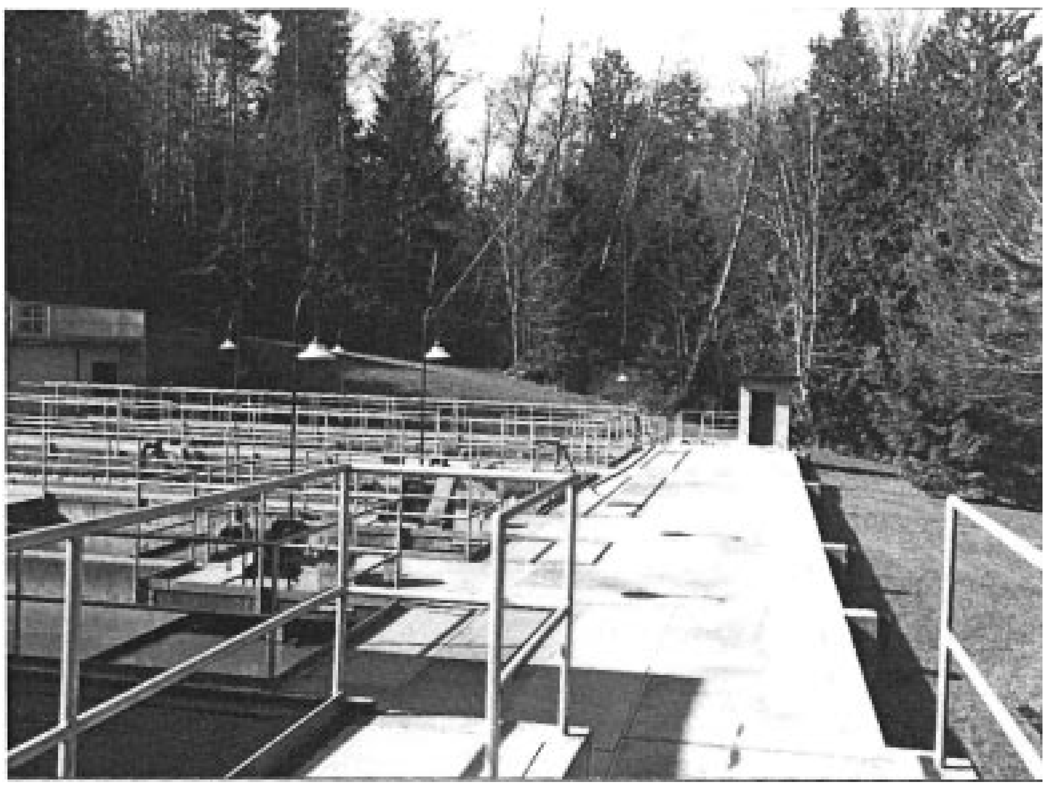
# *Value Engineering for Municipal Projects*



**Ministry of Community, Aboriginal and Women's Services**

# *Value Engineering for Municipal Projects*

Prepared by

UMA ENGINEERING LTD.

in association with

LEWIS & ZIMMERMAN ASSOCIATES, INC.

for

Ministry of Community, Aboriginal
and Women's Services

March 1995

# FOREWORD

The purpose of this guide is to provide municipal authorities with a description of Value Engineering and the Value Engineering process. It also provides a reference document for planning, contracting, and performing Value Engineering studies.

Value Engineering is a formal, organized procedure for assessing a project with the objective of finding alternatives that will provide the required functions at lower cost or increased reliability.

While Value Engineering is relatively new to British Columbia, it has been utilized elsewhere, principally in the United States. Applying the Value Engineering process has consistently delivered improved value to project owners.

Currently, government expenditures are being increasingly scrutinized by the public. In response to this demand for cost-effective designs and reduced life cycle costs, the Ministry of Community, Aboriginal and Women's services now requires a formal Value Engineering study for all water and sewer projects over $10 million that receive grants, and encourages its use on all projects.

Readers whose interest is whetted by this brief publication are referred to the bibliography for more information on Value Engineering.

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# 1. INTRODUCTION

## What Is Value Engineering?

Value Engineering (VE) is a proven management technique using an intensive, systematic, and creative study to seek the best functional balance between cost, reliability, and performance of a product, project, process, or service.

For a municipal project, the VE team selected to conduct a VE study is composed of a multi-disciplinary group of experienced and specialized professionals. They are independent of the design team and have experience in the field of the particular project to be studied. Working as an extension of the design team, the VE team analyses the project from a function/cost standpoint, providing alternative design suggestions that may affect initial construction costs, life cycle costs, construction methods or schedules, and flexibility in operating and maintaining the project. The common objective for all is to provide the most cost-effective, quality design for the owner.

## History

The concept of Value Engineering originated at the General Electric Company during World War II. Substitutions made to overcome shortages of materials and labour frequently reduced costs and improved the product. Since then, this technique has been refined and is widely used for cost/performance optimization of various products, processes, and projects. In 1976, the US Environmental Protection Agency mandated that all large wastewater treatment projects receiving program funding be subjected to a VE study.

Value Engineering is relatively new to British Columbia municipalities. Formal VE studies have been undertaken by only five municipalities between 1991 and 1994. The City of Kelowna was the first to employ structured, formal VE studies led by a Certified Value Specialist (CVS). The Greater Vancouver Regional District has also conducted several VE studies on projects to include secondary treatment processes in their wastewater facilities. Both municipalities are pleased with the outcome of their studies.

## Benefits and Goals of Value Engineering

For 50 years, engineers and manufacturers have amply demonstrated that the use of VE techniques can improve value, reduce costs, and enhance the operation and reliability of products and projects. The strength and ultimate success of Value Engineering lie in its systematic, functional, and creative approach.

The complex nature of the design process leads to a high probability that most project designs contain unnecessary costs. The design process requires a group of talented technical professionals to consider many variables and alternatives within budget and schedule constraints. Numerous design options and details must be appraised and correlated, placing a limit on the time available to consider further options that have the potential to reduce costs.

Here are some common reasons that lead to unnecessary project costs:

- **Strict adherence to requirements:** Sometimes requirements are unrealistically specified without fully weighing their value. Where some features are not specified, designers usually make their own assumptions about the value of each. Since designers tend to be conservative, unnecessary costs may be included in the design. A challenge of deemed requirements may be appropriate.

- **Time constraint:** When a project is given approval to proceed, the owner usually wants to complete the design quickly and get on with construction. A tight design timeline can result in a perfunctory examination of alternatives and the adoption of a workable but not necessarily optimal design solution. Time is needed to consider alternative solutions and to make cost comparisons that will allow an owner to determine which solution offers the best value.

- **Standard designs:** Designers tend to reuse those design features or standards that worked well previously, whether devised by themselves or others. Although this practice minimizes risks, it can increase project costs by using design features that may be out-of-date, unnecessary, or inappropriate for the project.

- **Lack of creative ideas:** Occasionally a key idea results in an innovative design solution that is responsible for a substantial cost reduction. If the process does not encourage creative ideas, the design may contain excessive costs.

- **Budgetary constraint:** To maintain a design budget, a design team limits the number of design solutions they can examine. Drawing on past experience, a designer sometimes subjectively rejects a number of options, ones that might be adopted if they were more closely examined. Although a design budget represents a small proportion of the total facility cost, an inadequate design budget will adversely affect the total cost.

- **Technological change:** Processes, products, and materials are constantly changing, providing an opportunity for lower costs. Because of these rapid technological changes, no one can be completely current, even in their own field.

- **Political influences:** Politicians, administrators, and citizen groups often require certain design features. These features may be desirable but may not be the most cost-effective alternatives. Limited funding may also emphasize savings in initial costs rather than savings in the life cycle of a facility.

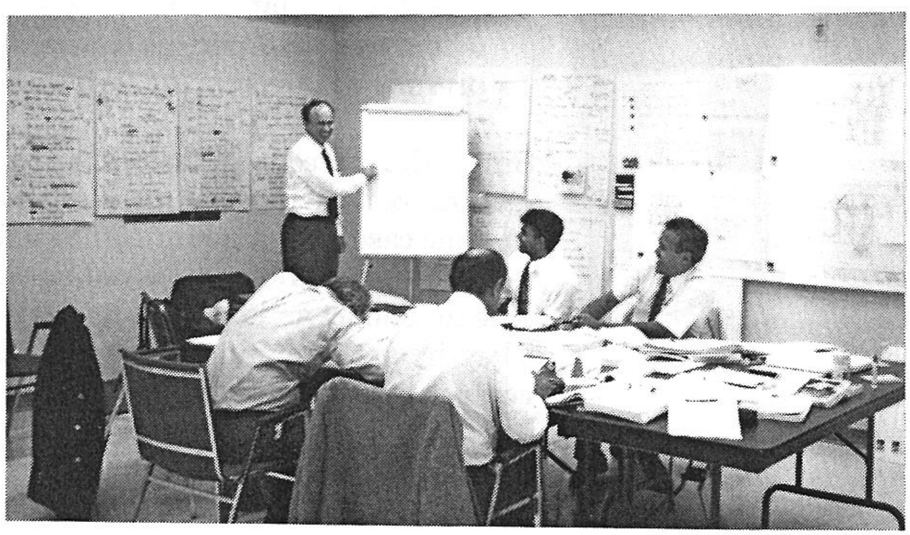
- **Temporary decisions that become permanent:** To advance the design or to maintain progress, the designer sometimes makes a temporary decision, intending to review this decision later. Such decisions can become permanent when time and budget constraints or other factors do not present an opportunity for reassessment.

Since the preceding factors are prevalent in most project designs, cost savings can probably be identified by a VE team. In some cases, the amount can be substantial. Because the VE team members are not involved in the original design, they are able to conduct an impartial review using a fresh point of view. They have the mandate and the opportunity to identify and compare design alternatives.

A VE study provides a number of potential benefits. A VE study:

- Induces preparation of construction cost estimates, thus increasing the owner's knowledge of project details and facilitating planning

- Generates capital cost savings while increasing reliability
- Significantly reduces operation and maintenance costs over the life of the facility
- Increases the sensitivity to and awareness of project costs
- Assures that overall design objectives are met and that the facility fits the master plan
- Enhances the skills of the designer and raises the overall level of expertise of the design professionals
- Improves communication and fosters understanding and team building among the various groups involved in the design process
- Increases the confidence of the owner and the designer that the design will give best value for the project budget and that the facility reliability and operability are satisfactory
- Achieves results with a relatively low expenditure of project funds and administrative effort, with typical results of $10.00 of savings for $1.00 spent on VE studies



# 2. The Value Engineering Study Approach

**Overview**

A VE study combines technical capability with a systematic approach. It is an in-depth cost study in order to achieve the function required by the owner at the lowest life cycle cost. The study focuses attention on the total life of the project, accounting for the impacts of the cost of money and the escalating costs of labour, fuels, power, and materials. Value Engineering is not something every good designer would ordinarily perform on all projects.

