SUCCESSFUL APPLICATION OF VALUE ENGINEERING AT CONCEPTUAL STAGE OF DESIGN

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Mr. Gernerd has directed and overseen the development of Interior's VE policy manual and the VE Guidance Handbook as well as numerous training workshops and conferences throughout the Department. He promotes VE as a significant contributor to attaining a culture of quality, saving scarce dollars, and providing better value within the Interior Department and throughout Federal Government.

ABSTRACT

This paper discusses the benefits of applying VE at the conceptual stage of design. It includes several case studies and examples, and shows how this application of VE represents cost savings that can be counted as cost avoidance. Cost avoidance is a new term and data requirement in the newly revised Office of Management of the Budget (OMB) Circular A-131.

INTRODUCTION

Department of the Interior construction projects vary in size, shape and complexity, from fish hatcheries, National Park visitor centers, water supply dams, hydropower plants, irrigation canals, and Indian school complexes, to campgrounds. VE/Value Analysis (VA) is an important methodology for pursuing improved design at all stages of planning and design. Many construction projects, by the various agencies and bureaus within the Department of the Interior, involve complex environmental and public process considerations, as well as specific project user requirements and design constraints. Given all the critical decision requirements that are needed in the early stages of planning and design, we embarked upon the usage of VE and VA at the conceptual stage of design.

VE analysis at the conceptual design stage is conducted when the "preferred alternative" has been selected. Project functions such as facility siting, interrelationship of project elements, optimum location and magnitude of project elements, treatment processes, supply alternatives, system and subsystem selection, mitigation measures, resource impacts and other major project decisions have been conceptually designed through the project planning process. Before formal project design, these project elements can be systematically evaluated at conceptual stage of design using VE methodology.

The Federal Government is under ever-increasing demands to provide products and services to the American public that meet the highest quality and value standards. The planning, design, and construction of facilities that support the many programs and responsibilities of the Department of the Interior are no exception. The wide variety of legislative requirements, geographic locations, and diverse constituency that form and shape the missions and responsibilities of the bureaus and offices within Department of the Interior, create a situation that requires a multitude of individually and uniquely designed structural facilities.

VE is a mandatory program of all Department of the Interior bureaus and offices that perform or contract for the design, construction, repair and rehabilitation/renovation of federal facilities.

CONCEPT STAGE OF DESIGN

VE studies have been performed on a wide variety of Department of the Interior construction project designs for many years, however, recently several Bureaus have successfully applied the VE methodology to construction projects at the concept stage. Concept stage of design is defined as the stage in a project's development when the planning process is complete but the design contract has not yet been awarded or the in-house design team has not yet begun design. The planning for many Interior construction projects includes environmental impact assessments, extensive public involvement, and facility siting determinations. When the planning stage of a construction project is completed, the project function(s) are fully defined and major project elements have been identified and supported by the public process through information sharing, public meetings if necessary, and public review of the intended project functions and alternatives.

The planning process defines the project functions and elements as developed through the environmental and public process considerations, as well as specific project user requirements and design constraints. The result of the planning is selection of a "preferred alternative" for project design purposes. It is at this juncture that the VE methodology is applied to the project conceptual design. The various users and stakeholders of the construction project have participated in identifying the major project element requirements and a conceptual project design is formulated in the final planning documentation. Project planning does not always evaluate project elements or components for the function they perform or their functional interrelationship within the project. Value must reside not only in the project elements themselves, but in their ability to perform the necessary functions efficiently and economically.

In all construction projects, especially large complex projects that involve a variety of user groups, outside interested parties, and federal funding, there exists a considerable level of specific project components that are a product of the planning process and public or user group perceptions of project requirements. This is to say that frequently the projects carry with them into the design stage, project components or elements that do not meet the desired project function in the most cost effective manner. The planning process provides an accurate description of the projectelements, however the planning documents usually do not specifically define the desired project element design; or in some cases, the project elements do not always contribute to meeting the project function.

COST AVOIDANCE

The concept stage of construction design carries with it many desired project elements and design constraints but usually provides very little direction on which specific design criteria will provide the desired project elements at the best value. The designer (engineer/architect) is usually assigned this task with only the requirement to design within acceptable industry and Agency codes and building standards.

