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16. Abstract

The National Cooperative Highway Research Program (NCHRP) Project 20-7, Task Order 1 proposed a probabilistic model to be used as a management tool in establishing the priority for roadside safety improvements. It was expected that each state would adapt the research findings to its own specific needs and administrative structure. This report covers a phase of research to develop a formalized implementation procedure compatible with Texas Highway Department policy, to program roadside safety improvements on controlled access highways based on the generalized NCHRP 20-7 research. The extremely large number of hazards that must be inventoried and the feasible safety improvement alternatives necessitate use of a systematic coding procedure for eventual analysis by computer. To accomplish this, a Roadside Hazard Inventory form and a Roadside Hazard Improvement form were developed to accommodate applicable hazards located within the 30-ft. recovery zone adjacent to the roadway. This report includes detailed descriptions of the use of each form and discussion of the data input/output format. Several examples of safety improvement alternatives for selected hazards are presented to illustrate the manner in which the forms must be completed and the output is shown and interpreted.

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PROCEDURES MANUAL

FOR

ROADSIDE HAZARD INVENTORY AND SAFETY IMPROVEMENT ALTERNATIVES

by

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and

Donald L. Woods

Research Report 11-1

Research Study 2-8-72-11

Cost-Effectiveness Priority Program
for Roadside Safety Improvements on Texas Freeways

Sponsored by

The Texas Highway Department
in Cooperation with the
U. S. Department of Transportation
Federal Highway Administration

August, 1973
Revised January, 1974

TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843

IMPLEMENTATION

The cost-effectiveness analysis procedure for roadside safety improvement evaluation has been developed on an immediate implementation basis. This report documents the procedures to be applied in conducting the physical roadside hazard inventory and recommending safety improvement alternatives on Texas freeways. Immediate implementation of the material in this report is anticipated on a statewide basis.

FOREWORD

This report is one phase of Research Study No. 2-8-72-11, entitled "Cost Effectiveness Priority Program for Roadside Safety Improvements on Texas Freeways."

Special acknowledgement is given Messrs. Paul R. Tutt and Edwin M. Smith of the Texas Highway Department and Mr. Ed Kristaponis (FHWA) for their cooperation and assistance through the developmental stages and field testing of the program. Their suggestions were invaluable in achieving an implementable research product.

The researchers are indebted to personnel of the Texas Highway Department, particularly from three Districts: Fort Worth, Houston, and Austin, where extensive field trials were conducted during the developmental phases. Special thanks are due Messrs. J. R. Stone, C. E. McCarty, and Billie E. Davis (Fort Worth); Messrs. Dale D. Marvel, John M. Lipscomb, and James H. Doss (Houston); and Mr. Billy M. Schnerr (Austin) for assisting in field trials and offering numerous suggestions to improve the cost-effectiveness program. Appreciation is expressed to Messrs. Larry Walker and Richard Jameson (THD Automation, Austin) for their cooperation and assistance in adapting the cost-effectiveness model to the Texas Highway Department computer equipment.

DISCLAIMER

SUMMARY

PROBLEM DEFINITION

Roadside safety improvement programs, like any phase of highway construction or maintenance, must compete for limited funds. As increasing emphasis is being directed toward roadside safety, it is apparent that a definite need exists for methods by which administrators may evaluate alternative safety improvements and program those to realize the greatest return within the budget constraints of their available roadside safety improvement funds.

The National Cooperative Highway Research Program (NCHRP) Project 20-7, Task Order 1 (3) proposed a probabilistic model to be used as a management tool in establishing the priority for roadside safety improvements. It was expected that each state would adapt the research findings to its own specific needs and administrative structure. The overall goal of Project 11 is to develop a formalized implementation procedure, compatible with Texas Highway Department policy, to program roadside safety improvements on controlled access highways based on the generalized NCHRP 20-7 research.

This report documents the procedures developed to inventory roadside hazards and safety improvement alternatives for input to a computer program. Details of the computer program including a user's manual are presented in two other reports (Research Reports 11-2 and 11-3). Interpretation of the cost-effectiveness program output is discussed in Research Report 11-4.

SCOPE OF ROADSIDE INVENTORY

Accepted practice in most existing roadside improvement programs has been to consider the primary and secondary recovery areas, which would benefit approximately 85 percent of drivers encroaching the roadside. The inventory procedure proposed in this study includes all applicable roadside hazards located within the 30-ft lateral distance adjacent to the outer edge of the traveled lane.

Hazards have been categorized in three major classifications for purposes of inventorying: (1) point hazards, (2) longitudinal hazards, and (3) slopes. Classification codes have been assigned to all applicable hazards.

PROCEDURE FOR CONDUCTING SAFETY IMPROVEMENT PROGRAM

The procedure to evaluate safety improvements for roadside hazards comprises three related functions:

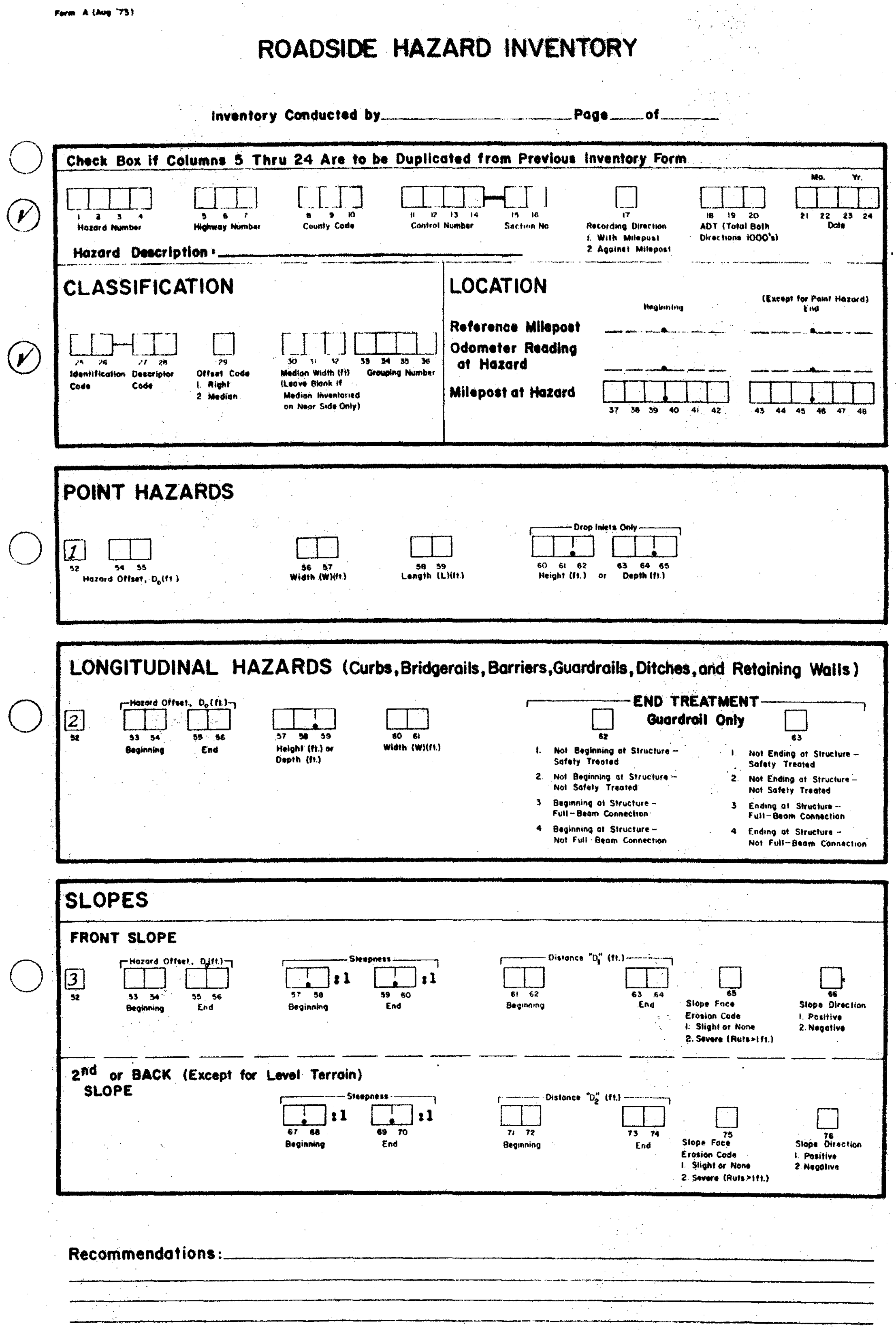
(1) conducting a detailed physical inventory of the Interstate highway system to identify and locate each roadside hazard,

(2) recommending feasible safety improvement alternatives for each hazard or for groups of hazards, and

(3) evaluating the recommended safety improvement alternatives using the cost-effectiveness model.

