STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND
PUBLIC FACILITIES

COST-EFFECTIVENESS ANALYSIS PROCEDURE

USER'S GUIDE

(Written JULY 1994)

Revisions through 1998

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
COST-EFFECTIVENESS ANALYSIS PROCEDURE - USERS GUIDE

FOREWORD

This information is provided as a general guide to the use of the cost-effectiveness analysis procedure and ROADSIDE.XLW, an Excel spreadsheet workbook. ROADSIDE.XLW is the **official computation format** used and required by the State of Alaska, Department of Transportation and Public Facilities. This information does not relieve the user from studying, understanding, and applying the underlying principles of the cost-effectiveness analysis procedure and standard engineering economics. All users should reference the following documents:

State of Alaska, Department of Transportation and Public Facilities, Highway Preconstruction Manual, Section 1130, "Cost-Effectiveness Analysis"

1989 American Association of State Highway and Transportation Officials (AASHTO) Roadside Design Guide, Appendix A, "A Cost-Effectiveness Selection Procedure"

Federal Highway Administration (FHWA) Technical Advisory T7570.2, October 31, 1994, "Motor Vehicle Accident Costs"

1991 Federal Highway Administration (FHWA) "Supplemental Information for Use with the ROADSIDE Computer Program"

1977 American Association of State Highway and Transportation Officials (AASHTO) Guide for Selecting, Locating, and Designing Traffic Barriers, Section VII, "A Cost-Effectiveness Selection Procedure"

A standard engineering economics textbook

Transportation Research Board (TRB) Report 416, October 1993, Issues Surrounding Highway and Roadside Safety Management (the following related articles):

Ray, Malcolm H., "Quantifying Safety and Managing the Roadside Environment"
Troxel, Lori A., "Severity Models for Roadside Objects"
Mak, King K., "Cost-Effectiveness Evaluation of Roadside Safety Improvements"
Stephens, Louis B., "Guardrail Warrants for Low Volume Roads"

Pigman, Jerry G., and Agent, Kenneth R., "Guidelines for Installation of Guardrail", Transportation Research Record (TRR) No. 1302 Roadside Safety Features 1991

Reference to the "**Department**" refers to the direct and indirect involvement of the Department of Transportation and Public Facilities in the application of the cost-effectiveness analysis procedure.

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
COST-EFFECTIVENESS ANALYSIS PROCEDURE - USERS GUIDE

TABLE OF CONTENTS

			PAGE
I.	INTRODUCTION		1130-43
II.	USING ROADSIDE.XLW		1130-44
III.	BASIC INPUT DATA		1130-44
	A.	TITLE	1130-44
	B.	TRAFFIC INPUT	1130-44
	C.	ECONOMIC INPUT	1130-48
	D.	ROADSIDE MODEL INPUT	1130-48
	E.	SEVERITY INDEX INPUT	1130-50
	F.	PROJECT COST INPUT	1130-51
IV.	BACKGROUND ROADSIDE MODEL COMPUTATIONS		1130-53
	A.	COMPUTED COST FACTORS	1130-53
	B.	"WILLINGNESS-TO-PAY" and ASSOCIATED ACCIDENT COSTS	1130-53
	C.	ENCROACHMENT RATE	1130-56
	D.	ROADSIDE ZONE CALCULATIONS	1130-57
	E.	ROADSIDE ZONE GENERAL CHARACTERISTICS	1130-58
V.	BASIC OUTPUT DATA		1130-58
	A.	ACCIDENT PREDICTION OUTPUT	1130-59
	B.	PROJECT COSTS OUTPUT	1130-59
VI.	SENSITIVITY ANALYSIS - VARIATION OF INPUTS		1130-59
VII.	APPLICATION		1130-60

FIGURES **PAGE**

1	Sheet 1 of ROADSIDE.XLS	1130-45
2	Sheet 2 of ROADSIDE.XLS	1130-54

TABLES

1130-1	Slope Adjustment Factors Used to Determine Effective Offset	1130-50
1130-2	FHWA T7570.2 Comprehensive Costs by K-A-B-C-O Scale Severity	1130-55
1130-3	AASHTO Roadside Design Guide 1994 "Table A-2" Proportions of Accident Severity Levels Estimated at Various Severity (SI) Levels	1130-55
1130-4	Alaska DOT&PF Cost Effectiveness Procedure Resulting Severity Index-Accident Cost Relations	1130-55
1130-5	Multilane Adjustment Factors for a Four Lane Highway	1130-56
1130-6	Multilane Adjustment Factors for a Six Lane Highway	1130-57
1130-7	Summary of Input Variable Relative Significance	1130-60

APPENDICES

A Recommended Severity Index Tables 1130-61

1. Longitudinal Barriers, Barrier Terminals, and Crash Cushions
2. Parallel Slopes and Cross Slopes
3. Culvert Openings and Miscellaneous Drainage Items
4. Rigid Objects

B ROADSIDE.XLW Example Problems 1130-63

1. Single Point Obstacle 1130-63
2. Multiple Point Obstacle 1130-63
3. Analysis of Slope Cross-Section Alternatives 1130-67

I. INTRODUCTION

This document supplements the information presented in Appendix A of the **1989 AASHTO Roadside Design Guide** The **Roadside Design Guide** should be referred to for computations and accident modeling information not presented in this manual. This manual provides more detailed information and guidance on the use of the cost-effectiveness analysis procedure. It provides directions for inputting information into the ROADSIDE.XLW Excel workbook and example solutions.

The spreadsheet workbook, ROADSIDE.XLW, is a useful tool for highway engineers making decisions regarding the design of a roadside and placement of highway hardware. It aids the designer in selecting an alternative treatment, which offers the greatest anticipated return in terms of safety benefits compared to the amount of funds spent. ROADSIDE.XLW is the spreadsheet version of the Cost-Effectiveness Selection Procedure (Appendix A) in the **1989 AASHTO Roadside Design Guide** It consists of a spreadsheet, ROADSIDE.XLS, and a macro sheet, ROADSIDE.XLM. Both are written in Microsoft EXCEL 4.0 and can be translated to other spreadsheets. Opening the workbook file ROADSIDE.XLW automatically opens them both. A working knowledge of spreadsheets is required. They have been password protected to prevent any changes to the computation format. All proposed revisions and changes to the spreadsheets must be presented to the Department's Engineering and Operations Standards Section in Juneau for review and approval.

A. Supplement to Economic Analysis

It is important to stress that ROADSIDE.XLW is not a "black box" which automatically determines the benefits and costs of a problem. A considerable amount of data collection is required prior to inputting data. Half of ROADSIDE.XLW output is nothing more than standard economic analysis. That part requires a realistic choice of options and estimated costs for right-of-way acquisition, utilities relocation, design, installation, and maintenance.

The added value of using ROADSIDE.XLW, when compared to standard economics, is its ability to predict accident rates and costs associated with a given "roadside model." The design life, traffic volumes, growth rates, and geometric inputs must all be determined prior to using the spreadsheet. Resulting accident costs are then combined with the other project costs mentioned above, to provide a total cost of an option.

The cost-effectiveness analysis is best used to provide relative estimates for comparison of alternatives, rather than exact dollar figures for accidents.

II. USING ROADSIDE.XLW

The following files are contained on the ROADSIDE diskette:

ROADSIDE.DOC	User's Guide for ROADSIDE.XLW workbook, written in Microsoft Word for Windows ver. 5.0.
ROADSIDE.XLW	Workbook file, when opened - automatically opens the following two files written in Microsoft Excel ver. 5.0.
ROADSIDE.XLS	Input/Output spreadsheet for cost-effectiveness analysis
ROADSIDE.XLM	Macro sheet linked with ROADSIDE.XLS, no input required

Copy these files to the directory C:\ROADSIDE on your hard disk. Access the files by running EXCEL and opening the ROADSIDE.XLW workbook. In the lower right corner of the workbook screen, toggling a mouse pointer on the little page icons will produce the main screen of the ROADSIDE.XLS spreadsheet.

III. BASIC INPUT DATA

All user input is performed in the ROADSIDE.XLS sheet. The format of the first page of this sheet is shown as input and output blocks in Figure 1. All cells other than input cells are locked. It is only possible for the user to input data in the correct cells. Much of the background data is contained on a second sheet. Printing the second sheet is optional. The first sheet is essential to showing the basic problem being analyzed. The following inputs are required:

A. TITLE

At the top left corner of the spreadsheet, a place is provided for the name of the project, and the "option" or name of the particular cost-effective solution being evaluated. Above these inputs the spreadsheet automatically shows the internal date and time of the computer.

B. TRAFFIC INPUT

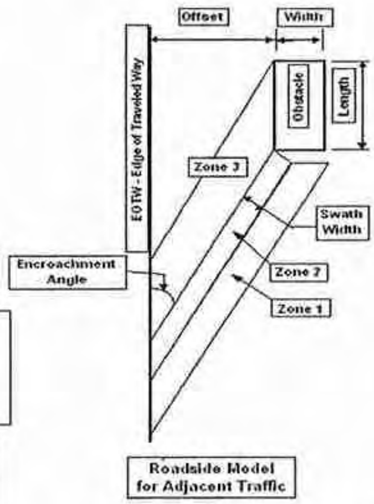
1. Average Daily Traffic (ADT)

Input the initial year two-way traffic volume for your project. Other input years such as a "mid-life" year, or design year volume may be used. However, then the following input of "Traffic Growth Factor" should be 0.0%. Traffic volume is a significant factor for determining user costs; therefore, using accurate volumes is important. The model assumes the characteristics of the highway facility are uninterrupted flow with no interaction among vehicles in the traffic stream. When traffic volumes reach capacity, the volume-encroachment relationship is no longer valid as the roadway changes to interrupted flow. Therefore, it is recommended the user input for initial year traffic volumes be limited to 10,000 vehicles per day for two lane roadways and 15,000 vehicles per lane per day for multilane roadways. Most, if not nearly all, of Alaska's roadways fall below these limits.

DATE: 1/26/98 3:42 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 1
OPTION:
Single Point Obstacle



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	38800	veh/day	57,700
Traffic Growth Factor	2	%	
Speed	65	mph	
Grade (+ = uphill , - = downhill)	0	%	
Degree of Curve (+= inside, -= outside)	0	degrees	
No. of Lanes Each Direction	3	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	D	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	2.00		
Opposing Lane User Factor	2.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

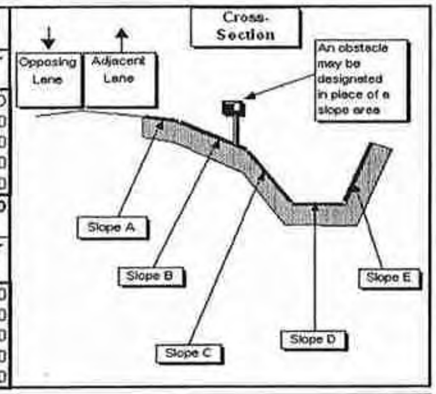
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill *)
C = Cut Slope (uphill *)
O = Obstacle
* from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	12	0	0	0	0
Slope/Obstacle Width (ft)	1	0	0	0	0
Slope/Obstacle Length (ft)	1	0	0	0	0
Effective Offset (computed)	12	0	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	3.1	0	0	0	0
Upstream Corner	3.1	0	0	0	0
Face	3.1	0	0	0	0
Downstream Corner	3.1	0	0	0	0
Downstream Side	3.1	0	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.0471	0.0000	0.0000	0.0000	0.0000	0.0471 impacts per year
Impacts Over Project Life	0.8724	0.0000	0.0000	0.0000	0.0000	0.8724 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$0
Utilities Costs	$0
Construction Costs	$0
TOTAL INSTALLATION COSTS	$0
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$5,400
Upstream Corner	$5,400
Face	$5,400
Downstream Corner	$5,400
Downstream Side	$5,400

PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$0	$0
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$17,226	$1,626
Opposing Accidents	$0	$0
Repairs due to Adjacent Accidents	$3,168	$299
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$17,226	$1,626
Net Costs to Department	$3,168	$299
TOTAL COSTS (Rounded)	$20,000 Project Life	$2,000 Per Year

Figure 1130-1

2. **Traffic Growth Factor**

Input the traffic growth rate from the initial year to the design year in percent. To the right of this is a tab called "Resulting Design Year ADT" which computes a value for the design year traffic volume. This allows the user to compare with the design volume data, which is available for most highway design projects. The growth rate does not significantly affect the user and agency costs. A rate of two percent may be used if other information is not available.

3. **Speed**

Input the speed for the problem. This may be the design speed on a new project, or the 85th percentile speed or posted speed limit for an existing highway problem. This value is used to select the appropriate lateral extent probability curves as shown in figure A.5 of the **Roadside Design Guide** It is also used to determine the encroachment angle published in table A.8 of the **Roadside Design Guide**

4. **Grade**

Input the grade of the segment being studied. Use positive (+) numbers for uphill grades in the right or adjacent traffic lane. Use negative (-) numbers for downhill grades. These are used to apply adjustment factors for grade in accordance with figure A.2 of the **Roadside Design Guide**

5. **Degree of Curve**

Input the degree of curve being studied. Curves to the right (from the perspective of adjacent traffic) are assigned a (+) sign. Curves to the left (from the perspective of adjacent traffic) are assigned a (-) sign. Curvature adjustment factors are shown in figure A.2 of the **Roadside Design Guide**

6. **No. of Lanes in Each Direction**

Input the number of lanes in the direction to be analyzed. If it is a two lane roadway, enter "1". If it is a four lane undivided highway, enter "2". If it is a six lane divided highway, enter "3". If it is a one-way roadway, enter the total number of through lanes.