The Department of the Interior has utilized VE methodology to evaluate project element/component design alternatives in the early concept stage prior to actual design. Value is maximized by providing the optimum combination of performance, quality and cost for each project element. When the selected project elements, identified in the planning process, can be modified and improved through VE study, then cost avoidance is realized by sending the conceptual project design requirements to the design team or design contractor with specific design criteria that meet the users needs at the lowest life cycle costs.

The amount of costs avoided can be very significant and can range from fine tuning a project element, to changing overall project design direction in some cases. Cost avoidance is the cost differential between the proposed project configuration developed by the planning efforts and the actual project configuration that is sent forward for design. If a VE study is conducted at the end of the planning stage when the project is conceptually designed, and a different alternative is identified that is of lower cost and is consistent with project required performance, reliability, quality, and safety, then the change in project estimated cost would constitute a cost avoidance.

Because a construction project is subjected to a VE study before any design costs are realized, the costs are avoided in two ways:

1. Higher cost, less functional project elements/components are eliminated from the project, this may include initial capital costs and life cycle costs; and

2. Design costs and/or redesign costs for those project elements/components modified are eliminated.

EXAMPLES OF COST AVOIDANCE

The following examples are recent studies conducted by bureaus within the Department of the Interior. With each example is a brief narrative and functional analysis and life-cycle cost analysis worksheets where available.

Example 1: Visitor Viewing Platform.

A VE group of the Bureau of Reclamation performed a study on alternatives to provide visitor access to the tailrace section of the Hoover Dam. Hoover Dam, a 726 foot high concrete arch-gravity type dam, was completed in 1936. The Bureau of Reclamation operates and maintains the dam, reservoir, hydro-powerplant, intake and outlet works, and spillway. The National Park Service administers the reservoir created by Hoover Dam - Lake Mead as part of the Lake Mead National Recreation Area.

The project under VE study is a Visitor Viewing Platform that is proposed for the Hoover Dam powerplants. The project evolved out of the need to limit or exclude visitor tours from the third floor of the powerplant. The project objectives are to eliminate visitor and employee inter-actions/ conflicts, and accommodate increased visitor attendance and tour sizes; to provide access to the tailrace of the dam for viewing and photography while ensuring that the historic fabric of the structure is preserved. The main consideration in providing access is that a walkway within the powerhouse may be needed and the viewing platform must be designed in such a way as to allow or not impede access to the generators and equipment in the powerplant.

The original concept was to build a walkway on level 5 along the interior of the powerhouse wall, over the generators to an exterior viewing platform for viewing Hoover Dam. The original concept proposed removable sections of the walkway for access to the generators and equipment using an overhead gantry crane and store walkway sections in a warehouse during repair, rewind or replacement of generators.

A complete VE study was performed and several alternatives were evaluated, includingrooftop access, modifying the removable walkway support system and

administrative/management changes to modify tours, the original conceptual design of removable walkways on bracket supports which also would require removal when access to the generators was necessary. Proposed in the original concept,

Item: *Visitor Viewing Plat.*
Life-Cycle Period: ____
Date: ____ Interest Rate: ____