The extremely large number of hazards that must be inventoried and feasible safety improvement alternatives necessitates the use of a systematic coding procedure for eventual analysis by computer. Two forms were developed to accomplish this. The Roadside Hazard Inventory form is shown in Figure S-1. Figure S-2 illustrates the counterpart, the Roadside Hazard Improvement form.

The report includes detailed descriptions of the use of each of these forms. Also included is a discussion of the date input/output format and several examples of selected hazards to illustrate the manner in which the forms must be completed.


Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by __________ Page ___ of ___

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

1 2 3 4 Hazard Number | 5 6 7 Highway Number | 8 9 10 County Code | 11 12 13 14 Control Number | 15 16 Section No | 17 Recording Direction 1. With Milepost 2. Against Milepost | 18 19 20 ADT (Total Both Directions 1000's) | Mo. Yr. 21 22 23 24 Date

Hazard Description: __________

CLASSIFICATION

25 26 Identification Code | 27 28 Descriptor Code | 29 Offset Code 1. Right 2. Median | 30 31 32 Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only) | 33 34 35 36 Grouping Number

LOCATION

Beginning | (Except for Point Hazard) End

Reference Milepost

Odometer Reading at Hazard

Milepost at Hazard 37 38 39 40 41 42 | 43 44 45 46 47 48

BOX 1

POINT HAZARDS

1 (52) | 54 55 Hazard Offset, D_o(ft) | 56 57 Width (W)(ft) | 58 59 Length (L)(ft) | Drop Inlets Only: 60 61 62 Height (ft.) or 63 64 65 Depth (ft)

BOX 2

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

2 (52) | Hazard Offset, D_o(ft): 53 54 Beginning, 55 56 End | 57 58 59 Height (ft.) or Depth (ft.) | 60 61 Width (W)(ft.)

END TREATMENT — Guardrail Only

62
1. Not Beginning at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated
3. Beginning at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full-Beam Connection

63
1. Not Ending at Structure – Safety Treated
2. Not Ending at Structure – Not Safety Treated
3. Ending at Structure – Full-Beam Connection
4. Ending at Structure – Not Full-Beam Connection

BOX 3

SLOPES

FRONT SLOPE

3 (52) | Hazard Offset, D_o(ft): 53 54 Beginning, 55 56 End | Steepness: 57 58 :1 Beginning, 59 60 :1 End | Distance "D_1" (ft.): 61 62 Beginning, 63 64 End | 65 Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts>1ft.) | 66 Slope Direction 1. Positive 2. Negative

2nd or BACK (Except for Level Terrain) SLOPE

Steepness: 67 68 :1 Beginning, 69 70 :1 End | Distance "D_2" (ft.): 71 72 Beginning, 73 74 End | 75 Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts>1ft.) | 76 Slope Direction 1. Positive 2. Negative

BOX 4

Recommendations: __________

Roadside Hazard Inventory Form

Figure S-1

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

BOX 1

1 2 3 4 Hazard Number — 5 6 7 Highway Number — 8 9 10 County Code — 11 12 13 14 Control Number — 15 16 Section Number — Hazard Description

17 18 19 20 21 22 First Cost of Improvements ($)

Repair Cost per Collision ($): 23 24 25 26 Hazard — 27 28 29 30 Improvement

Normal Maintenance ($/yr): 31 32 33 34 Hazard — 35 36 37 38 Improvement

POINT HAZARD IMPROVEMENTS

BOX 2

[1] 40 [1] 42 Alleviate Hazard — [ ] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — 48 49 50 Length (ft) — 51 52 Width (ft) — 53 54 Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

[2] 40 [1] 42 Curb — [ ] 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — [ ] 43
1. Rigid
2. Semi-rigid

[ ] 44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail — [ ] 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — [ ] 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning — 47 48 End

Median Far Side — Lateral Offset (ft): 49 50 Beginning — 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft): 53 54 55 Beginning — 56 57 58 End

Shorten (ft): 59 60 61 Beginning — 62 63 64 End

SLOPE IMPROVEMENTS

BOX 4

FRONT SLOPE

[3] 40

Hazard Offset D_0 (ft): 42 43 Beginning — 44 45 End

Steepness: 46 47 Beginning [.]:1 — 48 49 End [.]:1

Distance "D_1" (ft): 50 51 Beginning — 52 53 End

[ ] 54 Slope Direction
1. Positive
2. Negative

2nd or BACK SLOPE

Steepness: 55 56 Beginning [.]:1 — 57 58 End [.]:1

Distance "D_2" (ft): 59 60 Beginning — 61 62 End

[ ] 63 Slope Direction
1. Positive
2. Negative

Beginning: 64 65 66 . 67 68 69 — End: 70 71 72 . 73 74 75 — Hazard Milepost (Complete if Different From Inventory)

BOX 5

[4] 40 **No Improvement Recommended**

Roadside Hazard Improvement Form

Figure S-2

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TABLE OF CONTENTS, CONT.

V. DATA INPUT/OUTPUT

I. INTRODUCTION

PROBLEM STATEMENT

Single vehicle accidents constitute a sizable portion of all highway accidents, particularly on freeways--accounting for about one half of the fatal accidents and 40 percent of all accidents on freeways (1). Texas accident statistics (2) revealed that 35 percent of statewide accidents involved single vehicles striking fixed objects or running off the roadway. The elements of roadside design that contribute heavily to single vehicle accident severity are obstacles such as bridge abutments and piers, bridge rails, utility poles, trees, drainage headwalls, steep side slopes and guardrails.

Considerable emphasis has been placed on roadside safety improvements to the extent that many highway departments maintain funded programs to reduce the roadside hazard on existing facilities. Notable examples of such programs are the breakaway sign and luminaire programs of the Texas Highway Department, the CURE program of the California Division of Highways, and similar programs in Utah and Colorado.

Programs of this type generally have followed the same roadside improvement strategy:

1. Remove roadside obstacles.
2. Move those obstacles that cannot be removed. This includes moving to a protected location and moving laterally.
3. Reduce the impact severity of those obstacles that cannot be moved. This includes improvements such as breakaway devices, turning down guardrail ends, and flattening roadside slopes.

4. Protect the driver from those obstacles that cannot be improved otherwise, using attenuation or deflection devices.

This strategy would be ideal if sufficient funds were available to accomplish all four steps throughout a particular highway. However, this is seldom realized because safety improvements, like any phase of highway construction or maintenance, must compete for limited funds. What is lacking is a method by which administrators may evaluate alternative safety improvements and program those to realize the greatest return within the budget constraints of their available roadside safety improvement funds.

The National Cooperative Highway Research Program (NCHRP) Project 20-7, Task Order 1 (3) proposed a probabilistic model to be used as a management tool in establishing the priority for roadside safety improvements. The requirement that this research be applicable on a national scale resulted in a high degree of generalization in the model and, therefore, it was not implementable in its current form for specific needs. It was expected that each state would adapt the findings of this research to its own specific needs and administrative structure. This research has as its basic objective the adaptation of the findings of NCHRP 20-7 to meet the requirements of the Texas Highway Department.

OBJECTIVES

The overall goal of Project 11 is to develop a formalized implementation procedure, compatible with Texas Highway Department policy, to program roadside safety improvements on freeways based on the generalized NCHRP 20-7 research. The specific objectives within the study to achieve the overall goal are summarized:

1. Develop a procedure to systematically inventory roadside hazards existing along Texas freeways.
2. Develop a procedure to identify appropriate measures that may be taken to alleviate or reduce existing hazards.
3. Incorporate the above procedures into a computer program based on the NCHRP 20-7 probabalistic cost-effectiveness model from which may be determined a priority ranking of improvement alternatives to assist administrators in preparing safety improvement programs.
4. Document the hazard inventory and improvement procedures, computer program, and the general study.

This report documents the procedures developed to inventory roadside hazards and safety improvement alternatives. Details of the computer program including a user's manual are presented in two other reports (Research Reports 11-2 and 11-3). Interpretation of the cost-effectiveness program output is discussed in Research Report 11-4.

