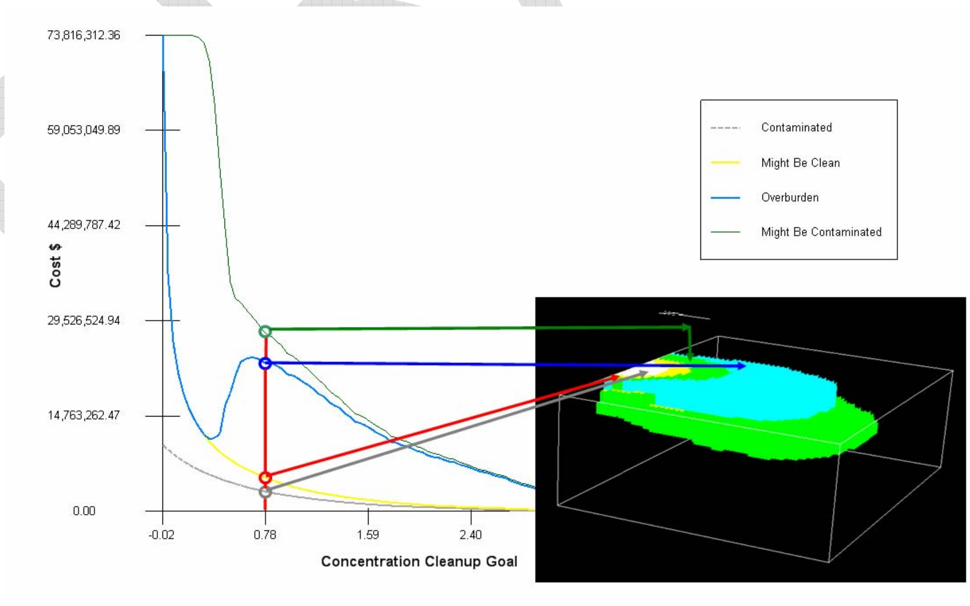
Chapter 35: Cost Benefit Analysis

We continue the decision analysis discussion from the last chapter with an exploration of cost-benefit analysis regarding the area of concern and the decision criteria. An important component to decision analysis software is cost/benefit analysis. This may be translated as payoff per level of effort. In a cost/benefit analysis, the level of effort or cost required to achieve a desired goal is modeled or estimated. Often, if the goal is numerically definable and ranges over a set of values, cost benefit curves incrementally show how cost increases, decreases, or fluctuates across an increasing range of goal values through an XY graph. SADA provides cost/benefit curves for a range of remedial action goals. These goals may range over the minimum and maximum sample values or may range over the corresponding human health risk values, ecological benchmark ratios, or custom analyis values.

It is important to remember that typical XY lines in SADA are often calculated exactly for specific values of X. These points of exact calculation are usually distributed regularly along the X axis. Between these points, a simple linear interpolation is used to approximate values. Typically the approximated value and actual value are very close. However, if an exact calculation is required for any given x or y, this value should be computed directly. For example, if one is querying a cost curve and must know the exact cost associated with a specific decision threshold, the Area of Concern tool should be used instead. It will calculate the exact volume at the point of interest.

Recall that with geostatistical interpolants, this tool will strictly use the results of the interpolation routine. That is, if one plots a 10th percentile map, then the decision criteria is applied about (or centered about when developing uncertainty model) the 10th percentile map. If a mean map is produced, then the decision criterion is applied to the mean map.

Let's take a look at a cost-benefit result before we demonstrate how to derive it.