7. **Lane Width**

Input the typical width of the adjacent traffic lanes.

8. **Swath Width**

In the roadside model drawn on the spreadsheet, this is the width of the errant vehicle path approaching the obstacle. The Roadside Design Guide suggests a value of 12 feet.

9. **Highway Type**

Enter "U" for undivided roadways, "D" for divided highways, and "O" for one-way roadways. For undivided highways, encroachments on one side of the road by both adjacent and opposing traffic are calculated. Encroachments from the opposite direction are not computed on divided and one-way highways.

10. **Median or Roadside Analysis**

Input "R" or "M". A roadside analysis (R) is for an obstacle to the right of the adjacent traffic lanes, or located off the shoulder. A median analysis (M) is for an obstacle to the left of the adjacent traffic lanes, or located over the centerline.

For undivided highways, median and roadside analyses include encroachments from opposing traffic. For divided highways only encroachments from adjacent traffic are considered. For obstacles within the median of a divided highway, a separate program run is needed if encroachments are to be considered from opposing traffic.

11. Adjacent Lane & Opposing Lane User Factors

This is a factor which can be applied to adjust the encroachment rate per mile per year (the rate vehicles are estimated to cross the edge-of-traveled-way). It is rarely used. Any number input here would have to be well supported based upon accident research for the individual roadway segment being studied. Examples of potential user factors include:

a. Accident History User Factor

The cost-effectiveness analysis computes the predicted number of impacts with an obstacle per year and over the design life. If the historical accident record consistently shows that the number of impacts with the same obstacle is significantly higher than the computed results, then it is permissible to apply a user factor greater than or equal to one **(>=1.00)** to adjust for this. Due to the potential for unreported accidents, user factors based on accident history shall not be less than 1. Example 1 at the end of this report demonstrates this type of problem. This is only applicable when the roadway and roadside conditions are to remain the same as they were during the period of historical record.

b. Open Water User Factor

The collision frequency with an object is directly related to the quantity of time traffic is exposed to the object. Open water surfaces such as lakes, streams, and wetlands are typically frozen for several months out of the year. During this time, they can be considered less severe than when they are thawed (see severity index tables in Appendix A). Adjacent to these types of areas, it is recommended a user factor of **0.67** be used to reflect the approximate duration of eight months of the open water. In Southeast Alaska, this factor should be omitted. In Northern Alaska, the duration of a frozen water surface may be much longer. The user will have to make reasonable adjustments to reflect the varying conditions of water hazards.

c. Roadside Snow Berms User Factor

For a minimum of four months each year, during the winter season, Alaska roadsides are covered in a blanket of snow. This cover is usually deep enough and dense enough that the speed of errant vehicles is quickly reduced. Driving off the road from mid-November through mid-March is much like impacting a crash cushion. Vehicles typically do not travel far off the edge-of-traveled-way when the roadside slopes are 4:1 or flatter. Based upon this idea, it has often been suggested there should be a user factor, which reduces accident severity due to the presence of snow berms in Alaska. However, at the same time road surface conditions such as ice and snow may lead to a higher rate of encroachments.

At present, there is no research to determine the reduction in severity of roadside slopes due to the presence of snow cover. In 1989, the Department concluded field research was necessary to develop user factors to account for this. Until this information can be developed and distributed by the Department, a user factor should not be applied for roadside snow berms.

C. ECONOMIC INPUT

1. Period

Input the period of years over which the obstacle or slope is to be evaluated. This may be the project design life.

2. Interest Rate

Input the interest rate to be used in the economic analysis. A rate of seven percent should be used unless otherwise approved at the Department's Project Manager level.

D. ROADSIDE MODEL INPUT

ROADSIDE.XLW defines a roadside obstacle as a rectangle by its lateral offset from the edge-of-traveled-way, its length, and its width perpendicular to oncoming traffic. Errant vehicle approaches to the obstacle are broken up into three zones for each direction of traffic as shown in figure A.4 of the **Roadside Design Guide.**

The obstacle can be a bridge pier, a large box culvert inlet and channel, an embankment. It can also be a traffic barrier designed to shield a roadside obstacle or non-traversable terrain feature. Simple or complex cross-sections can also be modeled, even with a point obstacle at the base. User costs are sensitive to the offset distance and length of the obstacle. The closer to the roadway and the longer the obstacle, the more chances for collisions. Agency costs are also sensitive to obstacle length. The width of the obstacle does not significantly influence costs.

1. Fill, Cut, or Obstacle

Referring back to Figure 1, the first input in this block is to determine whether each of the sideslope areas is a fill slope (downhill), cut slope (uphill), or an obstacle. If input is only filled in for area A, then only a single object is to be evaluated. If additional slope areas are needed, then the cross-section can be broken down to use areas A through E.

The correct rules to apply when using slope or obstacle areas are:

a. If the obstacle lies on the breakpoint between two different slopes, then the problem can be performed in a single spreadsheet calculation using slope area A, obstacle area B, and slope area C.

b. If the obstacle lies within a single uniform slope, then two problems will have to be solved. First, solve the problem without the obstacle, inputting information only for slopes in areas A through E. Next, solve the problem using only the slopes from the edge-of-traveled-way to the obstacle, or for example slope area A and obstacle area B. As shown later, a backup calculation sheet allows the costs associated with obstacle area B to be separated from the other slope areas. Manually add together the cost of the obstacle area B with the cost of slopes A through E in the first solution to obtain the total roadside cost.

c. Do not break a uniform slope in order to input the obstacle in area B, and then continue on with the same slope in area C. Though it may appear to reduce the problem to a single solution, this will erroneously double the accident costs associated with the slope. This has the effect of creating two Zone 3 encroachment areas (Figure 1), or two "faces" of the same slope parallel to the roadway, while there is actually only one slope area.

d. In order to have a good comparison, all multiple hazard solutions should be worked with a similar approach to each problem. Traverseable slopes should be compared over a similar width. The problem must either be considered by reducing all solutions to single slopes or obstacles, or by comparing multiple hazards over the same width. If the same approach is not used in developing alternative solutions, the results may not be relative to each other.

e. Once the vehicle has hit a non-traverseable cut slope or severe non-breakaway object, then it is unlikely to continue on to another object or slope. If the vehicle has entered a non-traverseable or steep slope, it is likely to continue or roll to the next object or slope. If the second slope or object has a higher severity, the higher Severity Index SI value could be used. The inaccuracy of modeling two adjacent high severity, non-recoverable hazards will tend to make it a more costly alternative. This is reasonable since this is a less desirable option for design.

f. If the obstacle is within the slope and of the same severity range, then it could be ignored.

2. Slope Rate

If the areas A through E on the spreadsheet are slopes, enter the slope rate as A whole number "X" in terms of an "X":1 slope. Valid inputs are 1, 2, 3, 4, 5, 6, and 10. A 10:1 slope can be used for flat slopes.

3. Offset to Slope/Obstacle

Input the actual horizontal offset from the edge-of-traveled-way to each of the roadside model areas A through E. For varying or multiple offset distances, an average offset distance should be used.

4. Slope/Obstacle Width

Input the horizontal width of the slope or obstacle perpendicular to the roadway for each of the areas A through E.

5. Slope/Obstacle Length

Input the length of the slope or obstacle parallel to the roadway for each of the Areas A through E. The length of an obstacle may vary from the length of slope areas.

6. Effective Offset

The spreadsheet uses the slope rate input to apply rounded slope adjustment factors presented in Appendix B of the "Supplemental Guide for Use with the ROADSIDE Computer Program". The slope factors adjust the lateral offset distance to the next area, developing the "effective offset". This value is not an input item. If a vehicle was to traverse down a slope to an obstacle, the effective offset may be adjusted to less than the actual offset because of the downhill grade. The reverse is applied to uphill slopes.

Table 1130-1. Slope Adjustment Factors Used to Determine Effective Offset

		Fill Section	
Slope	<=6:1	5:1 / 4:1	>4:1
Offset Factor	1.0	0.8	0.0

		Cut Section	
Slope	<=6:1	5:1 / 4:1	>=3:1
Offset Factor	1.0	1.2	1.4

E. SEVERITY INDEX INPUT

To convert accidents to costs, a severity index (SI) must be assigned to impacts with an obstacle. Essentially, assigning a SI to an object determines the relative cost per accident. The relationship between severity index and the percent accident type is shown on page A-12 of the **Roadside Design Guide**. The costs associated with each severity index are provided in Table 2. These were determined using Willingness-to-Pay costs "per accident" as recommended by FHWA in Technical Advisory T7570.2, October 1994.

ROADSIDE.XLW has no capability to select an appropriate Severity Index. It is dependent upon the user for this information. Appendix A provides a list of Severity Indices adopted by the Department as guideline values. These are taken from the FHWA document "Supplemental Information for Use with the ROADSIDE Computer Program". Severity indices for ditch sections with combined slopes have not been adopted based upon the Department's testing of typical design problems. Instead, It is preferable to break down the roadside into more defined slope areas.

Severity index values must be assigned to the sides, corners, and face of the obstacle in the roadside model. The roadside model is pictured in the top right corner of the spreadsheet. This same figure can also be found in the **Roadside Design Guide**. Indices for the face or sides of the model may also be used for the corners of the roadside model.

1. Upstream Side

Input the Severity Index (SI) chosen for the upstream side of the obstacle. Do this for each of the slope areas A through E as needed. This is equivalent to Zone 1 in the roadside model. It will be impacted only by adjacent traffic. For slopes over long distances, such as 1000 feet or more, the SI value may be zero. See Appendix A for recommended SI values for the "Side" of an obstacle.

2. Upstream Corner

Input the Severity Index (SI) chosen for the upstream corner of the obstacle. Do this for each of the slope areas A through E as needed. This is equivalent to Zone 2 pictured in the roadside model. It will be impacted only by adjacent traffic. For slopes over long distances, such as 1000 feet or more, a SI value of zero may be used. For slopes of short length and for obstacles, this SI value may be the same as used for the "Side" of the obstacle.

3. Face

Input the Severity Index (SI) chosen for the face of the obstacle. Do this for each of the slope areas A through E as needed. This is equivalent to Zone 3 pictured in the roadside model. The face of the obstacle lies parallel to the roadway. For undivided highways, it will be impacted by both adjacent traffic and opposing traffic. If opposing traffic has to cross the adjacent lanes, the probability of collisions is typically lower for opposing traffic. For divided highways, the obstacle will be impacted by adjacent traffic only. See Appendix A for recommended SI values for the "Face" of an obstacle.

4. Downstream Corner

Input the Severity Index (SI) chosen for the downstream corner of the obstacle. Do this for each of the slope areas A through E as needed. This is equivalent to Zone 2 pictured in the roadside model, except it is on the trailing side of the obstacle. Opposing traffic can impact it only on undivided highways. Use the same method for choosing the SI value as used for the Upstream Corner.

5. Downstream Side

Input the Severity Index (SI) chosen for the downstream side of the obstacle. Do this for each of the slope areas A through E as needed. This is equivalent to Zone 1 pictured in the roadside model, except it is on the trailing side of the obstacle. Opposing traffic can impact it only on undivided highways. Use the same method for choosing the SI value here as used for the Upstream Side.

Severity Index Range

The severity indices shown in Appendix A incorporate the ranges "Low", "Medium", and "High" for each obstacle. The range covers other performance factors beyond those considered in the model. When selecting a severity index, the user should read the general descriptions provided below each table. The slope or obstacle being modeled does not have to exactly match the information provided. These descriptions are a list, and one or more of the characteristics may apply to the roadside being modeled.

An example would be a new breakaway pole foundation. Because it is a new installation, Table 4 in Appendix A would place this obstacle in the "Low" severity index range. But if the slip plane of the breakaway base is over 4 inches above the ground, or it is placed on a steep slope, then the severity index would have to be chosen near the "High" range.

In the case of multiple obstacles at one location, input the severity of the most severe obstacle.

F. PROJECT COST INPUT

The installation, repair, maintenance and salvage value costs are the final basic inputs to the program.

1. Installation Costs

Installation cost is broken down into the components typically used in the highway construction process: design, right-of-way, utilities, and construction. Design costs may not be a factor in determining the outcome of a project, which is already in the process of design. However, some projects are simply preliminary location projects, which identify many potential intersections or roadway segments for improvements. An example would be capacity or safety improvement projects. During the location stage, design costs may be useful in determining whether or not to even begin these types of projects.

Right-of-way costs involve the necessary right-of-way costs associated with each design option being evaluated. Utility costs are the costs to relocate or adjust utilities for each design option.