II. PROGRAM CONCEPT DEVELOPMENT

BASIC CONCEPT

Every segment along a roadway has an associated degree of roadside hazard for vehicles traveling through that segment. The hazard may be relatively small for a flat slope free of fixed objects while on the other hand, the hazard may be very high for a steep side slope or a large rigid object near the edge of the roadway (3). From this, it is seen that the degree of potential hazard is influenced by proximity to the roadway and by the severity of resulting impact if the object is struck. The severity can be assumed to be independent of distance, that is, the severity associated with striking a rigid object located ten feet from the roadway is no different than if the same object was struck at fifty feet from the roadway. The probability of encroaching the latter distance, however, is much smaller. Also influencing the potential hazard is the probability that a vehicle will encroach on the roadside at a location such that the obstacle is in the vehicle path and will be impacted. This is a function of the traffic volume and expected encroachment rate, the latter being derived empirically from research. Obviously, a small rigid obstacle exhibits a smaller probability of being struck than does, for example, a continuous guardrail at the same offset distance. To strike the rigid obstacle, a vehicle must leave the roadway within a relatively small segment whereas it may collide with the guardrail after leaving the roadway anywhere along the rail length. The severity of striking the rigid obstacle may be extremely high as is the case for a bridge pier. On the other hand, the severity of striking the guardrail is substantially less. Therefore, trade-offs must be considered--probability of impact versus severity of impact--in many situations.

If quantitative measures can be assigned to these influencing parameters and costs associated with improvement alternatives can similarly be determined, cost-effectiveness techniques may be used to evaluate various recommended safety improvements. To accomplish this, objects (hazards) must be identified and assigned some relative degree of hazard (severity index). Encroachment distances and frequency must be defined. Feasible improvement alternatives must be defined for each hazard identified and costs must be determined for the hazard as it exists and after each improvement. These factors may be used in the cost-effectiveness program to evaluate the alternatives.

The cost-effectiveness methodology requires a rather comprehensive inventory of roadside obstacles (size of obstacle, lateral placement, severity of a collision with the obstacle, etc.). Some of these may be identified in the office while others can be determined only by a field inventory procedure. The inventory of existing roadside hazards is the underlying key to improved cost-effectiveness because it forms the basis of comparison for alternative recommended improvements and, hence, influences directly the relative rating of the improvement. Since the inventory is so vital to the end product of the program, detailed procedures are required to insure that an accurate and comprehensive inventory is made in a uniform manner throughout all regions to which the improvement program is applicable (usually a District).

Since safety improvements for each hazard (or group of hazards) will be compared to the existing hazard in the computer model, it is equally important that detailed procedures for identifying improvements are established and used to provide the necessary information in the required format for computer input. These two procedures form the basis for the computer program developed. As with any computer program, input data must be furnished in a precise manner. Forms have been developed, field tested and refined to accommodate data collection for both the hazard inventory and safety improvement alternatives. These forms and a detailed procedure of their use are discussed in later sections of this report.

SCOPE OF ROADSIDE INVENTORY

The roadside obstacles to be included in the inventory and the lateral boundaries assumed for inventory purposes are administrative decisions. Accepted practice in most existing roadside improvement programs has been to consider the primary and secondary recovery areas (30-ft lateral clearance) as sufficient. From available information (4), safety improvements within this region would benefit approximately 85 percent of drivers encroaching the roadside. The inventory procedure proposed in this study includes all applicable roadside hazards located within the 30-ft lateral distance adjacent to the outer edge of the traveled lane. Under a particular case involving a critical slope, inventorying the 30-ft lateral distance may be exceeded. This is discussed later in this report.

Each roadside obstacle has associated with it some degree of hazard. However, certain obstacles such as sign posts and luminaire supports, through the advanced technology in breakaway concepts, have been designed such that the hazard of impact is virtually negligible. Also, the state of technology is such that very little can be done to reduce the impact severity below its current level. Through the breakaway program throughout Texas, very few rigid base signs or luminaire supports exist on freeways and interstate highways. Therefore, by joint decision of project personnel of the Texas Highway Department and the research staff, breakaway sign supports and luminaire supports will not be included in the inventory.

Other roadside obstacles are placed along freeways for operational control which, although their presence constitutes a hazard, if omitted would allow operational maneuvers that would produce greater hazard. Post and cable installations placed between main lanes and frontage roads or in the median to prohibit intentional vehicle crossover is an example. Similarly, median barriers and fences fall within the same category. These obstacles will not be included in the inventory under normal inventorying procedures unless it is desired to evaluate the cost-effectiveness of a different type of barrier. It is highly probable that a recently installed double flex beam median barrier would not be removed and replaced by some other type of barrier; however, the decision might be made to evaluate replacement of an older barrier with a concrete median barrier. Provision is made in the inventory procedure to do this. Retaining walls constitute another "necessary" hazard, particularly on depressed urban facilities. Although provision is made to evaluate several alternatives, it is probable that certain retaining walls cannot be substantially changed because of geometric and right-of-way considerations and would not be inventoried.

IDENTIFICATION OF ROADSIDE HAZARDS

Uniformity in inventory procedure and content is essential to the operation of the cost-effectiveness computer program. Therefore, those roadside obstacles that will be included in the inventory have been identified and assigned an input coding system as shown in Table II-1. Hazards are grouped by descriptive title under general identification code designation and, where necessary, each general classification is sub-divided into several categories with each being identified by a descriptor code designation. This classification system permits greater flexibility in recording hazards by allowing the addition of new general categories or, more often, additional descriptor codes when "special" or unusual hazards are encountered during the field inventory. Any code additions would necessitate computer program modification prior to implementation. Table II-1 includes a comprehensive list of hazards, but it is anticipated that additional descriptor codes will be needed to accommodate all hazards that can be found along the roadway, and provisions for including these will be made in the development of the computer cost-effectiveness model.

For purposes of inventorying, all hazards have been categorized in three major classifications:

(1) point hazards

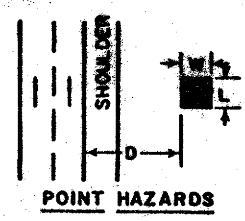
(2) longitudinal hazards

(3) slopes

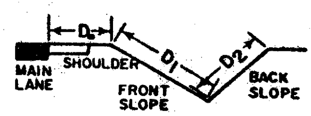
The above general classification system was selected to facilitate recording inventory data and to organize the computer program logic. To maintain uniformity between hazard inventory and hazard improvement

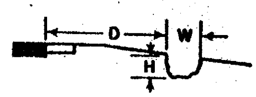
TABLE II-1

Hazard Classification Codes



IDENTIFICATION CODE	DESCRIPTOR CODES
◇01 Utility Poles	(00)
◇02 Trees	(00)
◇03 Rigid Signpost	(01) single-pole-mounted (02) double-pole-mounted (03) triple-pole-mounted (04) cantilever support (05) overhead sign bridge
◇04 Rigid Base Luminaire Support	(00)
05. Curbs	(01) mountable design (02) non-mountable design less than 10 inches high (03) barrier design greater than 10 inches high
06. Guardrail or Median Barrier	(01) w-section with standard post spacing (6 ft-3 in.) (02) w-section with other than standard post spacing (03) approach guardrail to bridge--decreased post spacing (3 ft-1 in.) adjacent to bridge (04) approach guardrail to bridge--post spacing not decreased adjacent to bridge (05) post and cable (06) median fence (07) median barrier (CMB design or equivalent)
07. Roadside Slope	(01) sod cut slope (02) sod fill slope (03) concrete-faced cut slope (04) concrete-faced fill slope (05) rubble rip-rap cut slope (06) rubble rip-rap fill slope
08. Washout Ditch (Does not include ditch formed by intersection of front and back slopes)	(00)
◇09 Culverts	(01) headwall (or exposed end of pipe culvert) (02) gap between culverts on parallel roadways (03) sloped culvert with grate (04) sloped culvert without grate
◇10 Inlets	(01) raised drop inlet (tabletop) (02) depressed drop inlet (03) sloped inlet
11. Roadway Under Bridge Structure	◇01 bridge piers (02) bridge abutments
12. Roadway Over Bridge Structure	◇01 open gap between parallel bridges (02) closed gap between parallel bridges (03) rigid bridgerail--smooth and continuous construction (04) semi-rigid bridgerail--smooth and continuous construction (05) other bridgerail--penetration likely; severe snagging likely; severe pocketing and snagging likely; or, vaulting likely (06) elevated gore abutment
13. Retaining Wall	(00)





◇ Denotes Point Hazard

procedures, the same classification system was used for the improvement data input. Section III of this report presents details concerning the formal inventory procedure and Section IV deals with the recommended improvement alternatives data input. The forms necessary for these input factors are described in their respective section.

PROCEDURE FOR CONDUCTING SAFETY IMPROVEMENT PROGRAM

The procedure to evaluate safety improvements for roadside hazards comprises three related functions: (1) conducting a detailed physical inventory of the Interstate highway system to identify and locate each roadside hazard, (2) recommending feasible safety improvement alternatives for each hazard or for groups of hazards, and (3) evaluating the recommended safety improvement alternatives using the cost-effectiveness model. The general procedure for the inventory and improvement recommendations phase is discussed below.

