contigencies + (NPV Multiplier x Total Adjusted Operating Cost)

For example:
for 1% and 1 year = $15,254,348.62 + (0.99 x $282,890.84) = $ 15,534,693

Notes:

* Total capital cost for active treatment system is not included in the total net present worth calculation because the system is already in place.

1) Used as a basis to prepare Table 3

FIGURE 2 TOTAL PRESENT VALUE COSTS FOR DIFFERENT TIME FRAMES AND NET DISCOUNT RATES

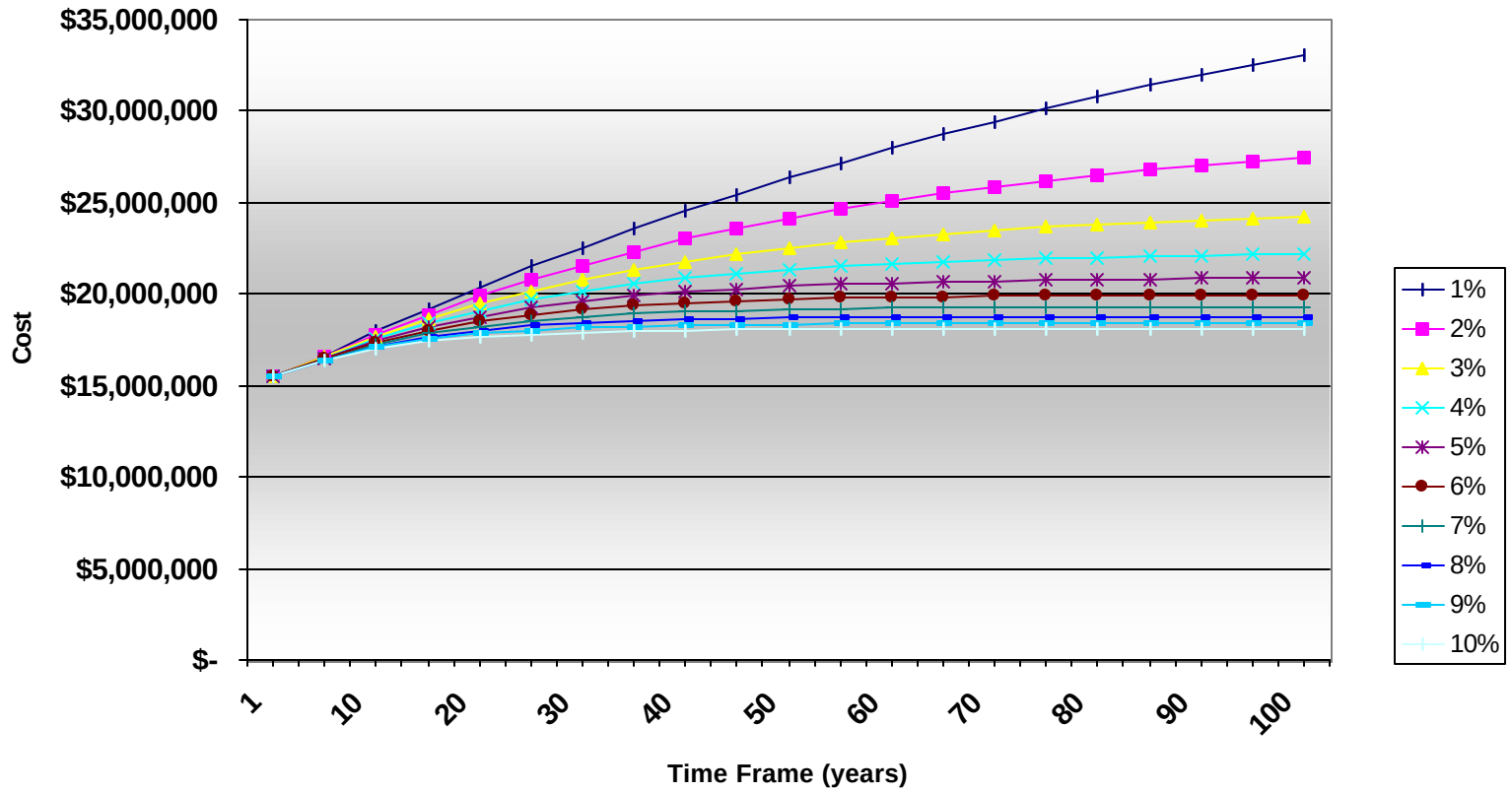
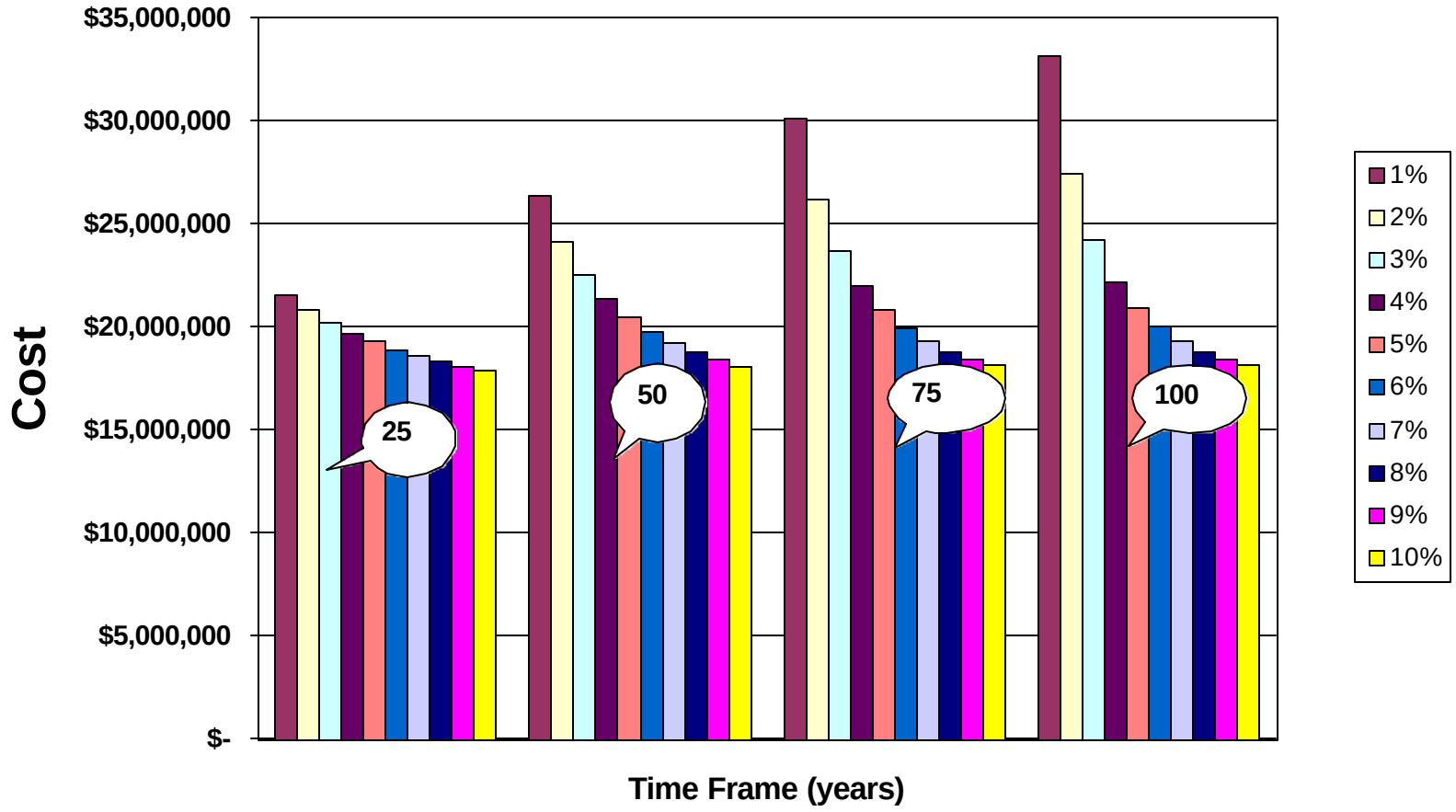


