VALUE ENGINEERING WORKBOOK

FOR SMALL TRANSPORTATION PROJECTS

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INTRODUCTION: THE VE STUDY

This workbook is intended for use on small transportation projects that have the following characteristics:

(1) use of federal or state funds (from FHWA or a state DOT);

(2) non-transit transportation facilities (roadway, intersection, bridge, bikeway, etc.); and

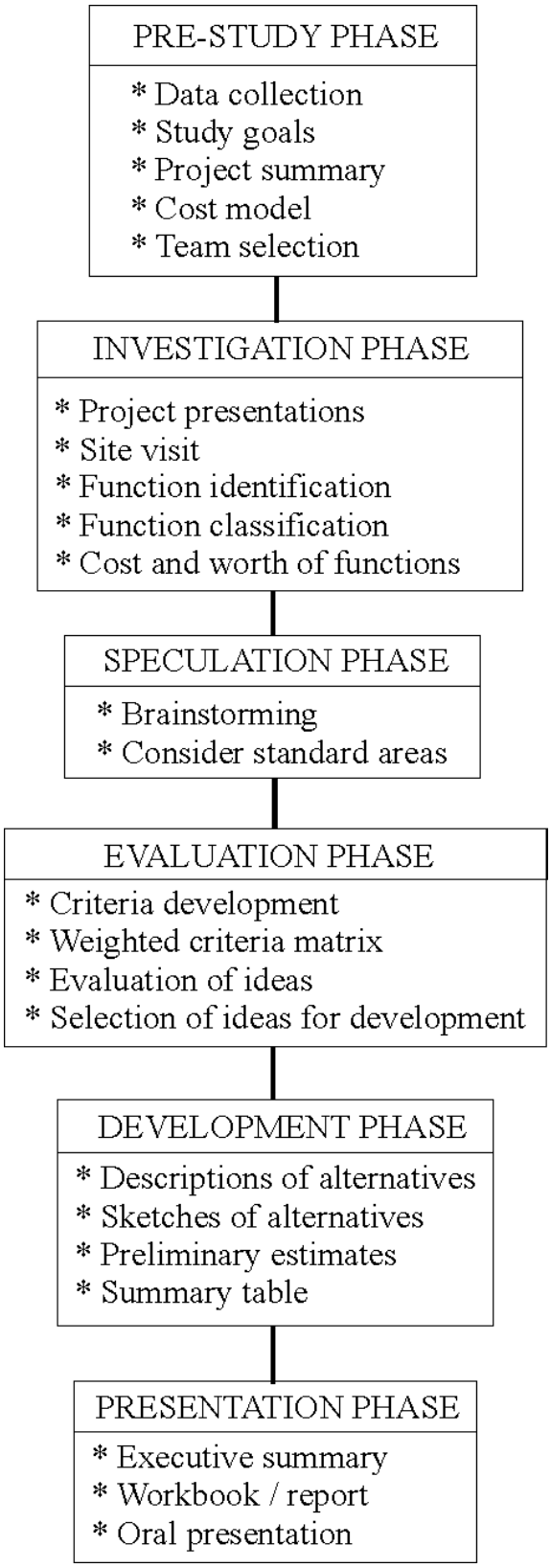
(3) estimated cost of under $10 million (including design, right-of-way, construction, and mitigation).

The body of the workbook contains forms for each phase of the VE study and instructions for their use. These forms are also provided in Microsoft Excel 95 format. By using the forms, a VE study can be completed with little preliminary training, particularly if the team leader is experienced in VE techniques.

Appendices A and **B** contain information that will be helpful in the study process. **Appendix C** contains a form to assist in selecting projects for a VE study by assessing their VE potential. Finally, **Appendix D** contains forms to aid in implementing VE recommendations and tracking their results.

For more information regarding this document, refer to *Value Engineering for Small Transportation Projects* by Jennifer Clark (WPI Master's Thesis).

Job Plan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PRE-STUDY PHASE

This phase should be completed before the VE team is assembled for the study. While gathering information about the project to be studied, complete the three forms in this section. Distribute copies of these forms to the members of the VE team prior to the first meeting.

