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Value Engineering For Wastewater Treatment Works

VALUE ENGINEERING FOR WASTEWATER TREATMENT WORKS

Prepared for:

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FOREWORD

The Environmental Protection Agency's value engineering program is an extremely successful element in its construction grants program. Over the seven-year period from 1977 through 1983, the value engineering program produced a $15 dollar return on each dollar invested in value engineering and a 5.4 percent net capital savings on $7.5 billion worth of total project costs. In addition to the obvious benefit of lowering capital costs for wastewater treatment facilities without sacrificing performance or reliability, the value engineering program produces additional benefits of operating and maintenance cost savings and enhanced reliability for the facilities.

Although value engineering is required on large wastewater projects, the Agency encourages its use on smaller projects since they offer similar potentials for cost savings.

This document provides users with state-of-the-art guidance for conducting value engineering on wastewater treatment projects. The guidance document strives to:

- Promote broader use of value engineering;
- Increase the knowledge of the value engineering process; and
- Improve the quality and effectiveness of value engineering in the construction grants program.

With the positive application of the value engineering process described in this document, capital cost savings of five to ten percent plus additional operation and maintenance cost savings can be achieved for individual wastewater treatment facilities.

Value engineering presents communities with an excellent opportunity to reduce the present and future costs of their wastewater treatment projects.

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INTRODUCTION

1.1 OVERVIEW

In 1974, the United States Environmental Protection Agency (EPA) started a voluntary program to encourage the use of value engineering (VE) in its construction grants program. Since 1976, the Agency's value engineering program has been a mandatory design element for all large wastewater treatment works. The success of this value engineering effort has improved the reliability of new wastewater treatment works while reducing their costs.

Value engineering is a specialized cost control technique performed by an independent group of experienced professionals. The technique involves an intensive, systematic and creative study to reduce costs while enhancing reliability and performance. The technique is used to achieve the best functional balance between cost, reliability, and performance of a product, process, system, or facility. The value engineering effort provides a project designer with an additional source of engineering, construction, and operations expertise to enhance the project's design and operability. When the VE efforts are properly coordinated, they will not delay work on a project's design.

A glossary of terms common to value engineering is presented in Appendix A. Users of this guidance document are encouraged to consult this glossary prior to a detailed reading of this document.

1.2 PURPOSE AND SCOPE

The purpose of this guidance document is to provide municipal authorities, state agencies, design engineers, and VE teams with state-of-the-art guidance for conducting effective VE studies on wastewater treatment works. This guidance document serves as a reference source for contracting, planning, performing, reporting, and evaluating value engineering studies. It also consolidates and updates the EPA's existing information and experience on value engineering. This document has not been developed as a training manual or textbook on value engineering. The value engineering techniques are adequately described in numerous texts on the subject. (Refer to the select bibliography in Appendix B).

1.3 BENEFITS OF VE

The use of value engineering methodology to reduce costs and enhance the operation and reliability of products and processes has been successfully demonstrated by manufacturers and engineers for over thirty years. The strength and ultimately the success of VE in the design of wastewater treatment works lies in its systematic, functional and creative approach.

All project designs contain unnecessary costs due primarily to the complex nature of the design process. The design of a project requires the interaction of a variety of experienced and talented technical professionals working under schedule and budget constraints. During the design process, countless variables must be considered, selected, and coordinated under circumstances which limit consideration of many alternative design options with the potential to reduce project costs.

The following are the most common reasons that lead to unnecessary project costs:

- Lack of Time: Schedule constraints preclude the investigation of all design options and the development of cost comparisons for multiple design options.

- Lack of Information: Since technological changes are occurring at a rapid pace, no designer can be expected to be knowledgeable and up-to-date on all new products and techniques.

- Lack of a Key Idea: Sometimes an innovative, cost-saving idea is not recognized in time to influence the design.

- Lack of Budget: Shortcuts taken to stay on schedule and maintain the design budget frequently minimize the analysis of alternatives which can improve the cost effectiveness of the facility. Even though the design budget is a small part of the total cost of a facility, it can adversely influence the total costs if it is deficient.

- Temporary Decisions which become Permanent: Often a temporary decision is made in a particular area of the design to maintain progress, but time restraints or other factors do not provide an opportunity for its re-evaluation. When temporary design decisions become permanent, they can have a cost impact on more than the original facility because they become a standard for future designs.

- Habits: Habits promote the use of standard design features because "we've always done it this way." Habit may increase project costs by the use of a design feature which may be outmoded, unnecessary or inappropriate for the current project.

- Politics: Political factors and forces are complex and often dictate design features which are not the least-cost alternatives. Pressure from local citizenry may "force" the use of certain design features. Funding constraints may allow first-cost considerations to prevail over life cycle cost considerations. Architectural and esthetic, or other, constraints may be imposed on the project by outside participants.

With the preceding factors inherent in every project design, an independent VE team will, almost without exception, identify areas of substantial cost savings. The VE team has a somewhat easier task than the project designer since the VE team is simply reviewing instead of developing the design. In a sense, the VE team is in the position of a Monday-morning quarterback. The VE team members are able to conduct their review from a detached viewpoint since they did not participate in the initial design. The team has a unique opportunity to identify and compare design alternatives using the systematic and creative VE techniques.

The use of value engineering provides benefits for everyone involved with wastewater treatment. For example:

- Value engineering generates substantial cost savings while increasing facility reliability.

- The VE results are achieved with a relatively low expenditure of total project funds and administrative effort.

- Substantial operating and maintenance savings may be realized over the life of the wastewater treatment works.

- The overall level of design expertise for the entire wastewater treatment profession is raised by the widespread use of value engineering studies.

- VE increases overall sensitivity to project costs.

- Designers can utilize the value engineering studies to enhance their designs while minimizing the overall project costs.

- A value engineering study by a group of experienced design, construction, and operations professionals provides a confidence factor for both the project owner and the designer. The owner is assured of receiving the best value for the project budget and the designer is more secure about the reliability and operability of the facility. The latter is of increased importance to the designer with the advent of operability requirements in the EPA construction grants program.

- A value engineering study often results in a detailed construction cost estimate earlier than usual in the project schedule. This provides an additional planning aid which increases the owner's awareness of the project's details.

It is important to note that similar benefits are not achieved with peer reviews, traditional cost-reduction analysis, or cost-effectiveness analysis. These techniques are often incorrectly confused with value engineering. Peer reviews are generally limited to technical review of the design without specific regard to costs or cost-savings. Traditional cost-reduction analysis generally focuses on straightforward cost-cutting such as providing smaller quantities or less-expensive materials. Cost-effectiveness analysis tends to be very broad in scope and applied by the designer in the early facility planning stages to establish design criteria. Value engineering is not a substitute for any of the foregoing; rather, it is a procedure which uses a systematic, functional and creative approach to identify major savings in a facility without reducing its reliability or performance.

1.4 HISTORY AND ACCOMPLISHMENTS

The concept of value engineering has been in existence for many years. It evolved during World War II at the General Electric Company when shortages of materials and labor forced the introduction of many substitutes. It was observed that these substitutes frequently reduced costs and improved the product. The underlying reason for this phenomena was that even though the materials and design features were changed the function remained constant. After the war, General Electric refined this approach into a specific program for improving products and optimizing their costs. This new systematized approach was developed by Lawrence Miles and called value analysis. As the value analysis techniques were adapted to other processes, the name was changed to value engineering.

In 1954, the Navy's Bureau of Ships changed the value analysis terminology to value engineering when it applied the same techniques to its design process. The reason for the change in terminology was significant. Previously, the GE program was directed at the manufacturing process for analyzing existing products. The Bureau's program was directed at engineering drawings prior to procurement. Following the Navy's lead, the Army and Air Force also started using value engineering as part of their procurement programs.

During the 1950's, when many companies in the private sector established value engineering programs, a need developed for a forum to share value engineering ideas. As a result, the Society of American Value Engineers (SAVE) was created to develop and administer a certification program for value engineering practitioners. The certification program provides peer recognition as a Certified Value Specialist (CVS).

A major stimulus for value engineering occurred in 1964 with Secretary Robert McNamara's emphasis on cost reduction programs at the Department of Defense.

In 1967, value engineering received a stimulus when the U.S. Senate Committee on Public Works held hearings on its use in Government agencies. About this time, the General Services Administration (GSA) became the first agency to establish value engineering as a requirement for its architect/ engineer contracts. In 1968, the National Aeronautics and Space Administration (NASA) began applying value engineering to their projects.

The EPA initiated a voluntary VE effort for its wastewater treatment works construction grants program in 1974. The success of this VE effort prompted the Agency, in 1976, to require VE on all treatment works projects with a total estimated construction cost of $10 million or greater. Congress formalized the Agency's VE requirements in the Clean Water Act Amendments of 1981.

More recently the Department of Transportation, Federal Highway Administration, adopted a voluntary value engineering program for its transportation projects.

In 1983, a General Accounting Office (GAO) report recommended that the Urban Mass Transportation Administration (UMTA) of the Department of Transportation begin using VE to reduce the costs of its transit systems. The GAO report concluded that "millions of dollars in Federal, state, and local construction funds can be saved by applying value engineering."

Recent publications have reported the successful application of value engineering to management functions in the area of administration as well as the customary VE areas of design, manufacturing and construction. Thus, the successful application of value engineering programs in both the Federal Government and the private sector is a well established fact.

The use of VE in foreign countries has also increased steadily in recent years. Japan plus most European and Scandinavian countries currently have active value engineering programs.

1.5 VE IN THE EPA CONSTRUCTION GRANTS PROGRAM

During the seven year history of the EPA's mandatory VE program, documented in Table 1-1, VE studies were conducted on 273 projects with a resulting net capital savings of $401 million. The program has produced a $15 return for each dollar invested in VE costs and a 5.4 percent net capital savings on $7.5 billion worth of total project costs. These substantial savings and high rates of return make VE an extremely successful element in the Agency's construction grants program.

TABLE 1-1

SUMMARY OF VE SAVINGS

EPA CONSTRUCTION GRANTS PROGRAM

Fiscal Year	Number of VE Studies	Total Est. Const. Costs*	Accepted VE Savings* Capital	Accepted VE Savings* O/M	Cost* of VE Studies	Net VE Savings* Capital	Net VE Savings* O/M	Net VE Savings Percentage Capital	Net VE Savings Percentage O/M	Capital Savings to Cost Ratio
1983	76	2,143,252	120,233	31,119	8,833	111,400	31,119	5.2	1.4	13:1
1982	58	1,174,578	72,433	7,758	3,910	68,523	7,758	5.8	-	18:1
1981	39	943,378	66,378	-	2,348	64,030	-	6.8	-	27:1
1980	18	490,229	18,004	-	1,061	16,943	-	3.5	-	16:1
1979	31	807,220	48,354	-	3,287	45,067	-	5.6	-	14:1
1978	23	501,897	23,532	-	1,660	21,872	-	4.4	-	13:1
1977	28	1,426,700	79,958	-	6,354	73,604	-	5.2	-	12:1
TOTALS	273	7,487,254	428,892	-	27,453	401,439	-	5.4	-	15:1

* in thousands

- not available

SECTION 2

MANAGEMENT OF VALUE ENGINEERING

2.1 GENERAL

Successful value engineering involves the cooperative participation of three primary parties: the project owner, the project designer, and the VE team coordinator (VETC). It is important to note that the VE goal of all three parties is identical, i.e., to ensure that the final design of the wastewater treatment works represents the most efficient combination of cost, performance, and reliability. During the design of a facility, the owner, the project designer, and the VETC function as a team.

The success of VE depends heavily on the management and organization of the VE study as well as the attitude and cooperative spirit of the participants. The diverse viewpoints and perspectives of the VE team provide an excellent opportunity for the owner and designer to enhance the value and reliability of the facility without delaying the design efforts.

2.2 VE SEQUENCE AND TYPICAL SCHEDULE

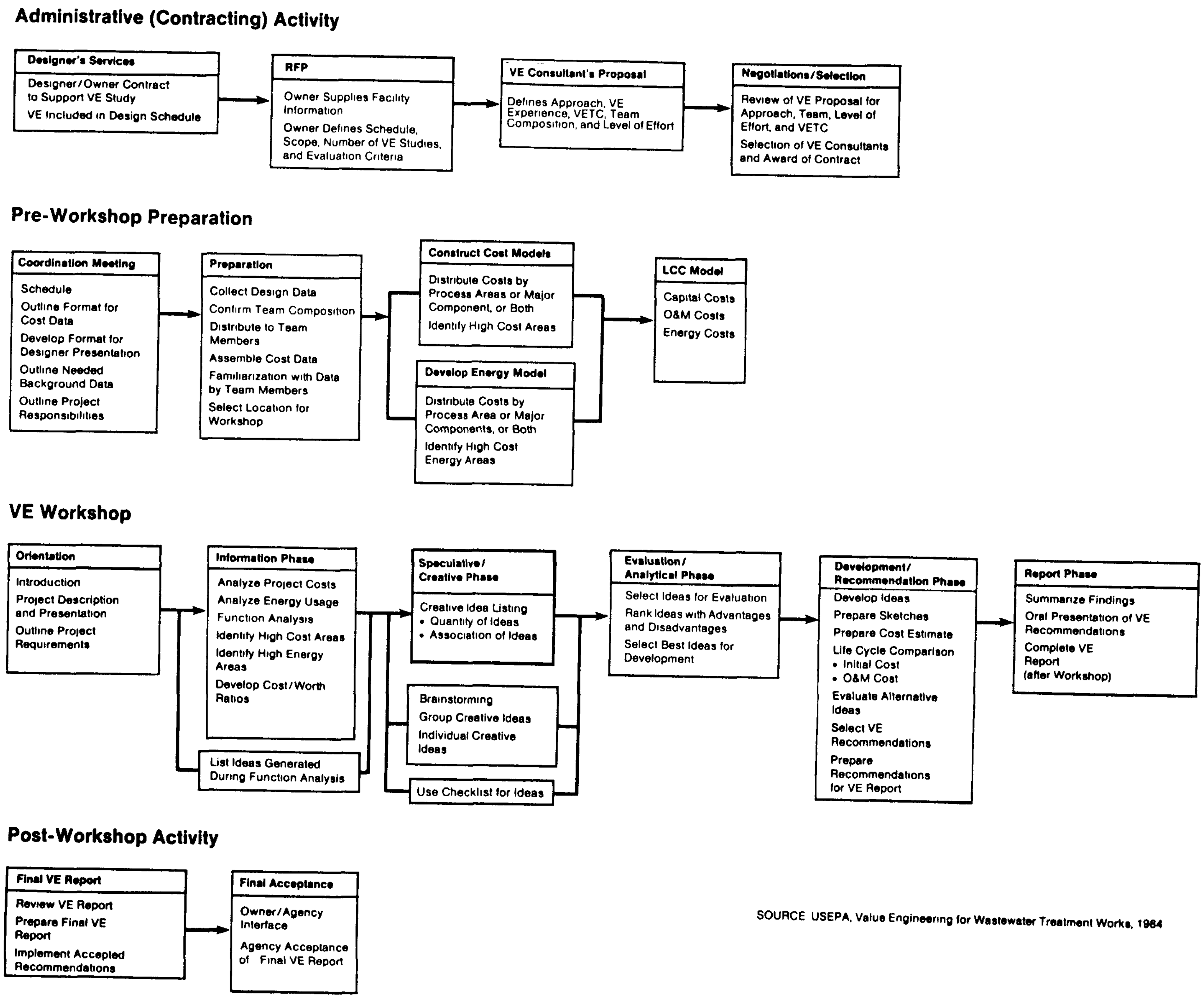
The VE effort can conveniently be divided into four sequential periods of activity: (1) administrative (contracting) activity, (2) pre-workshop activity, (3) VE workshop, and (4) post-workshop (report) activity. Figure 2-1 is a task flow diagram which outlines the effort which occurs during these periods of activity.

For most wastewater treatment works designs, two VE studies are held at different stages of design completion to obtain maximum benefits. In these instances, the pre-workshop activities, the workshop, and the post-workshop activities will be performed twice. Figure 2-2 is a schematic flow diagram illustrating the primary sequential steps for conducting VE on a project with two VE studies.

Administrative Activity

During this period, the owner issues a request for proposal (RFP) for the services of a VE consultant. The RFP defines the wastewater treatment project, the VE schedule, the scope of VE studies, the available technical information, and the selection criteria for the VE consultant. At the completion of this period, the owner will evaluate the proposals and select a VE consultant.

FIGURE 2-1 VE STUDY TASK FLOW DIAGRAM



SOURCE USEPA, Value Engineering for Wastewater Treatment Works, 1984

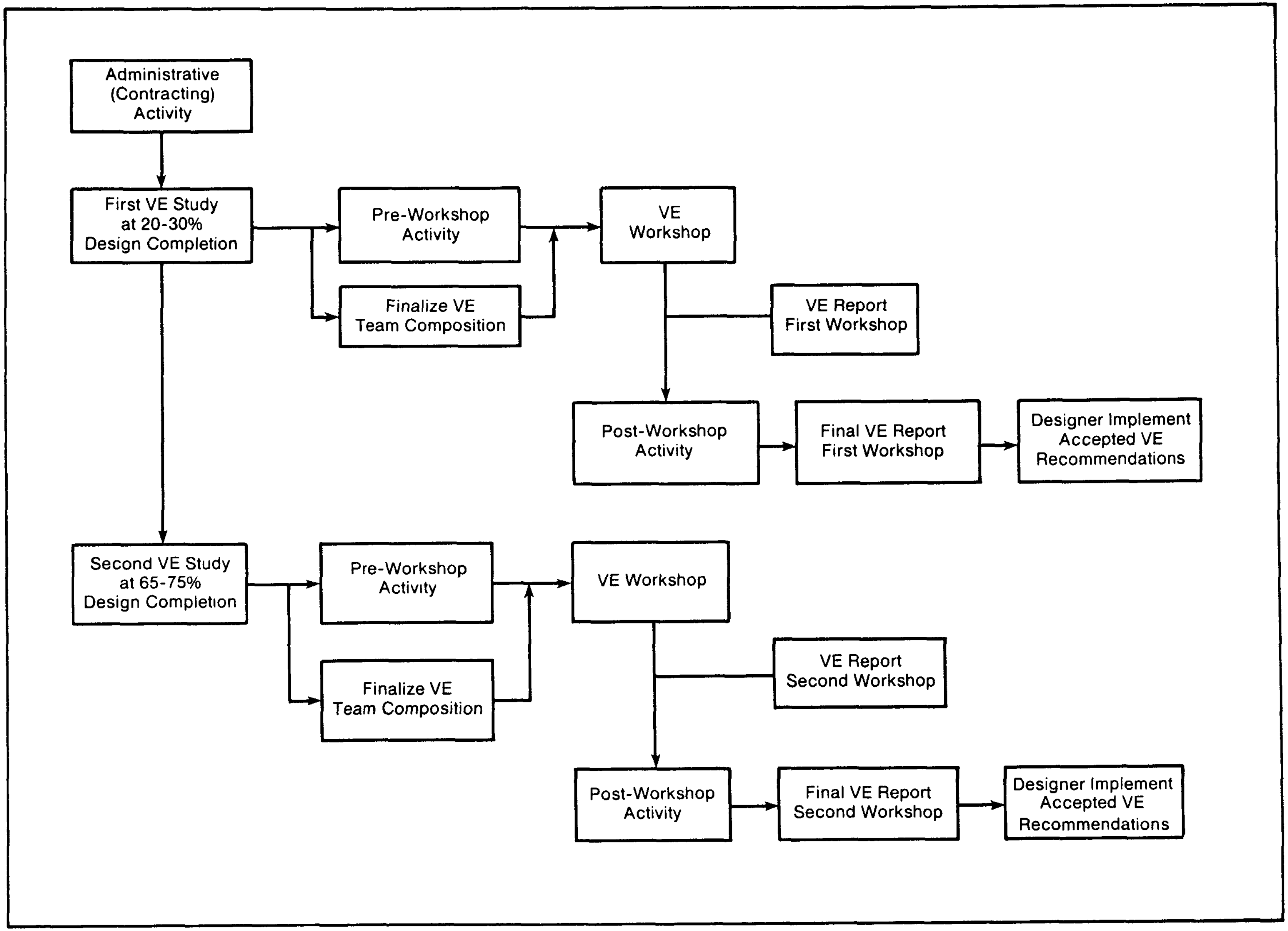


FIGURE 2-2 VE FLOW DIAGRAM: NORMAL SEQUENCE (TWO VE STUDIES)

Pre-Workshop Activity

The VE team coordinator (VETC) uses this period to become familiar with the project, obtain and review the technical and cost data, complete logistical arrangements for the VE workshop, coordinate timing for the VE workshops, complete the selection of VE team members, and establish a comfortable working relationship with the owner and the designer.

VE Workshop

The VE Workshop typically lasts 40 hours and culminates in the oral presentation of the VE team's recommendations.

The VE methodology (Job Plan) used by the VE team during the VE workshop has five distinct phases. Briefly, these phases are:

(1) Information Phase: During this phase, the VE team gains as much information as possible about the project design, background, constraints, and projected costs. The team performs a function analysis of systems and sub-systems to identify high cost areas.

(2) Speculative/Creative Phase: The VE team uses a group interaction process to identify alternative ideas for accomplishing the function of a system or sub-system.

(3) Evaluation/Analytical Phase: The ideas generated during the Speculative/Creative Phase are screened and evaluated by the team. The ideas showing the greatest potential for cost savings and project improvement are selected for further study.

(4) Development/Recommendation Phase: The VE team researches the selected ideas and prepares descriptions, sketches and life cycle cost estimates to support the VE recommendations.