FIGURE 3 TOTAL PRESENT VALUE COSTS FOR SELECT OPERATING TIME FRAMES



SENSITIVITY ANALYSIS OF THE METHODOLOGY FOR ESTIMATING THE COSTS OF TREATMENT OF MINE DRAINAGE FROM A MINE IN PENNSYLVANIA

TABLE 4
TOTAL NET PRESENT VALUE COST FOR DIFFERENT TIME FRAMES AND NET DISCOUNT RATES

Time	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	$ 774,257	$ 768,906	$ 763,555	$ 758,738	$ 753,922	$ 749,106	$ 744,290	$ 739,474	$ 735,193	$ 730,911
5	$ 2,841,480	$ 2,766,561	$ 2,694,853	$ 2,626,356	$ 2,561,070	$ 2,498,459	$ 2,438,524	$ 2,380,729	$ 2,325,611	$ 2,272,632
10	$ 5,312,728	$ 5,051,048	$ 4,809,167	$ 4,584,411	$ 4,376,244	$ 4,183,061	$ 4,002,720	$ 3,835,224	$ 3,678,429	$ 3,532,338
15	$ 7,664,107	$ 7,120,411	$ 6,632,369	$ 6,194,094	$ 5,798,630	$ 5,441,696	$ 5,117,940	$ 4,824,686	$ 4,557,654	$ 4,314,704
20	$ 9,900,967	$ 8,994,450	$ 8,205,663	$ 7,516,945	$ 6,913,314	$ 6,381,926	$ 5,913,684	$ 5,498,420	$ 5,129,177	$ 4,800,070
25	$ 12,029,730	$ 10,691,895	$ 9,562,762	$ 8,604,337	$ 7,786,118	$ 7,085,092	$ 6,480,391	$ 5,956,495	$ 5,500,560	$ 5,101,886
30	$ 14,054,677	$ 12,229,335	$ 10,733,100	$ 9,498,011	$ 8,470,554	$ 7,610,058	$ 6,884,952	$ 6,268,478	$ 5,741,906	$ 5,288,647
35	$ 15,981,694	$ 13,621,753	$ 11,742,898	$ 10,232,215	$ 9,006,758	$ 8,002,847	$ 7,172,854	$ 6,480,926	$ 5,898,700	$ 5,405,307
40	$ 17,815,063	$ 14,883,064	$ 12,613,561	$ 10,835,846	$ 9,426,838	$ 8,296,100	$ 7,378,345	$ 6,625,412	$ 6,000,911	$ 5,477,550
45	$ 19,559,600	$ 16,025,575	$ 13,364,889	$ 11,332,450	$ 9,755,946	$ 8,514,970	$ 7,524,972	$ 6,723,877	$ 6,067,267	$ 5,521,966
50	$ 21,219,585	$ 17,059,989	$ 14,012,936	$ 11,740,222	$ 10,013,345	$ 8,678,721	$ 7,629,323	$ 6,790,768	$ 6,110,078	$ 5,549,793
55	$ 22,798,765	$ 17,997,008	$ 14,572,151	$ 12,075,216	$ 10,215,626	$ 8,801,267	$ 7,703,707	$ 6,836,255	$ 6,137,905	$ 5,567,452
60	$ 24,301,422	$ 18,845,731	$ 15,054,307	$ 12,350,810	$ 10,374,025	$ 8,892,775	$ 7,757,220	$ 6,867,293	$ 6,156,099	$ 5,578,155
65	$ 25,730,764	$ 19,614,718	$ 15,470,106	$ 12,577,172	$ 10,498,176	$ 8,961,272	$ 7,794,680	$ 6,888,163	$ 6,168,408	$ 5,584,576
70	$ 27,091,075	$ 20,310,928	$ 15,829,181	$ 12,763,398	$ 10,595,036	$ 9,012,109	$ 7,821,971	$ 6,902,611	$ 6,175,899	$ 5,588,858
75	$ 28,385,564	$ 20,941,851	$ 16,138,488	$ 12,916,447	$ 10,671,025	$ 9,050,104	$ 7,841,236	$ 6,912,779	$ 6,180,716	$ 5,591,533
80	$ 29,616,907	$ 21,512,839	$ 16,405,520	$ 13,042,203	$ 10,730,960	$ 9,079,001	$ 7,855,150	$ 6,919,201	$ 6,183,926	$ 5,593,139
85	$ 30,788,315	$ 22,030,313	$ 16,636,163	$ 13,145,484	$ 10,777,516	$ 9,099,871	$ 7,864,782	$ 6,923,482	$ 6,186,067	$ 5,593,674
90	$ 31,902,999	$ 22,498,555	$ 16,834,698	$ 13,230,570	$ 10,814,441	$ 9,115,925	$ 7,871,739	$ 6,926,692	$ 6,187,672	$ 5,594,744
95	$ 32,963,635	$ 22,923,452	$ 17,005,940	$ 13,300,138	$ 10,842,803	$ 9,127,698	$ 7,876,555	$ 6,928,833	$ 6,188,743	$ 5,594,744
100	$ 33,972,897	$ 23,307,678	$ 17,153,637	$ 13,357,397	$ 10,865,278	$ 9,136,796	$ 7,880,301	$ 6,930,438	$ 6,189,278	$ 5,595,279

Cost Information[1]:

		Active	Source	Total
Total Capital Cost*:		$ 2,758,798.14	$ 175,243.96	$ 2,934,042.10
Total capital cost ajdusted for engineering exxpenses and contigencies		$ -	$ 243,939.59	$ 243,939.59
Total Operating Cost:		$ 440,067.73	$ 5,877.23	
Operating Contigencies	20%	$ 88,013.55	$ 1,175.45	
Adjusted Operating Cost		$ 528,081.28	$ 7,052.68	$ 535,133.95

Equation:

Total Net Present Value Cost = (NPV Multiplier x Total Adjusted Operating Cost) + Total Capital Cost Adjusted for Engineering Expenses and Contigencies

For example:
for 1% and 1 year = $243,939.59 + (0.99 x $535,133.95) = $ 774,257

Notes:

* Total capital cost for active treatment system is not included in the total net present worth calculation because the system is already in place.

1) Used as a basis to prepare Table 3

FIGURE 4 TOTAL PRESENT VALUE COSTS FOR DIFFERENT TIME FRAMES AND NET DISCOUNT RATES

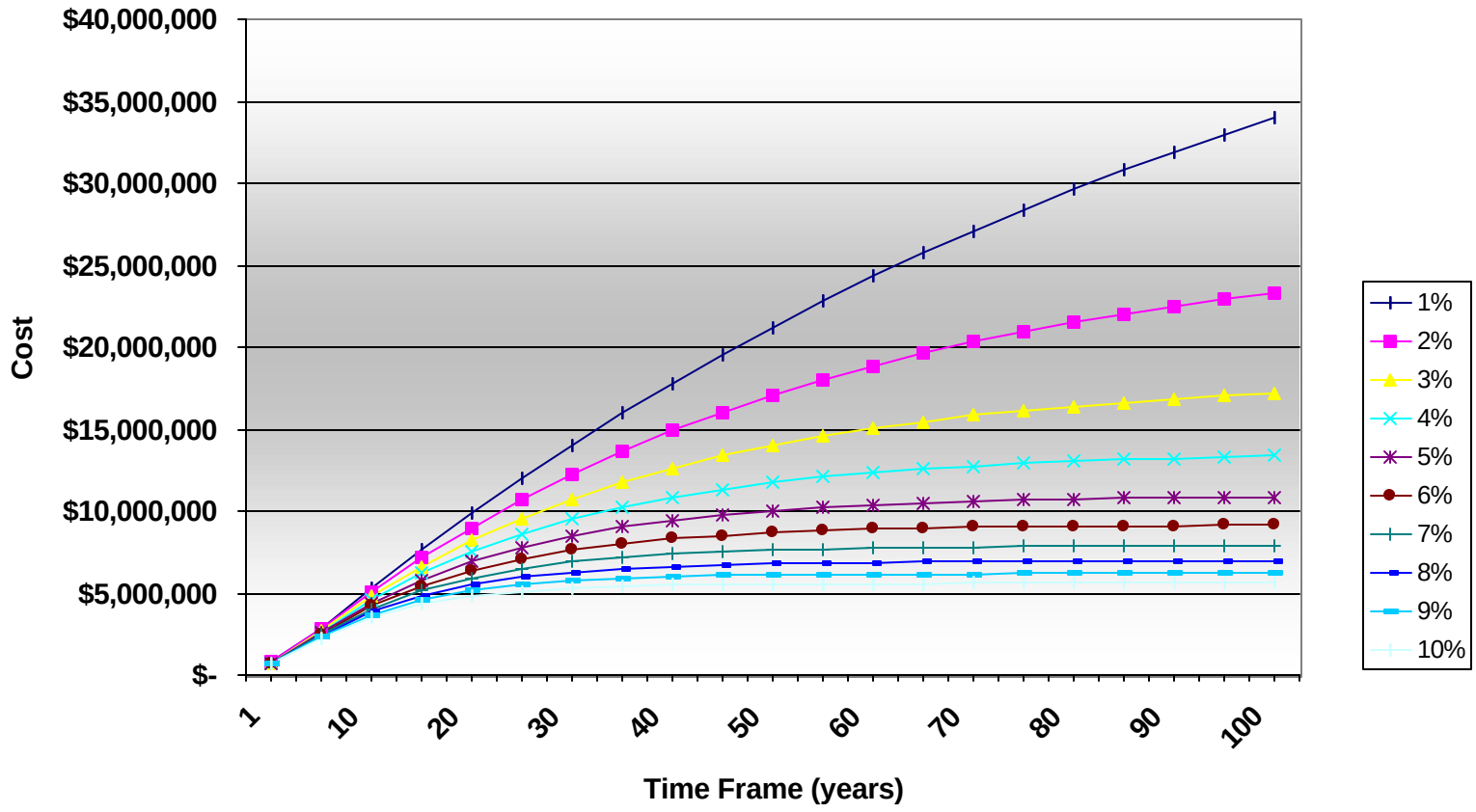


FIGURE 5 TOTAL PRESENT VALUE COSTS FOR SELECT OPERATING TIME FRAMES

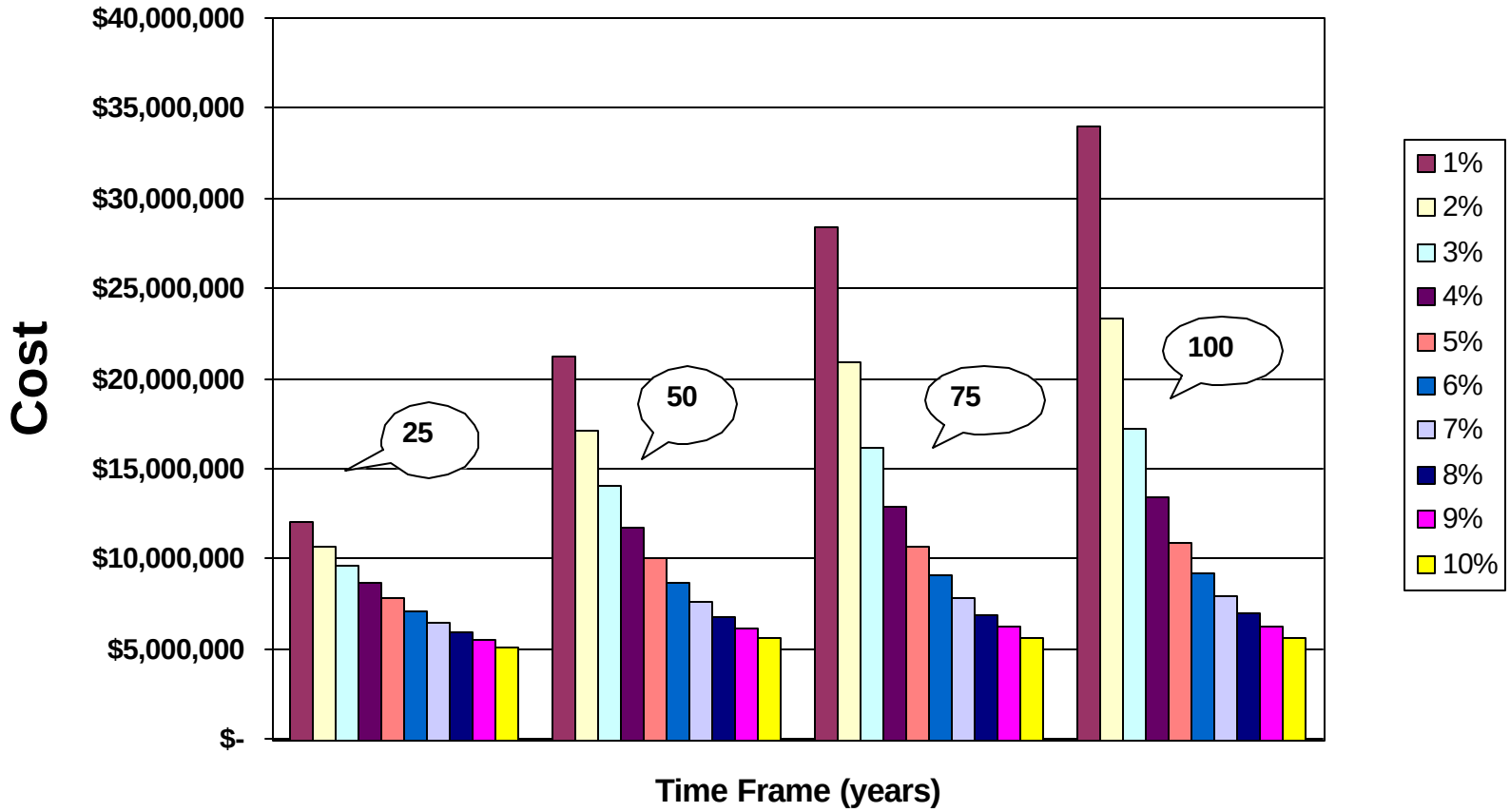


TABLE 6
West Virginia Mine Site
Total Cost for Different Variation of System Maintenance & Replacement Factors