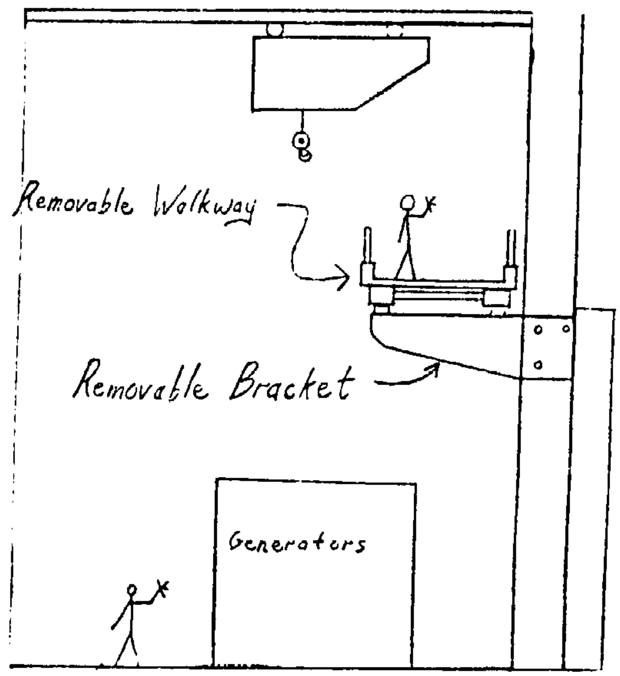
		VVP ORIGINAL		VVP + Mods ALTERNATE NO. 1	
		Estimated Costs	Present Worth	Estimated Costs	Present Worth
COLLATERAL / INITIAL COSTS	Base Cost	517,500	517,500	543,375	543,375
	Interface Costs				
	a. USBR Overhead @ 30%	135,250	135,250		163,000
	b. lost O&M productivity	30,000	30,000		30,000
	c.				
	Other Initial Costs				
	a.				
	b.				
	Total Initial Cost Impact (IC)	702,750	702,750		736,375
SALVAGE & REPLACEMENT COSTS	Single Expenditures @ 10% Interest				
	1. Year 5 PW Factor 0.621	15,000	9,313	15,000	9,313
	2. Year 10 PW Factor 0.386	15,000	5,783	15,000	5,783
	3. Year 15 PW Factor 0.239	15,000	3,591	15,000	3,591
	4. Year 20 PW Factor 0.149	15,000	2,229	15,000	2,229
	5. Year ____ PW Factor ____				
	Salvage ____ PW Factor ____	-4,500	-420	-4,000	-400
	Total Present Worth		20,496		20,516
ANNUAL COSTS	Annual Costs @ 10% Interest				
	a. Maintenance Escal. Rate ____ PWA Factor 9.077	18,930	171,827	17,900	162,478
	b. Operations Escal. Rate ____ PWA Factor 9.077	126,000	1,134,626	36,000	326,772
	c. Others Escal. Rate ____ PWA Factor ____				
	d. Others Escal. Rate ____ PWA Factor ____				
	Total Annual Costs		1,306,453		479,250
	Total Present Worth Costs		2,029,699		1,246,141
	Life Cycle (PW) Savings				

PW - Present Worth PWA - Present Worth of Annuity

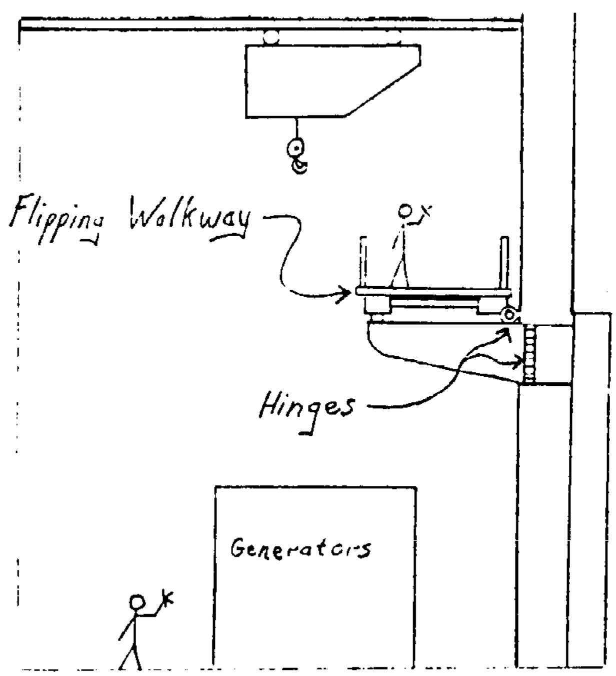
Life-Cycle Cost Analysis - Hoover Dam Viewing Platform

After functional analysis of the alternatives and life-cycle cost analysis the alternative to construct an exterior visitor viewing platform and modify the original design concept of a removable third floor walkway had the highest VE savings.

The modification to the original conceptual design is to use hinged walkway support brackets whereby the walkway sections and the supports can swing out of the way for access to the generators and powerhouse equipment as needed. Original concept estimated costs, both initial and life cycle, total $ 2,029,699 and the VE proposed project conceptual design total cost is $ 1,246,141. This represents a cost avoidance of $ 783,558.



