A VALUE ENGINEERING APPROACH TO WATER TREATMENT PROCESS EVALUATION AND SELECTION AT A MIXED WASTE SITE

Galen Freeman and Linda Meyer
Jacobs Engineering Group

Bruce Ballew
Professional Analysis, Inc.
Weldon Spring Site Remedial Action Project

ABSTRACT

The Weldon Spring Site Remedial Action Project (WSSRAP) has recently begun operations of a second water treatment plant. The conceptual design for the Site Water Treatment Plant was written in 1988 but the specifications were not required until late 1992. So in trying to bridge the long gap separating the initial conceptual design stage and specification writing an Alternative Evaluation Study (AES) was conducted.

The AES is a process based after a Value Engineering Study, but unlike the Value Engineering (VE) Study that concentrates on cost analyses, the AES also looks at the total concept of the engineering project. Essentially it is a revisitation of the conceptual design stage, and in the case of the Site Water Treatment Plant it was necessary to take a fresh look at the initial design since nearly four years had gone by. In that four years a number of changes in the general concept for the treatment plant had taken place, as well as more information from the start up of a similar water treatment plant at the Weldon Spring Quarry.

Techniques of the VE study have been optimized to focus on criteria, alternative and viable scenario developments in contrast to VA studies which emphasize cost savings by providing an alternative that satisfies a function The AES parallels the RI/FS philosophy of alternative development that is not based upon cost unless all other criteria (effectiveness, implementability) are equal. After designs reach a point beyond the conceptual level and detailed costs of each component are available, then classic VE techniques should be utilized to optimize these designs.

The AES process should be a flexible and still document process and criteria and alternative development. Use the process to develop and document, but be creative enough to delete or add to the process required.

REQUESTING AN AES

The AES should be a formalized process that includes procedures and has form. Inside this process, a format for initiating the AES is necessary.

At the WSSRAP, the originator, who could be anyone associated with a particular project, completes a form that includes a section proposing the manpower. The originator should propose a facilitator and four to six members. Estimated manhours required to complete the study should also be noted. When completed, the request form should be reviewed and signed by the Conceptual Design Manager, Deputy Project Manager and Project Manager. A facilitator should be assigned to work with the originator to plan and schedule the study.

INFORMATION PAGE

Most of the information concerning the particular AES should be listed during the initial stages of the study. For example:

- Background/Description of Problem

  A brief description of the problem, how it was discovered and the potential effects if not corrected.

- Given criteria

  Criteria defined by the evaluation team common to all discussions and decision. (e.g. adherence to regulatory requirements, protection of public safety and health, etc. Identification of given criteria allows the team to focus on specific criteria rather than skewing decisions toward obviously important criteria.

- Restrictions

  List restriction placed on the evaluation. Examples are; on site disposal only, off site disposal only, daylight work only, no salvage, etc.

- References

  List reference documents that pertain to the study.

FAST DIAGRAM

FAST (Functional Analysis System Technique) diagram may be completed if the nature of the subject to be studied is detailed enough to focus on specific actions. General or global concepts are sometimes difficult to diagram using this technique. If so, the team should select function(s) appropriate for study from group discussion rather than the FAST diagram. These functions should be listed for documentation purposes in lieu of the FAST diagram.

The diagram is created by reducing the study activity into two word functions (transitive verb & noun). For example, one basic function of a door may be to "secure entrance." A horizontally divided door may provide two basic functions; "exclude children" for the bottom half and "monitor activities" for the top half. Functions are placed in logical order asking How? from left to right and Why? from right to left. The highest order function will appear on the extreme left portion of the diagram with functions, indicating action (build, excavate, etc) on the extreme right leaving basic design functions in the middle. If there are several ways of completing the questions How? and Why?, these functions should be listed horizontally. After completion, the FAST diagram should be studied by the team with the intention of selecting the basic design function(s) for alternative development.