In the inventory phase, each applicable hazard will be located longitudinally along the highway by milepost using data input forms discussed in Section III of this report. As each hazard is located and evaluated, recommendations for remedial action necessary for safety improvement will be made and this information recorded on data forms discussed in Section IV. These two data sources provide basic input information for evaluation by the cost effectiveness computer program. It is apparent that the quality of the results depends to a very large degree on the quality of the input data.

Since the recommendations for alternative safety improvements will govern to a great extent the cost-effectiveness results, the inventory team must include personnel having considerable experience in traffic operations, geometric design, and maintenance. Preliminary field trials of the inventory procedure have indicated that a four-person team represents an efficient working force, including a driver and data recorder. The more experienced the team members, the more flexibility is afforded to rotate duties. However, based on experience gained during the inventory field trials, the following team composition is strongly recommended: one driver, one data recorder, and two decision-makers to recommend safety improvement alternatives. The following procedure was found to work very efficiently. The driver assumed the responsibility of identifying each hazard as he drove along the highway shoulder at low speed, and stopped adjacent to each hazard to read the odometer. All data were recorded by one member of the team who was familiar with the hazard inventory form. The driver called out hazard milepost and identified the hazard by name. These were recorded and necessary identification codes assigned. Offset distances and other applicable data (hazard number, grouping code number, etc.) were recorded while the two decision-makers were evaluating the hazard situation to select improvement alternatives.

Since all data were recorded by one person, considerable time was saved because the identification codes and necessary data for each type of hazard (in addition to the location on the form where these data must be recorded) became memorized. It was evident that considerably less recording errors (omissions, erroneous codes, etc.) were made when the data recording operation was done by one person rather than rotating throughout the inventory team.

It is emphasized that the driver must be well aware of every type of hazard to be inventoried to avoid his bypassing hazards.

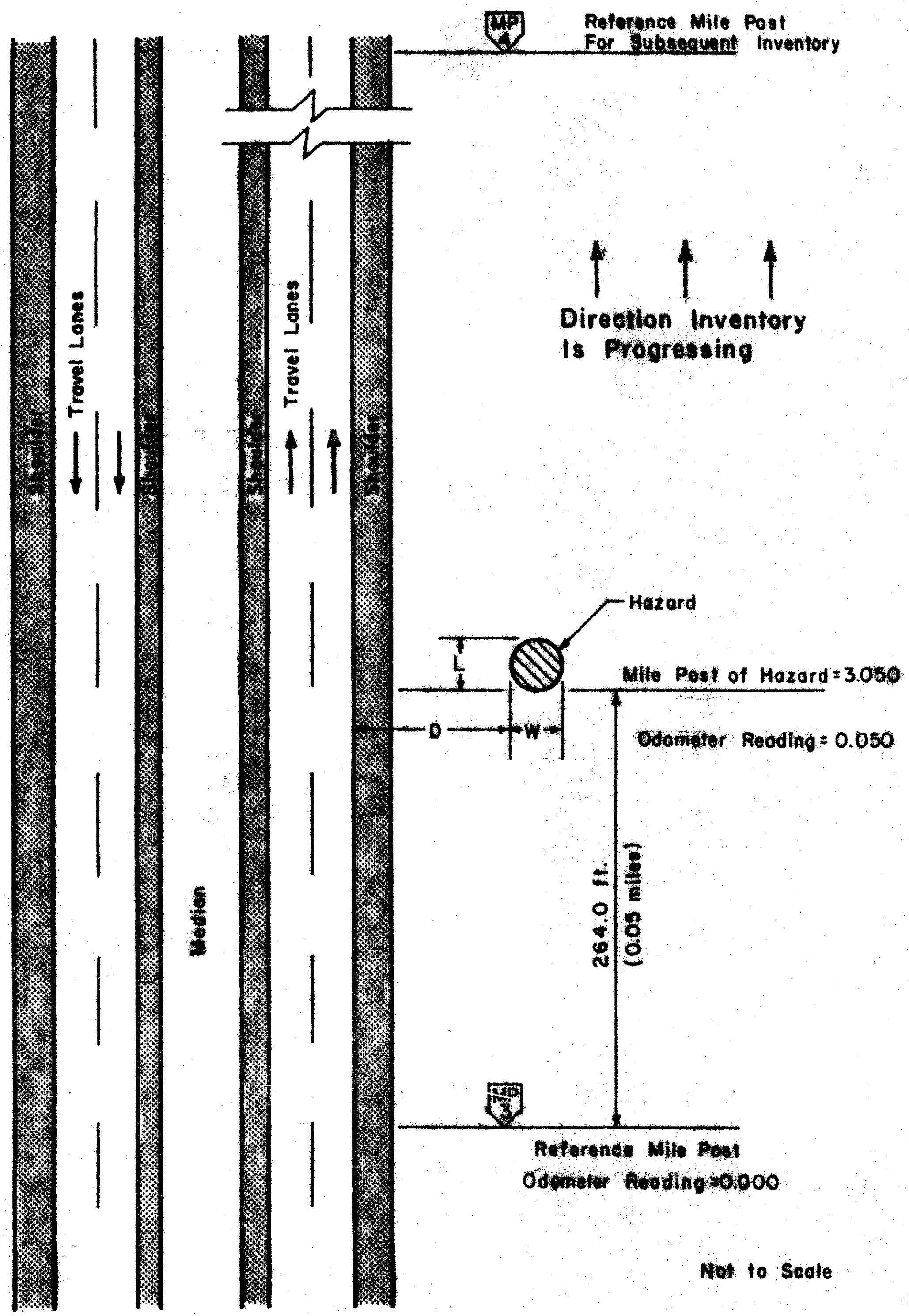
Two decision-makers are recommended to alleviate bias in improvement alternative recommendations. It proved advantageous in many cases because opposing views for improvement alternatives were presented or reinforcement added.

Odometer Measurements

Roadside hazards may be located in reference to existing milepost signs with sufficient accuracy using a vehicle equipped with an odometer capable of recording to one thousandth of a mile (approximately 5 ft). The procedure is as follows. The odometer is zeroed at a milepost sign. The vehicle is driven along the shoulder until a roadside hazard is encountered. The odometer reading is recorded as the front bumper is adjacent to the beginning (upstream end) of the hazard. Figure II-1 illustrates the method to locate a point hazard. If the hazard is a longitudinal hazard such as a guardrail, the beginning point is located as above and the odometer reading is again recorded when the vehicle reaches the downstream end. The length of the longitudinal hazard is computed by the program through subtraction. Figure II-2 illustrates how a longitudinal hazard is located. A roadside slope is located in the same manner as a longitudinal hazard. The criteria used to identify a critical slope are discussed in Section III.