A major factor in a VE study's success is the leadership of a Certified Value Specialist (CVS). A CVS applies the VE methodology and coordinates the VE study activities, and this type of management reveals the difference between a VE study and a peer review or a cost cutting analysis. A peer review is usually limited to a technical review of the design without specific regard to costs or cost savings. A traditional cost-reduction analysis generally focuses on providing smaller quantities or less expensive materials. VE methodology, however, is responsible for identifying both savings and the improved performance of a facility. Experience shows that project studies that are not led by a CVS often resemble a peer review of the design in which the team may find errors in the plans but may not achieve the cost savings and enhanced operational reliability.

**Certified Value Specialist**

The Society of American Value Engineers administers and maintains a certification program for Value Engineering practitioners. To qualify to use the CVS designation, an engineer is required to take one 40-hour and one 24-hour training course, be a study team participant and team leader, devote a total of two years to the practice of Value Engineering within a four-year time period, pass a two-part written examination, and write a paper. To maintain the CVS standing, a specialist must devote 50 percent of his or her time to various facets of Value Engineering. Periodic participation in 24-hour skills upgrading workshops is also required.

For an up-to-date list of Certified Value Specialists contact:

Society of American Value Engineers
60 Revere Drive, Suite 500
Northbrook, Illinois 60062 USA
Phone: (708) 480-1730
Fax: (708) 480-9282

At the time of printing of this publication there is no Canadian body that provides a list of Certified Value Specialists.

**Team Composition**

The composition of team members is critical to the success of any VE study. The facility design to be analysed is invariably complex and entails a myriad of issues to be considered and reconsidered during the stages of planning, design, Value Engineering, and construction. Professionals with the appropriate background and experience are selected to cover particular facets of the project. Together the team provides a blend of practitioners who will enhance the value of the project under the leadership of a CVS.

A typical VE team for a water or wastewater treatment plant would be comprised of the following:

- Certified Value Specialist
- Structural engineer
- Process/operations specialist
- Civil/site designer
- Electrical/instrumentation specialist
- Mechanical engineer
- Cost/constructibility specialist

The VE team for other types of projects will include a mix of professionals who reflect the disciplines involved in the project to be studied.

**Human Relations**

The way the VE team, owner, and designer deal with each other is an important element in a VE study. Good human relations are essential for success. The development of favourable attitudes and the acceptance of change sometimes require time. Adherence to the following tenets of social behaviour will help build support for the VE study process and results:

- Practise empathy in dealing with others.
- Recognize the individuality of all participants.
- Introduce new ideas tactfully.
- Demonstrate positive and dynamic action.
- Listen thoughtfully to other points of view.
- Display flexibility toward suggested changes.

Attention to good human relations must be a continuing effort, particularly on the part of the VE team. Otherwise there will be no enthusiasm for the VE recommendations. If no desirable changes are implemented, the exercise will be a wasted effort.

## Construction Contract Change Proposals

Value Engineering focuses on changes at the design stage. At the construction stage, contractors frequently find less expensive ways to construct projects while still achieving the function required by the owner. However, since normal contract changes will reduce the amount payable to the contractor and the proportionate share of profit, there is little incentive for the contractor to propose changes even though the owner could benefit from them.

To encourage contractors to submit cost-reducing ideas, the Government of the United States has implemented Value Engineering Change Proposals in its construction contracts. These promise a share of the savings to the contractor. The contractor may be paid for two types of savings.

The first is "instant savings," which arise directly from the performance of the contract. Instant savings are derived by taking the savings yielded by the contractor's cost-reducing proposal minus the development cost of the contractor's proposal and minus the government's cost of examining and implementing the change proposal. The sharing arrangement gives 55 percent of the instant savings to the contractor, and the government accrues the other 45 percent.

The second type of savings is "collateral savings." These result from savings realized by the government in the cost of operation, maintenance, logistical support, and government-furnished property by the implementation of a change proposal. The contractor's share is 20 percent of the estimated savings in a typical year of use but not exceeding the contract price or $100,000, whichever is greater.

Municipalities may wish to consider including such contractor incentive clauses in their construction contracts.

# 3. THE IMPORTANCE AND EVALUATION OF FUNCTION

**Function**

Whenever an owner builds a facility, the owner expects that it will perform a function at the cost which he or she is willing to pay for it. If the function is not provided, the facility is of no value, and no amount of cost cutting will improve its value.

Any action that sacrifices the required function reduces the value to the owner. However, if the facility (or project) provides functions beyond the actual needs of the owner, the unnecessary functions are likely of low value to the owner. Thus, anything less than the desired performance is unacceptable; anything more is unnecessary and wasteful. The challenge of function analysis is to identify and define true project needs.

**Function Analysis System Technique**

Function analysis is the cornerstone of Value Engineering, distinguishing it from a cost-reduction exercise. All members of the VE study team participate in function analysis because this step is essential and it assists the study team in its problem solving.

The technique applied in this step is the Function Analysis System Technique, or FAST. FAST helps people with various technical backgrounds to effectively communicate, interact, and resolve issues that require multi-disciplinary considerations.

The rules for FAST are few and appear deceptively simple. In order to be effective, they must be followed rigorously. The system links two simply stated words: a verb (reduce, generate, pump, control, support, etc.) and its noun object (contaminants, temperature, liquid, load, sound, etc.) in order to describe the functions of each component of a complex project. The functions are divided into basic and secondary. A basic function defines a performance feature that must be attained. A secondary function defines a performance feature other than those that must be accomplished.

A good deal of discipline and critical appraisal are needed to derive a FAST model, which defines function simply and logically. Simple expressions of each function help participants with various levels of training and experience to understand complex subjects.

For more information about FAST and developing a FAST model, see Appendix A.

# 4. Conducting a Value Engineering Study

**Overview**

To be successful, a VE study requires the cooperative participation of three primary parties: the project owner, the project designer, and the VE specialist. The goal of all three must be identical -- to derive a final design for the facility that represents the most efficient combination of cost, performance, and reliability.

The project owner sets the tone for the effort. The owner must communicate full support of the VE process for the achievement of the goal. The skill of the VE specialist and the organization of the VE study as well as the attitude and cooperative spirit of the participants are the other contributing factors that produce a successful study. 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 under design.

The VE methodology is based on three specific phases:

- Prestudy preparation phase
- Project study workshop phase
- Post workshop phase

At the end of the description of these three phases, there is a flow diagram outlining the tasks involved (pages 16 and 17).

**Study Duration**

The VE workshop lasts from a minimum of three days to a maximum of five days. In some instances, particularly where there is limited information for a discipline, the discipline specialist attends only a portion of the workshop.

**Prestudy Preparation Phase**

Good coordination of the VE effort contributes to the study's success. A meeting is usually held with the owner, the designer, and the VE team leader to promote a common level of understanding about the objectives of the VE workshop, to confirm the schedule of events, and to review the information needed for the workshop. The designer is left with a list of information required by the VE team.

As can be expected, designers are sometimes apprehensive about the VE process, feeling that it will be unduly critical of their work. It is the task of the VE leader to ease these fears. In essence, the VE team is acting as a creative extension of the designer. The VE team is analyzing the project from an objective function/cost perspective to see if any alternative approaches are feasible. All participants must understand that the main goal of the exercise is to yield a better project for the owner.

The VE team must become familiar with the project in a short time frame. The project data is collected and distributed for review *before* the formal workshop. The VE team reviews the distributed information and develops relevant questions for discussion with the project team after the designer's presentation of the project on the first day of the workshop.

Each owner and operating staff have their own set of value objectives in undertaking a project. The VE team must be aware of these value objectives so that their recommendations are in keeping with the requirements of the project. Examples of value objectives are noise or odour minimization, schedule compliance, operational simplicity, life cycle cost minimization, facility longevity, and aesthetics. The owner should articulate these objectives.

During the preparation phase, the VE team develops models of capital costs, energy costs, and life cycle costs, as appropriate. These models organize initial, energy, and life cycle costs by system and by trade to determine where high consumption and costs are prevalent. The models lead to a better understanding of the project.

There are two general types of cost models used. One type is a cost matrix, 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. An example of a cost matrix model is provided in Appendix B.

The other type of cost model is a functional cost model, which represents both estimated and target construction costs distributed by subsystem or functional area. The target cost is not determined until the VE workshop since it represents the VE team's estimate of the least cost needed to perform the function of each subsystem or functional area.

## Project Study Workshop Phase

The VE workshop takes place at a location convenient to the owner, the designer, and the VE team. Frequently it is held at the owner's premises near the project site.

Value Engineering is a systematic approach for searching out high cost areas in a design and arriving at the best balance between cost, performance and reliability. It is not a design review. A basic VE job plan is followed in all VE studies, and requires a positive attitude and willingness to bypass road blocks that thwart creative thinking.

The VE workshop begins with a kick-off meeting with the following agenda:

- Introduction
- Briefing on Value Engineering by VE team leader
- Presentation of the project design by the project designer
- Outline of project constraints
- Questions by VE team members for the designer

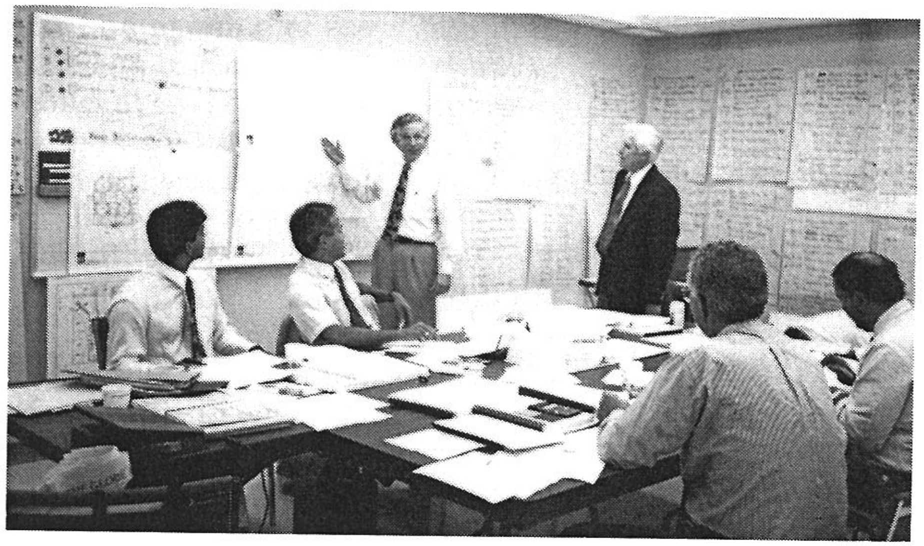
After the designer's oral presentation and the question-and-answer period, it is desirable for the owner and the designer to escort the VE team on a brief site visit. This first-hand viewing gives the VE team an improved understanding of existing conditions.