System Maintenance & Replacement Factor (% of Total Capital Cost)	System Maintenance & Replacement of Active Treatment (1)	System Maintenance & Replacement of Active Treatment Plus Contigencies (2)	Total NPV of Lifetime Operating Cost with Variation of System Maintenance & Replacement of Active Treatment System (3)	System Maintenance & Replacment of Source Control (4)	System Maintenance & Replacement of Source Control Plus Contigencies (5)	Total NPV of Lifetime Operating Cost with Variation of System Maintenance & Replacement of Source Control System (6)
1%	$ 3,420.09	$ 4,104.11	$ 5,109,590.65	$ 109,585.84	$ 131,503.01	$ 4,723,040.12
2%	$ 6,840.19	$ 8,208.23	$ 5,286,473.85	$ 219,171.68	$ 263,006.02	$ 9,446,080.24
3%	$ 10,260.28	$ 12,312.34	$ 5,463,357.06	$ 328,757.52	$ 394,509.02	$ 14,169,120.35
4%	$ 13,680.38	$ 16,416.46	$ 5,640,240.26	$ 438,343.36	$ 526,012.03	$ 18,892,160.47
5%	$ 17,100.47	$ 20,520.57	$ 5,817,123.46	$ 547,929.20	$ 657,515.04	$ 23,615,200.59
6%	$ 20,520.57	$ 24,624.68	$ 5,994,006.67	$ 657,515.04	$ 789,018.05	$ 28,338,240.71
7%	$ 23,940.66	$ 28,728.80	$ 6,170,889.87	$ 767,100.88	$ 920,521.06	$ 33,061,280.83
8%	$ 27,360.76	$ 32,832.91	$ 6,347,773.08	$ 876,686.72	$ 1,052,024.06	$ 37,784,320.95
9%	$ 30,780.85	$ 36,937.02	$ 6,524,656.28	$ 986,272.56	$ 1,183,527.07	$ 42,507,361.06
10%	$ 34,200.95	$ 41,041.14	$ 6,701,539.48	$ 1,095,858.40	$ 1,315,030.08	$ 47,230,401.18
11%	$ 37,621.04	$ 45,145.25	$ 6,878,422.69	$ 1,205,444.24	$ 1,446,533.09	$ 51,953,441.30
12%	$ 41,041.14	$ 49,249.37	$ 7,055,305.89	$ 1,315,030.08	$ 1,578,036.10	$ 56,676,481.42
13%	$ 44,461.23	$ 53,353.48	$ 7,232,189.10	$ 1,424,615.92	$ 1,709,539.10	$ 61,399,521.54
14%	$ 47,881.33	$ 57,457.59	$ 7,409,072.30	$ 1,534,201.76	$ 1,841,042.11	$ 66,122,561.65
15%	$ 51,301.42	$ 61,561.71	$ 7,585,955.51	$ 1,643,787.60	$ 1,972,545.12	$ 70,845,601.77

SENSITIVITY ANALYSIS OF THE METHODOLOGY FOR ESTIMATING THE COSTS OF TREATMENT OF MINE DRAINAGE
SYSTEM MAINTENANCE AND REPLACEMENT

Equations for Table 6:

(1) System Maintenance & Replacement of Active Treatment System = Adjusted Operating Cost Without System Maintenance & Replacement of the Active Treatment System X System Maintenance & Replacement Factor (% of Total Capital Cost)

(2) System Maintenanc & Replacement of Active Treatment Plus Contigencies = System Maintenance & Replacement of Active Treatment System X (1 + Operating Contingency Factor)

(3) Total NPV of the Lifetime Operating Cost with Variation of System Maintenance & Replacement of Active Treatment System = (System Maintenance & Replacement of Active Treatment Plus Contigencies + Adjusted Operating Cost Without System Maintenance & Replacement) X NPV Multiplier (2% Net Rate of Return and 100 years time frame)

(4) System Maintenance & Replacement of Source Control System = Adjusted Operating Cost Without System Maintenance & Replacement of the Source Control System X System Maintenance & Replacement Factor (% of Total Capital Cost)

(5) System Maintenanc & Replacement of Source Control Plus Contigencies = System Maintenance & Replacement of Source Control System X (1 + Operating Contingency Factor)

(6) Total NPV of the Lifetime Operating Cost with Variation of System Maintenance & Replacement of Source Control System = (System Maintenanc & Replacement of Source Control Plus Contigencies + Adjusted Operating Cost Without System Maintenance & Replacement) X NPV Multiplier (2% Net Rate of Return and 100 years time frame)

Figure 6 Total NPV of the Lifetime Operating Costs for Different System Maintenance & Replacement Factors