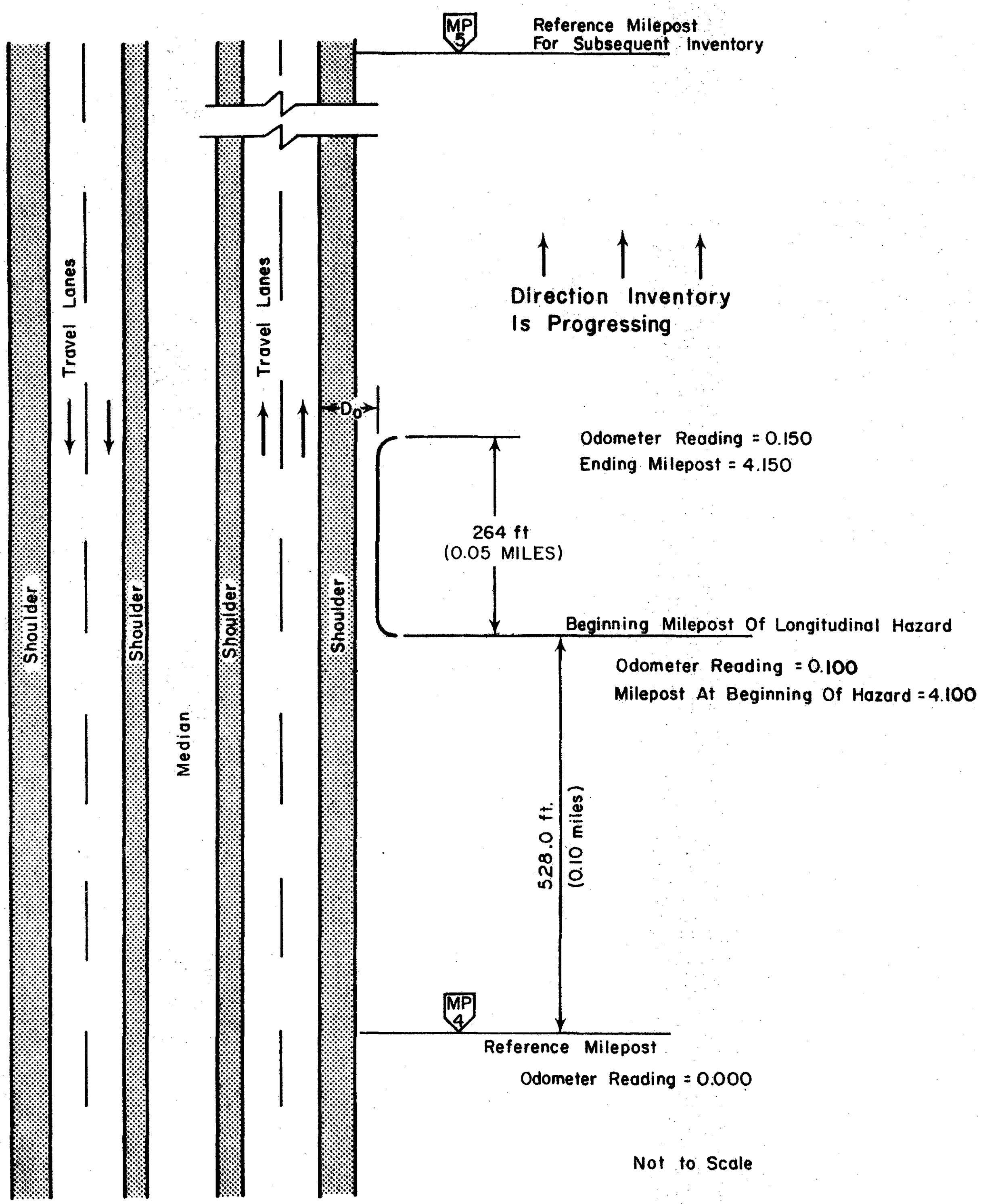
Slope Measurements

Slopes of 4:1 or steeper are included in the inventory. The longitudinal length of a slope is the distance between the point where the slope becomes 4:1 and the point at the downstream end where it becomes flatter



Point Hazard Location and Dimensions

Figure II-1



Longitudinal Hazard Location and Dimensions

Figure II-2

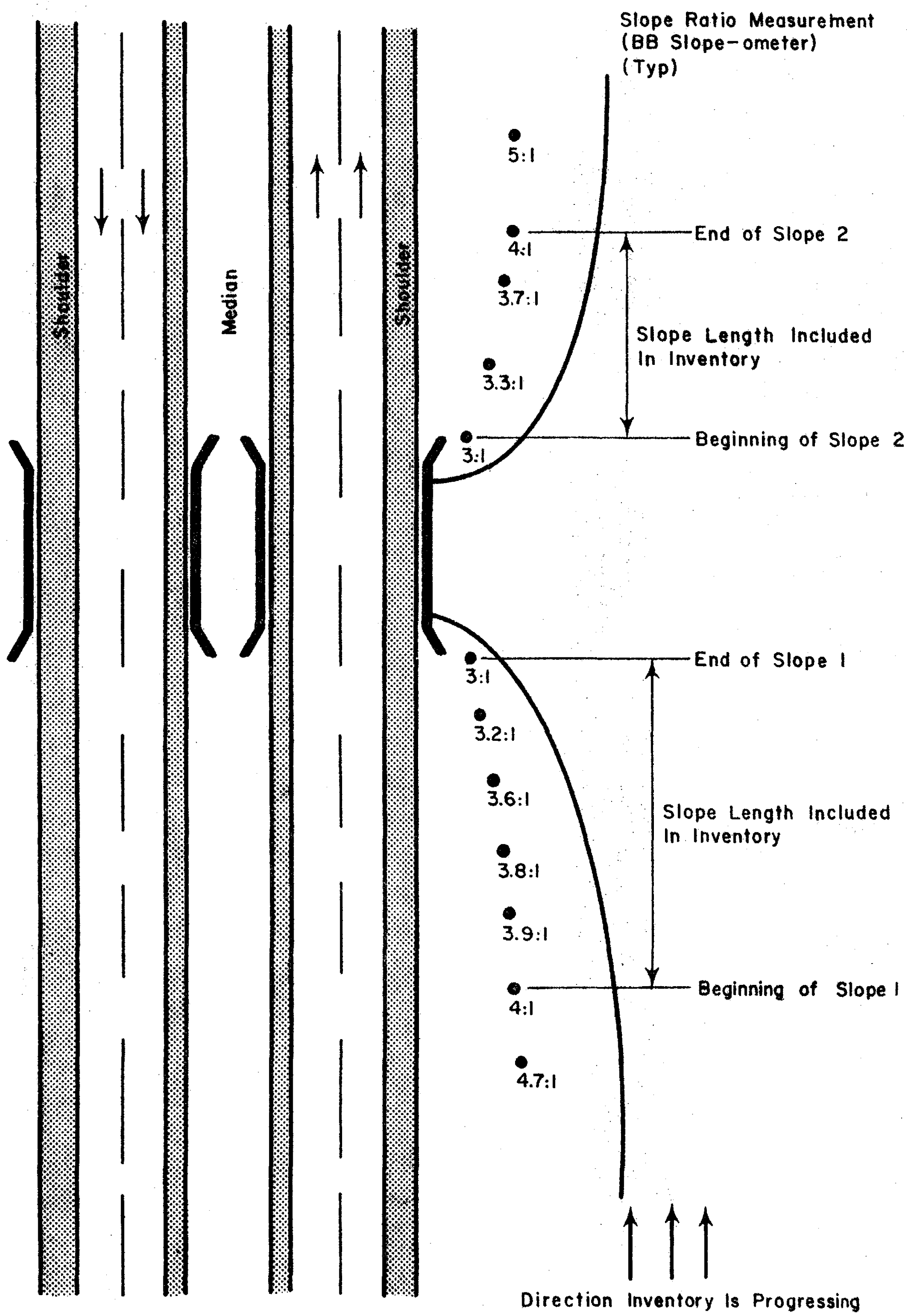
than 4:1, or terminates such as would be the case where the slope meets a cross-street under a structure. The end point of a slope approaching an overcrossing structure may be considered to be the beginning point of the bridge rail. Figure II-3 illustrates the method of determining the beginning and end mileposts of a roadside slope.

The steepness of all slopes should be measured to avoid omitting slopes that appear to be flatter than 4:1 but are, in fact, steeper than 4:1. To alleviate the time-consuming operation of measuring slope steepness by conventional surveying techniques, a device called a "slope-ometer" was designed to permit rapid steepness measurement. This device consists of a steel ball that rolls within a 6-inch radius groove adjacent to a slope ratio scale. It is attached to a 3-ft rod which is placed on the slope face and the slope ratio is read directly below the position at which the ball comes to rest in the groove due to gravity.

This instrument may be used to quickly determine if a slope is indeed 4:1 or steeper and, hence, should be inventoried. Also, the beginning and end points of a slope may be quickly determined by a series of measurements along the slope face as shown in Figure II-3.

Length of Inventory Section

Preliminary field implementation has indicated that about 30 to 50 hazards per mile of roadway can be expected in urban facilities. Based on time required to inventory several miles of urban freeway and on the average number of hazards encountered, it appears that the control-section represents a convenient length of roadway to inventory as a unit. Also, based on an expected number of hazards, the amount of data collected in



Determination of Slope Beginning and End Points

Figure II-3

the average section length provides a workable unit from a computer operations standpoint.

It is strongly recommended that a computer run of the field data be made as early as possible--definitely before large amounts of data are collected (no more than one-half day). Initial computer runs will identify errors in data recording that can be corrected in subsequent inventorying and permit the inventory team to determine problems that can be avoided both in recording hazards and selecting improvement alternatives.

III. ROADSIDE HAZARD INVENTORY

GENERAL

The extremely large number of hazards that must be inventoried along a section of roadway necessitates use of a systematic coding process for eventual analysis by computer. This can best be accomplished through use of a detailed roadside hazard inventory form such as shown in Figure III-1. The inventory form was developed cooperatively by personnel of the Texas Highway Department, Federal Highway Administration, and the Texas Transportation Institute and represents the culmination of repeated trials and modifications after field implementation on existing freeways and interstate highways in the Fort Worth, Houston, and Austin Districts.

ROADSIDE HAZARD INVENTORY FORM

The hazard inventory form has been designed to collect data under four categories, labeled Boxes 1 through 4. Box 1 contains hazard identification information including specific milepost location and other general location information needed for cross-reference filing and computer program operation. Space is also provided to identify the hazard by general name in words for manual review of the forms. Hazards have been classified into three categories--*point hazards*, Box 2; *longitudinal hazards*, Box 3; and *slopes*, Box 4. <u>Box 1 must be completed on every form</u>. Since a separate form is used to inventory each roadside hazard, only one of Boxes 2, 3, or 4 will be completed on each form.