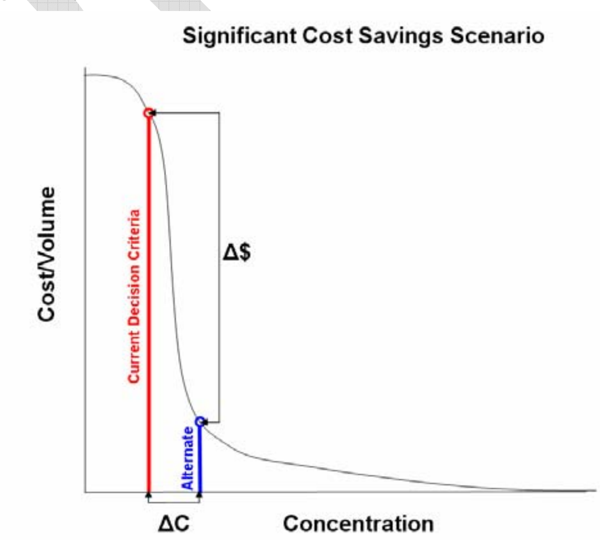


The image above shows a cost-benefit curve where the volume and/or cost of remediation is determined for over 100 evenly spaced values between the lowest and highest modeled values. For each value, the entire area of concern including any uncertainty or overburden is computed. Between values, a simple linear interpolation is used as approximation in order to create continuous cost-benefit curves. What this means is that for each point on the graph there is a complete AOC model available (behind the scenes). For example, consider a concentration cleanup criteria of 0.78pCi/g. This was selected because its conveniently found at a X-Axis tick mark. If you draw a vertical line at this criteria value, notice that it will intersect four lines each color coded so that they match the corresponding AOC map from which they are taken. The gray line corresponds to that portion of the AOC that is certainly a problem even when considering uncertainty. The yellow line represents the volume associated with the part of the AOC that might actually be clean and we are potentially wasting resources. The blue line is the overburden (including any benching angles) that would need to be removed before accessing the contaminated media. The green line is the volume outside our designated AOC that might actually be contaminated when one considers uncertainty. This results are shown cumulatively in this graph. For example, the intersection of our 0.78pCi/g line with the blue line is the cumulative volume of the gray area + the yellow area + blue area at that decision criteria. It is also possible to show noncumulative results as we'll seen momentarily. In the case of 0.78pCi/g, we show the actual 3d AOC along with the plot. Lines are drawn from each line to its corresponding volume on the plot. The cost axis is trivially calculated as the

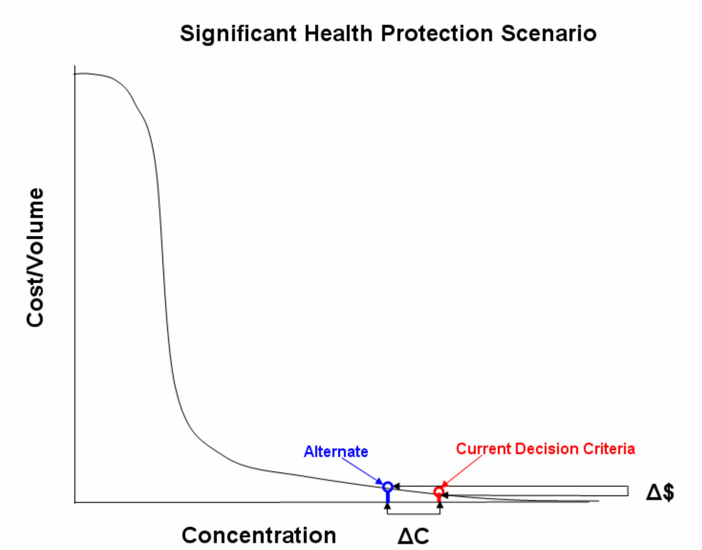
$$Cost = volume \times \frac{\text{cost}}{\text{unit volume}}$$

So a cost per unit volume of one would simple plot the volume.

An important thing to look for are two scenarios: "significant cost savings" or "significantly increased health protection" in the vicinity of the decision crititeria. Suppose that a decision criteria has been selected resulting in a fairly large AOC volume. By plotting a cost-benefit curve it may be possible to identify how small negotiations in the decision criteria may yield large project savings with little impact to environmental protection. The following graph shows that if the decision criteria is found in along a steep portion of the curve, then small changes in the the criteria (an alternate criteria) may yield big cost savings. This is foms the connection between risk, site geography, and cost.

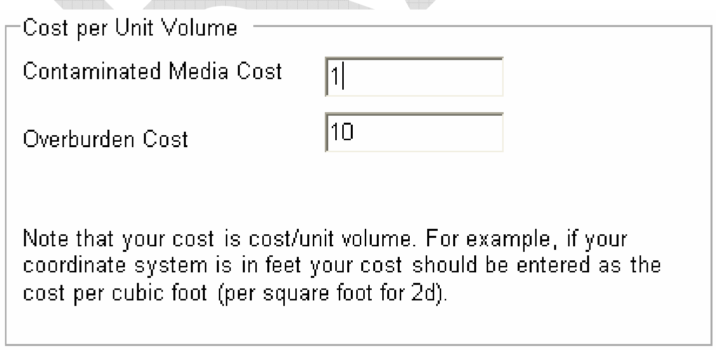


Conversely, for the same change in the ΔC for a decision criteria found in the upper end of the concentration range, you might be able to significantly increase the level of environmental protection at little cost.