The most important of these costs is the construction and contract administration cost. Construction costs most directly affect Department costs. Since this is a significant factor, the construction costs used in the analysis should be current and obtained from accurate sources.

2. Annual Maintenance

All routine maintenance costs should be considered here. Regular hardware maintenance and upkeep are examples. Depending on the alternatives being evaluated, even the relative effects of solutions on snowplowing and clearing efforts can be a factor.

Annual maintenance costs may be obtained through several sources, including the Department's Maintenance & Operations Section, other persons familiar with the road upkeep, and magazine or journal articles. Similar to determining installation costs, the designer must independently research the life cycle costs of the proposed option.

3. Salvage Value

Input the salvage value of the installation at the end of the project life. In most applications, this value is zero. In some situations, there may be a recovery value associated with items such as lighting and traffic control hardware.

4. Damage Costs Per Accident

Input the accident damage costs for each of the zones of the obstacle discussed earlier (e.g. upstream side, upstream corner, face, downstream corner, downstream side). Damage costs per accident are the costs by the Department necessary to repair an impacted obstacle.

Once this information is provided, accident prediction output and project costs output are automatically computed. This output will be discussed later in this guide. Before computing project costs, the spreadsheet performs a series of background computations.

IV. BACKGROUND ROADSIDE MODEL COMPUTATIONS

All of the installation, maintenance, and other project costs are nothing more than fundamental engineering economics which do not require the use of this spreadsheet. Probably the most important purpose of the cost-effectiveness analysis procedure is its ability to model accident costs associated with a given roadside model input. Accident costs, combined with project costs, provide a useful estimate of the overall project impact.

The second page of the spreadsheet (Figure 2) contains tables, which show the results of background calculations. These are values used to develop the total accident frequency and costs associated with the option being analyzed.

A. COMPUTED COST FACTORS

The Capital Recovery Factor (A/P), Sinking Fund Factor (A/F), and Single Payment Compound Amount Factor (F/P), are all used in this analysis procedure. They can be found in any economics text. The "Economic Factor", Kc, is defined in the **Roadside Design Guide** It takes into account the traffic growth rate in addition to the interest rate. This factor helps determine the final collision frequency with the roadside model, thus also affecting the damage costs and repair frequency of any option.

B. "WILLINGNESS-TO-PAY COSTS" and ASSOCIATED ACCIDENT COSTS

FHWA Technical Advisory T7570.2 presents "willingness-to-pay" costs which can be assigned to each fatality, injury, and property damage accident. Using the severity indices for each zone of the roadside model, accident costs per collision are computed and presented in the backup computations. These are determined based upon the combination of Table A.2 of the **Roadside Design Guide** and FHWA Technical Advisory T7570.2. Table A.2 provides the percentage distribution of accidents occurring in the fatality, injury, and property damage ranges for a given severity index. The resulting accident cost distribution is shown in Table 2.

BACKGROUND ROADSIDE MODEL COMPUTATIONS

PROJECT: **EXAMPLE 1**
OPTION: **Single Point Obstacle**

DATE: 1/26/98
2:31 PM

COMPUTED COST FACTORS		
Capitol Recovery Factor	0.09439	A/P
Sinking Fund Factor	0.02439	A/F
Single Payment Compound Amount Factor	3.86968	F/P
Economic Factor	12.44265	Ke

WILLINGNESS-TO-PAY COSTS		Severity Code
Fatality	$1,700,000	K
Incapacitating Injury	$47,000	A
Nonincapacitating Injury	$19,000	B
Possible Injury	$8,500	C
Property Damage Only	$3,000	O

ASSOCIATED ACCIDENT COSTS	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	$29,364	$0	$0	$0	$0
Upstream Corner	$29,364	$0	$0	$0	$0
Face	$29,364	$0	$0	$0	$0
Downstream Corner	$29,364	$0	$0	$0	$0
Downstream Side	$29,364	$0	$0	$0	$0

ENCROACHMENT RATE	Adjacent Traffic	Opposing Traffic
Encroachment Angle (degr)	11.6	11.6
Baseline Encr. Frequency	9.70	0.00
Curve Adjustment Factor	1.00	1.00
Grade Adjustment Factor	1.00	1.00
Multilane Adjustment Factor	0.53	1.00
User Factor	2.00	2.00
Total Encroachments	10.28	0.00

Adjacent Traffic

	Zone Length A	Zone Length B	Zone Length C	Zone Length D	Zone Length E
Zone 1	5	0	0	0	0
Zone 2	60	60	60	60	60
Zone 3	1	0	0	0	0
Total	66	60	60	60	60

	Encroachment Frequency A	Encroachment Frequency B	Encroachment Frequency C	Encroachment Frequency D	Encroachment Frequency E
Zone 1	0.0095	0.0000	0.0000	0.0000	0.0000
Zone 2	0.1162	0.1162	0.1162	0.1162	0.1162
Zone 3	0.0019	0.0000	0.0000	0.0000	0.0000
Total	0.1276	0.1162	0.1162	0.1162	0.1162

	Lateral Extent Probability A	Lateral Extent Probability B	Lateral Extent Probability C	Lateral Extent Probability D	Lateral Extent Probability E
Zone 1	0.2716	0.0000	0.0000	0.0000	0.0000
Zone 2	0.3757	0.0000	0.0000	0.0000	0.0000
Zone 3	0.4661	0.0000	0.0000	0.0000	0.0000
Total					

	Collision Frequency (impacts/yr)A	Collision Frequency (impacts/yr)B	Collision Frequency (impacts/yr)C	Collision Frequency (impacts/yr)D	Collision Frequency (impacts/yr)E
Zone 1	0.0026	0.0000	0.0000	0.0000	0.0000
Zone 2	0.0437	0.0000	0.0000	0.0000	0.0000
Zone 3	0.0009	0.0000	0.0000	0.0000	0.0000
Total	0.0471	0.0000	0.0000	0.0000	0.0000

	Accident Costs per year A	Accident Costs per year B	Accident Costs per year C	Accident Costs per year D	Accident Costs per year E
Zone 1	$76	$0	$0	$0	$0
Zone 2	$1,282	$0	$0	$0	$0
Zone 3	$27	$0	$0	$0	$0
Total	$1,384	$0	$0	$0	$0

Adjacent Traffic	Total Initial Accident Costs First Year
Zone 1	$76
Zone 2	$1,282
Zone 3	$27
Total	$1,384

Opposing Traffic

	Zone Length A	Zone Length B	Zone Length C	Zone Length D	Zone Length E
Zone 1	5	0	0	0	0
Zone 2	60	60	60	60	60
Zone 3	1	0	0	0	0
Total	66	60	60	60	60

	Encroachment Frequency A	Encroachment Frequency B	Encroachment Frequency C	Encroachment Frequency D	Encroachment Frequency E
Zone 1	0.0000	0.0000	0.0000	0.0000	0.0000
Zone 2	0.0000	0.0000	0.0000	0.0000	0.0000
Zone 3	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000

	Lateral Extent Probability A	Lateral Extent Probability B	Lateral Extent Probability C	Lateral Extent Probability D	Lateral Extent Probability E
Zone 1	0.0413	0.0000	0.0000	0.0000	0.0000
Zone 2	0.0612	0.0000	0.0000	0.0000	0.0000
Zone 3	0.0780	0.0000	0.0000	0.0000	0.0000
Total					

	Collision Frequency (impacts/yr)A	Collision Frequency (impacts/yr)B	Collision Frequency (impacts/yr)C	Collision Frequency (impacts/yr)D	Collision Frequency (impacts/yr)E
Zone 1	0.0000	0.0000	0.0000	0.0000	0.0000
Zone 2	0.0000	0.0000	0.0000	0.0000	0.0000
Zone 3	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000

	Accident Costs per year A	Accident Costs per year B	Accident Costs per year C	Accident Costs per year D	Accident Costs per year E
Zone 1	$0	$0	$0	$0	$0
Zone 2	$0	$0	$0	$0	$0
Zone 3	$0	$0	$0	$0	$0
Total	$0	$0	$0	$0	$0

Opposing Traffic	Total Initial Accident Costs First Year
Zone 1	$0
Zone 2	$0
Zone 3	$0
Total	$0

ROADSIDE ZONE GENERAL CHARACTERISTICS Totals	Adjacent Traffic	Opposing Traffic	Total
Impacts per year	0.0471	0.0000	0.0471
Impacts over Project Life	0.8724	0.0000	0.8724
Initial Accident Costs per year	$1,384	$0	$1,384

Figure 1130-2

Table 1130-2. FHWA T7570.2

Comprehensive Costs by K-A-B-C-O Scale Severity (1994 Dollars)

FHWA T 7570.2 Comprehensive Costs			
K	Fatality	$	2,600,000
A	Incapacitating	$	180,000
B	Evident Injury	$	36,000
C	Possible Injury	$	19,000
O	Prop. Dmg. Only	$	2,000

Table 1130-3. AASHTO Roadside Design Guide 1994 "Table A-2" Proportions of Accident Severity Levels Estimated at Various Severity (SI) Levels

Severity Index	O PDO(1)	O PDO(2)	C Slight Injury	B Moderate Injury	A Severe Injury	K Fatality
0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	100.0	0.0	0.0	0.0	0.0	0.0
1	66.7	23.7	7.3	2.3	0.0	0.0
2	0.0	71.0	22.0	7.0	0.0	0.0
3	0.0	43.0	34.0	21.0	1.0	1.0
4	0.0	30.0	30.0	32.0	5.0	3.0
5	0.0	15.0	22.0	45.0	10.0	8.0
6	0.0	7.0	16.0	39.0	20.0	18.0
7	0.0	2.0	10.0	28.0	30.0	30.0
8	0.0	0.0	4.0	19.0	27.0	50.0
9	0.0	0.0	0.0	7.0	18.0	75.0
10	0.0	0.0	0.0	0.0	0.0	100.0

Table 1130-4. Alaska DOT&PF Cost Effectiveness Procedure Resulting Severity Index Accident Cost Relations (1998 Dollars)

Severity Index	Accident Cost
0	$
0.5	$ 2,200
1	$ 4,500
2	$ 8,800
3	$ 46,000
4	$ 115,000
5	$ 265,000
6	$ 560,000
7	$ 915,000
8	$ 1,500,000
9	$ 2,200,000
10	$ 2,800,000

C. ENCROACHMENT RATE

The encroachment rate is determined by first calculating a baseline value and then making adjustments through a series of factors. The encroachment rate represents the frequency at which vehicles are expected to cross over the edge-of-traveled-way per mile, per year.

1. Encroachment Angle

The encroachment angles are automatically determined based upon traffic speed. These are defined in table A.8 of the **Roadside Design Guide**

2. Baseline Encroachment Rate

The baseline encroachment rate is determined by using a factor of 0.0005 multiplied by the two-way ADT as outlined in the **Roadside Design Guide**

3. Curve and Grade Adjustment Factors

Curve and grade adjustment factors are computed as per figure A.2 of the **Roadside Design Guide**

4. Multilane Adjustment Factor

As shown in the "Supplemental Information for Use with the ROADSIDE Program" distributed by FHWA, a multilane factor is used to adjust for encroachments on multilane highways. It takes into account the distribution in traffic amongst the various lanes. In older programs, each lane and each direction of travel were analyzed as separate problems. With this factor applied to both directions of travel, it is now possible to analyze a multilane highway in one computer "run". A few numbers in the six lane "roadside" analysis for 60 mph had to be rearranged. They were transposed incorrectly in the FHWA supplement. The multilane adjustment factors used in the spreadsheet macro are as follows:

Table 1130-5. Multilane Adjustment Factors for a Four Lane Highway

	Median	**Analysis**		
ADT	40 mph	50 mph	60 mph	70 mph
12,000	0.39	0.47	0.53	0.57
24,000	0.43	0.50	0.56	0.60
36,000	0.49	0.55	0.60	0.64
48,000	0.55	0.61	0.65	0.68
60,000	0.62	0.67	0.70	0.73
	Roadside	**Analysis**		
ADT	40 mph	50 mph	60 mph	70 mph
12,000	0.85	0.87	0.88	0.89
24,000	0.81	0.83	0.85	0.87
36,000	0.75	0.78	0.80	0.82
48,000	0.69	0.73	0.76	0.78
60,000	0.62	0.67	0.70	0.73

Table 1130-6. Multilane Adjustment Factors for a Six Lane Highway

	Median	**Analysis**		
ADT	40 mph	50 mph	60 mph	70 mph
24,000	0.35	0.42	0.48	0.52
48,000	0.43	0.49	0.54	0.58
72,000	0.46	0.52	0.56	0.60
96,000	0.48	0.53	0.58	0.61
120,000	0.48	0.53	0.57	0.61
	Roadside	**Analysis**		
ADT	40 mph	50 mph	60 mph	70 mph
24,000	0.44	0.50	0.55	0.59
48,000	0.44	0.47	0.49	0.53
72,000	0.37	0.43	0.48	0.53
96,000	0.37	0.43	0.48	0.52
120,000	0.36	0.43	0.48	0.52

5. User Factor

This is an input value described earlier, which must be determined by the user. At present the only recommended factors for this program are for open water hazards or accident history comparisons, as discussed earlier for the Traffic Input block. The use of any other user factors must be approved at the Department's Project Manager level before they are used, in order to prevent indiscriminate adjustments to the results of the analysis.