(5) Report Phase: VE recommendations are presented to the owner and designer during an oral presentation at the conclusion of the VE workshop. Shortly after completion of the workshop, the written VE Report is prepared by the VETC.

Post-Workshop Activity

Following the VE workshop, the owner and designer thoroughly review the VE Report and decide whether to accept or reject each of the VE team recommendations. The designer prepares a Final VE Report which documents the acceptance or rejection of each recommendation.

Typical Schedule

Typical time periods for accomplishing VE are:

- Administrative/Contracting Activity — 6 to 12 weeks
- Pre-Workshop Activity (each) — 3 to 6 weeks
- VE Workshop (each) — 1 week
- Prepare and Issue VE Report (each) — 1 to 3 weeks
- Post-Workshop Activity (each) — 2 to 4 weeks

2.3 ADVERTISING FOR VE CONSULTANT SERVICES

A logical time for the owner to contract for the VE services is at the time contracts are established for the design services. The scope of the VE study can be readily defined and coordinated with the design contract at that time.

The designer's services required to support the VE study and implement the accepted VE recommendations should be included as part of the designer's contract. Every effort should be made to avoid the development of a competitive situation between the designer and the VE consultant. Such a situation should not develop if all parties fully understand the functions and objectives of the VE study.

The request for proposal (RFP) to perform the VE study should include the following information:

- A description of the facility. The Facility Plan should be referenced and available for review. The project designer should be identified if a design contract has been awarded by the owner.

- The design schedule (typically in milestone form, showing percentage completion vs. date).

- The estimated construction cost for the facility.

- The scope of the VE study (normally the entire wastewater treatment works as described in the Facility Plan).

- The number of VE studies to be performed and the points in time (i.e. percentage of design completion) at which each VE workshop is expected to be performed.

- The evaluation criteria which will be used to rate the proposals and select the VE consultant (e.g., relative weight to be applied to qualifications, proposed approach, oral proposal presentation and cost).

2.4 RESPONSE TO THE RFP (VE CONSULTANT'S PROPOSAL)

The VE consultant's response to the RFP should include the following information:

- The proposed approach and schedule for performing the VE study, including a brief description of how the pre-workshop activity, VE workshop, and post-workshop activity will be conducted.

- The proposed number of VE teams for each workshop and the composition of each team.

  Note: The response should qualify the team composition and allow some flexibility in the final makeup of each team. This is due to the fact that the design schedule for the major disciplines (structural, mechanical, electrical,...) differs for each design firm. For example, some firms develop electrical one-line diagrams with pump horsepower and other electrical loads early in the design; other firms perform this effort later in the design. Therefore, precise composition of the team(s) should be subject to adjustment by the VE consultant based on the progress of the design and the high cost areas identified during the pre-workshop activity. Resumes showing qualifications and experience of all potential team members should be provided in the response to the RFP. Also, since the objectivity and independence of the VE team members is essential to the success of the VE study, the response must describe how this will be achieved by the VE consultant.

- The qualifications of the VETC including VE training and experience.

- The proposed level of effort (hours) with details for each VE study.

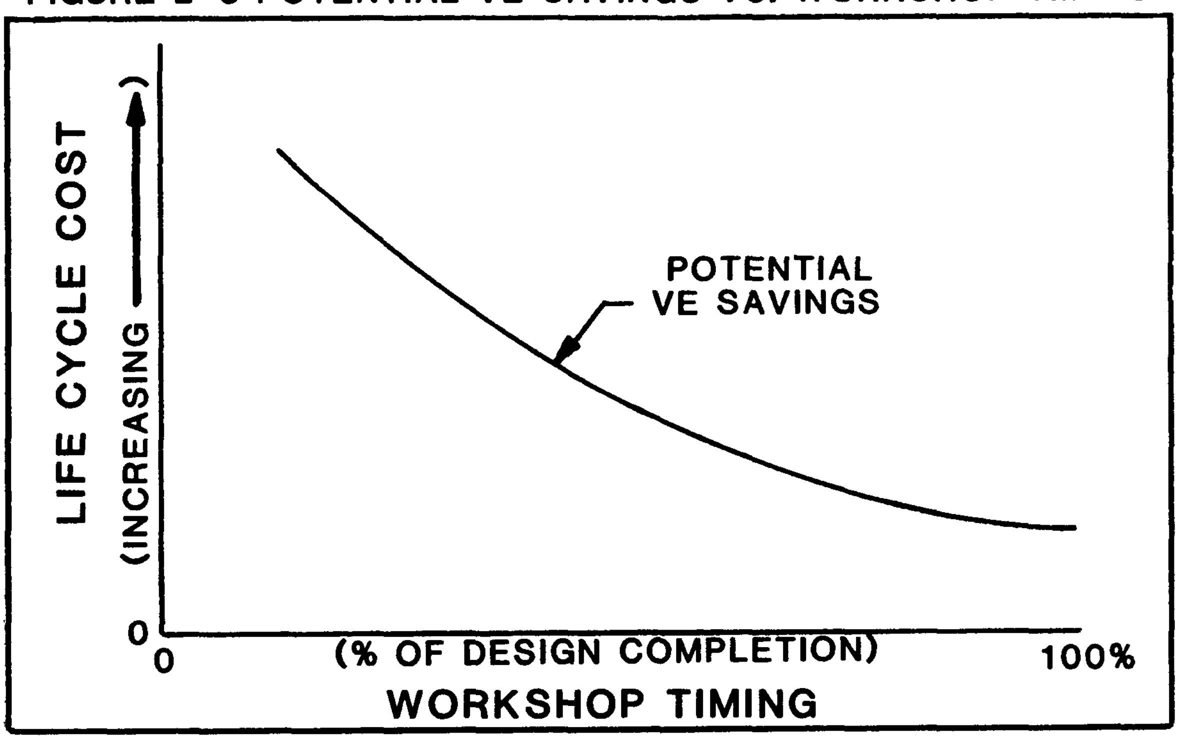
2.5 NUMBER AND TIMING OF VE STUDIES

All owners are encouraged to conduct VE studies on their facilities to enhance cost-effectiveness and reliability. However, it is emphasized that any wastewater treatment facilities with estimated construction costs greater than ten million dollars must use VE in the design process.

The scope of the VE effort depends on the size, cost, and complexity of the facility. Two VE studies are normally performed on facilities costing in excess of ten million dollars. Facilities with costs below ten million dollars frequently benefit from two studies, but the actual number of studies should be based on the complexity of the specific facility. On small non-complex facilities, one VE study will usually be sufficient.

Since design decisions have a tremendous impact on the costs of a facility, the highest return on the VE effort can be expected when a VE workshop is performed early in the design process before major decisions have been completely incorporated into the design. This principle is illustrated schematically in Figure 2-3.

FIGURE 2-3 POTENTIAL VE SAVINGS VS. WORKSHOP TIMING



When two VE studies are performed, the first VE workshop should be held at the 20 to 30 percent stage of design completion and the second at 65 to 75 percent of design completion. If only one VE study is determined to be sufficient, the workshop should be performed at the 20 to 30 percent stage of design completion.

Typical study areas for a 20 to 30 percent VE workshop are the overall facility layout, hydraulic profile, architecture, materials of construction, interior layout for buildings, selection of unit processes, foundation designs, electrical concepts and process control concepts. For the 65 to 75 percent VE workshop, typical study areas include: piping layouts; structural, mechanical and electrical design drawings and specifications; HVAC; and architectural details.

When the VE studies are factored into the overall design schedule from the start of the project, they can be accomplished concurrently with the design and not delay its completion.

2.6 VE Team

The VE team members should be experienced design, operation and construction professionals familiar with the principles of value engineering. Their minimum level of VE experience should include completion of a 40-hour VE training seminar and/or participation as a team member in a VE workshop.

The technical composition of each VE team should reflect the complexities of the specific project. At least two members of each VE team should be experienced in the major high cost areas of the project. This criterion normally results in two civil/sanitary engineers being on the VE team for a wastewater treatment facility. The creativity of a team will be proportional to the competence of its members, the mix of disciplines represented, and the ability of the team members to interact in a cooperative manner.

The VE team may be assembled by either selecting individual members from different firms or a single firm. The team should not have any members from the designer's firm. The key to a team's success, ultimately, hinges on the cooperation, competence, and objectivity of the individual team members. It does not depend on the single-firm or multiple-firm composition of the team.

A VE team studying a wastewater treatment facility should consist of at least five multidisciplined members including the VETC. The following disciplines should be represented on the team:

- Civil/Sanitary
- Civil/Structural
- Mechanical
- Electrical
- Construction Cost Estimating
- Operations

It must be emphasized that the foregoing disciplines are necessary for an effective VE study. On a minimum size VE team, one member can represent more than one discipline (e.g. the civil/sanitary engineer may also provide the operations experience). In every VE study, the number of members and disciplines of the team must be adjusted to the characteristics of the particular project. For example, if unusual foundation problems are evident, a soils engineer should be included on the VE team.

The data presented in Table 2-1 show a breakdown of major construction categories and their percentage of costs for a typical wastewater treatment facility. An examination of the data reveals the relative importance of various disciplines in the design of a wastewater treatment facility. The major costs are typically in concrete, equipment, and mechanical components, each representing approximately twenty percent of facility costs. The next lower tier of construction costs includes site work, metals, special construction, and electrical/instrumentation work, each averaging between five and eleven percent of the facility cost. The combined total of the remaining categories represents approximately ten percent of the total construction costs. These facts should be carefully considered in the selection of VE team members because high cost categories would be expected to offer the greatest potential for cost savings. The composition of a typical VE team usually includes civil/sanitary and civil/structural engineers since these two disciplines normally control approximately seventy percent of the construction cost on wastewater treatment facilities.

Additional considerations for the selection of a VE team include:

- When particular disciplines do not represent major cost areas or the design in a particular discipline is not sufficiently completed to warrant an in-depth study, consideration should be

TABLE 2-1. IDENTIFICATION OF CONSTRUCTION COSTS

Construction Specifications Institute (CSI) Division Title	Percent of Total Construction Costs	
	Average	Range
Concrete	21.4	12.7 - 35.0
Mechanical Equipment	21.3	12.5 - 30.4
Mechanical Components	17.1	10.0 - 30.5
Sitework	11.0	6.0 - 21.7
Electrical	9.3	5.0 - 18.0
Metals	5.4	2.6 - 10.0
Special construction	4.9	2.3 - 7.4
General requirements	2.6	1.6 - 4.0
Finishes	1.5	0.8 - 1.6
Masonry	1.5	0.0 - 2.9
Wood and plastics	0.9	0.1 - 3.8
Thermal and moisture protection	0.9	0.4 - 1.5
Doors and windows	0.6	0.3 - 0.9
Specialties	0.5	0.0 - 1.0
Furnishings	0.7	0.0 - 1.7
Conveying Systems	0.4	0.0 - 1.4

The treatment facilities used to determine the costs in Table 2-1 represent a cross-section of geographical locations, facilities and designs. Since the facilities vary in size and complexity, they are representative of the treatment facilities constructed in the U.S.A.

given to the use of part-time VE team members. For example, an architect or electrical engineer may be needed for only two or three days during a VE workshop conducted at 20 to 30 percent of design completion.

- Although electrical work represents a relatively small percentage of a facility's construction cost, electrical (energy) consumption will be a major operational cost. Accordingly, an electrical engineer is normally included on the VE team to aid in the identification of operational cost savings.

- Since operation and maintenance considerations and costs are a vital part of a VE study, one member of the VE team should have experience in the operation of wastewater treatment facilities.

- The VE workshop conducted at the 65 to 75 percent stage of design completion should have one or more VE team members with substantial construction experience. This experience stimulates VE recommendations related to the project's "constructibility."

2.7 VE Team Coordinator (VETC)

The VETC plays a key role in the success of a VE study. This individual is solely responsible for managing all aspects of the VE Study including management of the team members during the workshop. Therefore, the VETC must have extensive experience with VE of wastewater treatment works. A typical level of experience for a VETC would be:

- Completion of a 40-hour VE training seminar.

- Participation in at least 10 VE workshops on wastewater treatment works.

A Certified Value Specialist (CVS)[1] would typically possess these qualifications if a major portion of the CVS's VE experience has been in the field of wastewater treatment.

[1] CVS certification is administered by the Society of American Value Engineers (SAVE) as a national standard recognizing competence in the field of value engineering.

Additional attributes for the VETC include:

- Strong leadership, management, and communication capabilities.

- Knowledge of the abilities and work attitudes of the team members.

The VETC's duties include: final selection of VE team members to ensure appropriate disciplines and cooperation; coordination of all aspects of the VE study with the owner and designer; collection and organization of design and cost information during the pre-workshop activity; management of the VE team(s) during the VE workshop; organization of the oral presentation which concludes the workshop; preparation of the VE Report; and providing assistance to the owner and designer in evaluating the VE recommendations.

2.8 Level of Effort

The level of effort required for a VE study is normally a function of the complexity of the facility's design. Frequently, a simple increase in the number of team members may be adequate to achieve sufficient disciplines and experience to maximize the potential for identifying a complete cross-section of cost-saving ideas. For facility designs of average complexity, one VE team per workshop with five to eight members is generally sufficient. As the design complexity and construction cost increase, more than one VE team per workshop is needed to focus additional attention on particular sub-systems. Therefore, the number of VE teams and team members will vary with the study areas and complexities of the project.

Although each additional team member added to the study produces an increase in the costs, the additional team members will not produce a proportional increase in the efforts for the pre-workshop activity or the post-workshop activity. The pre-workshop effort will generally remain independent of the number of team members or teams. The post-workshop effort increases to some degree as team members and teams are added since their effort during the workshop increases the reporting effort. For guidance purposes, Table 2-2 illustrates the breakdown of effort for a "typical" VE study.

TABLE 2-2

TYPICAL LEVEL OF EFFORT FOR ONE VE STUDY

	Effort (hours)				
	VE Consultant				
Period	VETC	Cost Estimator	Team Member	Secretary/ Drafting	Designer
- Project Management	20-30				20-30
- Pre-Workshop	40-80	20-40	4-8 each	16-24	60-120[1]
- VE Workshop	40	40	40 each	8	10-20
- VE Report	60 to 120	12-24		40-60	
- Final VE Report	20				140[2]
Total Hours	180-290	72-104	44-48 each	64-92	230-310

Notes: 1. Represents preparation of the data required for the VE workshop.

2. Includes management, engineering, cost estimating, and secretary/clerical time. Does not include any redesign time.

Meaningful cost guidance for a typical VE study is difficult to establish since cost variables include design complexity, number of VE studies, number of VE teams per workshop, size and experience level of each VE team, and expense rates for the VE consultants and project designers.

A review of historical cost data shows that VE study costs are often less than 0.4 percent of the total construction costs. This figure represents a relatively insignificant cost when considering the VE study has the potential to yield an average net capital cost savings of 5.4 percent and a return of 15 dollars for each dollar invested in the VE study (refer to 1.5 in Section 1). For this reason, the owner should focus more emphasis on the qualifications of the VETC and the proposed VE team rather than on the proposed VE study costs when contracting for VE services. A slight increase in the study costs for a quality VE team will typically yield significantly greater increases in the VE savings and the quality of the VE study.

2.9 SELECTING THE VE CONSULTANT

The owner should review each VE consultant's proposal for conformance with the evaluation criteria contained in the RFP and the guidance contained in this document. The major evaluation factors for selecting a VE consultant are listed below:

- Team Composition: Ensure the proper mix of team disciplines; proper levels of design, construction, operational, and VE experience; appropriate number of teams and team members; and acceptable employment affiliations of team members (no members from the designer's firm).

- VETC: Ensure the proper level of VE and management experience; ability to establish a productive working relationship with the proposed VE team members and the project designer.

- Schedule. Ensure compliance with the design schedule.

- Approach. Ensure that the proposed approach for conducting the VE study is consistent with the guidance in this document.

- Level of Effort. Ensure that the proposed level of effort is sufficient to meet the project needs and the intent of this guidance document. Recognize that the ultimate project cost savings will far exceed the higher study costs for a quality VE consultant and team.

- References. Ensure a satisfactory level of performance on previous VE studies.

2.10 TYPES OF CONTRACTS FOR VE SERVICES

Owners should favor the use of their normal engineering procurement procedures to contract directly for the services of the VE consultant. However, in special circumstances, the owner may have the project designer procure the VE services under a subcontract arrangement.

Lump sum contracts are usually the preferred method of procurement for VE studies of average complexity because the level of effort can be predicted with reasonable accuracy.

Cost plus fixed-fee contracts are appropriate for VE studies of large complex facilities since the final team size or number of teams per study may fluctuate significantly between the time of the VE consultant's proposal and the pre-workshop activity. Similarly, cost plus fixed-fee designer contracts are generally appropriate for large complex projects since it is difficult to predict the designer's efforts required to review the VE recommendations, prepare the Final VE Report, and implement the resultant design changes.

Regardless of the type of contract, the owner should make adequate compensation provisions for those items where the level of effort cannot be readily determined at the time of the proposal, such as the number of VE teams and team members. These items can be handled in a lump sum contract by stipulating optional lump sum add-ons (or deletions) to the proposed level of effort.

SECTION 3

PREPARATION FOR THE VE WORKSHOP

3.1 OVERVIEW

The success of the overall VE study depends heavily on the organization and management of the pre-workshop activity. During the three to six weeks of preparation for the VE workshop, the following activities should be accomplished in the general sequence listed below:

- A coordination meeting between the owner, project designer and value engineering team coordinator (VETC).
- Accumulation of the project's technical and cost data.
- Confirmation of the composition of each VE team and logistical arrangements for the VE workshop.
- Preparation of cost, energy, and life cycle models.
- Distribution of the technical and cost data to VE team members.

3.2 COORDINATION MEETING

A meeting is held with the owner, designer, and VETC at the beginning of the pre-workshop activity to promote a common level of understanding about the objectives of the VE workshop, establish a productive working environment, confirm the schedule of events, and establish the responsibilities for completing the VE workshop preparations. Items discussed during the meeting would include the availability and format of technical and cost data, conduct of the VE workshop, processing of the VE recommendations, plus the date, location, and other logistical arrangements for the VE workshop.

The coordination meeting provides an ideal opportunity for the designer/owner to provide a general overview of the project and identify any unique aspects, constraints, or critical design features.

The format of the designer/owner's presentation of project information to the VE team at the start of the VE workshop should be established during the coordination meeting.

3.3 TECHNICAL AND COST DATA

The effectiveness of the VE workshop is ultimately dependent on the technical and cost data available for the VE workshop. The designer and owner should supply the project data to the VETC at least two weeks before the VE workshop to allow sufficient time for review and development of the VE study models.

The technical data consist of feasibility and engineering reports, pertinent regulations, discharge permits, plus all current drawings and specifications. The cost data consist of equipment, construction, operations (including energy), and maintenance cost estimates for the wastewater treatment works.

The development and organization of detailed technical and cost data prior to the VE workshop benefits both the design effort and the VE study by documenting the evolution of the design and identifying high cost areas of the project. This activity provides the owner with an updated cost estimate for the wastewater treatment works which bridges the gap between the feasibility cost estimates and the construction cost estimates developed at the completion of design. These up-dated cost estimates allow the owner an opportunity to make design changes or budget adjustments to accommodate the construction costs.

Data for VE Workshop at 20 to 30 Percent Design Completion

The technical and cost data provided by the designer/owner to the VETC before the VE workshop at 20 to 30 percent of design completion should include the following:

- A project summary which describes and highlights the major project considerations, including:
  - NPDES discharge requirements.
  - Design flows.
  - Site conditions including subsurface conditions, flood data, existing property boundaries, and additional property availability.
  - Project constraints and the reason for each constraint.
  - Unit processes selected and alternatives evaluated.

- Design redundancy requirements.
- Major equipment selected and alternatives evaluated.
- Architectural considerations.
- Power requirements and standby capacity.
- Method of sludge disposal and alternatives evaluated.
- Operation and control philosophy.
- Planned construction schedule and required date for facility completion.

- Facilities Plan.
- Local design and materials standards.
- Reports of subsurface investigations, conditions, and recommendations for major foundations, including design loads.
- Site and general layout drawings.
- Process and instrumentation diagrams.
- Mass balance and hydraulic profile.
- Preliminary drawings and sketches for major units, sub-systems, structures, and buildings.
- Design criteria for each unit process including criteria for process control. Pertinent design calculations should be included where appropriate to clarify and document the design.
- Design criteria for support facilities which include criteria for administration, storage, maintenance, employee facilities, roads, parking, plus vehicle storage and maintenance.
- Estimated energy demand (kwh) at average and peak flow conditions for each major unit process, subsystem, and support facility. Explanatory material and/or backup calculations should be provided to clarify the estimates.
- Estimated construction cost for each major unit process, subsystem and support facility including backup cost estimating worksheets with quantity takeoffs.

- Estimated annual operations and maintenance costs (including energy, labor, and chemicals) with backup worksheets broken down as much as practical into the same categories as the construction costs.

- Estimated costs and frequency of replacement for major equipment and components requiring replacement during the planning period.

- Power rate structure for the utility serving the project site.

- If the project involves the modification and/or expansion of an existing facility, the following additional information should also be provided:

  - Construction or "as-built" drawings for the facility.

  - A description of existing facilities, method of operation, flow rates, special operating problems, and degree of treatment.

  - Current annual operating costs broken down into labor, energy, and chemicals.

  - Current annual maintenance costs broken down into labor, repair, and replacement.

  - Description of the condition of existing major equipment and structures.

  - Method and cost of sludge disposal.

