LATEST STRATEGIES TO ENHANCE THE ENVIRONMENTAL VALUE OF WASTEWATER TREATMENT PLANTS

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ABSTRACT

This paper addresses the potential need for value improvement of wastewater treatment plants (WWTP) to meet current budget and permit requirements. Strategies are discussed for environmental value enhancements and the optimum selection of the VE team members to conduct a WWTP study. In addition, this paper presents an environmental value comparative analyses of selected WWTP projects I conducted using the VM function approaches as a tool to achieve higher quality wastewater treatment process following the VE Job Plan recommended by the SAVE.

INTRODUCTION

Today's major environmental problems are related to the 1960's industrial revolution. Back then, little recognition of hazardous waste and limited focus were given to air and water quality. The lack of governmental involvement and private agencies interest in environmental issues at that time led to minimum environmental regulations. Now, the world is facing rapidly changing expectations and fast technological development that demands improvement to the environment we live in. Therefore, strict new permit requirements and the public's changing expectations in favor of protecting the environment requires the use of the most cost effective approach coupled with the latest environmental technology. Governmental agencies took initiatives to respond to the environmental problems spawned innovations that resulted in cost savings and yielded better performance beyond permit compliance. Therefore, both government and private agencies began to move towards managing the environmental improvement issue as it is becoming the cornerstone of quality. This encouraged the different agencies to start considering VE techniques to be applied to WWTP projects for value enhancement and environmental quality improvements. Therefore, the Environmental Protection Agency initiated VE efforts for its wastewater treatment plants construction grant program in 1974. The success of these VE efforts prompted Congress to require VE studies in all WWTP projects with a total construction cost of $10 million or more as per the Clean Water Act Amendments of 1981, to enhance project quality and make full use of taxpayer's money.

ENVIRONMENTAL VE APPROACH

The following is a discussion of the VE approach applied to the environmental projects including VE team member selection, process cost model, energy/ life cycle cost model and an environmental function analysis system technique (FAST) diagram for a waste water treatment plant (WWTP) project

VE TEAM SELECTION:

The environmental VE team leadership normally includes a facilitator who is a CVS and professional engineer (PE) who is familiar with the WWTP process. The team leader follows the VE job plan according to SAVE and as illustrated in Figure 1.

The VE team should include a specialist in wastewater process and hydraulics. The other team members should be professional engineers with specialities in structures, civil, cost/ constructibility, electrical/instrumentation, mechanical and architec- ural as needed.

FUNCTION COST / WORTH MODEL:

The function cost/worth model was developed for a VE study I led on Riyadh WWTP upgrade and expansion with a capacity of approximately 52.8 million gallon per day(MGD). The estimated cost for this expansion project was $99.24 million. Figure 2 illustrates the distribution of this cost and the associated worth by function for both process and facilities.

ENVIRONMENTAL PROCESS FUNCTION ANALYSIS:

The function approach is considered to be the heart of VE that best defines the objectives, needs and creative solution opportunities. The function logic diagram depicted by Figure 3 illustrates the process and summarizes the design criteria used for the WWTP expansion and improvements.

The treatment process for that study is based on biological removal of carbonaceous and nitrogenous compounds in one stage. The biological tanks are of the activated sludge type with Bordonpho modification employing fine bubble air diffusion system and anoxic chambers. The sludge from primary and secondary sedimentation tanks is thickened and digested in anaerobic digesters before dewatering on half filter press.

LIFE CYCLE/ ENERGY MODEL:

The life cycle\ energy model depicted in Figure 4 was developed for the same VE study of Riyadh WWTP expansion project. This Life Cycle Cost (LCC)/ Energy model was based on 55 people including five laboratory staff working one shift for 8.5 hours / day and a 5.5 days per week. Cleaning staff includes 20 laborers working a similar shift. The life cycle cost data includes energy consumption of 12,080 KVA (9,700 kw) with a 60% demand factor operating 24 hrs/day for 365 days/year. Parts replacements and equipment maintenance are estimat- ed to be 1% of the equipment value per year. The building maintenance and operation annual cost are considered as 1.0 $/sf per year. The present worth method was employed at 8% discount rate over 20 years to calculate the LCC of the project.