Form: Approval Authority / Information Sources

Purpose: Record project information.

(1) Heading: Fill in project number, project name, and VE study number.

(2) Authorizing Persons: Include Project Manager and any other people responsible for reviewing and/or authorizing recommendations. Phone, fax, and email should be included if available.

(3) Data Sources: Document all sources of data to be used in the study, with names, title if relevant, and dates. "Data type" is cost estimate, drawings, standards, etc.

(4) VE Team: Include all members of the VE Team when they are known. As much contact info as possible should be recorded.

Project # *Project:*			VE Study # Approval Authority/ Information Sources		
Authorizing Persons					
Name	Position		Phone	Fax	Email
	Project Manager				
Data Sources					
Data Type	Source		Notes		
VE Team					
Name	Position/Organization		Phone	Fax	Email

Form: Study Identification and Summary

Purpose: Record project information for distribution to team members.

(1) Project Description: Include as much information as is known.

(2) Major Project Elements: Break the project up into large pieces and describe them. "Type" may be bridge, paving, road improvements, intersection improvements, bikeway, etc.

(3) Route Conditions/Other Projects: Describe conditions and/or projects (recent, current, and planned) on adjacent segments and the overall route. This applies to bike/pedways as well as roads.

(4) Study Description: Record the dates of the study. Also, list the major goals of this particular study, e.g., "reduce cost" or "generate alternatives to undesirable solution." Include other notes as needed.

Project # *Project:*	VE Study # Study Identification and Summary

Project Description

District:		Length:	
City/Town:		Design Speed:	
Type of Project:		Projected Traffic	
Street/Route:		ADT:	
Location:		Year:	
Total Cost:		Project Phase:	
Type of Funds:		Milestone:	
Scheduled Award Date:			

Major Project Elements

Type	Description

Route Conditions / Other Projects

Adjacent Segments	Overall Route

Study Description

Study Dates:	Study Goals:
Other Notes:	

Form: Cost Model

Purpose: Categorize costs and examine the sources of costs in order to understand where the costs are concentrated.

(1) Estimate: Record source and date of estimate. The costs may be at any level of detail; group them into ten to twelve categories. (Examples: right-of-way, traffic signals, paving.) List the items and their costs, along with any notes.

(2) If completing the form on a computer, sort the items according to cost (in increasing order); the percentages and Pareto analysis will fill in automatically, and the cost chart will need minor adjustments to the axes. If completing manually:

   (a) For each cost item, calculate the percent of the project cost it represents (item cost divided by total cost).

   (b) For the Pareto analysis, estimate the smallest number of items needed to make up 80% of the total cost. The easiest way to do this is start with the largest cost item and work down, adding percentages until you reach approximately 80%.

   (c) Sketch a chart of the costs, with items on the vertical axis and cost on the horizontal axis.

Project # *Project:*	VE Study # Cost Model

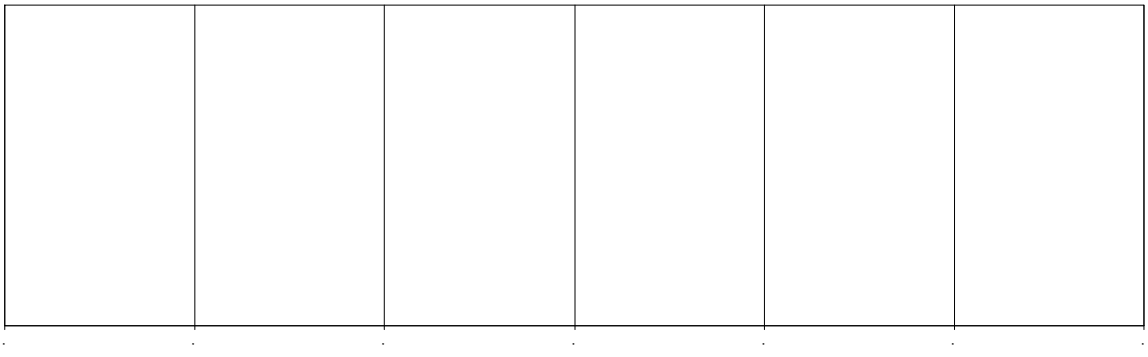
Source of Estimate: Date:

Item	Cost	% of Project	Notes
Total	*$*		

Pareto Analysis

% of Costs	# of Items	
	1	
	2	% of the costs are contained in
	3	of the items.
	4	
	5	
	6	

Cost Chart



INVESTIGATION PHASE

This phase should begin with presentations (briefings) by the project manager and designer, giving an overview of the project and the issues and concerns associated with it. A site visit should also be incorporated in the initial part of this stage. A copy of the "Team Member Notes" form should be given to each VE team member to record his or her observations during the presentations and site visit.

The other two forms guide the team through the function analysis process, which identifies functional areas with the most opportunity for value improvement. These forms should be completed as a team.

Form: Team Member Notes

Purpose: Provide a record of notes and observations for use in the study.

One form should be completed by each team member. Record notes and observations from the project briefings/presentations and the site visit. Note particularly what elements the designers or other parties are likely to be flexible about, and what elements should be left unchanged.

Project # *Project:*	VE Study # Team Member Notes
Team Member:	

Project Briefings/Presentations

Site Visit

Form: Function Analysis

Purpose: Perform function analysis to identify potential areas of savings and/or improvements

(1) Use the items from **Cost Model**.

(2) For each item, identify one or more functions the item performs. Each function consists of a verb + a noun. Also, classify each function as basic, required secondary, secondary, or unwanted. A basic function is one that is essential to the project. A required secondary function (1) is necessary for supporting a basic function, (2) must be achieved to meet codes or standards, or (3) must be included to satisfy the owner. A secondary function is not necessary and has a "worth" of zero. An unwanted function is an undesirable effect that may require mitigation.

(3) The "cost" for each item comes from the estimate on **Cost Model**. If practical, allocate the item cost among its functions.

(4) The "worth" of each function is the estimated cost of the least expensive way to fulfill that function. For example, the least expensive way to "transport water" may be a simple ditch.

(5) Record any notes about functions, costs, and worths in the "Comments" field.

(6) Identify the function(s) of the entire project. Sum the "costs" and "worths" to get the project cost and worth.

Project # *Project:*						VE Study # Function Analysis	
Function = Active Verb + Measurable Noun				*Kinds: (B)asic, (S)econdary, (R)equired (S)econdary, (U)nwanted*			
Item #	Item Description	Function		Kind	Cost	Worth	Comments
1							
2							
3							
4							
5							
6							
7							
8							
9							

Project # *Project:*						VE Study # Function Analysis	
Function = Active Verb + Measurable Noun				*Kinds: (B)asic, (S)econdary, (R)equired (S)econdary, (U)nwanted*			
Item #	Item Description	Function		Kind	Cost	Worth	Comments
10							
11							
12							
ALL	Entire project						

Form: Cost/Function Analysis

Purpose: Continue the function analysis.

(1) Record functions from **Function Analysis**. Also, record their kind, cost, and worth.

(2) Calculate the percentage of the total cost and total worth that each function represents.

(3) Rank the functions in descending order. You may also want to calculate their cost/worth ratio.

Based on these factors, choose the functions to consider in the speculation phase.

Project # *Project:*				VE Study # Cost/Function Analysis	
Function = Active Verb + Measurable Noun *Kinds: (B)asic, (S)econdary, (R)equired (S)econdary, (U)nwanted*					
Function		Kind	Cost / % of Total	Worth / % of Total	Comments
Total					

SPECULATION PHASE

This phase consists of a team brainstorming session to generate ideas. Guidelines for brainstorming appear in *Appendix A*. A form is provided for recording the results of the session.

Form: Speculation Phase (Brainstorming)

Purpose: Record results of brainstorming session.

(1) Complete a separate form for each function. Summarize the original design in one line.