The preceding listing is representative of the technical and cost data which should be provided for the VE study and the development of the cost and energy models. Sample forms for tabulating portions of the data are described in Section 3.6 and contained in Appendix C.

<u>Data for VE Workshop at 65 to 75 Percent Design Completion</u>

The technical and cost data which should be provided by the designer/owner before the VE workshop at the 65 to 75 percent stage of design completion includes all of the above data plus updated technical specifications, design drawings and cost estimates.

3.4 VE TEAM COMPOSITION AND LOGISTICAL ARRANGEMENTS

The final selection of the VE team members should be accomplished by the VETC after a detailed review of the project's technical data to identify the need for specialized disciplines. The selection of team members should be consistent with the guidance presented in Section 2.6.

Once the VE team(s) selection is finalized, the VETC should distribute the project's technical and cost data to each team member for a brief review prior to the workshop. The pre-workshop review should typically take 4 to 8 hours per team member. This review is important because it avoids using valuable workshop time for this purpose.

The VE workshop should be located at a site which is mutually agreeable with the owner, designer, and VETC. A location in reasonably close proximity to the designer's office is usually desirable. A site visit prior to the start of the workshop is frequently beneficial for the VETC and selected VE team members.

Arrangements for the VE workshop facilities should be made with the following considerations in mind:

- The location should isolate the team members from their normal on-going work activities and promote interaction of the team members throughout the study.
- The facilities should be well lighted with ample working space. The amenities should include a large table for each team member plus telephone, copying, and food services.

3.5 COST ESTIMATES

The availability of accurate and comprehensive cost data is an essential element in the success of all VE studies. This point cannot be overemphasized. The VE team uses cost data as its primary tool for evaluating alternative ideas. The quality of the team's evaluations and recommendations will be only as good as the cost data. Inadequate or inconsistent prestudy cost data must be avoided to achieve effective VE study results since such data reduce the productivity of the VE team by diverting its efforts to the development of cost data and resolution of cost inconsistencies.

The cost data should be prepared in a detailed and organized manner to serve as the basis for evaluating all VE recommendations. Any identifiable differences concerning cost estimating procedures and practices should be resolved by the designer and the VETC prior to the start of the VE workshop.

Particular attention should be devoted to establishing operational, maintenance, and energy costs. The replacement frequency and costs of major subsystems or components with a service life less than the planning period should be established prior to the study.

All cost data should be developed on the basis of market prices prevailing at the time of the VE study. Inflation is usually not considered since all costs tend to change by approximately the same rate causing the real value of goods, services and monies for wastewater treatment facilities to remain relatively constant over a given time-period.

For wastewater treatment works, the salvage value of subsystems and components having a service life in excess of the planning period should be considered equal to zero for the following reasons:

- Identifying a specific use for wastewater treatment subsystems and components at the end of the planning period is very unpredictable. Frequently, the equipment and facilities are abandoned.

- Predicting the end-condition of the subsystems and components is difficult. Rehabilitation costs may offset some or all of the salvage value.

- Assigning a reasonable salvage value for the end of the planning period (usually twenty years in the future) is very difficult.

3.6 COST AND ENERGY MODELS

In VE studies, the cost and energy data are organized in a manner to facilitate rapid analysis and identification of high cost systems or components. This is accomplished by assembling the cost and energy data in the form of models. The VETC typically prepares the cost, energy and life cycle models with the assistance of a cost estimator prior to the VE workshop.

Cost Models

A cost model is a VE study tool. There are two general types of cost models commonly used for VE studies. One type is a <u>cost matrix</u> which presents estimated costs by subsystem, functional area, or construction trade. The cost matrix provides a one page comparative display of each major cost element. The other type of cost model is a <u>functional cost model</u> which presents both estimated and target construction costs distributed by subsystem or functional area. The target cost is determined during the VE workshop since it represents the VE team's estimate of the least cost to perform the function of each subsystem or functional area.

Figures 3-1 and 3-2 (pages 3-11 and 3-12) are examples of cost matrix-type models. Figure 3-1 is a one-dimensional matrix which presents the wastewater treatment works costs distributed by major cost category. Figure 3-2 is a two-dimensional matrix which presents the same costs distributed by major unit process and structure, and by CSI Division No. Figures 3-1 and 3-2 present individual costs and/or individual percentages of the total cost. The matrix cost models are useful for identifying high cost subsystems or functional areas which warrant special attention (high potential for savings) during the VE workshop.

Figure 3-3 (page 3-13) is an example of a functional cost model. This type of model breaks the total cost for the wastewater treatment works down in terms of major functional area, such as process stream, solids handling, site, buildings, and support. This process is continued to successively lower levels.

In a functional model, costs can be represented on either a dollar or parametric basis. The value of a parametric format such as dollars per million gallons of flow would be for ready comparison to historical cost data.

Even though the functional model is constructed prior to the workshop, the identification of target costs occurs during the workshop. The past experiences of team members and historical cost data serve as the basis for developing the target costs. The target costs represent the least possible cost for each subsystem or functional area. The target cost can be a historical average value or the worth (a concept discussed in Section 4). Large differences between estimated costs and target costs highlight areas with potential for large cost savings.

The cost models are used by the VE team for quick identification of high-cost subsystems or functional areas since these areas frequently offer the greatest potential for cost savings. An Italian economist named Pareto formulated a law of economic distribution which lends credence to this approach. Pareto's law states that 80 percent of the cost will normally occur in 20 percent of the constituents. Because this law of economic distribution holds true for construction projects, the cost models aid in the identification of the relatively few treatment works systems or components which constitute the bulk of the cost.

The strong emphasis placed on identifying high cost elements within a project is based on the fact that the VE team has a very limited timeframe to understand a project and develop recommendations for improving its value.

Energy Model

The rising cost of energy continues to have a substantial impact on the cost of operating wastewater treatment works. Therefore, energy optimization must be one of the goals of a VE study. To achieve this goal, the VETC assembles an energy model for the VE team to use in the same manner as the cost models. Such energy models present displays of energy consumption for the wastewater treatment works by subsystem or functional area. The models typically express energy in units of KWH per year or KWH per MGD. An energy model is normally based on average flow conditions with separate notations for peak flow demands. As in the functional cost model, target energy consumption estimates are assigned to each area by the VE team during the workshop. The target estimates represent the least possible energy consumption for each subsystem or functional area based on historical energy data and the VE team's experience.

It is important to note that great precision is not essential in determining energy consumption for each subsystem or functional area. The energy model is not intended to provide a precise projection of energy demand or cost. Its primary purpose is the rapid identification of energy intensive areas which offer a high potential for energy reductions and cost savings.

Figure 3-4 (page 3-14) is an example of an energy model for a wastewater treatment works. The energy model lists all major energy consuming items such as motors, lighting, heating/cooling equipment, and emergency generators. The motor horsepower, electrical demand, fossil fuel consumption, or other appropriate energy parameters are converted into common energy units of equivalent KWH/yr before they are transferred to the energy model.

Life Cycle Cost Model

Since the cost and energy models do not predict the total costs of owning and operating the wastewater treatment works, a life cycle cost (LCC) model is prepared to illustrate these costs. The LCC model provides a complete cost picture for the wastewater treatment works and serves as a baseline for the VE team's determinations of the cost impacts of VE recommendations. In certain instances, it may be advantageous to develop LCC models for individual subsystems or functional areas.

Since the total cost of owning an asset consists of initial costs and all future costs, the latter must be discounted to present value (present worth) before they can be combined with initial costs to obtain the total life cycle costs. In other words, the time value of the future costs must be taken into account. For example, a $100,000 replacement cost ten years in the future would have a present worth of $38,554 at a 10% discount rate. More detailed discussions of life cycle costing and present worth are contained in Bibliography References 1 through 6.

The interest or discount rate used to prepare LCC models should be an appropriate value established by the owner, designer and VETC.

The data from the cost and energy models are used in the development of the life cycle cost model. However, these models contain only a portion of the data needed to establish the total life cycle costs for a wastewater treatment works. The model must also include the additional costs of operation, staffing, maintenance and equipment replacement.

Operation, maintenance and replacement costs are typically the most difficult of all cost categories to estimate because of limited reference materials and historical data. Different operational philosophies cause operation and maintenance levels to vary greatly from facility to facility. Frequently, facilities with high levels of operation and maintenance have lower equipment replacement costs. The most effective method for estimating operation and maintenance costs involves an examination of the historical data from existing facilities.

Flow dependent operation and maintenance costs are normally estimated on the basis of average flow conditions. Since these conditions will not normally be reached until well into the future, operation and maintenance costs at the time of facility start-up are usually considerably less than those presented in the cost models.

Staffing costs for a facility can often be effectively estimated at the pre-workshop coordination meeting. This joint effort can be beneficial since it (1) increases the VETC's understanding of how the facility will be staffed and operated, (2) encourages the owner's early involvement in defining the staffing requirements, and (3) increases the designer's knowledge of the owner's operating philosophy and any attendant impact on the design features.

An example of an LCC model for a wastewater treatment works is presented in Figure 3-5 (page 3-15).

WORKSHEETS

The following worksheets are provided in Appendix C to assist in the development of the various models.

Title	Number
Cost Summary	WS-1
Cost (or Energy) Model	WS-2A
Matrix Cost Model	WS-2B
Cost Summary Bar Chart	WS-2C
Electrical Energy	WS-3
O/M Labor	WS-4A
O/M Chemicals	WS-4B
Equipment Replacement	WS-4C
LCC Summary	WS-4D

Filled-in examples of these worksheets are included with the Sample VE Report in Appendix D.

FIGURE 3-1 COST SUMMARY MODEL

PROJECT XYZ WWTP (65% Design)

ITEM COST VS. MAJOR COST CATEGORY

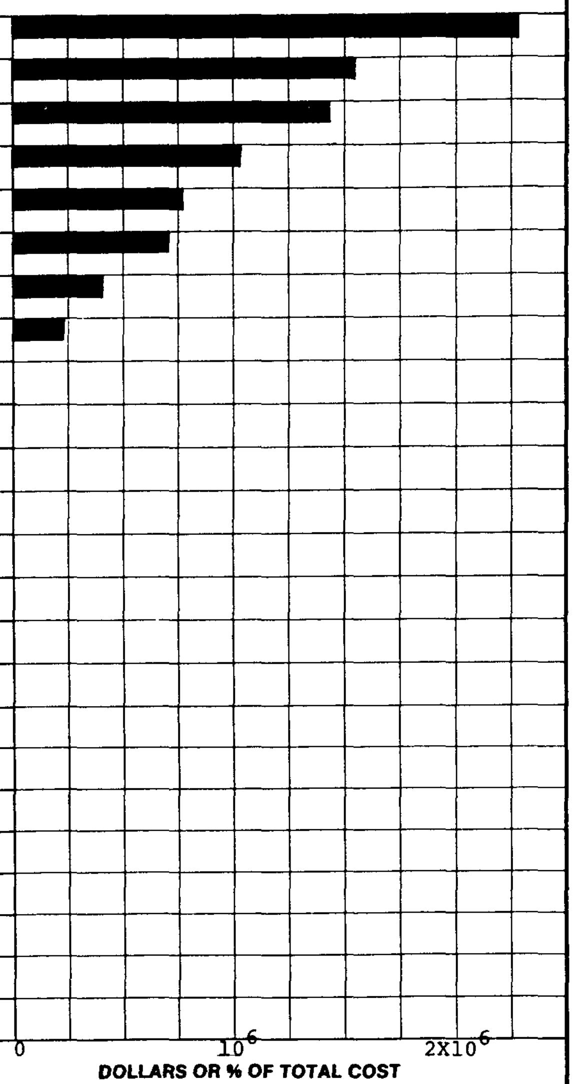
COST SUMMARY BAR CHART

TEAM NO. 1 **SHEET** 1 **OF** 1

Check one, use separate sheet for each

- **Construction Costs** ☒
- **O&M Costs** ☐
- **Replacement Costs** ☐
- **Energy Costs** ☐

Major Unit or Cost Category	Cost
Control Building	$2,280,000
General and Site	1,615,000
Pump and Blower Bldg.	1,388,000
Final Clarifiers	1,083,000
Aeration Tanks	775,000
Gravity Thickeners	718,000
Existing Structures	382,000
Chlorine/Postaeration	229,000
Subtotal	8,470,000
Contingency 5%	424,000
Grand Total	$8,894,000



WS-2C

FIGURE 3-2 EXAMPLE MATRIX COST MODEL

PROJECT XYZ WWTP (65% Design)

ITEM COST MATRIX: CSI DIVISION NO. VS. UNIT PROCESS

MATRIX COST MODEL No. ____

TEAM NO. 1 **SHEET** 1 **OF** 1

No. CSI	Description	Cost Category: GENERAL & SITE	EXIST.* STRUCTS.	** CONTROL BUILDING	BLOWER BLDG.	AERATION TANKS	FINAL CLARIFIER	DISINFEC-TION	GRAVITY THICKENER	Total Cost
1	General Requirements	135,210	43,120	133,290	135,310	57,695	62,245	25,610	55,500	647,980
2	Sitework	985,010	-0-	13,455	11,900	64,170	113,860	47,165	15,410	1,250,970
3	Concrete	-0-	-0-	151,885	188,990	392,680	724,065	108,650	135,150	1,701,420
5	Miscellaneous Metals	-0-	-0-	79,865	47,160	43,870	25,500	12,760	25,375	234,530
6-9	Building Work	-0-	6,540	421,240	123,730	10,900	3,270	3,270	119,900	688,850
11	Mechanical Equipment	-0-	176,220	388,140	244,510	148,890	148,860	-0-	231,315	1,337,935
12	Furnishings	-0-	-0-	73,860	-0-	-0-	-0-	-0-	-0-	73,860
13	Instrumentation	-0-	20,575	38,400	27,125	-0-	-0-	-0-	22,700	108,800
15	Mechanical Components	456,550	125,660	248,960	132,740	39,975	-0-	25,875	85,750	1,115,510
16	Electrical	38,150	9,810	731,170	476,550	16,350	5,450	5,450	27,250	1,310,180
	SUBTOTAL (rounded)	1,615,000	382,000	2,280,000	1,388,000	775,000	1,083,000	229,000	718,000	8,470,000
	Contingency	81,000	19,000	114,000	69,000	39,000	54,000	12,000	36,000	424,000
	*Includes modifications to existing headworks, pump room, and primary sludge pump room. **Includes belt filter presses									
	Total Cost	1,696,000	401,000	2,394,000	1,457,000	814,000	1,137,000	241,000	754,000	8,894,000
	Percent of Cost	19.1	4.5	26.9	16.4	9.1	12.8	2.7	8.5	100

WS-2B

FIGURE 3-3 EXAMPLE COST MODEL

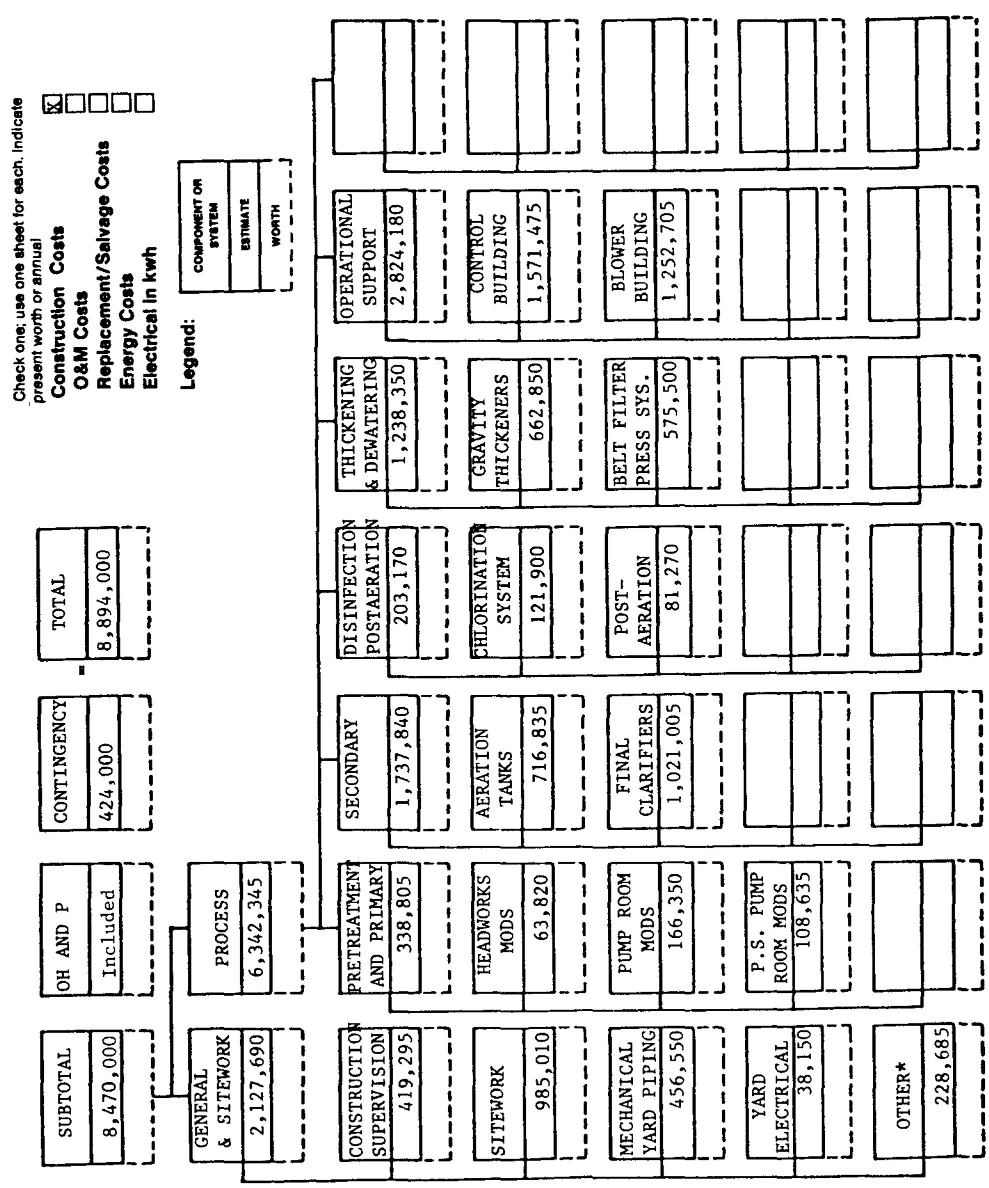
PROJECT XYZ WWTP (65% Design)

ITEM CONSTRUCTION COST MODEL

COST (OR ENERGY) MODEL

TEAM NO. 1 **SHEET** 1 **OF** 1

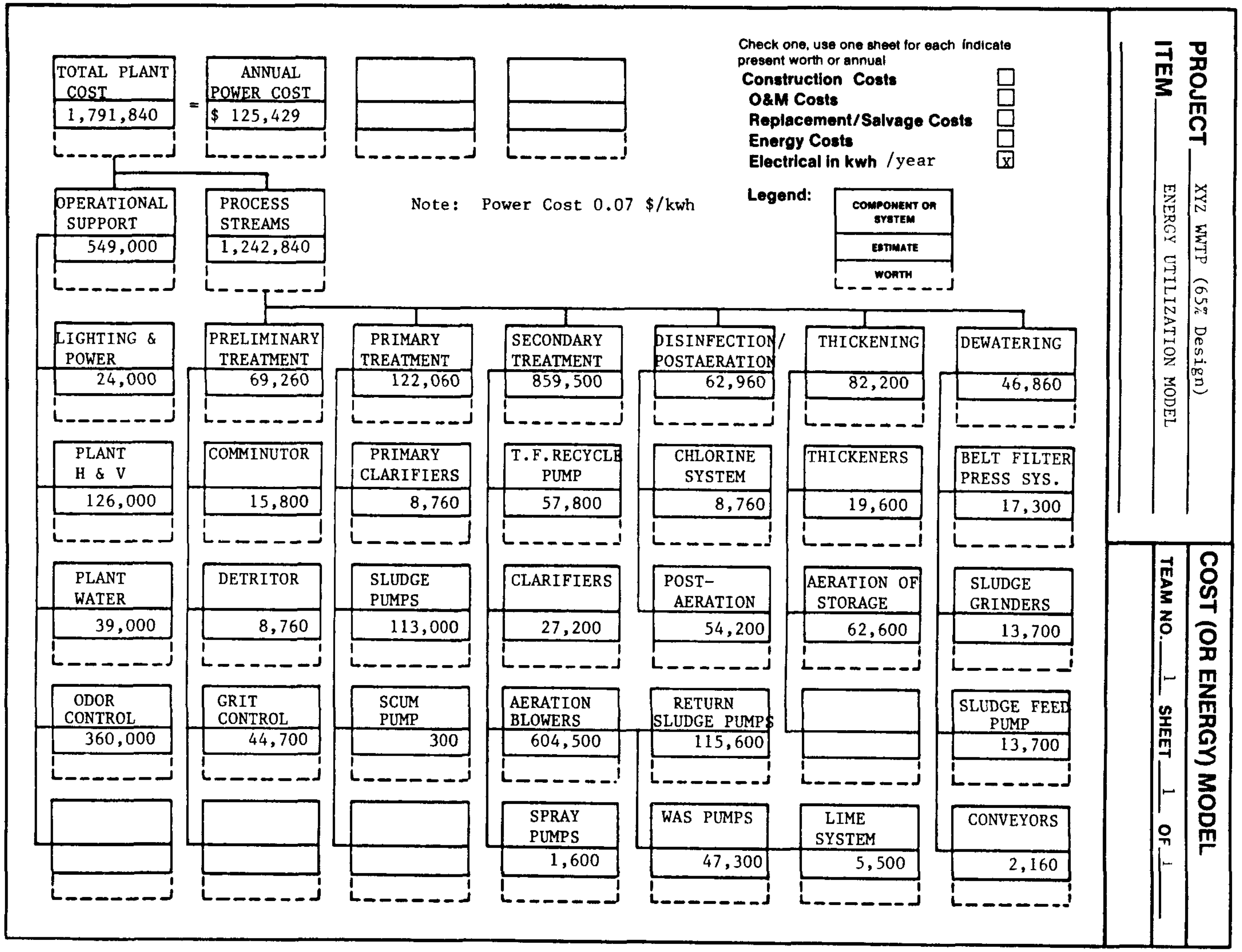
Check one; use one sheet for each. Indicate present worth or annual
- [x] Construction Costs
- [ ] O&M Costs
- [ ] Replacement/Salvage Costs
- [ ] Energy Costs
- [ ] Electrical in kwh