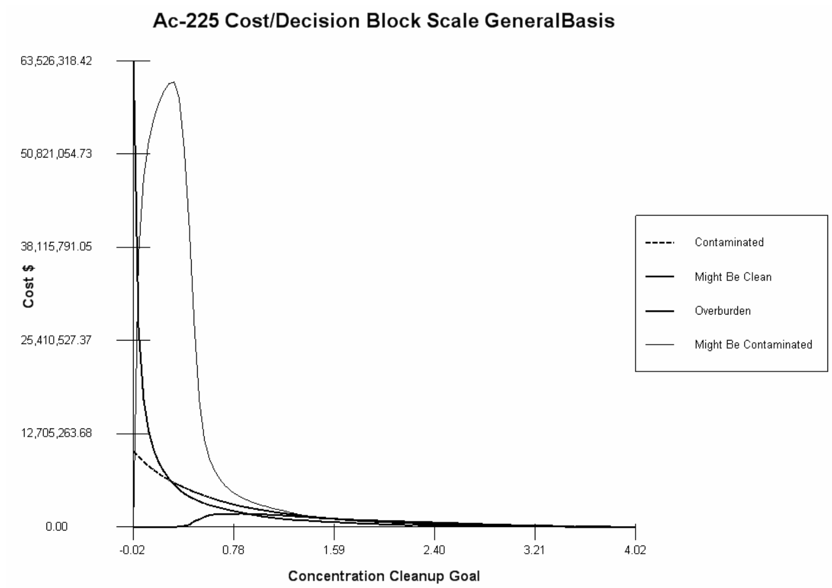


A Cost-Benefit Example

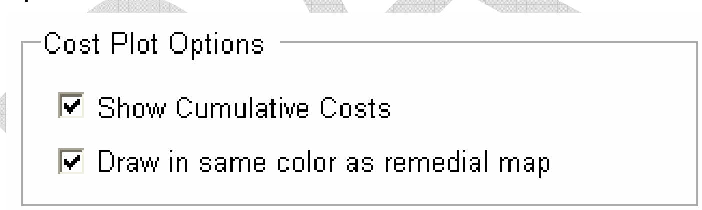
To demonstrate the cost-benefit analysis feature, open the file CostBenefit.sda. Select the interview Calculate cost vs cleanup. Make sure soil and Ac-225 are both selected. The first step in establishing a cost-benefit analysis is to select an appropriate geospatial model. In the interest of brevity, we have already calibrated an ordinary kriging model for you. The next requirement is to calibrate your decision parameters (e.g. parameters under the set decision criteria step) discussed in the previous chapter. Click on the Set decision criteria step now to view how this part as alread been initialized for you. Now click on the Set Cost Information step.



In the first parameter box we entered a value of $1/unit volume as the cost of dealing with contaminated media. This produces a simple volume value. In the overburden cost entry is where the cost of dealing with uncontaminated media will go. In this example, we absurdly entered a value of $10/unit volume which is 10 times the cost of dealing with contaminated media. We did this to exaggerate the overburden in the cost-benefit analysis discussion above. Sometimes the overburden cost is so small that it is difficult to distinguish from the other lines. Let's change this now to a value of $1/unit volume. Press the Show The Results button.