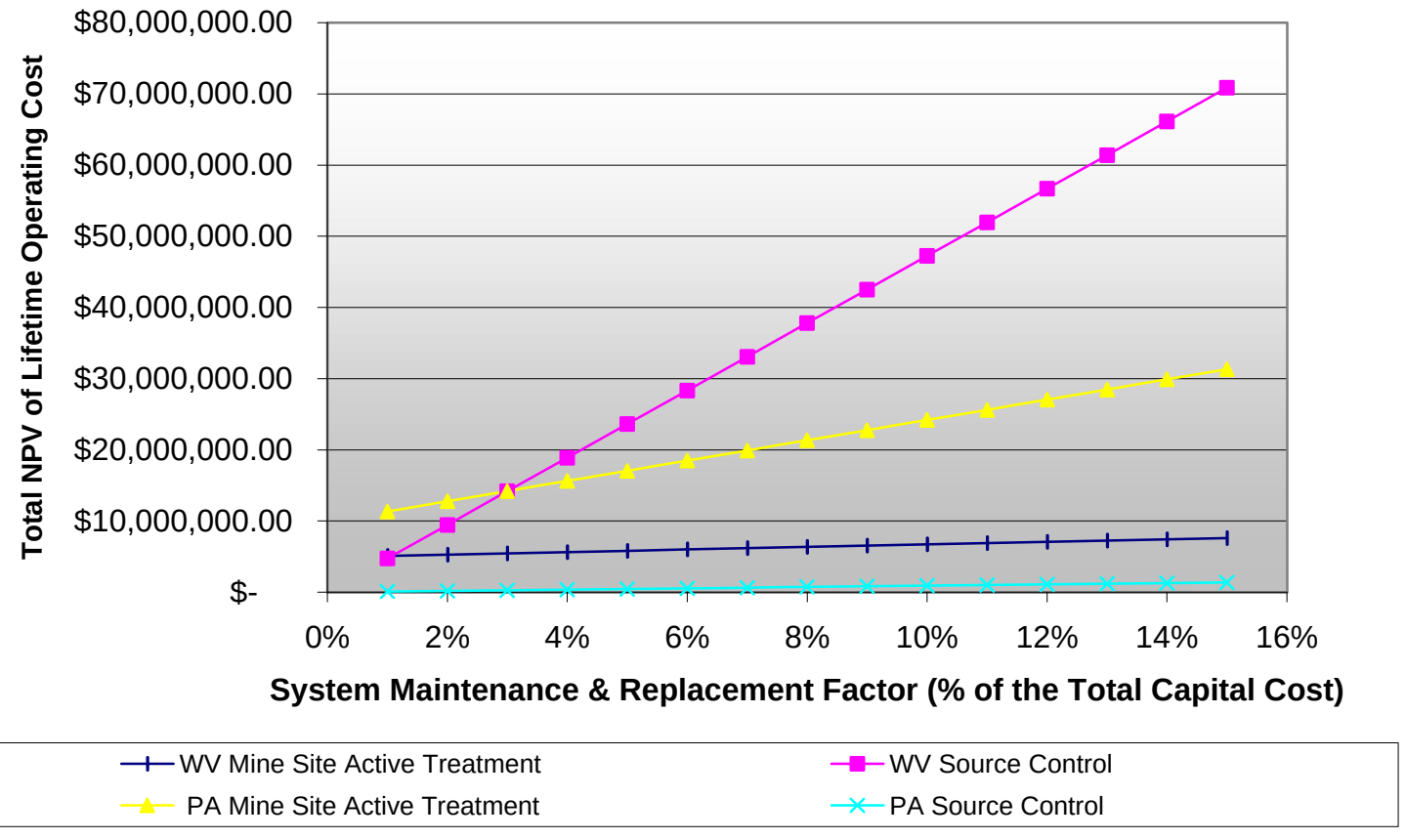


TABLE 7
Pennsylvania Mining Site
Cost Summary

Cost Information:		Active	Source	Total
Total Capital Cost:		$ 2,758,798.14	$ 175,243.96	$ 2,934,042.10
Total Operating Cost Without System Maintenance & Replacement:		$ 191,775.90	$ -	
Operating Contigencies	20%	$ 38,355.18	$ -	
Adjusted Operating Cost Without System Maintenance & Replacement		$ 230,131.08	$ -	$ 230,131.08

TABLE 8
Pennsylvania Mining Site
Total Cost for Different Variation of System Maintenance & Replacement Factors