The VE team then proceeds with an intensive workshop comprised of the following phases:

- Information phase
- Creative phase
- Judgement phase
- Development phase
- Presentation phase

### *Information Phase*

The VE team familiarizes itself with the project plans and specifications in conjunction with the models for capital costs, energy costs, and life cycle costs. In developing the cost models during the preparation phase, the VE team leader has separated each of the major project elements into its parts. In the next step, the VE team undertakes a function analysis first of the project as a whole and then of each component part represented in the cost models. The intent is to justify each component and determine its functional requirements. Areas of high capital cost and high energy usage are also evaluated.



### *Creative Phase*

The VE team lists creative ideas generated from their review of the project. The aim is to obtain a large number of ideas from an association of ideas by eliminating the roadblocks that inhibit creative thinking. The team may use checklists from other studies to spur their creativity.

### *Judgement Phase*

The VE team analyses the ideas generated in the creative phase and selects the best ideas for further development. Each idea is assessed in the context of the owner's unique set of value objectives. The VE team reviews the idea list with the designer to discuss whether the ideas could be implemented and to benefit from the designer's experience on the project. Some ideas may be abandoned at this point if the designer demonstrates that the matter has already been sufficiently considered.

See Appendix B for a sample of a creative idea listing and the judgement, or evaluation, of those ideas.

### *Development Phase*

VE team members prepare alternative designs for consideration, with life cycle cost comparisons of the original designs and proposed alternatives. All recommendations are supplemented with written descriptions, sketches, basic design concepts, technical information, and cost summaries.

See Appendix B for a sample of a VE recommendation and four supporting documents.

### *Presentation Phase*

The VE team orally presents a summary of their findings to the owner and the designer. The team explains the basic ideas being recommended, cost information, and the rationale for each VE recommendation, along with the background information used to form the idea. All information generated by the VE team is given to the owner and the project designer at the end of the workshop so that they may review the recommendations. The presentation is not intended to be a design critique but rather a sharing of information and an exchange of knowledge.

See Appendix B for a sample of a summary of potential cost savings.

## Post Workshop Phase

Upon completion of the VE workshop, the VE team prepares a study report for the owner. The report is completed and submitted in a timely manner so that the design process may continue.

The owner and the designer consider the VE recommendations and jointly decide which items have merit and are to be implemented in a revised design. The redesign costs are paid by the owner.

The following flow diagram shows the tasks in each phase of a VE study.

# Value Engineering Study

## Prestudy Preparation Phase

### Project Coordination

Verify schedule
Establish VE study responsibilities
Outline needed background data
Outline format for cost data
Suggest format for designer presentation
Define project value objectives
Identify project constraints

### Prestudy Preparation

Collect background data
Collect operational and other data
Verify cost data
Outline project constraints
Distribute information to VE team
Arrange VE team logistics

## Project Study Workshop Phase

### Orientation

Introduction by VE team leader

Presentation by designer

Outline of project information

Outline of owner requirements

### Information Phase

Undertake function analysis

Prepare FAST diagram

Analyze project costs

Analyze energy usage

Develop cost/worth ratio

Identify high-cost areas

Identify high-energy areas

### Creative Phase

Introduction by VE team leader

Produce creative idea li
Use following methods
- individual
- group
- brain storming
- checklist

## Post Workshop Phase

### VE Study Report

Prepare VE study report

### Review

Owner and designer
- evaluate VE study report
- decide which recommendations to implement

# Task Flow Diagram

### Construct Cost Model

Distribute by process
Distribute by trade
Construct cost model
Outline high-cost areas

### Develop Energy Model

Distribute by process
Distribute support activities
Construct energy model
Outline potential energy saving areas

### Life Cycle Cost Model

Derive life cycle cost model for:
- process area
- staffing
- chemicals
- energy
- impact on user

### Judgement Phase

Review creative ideas with Designer
Eliminate impractical ideas
Discard ideas properly considered by designer
Rank ideas with advantages and disadvantages
Develop weighted evaluation based on all considerations
Select best ideas for development

### Development Phase

Develop preliminary design of ideas
Prepare alternative design sketches
Prepare cost estimates
Produce life cycle comparison including:
- initial cost
- redesign cost
- operation and maintenance cost

### Presentation Phase

Summarize findings

Present VE ideas to owner and designer

Provide draft copy of VE recommendations

Determine acceptance of ideas

### Implementation

Designer
- produces redesign
- estimates costs
- submits to owner
- prepares a report on adopted recommendations

### Project Follow-Up

Owner and designer
- conduct bid analysis
- compare estimates with actual costs for VE recommendations
- document results
- conduct post-operational evaluation

# 5. When to Undertake a Value Engineering Study

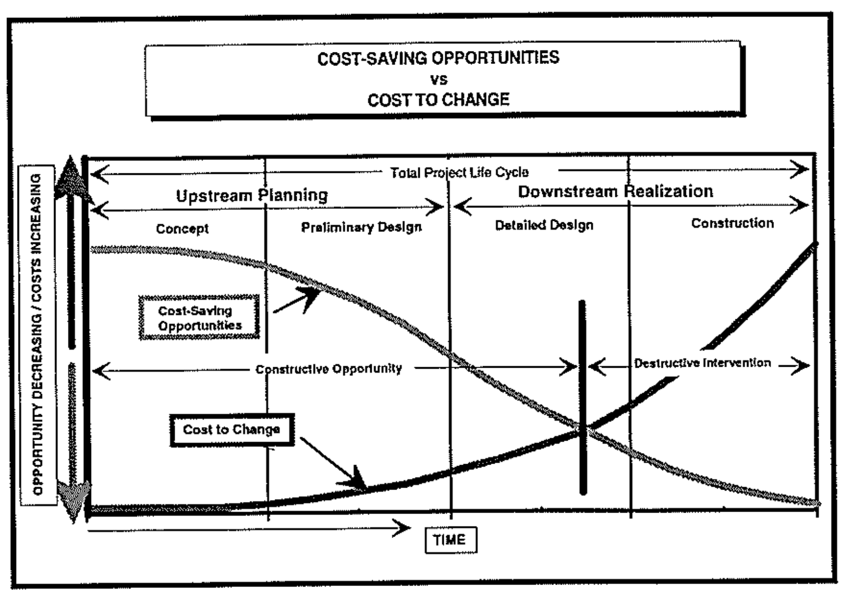
**Project Size**

Owners are encouraged to conduct VE studies on their facilities to enhance their cost-effectiveness and reliability. From a practical point of view, the lower limit for a VE study would be a project capital cost of $4 million. Any municipal facility project with estimated construction costs greater than $10 million that receive grants *must* incorporate a VE study in the design process, as required by the Ministry of Municipal Affairs.

The scope of the VE effort depends on the size, cost, and complexity of the facility. Two VE studies are recommended when the facility cost exceeds $20 million. A single VE study is usually sufficient for a project with a value up to $20 million. The actual number of studies should be based on the complexity of the specific facility. A complex project with costs of $10 million can benefit from two studies.

**Timing**

The cost of making changes in the project design depends upon the stage of the project. Changes at the concept or preliminary design stage can be accomplished at a low cost. Implementation of changes during detail design incur higher costs. Changes during construction are the most expensive to implement. Conversely, new ideas generated early in the design process offer the greatest opportunity to influence project costs. This principle is illustrated in the figure below.



The owner must decide the best time to conduct one or more VE studies. Experience has shown that when two VE studies are performed, the first should be held at approximately the 15 percent stage and the second at about the 65 percent stage of the detailed design phase. If only one VE study is needed, the ideal time for conducting the VE workshop is at the 25 percent stage of design completion.

If the project is mainly a renovation, rehabilitation, or modification of an existing facility, the VE study should occur at the 45 percent stage of detailed design since much of the cost of such projects is in the details of the change. Unless these details are well defined, it is difficult to determine the opportunities for value improvement.

Typically the 15 percent VE workshop focuses on global issues such as overall facility layout, hydraulic profiles, selection of unit processes, architecture, materials of construction, interior layout of buildings, foundation designs, electrical concepts, and process control concepts. The VE study also considers the planned facility and its relationship to the master plan, if any.

The 65 percent VE workshop deals with the details of accomplishing the project such as piping layouts; structural, mechanical, electrical, and instrumentation design; specifications; and architectural details.

If an extremely large or complicated project is contemplated, VE studies at the conceptual and/or preliminary engineering stage can also be beneficial.

**Study Level of Effort**

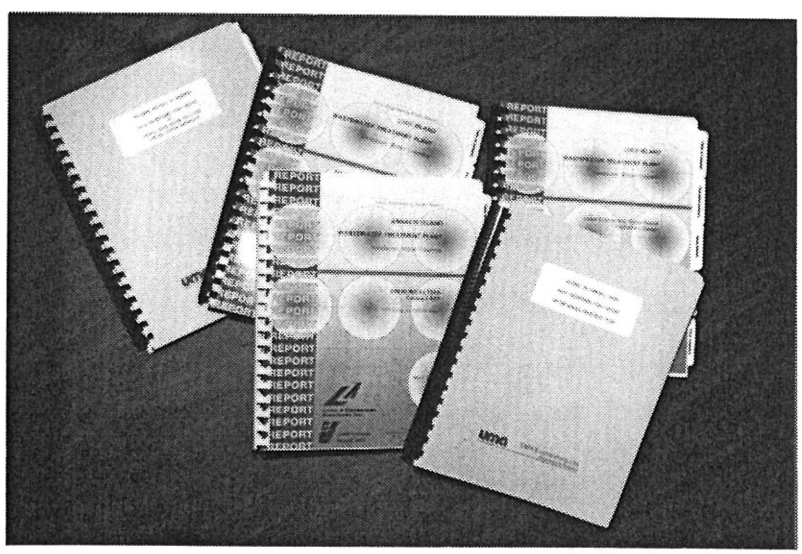
The level of effort required for a VE study is a function of the facility complexity and timing of the study. For projects of average complexity, five to six members are generally adequate to assure that all aspects of the project are addressed. As design complexity and construction cost increases, more disciplines are added to focus on particular facets of the project.