The form has been developed to permit direct transfer of inventory data to computer card for entry to the cost-effectiveness program.

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by ______ **Page** ___ **of** ___

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

1 2 3 4 Hazard Number | 5 6 7 Highway Number | 8 9 10 County Code | 11 12 13 14 Control Number | 15 16 Section No. | 17 Recording Direction 1. With Milepost 2. Against Milepost | 18 19 20 ADT (Total Both Directions 1000's) | Mo. Yr. 21 22 23 24 Date

Hazard Description: ______

CLASSIFICATION

25 26 Identification Code | 27 28 Descriptor Code | 29 Offset Code 1. Right 2. Median | 30 31 32 Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only) | 33 34 35 36 Grouping Number

LOCATION

Beginning | (Except for Point Hazard) End

Reference Milepost

Odometer Reading at Hazard

Milepost at Hazard 37 38 39 40 41 42 | 43 44 45 46 47 48

BOX 1

POINT HAZARDS

1 (52) | 54 55 Hazard Offset, D_o(ft) | 56 57 Width (W)(ft) | 58 59 Length (L)(ft) | Drop Inlets Only: 60 61 62 Height (ft) or 63 64 65 Depth (ft)

BOX 2

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

2 (52) | Hazard Offset, D_o (ft): 53 54 Beginning, 55 56 End | 57 58 59 Height (ft) or Depth (ft) | 60 61 Width (W)(ft)

END TREATMENT Guardrail Only

62:
1. Not Beginning of Structure – Safety Treated
2. Not Beginning of Structure – Not Safety Treated
3. Beginning of Structure – Full-Beam Connection
4. Beginning of Structure – Not Full-Beam Connection

63:
1. Not Ending of Structure – Safety Treated
2. Not Ending of Structure – Not Safety Treated
3. Ending of Structure – Full-Beam Connection
4. Ending of Structure – Not Full-Beam Connection

BOX 3

SLOPES

FRONT SLOPE

3 (52) | Hazard Offset, D_o(ft): 53 54 Beginning, 55 56 End | Steepness: 57 58 Beginning :1, 59 60 End :1 | Distance "D_1" (ft): 61 62 Beginning, 63 64 End | 65 Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts>1ft) | 66 Slope Direction 1. Positive 2. Negative

2nd or BACK (Except for Level Terrain) SLOPE

Steepness: 67 68 Beginning :1, 69 70 End :1 | Distance "D_2" (ft): 71 72 Beginning, 73 74 End | 75 Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts>1ft) | 76 Slope Direction 1. Positive 2. Negative

BOX 4

Recommendations: ______

Roadside Hazard Inventory Form

Figure III-1

Only those data within the numbered spaces in each box will be entered on computer cards. The number below each space denotes the column number on the computer card. Any unnumbered spaces in a box (ex. "hazard description" or "odometer reading" in Box 1) are included in the form for descriptive purposes or computational purposes and will not be key-punched. The former facilitates manual cross-referencing of information or category filing while the latter organizes data collection for form completion at a later date (ex. in the office).

Each hazard inventory form constitutes a single computer card data input source. The format has been simplified as much as possible to assist the key-punch operator in transferring the data to cards. Wherever possible, data spaces have been located in a straight line reading from left to right. A circle appears in the left margin adjacent to each row of data spaces. Since only certain rows of spaces must be key-punched from each form, and these rows may differ between consecutive forms, a check mark (✓) <u>must</u> be placed in the circle adjacent to the appropriate completed row of spaces. The key-punch operator may use the check mark to quickly locate the data to be key-punched from that form. Two of the circles adjacent to Box 1 contain pre-printed check marks because the data in these two rows of spaces <u>must be key-punched from every</u> form. Across the top of Box 1 appears the statement, "Check Box if Columns 5 thru 24 are to be Duplicated from Previous Inventory Form." It can be expected that columns 5 through 24 will contain identical information throughout a substantial length of roadway during inventorying. A new hazard number will be assigned to each individual hazard as the inventory progresses, therefore, columns 1 through 4 cannot be duplicated.

The automatic duplicating feature on a key-punch machine can complete columns 5 through 24 more rapidly than the person completing the inventory form, and this check box is provided so that he does not have to complete these boxes each time he fills out an inventory form. He has only to assign a new hazard number (columns 1-4) as each hazard is encountered and check the duplication box. The complete row of data spaces (columns 1 through 24) should be filled in for the first inventory form completed at the beginning of each day or inventory section, so that this information is available in each package of inventory forms that the key-punch operator receives.

It is emphasized that a check mark must be placed in a circle along the left margin adjacent to any row of data spaces in which entries are made. If the check mark is omitted, the key-punch operator may overlook certain data. Each data space contains information pertinent to a particular function in the computer program, and therefore, each numbered space must be completed in a prescribed manner to avoid rejection by the computer program of all data on that form.

Box 1--Hazard Classification and Location Information

Contained in this category are general information from which the hazard may be located by highway number, county, control number, and section number. These four location designations permit not only information retrieval by hazard location ranging from general (county) to specific (control-section), but provide a means whereby a large number of inventory forms may be sorted and classified by the computer for a variety of analyses using selected location designation to specify needed data input source.

The hazard number (columns 1-4) is assigned consecutively throughout the inventory section, beginning with number 0001. No two hazards within the same inventory length may be assigned the same hazard number. If additional hazards are inventoried after the initial inventory (or, if one was omitted) a new number must be assigned to the omitted hazard. The form may be inserted at the appropriate place within a sequence of inventory forms (say, arranged according to increasing milepost) even though the hazard numbering sequence is thus non-consecutive.

Space is supplied for a three-digit highway number (columns 5-7). No prefixes are used in recording the highway number. For example, Interstate Highway 10 would be recorded as 010, and Interstate Highway 620 (loop) would be coded as 620. A problem will arise in coding highways carrying the same route number but having East or West designation such as 620E or 620W which start at a bifurcation. In situations such as this, one highway must be assigned a "dummy" inventory highway number (such as 999 or 998, etc.) that does not conflict with an existing highway number in the state (or another dummy route number already used). Since the computer output will list the "dummy" number, cross-reference filing will be necessary to identify the "dummy" route number at a later date.

The county codes (columns 8-10) are listed in Table III-1 which agrees with the standard Texas Highway Department alphabetical-numerical designation.

The control and section number identification, used by the Texas Highway Department, generally is used more widely than the county or highway number. To facilitate cross-referencing hazard inventory forms to on-site location, space is supplied to record both control number (columns 11-14) and section number (columns 15 and 16). These data