* Includes Start-Up and Test; Job Indirects; Insurance and Bonds

WS-2A

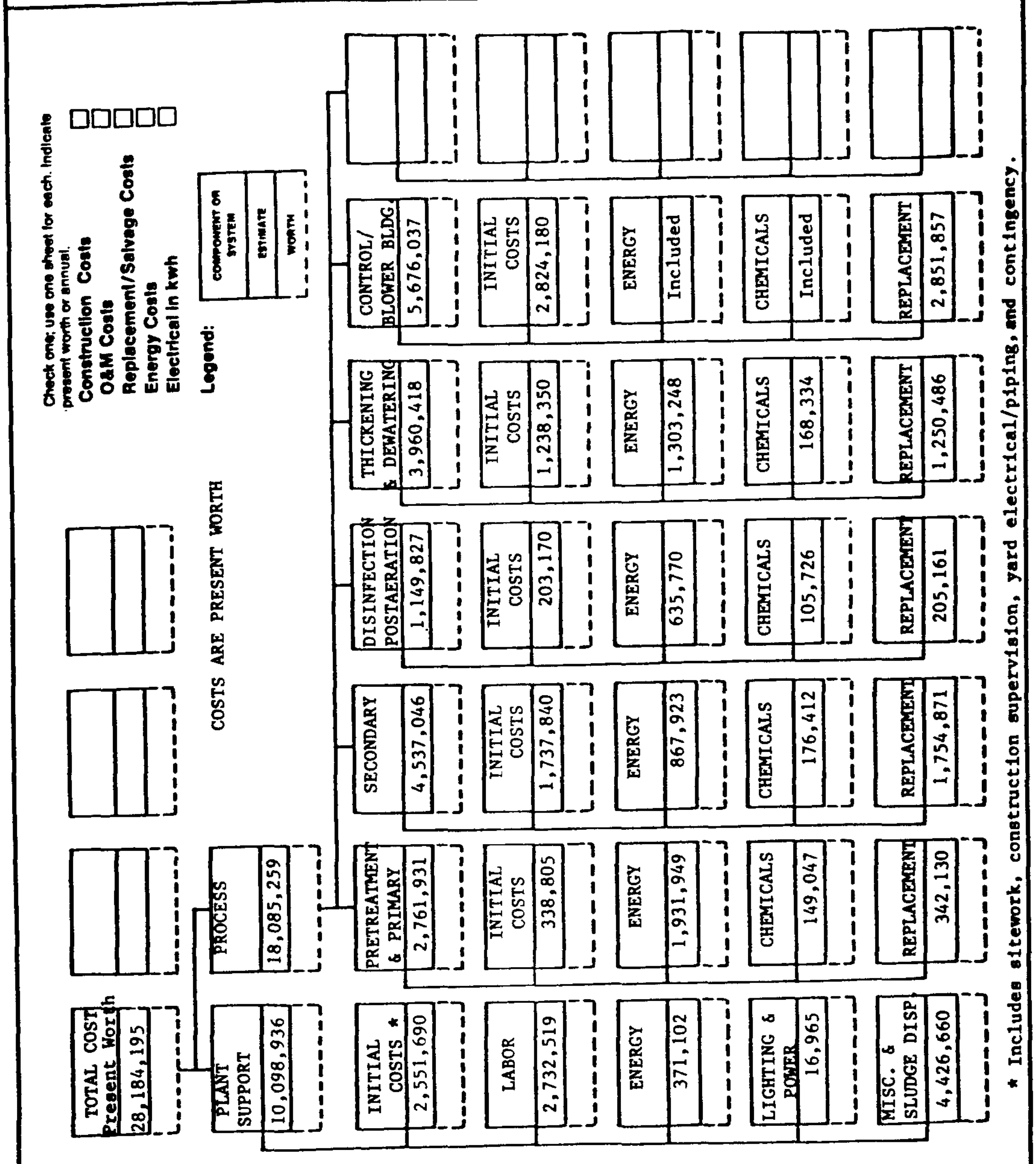
FIGURE 3-4 EXAMPLE ENERGY MODEL



WS-2A

FIGURE 3-5 EXAMPLE LIFE CYCLE COST MODEL

PROJECT XYZ WWTP (65% Design)	COST (OR ENERGY) MODEL
ITEM LIFE CYCLE COST MODEL	TEAM NO. 1 SHEET 1 OF 1



WS-2A

SECTION 4

THE VE WORKSHOP

4.1 VE JOB PLAN

The VE workshop is the major component of a VE study. The systematic methodology used by the VE team to accomplish the workshop is called the VE Job Plan.

Use of the Job Plan assists the VE team in a number of ways:

- It is an organized approach which allows the VE team to analyze a project by quickly identifying high cost to worth areas and selecting alternatives which minimize costs while maximizing quality. VE teams which do not follow a formal VE Job Plan tend to perform design or cost-cutting reviews rather than true value engineering studies.

- It encourages the VE team to think in a more thoughtful and creative manner, i.e., to look beyond the use of common or standard approaches.

- It emphasizes total ownership costs (life cycle costs) for a facility, rather than just initial capital costs.

- It leads the VE team to develop a concise understanding of the purposes and functions of the facility.

The VE Job Plan consists of the following five distinct phases:

1. Information Phase.
2. Speculative/Creative Phase.
3. Evaluation/Analytical Phase.
4. Development/Recommendation Phase.
5. Report Phase.

The five VE Job Plan phases from the Information Phase through the oral presentation of the VE team recommendations in the Report Phase are normally performed during a one week (five consecutive days) VE workshop.

It should be noted that throughout the field of value engineering there are variations in the titles for these phases. However, despite these variations in terminology, all job plans represent the same basic methodology.

To aid the VE team in performing the five phases of the Job Plan, sample worksheets are contained in Appendix C. The use of these worksheets is discussed in the remainder of this section.

4.2 INFORMATION PHASE

During the Information Phase, the VE team solicits owner/designer comments on the technical and cost data to develop an overall understanding of the project's functions and requirements. Most of the data, including the cost and energy models, will have been reviewed by the VE team members prior to the workshop. The Information Phase occurs during the morning of the first day of the workshop.

An oral presentation by the owner and designer on the first morning of the workshop provides the VE team with an understanding and appreciation of the factors that have influenced the project's design. This oral presentation serves to open the lines of communication between the VE team members, the owner, and the designer. It allows the designer to expose the VE team to the difficulties encountered during the design of the project.

The oral presentation should include a description of the rationale, evolution, constraints, alternatives, and percentage completion for the major design components. The quality and organization of the data presented by the owner and designer are important since these factors directly impact the usefulness of the VE recommendations.

Following the oral presentation, the owner and the designer usually leave the VE workshop but remain available to answer questions which may arise during the week. Frequently, the VE team may solicit owner/designer comments on the creative ideas before proceeding with the Evaluation/Analytical Phase of the workshop.

Discipline must be exercised by the VE team during this phase to ensure that sufficient time is taken to collect and verify data before starting the development of alternative ideas. The development of inappropriate VE recommendations can often be avoided by the careful evaluation of project background information.

It is important for the VE team to appreciate that the designer has spent considerable time and effort in the development of the project's drawings and specifications. The team should understand the designer's rationale for the project's development, including the assumptions used to establish the design criteria and select the materials and equipment. The VE team should identify and review the alternatives considered by the designer.

Function Analysis

Function analysis is the cornerstone of value engineering since it separates VE from other cost reduction techniques. The function analysis approach is used in value engineering to arrive at the basic purpose of wastewater treatment systems and sub-systems. It aids the VE team in determining the least costs to perform primary functions and peripheral or support functions. While function analysis sounds like a very simple technique, it is probably one of the most misunderstood tools in value engineering. A VE team must be careful not to gloss over the function analysis and simply start listing creative ideas to reduce costs. Cost reduction studies simply list creative ideas for reducing costs while value engineering focuses on a functional analysis of the entire project. The function analysis approach provides the VE team with the mechanism for becoming deeply involved in the facility design and identifying costs which can be reduced or eliminated without affecting the performance or reliability of the facility.

Functions are identified by a two word verb-noun description. The verb is an action verb and the noun is a measurable noun. As an example, the function of an electric cable is to "conduct current." "Conduct" is the action verb and "current" is the measurable noun. Other examples are to "support load," "convey flow," and "concentrate sludge."

The basic function of an item is the specific task or work it must perform. Secondary functions are those functions that may be needed but are not actually required to perform the specific task or work. Required secondary functions are absolutely necessary to accomplish the specific task or work, although they do not exactly perform the basic function. As an example, the basic function of an aerator is to supply air; however, it also mixes the wastewater. In this case, mixing is a required secondary function for the aerator mechanism.

The following is a list of questions which are helpful in determining the functions of an item:

1. What is its purpose?

2. What does it do?

3. What is the cost?

4. What is it worth?

5. What alternative would accomplish the same function?

6. What would that alternative cost?

In function analysis, it is important to identify functional areas sequentially since the functions vary according to the selected area. For example, the function of the total facility would be established before functions are established for the unit processes.

The most difficult part of the function analysis is establishing an estimation of the worth of each subsystem or component for comparison with its estimated cost. Since worth is an indication of the value of performing a specific function, extreme accuracy in estimating the worth is not critical. Worth is merely used as a mechanism to identify areas of high potential savings. Subsystems performing secondary functions have no worth because they are not directly related to the basic function. As an example, an access road to a treatment facility does not provide the primary function of treating wastewater even though the road may provide a required secondary function for the facility. Thus, the road is an area to examine for potential savings without affecting the basic function of the facility.

Value engineering looks for alternatives to the original design that might effectively increase the value and/or reduce the cost of the project. Alternatives may be developed by asking the basic question, "What else will perform the essential function, and what will it cost?" The alternatives for performing a function identified in determining worth become part of the creative idea listing for the function. Thus, the creative phase of value engineering usually begins during the function analysis. When creative ideas are identified in the Information Phase, the VE team should simply record the ideas for later use in the Speculative/Creative Phase.

Worksheet WS-5 can be used by the VE team to accomplish a function analysis. To complete this worksheet, the VE team would follow the sequential steps listed below:

1. Identify the study area.

2. Identify the basic verb/noun function of the study area.

3. List the component parts of the study area.

4. List the verb/noun function of each component and subcomponent.

5. Identify whether each function is basic, secondary, or a required secondary function.

6. Identify the estimated construction cost of each function.

7. Speculate on the worth or the least cost to accomplish the function.

To illustrate the use of function analysis, an example worksheet for a wastewater treatment facility is presented in Figure 4-1 (page 4-14). As shown, the function of the treatment facility, the unit processes, and other subsystems are identified in a verb/noun description with the type of function, i.e., basic or secondary or required secondary. Similarly, the estimated cost and worth is indicated for each of the components.

As part of the function analysis, the VE team makes a comparison of the cost-to-worth ratios for the total facility and its subsystems. These cost-to-worth ratios are obtained by dividing the estimated cost of the system or subsystems by the total worth for the basic functions of the system or subsystem. High cost-to-worth ratios suggest areas of large potential cost savings and identify systems or subsystems which would be selected for further study by the VE team. Similarly, low cost-to-worth ratios indicate areas where further study efforts would not be justified due to diminished potential for cost savings. Cost-to-worth ratios greater than two usually indicate areas with the potential for substantial cost savings.

To refine the identification of study areas offering potential for cost savings, each facility can be divided into subsystems which in turn can be divided into components. The cost-to-worth ratio of each component would be determined in the same manner described for the facility or its subsystems. For example, the basic function of the aeration tank subsystem shown in the Figure 4-2 example worksheet (page 4-15) differs from the basic function of the facility. The basic function of the aeration tank is "convert BOD and ammonia," while the facility's basic function is "remove pollutants." When the subsystem is broken down into its components, items such as reinforcing steel which are not directly related to "remove pollutants" acquire worth.

FAST Diagramming

FAST is an acronym for Function Analysis System Technique. It is a tool that graphically shows the logical relationship of the functions of an item, subsystem, or facility. The FAST diagram is a block diagram based on answers to the questions of "Why?" and "How?" for the item under study.

A FAST diagram is most appropriately used on complex systems as a road map for clear delineation of the basic and secondary functions of a particular system.

FAST diagramming may be used to augment the function analysis portion of the Information Phase.

A detailed description of the FAST diagramming process can be obtained from the texts listed in the Select Bibliography.

4.3 SPECULATIVE/CREATIVE PHASE

The Speculative/Creative Phase is a group interaction process which the VE team uses to identify alternative ideas for accomplishing the function of systems or subsystems associated with specific study areas. This phase involves an open discussion without any restrictions on the imagination or inventive thinking of individual team members. All analysis, evaluation, or judgement of the ideas generated is delayed until the Evaluation/Analytical Phase. All ideas should be immediately recorded to avoid forgetting them as the discussion continues. The ideas should be listed by system, subsystem, and component to facilitate effective organization of the study.

The desired objective of the Speculative/Creative Phase is to generate a completely free interplay of ideas between team members to create an extensive list of alternative ideas for later evaluation. The key to successful results is the deferral of any critical judgments or comments which might inhibit any of the team members.

Since a value engineering team is composed of a variety of personalities, some individuals will readily supply many ideas while others will have to be encouraged to express their ideas. The active participation of all team members must be encouraged in the creative development of ideas. A VETC must effectively provide a climate for the free exchange of ideas by directing the team members away from discussion or arguments about relative merits of individual ideas during this phase since such evaluations tend to suppress the creative thinking process. Some thought provoking questions to activate a creative session include:

- What is the function?
- What is the input?
- What is the output?
- Is all of the known information available?
- Are specifications tight or loose?
- What other materials would accomplish this job?
- Could this be done somewhere else?
- What would happen if this weren't done at all?
- Could this be done mechanically? Electrically? By hand?
- Could present structures be reconfigured or reoriented to improve them?

- What other fields experience this problem?
- How much of this is a result of custom? Tradition? Opinion?
- How would postponement of this objective affect the project?
- Can better use be made of existing facilities?
- What can be combined?
- What other layout might be better?
- Can it be made safer?

Many engineers are very inhibited by the creative phase of a VE study since it requires them to step beyond the normal bounds of their problem solving habits. To overcome this reluctance to venture outside familiar areas and risk the embarrassment of proposing an idea that might be subject to ridicule, the "YES/IF" technique is often used by the VE team. When a team member expresses an idea, another team member would respond with the statement "YES that idea might work, IF we take the idea and improve it as follows" rather than condemning the idea. In this manner, team members build upon the idea of a fellow team member to improve and refine the idea.

The VE team should strive for quality and performance through the free association of ideas. As ideas are brought forward in a creative session, they stimulate additional ideas from other team members. This process frequently causes VE team members to express perfectly logical ideas outside their discipline. As an example, an architect may make recommendations concerning the method of cleaning a digester system based on the team's discussion of the functions.

The following points should be considered during the Speculative/Creative Phase.

1. When team members believe that improvements can be made to the project, they will work to achieve it.

2. There is always room for improvement in a project. Most designers will have many ideas for improving their project after observing its construction.

3. The word "impossible" should be eliminated from the team's thinking. The synergistic effect of free flow of information generated by a multidisciplined team can create extraordinary results.

4. Develop as many ideas as possible. This stimulates the creative ability of team members.

5. Look for associations of ideas. Often a function can be performed by a technique currently applied to another area or industry.

6. Ask questions which elicit information based on the knowledge and experience of team members.

7. Record all ideas as they are identified rather than risk forgetting them.

Speculative/Creative ideas generated by the VE team can be listed on Worksheet WS-7. This worksheet is used for both listing and evaluating ideas. An example worksheet listing the ideas developed during the Speculative/Creative Phase is presented in Figure 4-3 (page 4-16).

4.4 EVALUATION/ANALYTICAL PHASE

During the Evaluation/Analytical Phase, the ideas developed in the Speculative/Creative Phase are examined to assess which have the best opportunity for implementation and cost savings. The VE team evaluates the feasibility of each idea by identifying its advantages and disadvantages. The ideas are then rated on a scale of one to ten. A ten represents either the best technical idea or the one with the greatest potential for cost savings.

Even though detailed cost estimates for ideas are not developed until later in the study, the VE team would use its experience to estimate rough cost savings for ideas to aid in the evaluation process. It is important to note that many ideas with high cost savings potential may not benefit the facility's design because they may reduce the wastewater treatment efficiency.

In ranking ideas, the VE team should consider the following:

- Are the performance, quality and reliability requirements met or exceeded?

- Will excessive redesign or project delay be created?

- Is there improvement in operation and maintenance?

- Will life cycle cost savings be achieved?

The ideas with the highest ratings are selected by the VE team for more detailed investigations in the Development/Recommendation Phase.

The evaluation of creative ideas can be done on the right hand side of Worksheet WS-7. An example worksheet for the evaluation and ranking of creative ideas is presented in Figure 4-4 (page 4-17).

4.5 DEVELOPMENT/RECOMMENDATION PHASE

In the Development/Recommendation Phase, the best ideas from the Evaluation/Analytical Phase are developed into workable VE recommendations. The VE team researches and develops preliminary designs and life cycle cost comparisons for the original designs and the proposed alternative ideas.

During this phase, the technical expertise of each team member becomes very important. A multidisciplined team provides the resources essential for the development of sound VE recommendations. Frequently, VE team members must consult outside experts, vendors, and reference sources to obtain additional evaluation information before developing the VE recommendations.

The development of an idea into a recommendation should include the following steps:

1. Description of the original design and each alternative idea.

2. Sketch of the original design and each alternative idea.

3. Preparation of a life cycle cost analysis for the original design and each alternative idea.

4. Discussion of the advantages and disadvantages of each alternative idea including its impact on life cycle costs.

5. Identification of the recommended alternative idea or a discussion for maintaining the original design.

6. Discussion of the requirements for implementing the recommendation.

Worksheet WS-8 can be used to display the developmental information for each alternative idea and for presentation of VE recommendations. All supporting documentation for a VE recommendation such as design calculations, cost estimates, and sketches should be attached to Worksheet WS-8 to aid the review process. When the determination of life cycle costs becomes too complex to be accomplished on WS-8, the data from the cost worksheets WS-1, WS-4A, WS-4B, WS-4C, and WS-4D can be transferred to Worksheet WS-9 to calculate the life cycle costs. Filled out examples of these worksheets are included with the sample VE Report in Appendix D. Worksheet WS-10 can be used to summarize the VE recommendations.

It is important that the VE team be able to convey the concept of each VE recommendation in a clear and concise manner to avoid its rejection due to a lack of understanding by the owner or designer. In preparing VE recommendations, each team member should strive to view the recommendation from the designer's perspective for reliability, cost effectiveness and implementation.

In the development of the VE recommendations, each alternative idea should be presented as a single VE recommendation on a separate worksheet. This procedure assures each recommendation will be reviewed on its own merit.

Frequently, a number of ideas are identified by the VE team which have little impact in terms of cost savings. However, these ideas may be worthwhile in terms of operation, maintenance, or design improvements. The designer and owner should receive the benefit of reviewing these ideas even though they were not developed into formal VE recommendations. These ideas should be labeled as design suggestions and presented to the designer in the form of a simple list.

4.6 REPORT PHASE

The Report Phase consists of both an oral and written presentation of the results from the VE study.

Oral Presentation

The VE recommendations are presented by the VE team in an oral presentation on the last day of the VE workshop (typically Friday afternoon). The oral presentation should be a relaxed and informal meeting which lasts approximately one to three hours. The presentation provides an opportunity for the owner and designer to discuss the VE recommendations with the VE team.

The VETC should start the presentation with an overview of the VE study and a summary of the VE recommendations including the potential cost savings. The major factors which influenced the study would be highlighted by the VETC. This presentation would be followed by a brief description of each VE recommendation by selected team members. The owner and designer should seek only to understand the concept and background of each recommendation during the oral presentation. They should delay discussions on the merits of the recommendations until subsequent meetings.

Copies of the handwritten VE recommendations should be provided to the owner and designer during the oral presentation so they can commence their review and analysis prior to the receipt of the VE report.

VE Report

The VE consultant prepares a written VE Report which summarizes the results of the entire VE study. This report is used by the owner and designer in their review and evaluation of the VE recommendations. The report should be prepared and submitted to the owner/designer within one to three weeks following the workshop to avoid delaying the project's design. Since the VE Report stands alone as an independent document, it should contain at least the following information:

1. Executive Summary.

2. Project Name.

3. Scope of the VE study.

4. Names of the owner, designer, and VE team members and their related responsibilities.

5. Location and date of the workshop.

6. List of the data provided by the owner/designer (list data obtained during the pre-workshop activity as well as during the workshop).

7. Project constraints.

8. Information important to the background of the VE study, i.e., major environmental impacts and discussions at public meetings.