ORIGINAL CONCEPT



VE CONCEPT

(VE Study Drawing)

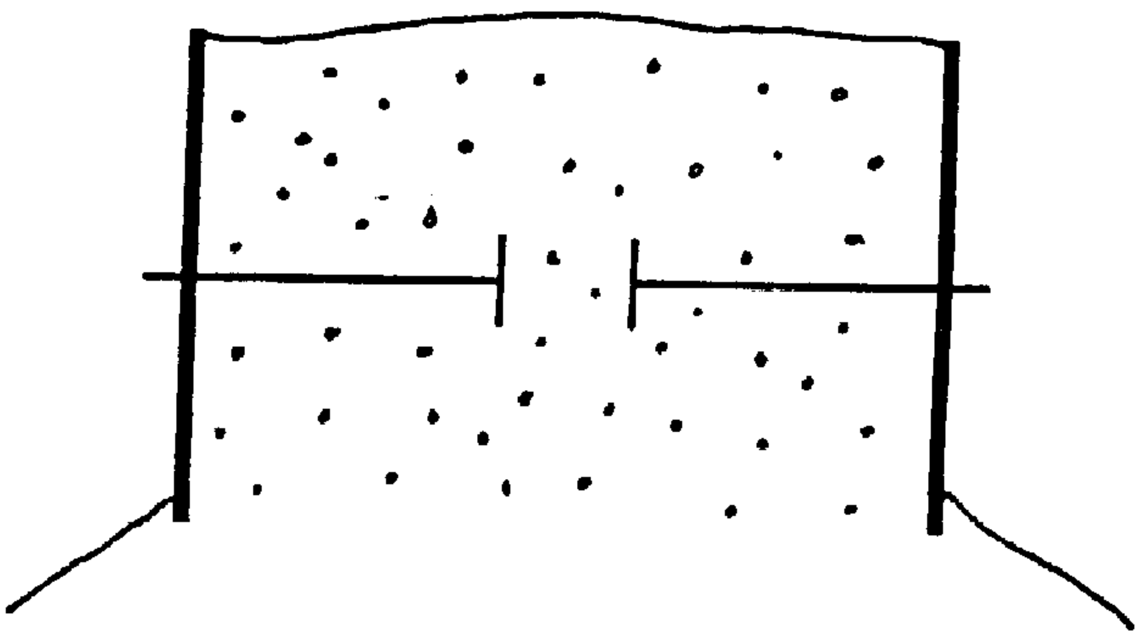
Example 2: Increase Water Storage Capability at Existing Dam

The Middle Creek Dam in Montana is the subject of this VE study. The Middle Creek Dam is owned by the State of Montana and the Middle Creek Water Users Organization uses this dam to store and release water. The Bureau of Reclamation was contacted to assist in performing a dam safetyanalysis and make recommendations for remediation and/or rehabilitation.

Under new Probable Maximum Flood (PMF) guidelines and a Corps of Engineers study, Middle Creek Dam is rated a large dam with high downstream hazard potential. The existing dam can only pass 29 percent of the PMF before overtopping. Therefore the dam must be upgraded to pass the PMF without damage to the structure or downstream occupants. Any increased water storage will be used by local municipality and irrigators downstream.

The existing dam is an earthen structure with a total storage capacity of 8,393 acre-feet and includes a 40-foot wide spillway with a 60-inch diameter low level outlet conduit located in the center of the dam. Dam upgrade design constraints include preserving a mountain access road across the dam and the environment must be protected because the Gallatin National Forest surrounds the project. Project functional objectives are to pass the PMF and prevent damage.

The original project design concept was to modify the primary spillway, add an auxiliary spillway and raise the dam embankment for a total estimated cost of $ 2,415,000. The VE study proposes to use only one combined spillway constructed of roller compacted concrete and replaces the original raised earthen dam embankment reinforcing hexagonal concrete panels with rectangular reinforcing panels. This VE concept is estimated to cost $ 1,925,000 which equates to a construction project cost avoidance of $ 490,000.



Willow Creek Reinforcing Panels (Cross Sectional View)

Example 3: Two-way Pumping Station

A VE study was performed to determine if the conceptual design of a two-way pumping station for the Fish and Wildlife Service's Ottawa National Wildlife Refuge (N.W.R.) was the best alternative to meet the refuge needs. The Ottawa N.W.R. located near Lake Erie in Ohio, is an important migration stopover for thousands ducks and geese each year. The refuge provides important natural wetland vegetation and food sources.