D. ROADSIDE ZONE CALCULATIONS

The two largest tables on the second page of printout present the step by step background calculations used to determine the adjacent and opposing accident costs.

Purpose of the tables show the user what zones and portions of a roadside are having the greatest impact on accident costs. The user can observe this table to determine where the most effective adjustments can be made to improve a design roadside.

1. Zone Length

Based upon input traffic speeds and obstacle offset, length, and width, the first part of this table computes the resulting roadside zone lengths. Zones 1 through 3 represent the extension of the obstacle to the edge-of-traveled-way. This determines the length of roadway along which the obstacle lies in the path of an errant motorist.

2. Encroachment Frequency

This section computes the number of encroachments per mile per year expected for each zone in the roadside model. In other words, this is the number of vehicles, which are expected to cross over the edge-of-traveled-way each year, into the path of the obstacle. This is calculated as shown in the **Roadside Design Guide**, using a factor of 0.0005 times the Average Daily Traffic multiplied by the length of the zone. The number of vehicles actually expected to impact the obstacle is not calculated until step four below.

3. Lateral Extent Probability

Lateral extent probabilities are determined using lookup tables defined from Table A.1 of the **Roadside Design Guide** This value represents the likelihood of a vehicle reaching the obstacle or slope being modeled. They are determined for each of the roadside model zones 1 through 3 and areas A through E. Totals for adjacent and opposing directions are presented.

4. Collision Frequency (Impacts/year)

Next the program computes the number of impacts associated with the roadside model over the project life. This is determined by multiplying the encroachment rate by the lateral extent probability. These are also shown for each zone and each roadside model area.

5. Accident Costs Per Year

Once the number of collisions has been predicted, the severity index assigned to the obstacle or slope can be applied to determine the initial cost of collisions in each zone. This is computed by multiplying the number of collisions by the accident cost per collision. These initial costs are beginning-of-year costs. Once adjusted for the interest rate, they will be slightly higher in the final output.

6. Total Initial Accident Costs Per Year

In the small boxes below this section, the initial accident costs are summed up for both adjacent and opposing traffic in all zones. The result is an estimate of the initial annual cost of the predicted accidents due to the obstacle.

E. ROADSIDE ZONE GENERAL CHARACTERISTICS

In order to sum up the results of all the accident prediction formulas, an additional table is provided at the bottom of the background calculation page. This table simply sums the results of the individual calculations for each slope/obstacle area.

1. Impacts Per Year

This is just the sum of the collision frequencies determined earlier for each of the slope/obstacle areas. Totals are presented for both adjacent and opposing traffic.

2. Impacts Over Project Life

Based upon the impacts per year and the traffic growth rate, the impacts over the project life are computed. Totals are presented for both adjacent and opposing traffic.

3. Initial Accident Costs Per Year

This is just the sum of the accident costs per year determined earlier for each of the slope/obstacle areas. Totals are presented for both adjacent and opposing traffic.

V. BASIC OUTPUT DATA

Once all of the background calculations have been completed, the spreadsheet returns to the first page. Summing up background data output data is presented in two blocks:

A. ACCIDENT PREDICTION OUTPUT

This block just carries forward values from the background calculations. This retains useful information to the designer if they choose to print only the first page of the analysis. For each slope/obstacle area, the expected impacts per year and impacts over the project life are presented.

B. PROJECT COSTS OUTPUT

The most important part of the analysis, the "bottom line", is presented in the bottom right corner of the spreadsheet. Both present worth and annual costs are determined. They are divided into principal categories - project costs and accident costs. These are subtotaled as net costs to the Department and net costs to the public. The resulting annual costs of the modeled option are rounded to the nearest thousand dollars. The final results cannot be considered accurate or relative beyond that point. The cost-effectiveness analysis procedure is typically not used to put a fixed dollar figure on a "stand-alone" design option. Instead, its primary purpose is to enable the design engineer to make relative comparisons between an existing condition and several proposed alternative designs.

Any solutions that are within 10% of each other can be considered equivalent. This is demonstrated in the example problems in Appendix B.

VI. SENSITIVITY ANALYSIS

Sensitivity is the relative effect that an input variable may have on the outcome of an option. The degree of sensitivity of each input variable is described in Table 5. Use of the computer program makes it easy to vary an input variable. It may be desirable to test the effects of variations of the significant input variables on the selection of an alternative. The most important variable to analyze is the severity index. For most highway design work, the other variables, which have a significant effect on the output, are typically fixed. These include traffic volume, growth rate, and accident costs.

The program is very sensitive to the selection of a severity index. The suggested SI values in Appendix A are based on the Severity Index Tables contained in the AASHTO Roadside Design Guide, 1996. Actual conditions may not fit exactly the conditions cited in the SI tables. The user may have experience or data that suggests different SI values should be used.

Traffic volumes will also have a significant impact on the results. The cost-effective solution for a low-volume roadway (i.e. < 2000 vehicles per day) will likely not be the most cost-effective solution for a higher volume roadway. For a low-roadway, the chosen alternative may be an unshielded steep embankment. For higher volumes, the chosen alternative may require flatter slopes or barrier.

The sensitivity of different input values should be analyzed as to their impact on resulting costs. The analyst should always apply the test of reasonableness to the output of ROADSIDE.XLW. Relying upon a single solution alone is not accurate enough to establish a design option or safety policy. The cost-effectiveness analysis procedure is best used as a relative comparison of one solution against another.

Table 1130-7. Summary of Input Variable Relative Significance

Input Variable	User Cost	Agency Cost
Traffic Volume	**Significant** (Usually Determined by the Project)	Minor
Traffic Growth	Minor	Minor
Curvature/Grade	Minor	Minor
Design Speed	Minor	Minor
Lateral Placement	**Significant**	Minor
Longitudinal Length	**Significant**	**Significant**
Width	Minor	Minor
Severity Index	**Significant** (Tables in Highway Preconstruction Manual)	N/A
Project Life	Minor	Minor
Interest Rate	Minor	Minor
Installation Cost	N/A	**Significant**
Repair Cost	N/A	Minor
Accident Cost	**Significant** (Fixed by the Department)	N/A

VII. APPLICATION

Some general tips on the use of the spreadsheet are as follows:

- Inputs are outlined in the spreadsheet with a heavy black box. These input boxes are aligned along the left side of the spreadsheet. It is useful to start at the top of the spreadsheet and work down. All of the input boxes will be visible on the computer monitor because they are on the left side of the spreadsheet.

- It is divided into two pages. The first page is most critical as it contains the input and output. When testing out many solutions or several variations, the user may wish to print out results of the first page only and may not be concerned with the background computations. During the print option, simply select page 1 as the print area.

- Cells have been locked in the spreadsheet. The macro sheet is also a protected document. Any alterations of these cells must be reviewed and approved by the Department's Headquarters, Engineering & Operations Standards Section, which distributes and maintains the program.

- When opening this program as a workbook, ROADSIDE.XLW, it is possible to save multiple solutions. Simply drag the unbound document ROADSIDE.XLS from the workbook window and save each completed ROADSIDE.XLS option under a different filename. All of the different options spreadsheets, which are open on the screen, can be saved in a renamed workbook file, along with the original ROADSIDE.XLS. All renamed *.XLS files must use ROADSIDE.XLM macro sheet in order to perform computations.

- To analyze the cross-sections or typical sections of a long roadway, consider applying calculations to segments that are basically uniform. The roadway can be broken down into typical fill sections or cut sections as if on tangents. Special locations with hills and curves which will require adjustment factors may require special computation runs. Grade and curve adjustment factors are applied as shown in figure A.2 of the **Roadside Design Guide.**

Appendix A

SEVERITY INDEX TABLES

Severity Index Tables are found in the AASHTO Roadside Design Guide 1996.

For the convenience of the readers, the conversion from kilometer per hour speeds, used in the AASHTO Roadside Design Guide 1996, to miles per hour are shown in the following table.

km/h speed	mph speed
30	18.64
40	24.85
50	31.07
60	37.28
70	43.50
80	49.71
90	55.92
100	62.14
110	68.35
120	74.56

Appendix B

ROADSIDE.XLW EXAMPLE PROBLEMS

1. SINGLE POINT OBSTACLE
2. MULTIPLE POINT OBSTACLE
3. ANALYSIS OF SLOPE CROSS-SECTION ALTERNATIVES

EXAMPLE 1 SINGLE POINT OBSTACLE
EXAMPLE 2 MULTIPLE POINT OBSTACLE

Problem Discussion:

Consider the accident costs for a segment of highway with existing continuous mast arm lighting located on the roadside just beyond the shoulder. The segment experiences an accident rate well above average when compared to similar roadways. Electroliers have slip bases extending less than four inches above the ground surface. Ignore curvature and grade. There are no project costs associated with the existing installation. The following information is given:

ADT:	38,800 vpd
Segment Length:	6.25 miles
No. of Lanes:	6 lanes, divided highway
Lane Width:	12 feet
Average Speed:	65 MPH
Shoulder Width:	10 feet
Foreslope:	6:1 fill section
Project Life:	20 years
Traffic Growth Rate:	2%
Interest Rate:	7%
Pole Spacing:	250 feet
Number of Poles:	132 each direction
Pole Offset:	12 feet from edge-of-traveled-way
Maintenance Cost Per Knockdown:	$5,400 each
Historical Accident Record:	15 pole knockdowns per year

Determine:

1. The accident and department costs associated with a single pole.

2. The accident and department costs associated with multiple poles over a one mile segment.

Solution:

Single Point Obstacle

1. Based upon the conditions above, choose a severity index of 3.1 in the Mid-Range from Appendix A - Severity Index Tables.

2. Input all the values above into the spreadsheet for a single pole.

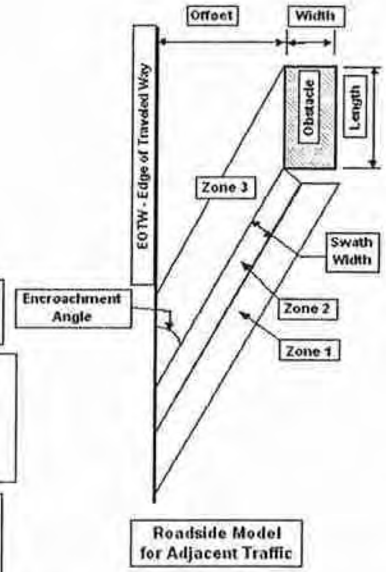
3. Note the number of impacts per pole per year is computed to be 0.024. Multiplying by the number of poles over 6.25 miles (132 poles @ 250 foot spacing X two sides of highway) results in 8 impacts per year over the whole segment. This is equal to half of the historical accident record.

4. In order to accurately reflect the above average accident rates along this segment, a user factor of 2.0 may be used to adjust the computed accident rate. This results in 0.047 impacts per pole per year, or about 12-13 knockdowns per year. A single pole is expected to have cost of $1600 per year to the public and $300 per year to the Department, or **$2,000 per year**in annual costs. This is accident costs only and does not include other lighting costs such as routine electrical maintenance.

DATE: 1/26/98 2:38 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 1
OPTION:
Single Point Obstacle



TRAFFIC INPUT

			Resulting Design Year ADT
Average Daily Traffic (ADT)	38800	veh/day	57,700
Traffic Growth Factor	2	%	
Speed	65	mph	
Grade (+ = uphill , - = downhill)	0	%	
Degree of Curve (+= inside, -= outside)	0	degrees	
No. of Lanes Each Direction	3	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	D	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roaday
O = One-Way Roadway

R = Roadside Analysis (obstacle right of adjacent traffic)

M = Median Analysis (obstacle left of adjacent traffic)

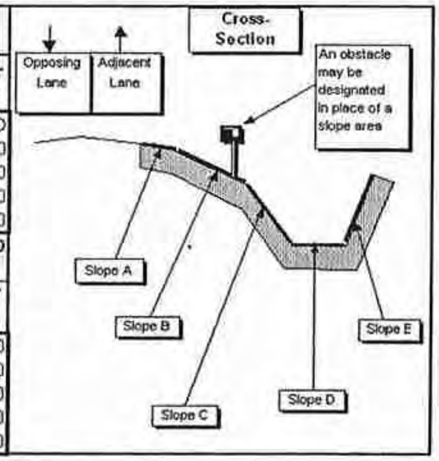
F = Fill Slope (downhill *)
C = Cut Slope (uphill *)
O = Obstacle
* from the edge-of-traveled-way

ECONOMIC INPUT

Period (n)	20	years
Interest Rate (I)	7	%

ROADSIDE MODEL INPUT

	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	12	0	0	0	0
Slope/Obstacle Width (ft)	1	0	0	0	0
Slope/Obstacle Length (ft)	1	0	0	0	0
Effective Offset (computed)	12	0	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	3.1	0	0	0	0
Upstream Corner	3.1	0	0	0	0
Face	3.1	0	0	0	0
Downstream Corner	3.1	0	0	0	0
Downstream Side	3.1	0	0	0	0

ACCIDENT PREDICTION OUTPUT

	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.0236	0.0000	0.0000	0.0000	0.0000	0.0236 impacts per year
Impacts Over Project Life	0.4362	0.0000	0.0000	0.0000	0.0000	0.4362 impacts over project life

PROJECT COST INPUT

INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$0
Utilities Costs	$0
Construction Costs	$0
TOTAL INSTALLATION COSTS	$0
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$5,400
Upstream Corner	$5,400
Face	$5,400
Downstream Corner	$5,400
Downstream Side	$5,400

PROJECT COSTS OUTPUT

	Present Worth	Annual Costs
Installation	$0	$0
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$8,613	$813
Opposing Accidents	$0	$0
Repairs due to Adjacent Accidents	$1,584	$150
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$8,613	$813
Net Costs to Department	$1,584	$150
TOTAL COSTS (Rounded)	$10,000 Project Life	$1,000 Per Year

EXAMPLE 1 DIAGRAM dated 7/11/94 (9:02 AM)

Multiple Point Obstacle

1. In order to evaluate multiple poles, simply determine the equivalent number of poles over one mile. Multiply this times this resulting annual cost from example 1.