9. Project description, design criteria, process flow diagram, plant layout, description of each unit process, influent/effluent criteria, description of physical characteristics of the site, major design concerns, and existing facilities.

10. All cost, energy, and life cycle models, and worksheets from the Job Plan phases.

11. A summary of the conclusions from each phase of the VE Job Plan.

12. Summary of VE recommendations and cost savings.

13. Specific VE recommendations with supporting documentation.

14. Appendix with additional information which the VETC may find appropriate.

The most important element in the VE Report are the VE recommendations. The VE team should refrain from suggesting additional VE recommendations after the oral presentation. However, the information generated during the VE workshop can be further developed for accuracy and completeness before it is included in the VE Report. An abbreviated example of a VE Report is provided in Appendix D. The example highlights the information which should be contained in the report and the use of the VE worksheets.

FIGURE 4-1 EXAMPLE FUNCTION ANALYSIS WORKSHEET

PROJECT XYZ WWTP (65% Design)

ITEM Wastewater Treatment Facility

BASIC FUNCTION REMOVE POLLUTANTS

FUNCTION ANALYSIS No. 1

TEAM NO. 1 SHEET 1 OF 1

Function Analysis

Sub Component Description	Function			Initial Cost[2]	Worth[3]	Cost/ Worth	Comments
	Verb	Noun	Kind[1]				
Control Building	House	Support Equipment	RS	1,571,000	1,200,000	1.6	Simplify construction
Blower Building	House	Equipment	RS	1,253,000	900,000	1.4	Reduce building size
Aeration Tanks	Convert	BOD & Ammonia	B	717,000	600,000	1.2	Modify to four sections
Final Clarifiers	Concen- trate	Sludge	B	1,021,000	900,000	1.1	Consolidate; simplify construction & Reinforcing
Chlorine Tanks	Dis- infect	Effluent	B	203,000	170,000	1.2	Simplify construction; change gates
Gravity Thickeners	Concen- trate	Solids	RS	663,000	600,000	1.1	Increase loading; modify holding tank
Headworks	Remove	Grit & Screening	B	64,000	50,000	1.3	Reduce no. pumps; modify controls
Existing Pump Room	House	Equipment	RS	166,000	160,000	1.05	
Existing Pump Chamber	House	Equipment	RS	109,000	90,000	1.2	
Site & General	Support	Constru- tion	RS	1,480,000	1,250,000	1.2	Consolidate; reconfigure
Other (including contingency)				1,647,000	1,580,650		
TOTAL				8,894,000	7,500,650	1.2	**Basic function C/W only**

[1]B = Basic Function
S = Secondary Function

[2] Original Cost Estimate

[3] Worth - Least Cost to Accomplish Function.

WS-5

FIGURE 4-2 EXAMPLE FUNCTION ANALYSIS WORKSHEET FOR SUBSYSTEM

PROJECT XYZ WWTP (65% Design)

ITEM Aeration Tanks

BASIC FUNCTION CONVERT BOD AND AMMONIA

FUNCTION ANALYSIS No. 1

TEAM NO. 1 SHEET 1 OF 1

Function Analysis

Sub Component Description	Function			Initial Cost²	Worth³	Cost/ Worth	Comments
	Verb	Noun	Kind¹				
Earthwork	Prepare	Site	S	64,000	60,000	1.1	Modify berming
Concrete	Support	Load	B	393,000	275,000	1.4	Reduce weight and size Modify reinforcing
Miscellaneous Structural	Support	Load	B	44,000	40,000	1.1	
Electrical/ Instrumentation	Energize Control	Facility Process	B	16,000	12,000	1.3	Revise process controls
Process Pipe	Convey	Air Sludge	B	40,000	30,000	1.3	Change materials. Modify fittings/routing.
Mechanical Equipment	Support	Process	B	149,000	130,000	1.1	Reduce and/or modify gates
Start-Up	Support	Process	S	13,000	10,000	1.3	
Painting	Protect Finish	Equipment Space	S	11,000	6,000	1.8	Leave certain areas unpainted
TOTAL				730,000	563,000	1.3	Basic function C/W only

¹B = Basic Function
S = Secondary Function

² Original Cost Estimate

³ Worth - Least Cost to Accomplish Function.

WS-5

FIGURE 4-3 EXAMPLE SPECULATIVE/CREATIVE PHASE WORKSHEET

PROJECT XYZ WWTP (65% Design)

ITEM Aeration Tanks

CREATIVE/EVALUATION No.____

TEAM NO. 1 **SHEET** 1 **OF** 1

CREATIVE		EVALUATION		
NO.	**IDEA**	**ADVANTAGES**	**DISADVANTAGES**	**RATINGS***
1	Delete one interior wall to provide a four compartment tank			
2	Reduce size of tank to match flow if interior walls are eliminated			
3	Use thin-wall stainless steel for air piping			
4	Simplify reinforcing details			
5	Eliminate flared sections at top of walls			
6	Provide common wall construction with foundation for pump & blower P-3			
7	Reduce bouyancy safety factor			
8	Eliminate extension thimbles on sluice gates			
9	Eliminate bends in return activated sludge lines			
10	Modify flow controls for process adjustment and revise railing & access			
11	Reduce number of influent slide gates			
12	Revise piping at air main takeoffs (reduce no. of fittings)			

*10 = MOST FAVORABLE 1 = LEAST FAVORABLE

WS-7

FIGURE 4-4 EXAMPLE EVALUATION/ANALYTICAL PHASE WORKSHEET

PROJECT XYZ WWTP (65% Design)

ITEM Aeration Tanks

CREATIVE/EVALUATION No.____

TEAM NO.____ **SHEET**____ **OF**____

CREATIVE		EVALUATION		
NO.	**IDEA**	**ADVANTAGES**	**DISADVANTAGES**	**RATINGS***
1	Delete one interior wall to provide a four compartment tank	Less maintenance (particularly of gates)	Increase weight of outer walls for bouyancy off-set	5
2	Reduce size of tank to match flow if interior walls are eliminated	• Reduce capital cost • Regain some usable yard area	Redesign time	6
3	Use thin-wall stainless steel for air piping	• Improve diffuser operation • Reduce capital cost	May increase noise transmission	6
4	Simplify reinforcing details	Reduce capital cost	Minimal redesign	6
5	Eliminate flared sections at top of walls	Reduce capital cost	• Reduces aesthetic appearance • Flares may be used for walkways	8
6	Provide common wall construction with foundation for pump & blower P-3	• Reduce capital cost • Improve floatation	Redesign	9
7	Reduce bouyancy safety factor	Reduce capital cost	• Redesign • Safety margin decreased	9
8	Eliminate extension thimbles on sluice gates	• Reduce capital cost • Improve O&M		3
9	Eliminate bends in return activated sludge lines	• Improve function • Reduce capital cost	• Minimal redesign • Increased difficulty in routing	6
10	Modify flow controls for process adjustment and revise railing & access	• Improve function • Improve safety and reliability	Minimal redesign	6
11	Reduce number of influent slide gates	Reduce capital cost and O&M costs	Reduced operational flexibility	5
12	Revise piping at air main takeoffs (reduce no. of fittings)	• Reduce capital cost • Improve function (less pressure drop & less leakage potential)		9

*10 = MOST FAVORABLE 1 = LEAST FAVORABLE

WS-7

SECTION 5

POST-WORKSHOP ACTIVITY

5.1 REVIEW OF THE VE REPORT

The post-workshop VE activity involves a thorough review and evaluation of each VE recommendation presented in the VE Report and the preparation of the Final VE Report.

The owner and designer evaluate each VE recommendation on the basis of technical, operational, and life cycle cost savings considerations. (Normally, redesign and implementation costs for the recommendations are not considered since these costs are usually insignificant when compared to the potential cost savings.)

The owner and designer consult with the VETC to clarify any questionable items which arise during their review of the VE recommendations. An in-depth evaluation of each VE recommendation provides the best basis for reaching a sound decision to accept or reject a recommendation.

5.2 FINAL VE REPORT

Once all the VE recommendations have been reviewed by the owner and the designer, a Final VE Report is prepared by the designer to summarize the results of the VE study and describe the action taken on each of the VE recommendations. The Final VE Report and the VE Report serve as the complete documentation for the VE study. A separate VE Report and Final VE Report must be prepared for each VE study conducted on a project.

Accepted VE Recommendations

The acceptance of a VE recommendation requires no justification in the Final VE Report. Such action requires only a statement of acceptance. When certain elements of a VE recommendation are acceptable and other elements of the recommendation are unacceptable, a justification should be provided for only the rejected portion of the recommendation. Occasionally, the designer may modify a VE recommendation before incorporating it into the design. These modifications would be fully described in the Final VE Report.

Accepted VE recommendations should be incorporated into the design as soon as possible by the designer.

Rejected VE Recommendations

Each rejection of a VE recommendation must be supported by valid reasons which are specifically detailed in the Final VE Report. Several examples of insufficient reason for rejection of a VE recommendation are:

- Lack of reliability (increased liability for the designer)
- Lack of flexibility
- Unsafe
- Project delay
- Preference or opinion
- New or unfamiliar technology
- Unproven technique
- Violates regulatory requirements

In the Final VE Report, the specific reasons for the rejection or partial rejection of individual VE recommendations must be stated in sufficient detail to convince the reviewing agency of the validity of the rejection. For example, the reasons for rejecting a recommendation on the basis of safety would explain how and why the recommendation would create an unsafe condition.

Contents of the Final VE Report

The Final VE Report should include:

- A brief description of the project, the scope of the VE efforts (number of studies), and the percentage of design completion at the time of the study.
- The estimate of the project's total construction costs available prior to the VE study.
- A summary list of the accepted and rejected VE recommendations which includes a brief description of each recommendation plus its capital and life cycle cost savings expressed in present worth.
- A detailed explanation for each rejected VE recommendation.

- Tabulation of the total cost savings for the accepted VE recommendations which includes the capital costs and the present worth of the life cycle costs.
- Explanation of any significant differences between the Final VE Report's cost estimates and the VE Report's cost estimates.
- The total additional design costs required for implementing the accepted VE recommendations.
- An implementation schedule for incorporating the accepted recommendations into the design.
- The VE Report attached as an appendix.

The Final VE Report should be a brief document which does not duplicate the information provided in the VE Report. The report should use the same identification number for each recommendation as the VE Report.

An abbreviated example of a Final VE Report is contained in Appendix E. This example is intended to illustrate the overall format and content of a Final VE Report.

5.3 REVIEWING AGENCY COORDINATION AND APPROVAL

The owner should establish a working relationship with the reviewing agency's project officer during the early development of the project to ensure that it's final drawings, specifications, and VE reports are approvable for a construction grant award. The owner should consult with the reviewing agency's project officer prior to accepting VE recommendations which involve major design changes or rejecting VE recommendations which offer substantial cost savings.

The VE process concludes with the acceptance of the Final VE Report(s) by the appropriate reviewing agency.

APPENDIX A

GLOSSARY OF TERMS

APPENDIX A

GLOSSARY OF TERMS

VALUE ENGINEERING

Value Engineering (VE)

A specialized cost control technique which is applied by an independent team of experienced multidisciplined professionals during the design of a wastewater treatment facility. The technique provides a systematic, functional, and creative methodology for identifying project cost savings without sacrificing reliability or performance. The technique is used to achieve the best functional combination of cost, reliability, and performance for a specific product, process, system, or facility.

VE Study (Review)

The combined efforts of the owner, project designer, and VE consultant necessary for the successful accomplishment of value engineering on a wastewater treatment facility. Two separate VE studies are typically performed at different stages of a facility's design to achieve optimum VE benefits.

VE Workshop

The brief and intense working session in which a VE team(s) performs value engineering on the design of a specific facility. A workshop is typically conducted in 40 hours and culminates with an informal oral presentation of the VE recommendations.

VE Job Plan

The systematic methodology used by the VE team to perform value engineering. The VE Job Plan consists of five distinct phases performed sequentially during the VE workshop.

VE Team

An independent group of experienced, multidisciplined professionals. The group performs value engineering on the design of a specific facility during the VE workshop.

VE Team Coordinator (VETC)

The individual coordinating and managing the VE study. This individual leads the VE team(s) during the VE workshop.

VE Recommendation

A proposed change to the design of a facility. VE recommendations are developed during the VE workshop and documented in the VE Report.

VE Report

A written report which formally summarizes the results of the VE workshop and presents the VE recommendations.

Final VE Report

A written report which formally responds to the VE recommendations contained in the VE Report.

VE Training Seminar

A recognized course which provides at least forty hours of academic training in the methodology of value engineering. The training includes the application of VE techniques to example projects.

VE Consultant

The firm responsible for performing the VE workshop and preparing the VE Report. The firm provides the VETC and VE team.

Designer

The firm primarily responsible for the design of the wastewater treatment facility and the preparation of the Final VE Report.

Owner

The municipality or community which intends to construct the proposed wastewater treatment facilities.

Life Cycle Cost (LCC)

The total cost of ownership for an asset over its useful life. This cost includes the initial cost and all significant future costs, such as operation and maintenance costs. Since life cycle costs recognize the time value of money, all LCC's (initial and future) are developed and compared on a present worth basis.

Wastewater Treatment Works

Any devices and systems for the storage, conveyance, treatment, recycling, and reclamation of municipal sewage, domestic sewage, or liquid industrial wastes, or necessary to recycle or reuse water at the most economical cost over the useful life of the works. These include intercepting sewers, outfall sewers, sewage collection systems, individual systems, pumping, power, and other equipment and their appurtenances; extensions, improvement, remodeling, additions, and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment units and clear well facilities; and any works, including acquisition of the land that will be an integral part of the treatment process or is used for ultimate disposal of residues resulting from such treatment (including land for composting sludge, temporary storage of such compost and land used for the storage of treated wastewater in land treatment systems before land application); or any other method or system for preventing, abating, reducing, storing, treating, separating, or disposing of municipal waste or industrial waste, including waste in combined storm water and sanitary sewer systems. In this guidance document, the terms wastewater treatment works, wastewater treatment facility or wastewater treatment project are used interchangeably.

APPENDIX B

SELECT BIBLIOGRAPHY

SELECT
BIBLIOGRAPHY

1. Techniques of Value Analysis and Engineering, Lawrence D. Miles, McGraw-Hill Book Company, Second Edition, 1972.

2. Value Analysis in Design and Construction, James J. O'Brien, McGraw-Hill Book Company, 1976.

3. Value Engineering in the Construction Industry, Alphonse J. Dell'Isola, Van Nostrand Reinhold Company, Inc., Third Edition, 1982.

4. Value Engineering, A Practical Approach for Owners, Designers, and Contractors, Larry W. Zimmerman and Glen D. Hart, Van Nostrand Reinhold Company, 1982.

5. Life Cycle Costing, A Practical Guide for Energy Managers, Robert J. Brown and Rudolph R. Yanuck, The Fairmont Press, Inc., 1980.

6. Life Cycle Costing for the Design Professional, Alphonse J. Dell'Isola and Steven J.Kirk, McGraw-Hill Book Company, 1981.

7. Energy Conservation in Municipal Wastewater Treatment, U.S. EPA-430/9-77-011, March 1978.

8. Energy Management Diagnostics, U.S. EPA-430/9-82-002, February 1982.

APPENDIX C

WORKSHEETS

Reproduction of these worksheets is encouraged for use in VE studies.

PROJECT ____________________

ITEM ____________________

____

COST SUMMARY

TEAM NO.______ SHEET______ OF________

Check one, use separate sheet for each.

Construction Costs ☐
O&M Costs ☐
Replacement Costs ☐
Energy Costs ☐

Major Unit or Item	Original Estimate	New Estimate
TOTAL		

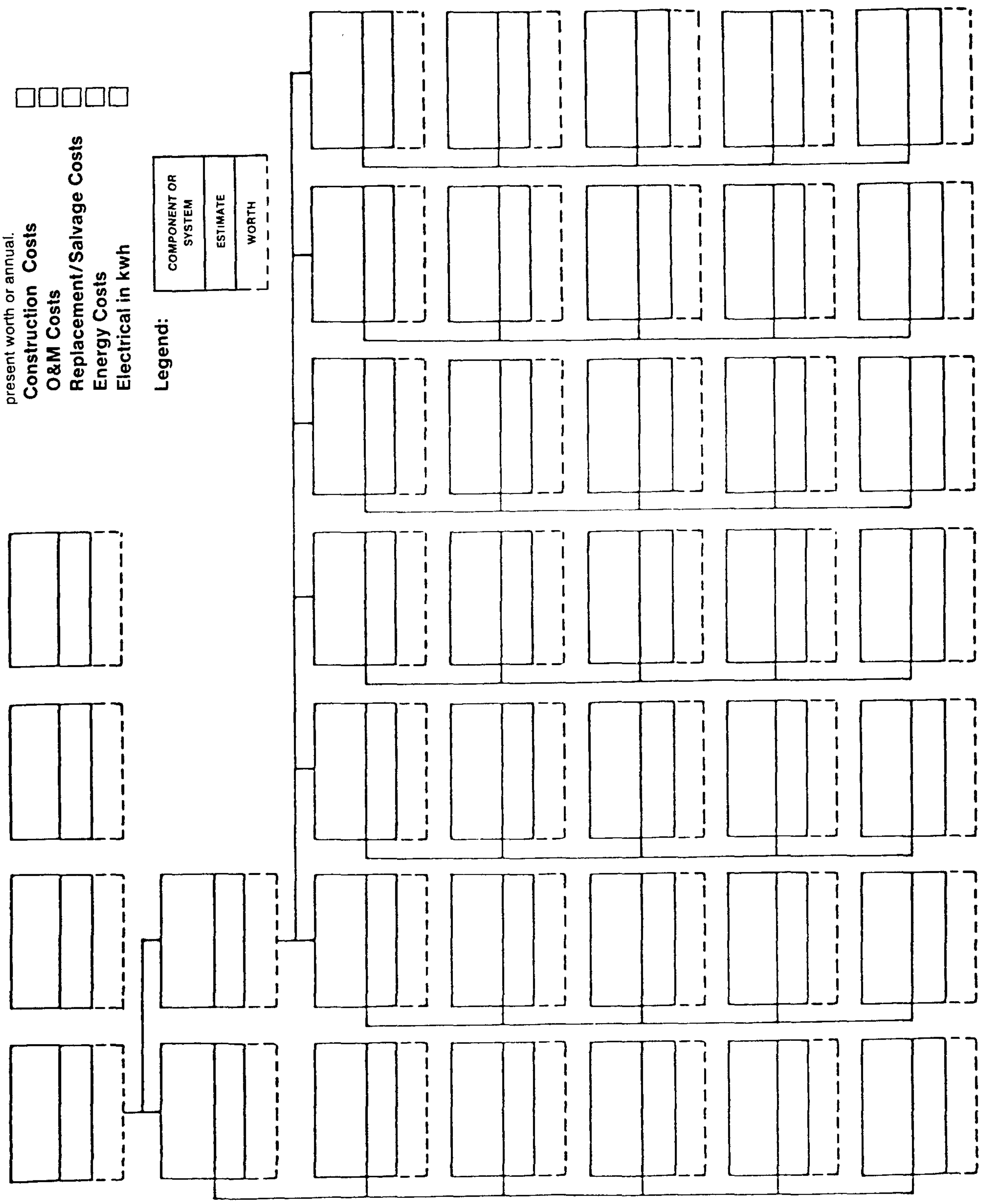
WS-1

PROJECT ______________________	COST (OR ENERGY) MODEL
ITEM ______________________	TEAM NO. _____ SHEET _____ OF _____

Check one; use one sheet for each. Indicate present worth or annual.

- **Construction Costs** ☐
- **O&M Costs** ☐
- **Replacement/Salvage Costs** ☐
- **Energy Costs** ☐
- **Electrical in kwh** ☐

Legend:



PROJECT ____________________

ITEM ____________________

____

MATRIX COST MODEL No. ________

TEAM NO. ______ SHEET ______ OF ____

Total Cost																				
Cost Category																				
Description																			Total Cost	Percent of Cost
No.																			X	X

WS-2B

PROJECT ______________________________

ITEM ______________________________

____

COST SUMMARY BAR CHART

TEAM NO.______ SHEET______ OF______

Check one, use separate sheet for each.