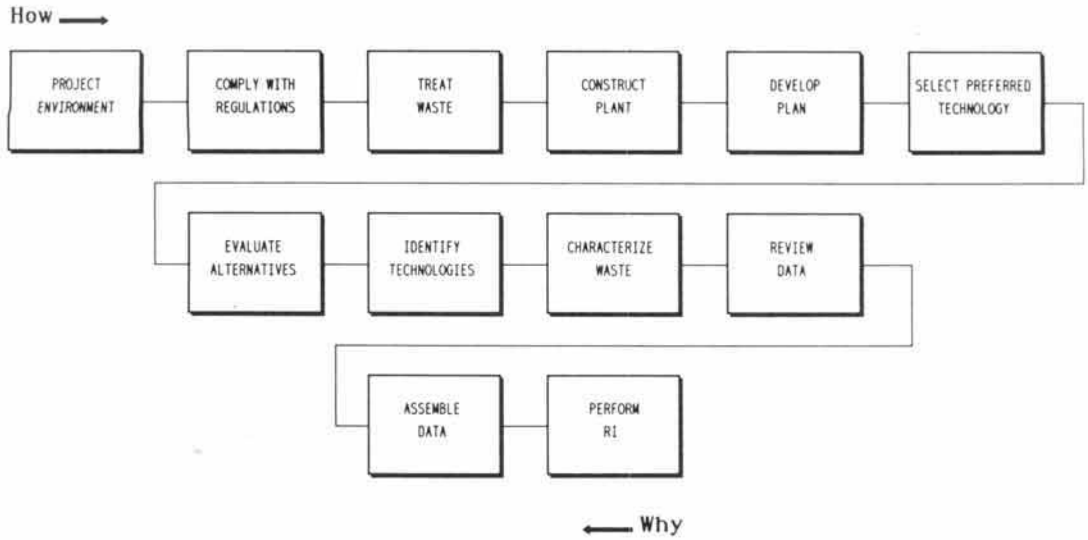

Fig. 1. Functional analysis system technique.

SPECULATION PHASE

Each function that has been chosen for alternative evaluation will undergo a speculative analysis. This analysis is documented on the Speculation Phase form. During this phase it is imperative that the team members understand that there are no bad ideas no matter how "off the wall" they may be. The purpose of this phase is to list all alternatives from the obvious to the bizarre. This analysis promotes an open atmosphere, induces creative thinking and possibly an idea will be generated worthy of further analysis. After the speculative alternatives have been listed, the team should discuss the viability of each and decide which to take forward for additional analysis. Select the alternatives to be taken forward and briefly describe the selection process for each alternative.

ALTERNATIVE DEFINITIONS

Definitions of the alternatives selected from the speculation phase should be listed. These alternatives will be used in a matrix analysis later in the study. The definitions will be referenced throughout the study; therefore, the team should agree on the definitions before going to the next task.

CRITERIA DEFINITIONS/WEIGHING PROCESS

The next step in the Alternative Evaluation process is to establish criteria then rank according to importance. The team should brainstorm criteria keeping in mind that "given criteria" have been defined. The definitions should be written. These will be referred to several times during the balance of the study.

The criteria is listed and discussed using a specialized form. As indicated by the matrix grid, criteria "A" is evaluated against criteria "B" and so on. When the matrix grid has been completed, the raw score for each criteria is calculated, and these raw scores indicate the ranking. Criteria receiving a raw score of 2 or less are dropped from further consideration.

ANALYSIS MATRIX

The Analysis Matrix form brings alternatives chosen during the speculative and criteria phase forward into a matrix analysis for each function being evaluated. The analysis matrix could also be used to select the speculative alternatives to be evaluated during this analysis.

ALTERNATIVE EVALUATION

The selected alternatives for each function as determined from the analysis matrix are listed according to rank or "initial ranking." The advantages and disadvantages of each alternative are discussed and documented. A final rating is established by the team after reviewing the advantages and disadvantages of each alternative.