(2) Brainstorm alternative design ideas, keeping in mind the overall goals of the study. Additional guidelines for brainstorming sessions appear in *Appendix A*. During the session, record all ideas. For the final form (report), write succinct idea descriptions.

Project # *Project:*	VE Study # Speculation Phase (Brainstorming)
Function: **Original design:**	
Ideas Generated	

EVALUATION PHASE

This phase is another group activity. The two forms guide the team through the evaluation process, in which the most promising alternatives are selected for development.

Form: Evaluative Criteria and Matrix

Purpose: Define criteria (and their relative importance) for judging ideas generated by brainstorming.

(1) Choose up to seven criteria that are key to the project. Include the following: reliability, life-cycle cost, safety, quality, and environmental impact (these may be modified to apply to the specific project). Add any comments needed for clarification.

(2) Complete the criteria matrix. Compare each pair of criteria and record their relative importance. For example, if criteria E is "safety" and criteria G is "aesthetics," and safety is considered more important than aesthetics, that section of the matrix would look like this:

E	?	e
F	?	
G		

(3) Calculate the total points for each criterion. Each "greater importance" is 1 point; each "equal importance" is 1/2 point. Sum the values for the "total points."

(4) Calculate the percentage of total points assigned to each criterion.

(5) Record any notes about the criteria matrix values in the comments/discussion section.

Project # *Project:*	VE Study # Evaluative Criteria & Matrix

Evaluative Criteria

ID	Description	Comments
A		
B		
C		
D		
E		
F		
G		

Criteria Matrix

							Total points	% of Total
A								
	B							
		C						
			D					
				E				
					F			
						G		
						Total		

a = *A is of greater importance*

a/b = *A and B are of equal importance*

Comments/Discussion

Form: Evaluation

Purpose: Judge ideas by criteria, and choose ideas to develop further.

(1) Complete one form for each function. From ideas generated (see **Speculation Phase - Brainstorming**), choose all ideas that the team considers to be feasible. List them, and assign a number or code to each.

(2) Discuss advantages and disadvantages (benefits and drawbacks) of each idea with regard to the evaluative criteria. Describe these briefly in the spaces provided.

(3) Judge the ideas by each criterion. Assign a number from 0 to 10, with 10 being the best.

(4) Calculate the total score of each idea. Multiply the value assigned for each criterion by the total points given to that criterion on **Evaluative Criteria and Matrix**, and sum the values for the "total score." (If you are entering the data into the computer, the spreadsheet should calculate the total score automatically.)

(5) Choose ideas to develop further (one or more of the top-scoring ideas).

Project # *Project:*	VE Study # Evaluation

Function:

Idea #	Idea Description	Criteria								Advantages	Disadvantages
		A	B	C	D	E	F	G	Score		

DEVELOPMENT PHASE

For this phase, a set of five forms is provided. One set should be completed for each proposed alternative. These forms help the team develop each idea into a preliminary design alternative.

Form: Development - Benefits

Purpose: Identify advantages and disadvantages of an alternative design.

(1) Complete one form for each idea/alternative.

(2) List the evaluative criteria in the spaces provided.

(3) For each criterion, discuss the advantages and disadvantages (benefits and drawbacks) of the proposed design.

Project # *Project:*	VE Study # Development - Benefits Recommendation # _____
Recommendation:	Page __ of __

Advantages & Disadvantages
Criterion:
Criterion:
Criterion:
Criterion:
Criterion:
Criterion:
Criterion:

Form: Development - Sketches

Purpose: Develop idea/alternative.

(1) Complete one form for each idea/alternative.

(2) Sketch original and proposed designs (if applicable) in the spaces provided.

Project # *Project:*	VE Study # Development - Sketches Recommendation # _____ Page __ of __
Recommendation:	

Form: Development - Estimate

Purpose: Estimate initial costs of idea/alternative.

(1) Complete one form for each idea/alternative.

(2) Record recommendation number, description, and page numbers.