- Construction Costs ☐
- O&M Costs ☐
- Replacement Costs ☐
- Energy Costs ☐

Major Unit or Cost Category	Cost										

DOLLARS OR % OF TOTAL COST

PROJECT ______________________________

ITEM_________________________________

____

ELECTRICAL ENERGY

TEAM NO.______ SHEET______ OF______

Equipment Description	Motors				Avg. Annual Operating Hours	Annual kwh	Peak Hourly Load (kw)
	No.	HP(ea)	Eff	No. On-Line			
TOTALS							X

PROJECT ____________________

MAJOR UNIT OR ITEM ____________________

____

O&M LABOR

TEAM NO.______ SHEET______ OF______

Classification	Number	Annual Salary	Annual Cost
TOTAL LABOR COST			

WS-4A

PROJECT ____________________

ITEM ____________________

____

O&M CHEMICALS

TEAM NO.______ SHEET______ OF______

	Type of Chemical				Type of Chemical				Type of Chemical			
Unit Process ↓	Avg. Units/ Day	Annual Units	Unit Cost	Annual Cost	Avg. Units/ Day	Annual Units	Unit Cost	Annual Cost	Avg. Units/ Day	Annual Units	Unit Cost	Annual Cost
TOTALS												

Unit Process ↓	Type of Chemical				Type of Chemical				Type of Chemical			
TOTALS												

WS-4B

PROJECT ________	EQUIPMENT REPLACEMENT No. ____
ITEM ________	TEAM NO.______ SHEET______ OF______
Original ☐ Proposed ☐ check one	

Replacement Item	Service Life	Future Replacement Cost	Present Worth Replacement Cost
		$	$

WS-4C

PROJECT ____________________

ITEM ____________________

LIFE CYCLE COST SUMMARY No.______

TEAM NO.______ SHEET______ OF______

INITIAL CONSTRUCTION COST ____________________ ________

CATEGORY	COMMENT/CALCULATION	COST Annual	COST Present Worth
Electricity			
• Motors ______			
• Lighting ______			
Other Utilities			
• Water ______			
• Natural Gas ______			
• Fuel Oil ______			
• Steam ______			
Chemicals ______			
Other			
• Sludge Disposal			
• ______			
• ______			
Labor ______			
Replacement ______			

TOTAL LCC ________

WS-4D

PROJECT ____________________

ITEM ____________________

BASIC FUNCTION ____________________

FUNCTION ANALYSIS No. ______

TEAM NO. ______ SHEET ______ OF ______

Function Analysis

Sub Component Description	Function			Initial Cost[2]	Worth[3]	Cost/ Worth	Comments
	Verb	Noun	Kind[1]				

[1] B = Basic Function
S = Secondary Function

[2] Original Cost Estimate

[3] Worth - Least Cost to Accomplish Function.

PROJECT ____________________

ITEM ____________________

____

CREATIVE/EVALUATION No. ____

TEAM NO. ____ SHEET ____ OF ____

CREATIVE		EVALUATION		
NO.	IDEA	ADVANTAGES	DISADVANTAGES	RATINGS*

*10 = MOST FAVORABLE 1 = LEAST FAVORABLE

PROJECT ______________________

ITEM ______________________

____

VE RECOMMENDATION No.______

TEAM NO.______ SHEET______ OF______

ORIGINAL: (Attach sketch where applicable)

PROPOSED: (Attach sketch where applicable)

DISCUSSION:

LIFE CYCLE COST SUMMARY	PRESENT WORTH COSTS		
	INITIAL COST	O & M COSTS	TOTAL
ORIGINAL			
PROPOSED			
SAVINGS			

PROJECT ____________________

ITEM ____________________

____

LIFE CYCLE COSTS No.______

TEAM NO.______ SHEET______ OF______

		Original	Alt. No. 1	Alt. No. 2
Initial Costs	1. Initial (Construction) Costs			
	a.			
	b.			
	c.			
	d.			
	e.			
	f.			
	2. Total Initial Cost			
	3. Initial Cost Savings	X		
Replacement Costs	Single Expenditures at ______ Interest (Discount) Rate Present Worth = Amount x PW Factor			
	4. Amount for Item ______ at Year ______			
	5. PW = Amount x (PW Factor ______) =			
	6. Amount for Item ______ at Year ______			
	7. PW = Amount x (PW Factor ______) =			
	8. Amount for Item ______ at Year ______			
	9. PW = Amount x (PW Factor ______) =			
	10. Amount for Item ______ at Year ______			
	11. PW = Amount x (PW Factor ______) =	( )	( )	( )
	12. Amount for Item ______ at Year ______			
	13. PW = Amount x (PW Factor ______) =	( )	( )	( )
Life Cycle Costs (Annualized or Present Worth)	Annual Owning Cost for 20 Years at ______ % PP Factor ______			
	14. Total Initial Cost (line 2) x PP Factor			
	15. Annualized Replacement Cost			
	a. PW (line 5) x PP Factor =			
	b. PW (line 7) x PP Factor =			
	c. PW (line 9) x PP Factor =			
	d. PW (line 11) x PP Factor =			
	e. PW (line 13) x PP Factor =			
	16. Annual O&M Costs (from WS-4B)			
	17. Annual O&M Savings	X		
	18. Total Annualized Costs (lines 14, 15, 16)			
	19. Annualized Savings	X		
	20. Present Worth of O&M Costs Line 16 x (PWA Factor ______) =			
	21. Total Present Worth of Costs (lines 2, 5, 7, 9, 11, 13 & 20)			
	22. Present Worth Savings	X		

Future Cost ☐ Present Cost ☐

PP = Periodic Payment Factor to Pay Off Loan of $1 = Uniform Capital Recovery Factor

PW = Present Worth Factor (What $1 *Due in Future* is *Worth Today*) = Single Present Worth Factor

PWA = Present Worth of Annuity Factor (What $1 Payable Periodically is Worth Today) = Uniform Present Worth Factor

DATE	BY	PROJECT	SUBJECT	CLIENT	PAGE OF

SUMMARY OF POTENTIAL COST SAVINGS FROM VE RECOMMENDATIONS

ITEM NO.	DESCRIPTION	PRESENT WORTH COST SAVINGS				
		ORIGINAL COST	PROPOSED COST	INITIAL COST SAVINGS	O & M COST SAVINGS	TOTAL COST SAVINGS

APPENDIX D

SAMPLE VE REPORT

VALUE ENGINEERING REPORT
XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
USA
25% DESIGN COMPLETION STAGE

April 1984

OWNER

SANITARY DISTRICT
USA

DESIGNER

A AND B ASSOCIATES, INC.
USA

VE CONSULTANT

ABC, INC.
USA

VALUE ENGINEERING REPORT
XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
USA
25% DESIGN COMPLETION STAGE

April 1984

TABLE OF CONTENTS

VALUE ENGINEERING REPORT
XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
USA

April 1984

EXECUTIVE SUMMARY

This report summarizes the results of the first value engineering study for the XYZ Wastewater Treatment Plant expansion program.

The proposed facilities are being designed by A and B Associates, Inc. The proposed facilities will expand the plant capacity from 12.5 to 19.6 mgd plus provide excess flow treatment and a storage facility for 50 mgd. The estimated construction cost of the proposed facility is $31.4 million.

The scope of this VE study is the analysis of the design documents and drawings for the proposed expansion at the 25% design completion stage. Areas of study include: raw sewage junction chamber; excess flow basin and control building; primary settling tanks; secondary settling tanks; nitrification aeration system; blower building; final clarifiers; sludge thickening; and odor control systems for the plant.

The study was conducted during the week of April 11-15, 1984 at the office of A and B Associates, Inc.

The VE team prepared cost, energy, and life cycle cost models for the total facility which identify the projected cost of owning and operating the plant. The VE team used the models to identify areas of high potential initial cost savings, energy savings, and operational cost savings. As a consequence, the VE team recommendations will save energy as well as initial costs, resulting in substantial life cycle benefits for the owner.

The VE team generated 75 alternative design ideas during the function analysis/creative idea listing phases of the study. From these ideas, 25 recommendations and 16 design suggestions were developed and presented herein to the Sanitary District and design engineers for consideration. They represent both initial cost savings and improved operating costs amounting to an estimated total present worth cost savings of $8,500,000.

Recognize that the proposals submitted are recommendations. Final acceptance rests with the Sanitary District, the design engineers and the state Environmental Protection Agency.

Major areas of potential cost savings identified in the VE study include: modular design and operation of odor control systems; modification to the excess flow basin; elimination of the excess flow basin control building basement, relocation of the north gallery from between the final chambers to a location north of and adjacent to the nitrification aeration tanks; and the deletion of the dissolved air flotation thickeners from the sludge process stream.

Other areas identified for potential initial cost and energy savings include a reduction in the number of primary clarifier tanks and the use of a different type of air diffuser device in the nitrification aeration tanks ...

VALUE ENGINEERING REPORT
XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
USA
25% DESIGN COMPLETION STAGE

April 1984

SECTION 1

INTRODUCTION

1.1 GENERAL

This report summarizes the findings and recommendations from the value engineering study of the design for the expansion of the XYZ Wastewater Treatment Plant. The topic of the VE workshop was the review of the design and conceptual plans for advanced wastewater treatment plant expansion of the existing capacity at the XYZ Plant, and for new facilities to provide for the storage of excess wastewater flows from the county-wide area.

ABC, Inc., was retained to conduct the value engineering workshop for the project at the 25% design completion stage. The project designer is A and B Associates, Inc.

The workshop portion of the study was held during the week of April 11-15, 1984 at A and B's offices. Prior to the value engineering workshop, the VETC visited the existing facilities to review physical constraints and to evaluate existing plant and operational procedures.

An oral report of the VE workshop results was made to the Designer and representatives of the Sanitary District on April 15, 1984.

Materials provided to the VE team by A and B Associates for this VE study included the following:

- 201 Facilities Plan (Vols. 1, 2, 3, and 4), dated March 1982.
- Process Design Data, dated September 1983 and revised October 29, 1983.

- Site plan with new facilities located.
- Plan and section drawings and sketches for all new structures at the 25% completion stage.
- Hydraulic Profile (latest revision 3/12/84).
- Unit process flow sheets for all new facilities (latest revision 3/12/84).
- Process Motor List.
- Preliminary Geotechnical Engineering Exploration and Analysis, dated August 17, 1983.
- Geotechnical Engineering Exploration and Analysis (Wastewater Treatment Plant), dated September 28, 1983.
- Geotechnical Engineering Exploration and Analysis (Stormwater Retention Basin), dated October 9, 1983.
- Preliminary Construction Cost Estimate, dated March 5, 1984.
- Narrative descriptions and design criteria.
- Electrical one-line diagram.
- State Recommended Standards for Sewage Works, dated March 1980.
- Miscellaneous supporting data.

1.2 SCOPE OF THE VALUE ENGINEERING STUDY

The scope of the value engineering services for the XYZ Wastewater Treatment Plant includes two studies on the proposed expansion of the waste treatment facilities and the excess flow treatment and storage facilities. The collection system, sludge transport and off-site sludge treatment facility are not part of the proposed expansion. These facilities have sufficient capacity for the projected loads. The first study, which is the scope of this report, is the evaluation of the treatment plant and the excess flow facilities at the 25% design completion stage. Layout, hydraulic profile, design criteria, equipment selection, building layouts and the system designs for electrical, architectural treatment and instrumentation are the basic areas for review ...

VALUE ENGINEERING REPORT
XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
USA
25% DESIGN COMPLETION STAGE

April 1984

SECTION 2

PROJECT DESCRIPTION

2.1 GENERAL

The Sanitary District (The District) operates four wastewater treatment plants. In the planning stage of the expansion program, the District commissioned preparation of a 201 Facilities Plan to address the future wastewater management needs of the entire District service area shown on Figure 2-1.* The report included recommendations to increase the treatment capacity of the plant at XYZ and construct new facilities to pretreat and store excess flows beyond the treatment plant capability. A and B Associates, Inc. was commissioned by the District to design the recommended facilities for the XYZ Plant.

The treatment facilities will increase the average annual flow capacity from 12.0 million gallons per day (mgd) to 19.6 mgd and expand the plant for a maximum treated flow capacity of 39.2 mgd. There are no present facilities on-site to treat flows in excess of plant capacity. The new required facilities will be 50-million gallons capacity and include: excess flow, first flush storage; pre-sedimentation; storage; and chlorination. The excess flow retained in the first flush, pre-sedimentation, and storage chambers will be conveyed to the treatment plant during periods of less than peak flow.

2.2 DESCRIPTION OF TREATMENT UNITS

The following description of the process elements has been excerpted from the narrative description of the design disciplines prepared by A and B and dated March 5, 1984. Additional information concerning design procedures, codes, et al., may be found in this document.

*Not included with sample.

The basic process expansion requirements were evaluated on a conceptual basis during the preparation of the Facilities Plan. This description provides additional information of process expansion developed prior to the 25% VE effort. The Process Design Data, page D-11, which follow the unit description, supplement and identify design loadings and criteria for each process area. The site layout, Figure 2-2, shows the existing and proposed treatment units as presently arranged.

Comments from the owner and detailed investigations by the designer resulted in some changes to the Facilities Plan. These changes are included in this narrative.

PRELIMINARY TREATMENT

Raw sewage will be pumped to the new raw sewage junction chamber from the existing raw sewage pumping station and from Pumping Station No. 5 (PS-5). Existing force mains will be extended to the location of the new junction structure. The raw sewage is screened with mechanical bar screens at the raw sewage pumping station and at PS-5. Screenings are landfilled. The raw sewage pumping station includes three pumps with a total capacity of 36 mgd. PS-5 includes four pumps with a total capacity of 40 mgd.

The new raw sewage junction chamber will include control valves to direct raw sewage to the new excess flow facility when the flow exceeds 39.2 mgd.

The new raw sewage meter will be a Parshall flume with a 5-foot throat. Provisions for chemical addition will be provided in the channel just upstream of the new raw sewage meter. The chemicals that could be added include ferric chloride, polymer, chlorine, and hydrogen peroxide. Existing storage and feed equipment will be utilized for all chemicals except hydrogen peroxide. Only hydrogen peroxide will be added to the raw sewage on a continuous basis.

The new raw sewage splitter box includes nine 5-foot weirs to split the raw sewage flow to the nine primary clarifiers. Overflows from the sludge thickening facilities will be returned to the new raw sewage splitter box ...

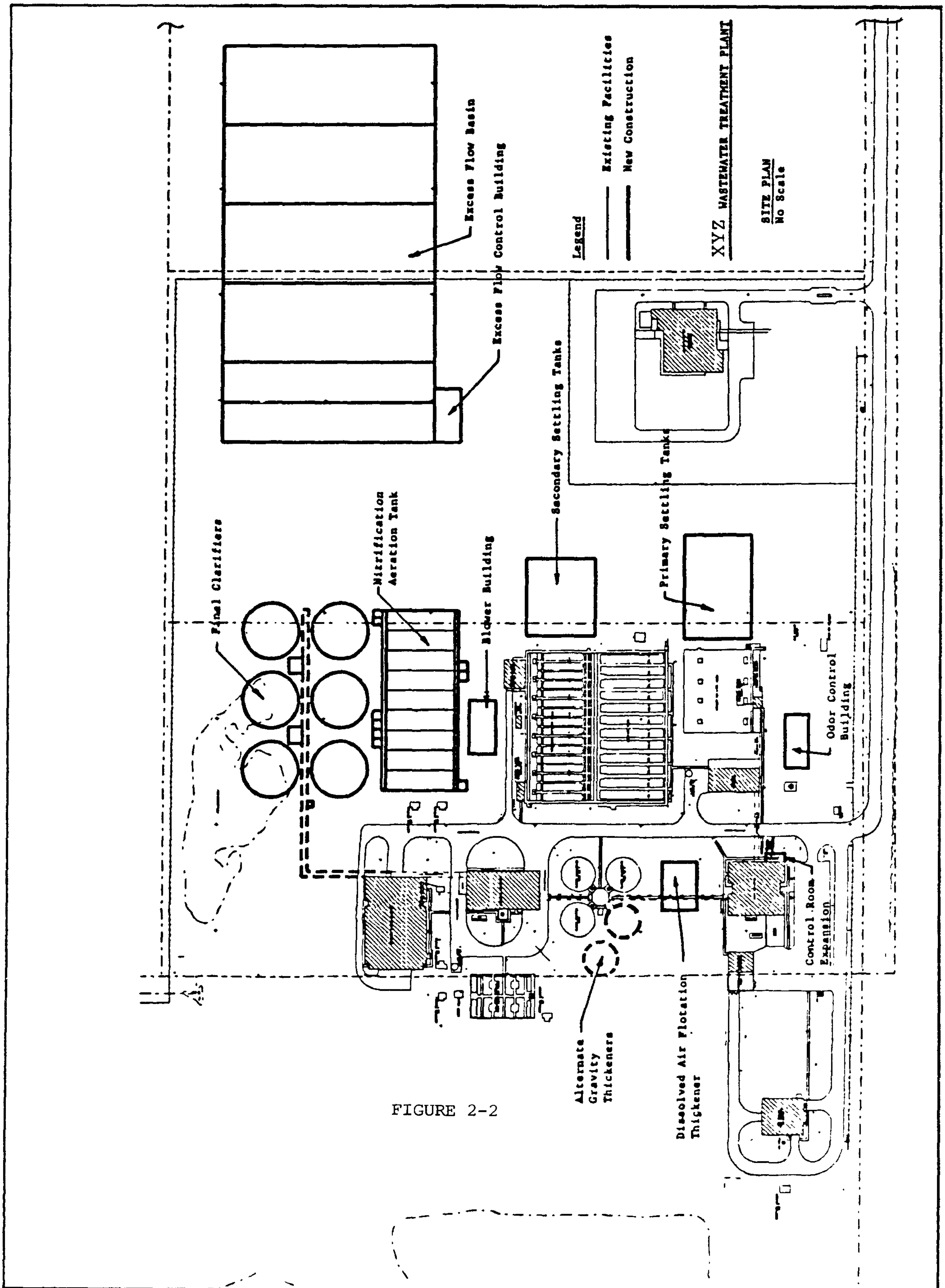

XYZ WASTEWATER TREATMENT PLANT
SITE PLAN
No Scale
Legend
Existing Facilities
New Construction
Excess Flow Basin
Excess Flow Control Building
Final Clarifiers
Nitrification Aeration Tank
Blower Building
Secondary Settling Tanks
Primary Settling Tanks
Odor Control Building
Control Room Expansion
Dissolved Air Flotation Thickener
Alternate Gravity Thickeners

FIGURE 2-2

2.3 PROCESS DESIGN DATA

XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
PLANT EXPANSION PROCESS DESIGN DATA

September 1983
Revision 1 October 29, 1983
(Prepared by A and B Assoc. Inc.)

Table of Contents

Secondary Clarifiers	Units	Annual Average	Maximum Week
Number of Units			
Existing		8	
New		4	
Total		12	
Tank Geometry			
Bays per tank		2	
Length	ft	114	
Bay width	ft	16.15	
Side water depth	ft	11	
State SWD Criteria	ft	12 (min)	
10 SS SWD Criteria	ft	12 (min)	
Surface area per tank	sf	3,700	
Total surface area	sf	44,400	
SOR (Plant Influent)	gpd/sf	441	883
State SOR criteria	gpd/sf		1,000
10 SS SOR criteria	gpd/sf		1,200
Fac. Plan SOR	gpd/sf	482	964
Solids Loading			
MLSS	mg/l	2,000	3,000
Return sludge flow	MGD	19.6	19.6
Total flow	MGD	40.6	60.8
Total SS	lb	680,540	1,521,220
Loading	lb/sf	15.3	34.3
10 SS loading criteria	lb/sf		50
Weir length per tank	lf	222.66	
Total weir length	lf	2,672	
Weir loading (plant influent)	gpd/lf	7,335	14,670
State weir loading criteria	gpd/lf		30,000
10 SS weir loading criteria	gpd/lf		15,000

VALUE ENGINEERING REPORT
XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
USA
25% DESIGN COMPLETION STAGE

April 1984

SECTION 3

VALUE ENGINEERING PROCEDURE

3.1 GENERAL

This section provides a description of the value engineering procedures followed during the study. It is included to allow the reader to: follow the thought processes of the VE team; review the conclusions drawn from each phase and understand the reasons for the recommendations.

The workshop followed the Value Engineering Job Plan. Each step in this plan plays an important part in achieving results and assuring eventual savings to the owner. A systematic approach is used in a VE study and the key procedures followed are organized into three distinct parts: 1) pre-workshop preparation; 2) VE workshop; and 3) post-workshop procedures.

3.2 PRE-WORKSHOP PREPARATION

Pre-workshop preparation consists of scheduling study participants and tasks; gathering necessary background information; and compiling project data into cost, energy and life cycle cost models. Information relating to the design, construction and operation of the facility is important as it forms the basis of comparison for the study effort. Information relating to funding, project planning, operating needs, comparisons of system evaluations, basis of cost, soils conditions and construction of the facility must be a part of the analysis ...

3.3 VE WORKSHOP

The VE workshop was an intensive 40-hour work session which analyzed the project using the VE methodology. A five-phase Job Plan was used during the workshop to identify high initial, energy, and life cycle costs. The workshop defined the functional requirements needed to operate and maintain the facility properly. The portions of the project with high initial or energy cost-to-worth ratios were selected as potential areas for cost reductions ...

The Job Plan included the following five distinct phases:

- Information Phase
- Speculative/Creative Phase
- Evaluation/Analytical Phase
- Development/Recommendation Phase
- Report Phase

Information Phase

To assist the VE team to understand the background and decisions that have influenced the development of the design, the design engineer presented an oral overview of the project ...

PROJECT XYZ WWTP (25% Design)

ITEM CONSTRUCTION COST SUMMARY

COST SUMMARY

TEAM NO. 1 **SHEET** 1 **OF** 1

ABC, Inc.

Check one, use separate sheet for each.

- **Construction Costs** [X]
- **O&M Costs** [ ]
- **Replacement Costs** [ ]
- **Energy Costs** [ ]

CSI NO.	Major Unit or Item	Original Estimate	New Estimate
1	General Requirements	$ 247,000	
2	Sitework (including excavation)	5,228,400	
3	Concrete	9,444,500	
5	Miscellaneous Metals	1,256,300	
6-9	Building Work	965,000	
11	Mechanical Equipment	5,613,000	
13	Instrumentation	500,000	
15	Mechanical Components	4,603,800	
16	Electrical	2,063,000	
	SUBTOTAL	29,921,000	
	Contingency	1,496,000	
	TOTAL	31,417,000	

PROJECT XYZ WWTP (25% Design)

ITEM CONSTRUCTION COST MODEL

COST (OR ENERGY) MODEL

TEAM NO. 1 **SHEET** 1 **OF** 1

ABC, Inc.

Check one; use one sheet for each. Indicate present worth or annual.