$\frac{\text{5,280 feet/mile}}{\text{250 ft spacing}}$ = 21 poles per mile X 2 sides = 42 poles per mile

Accident Costs to the Public

42 poles x $1600 per pole	=	$67,200 annually

Accident Costs to the Department

42 poles x $300 per pole	=	$12,600 annually
Total Cost	=	$80,000 annually

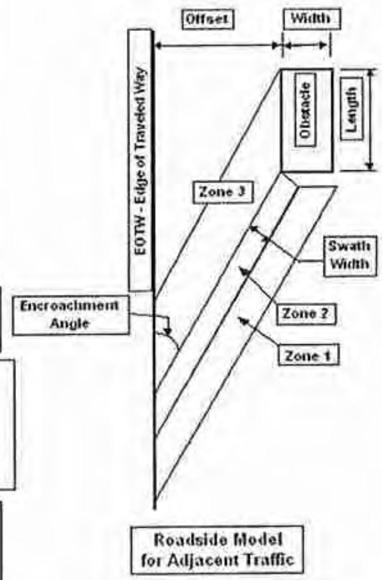
In this case the total roadside model zone length (Zones 1 through 3) for each pole is less than the pole spacing. A total of 66 feet out of 200 feet per pole, or 33% of the time a vehicle exits the roadway they are capable of hitting a pole. If the zone lengths were greater than the pole spacing, then there would be overlap between the poles, and the entire project length being studied would effectively be treated as a continuous breakaway luminaire.

This same approach works well with utility poles along the roadside. Slopes can also be input in combination with the poles. For slope solutions, see the next example.

DATE: 1/26/98 3:29 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT
EXAMPLE 1
OPTION:
Single Point Obstacle



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	38800	veh/day	57,700
Traffic Growth Factor	2	%	
Speed	65	mph	
Grade (+ = uphill , - = downhill)	0	%	
Degree of Curve (+= inside, -= outside)	0	degrees	
No. of Lanes Each Direction	3	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	d	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	2.00		
Opposing Lane User Factor	2.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

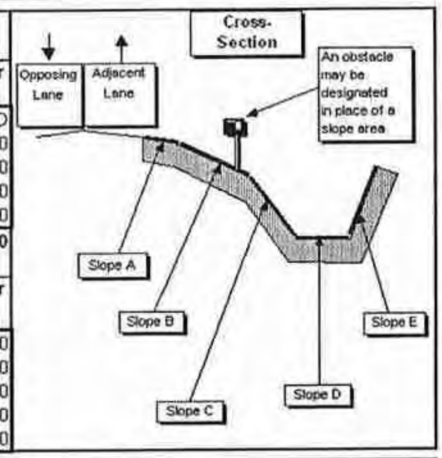
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (i)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	12	0	0	0	0
Slope/Obstacle Width (ft)	1	0	0	0	0
Slope/Obstacle Length (ft)	1	0	0	0	0
Effective Offset (computed)	12	0	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	3.1	0	0	0	0
Upstream Corner	3.1	0	0	0	0
Face	3.1	0	0	0	0
Downstream Corner	3.1	0	0	0	0
Downstream Side	3.1	0	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.0471	0.0000	0.0000	0.0000	0.0000	0.0471 impacts per year
Impacts Over Project Life	0.8724	0.0000	0.0000	0.0000	0.0000	0.8724 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$0
Utilities Costs	$0
Construction Costs	$0
TOTAL INSTALLATION COSTS	$0
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$5,400
Upstream Corner	$5,400
Face	$5,400
Downstream Corner	$5,400
Downstream Side	$5,400

PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$0	$0
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$17,226	$1,626
Opposing Accidents	$0	$0
Repairs due to Adjacent Accidents	$3,168	$299
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$17,226	$1,626
Net Costs to Department	$3,168	$299
TOTAL COSTS (Rounded)	$20,000 Project Life	$2,000 Per Year

Example 1 Diagram Dated 7/11/94 (9:16 AM)

EXAMPLE 3 ANALYSIS OF SLOPE CROSS-SECTION ALTERNATIVES
Problem Discussion:

Using the past example in the Highway Preconstruction Manual, Chapter 11-04 Cost-Effectiveness Analysis, reanalyze slope alternatives. The following information is given:

ADT:	500 vpd
Segment Length:	5000 feet
No. of Lanes:	2 lanes, undivided highway
Lane Width:	12 feet
Average Speed:	55 MPH
Shoulder Width:	6 feet
Foreslope:	6:1 fill section
Project Life:	20 years
Traffic Growth Rate:	0%
Interest Rate:	7%
Degree of Curve:	4 degrees to the left
Grade:	3 percent downhill
Fill section Height:	35 feet

Slope Options

1. 1.5:1 slope	Construction Cost $0	Right-of-Way Cost $0
2. 2:1 slope	Construction Cost $285,000	Right-of-Way Cost $9,000
3. 3:1 slope	Construction Cost $850,000	Right-of-Way Cost $26,000
4. 4:1/1.5:1 barn roof	Construction Cost $235,000	Right-of-Way Cost $4,000
5. barrier with 1.5:1 slope	Construction Cost $260,000	Right-of-Way Cost $2,000

Determine:

A. Analyze the variety of slope options listed above.
B. Use right-of-way costs and embankment costs as given above.
C. Determine the sensitivity of the results to the severity index.
D. Compare the results if the roadway were a tangent segment without a grade.
E. Examine the same tangent roadway with an ADT of 5,000 vehicles per day.

Solution:

Attached is a summary of the results of this analysis. This is followed by the basic spreadsheet results for the original problem with curvature and grade. These results will match the numbers found in Table A of the summary for the initial Severity Index. Background computations were not printed. The method used to develop these results was as follows:

1. Input the initial data for each problem options 1 through 5 and save each as a separate spreadsheet files. Record the **Costs to the Public** (accident costs) and the annual costs. (See Table A of summary, Severity Index costs.)

2. Next perform a **sensitivity analysis** of the severity index input. The values used in the examples were in the High Range due to the height of fill. Note that because of the length of the slopes being studied, severity indices were only assigned to the face of the roadside. Corners and Sides can be considered negligible in this case. If it was a short slope, the estimated slope rates of the corners and sides may have to be evaluated.

Because the difference in severity index between the Mid Range and High Range was typically 0.4 for the slopes studied, it was decided to vary the severity index by 0.2 each direction. This is half the difference between the ranges. The saved spreadsheets for each option were called up, the severities changed, and the results recorded into Table A of the summary. These results can be found under the headings "Severity Minus 0.2" and "Severity Plus 0.2". No printouts are required of this information, as it is easily duplicated from the original problem files attached.

3. Again, pull up the original input spreadsheet files. Next, change the curve and grade values to 0. Then alter the severity indices +/- 0.2 in each direction. Recording the results produced Table B of the summary.

4. Last, change the ADT to 5,000. Then alter the severity indices +/- 0.2 in each direction. Recording the output produced Table C. of the summary.

Interpretation of Results:

Table A. Original Problem - 500 vehicles/day, Downhill and Outside of Curve

Option 5, installing barrier, is the least cost option for this location, using the inputs given. In the original problem this resulted in minor right-of-way costs and smaller embankment costs. As the slopes increase, the costs to the Department increase due to added embankment and right-of-way. If the fill section were not so high, added embankment material might not require such a wide footprint and flatter slopes may become more cost-effective. The outside of the curve and a downhill grade apply factors, which greatly increase the probability of impacts at this location, thus making barrier more cost-effective than a 1.5:1 slope. This is because the severity index of the barrier is lower than the 1.5:1 slope.

Note also that options 1, 2 and 4, the steeper slopes are all relatively equal in cost when adjusting their severity indices. These costs are within 10 percent of each other, and thus these options can be considered generally equal. The difference in choosing these options is the underlying costs to the department. Less costs to the Department among these options means greater costs to the public, and vice versa. Combining Department and public costs, they are equal.

Table B. 500 vehicles/day, Tangent Section - No Curve and Grade

This table illustrates the effect curve and grade had on the original solution in Table A. On the tangent sections for the same problem inputs, Option 1, a 1.5:1 slope, and Option 5 are equally cost-effective solutions (within 10 percent of each other). In this case, the existing 1.5:1 slope incurs no costs to the Department and should be the option chosen. The costs to the Department are significant for Option 5. If there is doubt as to the desirability of a traffic barrier, consideration should be given to omitting the barrier because it is a collision hazard in itself.

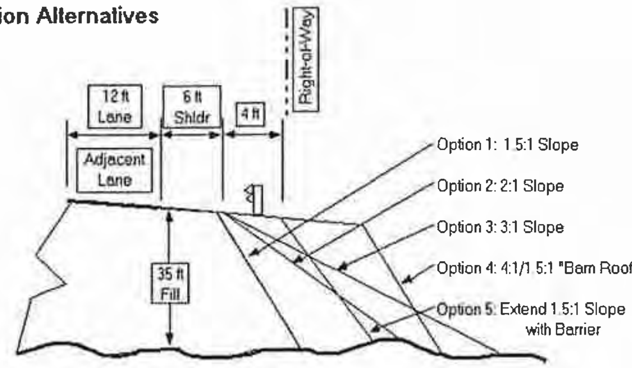
Table C. 5,000 vehicles/day, Tangent Section - No Curve and Grade

For illustration purposes, this table shows that as the traffic volume increases the desirable option may change. Note in Table B it was preferable to choose the existing slope over the cost of new construction and installing barrier. With a much higher Average Daily Traffic, it becomes desirable to shield traffic from the existing slope.

Example 3 Analysis of Slope Cross-Section Alternatives

Initial Input Data

ADT =	500	veh/day
Traffic Growth Rate =	0	percent
Speed =	55	MPH
Grade =	-3	percent
Curvature =	-4	degrees
No. of Lanes =	1	each direction
Lane Width =	12	feet
Highway Type =	U	Undivided
Design Life =	20	years
Length of Fill =	5000	feet



Annual Costs from Three Perspectives

TAble A. 500 veh/day, Downhill, Outside Curve

		Design Option	Construction Cost	R/W Cost	Maint. Cost	Accident Cost	Sensitivity: Severity Minus 0.2	Sensitivity: Severity Index	Sensitivity: Severity Plus 0.2
	1	1.5:1 Slope	$0	$0	$0	$70,000	$62,000	$70,000	$79,000
	2	2:1 Slope	$285,000	$9,000	$0	$33,000	$56,000	$60,000	$65,000
	3	3:1 Slope	$850,000	$26,000	$0	$12,000	$93,000	$94,000	$96,000
	4	"Barn Roof"	$235,000	$4,000	$0	$47,000	$63,000	$69,000	$75,000
* →	5	Barrier	$260,000	$2,000	$500	$5,000	$30,000	$31,000	$32,000

Table B. 500 veh/day, Tangent, Flat

		Design Option	Construction Cost	R/W Cost	Maint. Cost	Accident Cost	Sensitivity: Severity Minus 0.2	Sensitivity: Severity Index	Sensitivity: Severity Plus 0.2
* →	1	1.5:1 Slope	$0	$0	$0	$30,000	$27,000	$30,000	$34,000
	2	2:1 Slope	$285,000	$9,000	$0	$14,000	$40,000	$42,000	$44,000
	3	3:1 Slope	$850,000	$26,000	$0	$5,000	$87,000	$88,000	$88,000
	4	"Barn Roof"	$235,000	$4,000	$0	$20,000	$40,000	$43,000	$45,000
	5	Barrier	$260,000	$2,000	$500	$2,000	$27,000	$28,000	$28,000