WELDON SPRING SITE WATER TREATMENT PLANT TRAIN TWO CASE STUDY

Introduction

The Department of Energy (DOE) is responsible for conducting response actions at the Weldon Spring Site (WSS) under its Surplus Facilities Management Program (SFMP). The response actions include the management of contaminated waters impounded, decontamination and dismantlement of contaminated buildings, and the management of contaminated soils and sludges to name a few.

Background Information

The topic of this case study focuses on the management of contaminated waters at the site. These waters will be treated to reduce the concentration of the contaminants to below effluent limitations described in the NPDES permit issued by the State. There are two different types of water to be treated at the site. The major difference is the inorganic ion concentration, specifically, nitrates. All of the waters have radionuclides (U, Th, and Rd) and heavy metal contamination. These wastestreams have been designated train 1 (low nitrate) and train 2 wastestreams (high nitrate). Train 1 and 2 indicates which train of the Site Water Treatment Plant the water was planned to be treated in. The nitrate concentration in train 1 wastewater averages approximately 10 ppm, while train 2 averages approximately 2500 ppm. Train 1 wastewaters will be treated through a physico/chemical treatment system that utilizes lime precipitation, filtration, activated alumina, activated carbon, and ion exchange. Train 1 is nearing the completion of construction and start up. Train 2, as originally conceptualized, would consist of a low pressure/low temperature distillation system with a crystallizer or spray drier.

Train 2 was originally envisioned to treat all surface water at the Site. However, as more and better data became available on the surface water characteristics, it became apparent that a large portion of the surface water could be managed by Train 1 (which had the additional capacity). This prompted the Alternative Evaluation Study. As described previously, this involves revisiting the criteria on which the original decision was based to ensure that the criteria are still accurate. If conditions have changed, the revised criteria should be incorporated into the new design.

Alternative Evaluation Study

The evaluation group, hereinafter referred to as the Group, consisted of a facilitator, the WSSRAP project management contractor (Morrison-Knudsen Corporation/Jacobs Engineering Group, DOE support services subcontractor (PEER/Dames & Moore, Inc.), the train 1 design/build subcontractor (Resource Technologies Group), and a representative from a local engineering firm was invited. The meeting was held off-site and lasted for three days. It was important to conduct the study off-site to assure that day to day disruptions were minimized and the Group could focus on the task at hand.

The first step was to identify the original conceptual treatment process for Train 2. Train 2 was originally designed to treat water impounded in four (4) raffinate pits, raffinate pit groundwater infiltrate, water from the proposed chemical stabilization/solidification facility, and leachate from the proposed disposal cell. All of the waters contain contaminant concentrations above the effluent limitations prescribed in the WSSRAP Chemical Plant NPDES permit, thus require treatment. It was originally determined that a vapor compression/distillation type system would be the most appropriate technology for the management of these waters.

It was then necessary to develop a problem statement, identify restrictions, and establish basic criteria for which the group would use throughout the study. The problem statement was, The treatment of high nitrate contaminated waters, prior to discharge to the Missouri river, is required to meet the required regulatory requirements. The restrictions identified were,

- Restrictions For Which Each Alternative Must Satisfy
  - must be in operation in time to support raffinate pits 1 and 3 remediation
  - must meet regulatory requirements
  - must satisfy existing space requirements
  - must be a flexible process capable of treating water of variable influent concentrations and flows
  - must generate a waste form that is compatible with planned stabilization activities

Basic criteria were established which each alternative shall meet in order to be considered further. These criteria were,

- Basic Criteria For Which Each Criteria Must Satisfy
  - must meet regulatory requirements
  - must use proven dependable technology
  - must integrate with other planned activities at the Weldon Spring Site
  - must provide long term solution
  - must be protective of human health and the environment

Each alternative suggested during the speculation phase was evaluated against the problem statement, restrictions, and basic criteria to ensure that it satisfied the fundamental problem. If an alternative did not completely satisfy each of the above it was not considered any further.