The following table illustrates the range of the level of effort for a typical VE study.

### TYPICAL LEVEL OF EFFORT FOR ONE VE STUDY

| | Effort (hours) | | | | |
|---|---|---|---|---|---|
| | VE Consultant | | | | Designer |
| **Activity** | **Leader** | **Cost Estimator** | **Team Member** | **Secretary/ Drafting** | **Design Staff** |
| Management | 20-30 | | | | 20-30 |
| Prestudy | 20-80 | 10-30 | 4-8 each | 8-12 | 20-120[2] |
| VE Workshop | 24-40 | 24-40 | 24-40 each | 8 | 10-60 |
| Post Workshop | 40-120[1] | 12-24 | | 40-60 | 140[3] |
| Total Hours | 104-270 | 46-94 | 28-48 each | 56-80 | 190-350 |

Notes:
1. Per Report or Study Team.
2. Represents preparation of the data required for the VE workshop.
3. Includes management, engineering, cost estimating, and secretary/clerical time. Does not include any redesign time.



# 6. SELECTING A VALUE ENGINEERING CONSULTANT

**Terms of Reference**

An appropriate time for an owner to select a VE consultant is at the time a contract is being established for design services. The scope of the VE study can be defined at this time and coordinated with the design contract. The designer's scope of services can include the services required to support the VE process and implement the accepted VE recommendations.

The terms of reference to perform the VE study will include the following information:

- Description of the facility
- Relationship of the facility to a master plan
- Proposed design and construction schedule
- Estimated construction cost
- Name of the project designer
- Scope of the VE study or studies
- Number of VE studies and expected timing
- Criteria for evaluation of the VE proposals

The terms of reference will request that the VE consultant's response provide the following:

- Overall strategy for conducting the VE study
- Brief description of prestudy, workshop, and post workshop activities
- Experience of the firm
- Composition of the VE team
- Name, experience, and qualifications of the VE specialist
- Name, experience, and qualifications of other team members and their role
- Schedule for VE study activities
- Proposed level of effort
- Cost of the VE services
- List of references
- Any other data pertinent to the proposal

A sample terms of reference is included in Appendix C.

## Team Members

While most municipalities opt for the procedure outlined above, others have decided to first select the Certified Value Specialist and then jointly select professionals with the appropriate background and experience for the team. These professionals may be chosen based on the owner's and the VE specialists' knowledge of the industry or drawn from the staffs of design consultants who unsuccessfully competed for the project design. It might also be useful to invite a representative of the regulatory agency to participate in the VE session. This will facilitate regulatory feedback if the VE team suggests alternatives that differ significantly from previous project documentation.

## Cost Considerations

It is difficult to provide meaningful guidance for the costs of a typical VE study since cost variables include design complexity, size of the VE team, duration of the VE workshop, and fee rates of the VE consultant.

U.S. experience shows that VE study costs are about 0.4 percent of the total construction costs. This figure represents a relatively low expenditure when one considers that the VE study has the potential to realize a capital cost savings of over 5 percent and a return of over $10 for each dollar expended on the VE study. For this reason, the owner should focus on the experience and qualifications of the VE specialist and the proposed VE team rather than on fees when contracting for VE services.

For a VE study to succeed the following elements are required:

- Top level commitment and support from the owner
- A qualified VE team leader and experienced VE team members
- An appropriate project approach based on function analysis
- A well-managed VE program
- Cooperation between the owner, the VE team, and the designer, along with empathy for the designer's position

## Managing the Value Engineering Program

The owner must manage the VE program. The level of effort and its cost must be justified by the expected result. The owner must take responsibility for deciding the scope of the VE study and when the study is to take place, although the VE consultant can help the owner to determine these. The owner must also assign someone with responsibility and authority to participate and attend the VE sessions. Finally, when there is no consensus, the owner must become the ultimate decision-maker on VE recommendations after thoroughly assessing the technical positions of both the VE team and the designer.

**Greater Vancouver Regional District**

The Greater Vancouver Regional District (GVRD) is undertaking a $650 million program to upgrade the Annacis Island and Lulu Island wastewater treatment plants from primary to secondary treatment. This is a major project with public funds, and an important one for the GVRD to demonstrate that the new effluent and biosolids quality objectives can be met while controlling project costs. According to Mr. Don Littleford, M.B.A., P.Eng., Administrator of the GVRD's Wastewater Treatment Plants, Value Engineering helps meet this objective.

Based on the GVRD experience, Mr. Littleford stated: "Since design criteria assumptions and decisions drive construction costs greatly (80 percent of the program cost is in construction), it is imperative that designs and the assumptions they are based on are optimized. Value Engineering provides a mechanism for this. Engineering design is creative and subjective, and there are many ways to accomplish the end result; however, one way will usually have an edge over others in reducing present value cost. The Value Engineering process brings in fresh options and tests assumptions that drive designs and hence construction costs."

Mr. Littleford reported that the VE process has been very worthwhile and has produced results for the GVRD. By July 1994, three formal VE sessions had been held on the secondary treatment program. The total present value savings are about $17,000,000, of which about 90 percent are in capital costs. The GVRD is very pleased with its current average payback ratio of 24:1. The payback ratio is the ratio of savings to Value Engineering session and redesign costs.

Mr. Littleford also stated: "To work properly, the process must be a collaborative effort between the designer, the owner, and the VE consultant. Through the GVRD program there has been substantial communication between the owner, designer, and VE team. This open, interpersonal contact has generated the exchange of ideas and synergy necessary to ensure that all good ideas were put on the table for evaluation.

"It is our experience that the high degree of professionalism exhibited by both the designers and reviewers overcomes the defensiveness that one might expect from either party in defending their ideas. The individuals have demonstrated that they can advance and debate various alternatives, and surprisingly agree on many of the changes, regardless of origin. Via the interaction between designer and reviewer, VE is a way to build consensus among designers on the best possible designs.

"The owner must determine the appropriate level of VE on a project in consultation with the VE consultant, and manage the process. The owner must determine what level of effort is justified by the expected results. In addition, the owner must have the resources and take responsibility for being the ultimate decision maker on Value Engineering recommendations after thoroughly assessing both VE team and designer technical positions."

**Kelowna**

The City of Kelowna undertook its first formal VE study for a proposed solid waste composting facility in 1991 on the recommendation of Mr. Ron Westlake, P.Eng., engineering manager for the City. Since then, as of March 1995 the City has undertaken a total of five VE workshops. The following projects were the focus of these analyses:

1. Feasibility study for a co-composting facility
2. Pre-design of stage I wastewater treatment plant (WWTP) upgrade
3. Functional design of stage I, phases 1 & 2, WWTP upgrade
4. Constructability analysis for stage I, phases 1 & 2, WWTP upgrade
5. Functional design of stage I, phase 3, WWTP upgrade

The City plans to apply Value Engineering to further expansions to their WWTP and to their major transportation projects.

Mr. Westlake stated with enthusiasm: "The process has allowed us to properly judge value before recommending major investments by the City of Kelowna. It has greatly assisted us to demonstrate to our Finance Department and the Province that the value (level of service, environmental impact, etc.) of the project is sound.

"Value is the relationship between function and cost. Primary and secondary functions of a project and each subcomponent must be first defined and understood by the VE team. Once this is done then each optional means of delivering the stated functions can be identified and the costs estimated. By using this technique a team of specialists can effectively optimize the value of the project. We in Kelowna feel very fortunate to be able to tap into this technique for conceptualizing, optimizing, and implementing our major projects. It has saved us substantial amounts on planned capital expenditures."

In addition to cost savings, Mr. Westlake identified the following additional benefits of Value Engineering to Kelowna:

- It combines the knowledge base of the design consultant with other specialists in the field.
- It shares this knowledge base to allow cost-effective ideas to be available to others.
- It builds good relationships with regulatory agencies if they are included in the process, and at the same time it allows the VE team to understand the function of the regulations being applied to the project.
- It allows input from operational staff at key points in the project to incorporate the benefit of their experience and develops their analytical skills.
- It increases the project team's commitment.
- It compares capital investments with long-term life cycle costs.

## Regional District of Nanaimo

The Regional District of Nanaimo decided on a VE assessment of the French Creek Water Pollution Control Centre in early 1994. Although the estimated cost of $9.8 million was below the Ministry of Municipal Affairs' threshold, the District took the initiative and undertook the study.

Mr. Wayne Moorman, P.Eng., manager of Engineering Services explained why: "The District was concerned about its large expenditure and wanted to ensure that its taxpayers were getting value for their investment."

Mr. Moorman described the VE process: "During the creative phase of the study it was interesting to see new ideas developed through the synergy of the team members. The Value Engineering team demonstrated good knowledge of treatment plant design, construction methodology, and economics.

"The VE team did come up with a number of good recommendations, some of which were implemented while others were rejected. Some of the rejections arose because we were close to proceeding with tendering. It would have been beneficial for the Regional District to undertake the study earlier than the 85 percent design stage. The designer and the VE team do not need to feel badly because some of their designs were not accepted. The VE process is intended to be constructive by improving function and reducing cost. I was pleased to have been involved in the VE study. It was well worth my time."

**Prince George**

The City of Prince George is proceeding with an $8 million upgrade of its wastewater treatment centre. A VE study was conducted on this project when the design was 20 percent complete.

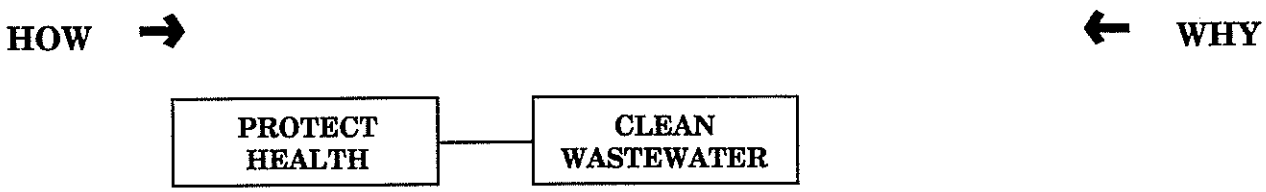
Bob Radloff, P.Eng., supervisor of the Environmental Services Division for the City said, "It was our observation that the expertise and effort brought into the Value Engineering effort by all participants had a direct bearing on the good result. Total savings realized by the study are estimated to be $350,000. The payback was about 10:1 . . . The design stage study could have benefited from additional design detail. However, there is merit in performing Value Engineering earlier in the design process. In our circumstances it is likely that a study at the predesign stage may have yielded more savings."