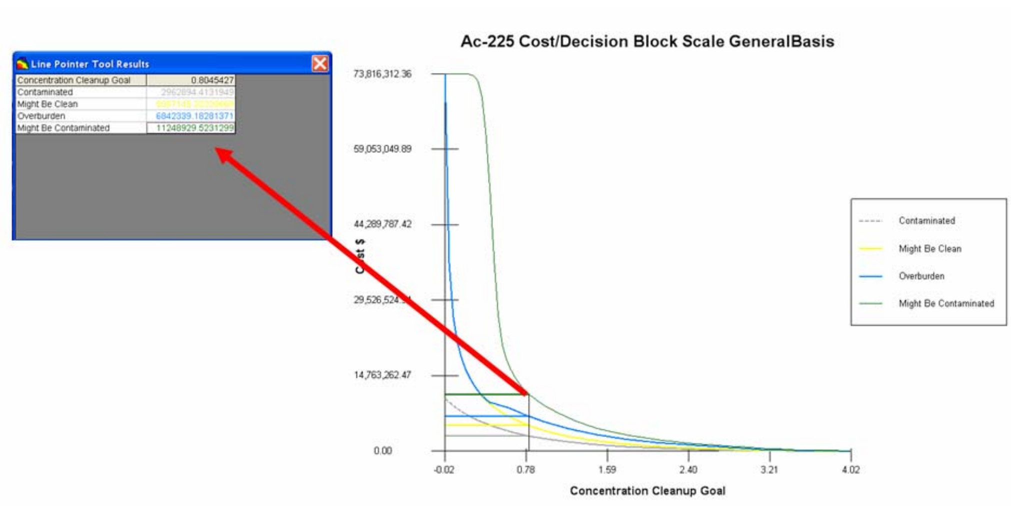
The first thing you may notice is that the result looks nothing like the result presented in the earlier discussion. This result is not reported as cumulative costs. So each line you see is the actual cost line associated with that part of the AOC. Also the lines are all drawn in black. This is the default setting for the cost-benefit curve. It is technically accurate but perhaps a bit difficult to interpret with various lines criss-crossing each other. Let's first convert this to cumulative costs and draw the lines in the same colors as we've set for AOC maps (Graphics→Set Various Colors→Remedial Map Colors). Click on the Format Picture step and check both of these options.



Now the plot is reported in cumulative costs per decision criteria and can be a little more tractable to interpret. There are two tools that can further aid in understanding the cost-benefit result.

Line Pointer Tool

The line pointer is a tool that will allow you to graphically scan a particular XY line graph such as a cost-benefit curve. By moving your mouse over the graph, the criteria/cost values will be reported in the status bar. You can access the tool by pressing the line pointer tool button ( ). Then simply move your mouse over the cost-benefit graph. You will see each line value reported along with the corresponding X (concentration) value.

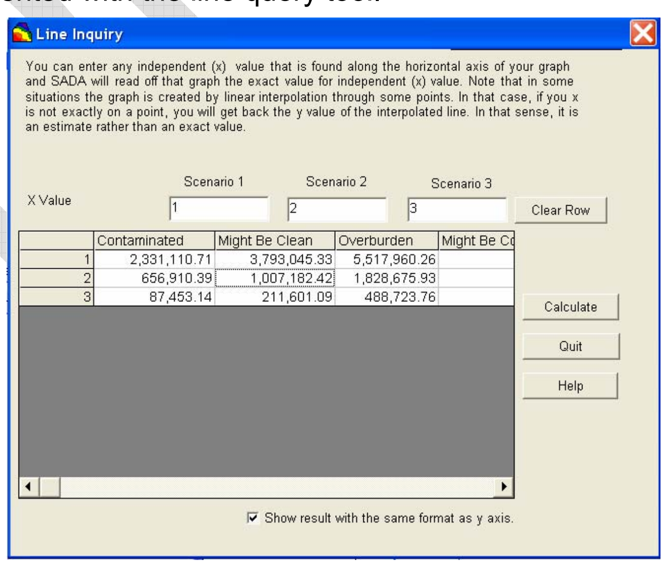


The text will be colored the same as the line. If the text is too hard to read you might want to change the line color (Graphics→Set Various Colors→Remedial Map Colors). When you are done, press the line pointer tool button again.

It is important to remember that typical XY lines in SADA are often calculated exactly for specific values of X. These points of exact calculation are usually distributed regularly along the X axis. Between these points, a simple linear interpolation is used to approximate values. Typically the approximated value and actual value are very close. However, if an exact calculation is required for any given x or y, this value should be computed directly. For example, if one is querying a cost curve and must know the exact cost associated with a specific decision threshold, the Area of Concern tool should be used instead. It will calculate the exact volume at the point of interest.

Line Query Tool

This tool allows you to query the graph for specific X values. Press the line query tool button ( ) and you are presented with the line query tool.