(3) Unit cost data should come from the project estimate, if possible. Include items at whatever level of detail is appropriate to show the sources of potential savings.

Project #					VE Study #	
Project:					Development - Estimate	
					Recommendation # _____	
Recommendation:					Page __ of __	
Element			Original Design		Proposed Design	
Item	Units	Unit Cost	# Units	Total	# Units	Total
		Totals:		$		$
		Initial savings/ cost avoidance:				$

Form: Development - LCC Cost

Purpose: Estimate life-cycle cost savings of alternative.

(1) Complete one form for each idea/alternative.

(2) Record recommendation number, description, and page numbers.

(3) Record discount rate to be used and estimated economic life of the design.

(4) List one-time expenditures and annual costs that can reasonably be expected, for both the original and proposed designs.

(5) Find the PW (Present Worth) factors from the chart in *Appendix B.* Calculate the PW of each cost by multiplying the cost by its PW factor.

(6) Sum the present worths of all costs for the "total life cycle cost."

Project # *Project:*				VE Study # Development - LCC Cost Recommendation # _____ Page __ of __	
Recommendation:					
Discount Rate:			Economic Life:	years	
Element	PW Factor	Original Design		Proposed Design	
		Cost	PW	Cost	PW
One-time Expenditures:					
Annual Costs:					
Total Life Cycle Costs			$		$

Form: Development - Summary

Purpose: Summarize a proposed alternative.

(1) Complete one form for each idea/alternative.

(2) Briefly describe the original and proposed designs, and discuss important advantages, disadvantages, and implications.

(3) Record costs and savings from other **Development** worksheets.

Project # *Project:*	VE Study #
	Development - Summary
Function:	Recommendation # _____ Page __ of __

Original Design

Proposed Design

Discussion

Cost Summary	Original Design	Proposed Design	Savings/Cost Avoidance
Initial Cost			$
Other Life Cycle Costs (Present Worth)			$
Total Life Cycle Savings/Cost Avoidance: $			

PRESENTATION PHASE

This phase should be an individual effort, unless a group presentation is desired. The team leader should complete the "Proposal Summary" form and write an executive summary of the study. Then, the completed workbook should be transcribed and printed as the final report.

Form: Proposal Summary

Purpose: Present proposal information in a summary table.

(1) For each proposed alternative, record recommendation number, description, and initial costs from **Development - Summary**.

(2) Also from **Development - Summary**, calculate initial, life-cycle (O&M), and total potential savings.

(3) Sum the costs and savings.

Project # *Project:*					VE Study # Proposal Summary	
#	Description	Original Design Cost	Proposed Design Cost	Initial Savings	O&M Savings	Total Savings
Totals		$	$	$	$	$

Executive Summary

Purpose: To present a summary of the study and its results.

(1) The executive summary should be concise, confined to one page if possible.

(2) General information should include a project description (including estimated cost) and a study description (dates, goals). This information comes from **Study Identification and Summary**.

(3) Include a summary of results indicating the number of VE proposals and their estimated savings. Also, give a brief description of some or all of the recommendations.

(4) Indicate the team leader or other contact person, along with contact information (phone, fax).

Appendix A: Brainstorming

Excerpted from UDOT's Manual of Instruction for Value Engineering:

BRAINSTORMING: This creative approach is an uninhibited, conference-type, group approach, based upon the stimulation of one person's mind by another's. A typical brainstorming session consists of a group of four to eight people spontaneously producing ideas designed to solve a specific problem. The objective is to produce the greatest possible number of alternative ideas for later evaluation and development. Rules observed during brainstorming:

1. Judicial thinking must be withheld. This means controlling the natural tendency to instantaneously evaluate ideas.
2. No criticism by word of mouth, tone of voice, shrug of shoulders or other forms of body language, that indicates rejection, is permitted.
3. "Free-wheeling" is welcomed. The wilder the idea, the better; it is easier to tame down than to think up.
4. Apply the technique of "hitchhiking" or "piggybacking" which is to expand on the ideas of others by offering many variations (synergism).
5. Combination and improvement of ideas is suggested.
6. Set a goal in the number of ideas, or time, to force hard thinking.