Specific criteria were identified and listed. Eleven criteria were identified and are presented below in no particular order (see Table I),

- **Specific Criteria Used To Evaluate Viable Alternatives**
  - dependability
  - operational flexibility
  - representativeness of treatability testing
  - ease of process residuals management
  - cost
  - public perception
  - schedule
  - physical size
  - safety/ALARA
  - ease and frequency of maintenance
  - long term solution

Each specific criteria were scored against the other so that a relative ranking could be established. The scoring was based on how important one specific criteria was over the other with the following numerical value assigned to each;

4 points	-major preference
3 points	-medium preference
2 points	-minor preference
1 point	-no preference

It was necessary to gain a consensus within the Group before we proceeded. This initiated a great deal of debate. However, it was helpful in understanding the significance of each specific criteria from several different points of view. The specific criteria were arranged in a matrix (presented in Table II) to facilitate comparison.

The specific criteria were ranked in the following order;

Rank And Score for Each Specific Criteria

Rank	Criteria	Score
1	Safety/ALARA	31.5
2	Operational Flexibility	24.5
3	Dependability	23.5
4	Ease of Residual Management	13.5
5	Long Term Solution	12.5
6	Ease of Maintenance	9.5
7	Representativeness of Treatability Testing	9
8	Schedule	7
9	Cost	6
10	Public Perception	3

Physical size was eliminated as a specific criteria since it received a score of zero. The scores will be used later in the study to evaluate the alternatives.

TABLE I
Criteria Definitions

A.	Dependability: Ability to run at rated capacity and *performance* for an extended period of time.
B.	Operational Flexibility: Capability of being operated with minimal operator effort under a variety of influent conditions.
C.	Ease of Residual Management:Minimal volume of residue which can be easily stabilized and handled.
D.	Cost: Lowest life cycle cost.
E.	Public Perception: Minimize risk,, minimize comments from public hearings.
F.	Schedule: Meets time requirements for completion of WSSRAP. In place to support ot her scheduled activities.
G.	Physical Size: Should fit within the planned area.
H.	Safety/ALARA: Minimize risk to operating personnel.
I.	Maintenance:Minimize preventive maintenance.
J.	Long Term Solution:Minimize effort for a long term solution.
K.	Treatability Testing:Ability to obtain representative samples and perform meaningful testing.

The speculation phase involved identifying every conceivable technology available to treat the raffinate pit and CSS waters. The number of technologies identified is only limited by the creativeness of the Group. There were over thirty technologies identified during this phase of the process. Besides identifying possible solutions, this process tends to open the thinking process of the Group. Once the alternatives are listed, a "reality check" is performed on them to determine which will be carried to the next process. The alternatives that passed the "reality check" are presented below:

Viable Alternatives To Be Considered Further

1. Vapor Compression Distillation/Biological Denitrification
2. Physico/Chemical Treatment/Biological Denitrification/Ion Exchange/Polishing
3. In Situ Denitrification/Physico-Chemical Treatment/Ion Exchange Polishing
4. Biological Denitrification/Blending with Train 1
5. Vapor Compression Distillation/Ion Exchange Polishing

The viable alternatives carried over from the speculation phase were then evaluated against each other using the specific criteria described above. These were arranged in a matrix format (presented below) for ease of scoring (see Table III).

For each alternative, the question "how well does this specific criteria rate for this alternative?" Using a 5 point scale (5 = excellent, 1 = poor), the alternatives were assigned a value. The value was then multiplied by the score for the specific criteria. The specific criteria score for each alternative were added to give a final score. The final scores for the alternatives generated a ranking (see Table IV).

Theoretically, the preferred alternative should be readily apparent by the highest score. However, one more "reality check" is required especially if the final scores are very close. The our case, alternatives 2 and 5 had scores of 619 and 613, respectively. The closeness of these two alternatives started much more discussion. In the end, the second ranked alternative (alternative 5) was selected as the preferred alternative.