TABLE III-1
COUNTY CODES

Co. No.	County Name	Dist. No.	Co. No.	County Name	Dist. No.	Co. No.	County Name	Dist. No.	Co. No.	County Name	Dist. No.
1	Anderson	10	65	Donley	25	129	Karnes	16	192	Reagan	7
2	Andrews	6	66	Kenedy	21	130	Kaufman	18	193	Real	22
3	Angelina	11	67	Duval	21	131	Kendall	15	194	Red River	1
4	Aransas	16	68	Eastland	23	66	Kenedy	21	195	Reeves	6
5	Archer	3	69	Ector	6	132	Kent	8	196	Refugio	16
6	Armstrong	4	70	Edwards	22	133	Kerr	15	197	Roberts	4
7	Atascosa	15	71	Ellis	18	134	Kimble	7	198	Robertson	17
8	Austin	12	72	El Paso	24	135	King	25	199	Rockwall	18
9	Bailey	5	73	Erath	2	136	Kinney	22	200	Runnels	7
10	Bandera	15	74	Falls	9	137	Kleberg	16	201	Rusk	10
11	Bastrop	14	75	Fannin	1	138	Knox	25	202	Sabine	11
12	Baylor	3	76	Fayette	13	139	Lamar	1	203	San Augustine	11
13	Bee	16	77	Fisher	8	140	Lamb	5	204	San Jacinto	11
14	Bell	9	78	Floyd	5	141	Lampasas	23	205	San Patricio	16
15	Bexar	15	79	Foard	25	142	LaSalle	15	206	San Saba	23
16	Blanco	14	80	Fort Bend	12	143	Lavaca	13	207	Schleicher	7
17	Borden	8	81	Franklin	1	144	Lee	14	208	Scurry	8
18	Bosque	9	82	Freestone	17	145	Leon	17	209	Shackelford	8
19	Bowie	19	83	Frio	15	146	Liberty	20	210	Shelby	11
20	Brazoria	12	84	Gaines	5	147	Limestone	9	211	Sherman	4
21	Brazos	17	85	Galveston	12	148	Lipscomb	4	212	Smith	10
22	Brewster	24	86	Garza	5	149	Live Oak	16	213	Somervell	2
23	Briscoe	25	87	Gillespie	14	150	Llano	14	214	Starr	21
24	Brooks	21	88	Glasscock	7	151	Loving	6	215	Stephens	23
25	Brown	23	89	Goliad	16	152	Lubbock	5	216	Sterling	7
26	Burleson	17	90	Gonzales	13	153	Lynn	5	217	Stonewall	8
27	Burnet	14	91	Gray	4	154	Madison	17	218	Sutton	7
28	Caldwell	14	92	Grayson	1	155	Marion	19	219	Swisher	5
29	Calhoun	13	93	Gregg	10	156	Martin	6	220	Tarrant	2
30	Callahan	8	94	Grimes	17	157	Mason	14	221	Taylor	8
31	Cameron	21	95	Guadalupe	15	158	Matagorda	12	222	Terrell	6
32	Camp	19	96	Hale	5	159	Maverick	22	223	Terry	5
33	Carson	4	97	Hall	25	160	McCulloch	23	224	Throckmorton	3
34	Cass	19	98	Hamilton	9	161	McLennan	9	225	Titus	19
35	Castro	5	99	Hansford	4	162	McMullen	15	226	Tom Green	7
36	Chambers	20	100	Hardeman	25	163	Medina	15	227	Travis	14
37	Cherokee	10	101	Hardin	20	164	Menard	7	228	Trinity	11
38	Childress	25	102	Harris	12	165	Midland	6	229	Tyler	20
39	Clay	3	103	Harrison	19	166	Milam	17	230	Upshur	19
40	Cochran	5	104	Hartley	4	167	Mills	23	231	Upton	6
41	Coke	7	105	Haskell	8	168	Mitchell	8	232	Uvalde	22
42	Coleman	23	106	Hays	14	169	Montague	3	233	Val Verde	22
43	Collin	18	107	Hemphill	4	170	Montgomery	12	234	Van Zandt	10
44	Collingsworth	25	108	Henderson	10	171	Moore	4	235	Victoria	13
45	Colorado	13	109	Hidalgo	21	172	Morris	19	236	Walker	17
46	Comal	15	110	Hill	9	173	Motley	25	237	Waller	12
47	Comanche	23	111	Hockley	5	174	Nacogdoches	11	238	Ward	6
48	Concho	7	112	Hood	2	175	Navarro	18	239	Washington	17
49	Cooke	3	113	Hopkins	1	176	Newton	20	240	Webb	21
50	Coryell	9	114	Houston	11	177	Nolan	8	241	Wharton	13
51	Cottle	25	115	Howard	8	178	Nueces	16	242	Wheeler	25
52	Crane	6	116	Hudspeth	24	179	Ochiltree	4	243	Wichita	3
53	Crockett	7	117	Hunt	1	180	Oldham	4	244	Wilbarger	3
54	Crosby	5	118	Hutchinson	4	181	Orange	20	245	Willacy	21
55	Culberson	24	119	Irion	7	182	Palo Pinto	2	246	Williamson	14
56	Dallam	4	120	Jack	2	183	Panola	19	247	Wilson	15
57	Dallas	18	121	Jackson	13	184	Parker	2	248	Winkler	6
58	Dawson	5	122	Jasper	20	185	Parmer	5	249	Wise	2
59	Deaf Smith	4	123	Jeff Davis	24	186	Pecos	6	250	Wood	10
60	Delta	1	124	Jefferson	20	187	Polk	11	251	Yoakum	5
61	Denton	18	125	Jim Hogg	21	188	Potter	4	252	Young	3
62	DeWitt	13	126	Jim Wells	16	189	Presidio	24	253	Zapata	21
63	Dickens	25	127	Johnson	2	190	Rains	1	254	Zavala	22
64	Dimmit	22	128	Jones	8	191	Randall	4			

constitute a principal sorting key for computer retrieval of specific roadway sections for analysis, the omission of which will automatically terminate program execution.

Two other information sources necessary for program execution are included in the top row of Box 1; the recording direction (column 17) and the total ADT on the facility (columns 18-20). The direction in which the inventory is being conducted (with or against increasing milepost) must be specified to direct the program to the proper routine. The ADT is used within the program in the probability of encroachment routine. The date (columns 21-24) is included for cross-reference purposes and for later estimates of inventory costs.

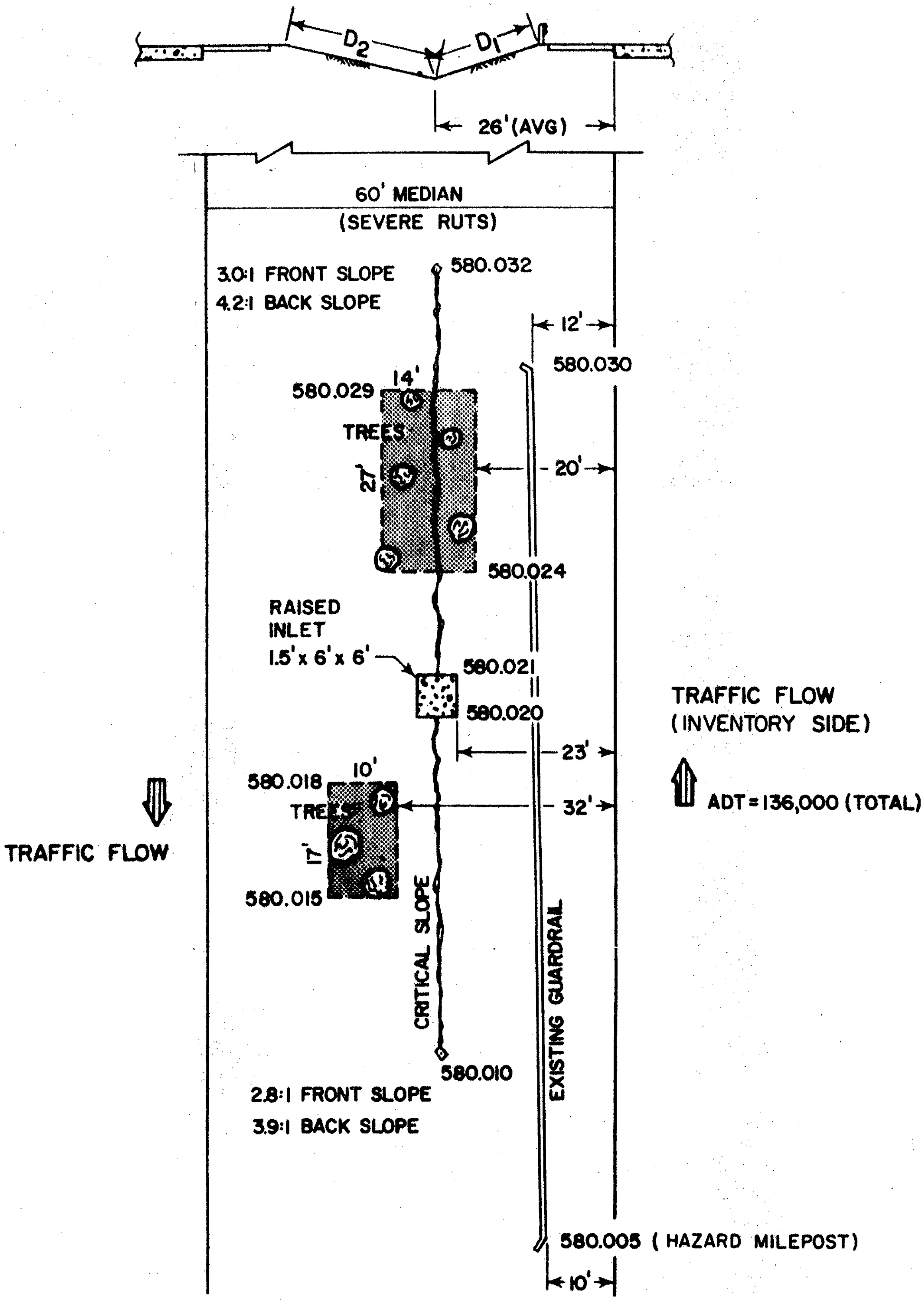
Classification (Box 1)--This information (columns 25-36) is vital to the computer program for several reasons. It provides the key to direct the program to perform certain analytical operations through information recorded in columns 29-36. The identification and descriptor codes (columns 25-28) identify the type of hazard from which the severity index is assigned.