# APPENDIX A

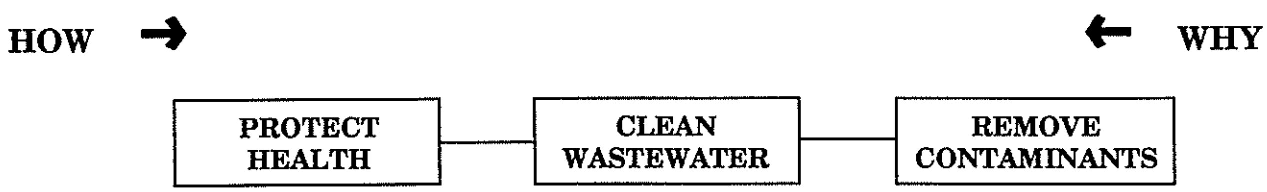
## Function Analysis System Technique

Function Analysis System Technique (FAST) is a powerful analysis process that helps people with various technical backgrounds to effectively communicate, interact, and resolve issues that require multi-disciplinary considerations. The system links two simply stated words, a verb and a noun object, to describe the functions of each component of a complex project. Looking at each function in terms of the two-word phrase helps the VE team in its problem solving. Participants with various levels of training and experience can understand complex subjects when the functions are described in two simple words.

Although the FAST rules appear deceptively simple, they must be followed rigorously to achieve results. A good deal of discipline and critical appraisal are also needed to make the FAST model appear simple and logical. In a FAST diagram, the questions "*How might* something be done?" and "*Why* should something be done?" are used to develop the relationship between various functions. The word WHY is always written on the right and can be answered by reading to the left. The word HOW is always written on the left and can be answered by reading to the right. For example, a VE team has been asked to solve the problem of "protecting the health and welfare of the community." A two-word function statement of the problem or goal to be achieved is "protect health." If the team asks, "How do we protect health?" the answer, in the form of a function, could be "clean wastewater," or "clean water," or several other alternatives.




If the team was reviewing a wastewater treatment plant, it would focus on the function "clean wastewater." Continuing in the HOW direction, the team would ask, "How do we clean wastewater?" The answer could be "remove contaminants."

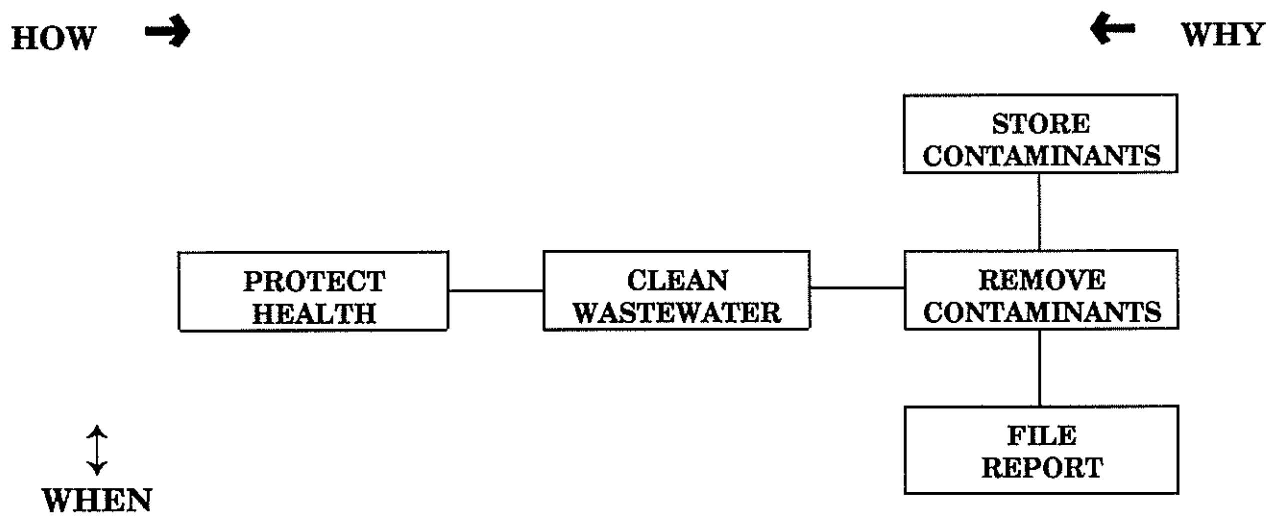



To test the intuitive logic of the example, we can read the functions in the reverse WHY direction. "Why do we want to remove contaminants?" and the answer is "to clean wastewater." Next we would ask, "Why do we want to clean wastewater?" The answer is "to protect health." If the team agrees with the answers, it continues to expand the FAST model in either the HOW or WHY direction.

This process is based on the application of intuitive logic. Intuitive logic uses an individual's intuition to determine if a step or an approach "feels right." Intuition is not a guess but rather is based on one's ability to put together bits of seemingly unrelated data to form a concept of the issue being studied.

There is a third direction to the FAST model -- the WHEN direction. This direction is not part of the intuitive logic process, but it supplements intuitive thinking. WHEN is not a time orientation; rather, it indicates cause and effect. In the figure below, WHEN is added in the following way: "When you remove contaminants, you should store contaminants." "Store contaminants" is an independent support function that supplements the function "remove contaminants." As an independent function, it can be expanded in the HOW-WHY directions to build a subsystem FAST model. Since the independent function is not on the major logic path, changing the function would not significantly affect the basic function.

The box below the function "remove contaminants" is an activity. Activities are not functions; they describe a specific action that is initiated when the logic path function is activated. In the figure below, it reads, "When you remove contaminants, you should file report. Since functions and activities can both be described using a verb and a noun, independent functions (above the logic path) and activities (below the logic path) are the result of satisfying the WHEN question.

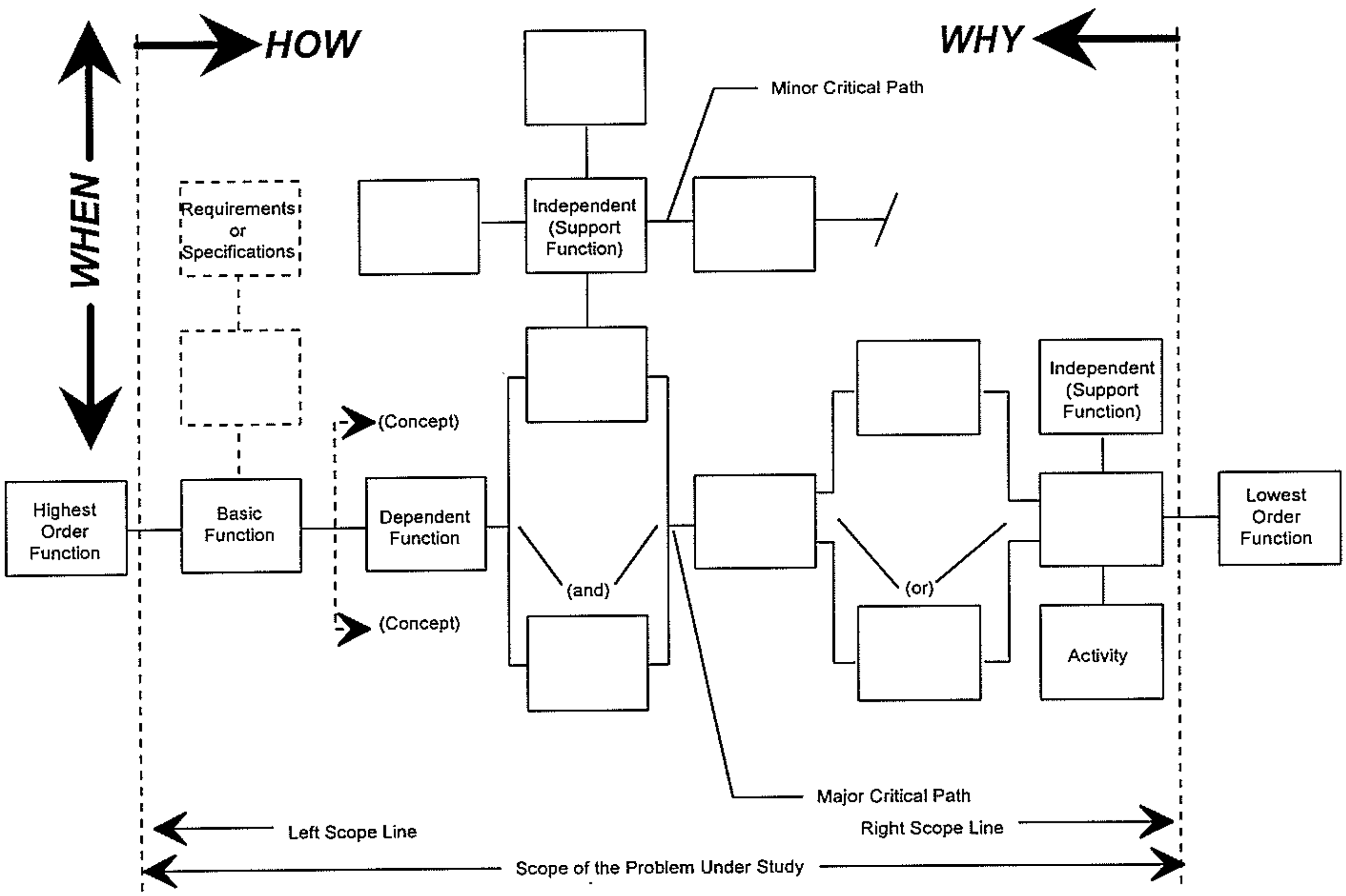



The basic elements of the FAST model are shown on the following page. These elements are described below.

*Scope Lines*

Scope lines represent the boundaries of the study and identify that aspect of the problem which the VE team is concerned with. There are left and right scope lines.

# The Basic Fast Model



*Highest Order Function*

The objective or goal of the study is called the highest order function. (There may be more than one goal or highest order function.) This box is located to the left of the basic function, outside the left scope line. Any function to the left of another function is a higher order function because reading the FAST model in the WHY direction will lead you to the basic function and the highest order function (or goal) of the subject under study.