Table C. 5,000 veh/day, Tangent, Flat

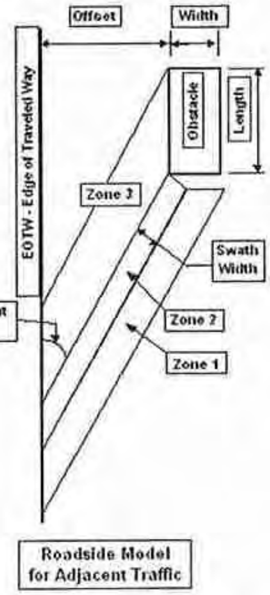
		Design Option	Construction Cost	R/W Cost	Maint. Cost	Accident Cost	Sensitivity: Severity Minus 0.2	Sensitivity: Severity Index	Sensitivity: Severity Plus 0.2
	1	1.5:1 Slope	$0	$0	$0	$301,000	$266,000	$301,000	$338,000
	2	2:1 Slope	$285,000	$9,000	$0	$139,000	$149,000	$167,000	$185,000
	3	3:1 Slope	$850,000	$26,000	$0	$50,000	$125,000	$133,000	$140,000
	4	"Barn Roof"	$235,000	$4,000	$0	$200,000	$197,000	$222,000	$248,000
* →	5	Barrier	$260,000	$2,000	$500	$23,000	$45,000	$49,000	$53,000

*** Cost-Effective Alternative, See Discussion on Previous Pages**

DATE: 1/27/98 2:15 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
2) 2:1 Slope



TRAFFIC INPUT			Resulting design year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roaday
O = One-Way Roadway

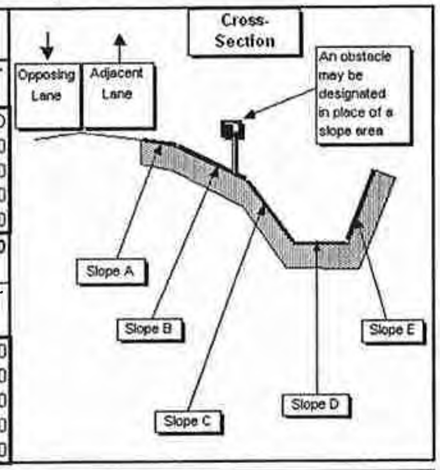
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	F	O	O	O	O
Slope Rate (X where X:1 ft/ft)	2	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	70	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	0	0
Upstream Corner	0	0	0	0	0
Face	4.8	0	0	0	0
Downstream Corner	0	0	0	0	0
Downstream Side	0	0	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2468	0.0000	0.0000	0.0000	0.0000	0.2468 impacts per year
Impacts Over Project Life	2.6145	0.0000	0.0000	0.0000	0.0000	2.6145 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$9,000
Utilities Costs	$0
Construction Costs	$285,000
TOTAL INSTALLATION COSTS	$294,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

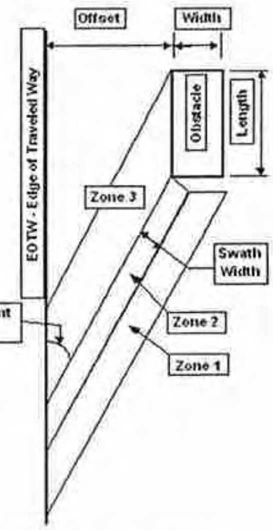
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$294,000	$27,751
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$247,338	$23,346
Opposing Accidents	$97,173	$9,172
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$344,511	$32,518
Net Costs to Department	$294,000	$27,751
TOTAL COSTS (Rounded)	$639,000 Project Life	$60,000 Per Year

Example 3 Analysis of Slope Cross-Section Alternatives

DATE: 1/27/98 2:15 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
2) 2:1 Slope



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

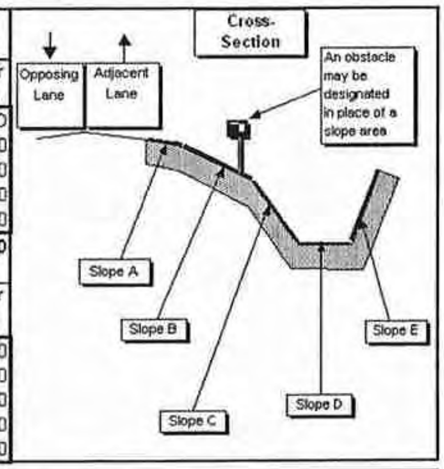
R = Roadside Analysis (obstacle right of adjacent traffic)
M = Median Analysis (obstacle left of adjacent traffic)

F = Fill Slope (downhill *)
C = Cut Slope (uphill *)
O = Obstacle
* from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (i)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	F	O	O	O	O
Slope Rate (X where X:1 ft/ft)	2	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	70	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0

SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	0	0
Upstream Corner	0	0	0	0	0
Face	4.8	0	0	0	0
Downstream Corner	0	0	0	0	0
Downstream Side	0	0	0	0	0



ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2468	0.0000	0.0000	0.0000	0.0000	0.2468 impacts per year
Impacts Over Project Life	2.6145	0.0000	0.0000	0.0000	0.0000	2.6145 impacts over project life

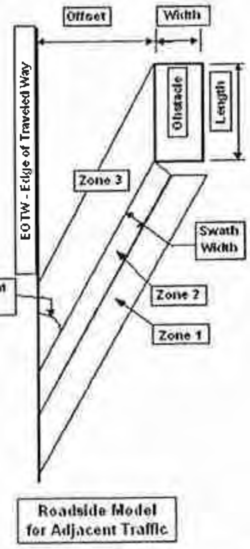
PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$9,000
Utilities Costs	$0
Construction Costs	$285,000
TOTAL INSTALLATION COSTS	$294,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$294,000	$27,751
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$247,338	$23,346
Opposing Accidents	$97,173	$9,172
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$344,511	$32,518
Net Costs to Department	$294,000	$27,751
TOTAL COSTS (Rounded)	$639,000 Project Life	$60,000 Per Year

DATE: 1/27/98 2:17 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
3) 3:1 Slope



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U.D. or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

R = Roadside Analysis
(obstacle right of adjacent traffic)

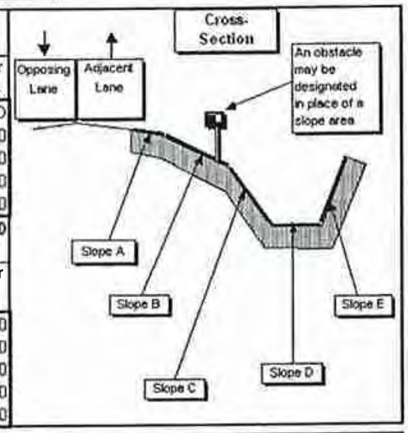
M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	F	O	O	O	O
Slope Rate (X where X:1 ft/ft)	3	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	105	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0

SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	0	0
Upstream Corner	0	0	0	0	0
Face	3.6	0	0	0	0
Downstream Corner	0	0	0	0	0
Downstream Side	0	0	0	0	0



ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2468	0.0000	0.0000	0.0000	0.0000	0.2468 impacts per year
Impacts Over Project Life	2.6146	0.0000	0.0000	0.0000	0.0000	2.6146 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$26,000
Utilities Costs	$0
Construction Costs	$850,000
TOTAL INSTALLATION COSTS	$876,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

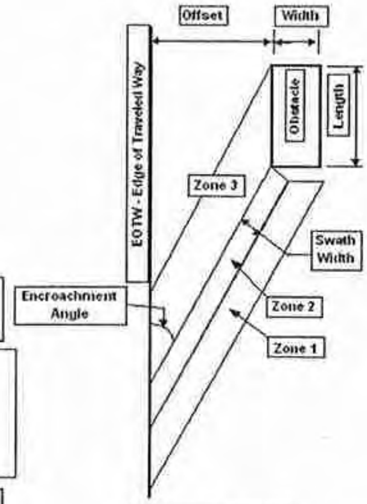
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$876,000	$82,686
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$88,680	$8,371
Opposing Accidents	$34,840	$3,289
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$123,520	$11,659
Net Costs to Department	$876,000	$82,686
TOTAL COSTS (Rounded)	$1,000,000 Project Life	$94,000 Per Year

Example 3
Option 1.5:1 Slope
Dated: 7/11/94 (2:08 PM)

DATE: 1/27/98 2:20 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
4) "Barn Roof"



Roadside Model for Adjacent Traffic

TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roaday
O = One-Way Roadway

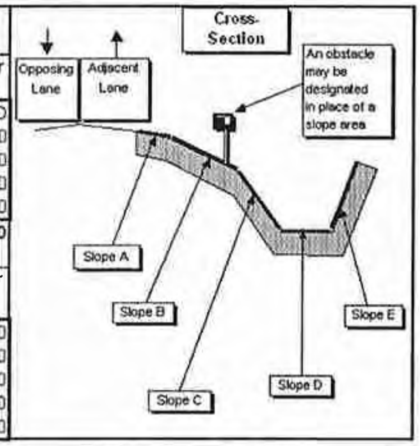
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	F	F	O	O	O
Slope Rate (X where X:1 ft/ft)	4	1.5	0	0	0
Offset to Slope/Obstacle (ft)	6	18	0	0	0
Slope/Obstacle Width (ft)	12	48	0	0	0
Slope/Obstacle Length (ft)	5000	5000	0	0	0
Effective Offset (computed)	6	15.6	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	0	0
Upstream Corner	0	0	0	0	0
Face	2.8	5.8	0	0	0
Downstream Corner	0	0	0	0	0
Downstream Side	0	0	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2460	0.1448	0.0000	0.0000	0.0000	0.1448 impacts per year
Impacts Over Project Life	2.6059	1.5339	0.0000	0.0000	0.0000	1.5339 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$4,000
Utilities Costs	$0
Construction Costs	$235,000
TOTAL INSTALLATION COSTS	$239,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

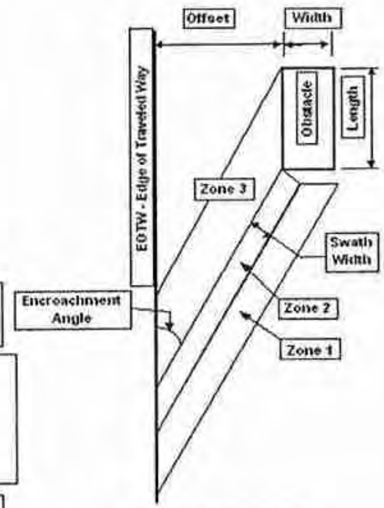
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$239,000	$22,559
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$351,982	$33,224
Opposing Accidents	$141,781	$13,383
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$493,763	$46,606
Net Costs to Department	$239,000	$22,559
TOTAL COSTS (Rounded)	$733,000 Project Life	$69,000 Per Year

Example 3
Option: 2:1 Slope
Dated: 7/11/94 (2:09 PM)

DATE: 1/27/98 2:22 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
5) Barrier



Roadside Model for Adjacent Traffic

TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

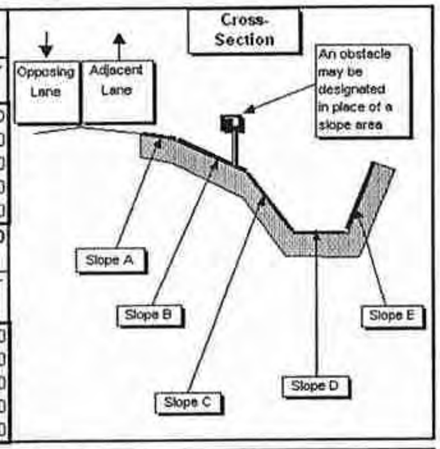
R = Roadside Analysis (obstacle right of adjacent traffic)

M = Median Analysis (obstacle left of adjacent traffic)

F = Fill Slope (downhill *)
C = Cut Slope (uphill *)
O = Obstacle
* from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	1	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	3.4	0	0	0	0
Upstream Corner	3.4	0	0	0	0
Face	2.8	0	0	0	0
Downstream Corner	3.4	0	0	0	0
Downstream Side	3.4	0	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2451	0.0000	0.0000	0.0000	0.0000	0.2451 impacts per year
Impacts Over Project Life	2.5966	0.0000	0.0000	0.0000	0.0000	2.5966 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$2,000
Utilities Costs	$0
Construction Costs	$260,000
TOTAL INSTALLATION COSTS	$262,000
ANNUAL MAINTENANCE	$500
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$750
Upstream Corner	$750
Face	$750
Downstream Corner	$750
Downstream Side	$750

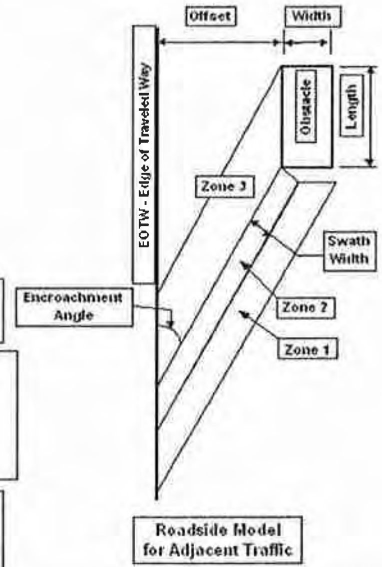
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$262,000	$24,730
Routine Maintenance	$5,297	$500
Salvage Value (Future)	$0	$0
Adjacent Accidents	$40,528	$3,825
Opposing Accidents	$15,927	$1,503
Repairs due to Adjacent Accidents	$1,398	$132
Repairs due to Opposite Accidents	$549	$52
SUBTOTALS		
Net Costs to Public	$56,455	$5,329
Net Costs to Department	$269,245	$25,414
TOTAL COSTS (Rounded)	$326,000 Project Life	$31,000 Per Year