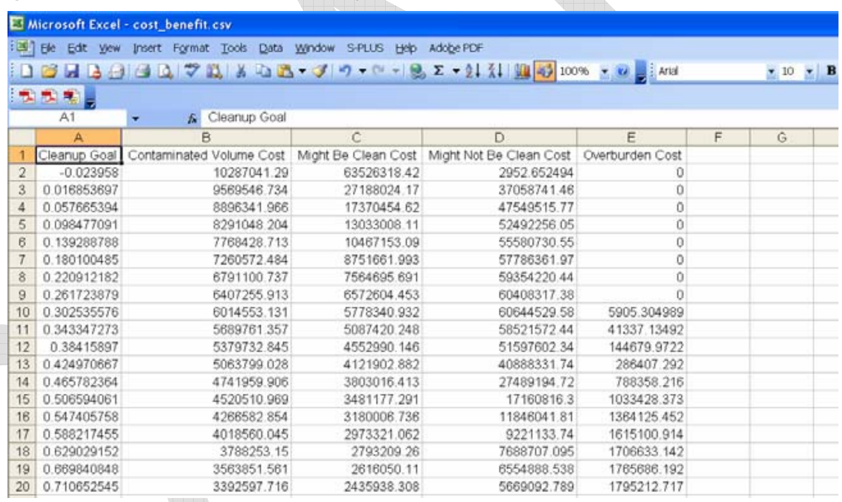
You can query for up to 3 X values at a time. The associated volume/cost line values are reported when you press the Calculate button. Enter 1, 2, and 3 into scenario 1, 2, and 3 respectively. Press the Calculate button. The results can be seen in the table. If you press the Clear Row button then all X scenario values are erased. The checkbox near the bottom of the tool window allows you to report values in the table in the same format as the y axis numerical format. Unfortunately, at the time of this user guide was written there is no way to export this table out automatically. Press the Quit button to terminate the tool.

Copy to Powerpoint (or other packages)

This is a good to refresh our memory on different methods of export in SADA. Let's start by pressing the copy to clipboard button (). This will copy whatever image is in the graphics window to the clipboard. Open Microsoft Powerpoint and open a new slide show. Select Edit→Paste.

Export to Exel (or another package)

Suppose you would like to bring this result into another graphing package to improve the look and feel. Press the export to text button () and enter cost_benefit into the save box and press Save. This will export the lines as columns in a comma separated format. Open Microsoft Excel and select File→Open. In the open dialogue window change the files of type to Text file (.csv, etc). Navigate to the location where you saved the cost_benefit file and select it now.



	Cleanup Goal	Contaminated Volume Cost	Might Be Clean Cost	Might Not Be Clean Cost	Overburden Cost
2	-0.023958	10287041.29	63526318.42	2952.652494	0
3	0.016853697	9569546.734	27188024.17	37058741.46	0
4	0.057665394	8896341.966	17370454.62	47549515.77	0
5	0.098477091	8291048.204	13033008.11	52492256.05	0
6	0.139288788	7768428.713	10467153.09	55580730.55	0
7	0.180100485	7260572.484	8751661.993	57786361.97	0
8	0.220912182	6791100.737	7564695.691	59354220.44	0
9	0.261723879	6407255.913	6572604.453	60408317.38	0
10	0.302535576	6014553.131	5778340.932	60644529.58	5905.304989
11	0.343347273	5689761.357	5087420.248	58521572.44	41337.13492
12	0.38415897	5379732.845	4552990.146	51597602.34	144679.9722
13	0.424970667	5063799.028	4121902.882	40888331.74	286407.292
14	0.465782364	4741959.906	3803016.413	27489194.72	788358.216
15	0.506594061	4520510.969	3481177.291	17160816.3	1033428.373
16	0.547405758	4266582.854	3180006.736	11846041.81	1364125.452
17	0.588217455	4018560.045	2973321.062	9221133.74	1615100.914
18	0.629029152	3788253.15	2793209.26	7688707.095	1706633.142
19	0.669840848	3563851.561	2616050.11	6554888.538	1765686.192
20	0.710652545	3392597.716	2435938.308	5669092.789	1795212.717

Summary

The results of the cost-benefit analysis may that the cost associated with remediation under such uncertainty may be too high. It may be more beneficial to first take some additional samples at key locations to reduce the uncertainty and produce an AOC that is less cost prohibitive. We take this discussion up in the next chapter.