*Lowest Order Function(s)*

Functions to the right and outside the right scope line represent the input side that "turns on" or initiates the subject under study. These are known as the lowest order functions. The right scope line identifies the beginning of the study and separates the input function or functions from the scope of the study.

Any function to the right of another function is a lower order function and it represents a method selected to carry out the function to its left. The terms higher and lower order functions should not be interpreted as relative importance, but rather as the input and output side of the process.

*Basic Function*

The function (or functions) to the immediate right of the left scope line represents the purpose or mission of the product or process under study and is called the basic function. Once determined, the basic function will not change. If the basic function fails, the product or process will lose its market value.

*Concept*

All the functions to the right of the basic function portray the conceptual approach selected to carry out the basic function. The concept describes the method being considered, or elected, to achieve the basic function. The concept could be either the current design or a proposed approach.

*Requirements or Specifications*

Requirements or specifications are conditions that describe the operating environment of the product or process. These parameters, specifications, or constraints, located above the basic function, must be maintained to achieve the highest order function of the system or process performing in its normal operations.

*Critical Path Function*

Any function on the HOW or WHY logic path is a critical path function. If a function along the WHY direction enters the basic function, there is a major critical path. If the WHY path does not lead directly to the basic function, it is a minor critical path. Changing a function on the major critical path will alter or destroy the way the basic function is performed. Changing a minor critical path will disturb an independent (support) function that enhances the basic function. Supporting functions are usually secondary. They exist to achieve the performance levels stated in the specifications of the basic function or because a particular approach was chosen to implement the basic function.

*Dependent Function*

Starting with the first function to the right of the basic function, each successive function is dependent upon the one to its immediate left for its existence.

*Independent or Support Function*

Independent or support functions describe an enhancement or control of a function located on the critical path. They do not depend on another function or method selected to perform that function. An independent function is located above the critical path function and is considered secondary, in terms of the scope, nature, and level of the problem and its critical path.

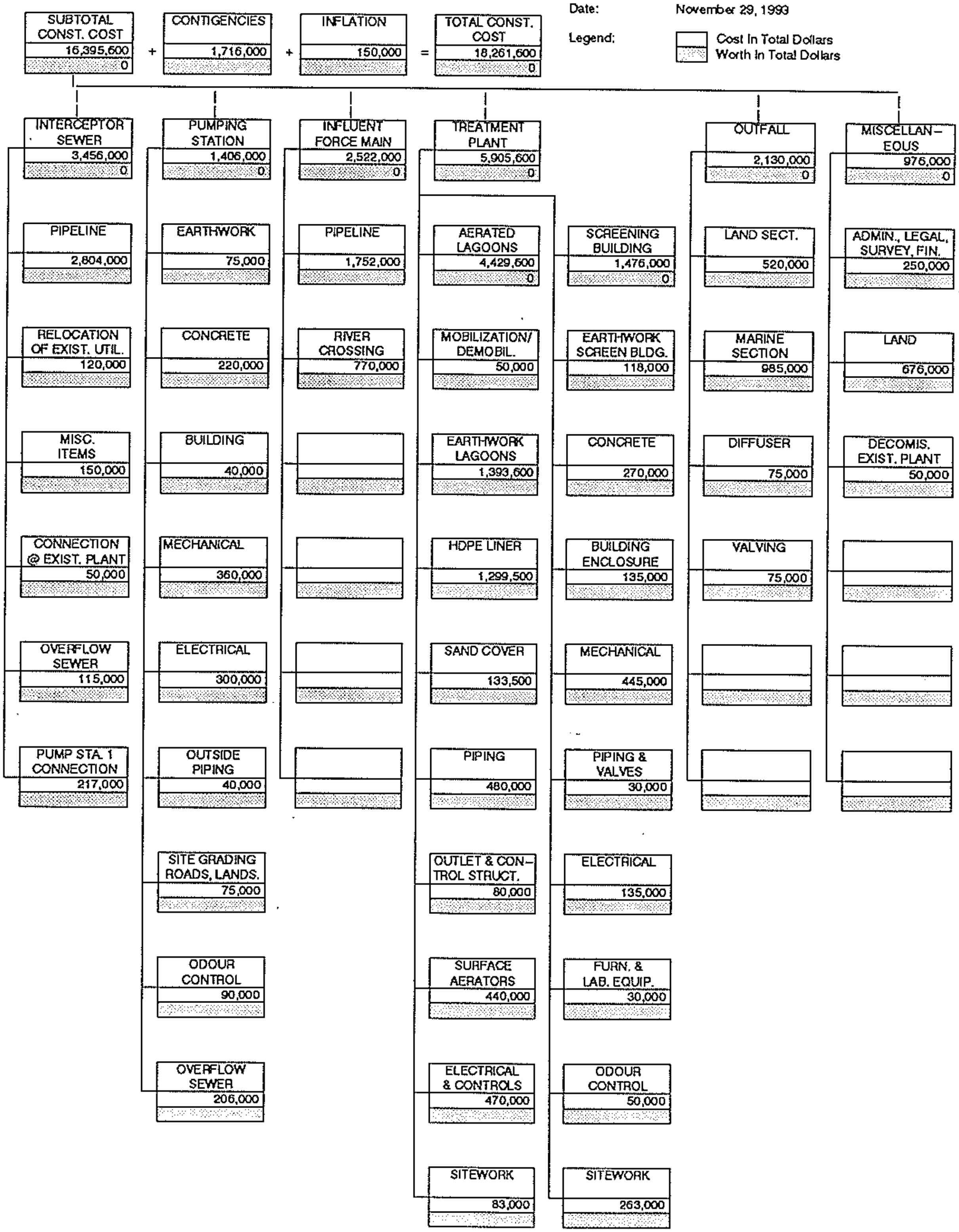
# APPENDIX B

Cost Model
Function Analysis Worksheet
Creative Idea Listing and Judgement Worksheet
Value Engineering Recommendation
Summary of Potential Cost Savings

# Cost Model

Project: LIQUID WASTE MANAGEMENT PLAN
Location: DISTRICT OF CAMPBELL RIVER, BRITISH COLUMBIA
Date: November 29, 1993

Legend: Cost In Total Dollars / Worth In Total Dollars



# Function Analysis Worksheet

## Lewis & Zimmerman Associates, Inc.

| | |
|---|---|
| PROJECT: Campbell River Sewage Treatment Project | **FUNCTION ANALYSIS** |
| LOCATION: Campbell River British Columbia<br>PAGE: 1 of 1 | ITEM: Lagoons<br>FUNCTION: Remove Solids<br>Remove BOD |

| No. | Description | Function | | | Cost | Worth | Comments |
|---|---|---|---|---|---|---|---|
| | | Verb | Noun | Kind | | | |
| | Mobilization | Facilitate | Construction | S | 50,000 | | |
| | Earthwork | Establish | Elevation | S | 1,999,600 | | |
| | | Create | Basin | B | | | |
| | HDPE Liner | Prevent | Leakage | S | | | |
| | Sand Cover | Protect | Liner | S | 133,500 | | |
| | Piping | Cover | Sewage | B | 480,000 | | |
| | Outlet and Control Structure | Control | Flow | S | 80,000 | | |
| | Surface Aerators | Add | Oxygen | B | 440,000 | | |
| | Electrical and Controls | Supply | Power | B | | | |
| | | Monitor | Process | B | 470,000 | | |
| | | Control | Equipment | B | | | |
| | Sitework | Support | Vehicle Loads | S | 5,500 | | |
| | | Secure | Area | S | 57,500 | | |
| | | Beautify | Area | S | 20,000 | | |
| | | Action Verb Kind B = Basic<br>Measurable Noun S = Secondary | | | Cost/Worth Ratio = ______<br>(Total Cost ÷ Basic Worth) | | |

# Creative Idea Listing and Judgement Worksheet

| PAGE 6 OF 6<br>PROJECT: Campbell River Sewage Treatment Project<br>CLIENT: Campbell River B.C.<br>DATE: 11/30 - 12/3/95 | | CREATIVE PHASE<br>CREATIVE IDEA LISTING | | JUDGMENT PHASE<br>IDEA EVALUATION<br>EVALUATION CRITERIA | | | | | | IDEA RATING |
|---|---|---|---|---|---|---|---|---|---|---|
| NO. | CREATIVE IDEA | ADVANTAGES | DISADVANTAGES | A | B | C | D | E | F | |
| | LAGOONS (L) | | | | | | | | | |
| L-1 | Use square lagoons | | | O | O | O | O | + | | 6 |
| L-2 | Reduce liner thickness from 60 mils. to 30 or 40 mils | | | O | O | - | O | + | | 8 |
| L-3 | Build only two lagoons | | | O | + | - | + | + | | 6 |
| L-4 | Build two larger lagoons | | | O | O | - | + | + | | 8 |
| L-5 | Use small complete mix cells at front of process | | | - | + | + | O | + | | 9 |
| L-6 | Reduce freeboard from 3 ft. to 2 ft. | | | O | O | - | O | + | | 8 |
| L-7 | Reduce the width of berms to metres | | | O | O | O | O | + | | 9 |
| L-8 | Place control structures off centerline of berm | | | O | O | O | + | O | | DS |
| L-9 | Move lagoons to west side of site with screen | Facilities future expansion, moves odour source away | Adds pipe cost and some head | - | + | O | O | - | | DS |
| L-10 | Use a SBR aerated lagoon | | | - | + | + | - | - | | 6 |
| L-11 | Provide a SBR system for treatment | | | - | + | + | - | - | | 6 |
| L-12 | Use baffle walls in lieu of berms between cells | | Complicates operations | O | O | + | O | - | | 4 |
| L-13 | Use 4:1 slope for berms | | | + | - | + | O | - | | 4 |
| L-14 | Stage purchase of aerators | | | + | O | O | + | + | | 10 |
| L-15 | Increase lagoon design liquid depth from 15 to 20 feet | | | + | O | O | O | + | | 9 |
| L-16 | Consider alternative lagoon aeration equipment to improve mixing | | | + | O | O | O | O | | DS |

Evaluation Criteria: A = Life Cycle Cost, B = Neighbors, C = Reliability (Meets Consent), D = Convenience, E = Ease of Operations, F = Capital Cost

# Value Engineering Recommendation

| Project: Campbell River Sewage Treatment<br>Location: Campbell River BC<br>Client: Dist. of Campbell River<br>Date: 11/30/ - 12/3/93<br>Page: 1 of 5 | ITEM:<br><br>USE ONE SMALL COMPLETE MIX CELL INSTEAD OF LARGE PARTIAL MIX CELL FOR THE FIRST CELL | ITEM NO.<br><br>**L-5** |
|---|---|---|

ORIGINAL DESIGN: (Sketch Attached_X_)

Three (3) aerated cells each with 6 days retention are indicated. The cells are designed with partial mix aeration.