Example 3
Option: 3:1 SLOPE
Dated: 7/11/94 (2:14 PM)

DATE: 1/27/98 2:25 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
Option 2 - 2:1 Slope



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

R = Roadside Analysis
(obstacle right of adjacent traffic)

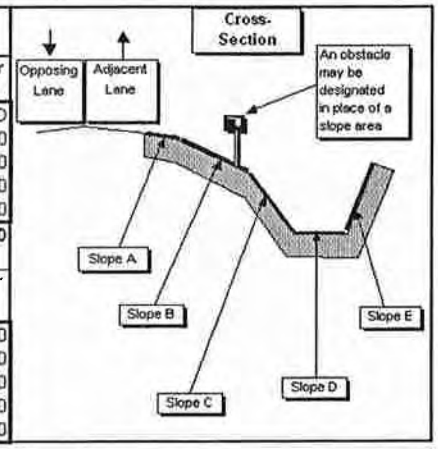
M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (i)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	F	O	O	O	O
Slope Rate (X where X:1 ft/ft)	2	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	70	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0

SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	0	0
Upstream Corner	0	0	0	0	0
Face	4.8	0	0	0	0
Downstream Corner	0	0	0	0	0
Downstream Side	0	0	0	0	0



ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2468	0.0000	0.0000	0.0000	0.0000	0.2468 impacts per year
Impacts Over Project Life	2.6145	0.0000	0.0000	0.0000	0.0000	2.6145 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$9,000
Utilities Costs	$0
Construction Costs	$285,000
TOTAL INSTALLATION COSTS	$294,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

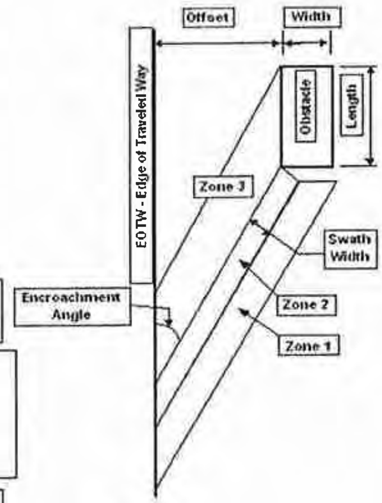
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$294,000	$27,751
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$247,338	$23,346
Opposing Accidents	$97,173	$9,172
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$344,511	$32,518
Net Costs to Department	$294,000	$27,751
TOTAL COSTS (Rounded)	$639,000 Project Life	$60,000 Per Year

Example 3
Option: BARN ROOF
Dated: 7/11/94 (2:16 PM)

DATE: 1/27/98 2:29 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
Option 3 - 3:1 Slope



Roadside Model for Adjacent Traffic

TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roaday
O = One-Way Roadway

R = Roadside Analysis
(obstacle right of adjacent traffic)

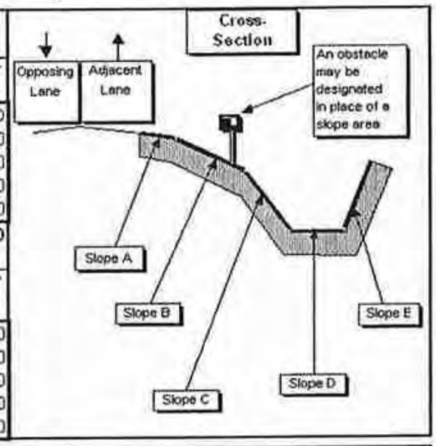
M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (i)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	F	O	O	O	O
Slope Rate (X where X:1 ft/ft)	3	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	105	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0

SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	0	0
Upstream Corner	0	0	0	0	0
Face	3.6	0	0	0	0
Downstream Corner	0	0	0	0	0
Downstream Side	0	0	0	0	0



ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2468	0.0000	0.0000	0.0000	0.0000	0.2468 impacts per year
Impacts Over Project Life	2.6146	0.0000	0.0000	0.0000	0.0000	2.6146 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$26,000
Utilities Costs	$0
Construction Costs	$850,000
TOTAL INSTALLATION COSTS	$876,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

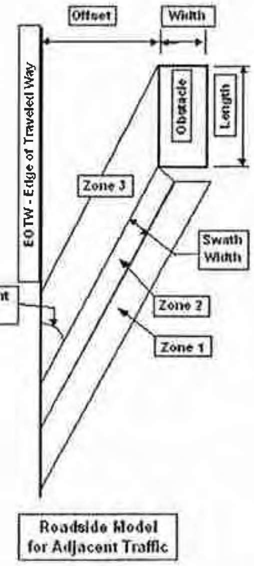
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$876,000	$82,686
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$88,680	$8,371
Opposing Accidents	$34,840	$3,289
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$123,520	$11,659
Net Costs to Department	$876,000	$82,686
TOTAL COSTS (Rounded)	$1,000,000 Project Life	$94,000 Per Year

Example 3
Option: Barrier
Dated: 7/11/94 (2:20 PM)

DATE 1/27/98 2:29 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
Option 3 - 3:1 Slope



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

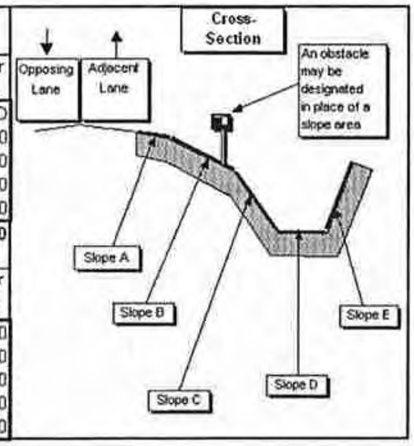
F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (i)	7	%

ROADSIDE MODEL INPUT

	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	F	O	O	O	O
Slope Rate (X where X:1 ft/ft)	3	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	105	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0

SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	0	0
Upstream Corner	0	0	0	0	0
Face	3.6	0	0	0	0
Downstream Corner	0	0	0	0	0
Downstream Side	0	0	0	0	0



ACCIDENT PREDICTION OUTPUT

	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2468	0.0000	0.0000	0.0000	0.0000	0.2468 impacts per year
Impacts Over Project Life	2.6146	0.0000	0.0000	0.0000	0.0000	2.6146 impacts over project life

PROJECT COST INPUT

INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$26,000
Utilities Costs	$0
Construction Costs	$850,000
TOTAL INSTALLATION COSTS	$876,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

PROJECT COSTS OUTPUT

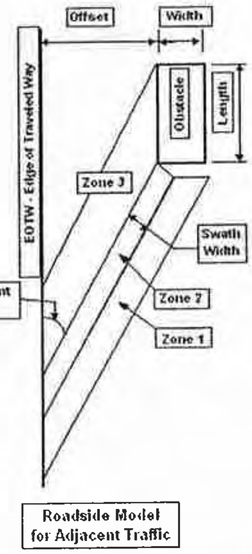
	Present Worth	Annual Costs
Installation	$876,000	$82,686
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$88,680	$8,371
Opposing Accidents	$34,840	$3,289
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$123,520	$11,659
Net Costs to Department	$876,000	$82,686
TOTAL COSTS (Rounded)	$1,000,000 Project Life	$94,000 Per Year

Example 3
Option: OPTION 2 - 2:1 SLOPE
Dated: 2/3/94 (10:29 AM)

DATE 1/27/98 2:37 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
EXAMPLE 3
OPTION:
Option 5 - Barrier



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	500	veh/day	500
Traffic Growth Factor	0	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	-3	%	
Degree of Curve (+= inside, -= outside)	-4	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	U	U,D, or O	
Median or Roadside Analysis?	R	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

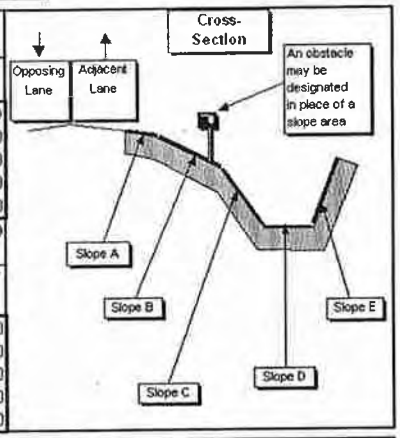
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill *)
C = Cut Slope (uphill *)
O = Obstacle
* from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	7	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	6	0	0	0	0
Slope/Obstacle Width (ft)	1	0	0	0	0
Slope/Obstacle Length (ft)	5000	0	0	0	0
Effective Offset (computed)	6	0	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	3.4	0	0	0	0
Upstream Corner	3.4	0	0	0	0
Face	2.8	5.8	0	0	0
Downstream Corner	3.4	0	0	0	0
Downstream Side	3.4	0	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.2451	0.0000	0.0000	0.0000	0.0000	0.2451 impacts per year
Impacts Over Project Life	2.5966	0.0000	0.0000	0.0000	0.0000	2.5966 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$2,000
Utilities Costs	$0
Construction Costs	$260,000
TOTAL INSTALLATION COSTS	$262,000
ANNUAL MAINTENANCE	$500
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$750
Upstream Corner	$750
Face	$750
Downstream Corner	$750
Downstream Side	$750

PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$262,000	$24,730
Routine Maintenance	$5,297	$500
Salvage Value (Future)	$0	$0
Adjacent Accidents	$40,528	$3,825
Opposing Accidents	$15,927	$1,503
Repairs due to Adjacent Accidents	$1,398	$132
Repairs due to Opposite Accidents	$549	$52
SUBTOTALS		
Net Costs to Public	$56,455	$5,329
Net Costs to Department	$269,245	$25,414
TOTAL COSTS (Rounded)	$326,000 Project Life	$31,000 Per Year

EXAMPLE 3
Option: Option 3 - 3:1 Slope
Example Computation Proofs

AASHTO EXAMPLE PROBLEM - Culvert with Headwall

1. DO NOTHING
2. SHIELD PIPE
3. EXTEND PIPE
4. MODIFY INLET

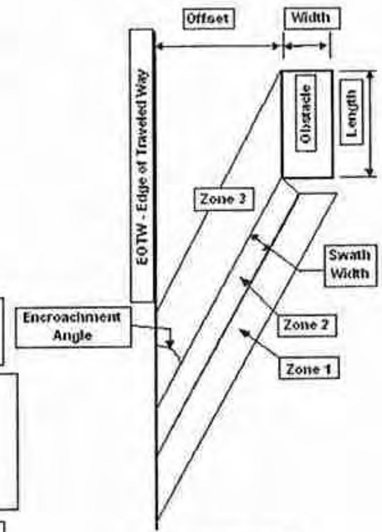
OTHER TEST PROOFS - Option 2

Test proofs for each slope/obstacle area using option 2

DATE: 1/27/98 2:40 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
AASHTO Option 1 with T7570.1 Costs
OPTION:
Existing Culvert



Roadside Model for Adjacent Traffic

TRAFFIC INPUT

			Resulting Design Year ADT
Average Daily Traffic (ADT)	7000	veh/day	10,400
Traffic Growth Factor	2	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	0	%	
Degree of Curve (+= inside, -= outside)	0	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	R	U,D, or O	
Median or Roadside Analysis?	U	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

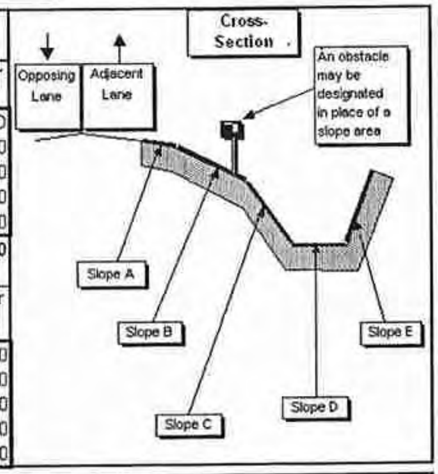
F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT

Period (n)	20	years
Interest Rate (i)	4	%

ROADSIDE MODEL INPUT

	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	10	0	0	0	0
Slope/Obstacle Width (ft)	20	0	0	0	0
Slope/Obstacle Length (ft)	12	0	0	0	0
Effective Offset (computed)	10	0	0	0	0



SEVERITY INDEX INPUT

	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	5.5	0	0	0	0
Upstream Corner	6	0	0	0	0
Face	4.8	0	0	0	0
Downstream Corner	6	0	0	0	0
Downstream Side	5.5	0	0	0	0

ACCIDENT PREDICTION OUTPUT

	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.0124	0.0000	0.0000	0.0000	0.0000	0.0124 impacts per year
Impacts Over Project Life	0.2997	0.0000	0.0000	0.0000	0.0000	0.2997 impacts over project life

PROJECT COST INPUT

INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$0
Utilities Costs	$0
Construction Costs	$0
TOTAL INSTALLATION COSTS	$0
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