INNOVATIVE STRATEGIC IDEAS TO ENHANCE WWTP/ ENVIRONMENTAL VALUE:

The research of 40 VE studies on WWTP projects including five studies conducted were led by me during the last three years resulted in several innovative ideas using the most recent technology application in this field. These projects have ranged from new WWTP projects to upgrades and expansion of existing facilities. I have categorized these innovative ideas into environmentalprocess/ hydraulics, engineering systems including site layout/ civil, structural, mechanical, electrical and architectural categories. Most of these ideas have been generalized to influence a broader range of valuable suggestions for implement- ation to similar projects.

- **Environmental Process/ Hydraulics**
  - Raise hydraulic profile to reduce excavation and disposal costs
  - Use dynasand system in lieu of multimedia filters
  - Use constant speed pumps where possible and minimize number of pump stages
  - Use submersible pumps with high capacity for wastewater
  - Use fewer variable speed pumps

- Use gravitation flow in lieu of force line pumps where possible

- Use magmeter in lieu of open partial flow channel to reduce headworks building size and minimize odors

  - Provide screens at inlet of raw sewage in the headworks building

  - Provide two stage biofilters for blowers, improve filtering flow distribution and maximize backwash

  - Use bypass pipes to connect clarifiers with oxidation tower for flexibility

  - Provide efficient fine bubble aeration system using gas engine drive on aeration blowers

  - Use conventional activated sludge process and minimize number of sludge hoppers for odor control

  - Provide high rate aerobic digesters

  - Use scum concentration instead of placing scum in digesters

  - Minimize number of secondary clairfiers and remove phosphorous in secondary clarifiers

  - Use flush clean system in lieu of comminutor

  - Use single chlorine feed system and conventional chlorine diffuser

  - Improve maintenance and operation efficiency and evaluate cost versus equipment replacement

  - Treat digester supernatant separately

  - Utilize gravity thickening sludge and clean/flush digesters periodically in lieu of digester expansion

  - Add top ring to the sludge tank for free board versus building new tank for expansion

  - Provide visible display instrumentation for influent efficient flow measurements and control

  - Use self pumping samples in all stations
  - Provide divider wall in wet well for ease of maintenance

  - Cover sludge tanks, grit hoppers and dumpsters area to minimize oder

◆ **Site Layout/ Civil**

  - Provide flexibility as needed for future expansion i.e. build just in time not just in case

  - Use hydro seed in lieu of sod and minimize landscaping

  - Arrange efficient truck turn around loop

  - Minimize road width and pavement thickness

  - Review elevations of process tanks and support faxcilities

  - Locate similar tanks close to each other by function

  - Consolidate lime and soda ash lines outside buildings

  - Reduce four lane roads to two lane roads

  - Minimize site lighting

● **Structural**

  - Minimize footing width and mat thickness

  - Use fixed dome covers in lieu of floating covers

  - Minimize tank wall thickness and use tapered or step down reinforced concrete walls

  - Minimize retaining walls on site

  - Use steel tank supported on perimeter ring foundation. Tank bottom to be supported on compacted granular fill on top of woven fabric in case of clay type soil in lieu of mat foundation

  - Use common wall between aeration tanks and eliminate interior water stop at partitions from aeration tanks

- Reduce width of cantilevered overflow channels around process tanks

- **Mechanical**

  - Minimize redundant dual piping systems
  - Minimize piping system and use lighter class/lower pressure pipe rating
  - Maximize use of PVC and ADS piping systems on site
  - Improve hydraulics by minimizing the total number of bends and valves
  - Use sulfur dioxide versus sodium bisulfate in liquid form
  - Interconnect scum lines where possible
  - Add polymer to piping entering final clarifier and splitter box
  - use polylined pipes in lieu of glass lined
  - Use vitaulic couplings in lieu of flanges for steel piping connections