System Maintenance & Replacement Factor (% of Total Capital Cost)	System Maintenance & Replacement of Active Treatment (1)	System Maintenance & Replacement of Active Treatment Plus Contigencies (2)	Total NPV of Lifetime Operating Cost with Variation of System Maintenance & Replacement of Active Treatment System (3)	System Maintenance & Replacment of Source Control (4)	System Maintenance & Replacement of Source Control Plus Contigencies (5)	Total NPV of Lifetime Operating Cost with Variation of System Maintenance & Replacement of Source Control System (6)
1%	$ 27,587.98	$ 33,105.58	$ 11,345,236.71	$ 1,752.44	$ 2,102.93	$ 90,634.07
2%	$ 55,175.96	$ 66,211.16	$ 12,772,054.00	$ 3,504.88	$ 4,205.86	$ 181,268.15
3%	$ 82,763.94	$ 99,316.73	$ 14,198,871.29	$ 5,257.32	$ 6,308.78	$ 271,902.22
4%	$ 110,351.93	$ 132,422.31	$ 15,625,688.59	$ 7,009.76	$ 8,411.71	$ 362,536.29
5%	$ 137,939.91	$ 165,527.89	$ 17,052,505.88	$ 8,762.20	$ 10,514.64	$ 453,170.37
6%	$ 165,527.89	$ 198,633.47	$ 18,479,323.17	$ 10,514.64	$ 12,617.57	$ 543,804.44
7%	$ 193,115.87	$ 231,739.04	$ 19,906,140.46	$ 12,267.08	$ 14,720.49	$ 634,438.51
8%	$ 220,703.85	$ 264,844.62	$ 21,332,957.76	$ 14,019.52	$ 16,823.42	$ 725,072.59
9%	$ 248,291.83	$ 297,950.20	$ 22,759,775.05	$ 15,771.96	$ 18,926.35	$ 815,706.66
10%	$ 275,879.81	$ 331,055.78	$ 24,186,592.34	$ 17,524.40	$ 21,029.28	$ 906,340.73
11%	$ 303,467.80	$ 364,161.35	$ 25,613,409.63	$ 19,276.84	$ 23,132.20	$ 996,974.81
12%	$ 331,055.78	$ 397,266.93	$ 27,040,226.93	$ 21,029.28	$ 25,235.13	$ 1,087,608.88
13%	$ 358,643.76	$ 430,372.51	$ 28,467,044.22	$ 22,781.71	$ 27,338.06	$ 1,178,242.95
14%	$ 386,231.74	$ 463,478.09	$ 29,893,861.51	$ 24,534.15	$ 29,440.99	$ 1,268,877.02
15%	$ 413,819.72	$ 496,583.67	$ 31,320,678.80	$ 26,286.59	$ 31,543.91	$ 1,359,511.10

SENSITIVITY ANALYSIS OF THE METHODOLOGY FOR ESTIMATING THE COSTS OF TREATMENT OF MINE DRAINAGE SYSTEM MAINTENANCE AND REPLACEMENT

Equations for Table 8:

(1) System Maintenance & Replacement of Active Treatment System = Adjusted Operating Cost Without System Maintenance & Replacement of the Active Treatment System X System Maintenance & Replacement Factor (% of Total Capital Cost)

(2) System Maintenanc & Replacement of Active Treatment Plus Contigencies = System Maintenance & Replacement of Active Treatment System X (1 + Operating Contingency Factor)

(3) Total NPV Cost with Variation of System Maintenance & Replacement of Active Treatment System = (System Maintenanc & Replacement of Active Treatment Plus Contigencies + Adjusted Operating Cost Without System Maintenance & Replacement) X NPV Multiplier (2% Net Rate of Return and 100 years time frame)

(4) System Maintenance & Replacement of Source Control System = Adjusted Operating Cost Without System Maintenance & Replacement of the Source Control System X System Maintenance & Replacement Factor (% of Total Capital Cost)

(5) System Maintenanc & Replacement of Source Control Plus Contigencies = System Maintenance & Replacement of Source Control System X (1 + Operating Contingency Factor)

SENSITIVITY ANALYSIS OF THE METHODOLOGY FOR ESTIMATING THE COSTS OF TREATMENT OF MINE DRAINAGE
SYSTEM MAINTENANCE AND REPLACEMENT

(6)

Total NPV Cost with Variation of System Maintenance & Replacement of Source Control System	=	(System Maintenance & Replacement of Source Control Plus Contigencies	+	Adjusted Operating Cost Without System Maintenance & Replacement)	X	NPV Multiplier (2% Net Rate of Return and 100 years time frame)