- [x] **Construction Costs**
- [ ] **O&M Costs**
- [ ] **Replacement/Salvage Costs**
- [ ] **Energy Costs**
- [ ] **Electrical in kwh**

Legend: COMPONENT OR SYSTEM | ESTIMATE | WORTH

COMPONENT OR SYSTEM	ESTIMATE	WORTH
SUBTOTAL	29,921,000	21,010,000
CONTINGENCY	1,496,000	1,050,000
= TOTAL	31,417,000	22,060,000

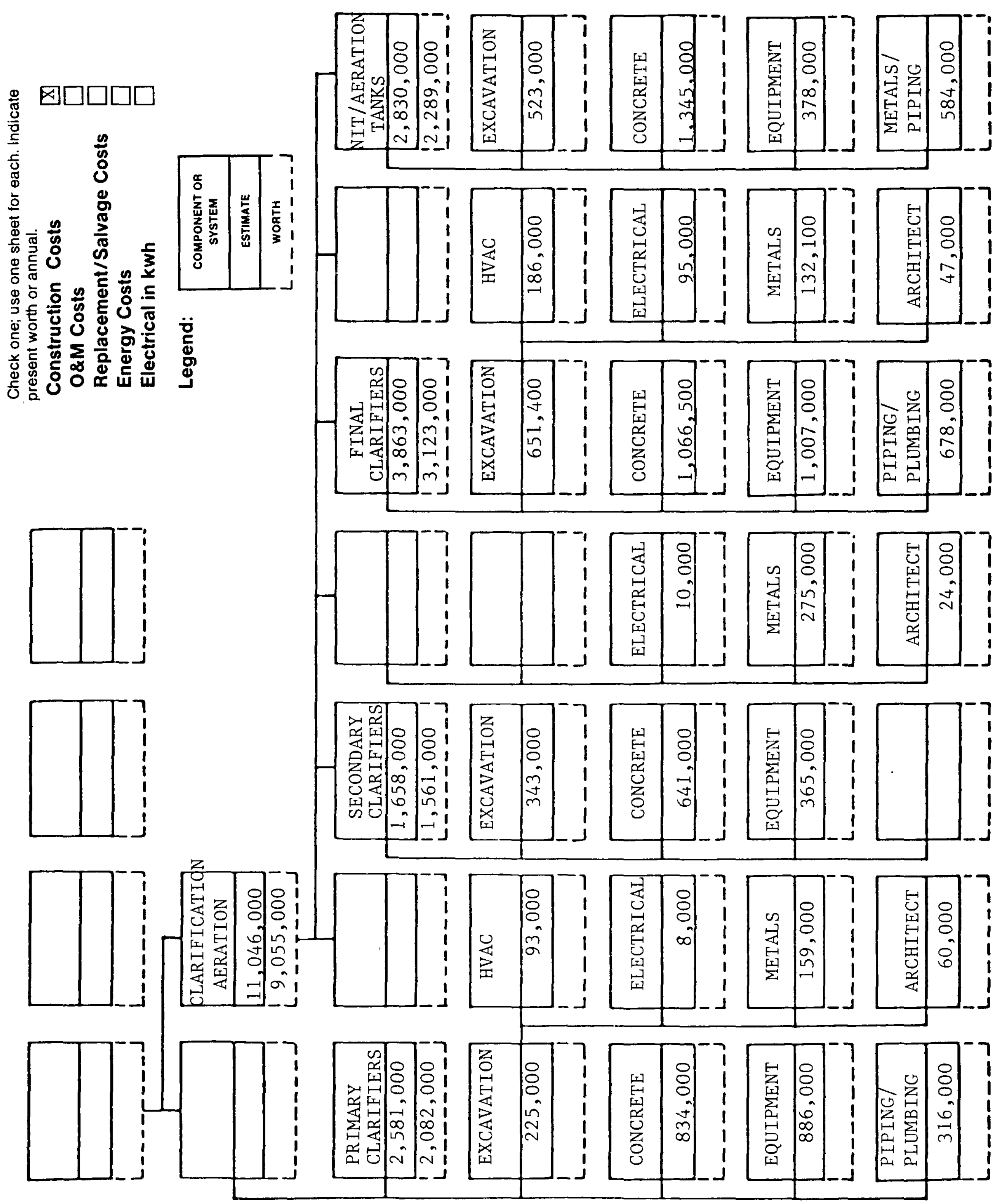
COMPONENT OR SYSTEM	ESTIMATE	WORTH
GENERAL & SITEWORK	3,002,000	2,678,000
SITEWORK	480,000	390,000
YARD PIPING	1,033,000	910,000
YARD ELECTRIC	839,000	728,000
INSTRUMENTATION	500,000	500,000
START-UP & TEST	150,000	150,000

COMPONENT OR SYSTEM	ESTIMATE	WORTH
PROCESS	26,919,000	18,332,000
HEADWORKS	114,000	110,000
R.S. JUNCTION CHAMBER	53,000	53,000
R.S. METER/WEIR BOX	61,000	57,000
* CLARIFICATION/AERATION	11,046,000	9,055,000
PRIMARY	2,581,000	2,082,000
SECONDARY	1,658,000	1,561,000
FINAL	3,863,000	3,123,000
NIT/AERATION TANK	2,830,000	2,289,000
SLUDGE THICKENING	2,716,000	317,000
THICKENER MODS	728,000	317,000
FLOATATION THICKENER	1,988,000	-0-
BUILDINGS	5,689,000	3,850,000
BLOWER BUILDING	1,488,000	1,145,000
CONTROL RM. EXPANSION	982,000	416,000
ODOR CONTROL BUILDING	1,964,000	1,249,000
E.F. CONTROL BUILDING	1,255,000	1,040,000
EXCESS FLOW BASIN	7,354,000	5,000,000

* Further breakdown in subsequent model.

WS-2A

PROJECT XYZ WWTP (25% Design)	COST (OR ENERGY) MODEL
ITEM CONSTRUCTION COST MODEL FOR CLARIFICATION/AERATION SYSTEM	TEAM NO. 1 SHEET 1 OF 1
	ABC, Inc.



PROJECT XYZ WWTP (25% Design)

ITEM ENERGY UTILIZATION MODEL

COST (OR ENERGY) MODEL

TEAM NO. 1 **SHEET** 1 **OF** 1

ABC, Inc.

Check one, use one sheet for each. Indicate present worth or annual.

- **Construction Costs** ☐
- **O&M Costs** ☐
- **Replacement/Salvage Costs** ☐
- **Energy Costs** ☐
- **Electrical in kwh**/year ☒

Legend: COMPONENT OR SYSTEM / ESTIMATE / WORTH

Note: Power Cost 0.045 $/kwh

Component or System	Estimate	Worth
TOTAL PLANT POWER	36,479,094	31,272,810
= ANNUAL POWER COST	$1,641,559	$1,407,276
OPERATIONAL SUPPORT	4,941,595	4,073,425
PROCESS STREAM	31,537,499	27,199,385

OPERATIONAL SUPPORT

Component or System	Estimate	Worth
BUILDING LIGHTING	1,601,430	1,300,000
SITE LIGHTING	1,210,500	1,000,000
PLANT WATER	373,425	373,425
ODOR CONTROL	1,756,240	1,400,000

PROCESS STREAM

Component or System	Estimate	Worth
PRELIMINARY	2,628,125	2,584,325
INFLUENT PUMPS	2,240,500	2,240,500
EQUAL. BASIN	243,800	200,000
SCUM	140,925	140,925
SCREENS & SUMP PUMPS	2,900	2,900
PRIMARY	1,299,790	1,299,790
CHANNEL BLOWERS	816,870	816,870
CLARIFIERS	61,190	61,190
SLUDGE PUMPS	420,100	420,100
SCUM	1,630	1,630
SECONDARY	10,675,194	9,661,000
AERATION BLOWERS	9,335,660	8,400,000
CLARIFIERS	294,074	280,000
RAS PUMPS	933,560	875,000
WAS/SCUM PUMPS	111,900	106,000
ADVANCED SECONDARY	10,324,430	8,666,890
AERATION BLOWERS	8,557,140	7,700,000
CLARIFIERS	65,350	65,350
RAS PUMPS	1,680,400	880,000
WAS/SCUM PUMPS	21,540	21,540
SLUDGE THICKENING	2,407,580	785,000
FLOTATION THICKENER	1,577,180	-0-
SLUDGE PUMPING	615,730	580,000
GRINDERS	140,000	135,000
MECHANISMS	74,670	70,000
DISINFECTION EFFLUENT	4,202,380	4,202,380
EFFLUENT FILTERS	3,621,640	3,621,640
POST AERATION	567,140	567,140
HYPO-CHLORITE	6,800	6,800
CHLORINE	6,800	6,800

PROJECT XYZ WWTP (25% Design)	ELECTRICAL ENERGY
ITEM PRELIMINARY/PRIMARY TREATMENT	TEAM NO. 1 SHEET 1 OF 1
and SECONDARY TREATMENT	ABC, Inc.

Equipment Description	Motors				Avg. Annual Operating Hours	Annual kwh	Peak Hourly Load (kw)
	No.	HP(ea)	Eff	No. On-Line			
Raw Sewage Pumps	3	200	70%	1.2	8,760	2,240,500	
H and V	2	15	80	1	8,760	140,035	
Sump Pump	2	7.5	70	1	2,000	15,985	
Air Compressor	2	7.5	70	1	1,000	10,660	
Sump Pump	1	10	70	1	1,000	10,660	
Screens	2	2	70	2	400	1,700	
Flush Pump/Nozzle	1	125 + 40	70	1	1,250	219,800	
Dewatering Pumps	1	5	70	1	4,500	24,000	
Clarifier Collectors	9	0.5	75	9	8,760	42,010	
Cross Collectors	9	0.5	70	9	4,000	19,180	
Scum Collectors	9	0.5	75	9	365	1,630	
Sludge Pumps	6	15	70	3	8,760	420,100	
Sump Pump	1	0.75	70	1	300	300	
Secondary							
Blowers	4	500	70	2	8,760	9,335,600	
Clarifier Collectors	12	0.5	60	12	8,760	65,350	
Cross Collectors	12	0.5	70	12	8,760	76,240	
Scum Collectors	24	0.5	70	24	8,760	152,480	
RAS Pumps	4	50	70	2	8,650	933,650	
WAS Pumps	4	15	70	2	3,000	95,900	
TOTALS	(this	sheet)				13,805,780	

Three additional sheets not included

D3-15
Sample

WS-3

PROJECT XYZ WWTP (25% Design)

MAJOR UNIT OR ITEM TOTAL FACILITY WORKFORCE

O&M LABOR

TEAM NO. 1 SHEET 1 OF 1

ABC, Inc.

Classification	Number	Annual Salary	Annual Cost
Superintendent	1	30,000	30,000
Assistant Superintendent	1	25,000	25,000
Chief Operators	4	20,780	83,120
Operator 3's	4	18,387	73,550
Operator 4's	2	17,330	34,660
Operator Trainees	2	15,000	30,000
Plant Mechanics	2	20,050	40,100
Laborers	5	17,621	78,105
Summer Help	2	2,240	4,420
SUBTOTAL	23		398,955
Overtime			51,100
Longevity			5,230
SUBTOTAL			455,285
Fringes (44%)			200,325
TOTAL LABOR COST			$655,610

Sample

PROJECT XYZ WWTP (25% Design)	**O&M CHEMICALS**
ITEM TOTAL FACILITY CHEMICAL USAGE	TEAM NO. 1 SHEET 1 OF 1
	ABC, Inc.

Unit Process ↓	Type of Chemical Hydrogen Peroxide				Type of Chemical NaCl				Type of Chemical Sodium Hydroxide			
	Avg. Units/ Day	Annual Units	Unit Cost	Annual Cost	Avg. Units/ Day	Annual Units	Unit Cost	Annual Cost	Avg. Units/ Day	Annual Units	Unit Cost	Annual Cost
PRIMARY CLARIFIERS	1350 lbs	492,750	0.35	172,500	910 lbs	332,150	0.02	6600	80 lbs	29,200	0.20	5800
GRAVITY THICKENERS					180 lbs	65,000	0.02	1300	16 lbs	6,000	0.20	1200
TOTALS												

Unit Process ↓	Type of Chemical CHLORINE				Type of Chemical SODIUM HYPOCHLORITE				Type of Chemical CATIONIC POLYMER			
EFFLUENT DISINFECTION	815 lbs	297,500	0.08	23,800								
EXCESS FLOW BASIN DISINFECTION						3200 gals	0.50	1600				
GRAVITY THICKENERS										246,000 lbs	1.23	302,600
TOTALS												

WS-4B

PROJECT XYZ WWTP (25% Design)	LIFE CYCLE COST SUMMARY No.
ITEM TOTAL FACILITY	TEAM NO. 1 SHEET 1 OF 1
	ABC, Inc.

INITIAL CONSTRUCTION COST Reference WS-2A $31,417,000

CATEGORY	COMMENT/CALCULATION	COST Annual	COST Present Worth
Electricity			
• Motors	Reference WS-3 (33,667,164 kwh/yr)	$1,515,022	14,953,267
• Lighting	Reference WS-3 (2,811,930 kwh/yr)	126,537	1,248,920
Other Utilities			
• Water	Unit Cost of $1.50 per 1000 gallons	12,000	118,440
• Natural Gas	Unit Cost of $1.307 per therm	170,000	1,677,900
• Fuel Oil	Gasoline for plant vehicles	2,000	19,740
• Steam		None	-0-
Chemicals	Reference WS-4B	515,400	5,086,998
Other			
• Sludge Disposal	Landfilled; $13x10^6$ gal/yr; 20% solids	540,000	5,329,800
• Equipment Rental/Repair		130,500	1,288,035
• Miscellaneous	Contract labor, insurance, supplies, telephone	196,900	1,943,403
Labor	Reference WS-4A	655,610	6,470,871
Replacement	Reference WS-4C	34,000	335,580

TOTAL LCC $69,889,954

Speculative/Creative Phase

This step in the VE workshop involved developing creative ideas. The VE team recorded all conceivable methods of providing the necessary functions within the project at a lower cost to the owner; or with an improvement to the project quality. Many of the ideas were generated during the function analysis by determining the worth of ...

PROJECT XYZ WWTP (25% Design)

ITEM Wastewater Treatment Facility

BASIC FUNCTION REMOVE POLLUTANTS

FUNCTION ANALYSIS No. 1

TEAM NO. 1 **SHEET** 1 **OF** 2

ABC, Inc.

Function Analysis

Sub Component Description	Function: Verb	Function: Noun	Function: Kind[1]	Initial Cost[2] (In thousands)	Worth[3] (In thousands)	Cost/Worth	Comments
Excess flow basin	Equalize	Flow	RS	7,354	4,996	1.5	Cost estimate low
Control Building	House	Equip.	RS	1,255	1,040	1.2	
Primary Clarifiers	Settle	Solids	B	2,581	2,082	1.2	Reduce Number
Secondary Clarifiers	Settle	Solids	B	1,658	1,561	1.1	Eliminate intake weirs
NAS (Nitrification Aeration System)	Remove	Ammonia	B	2,830	2,289	1.3	
Blowers	Support	Process	B	1,488	1,145	1.3	Reduce building volume
Final Clarifiers	Settle	Solids	B	3,863	3,123	1.3	Reduce number
Control Room	Support	Process	RS	982	416	2.4	$1,386/SF;$62/SF Building
Odor Control	Eliminate	Odors	RS	1,964	1,249	1.6	Use modular system
Gravity Thickeners	Concent.	Sludge	B	317	728	<1	Add thickeners
Flotation Thickeners	Concent.	Sludge	RS	1,988	-0-	∞	Eliminate

[1] B = Basic Function
S = Secondary Function

[2] Original Cost Estimate

[3] Worth - Least Cost to Accomplish Function.

(Continued on Sheet 2)

PROJECT XYZ WWTP (25% Design)

ITEM Wastewater Treatment Facility

BASIC FUNCTION REMOVE POLLUTANTS

FUNCTION ANALYSIS No. 1

TEAM NO. 1 **SHEET** 2 **OF** 2

ABC, Inc.

Function Analysis

Sub Component Description	Function			Initial Cost[2] (In thousands)	Worth[3]	Cost/ Worth	Comments
	Verb	Noun	Kind[1]				
Instrumentation	Control	Process	B	500	500	1	
Raw Sewage Junction Chambers	Divert	Flow	S	53	53	1	Appears low
RS Meter & Weir Box	Measure	Flow	S	61	57	1.1	
Yard Piping	Convey	Waste	RS	1,033	910	1.1	
Site Electrical	Distr-bute	Energy	B	839	728	1.2	
Site Work	Provide Prepare	Access Space	RS	480	390	1.2	
Start-up & test	Verify	Operation	S	150	150	1	
		SUBTOTAL		29,396	21,417		
	CONTINGENCY			1,470	1,071		
		TOTAL		30,866	22,488	1.4	

[1] B = Basic Function
S = Secondary Function

[2] Original Cost Estimate

[3] Worth - Least Cost to Accomplish Function.

PROJECT XYZ WWTP (25% design)

ITEM Speculative/Creative Phase

CREATIVE/EVALUATION No.____

TEAM NO. 1 **SHEET** 1 **OF** 5

ABC, Inc.

CREATIVE		EVALUATION		
NO.	**IDEA**	**ADVANTAGES**	**DISADVANTAGES**	**RATINGS***
	RAW SEWAGE JUNCTION CHAMBER (JC)			
JC-1	Use gates rather than butterfly valves	Improve function	Flow control More maintenance	8
JC-2	Review constructability while operating			9
JC-3	Use control gate on flume and weir to excess flow facilities	Improve function fewer problems		10
JC-4	Provide 2 Parshall flumes to plant	Improve metering turn down		5
JC-5	Review size and number of pipes to excess flow	Reduce head loss; improve operability		10
JC-6	Slope pipe to excess flow facilities to improve clean out	Combine with JC-5		
JC-7	Consider larger flow split box for energy dissipation at high flows	Improve function	Redesign cost	DS
JC-8	How will flow splitter box be expanded in future	Provide flexibility		DS
JC-9	Second pipe to splitter box	Emergency operation; construtability		DS
	EXCESS FLOW BASIN (EF)			
EF-1	In system storage	Reduce cost	Feasibility	5

*10 = MOST FAVORABLE 1 = LEAST FAVORABLE NOTE: DS = design suggestion

PROJECT XYZ WWTP (25% design)

ITEM

CREATIVE/EVALUATION No.

TEAM NO. 1 **SHEET** 2 **OF** 5

ABC, Inc.

CREATIVE		EVALUATION		
NO.	**IDEA**	**ADVANTAGES**	**DISADVANTAGES**	**RATINGS***
EF-2	Paved sloped bottom basins	Improved function		8
EF-3	Lagoon	Reduce cost	Odor control	3
EF-4	Rubber liner rather than concrete	Reduce cost	Maintenance	3
EF-5	Swirl concentrator	Reduce cost	Acceptance	5
EF-6	Raise tank to reduce excavation	Reduce cost		8
EF-7	Fence rather than railing	Reduce cost; improved security	Aesthetics	9
EF-8	Expand primary settling	Reduce cost	Criteria change	5
EF-9	Store first flush-swirl concentrate rest	Reduce cost	Acceptance	5
EF-10	Make storage chambers 1,2,3 & 4 into one	Reduce cost		8
EF-11	Eliminate wall between basins 3&4	Reduce cost		10
EF-12	Lower wall heights between basins	Improve function		9
EF-13	Eliminate weir into chlorination tank; use wall opening	Reduce cost		10
EF-14	Inverted cone tank	Reduce cost	Redesign	10

*10 - MOST FAVORABLE 1 = LEAST FAVORABLE

PROJECT XYZ WWTP (25% design)

ITEM

CREATIVE/EVALUATION No.

TEAM NO. 1 **SHEET** 4 **OF** 5

ABC, Inc.

CREATIVE		EVALUATION		
NO.	**IDEA**	**ADVANTAGES**	**DISADVANTAGES**	**RATINGS***
PC-1	Reduce number of tanks	Reduce cost		8
PC-2	Review train concept	Simplify operation		8
PC-3	Check soluble BOD of pharmaceutical wastes	Review with PC-1		
PC-4	Use concrete planks vs. checker plates for tank covers in selected areas	Reduce cost		8
	SECONDARY CLARIFIERS (SC)			
SC-1	Remove weirs on inlet end and check effluent weir length			NA
SC-2	Revise influent channel	Improve function		DS
SC-3	Remove walkways and handrail every other tank	Reduce cost	Some loss of convenience	9
SC-4	Add metering for RAS for clarifiers 9-12	Improve function		DS
SC-5	Use concrete planks vs. checker plates in selected areas	Reduce cost		8
	EXISTING BLOWER BUILDING (EBB)			
EBB-1	Use centrifugal blowers for carbonaceous aeration	Reduce cost Improve maintenance		DS
	NITRIFICATION AERATION SYSTEM (NAS)			

*10 = MOST FAVORABLE 1 = LEAST FAVORABLE

VALUE ENGINEERING REPORT
XYZ WASTEWATER TREATMENT PLANT
SANITARY DISTRICT
USA
25% DESIGN COMPLETION STAGE

April 1984

SECTION 4

SUMMARY OF RESULTS

4.1 GENERAL

The results are the central feature of a VE study since they represent the benefits which can be realized by the owner and the designer. The results will directly affect the project design and require coordination between the designer and the owner's design and operations staff to determine the implications of each proposal. The results of this VE study are contained in the recommendations included in this section of the report. Also included are VE design suggestions.