A two-way pumping system is needed to pump water into the refuge in the summer and fall to ensure adequate water levels and in the spring the high water levels must be drained to provide optimum water levels for nesting suitability. The project's functional objectives are to promote vegetation and maintain water levels. A wide variety of alternatives were evaluated that would serve to meet the project requirements. The refuge has an adequate number of ponds and dikes to contain the water in the refuge boundaries, yet maintaining desired water levels is the primary concern. The VE study therefore focused on the pumping system that was planned for the Darcy Marsh Unit of the Ottawa N.W.R.

The original concept was to construct a fixed permanent structure to house a two-directional pumping station with a capacity of approximately 7,000 gallons-per-minute (gpm). Design constraints/requirements for the pumping capability are that the pumps must have a minimum capacity of 4,538 gpm and a maximum capacity of 8,100 gpm. Electricity for the pump station can be acquired from power lines located at the entrance of the refuge approximately 0.5 miles from the pumping station.

The VE concept employs a mobile pumping unit to accomplish the original criteria. The mobile pumping unit will be composed of one 35-horsepower pump capable of pumping 8,100 gpm at approximately 11 foot head. The two-way pumping system will be accomplished by installing a manifold on the pumping unit. The intake and outlet areas will be rip-rapped. The original conceptual design is estimated to cost $ 406,520 and the VE conceptual design's estimated cost is $303,712 resulting in a project cost avoidance of $103,808.

Item: DARCY PUMPING STATION
Life-Cycle Period: 50 YRS.
Date: 4/19/90 Interest Rate. 10%

		ORIGINAL		ALTERNATE NO. 1	
		Estimated Costs	Present Worth	Estimated Costs	Present Worth
COLLATERAL/INITIAL COSTS	Base Cost				
	Interface Costs				
	a. SITEWORK		23,433		13,440
	b. CONCRETE STRUCTURE		26,703		350
	c. GATES & PUMPS	[illegible]	50,320	[illegible]	40,144
	Other Initial Costs MISC. (ELEC., MTG, O & P)		84,544		50,752
	a.		185,000		104,686
	b. ENGIN. DESIGN & G.A. 15%				15,703
	Total Initial Cost Impact (IC)		185,000		120,389
SALVAGE & REPLACEMENT COSTS	Single Expenditures @ 10% Interest				
	1. Year 15 PW Factor .239 (GATE)	32,450	7755	10,000	2390
	2. Year 30 PW Factor .057 (GATE)	32,450	1,850	10,000	570
	3. Year 45 PW Factor .014 (GATE)	32,450	454	10,000	140
	4. Year 20 PW Factor .149 (PUMP)	17,870	2663	28,637	4,267
	5. Year 40 PW Factor .022 (PUMP)	17,870	393	28,637	630
	Salvage ____ PW Factor .099		0		0
	Total Present Worth		11450		7997
ANNUAL COSTS	Annual Costs @ ____ Interest				
	a. Maintenance Escal. Rate ____ PWA Factor 9.915	9,687	96,047	9687	96,047
	b. Operations. Escal. Rate ____ PWA Factor 9.915	11,500	114,023	7895	78,279
	c. Others Escal. Rate ____ PWA Factor ____				
	d. Others Escal. Rate ____ PWA Factor ____				
	Total Annual Costs		210,070		174,326
	Total Present Worth Costs		406,520		302,712
	Life Cycle (PW) Savings				103,808

PW - Present Worth PWA - Present Worth of Annuity

Life-Cycle Cost Analysis Ottawa N.W.R. Pumping Station

SUMMARY

VE techniques and methodology have been successfully applied to evaluating conceptually designed construction projects of the Department of the Interior. Application of VE after the planning is complete and prior to formal design efforts begin will save design costs and improve project value.

The VE study performed at the concept stage is highly beneficial in building consensus on all major project design decisions. The VE study team is composed of participants from the design, planning, and project user interests and decision

makers. It has been our experience that when VE analysis is conducted at this stage the acceptance and implementation of recommendations is very high. The process produces a greater understanding of the project and project objectives, the design is improved, early consensus of decisions is developed, and design costs are reduced.