PROPOSED CHANGE: (Sketch Attached____)

Reduce the first cell (Cell #1) from 6 days retention (original design) to one day retention and complete mix aeration (8 watts/$m^3$ would be provided. Increase Cells 2 and 3 to 6.5 days retention.

ADVANTAGES:

- Reduces size of lagoons
- Less problem with inlet sludge accumulations
- Lowers capital cost

DISADVANTAGES:

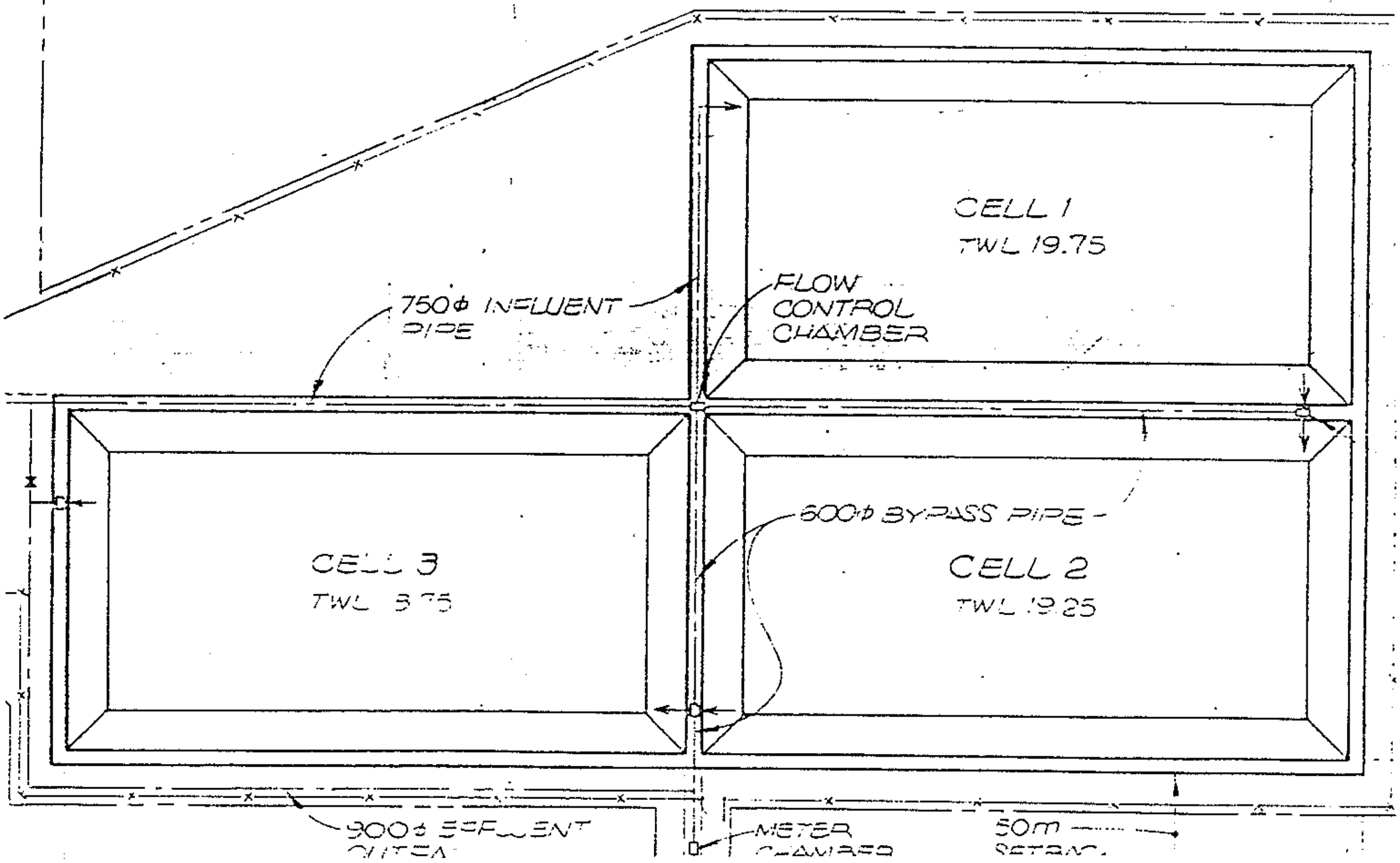
- Power requirements will be about 10% greater

DISCUSSION:

Alberta Environment reports excellent performance results with small complex mix cell followed by two partial mix cells. Capital costs can be reduced significantly. Therefore, this option should be seriously considered. The size of the complete mix cell must be restricted to about one day retention; otherwise the mixing energy costs become prohibitive.

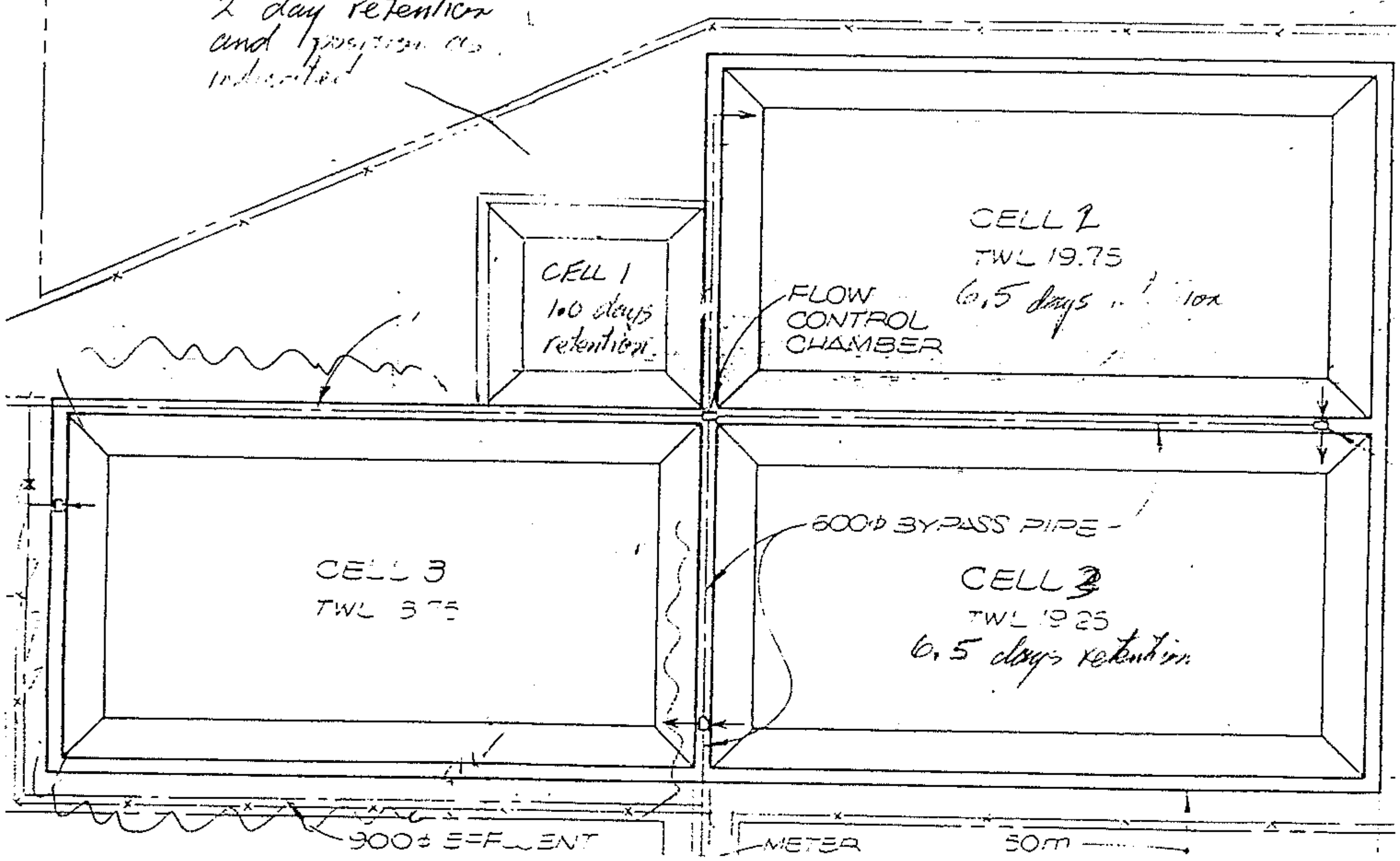
| | PRESENT WORTH COST SAVINGS | | |
|---|---|---|---|
| LIFE CYCLE COST SUMMARY | INITIAL COST | O&M COSTS | TOTAL |
| ORIGINAL DESIGN | 4,210,000 | 1,778,000 | 5,988,000 |
| PROPOSED CHANGE | 3,474,000 | 1,835,000 | 5,309,000 |
| SAVINGS | 736,000 | (57,000) | 679,000 |

L-5 ORIGINAL DESIGN



L-5 REVISED DESIGN

REDUCE CELL 1 TO 2 day retention and position as indicated



Assume:

- One-day complete mix cell
- Retention time based on max. month flow (20 yr) or 7.28 MGD = 33,000 $m^3/d$
- Reduced influent wastewater strength at max. flow = 150 mg/L BOD.
- Complete mix cell achieves 50% BOD removal (Alberta Environment, Karu Chinniah, 427-5877 advises that a 2 day complete mix cell ~~in Alberta achieves at least 67% BOD removal~~)
- Partial mix "k" at 9°C = $k_{20}\,\theta^{(T-20)}$
  $0.276 \times 1.036^{-11} = 0.19$
- Design final effluent quality is
  BOD = 15 mg/L to consistently meet
  BOD = 45 mg/L standard

Estimated Size of two equal sized partial-mix lagoons following complete mix:

$BOD_i = 0.5 \times 150 = 75$ mg/L

$BOD_e = 15$ mg/L

$P = BOD_e / BOD_i = 15/75 = 0.2$

$P = \left(\frac{1}{1+kT}\right)^2$ for 2 ponds in series

$P = 0.2 = \left(\frac{1}{1+0.19 \times T}\right)^2$

T = 6.5 days each pond (Cell 2 + Cell 3)

UMA Engineering Ltd.
Engineers & Planners

Design Calculations

Client: Campbell River

Project: VE

DATE: 93-12-03 BY: [signature] JOB No.: 

SHEET 4 OF 5

PROJECT Campbell River Sewage Treatment Project
LOCATION B. C.
CLIENT Dist. of Campbell Rvr.
DATE 93-12-02/03
PAGE 5 OF 5

# COST WORKSHEET

ITEM Use one (1) small complete mix cell instead of large partial mix cell for first cell.