- **Electrical**

  - Provide on site generator engine driven as a backup power source for critical pumps and selected equipment
  - Improve power factor of plant and use high efficiency motors
  - Improve power quality and energy consumption by performing harmonic analysis at power plant distribution brushes
  - Provide PLC and PC control using peak power controllers
  - Minimize number of primary circuit breakers, substation breakers and switchgear
  - Replace incandescent lighting with energy saving fluorescent lighting

- **Architectural**

  - Minimize height and size of support buildings
  - Use roof hatches in support buildings for equipment maintenance and repair
  - Minimize lateral walkways and railing around tanks
  - Eliminate brick cladding on surface of digester tanks
  - Centralize power plant and consolidate support facilities around plant
  - Minimize building overhang and glazed area
  - Use epoxy paint in lieu of ceramic tiles for floor and wall finishes
  - Use galvanized steel in lieu of stainless steel in support buildings

ENVIRONMENTAL VALUE COMPARATIVE ANALYSES

A comparison between estimated construction cost of selected WWTP projects and plant capacity in MGD is depicted in Table 1. Table 1 also illustrates the project cost before and after the VE study. It also indicates the percentage of potential savings resulted from the associated proposals developed during the VE workshop.

CONCLUSIONS:

The results of researching and conducting of 40 VE studies on WWTP have proven to :

- Be instrumental in identifying opportunities to reduce unnecessary costs of WWTP give the Department of Environmental Protection a forum to discuss more comprehensive approaches to water shed management.
- Increase functionality of WWTP projects by arranging the support facilities to best service the wasteater treatment process.
- Increase operation efficiency and optimize wastwater treatment process functionality
- Simplify constructibility and resolve conflict issues in a real time workshop setting through involvement of owner, user, designer,

nvolvement of owner, user, designer, contractor representatives and the VE team. This will result in minimizing recycling effort of project design.

- Reduce initial cost using the function cost worth model techniques.

- Reduce LCC and increase process efficiency through the development of the LCC/energy model

- Optimize environmental impact solutions and have a quick creative remediation design

- Use the interdiciplinary team approach and the full range of analysis techniques that the VETC could apply such as risk management, LCC analysis, statistical process control, weighted evaluation techniques within the VE workshop

- The environmental value parametric analyses summarized in Table 1 indicated that initial cost savings of those randomly selected WWTP projects ranges from 3% to 54% while the present worth LCC savings of those WWTP ranges from 0.34% to 30.48% of total estimated project cost. These results vary according to project capacity, cost and duration of VE study.

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Value Management Workshop Procedures