The development of a recommendation consists of a summary of the preliminary design, a life cycle cost comparison and a descriptive evaluation of the advantages and disadvantages of the proposed recommendation. Each recommendation included in this report is accompanied by a brief narrative to compare the original design and the proposed change. Sketches, where appropriate, are also presented. The comparisons reflect unit quantities, wherever possible, as well as overall cost. A breakdown of cost is provided and life cycle cost savings are shown.

When reviewing study results, it is important to consider each part of a recommendation on its own merits. There is often a tendency to disregard a recommendation because of concern regarding one portion of it. However, consideration should be given to the areas within a recommendation that are acceptable and those parts should be applied to the final design ...

DATE: 4-15-84	BY: ABC, Inc.	PROJECT: XYZ WWTP	SUBJECT: VE (25% Design)	CLIENT: Sanitary District	PAGE 1 OF 3

SUMMARY OF POTENTIAL COST SAVINGS FROM VE RECOMMENDATIONS

ITEM NO.	DESCRIPTION	PRESENT WORTH COST SAVINGS				
		ORIGINAL COST	PROPOSED COST	INITIAL COST SAVINGS	O & M COST SAVINGS	TOTAL COST SAVINGS
	RAW SEWAGE JUNCTION CHAMBER (JC)					
JC-1	Use sluice gates in lieu of butterfly valves	53,000	52,000	1,000	IMPROVED	1,000
JC-3	Use control gate on flume.	52,000	15,000	37,000	7,700	44,700
JC-5	Review size & number of pipes to excess flow					
	basin	362,600	170,000	192,600	-0-	192,600
	EXCESS FLOW BASIN (EF)					
EF-2	Construct excess flow basin w/paved sloping					
	surfaces	3,950,000	1,715,000	2,235,000	-0-	2,235,000
EF-7	Use chain link fence instead of alum.handrail	105,000	12,600	92,400	-0-	92,400
EF-10	Eliminate three division walls from basin	555,480	-0-	555,480	-0-	555,480
EF-12	Eliminate one division wall from basin	185,160	-0-	185,160	-0-	185,160
EF-13	Lower wall height between chambers	912,000	360,000	552,000	(44,400)	507,600
EF-15	Eliminate weir into chlorine contact chamber	2,000	-0-	2,000	-0-	2,000
EF-16	Re-configure excess flow basin design	6,407,000	4,334,000	2,073,000	(49,350)	2,023,650
EF-18	Eliminate Parshall flume. Use weir.	32,220	8,000	16,220	-0-	16,220
EF-19	Reduce freeboard of the excess flow basin	2,150,000	2,106,000	44,000	-0-	44,000
EF-24	Lower grading around excess flow basin	105,000	-0-	105,000	IMPROVED	105,000
	EXCESS FLOW CONTROL BUILDING (EFC)					
EFC-1	Delete one flushing water pump.	32,000	22,500	9,500	IMPROVED	9,500
EFC-2	Reduce size of basement & increase above					
	grade structure	813,700	298,764	514,936	IMPROVED	514,936

D4-3 Sample

DATE	BY:	PROJECT:	SUBJECT:	CLIENT:	PAGE 2
4/15/84	ABC, Inc.	XYZ WWTP	VE (25% DESIGN)	Sanitary District	OF 3

SUMMARY OF POTENTIAL COST SAVINGS FROM VE RECOMMENDATIONS

ITEM NO.	DESCRIPTION	PRESENT WORTH COST SAVINGS				
		ORIGINAL COST	PROPOSED COST	INITIAL COST SAVINGS	O & M COST SAVINGS	TOTAL COST SAVINGS
	PRIMARY CLARIFIER (PC)					
PC-1	Reduce number of tanks required	2,581,000	1,032,000	1,549,000	86,070	1,635,070
PC-2	Review flow train concept					
PC-4	Provide concrete planks instead of checkered					
	plate covers in selected areas	51,200	7,200	44,000	-0-	44,000
	SECOONDARY CLARIFIERS (SC)					
SC-3	Remove walkway & handrail every other tank	33,325	-0-	33,325	-0-	33,325
SC-5	Provide concrete planks instead of checkered					
	plate covers in selected areas	64,000	9,000	55,000	-0-	55,000
	NITRIFICATION AERATION SYSTEM (NAS)					
NAS-1	Relocate north gallery adjacent to nitrifica-					
	tion tanks	40,100	-0-	40,100	IMPROVED	40,100
NAS-5	Substitute WYSS diffuser for coarse bubble					
	aeration devices	-	-	-	1,428,600	1,428,600
NAS-13	Consolidate nitrification tank mixing chambers	149,000	47,800	101,200	-0-	101,200
NAS-16	Reverse orientation of mixing chambers to					
	facilitate future expansion				DESIGN	SUGGESTION
	FINAL CLARIFIERS (PC)					
PC-6	Improve final clarifier sludge removal	40,000	-0-	40,000	IMPROVED	40,000
	DISSOLVED AIR FLOTATION THICKENERS (DAF)					
DAF-1	Delete dissolved air flotation thickeners	1,293,000	486,200	806,800	636,400	1,443,200

D4-4
Sample

PROJECT XYZ WWTP (25% Design)	VE RECOMMENDATION No. JC-5
ITEM REVIEW SIZE AND NUMBER OF PIPES TO EXCESS FLOW BASIN	TEAM NO. 1 SHEET 1 OF 1
	ABC, Inc.

ORIGINAL: (Attach sketch where applicable)

Flow from the junction chamber to the retention basin is via 2-48 inch pipelines. The maximum headloss at 90 MGD is some 7 feet, meaning the excess flow basin must be placed deep into the ground.

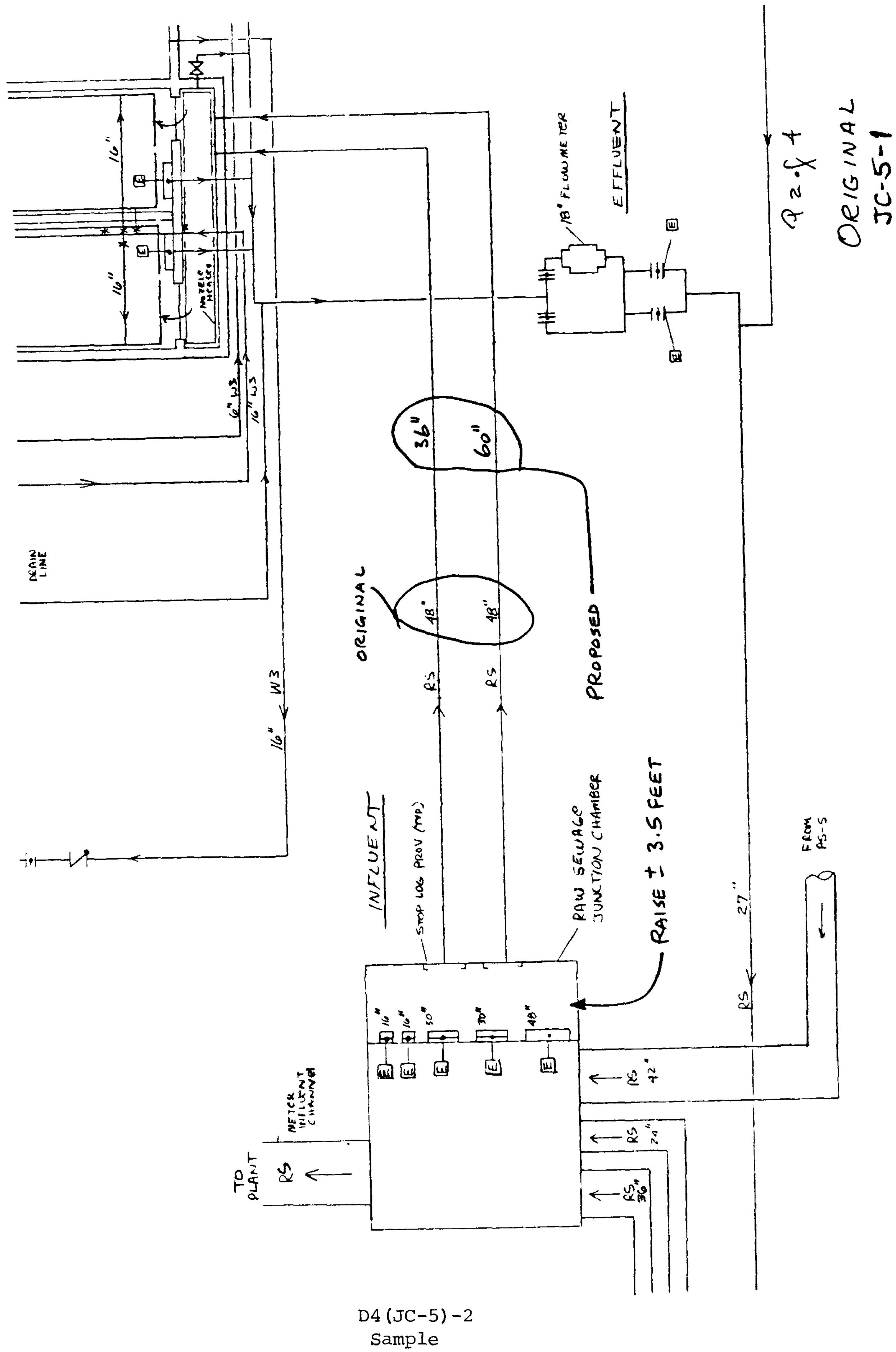
(See attached sketch JC-5-1)

PROPOSED: (Attach sketch where applicable)

Change the pipeline sizes to 1-36" diameter and 1-60" diameter to reduce headloss from 7 feet at maximum flow conditions to about 3.5 feet. The result is that the tanks may be raised some 3.5 feet. Scouring velocities are maintained by using a smaller pipe for low flow conditions and a larger pipe for higher flows. (See attached sketch JC-5-1)

DISCUSSION:

LIFE CYCLE COST SUMMARY	PRESENT WORTH COSTS		
	INITIAL COST	O & M COSTS	TOTAL
ORIGINAL	362,600	-0-	362,600
PROPOSED	170,000	-0-	170,000
SAVINGS	192,600	-0-	192,600



D4(JC-5)-2
Sample

CALCULATION SHEET

Subject: XYZ WWTP (25% DESIGN)

Date: 4/13/84

No.: JC-5

Calculations By: ABC, Inc.

FLOW CONDITIONS ASSUMED FOR CONVEYANCE INTO EXCESS FLOW BASIN:

LOW FLOW 4 MGD
HIGH FLOW 90 MGD

ELEVATION AT JUNCTION BOX 679.10

LENGTH OF PIPE TO EXCESS FLOW BASIN 1000 LF

PRESENT ELEVATIONS (BACKED-UP FROM BASIN)

	J.B.	BASIN	HL	
90 MGD	679.10	672.72	6.38	← MAX LOSS
50 MGD	674.93	672.49	2.44	
4 MGD	672.67	672.10	0.57	

ASSUME A MAXIMUM OF 2.5' HEADLOSS

$$\therefore \; 2.5'/1000 = \frac{0.25'}{100} = 66''\phi \text{ at } 90 \text{ MGD}$$

ASSUME A SMALLER PIPE FOR FLOWS UP TO 20 MGD.
USE 36" ϕ.

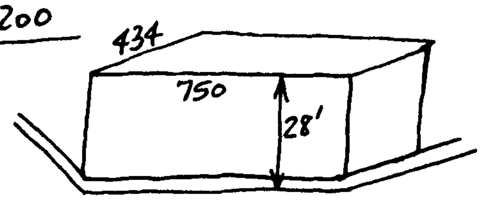
$Q_{BIG\ PIPE\ (60''\phi)}$ = 90 − 20 MGD = 70 MGD   USE 60" ϕ.

REDUCED HEADLOSS ALLOWS RAISING OF TANK BOTTOM BY 3.5 FEET.

EXCAVATION ON SIDE SLOPES 10,950 cy

$$\frac{(750)(434)(3.5)}{27} = 42,200$$

53,150 cy
× $4
$212,600



XYZ WWTP (25% DESIGN) 4/13/84 JC-5
Subject Date No.

ABC, Inc.
Calculations By

PIPELINE 1 — FOOTAGE (PCCP PIPING)

ORIGINAL	2 at 48" φ	2000	$75	$150,000	
	1 at 36" φ	1000	50	50,000	} 170,000
	1 at 60" φ	1000	120	120,000	

ORIGINAL

EXCAVATION	212,600
2 at 48"	150,000
	$362,600

NOTE: SOME DEWATERING SAVINGS MAY ALSO BE POSSIBLE.

PROPOSED

1 - 36" φ } $170,000
1 - 60" φ }

Δ = 192,600

PROJECT XYZ WWTP (25% Design)	**VE RECOMMENDATION** No. EF-19
ITEM REDUCE FREEBOARD OF THE EXCESS FLOW BASIN	**TEAM NO.** 1 **SHEET** 1 **OF** 1
	ABC, Inc.

ORIGINAL: (Attach sketch where applicable)

The top of the perimeter wall is at elevation 674.00. The water surface at maximum flow is at elevation 672.72 and at full flow it is at elevation 672.10. Corresponding freeboards are 1.28' and 1.90'.

PROPOSED: (Attach sketch where applicable)

Reduce elevation of top of perimeter wall to 673.5', resulting in a reduced freeboard of 0.78' (maximum flow) and 1.40 (full flow).

DISCUSSION:

Freeboard is required only for wave action and to contain pile-up of floatables. The freeboard provided after the proposed change is 1.4' under full flow and 0.78' under maximum flow. These are judged to be sufficient.

LIFE CYCLE COST SUMMARY	PRESENT WORTH COSTS		
	INITIAL COST	O & M COSTS	TOTAL
ORIGINAL	2,150,000	-0-	2,150,000
PROPOSED	2,106,000	-0-	2,106,000
SAVINGS	44,000	-0-	44,000

APPENDIX E

SAMPLE FINAL VE REPORT

FINAL VALUE ENGINEERING REPORT
SECOND VE STUDY (70%)
CITY OF MNO
EPA GRANT NO. C-000000-000

June 1984

OWNER

MNO SANITARY DISTRICT

DESIGNER

Y AND Z ASSOCIATES, INC.
USA

VE CONSULTANT

DEF, INC.
USA

SECTION 1

INTRODUCTION

PROJECT

The City of MNO's proposed wastewater treatment project involves improvements to the existing activated sludge treatment process and expansion of the facility's average capacity from 20 MGD to 30 MGD.

The estimated total construction cost for the project prior to the VE study was $14,500,000.

VE STUDY

The results of the first and second VE study are summarized below in Table 1. The total project capital savings achieved from the two studies was approximately 11% of the project's original construction cost estimate. The present worth of the O&M savings represents approximately 6% of the project's original construction cost. The first and second study were conducted at the 25% and 70% stage of the project's design, respectively.

This Final VE Report presents the results of the second VE study performed by DEF, Inc. It completes the VE effort on the City's proposed wastewater treatment project. Table 2 of this report contains the responses to each of the VE recommendations developed during the 70% VE workshop. The redesign costs and implementation schedule for all accepted VE recommendations are contained in Table 3.

A copy of the VE Report from DEF, Inc. is appended.

COST SAVINGS

Total estimated savings from the implementation of the accepted VE recommendations are summarized below:

Table 1

	Initial (Capital) Savings	Present Worth (O&M) Savings	Total Present Worth Savings
25% Study	$1,120,000	$320,000	$1,440,000
70% Study	450,000	530,000	980,000
TOTAL	$1,570,000	$850,000	$2,420,000

TABLE 2

SUMMARY OF VE RECOMMENDATIONS AND RESPONSE

VE Recommendation	Response	Initial Savings	Present Worth O&M Savings	Total Present Worth Savings
1. Reclaim & reuse existing D.I. and steel pipe.	Accepted	$25,000	-	$25,000
2. Eliminate standby power; use IP and L capability.	Accepted Option A	237,000	124,000	361,000
3. Delete main circuit breaker and current limit fuses, and reduce conduit size.	Partially Accepted	22,000	-	22,000
4. Use central computer for electrical load management.	Accepted	(-100,000)	342,000	242,000
5. Simplify slab placement sequence on clarifiers.	Accepted	27,000	-	27,000
6. Use 18-inch Class 50 D.I. pipe for the force main from Station A to the plant influent in lieu of 24-inch.	Rejected	35,000	-	35,000
7. Use Grade 60 reinforcing steel in lieu of Grade 40.	Accepted	211,000	-	211,000
8. Eliminate the berm and provide surface grading for drainage around settling tanks.	Accepted	34,000	-	34,000
9. Eliminate roof overhangs except at doors (Pretreatment Bldg.)	Accepted	5,000	-	5,000
10. Modify blower capacity for grit chamber.	Accepted	(-11,000)	64,000	53,000
11. Reduce bar screen divider walls.	Rejected	17,000	-	17,000

SECTION 2

RESPONSE TO VE RECOMMENDATIONS

2.1 RECOMMENDATION/RESPONSE

Item No. 1: Reclaim/Reuse Existing D.I. and Steel Pipe
Modify specifications to include an allowance for all D.I. and steel pipe which can be salvaged and reused on the project. All unused salvaged piping would be turned over to the City.

Response
Accepted.

Item No. 2: Eliminate Standby Power; Use IP and L
Eliminate the standby power generation system and make use of IP and L generating capability.

Response
During consideration of this recommendation, the original recommendation was rejected due to regulatory constraints; however, two different options were identified. These are as follows:

Option A: Install both proposed standby generators to allow start-up of the 1,750 hp effluent pumps. However, one 600 hp effluent pump drive unit will not be installed at this time since under the peak flow conditions of 60 mgd, the effluent can be pumped into the injection wells. The elimination of one effluent pump does not reduce the plant's total reliability but it will result in higher power costs in the early design years.

Option B: Install one generator in lieu of two proposed units. This would require EPA to permit less than 100 percent emergency generation and allow limited discharge of treated effluent into the Collection Basin. However, one generator would not be adequate for pumping untreated sewage during periods of power outage since two generators are needed to operate the 1,750 hp effluent pumps required for peak flows. The existing plant generator cannot be utilized in an automatic mode to substitute for one of the proposed units. This option reduces the overall plant maintenance reliability, and allows periodic discharge of treated effluent into the Collection Basin.

We recommend that Option A be implemented.

Item No. 3: Delete Main Circuit Breaker and Current Limit Fuses, and Reduce Conduit Size
The recommendation is to (1) delete the main circuit breaker at the motor control centers, (2) reduce conduit size to NEC standard, and (3) use intermediate grade conduit with socket connections.

Response
(1) Accepted.
(2) Rejected. The conduits are now sized to allow for future expansion.
(3) Accepted.

Item No. 4: Use Central Computer for Electrical Load Management

Response
Accepted.

Item No. 5: Simplify Clarifier Slab Placement Sequence

Reduce the number of pours on Clarifiers T-12A, B, and C from sixteen pours each to six pours each.

Response
Accepted.

ITEM NO. 6: Use 18-inch Class-50 Ductile Iron Pipe for the Station A to Plant Influent Force Main
Use 18-inch Class-50 ductile iron pipe on the downgrade section of the Section A to plant influent force main in lieu of the specified 24-inch pipe. Affected length is 7100 feet.

Response
Rejected. If the force main is reduced from 24 inches to 18 inches, the frictional head loss with a C-value of 100 is 57.7 feet, which is greater than the 44 feet of available static head. If the pipe is reduced, "pigging" will require a special tee and structure (cost $6,000).

Item No. 7: Use Grade-60 Reinforcing Steel
Use Grade-60 reinforcing steel in lieu of the specified Grade-40. Grade-60 is more common and available than Grade-40. The increase in allowable stress will reduce the amount of steel required.

Response
Accepted.

Item No. 8: Eliminate the Berm and Provide Surface Grading Around Final Settling Tanks
Eliminate the berm (diked area) and associated drainage swales and provide surface grading for drainage around the final settling tanks. The berm offers protection greater than that required since top of concrete is 14.5 feet and the 100-year flood level is projected to be 14.25 feet.

Response
Accepted.

Item No. 9: Eliminate Roof Overhangs Except at Doors

Response
Accepted.

Item No. 10: Modify Aeration Blower Capacity for Grit Chamber

Install four 7.5 HP positive displacement blowers instead of two 20 HP positive displacement blowers. Normal operation will be at flow of 10 MGD, requiring use of only 2 of 6 aerated grit chambers. One 7.5 HP blower can serve 2 grit chambers at approximately one-third the power cost of a 20 HP blower. As flow increases, add grit chambers in banks of two.

Response
Accepted.

Item No. 11: Reduce Size of Bar Screen Divider Walls

Response
Rejected. The 16-inch thickness downstream of the bar screens is dictated by the depth of grout pocket required at the bar screens for installation. Wall thickness of 6-inches and grout pocket of 10-inches is required between bar screens for installation of the specified type of bar screen.

2.2 DISCUSSION

COST DIFFERENCES

New cost estimates were developed for Item 2 since the accepted option is different from the VE recommendation.

SECTION 3

IMPLEMENTATION SCHEDULE AND REDESIGN COSTS

Table 3 summarizes calendar time for implementation and redesign costs.

TABLE 3

Item No.	Implementation Time	Redesign Costs
1	nil	0
2	3 weeks	3,500
3	1 day	600
4	3 weeks	4,000
5	1 day	700
6	--	--
7	4 weeks	3,500
8	1 week	1,500
9	1 day	500
10	1 week	1,800
11	--	--
	Total	$16,100

Implementation of these accepted recommendations will be concurrent with the normal design process and will not cause a delay in completion of the facility design.

*U.S. GOVERNMENT PRINTING OFFICE : 1984 0-461-221/24008