TABLE II
Criteria Weighing Process

PROJECT WSSTRAP - Train #2	TASK	
FUNCTION BEING ANALYZED Treatment of Nitrate Contaminated Water		
CRITRIA	RAW SCORE	RANKING OF CRITERIA
A. Dependability	23.5	3
B. Operational Flexibility	24.5	2
C. Treatability Testing	9	7
D. Ease of Residual Management	13.5	4
E. Cost	6	9
F. Public Perception	3	10
G. Schedule	7	8
H. Physical Size	0	
I. Safety Alarm	31.5	1
J. Maintenance	9.5	6
K. Long Term Solution	12.5	5

HOW IMPORTANT

4-Major preference
3-Medium preference
2-Minor preference
1-No preference, score one point for each letter

	B	C	D	E	F	G	H	I	J	K
A	B2	A3	A2.5	A35	A3	A2.5	A4	I2.5	A3	A2
	B	B4	B2	B3	B3	B2	B4	I2.5	B3	B1.5
		C	D3	C1	C2	C1	C2.5	I3	C1.5	C1
				E1		G1				K1
			D	D25	D1	D2	D3	I3	D1	D1
					F1				J1	K1
				E	E2	G1.5	E2	I4	E1	K2
									J1	
					F	G1.5	F2	I3.5	J2.5	K2
							G3	I3.5	J2	K2
						G	H	I4	J3	K3
								I	I3	I25
									J	K1.5

NOTE: DROP CRITERIA WITH A
RAW SCORE OF 2 OR LESS

TABLE III
Evaluation Matrix

		Alternatives									
	Relative	A		B		C		D		E	
Criteria	Weight	Ind.	Total	Ind.	Total	Ind.	Total	Ind.	Total	Ind.	Total
Dependability	23.5	3.7	87	4.5	106	2.0	47	4.0	94	4.5	106
Oper. Flexib.	24.5	4.0	98	4.5	110	3.0	74	4.0	98	5.0	123
Treat. Testing	9.0	5.0	45	5.0	45	3.0	27	5.0	45	5.0	45
Ease of Resid. Mgmt.	13.5	3.0	41	4.0	54	4.0	54	4.0	54	4.0	54
Cost	6.0	4.0	24	3.0	18	5.0	30	4.0	24	4.5	27
Public Percept.	3.0	4.0	12	4.0	12	3.0	9	2.0	6	4.5	14
Schedule	7.0	3.0	21	4.0	28	5.0	35	4.0	28	3.0	21
Safety/ALARA	31.5	4.5	142	5.0	158	4.5	142	5.0	158	4.75	150
Maintenance	9.5	3.0	29	4.0	3.8	5.0	48	4.0	38	3.0	29
Long Term Solution	12.5	4.0	50	4.0	50	4.0	50	4.5	57	3.5	44
TOTAL			549		619		516		602		613
RANK			4		1		5		3		2

5 - Excellent
4 - Very Good
3 - Good
2 - Fair
1 - Poor

TABLE IV
Alternatives Evaluation

Initial Rank	Alternative	Advantages	Disadvantages	Final Rank
4	A	- More flexible - Highest quality efluent - Handles widest variety of influent - Stand alone process for leachate treatment	- Greater maintenance - More solids - Bilogical is less developed for this higher concentration	3
1	B	- Conventional aplication - Similar to other processes at WSSRAP - Redundant operations	- More labor for operation	2
5	C	- Easy to implement - Ixpensive - Less space	- Unknown product for CSS - Less process control - Potential to worsen goundwater	5
3	D	- Less biomass - Inexpensive - Less space	- Must have TSA water available - Poor public perception - May overtax capacity of Train No.	4
2	E	- More flexible - Highest quality effluent - Handles widest range of contaminants - Stand alone process for leachate control - Higher comfort factor that is the better process based on EE/CA and CER Evaluations	- Greater maintenance - Nitrate not destroyed	1