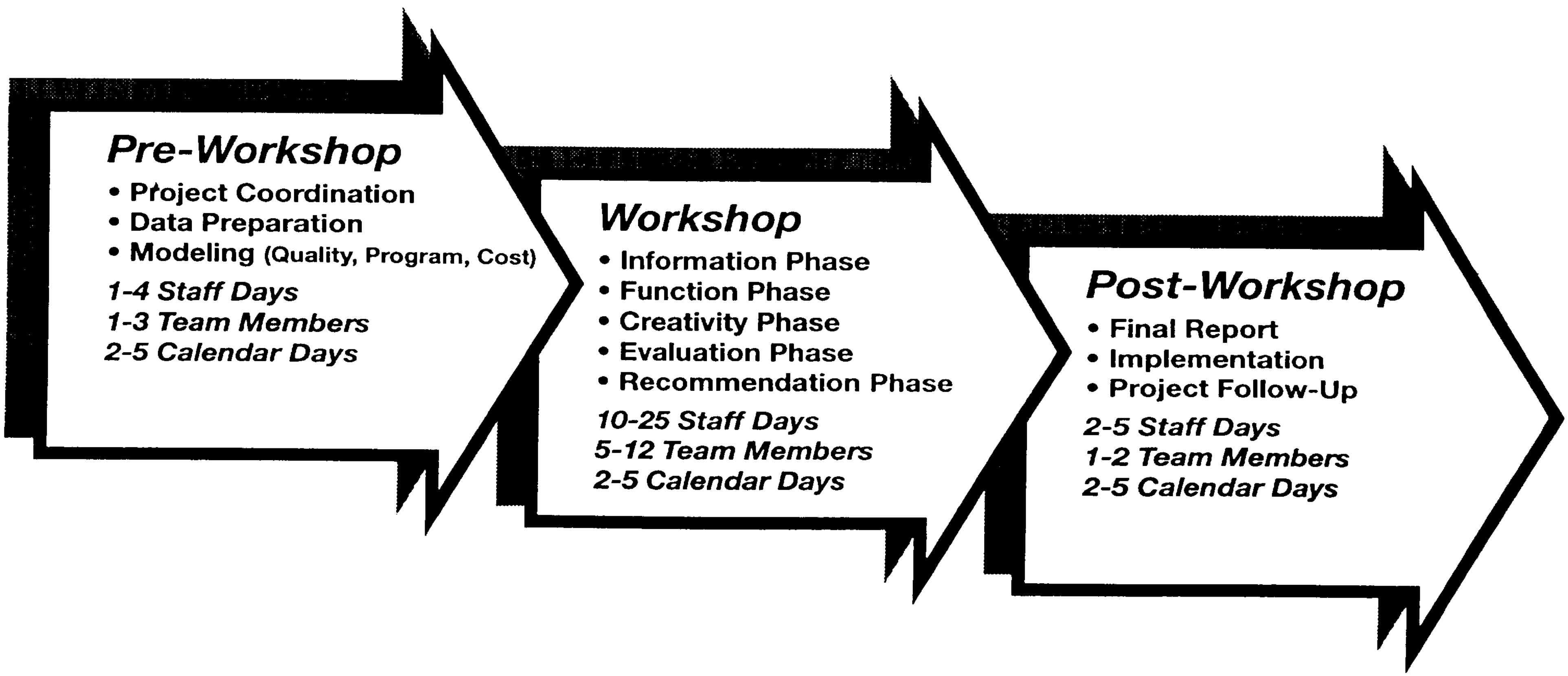

Figure 1

ENVIRONMENTAL VALUE PARAMETRIC ANALYSES

PROJECT NAME/ LOCATION	MAX DAY FLOW MGD (WINTER)	PROJECT ESTIMATED COST	TOTAL NO. OF PROPOSALS	VE INITIAL COST (I.C) SAVINGS	LCC COST SAVINGS	PROJECT WORTH	% age of VE SAVINGS	
							I.C.	LCC
Riyadh WWTP Expansion Riyadh, Saudi Arabia	52.80	$99,400,000	44	$29,173,000	$372,000	$69,855,000	29%	0.37%
City of Greenville WWTP Upgrade Improvements, Greenville, MI	2.30							
- First VE 2 Day Study		$3,650,000	17	$1,959,780	$32,000	$1,658,220	54%	0.88%
- Second VE 3 Day Study		$3,650,000	22	$141,859	$574,735	$2,933,406	4%	15.75%
New Castle WWTP Expansion New Castle, Pennsylvania	25.75	$13,300,000	54	$4,816,000	$45,000	$8,439,000	37%	0.34%
Brough of Hanover WWTP Hanover, Pennsylvania	3.65	$15,000,000	31	$3,300,000	$290,800	$11,409,200	24%	1.94%
SOD Run WWTP Expansion Harford County, MD	5.00	$8,300,000	16	$1,245,000	$475,000	$6,580,000	21%	5.72%
City of Henderson WWTP Henderson, Nevada	9.89	$8,066,260	15	$1,910,100	$2,458,750	$3,697,410	46%	30.48%
Guayama Sub- Region WWTP San Juan, Puerto Rico	20.00	$15,960,000	40	$4,546,000	$3,122,000	$8,292,000	48%	19.56%
Rockland County WWTP Expansion Orangeburg, New York	58.84	$46,000,000	39	$684,338	$875,490	$44,440,172	3%	1.90%
City of Fulton WWTP New York City	16.00	$12,000,000	35	$691,000	$430,820	$10,878,180	9%	3.59%

Table 1