The general procedure for brainstorming is:

1. The group has a free discussion, with the group leader only questioning and guiding and occasionally supplying problem-related information.
2. All ideas are listed so that all members of the group can see as well as hear the ideas. The use of a flip chart and crayons, or felt tip pens, is preferable. The filled sheets can be taped to the walls so that they are constantly in view.

Adapted from NJDOT's Value Engineering Unit Procedures:

Consider the following during speculation:

- Traffic:
  - Look for traffic squeeze points upstream/downstream
  - Simplify traffic control and staging
- Roadway
  - Utilize existing versus abandoning and/or realigning
  - Widen roadway on one side versus both sides
- Structures
  - Eliminate structures
  - Reconstruct versus rehabilitate
  - Construct new parallel structure versus widening existing
  - Retaining walls/ reinforced earth walls versus fill
- Utilities
  - Avoid utility conflicts
  - Simplify utilities
- Impacts
  - Reduce/eliminate environmental impacts (historic, wetlands, waste)
  - Avoid/improve access impacts
  - Reduce/eliminate right-of-way impacts
- Other
  - Innovative versus traditional methods
  - Traffic signal versus overpass
  - Reduce drainage system

Appendix B: Present Worth Factor Chart

Years	6%	7%	8%	9%	10%	12%	14%	16%	18%	20%
1	0.943	0.935	0.926	0.917	0.909	0.893	0.877	0.862	0.847	0.833
2	0.890	0.873	0.857	0.842	0.826	0.797	0.769	0.743	0.718	0.694
3	0.840	0.816	0.794	0.772	0.751	0.712	0.675	0.641	0.609	0.579
4	0.792	0.763	0.735	0.708	0.683	0.636	0.592	0.552	0.516	0.482
5	0.747	0.713	0.681	0.650	0.621	0.567	0.519	0.476	0.437	0.402
6	0.705	0.666	0.630	0.596	0.564	0.507	0.456	0.410	0.370	0.335
7	0.665	0.623	0.583	0.547	0.513	0.452	0.400	0.354	0.314	0.279
8	0.627	0.582	0.540	0.502	0.467	0.404	0.351	0.305	0.266	0.233
9	0.592	0.544	0.500	0.460	0.424	0.361	0.308	0.263	0.225	0.194
10	0.558	0.508	0.463	0.422	0.386	0.322	0.270	0.227	0.191	0.162
11	0.527	0.475	0.429	0.388	0.350	0.287	0.237	0.195	0.162	0.135
12	0.497	0.444	0.397	0.356	0.319	0.257	0.208	0.168	0.137	0.112
13	0.469	0.415	0.368	0.326	0.290	0.229	0.182	0.145	0.116	0.093
14	0.442	0.388	0.340	0.299	0.263	0.205	0.160	0.125	0.099	0.078
15	0.417	0.362	0.315	0.275	0.239	0.183	0.140	0.108	0.084	0.065
16	0.394	0.339	0.292	0.252	0.218	0.163	0.123	0.093	0.071	0.054
17	0.371	0.317	0.270	0.231	0.198	0.146	0.108	0.080	0.060	0.045
18	0.350	0.296	0.250	0.212	0.180	0.130	0.095	0.069	0.051	0.038
19	0.331	0.277	0.232	0.194	0.164	0.116	0.083	0.060	0.043	0.031
20	0.312	0.258	0.215	0.178	0.149	0.104	0.073	0.051	0.037	0.026

Appendix C: Selection Criteria

The following form should be completed for each small transportation project. When selecting projects for VE study, use the “total criteria points” as a measure of the VE potential of each project.

Form: Selection Criteria

Purpose: Assess the VE potential of a project in order to select the most promising projects for VE studies.

(1) For each criterion, indicate if it is satisfied and note any comments.

(2) The “total criteria points” is the number of criteria satisfied.

(3) Rank VE study candidates by their total criteria points. The projects with the highest score should receive the highest priority (subject to other factors, such as schedule).