PROJECT COSTS OUTPUT

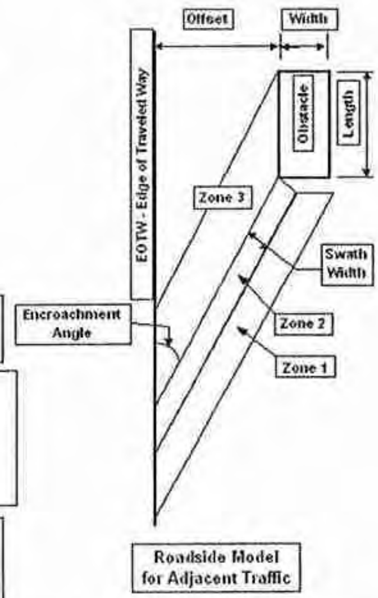
	Present Worth	Annual Costs
Installation	$0	$0
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$53,823	$3,960
Opposing Accidents	$0	$0
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$53,823	$3,960
Net Costs to Department	$0	$0
TOTAL COSTS (Rounded)	$54,000 Project Life	$4,000 Per Year

Project: AASHTO Option 1 with T7570.1 Costs

DATE: 1/27/98 2:42 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
AASHTO Option 2 with T7570.1 Costs
OPTION:
Shield Pipe



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	7000	veh/day	10,400
Traffic Growth Factor	2	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	0	%	
Degree of Curve (+= inside, -= outside)	0	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	R	U,D, or O	
Median or Roadside Analysis?	U	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roaday
O = One-Way Roadway

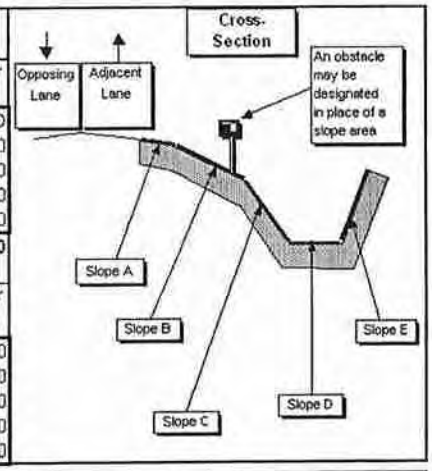
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	4	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	0	10	0	0	0
Slope/Obstacle Width (ft)	0	20	0	0	0
Slope/Obstacle Length (ft)	0	12	0	0	0
Effective Offset (computed)	0	10	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	5.5	0	0	0
Upstream Corner	0	6	0	0	0
Face	0	4.8	0	0	0
Downstream Corner	0	6	0	0	0
Downstream Side	0	5.5	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.0000	0.0124	0.0000	0.0000	0.0000	0.0124 impacts per year
Impacts Over Project Life	0.0000	0.2997	0.0000	0.0000	0.0000	0.2997 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$0
Utilities Costs	$0
Construction Costs	$0
TOTAL INSTALLATION COSTS	$0
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

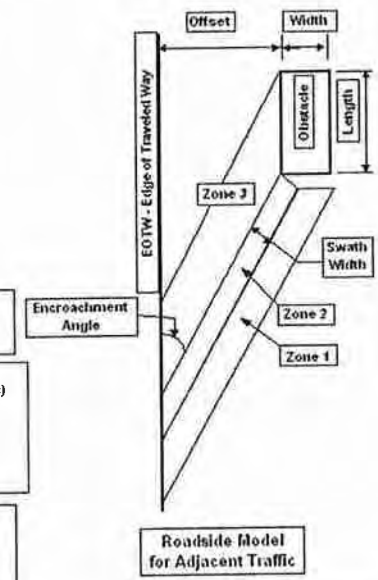
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$0	$0
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$53,823	$3,960
Opposing Accidents	$0	$0
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$53,823	$3,960
Net Costs to Department	$0	$0
TOTAL COSTS (Rounded)	$54,000 Project Life	$4,000 Per Year

Option: Existing Culvert

DATE: 1/27/98 2:47 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
AASHTO Option 4 with T7570.1 Costs
OPTION:
Modify Inlet



TRAFFIC INPUT			Resulting design Year ADT
Average Daily Traffic (ADT)	7000	veh/day	10,400
Traffic Growth Factor	2	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	0	%	
Degree of Curve (+= inside, -= outside)	0	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	R	U,D, or O	
Median or Roadside Analysis?	U	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roadway
O = One-Way Roadway

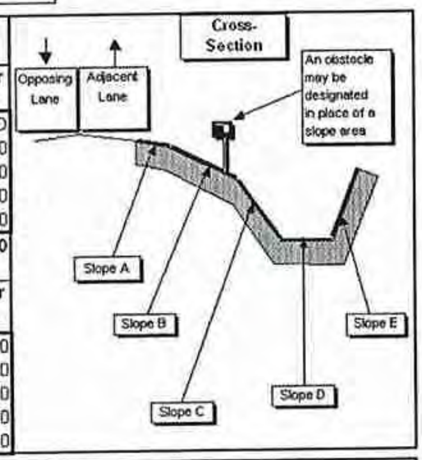
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill *)
C = Cut Slope (uphill *)
O = Obstacle
* from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (I)	4	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	10	0	0	0	0
Slope/Obstacle Width (ft)	40	0	0	0	0
Slope/Obstacle Length (ft)	12	0	0	0	0
Effective Offset (computed)	10	0	0	0	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	4	0	0	0	0
Upstream Corner	4	0	0	0	0
Face	4	0	0	0	0
Downstream Corner	4	0	0	0	0
Downstream Side	4	0	0	0	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.0136	0.0000	0.0000	0.0000	0.0000	0.0136 impacts per year
Impacts Over Project Life	0.3285	0.0000	0.0000	0.0000	0.0000	0.3285 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$0
Utilities Costs	$0
Construction Costs	$8,000
TOTAL INSTALLATION COSTS	$8,000
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

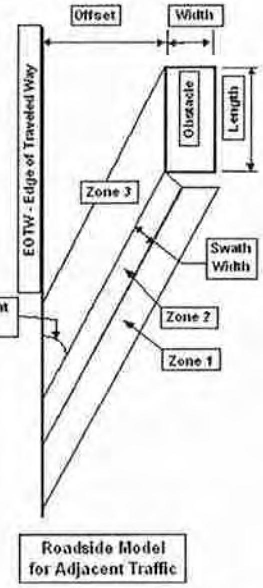
PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$8,000	$589
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$13,905	$1,023
Opposing Accidents	$0	$0
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$13,905	$1,023
Net Costs to Department	$8,000	$589
TOTAL COSTS (Rounded)	$22,000 Project Life	$2,000 Per Year

Project: AASHTO Option 2 with T7570.1 Costs

DATE: 1/27/98 2:50 PM

State of Alaska
Department of Transportation and Public Facilities
Cost-Effective Analysis Procedure

PROJECT:
AASHTO Option 2 with T7570.1 Costs
OPTION:
Shield Pipe



TRAFFIC INPUT			Resulting Design Year ADT
Average Daily Traffic (ADT)	7000	veh/day	10,400
Traffic Growth Factor	2	%	
Speed	55	mph	
Grade (+ = uphill , - = downhill)	0	%	
Degree of Curve (+= inside, -= outside)	0	degrees	
No. of Lanes Each Direction	1	lanes	
Lane Width	12	ft	
Swath Width	12	ft	
Highway Type	R	U,D, or O	
Median or Roadside Analysis?	U	M or R	
Adjacent Lane User Factor	1.00		
Opposing Lane User Factor	1.00		

Input Codes

U = Undivided Roadway
D = Divided Roaday
O = One-Way Roadway

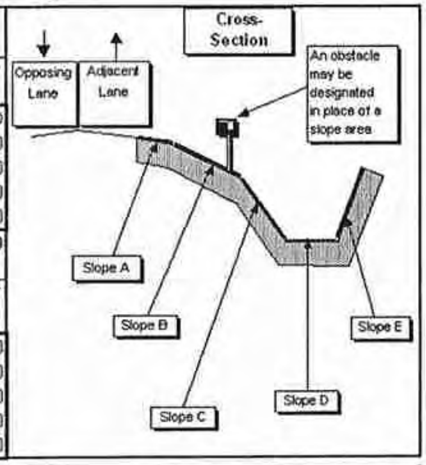
R = Roadside Analysis
(obstacle right of adjacent traffic)

M = Median Analysis
(obstacle left of adjacent traffic)

F = Fill Slope (downhill ')
C = Cut Slope (uphill ')
O = Obstacle
' from the edge-of-traveled-way

ECONOMIC INPUT		
Period (n)	20	years
Interest Rate (i)	4	%

ROADSIDE MODEL INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Fill,Cut, or Obstacle (F,C, or O)	O	O	O	O	O
Slope Rate (X where X:1 ft/ft)	0	0	0	0	0
Offset to Slope/Obstacle (ft)	0	0	0	10	0
Slope/Obstacle Width (ft)	0	0	0	20	0
Slope/Obstacle Length (ft)	0	0	0	12	0
Effective Offset (computed)	0	0	0	10	0



SEVERITY INDEX INPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle
Upstream Side	0	0	0	5.5	0
Upstream Corner	0	0	0	6	0
Face	0	0	0	4.8	0
Downstream Corner	0	0	0	6	0
Downstream Side	0	0	0	5.5	0

ACCIDENT PREDICTION OUTPUT	Slope A or Obstacle	Slope B or Obstacle	Slope C or Obstacle	Slope D or Obstacle	Slope E or Obstacle	Total Impacts at Outer Edge of Model
Initial Impacts Per Year	0.0000	0.0000	0.0000	0.0124	0.0000	0.0124 impacts per year
Impacts Over Project Life	0.0000	0.0000	0.0000	0.2997	0.0000	0.2997 impacts over project life

PROJECT COST INPUT	
INSTALLATION COSTS	
Design Costs	$0
Right-of-Way Cost	$0
Utilities Costs	$0
Construction Costs	$0
TOTAL INSTALLATION COSTS	$0
ANNUAL MAINTENANCE	$0
SALVAGE VALUE (Present)	$0
DAMAGE COSTS PER ACCIDENT	
Upstream Side	$0
Upstream Corner	$0
Face	$0
Downstream Corner	$0
Downstream Side	$0

PROJECT COSTS OUTPUT	Present Worth	Annual Costs
Installation	$0	$0
Routine Maintenance	$0	$0
Salvage Value (Future)	$0	$0
Adjacent Accidents	$53,823	$3,960
Opposing Accidents	$0	$0
Repairs due to Adjacent Accidents	$0	$0
Repairs due to Opposite Accidents	$0	$0
SUBTOTALS		
Net Costs to Public	$53,823	$3,960
Net Costs to Department	$0	$0
TOTAL COSTS (Rounded)	$54,000 Project Life	$4,000 Per Year

1130.07 PEDESTRIAN CROSSINGS

(1) Separation Structures for Pedestrian Crossings

(a) Warrants

A pedestrian grade separation may be justified if any one of the following three warrants is met.

1. **Warrant 1**- Volume Warrant.

   This warrant is met if either or both of the following requirements are met:

   a. When for **each** of any eight hours of an average day, the vehicular traffic volume is at least 600 vehicles per hour **and** the crossing pedestrian volume is at least 150 pedestrians per hour during the same eight hours

   b. When on an officially designated safe route to school, the vehicular volume is at least 400 vehicles per hour and the crossing school-age pedestrian volume during the same hour is at least 150 pedestrians during any one-hour period of an average day.

2. **Warrant 2**- Gap Warrant.

   This warrant is met if **all** of the following requirements are met:

   a. 85^{th} percentile speed of vehicles approaching the crossing site exceeds 60 km/h

   b. The width of traveled way (exclusive of shoulders or median) exceeds 12 m.

   c. The average vehicular volume exceeds 750 vehicles per hour during the two heaviest pedestrian crossing hours; and

   d. There are less than 60 gaps per hour in the vehicular stream adequate for pedestrian crossings during both peak pedestrian crossing hours. Determination of gap adequacy (time required to cross pedestrian) shall be as set forth in the ITE Recommended Practice *"A Program for School Crossing Protection"*

$$Gap\ Time = \frac{W}{1.07} + 3 + (N - 1) \times 2 \quad \text{seconds}$$

   W = Curb to curb width of roadway (meters)

   N = Number of rows of pedestrians

3. **Warrant 3**- Geometric Conditions.

   This warrant is met if either of the following requirements are met:

   a. Roadway conditions are such that the available sight distance is less than the stopping sight distance required by the 85^{th} percentile approach speed and no other crossings are available for a distance off 150 m from this location.

   b. A full freeway intersects a pedestrian way where no vehicular structure is to be built and no other pedestrian crossing of the freeway is available within a minimum distance of 150 m.

(b) ACCESS

1. **Access Control**

   Pedestrian access to the vehicular roadway shall be positively prevented by a two meter high fence or other physical barrier for:

   a. One hundred fifty meters each direction along both sides of the vehicular way from each end of the pedestrian structure or;

   b. Three hundred meters each direction along one side of the vehicular way from one end of the pedestrian structure or;

   c. An unspecified distance as required if the pedestrian structure is so located that its use by pedestrians is guaranteed because the pedestrian route via the structure requires substantially less time and effort than a route across the roadway at the vehicular grade.