ITEM NO. L-5

| CONSTRUCTION ELEMENT | | ORIGINAL ESTIMATE | | | NEW ESTIMATE | | |
|---|---|---|---|---|---|---|---|
| ITEM | UNITS | NO. UNITS | COST/UNIT | TOTAL | NO. UNITS | COST/UNIT | TOTAL |
| Clearing & Grubbing | acres | 39 | 2400 | 93,600 | 30 | 2400 | 72,000 |
| Stripping (18 in.) | $yd^3$ | 106,000 | 2.50 | 265,000 | 82,000 | 2.50 | 205,000 |
| Earthwork | $yd^3$ | 230,000 | 4.50 | 1,035,000 | 180,000 | 4.50 | 810,000 |
| HDPE liner | $ft^2$ | 1,130,000 | 1.15 | 1,299,500 | 880,000 | 1.15 | 1,012,000 |
| Piping (net) | lin ft | — | — | — | 600 | 150 | (90,000) ← CREDIT |
| Surface aerators | ea | 20 | 22000 | 440,000 | 22 | 22000 | 484,000 |
| Electrical | LS | | | 470,000 | | | 480,000 |
| Fencing | lin ft | 5750 | 10 | 57,500 | 4800 | 10 | 48,000 |
| Subtotal | | | | 3,660,600 | | | 3,021,000 |
| Contingency 15% | | | | 549,000 | | | 453,000 |
| TOTAL (Rounded) | | | | 4,210,000 | | | 3,474,000 |
| Operation & Maintenance | | | | | | | |
| Power | HP | 450 | 300 | 135,000 | 500 | 300 | 150,000 |
| (avg. power with provision for variable depth & some aerators out of service) | | | | | | | |
| Sludge removal | LS | | | 20,000 | | | 10,000 |
| TOTAL O&M | | | | 155,000 | | | 160,000 |
| Present Worth O&M (20 yr, 6%, 11.47 factor) | | | | 1,778,000 | | | 1,835,000 |

# Summary of Potential Cost Savings

| PROJECT: Campbell River Sewage Treatment Project<br>LOCATION: Campbell River B.C.<br>CLIENT: District of Campbell River<br>DATE: 11/30 - 12/3/93 | | VALUE ENGINEERING STUDY<br>SUMMARY OF POTENTIAL COST SAVINGS | | | | PAGE NO.<br>1 OF 1 |
|---|---|---|---|---|---|---|
| **ITEM NO.** | **DESCRIPTION** | **PRESENT WORTH COST SAVINGS** | | | | |
| | | **ORIGINAL DESIGN COST** | **PROPOSED CHANGE COST** | **INITIAL COST SAVINGS** | **O&M COSTS SAVINGS** | **TOTAL COST SAVINGS** |
| | **LAGOONS (L)** | | | | | |
| L-2 | Reduce Lagoon liner thickness from 60 mil. to 30 or 40 mil. | 1,495,000 | 1,300,000 | 195,000 | -0- | 195,000 |
| L-5 | Use one small complete mix cell instead of large partial mix cell for first cell | 4,210,000 | 3,474,000 | 736,000 | (57,000) | 679,000 |
| L-6 | Reduce Lagoon berms freeboard height from 3 ft. to 2 ft. | 1,393,600 | 1,267,375 | 126,225 | (57,000) | 679,000 |
| L-7 | Reduce width of Lagoon berms from 6 m. to 4 m. | 1,393,600 | 1,330,902 | 54,698 | -0- | 54,698 |
| L-8 | Place control structures off centerline of berms | **DESIGN** | **SUGGESTION** | | | |
| L-9 | Move Lagoons to west side of site with screening building on west side | **DESIGN** | **SUGGESTION** | | | |
| L-14 | Stage purchase of aeration | 506,000 | 380,000 | 126,000 | 446,000 | 572,000 |
| L-15 | Increase Lagoon design liquid depth from 15 ft. to 20 ft. | 2,126,000 | 1,616,000 | 510,000 | -0- | 510,000 |
| L-16 | Consider alternate lagoon aeration equipment to improve mixing | **DESIGN** | **SUGGESTION** | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

# APPENDIX C

## Sample Terms of Reference for a Value Engineering Study of a Wastewater Treatment Project

## Sample Terms of Reference for a Value Engineering Study of a Wastewater Treatment Project

This Appendix includes the terms of reference for a project for the fictitious City of Cedar Mills.

### Background

The City of Cedar Mills is in the process of expanding and modifying its wastewater treatment works located at Spruce Street adjacent to the Fraser River. The firm of Dewey, Owen & Howe completed a preliminary engineering report on the project in April 1995 and will be engaged to undertake the detailed design. The project is being fast-tracked with the objective of proceeding with construction in May 1996, in order to have the expanded facilities in service in August 1997. For your information a copy of the feasibility study is enclosed (not included in this appendix).

The project consists of a gravity interceptor, a pump station, a forcemain, treatment plant expansion and modifications, and a new river outfall. The interceptor will follow the alignment of Hemlock Street, and the pump station will be located near the intersection of Hemlock Street and Fir Avenue. The forcemain will follow Fir Avenue to the treatment works. The treatment works will include increasing the capacity to 35 megalitres and the addition of biological nutrient removal to the process. A new 800 mm river outfall is to be installed. A conceptual plan depicting the location of the various components is attached (not included in this appendix).

A summary of the estimated cost of each component is as follows:

| Item | Estimated Cost |
|---|---|
| Interceptor | $3,000,000 |
| Pump Station | $3,000,000 |
| Forcemain | $1,500,000 |
| Treatment Plant | $7,000,000 |
| River Outfall | $500,000 |
| **Total** | $15,000,000 |

The detailed design will commence in August 1995 and is scheduled to be complete in February 1996.

The design consultant contact is:

Mr. Tom Dewey, P.Eng.
Dewey, Owen & Howe
257 Fir Avenue
Cedar Mills, B.C.
V7V 3H3
Telephone: (604) 378-5311

The project manager for Cedar Mills is:

Mr. John Donaldson, P.Eng.
City of Cedar Mills
311 Spruce Street
Cedar Mills, B.C.
V7V 9G9
Telephone: (604) 378-2727

**Value Engineering Study Requirements**

A single Value Engineering study is proposed for this project. It will proceed at about the 25 percent stage of design completion, which is expected to occur in October 1995. The date of the workshop will be established by actual design progress and through mutual agreement between Cedar Mills project manager and the Value Engineering consultant.

The Value Engineering study is to examine the design work of the design consultant for all components of the wastewater treatment project. Dewey, Owen & Howe will provide relevant design documentation to the Value Engineering team 10 days in advance of the Value Engineering workshop.

The design consultant will make a presentation on the design parameters for the project at the initial session of the Value Engineering workshop. The designer's representatives will attend the review of the long list of ideas that the Value Engineering team generates and will also be present at the end of the session to receive the verbal presentation of the recommendations of the Value Engineering team.

Two staff members of the City of Cedar Mills will participate in the Value Engineering study throughout its duration. Members of Council may attend the verbal presentation of the recommendations.

The proposed site for the Value Engineering workshop is the boardroom of the City of Cedar Mills.

A formal report on the Value Engineering study is to be submitted to the City of Cedar Mills within three weeks of the conclusion of the workshop. Eight copies of the report are required. Informal copies of the Value Engineering study recommendations are to be provided as soon after the workshop as practicable to allow the designer to immediately consider the recommendations and, in concert with Cedar Mills, decide which recommendations are to be implemented.

**Study Team**

The study team will consist of a Value Engineering leader and at least five other members. The leader shall be a Certified Value Specialist (as designated by the Society of American Value Engineers) with experience in the analysis of projects of a similar nature.

The remaining team members shall be professionals having complementary expertise and the experience necessary for the assessment of all components of the project. Experience in Value Engineering studies would be preferred.

The person-hours to be expended by each of the members is to be provided.

**Study Cost**

The Value Engineering consultant shall indicate the cost of undertaking the Value Engineering study. A breakdown of the cost to show the portions attributable to fees and to expenses shall be provided. The proposed fee shall be submitted in a sealed envelope separate from the main proposal.

**Consultant's Proposal**

The consultant's proposal shall provide the following:

- Overall strategy for conducting the VE study
- Brief description of prestudy, workshop, and post workshop activities
- Composition of the VE team
- Name, experience, and qualifications of the VE specialist
- Name, experience, and qualifications of other team members and their role
- Schedule for VE study activities
- Proposed level of effort
- Cost of the VE services
- List of references
- Any other data pertinent to the proposal

Two copies of the consultant's proposal are to be submitted on or before Tuesday, July 25, 1995 to:

Mr. John Donaldson, P.Eng.
City of Cedar Mills
311 Spruce Street
Cedar Mills, B.C.
V7V 9G9

**Evaluation Criteria**

The City of Cedar Mills will award this assignment to the consultant with the best combination of a Value Engineering team and a sound and well-thought-out Value Engineering program. References will be contacted to determine the level of satisfaction with performance on other projects.

# Glossary

**Basic function:** The essential performance characteristic of a product, process, project, or service.

**Cost of function:** All costs incurred to obtain and use the specified function.

**Function:** Any performance characteristic that a product, process, project, or service achieves.

**Function Analysis System Technique (FAST):** An analytical technique that graphically portrays the interrelation of the basic and secondary functions of a product, process, project or service.

**Life cycle cost:** The total cost associated with ownership over the life of an item, including design, construction, operation, and maintenance costs.

**Secondary function:** An additional performance characteristic of the product, process, project, or service.

**Unnecessary cost:** Cost that is not associated with achieving the performance of a necessary function.

**Value:** The relationship of worth to cost.

**Worth of function:** An estimate of the lowest cost of achieving the performance of a function.

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