Project # *Project:*		VE Study # Selection Criteria
Criteria Satisfied?	Criteria Description	Comments
	Project cost (initial estimate) greater than $5 million	
	Project cost (initial estimate) exceeds the budget	
	Bridge work over 25% of total project cost	
	Roadway repair &/or realignment over 50% of total project cost	
	Roadside work over 25% of total project cost	
	Major changes to existing structures (new alignments, new interchanges, widening, major reconstruction)	
	Multiple construction stages, night work construction, &/or expensive construction traffic control	
	Expensive solutions (overly long material haul, non-standard items, difficult materials requirements, highly skilled labor, etc.)	
	Accelerated design (tight design schedule)	
	Statewide or districtwide impact	
	Wetland mitigation	
	Hazardous waste cleanup	
	Extensive environmental or geotechnical requirements	
	High estimated life cycle / maintenance costs	
	Total Criteria Points (14 maximum)	

Appendix D: Implementation & Auditing

IMPLEMENTATION AND AUDITING PHASES

Once the VE study has been completed, recommendations need to be reviewed, accepted, and implemented. During and after the implementation, the results also need to be tracked, or audited. The following forms will help in accomplishing these objectives.

Form: Review by Stakeholders

Purpose: To document the responses of project stakeholders to the VE recommendations.

(1) Distribute copies of the form to the stakeholders along with copies of the recommendations.

(2) Instruct stakeholders to write their comments on the form.

(3) Arrange a meeting of the stakeholders to discuss their responses and come to consensus on the status of the recommendation.

(4) Keep a copy of each stakeholder's form with the completed VE study.

Project # *Project:*	VE Study # Review by Stakeholders
Recommendation:	Recommendation # _____
Review Status: Accept Conditionally Accept Reject	
Prepared by:	Date:
Stakeholder Responses	
Technical Feasibility: *(including how the feasibility was evaluated)*	
Implementable Portions: (*can be implemented without further study)*	
Validated Cost Savings: *(including how the estimate was verified)*	
Schedule Impact:	
Safety Impact:	
Traffic Operations Impact:	
Issue Resolution: *(any issues that were resolved)*	
Stakeholder Consensus: *(what other parties need to be consulted)*	
Other Comments: *(any other benefits or concerns)*	

Form: Summary of Accepted Recommendations

Purpose: To document the approval status and savings of VE recommendations.

(1) On completion of the review process, list all recommendations from the VE study along with their approval status (accepted, conditionally accepted, or rejected) and estimated potential savings.

(2) On completion of the project or as recommendations are implemented, record the actual implemented savings realized, as well as any comments to clarify savings or suggest improvements.

Project # *Project:*					VE Study # Summary of Accepted Recommendations
Recommendation #	**Description**	**Potential Savings***	**Implemented Savings***	**Approval (A,CA,R)****	**Comments**
*All savings are initial cost savings only, unless otherwise noted. **A=Accepted, CA=Conditionally Accepted, R=Rejected					

Form: Tracking Data (2 pages)

Purpose: To record data about projects and VE studies for tracking purposes, particularly for entry into a database.

Fill out all information as completely as possible. Too much information is better than too little! Fill out a form for each VE study done, and keep at least some of the information in a database if possible.

Tracking Data

Project Name:
Project #:
Project Dates:
Project Manager:
Project Location:
Major Project Components:

- Bridge
- Road improvements
- Paving
- Intersection improv.
- Bikeway
- Other (_____)

Study Name:
Study #:
Study Dates:
VE Team Leader:
Other VE Team Members:

1.
2.
3.
4.
5.

Summary Data:

- Initial project cost estimate
- Final project cost
- # of recommendations
- # of approved recommendations
- Estimated value of all recommendations
- Estimated value of approved recommendations
- Implemented savings

Recommendations:	
	Name
	#
	Estimated value
	Review status
	Implemented savings
	Comments
Recommendations:	
	Name
	#
	Estimated value
	Review status
	Implemented savings
	Comments
Recommendations:	
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