Grouping Number--Of particular importance to the operation of the program is the grouping number. A "group" of hazards represents any two or more hazards in close proximity that are related to each other either by proximity or by interdependence in combined severity. For example, a guardrail protecting a point hazard on a critical slope constitutes a group of three hazards. As long as the guardrail is installed, the two hazards behind it cannot be impacted by the vehicle, yet they must be included in the group inventory if one of the alternative improvements is to remove the guardrail. The grouping number provides the only key to the program that more than a single hazard is to be considered. Therefore, if an improvement can affect any other hazard, that hazard must be included in the grouping number. The only type of hazard that is not considered part of a group is a single point hazard. Figure III-2 is used to illustrate the use of the grouping number. It is emphasized that if the grouping number is omitted (or if a hazard is omitted from a group) the program does not consider the improvement effects on related hazards.

The series of hazards located in the median (Figure III-2) represents a grouping consisting of five individual hazards: (1) the guardrail, (2) critical slope, (3) cluster of three trees considered to be a point hazard with peripheral dimensions, (4) a raised drop inlet, and (5) a cluster of five trees again considered as a point hazard. Each of these five hazards would be assigned an individual hazard number and all would be assigned the same grouping number.

The offset code (column 29, Figure III-1) must be the same for all hazards in a grouping. The grouping code is used at most overcrossing structures where a typical group would include approach guardrail, the bridge rail, departing guardrail, and a slope at each end of the structure. These hazards normally exist both on the right side and on the median side. A separate grouping number is assigned to the group of hazards on each side (right side and median side) of the travel lanes.

A second point of interest is illustrated in Figure III-2. Many times two or three individual point hazards will be located close together.

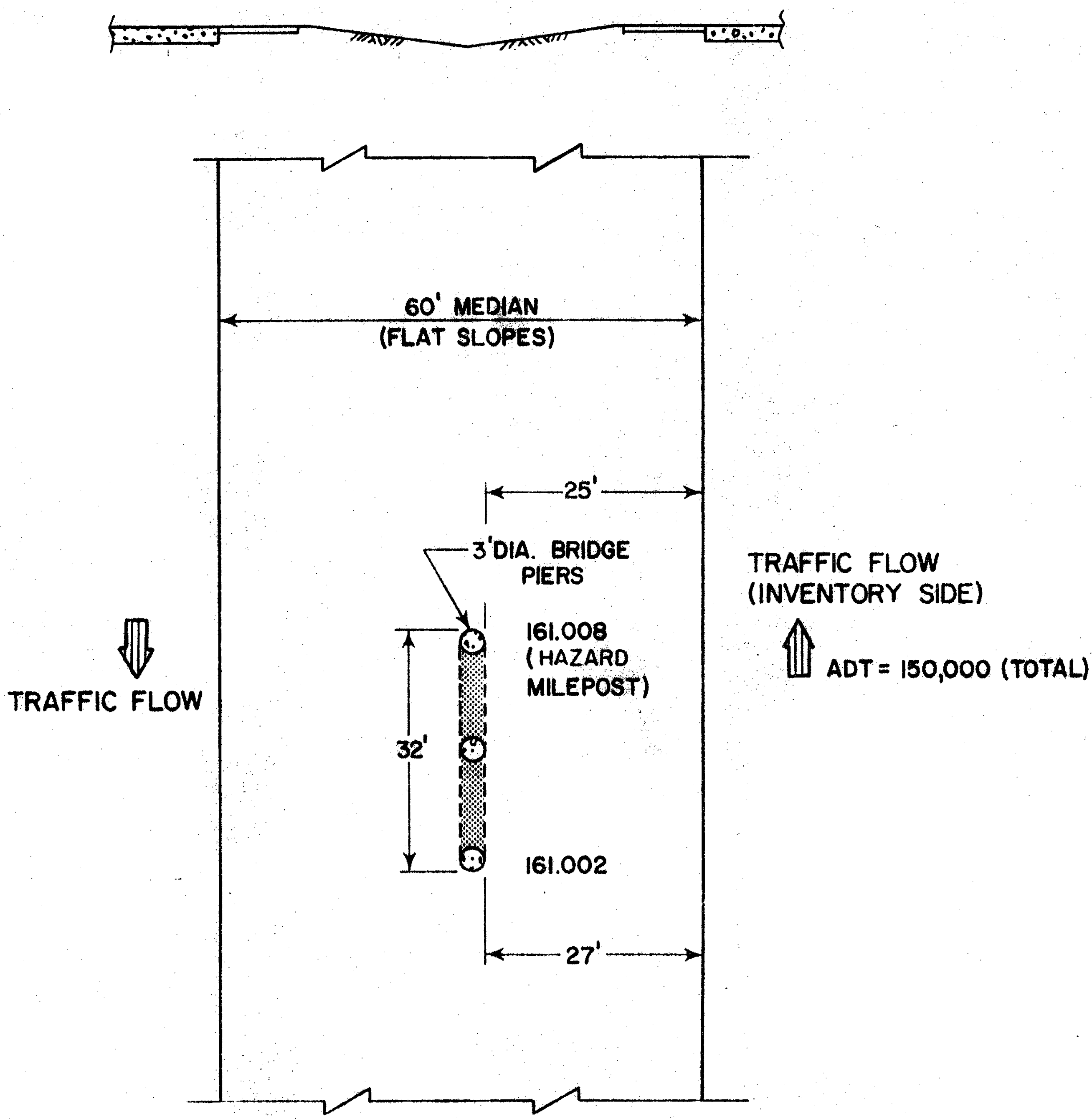


Grouping of Hazards in Median

Figure III-2

When these are encountered, the hazards may be inventoried as a single point hazard having dimensions of an imaginary box around their periphery. It is recommended that bridge piers be inventoried in this manner (Figure III-3) because a vehicle cannot pass between adjacent piers. Therefore, in effect, the individual piers act as a rectangular point hazard as shown in Figure III-3. No grouping number would be assigned in this case. Judgment must be used in clustering point hazards as a single hazard, but a realistic criterion is that it may be assumed to act as a single point hazard if a vehicle cannot pass between any two hazards.

Also included in the classification data block is space to record the median width. Two methods may be used to inventory hazards within the median. The whole median may be inventoried, regardless of its width, as the inventory is progressing along one set of main lanes. Where this may be desirable for narrow medians, it becomes impractical for wide medians on rural sections where median width may exceed 100 ft. The second method involves inventorying just the 30-ft width of the median adjacent to the main lanes (near side) in the direction of inventory. If the median is inventoried across its full width as the inventory progresses along one set of main lanes, the median width must be recorded in columns 30-32. The program determines from this whether or not the hazard may be impacted from both directions of traffic flow. On narrow medians, it is recommended that this method be used. If the median is inventoried on only the near side from each set of travel lanes, the median width data are not needed and columns 30-32 are left blank or zeroes may be entered.



TEST CASE I

Closely-Spaced Hazards Considered as a Single Point Hazard

Figure III-3

Location (Box 1)--All hazards are located in the field by milepost using the thousandth reading odometer as discussed previously in this report. When inventorying in the direction of increasing milepost, the milepost at the hazard may be entered directly in columns 37-42 or 43-48 with no computation required by simply recording the reference milepost in columns 37-39 and the odometer reading in columns 40-42 if the odometer is zeroed at each milepost. If the inventory is progressing against the milepost system, subtraction must be made on the form to compute the hazard milepost. Space is provided to record the reference milepost and the odometer reading at the hazard. The difference between these two values is recorded in the numbered data spaces.

It should be noted that only the beginning hazard milepost is required for point hazards. Both beginning and end hazard milepost must be recorded for longitudinal and slope hazards, the length being computed by the computer program by subtraction of the two values.

It is again emphasized that Box 1 must be completed on each inventory form regardless of the category into which the hazard is assigned (Box 2, 3, or 4).

Box 2--Point Hazards

The code 1 in column 52 designates that the hazard is a point hazard. With the exception of drop inlets, only hazard offset (columns 54-55), width (columns 56-57), and length (columns 58-59) are required in Box 2. All dimensions are recorded to the nearest foot. In the case of a raised drop inlet (table top design) the height must be recorded (columns 60-62) to the nearest tenth foot. For a depressed drop inlet, depth must be similarly recorded in columns 63-65. These data are necessary to assign different severity indices for various heights or depths of inlets.

Box 3--Longitudinal Hazards

Hazards assigned to this category include curbs, bridge rails, median barriers, guardrails, washout ditches, and retaining walls, and are so identified by the code 2 in column 52. Length of a longitudinal hazard is computed within the program from the beginning and end milepost recorded in Box 1. Offset distance at the beginning and end of the longitudinal hazard are recorded in columns 53-54 respectively. In many cases, both offset distances will be identical because the hazard is located parallel to the roadway; however, provision must be made for the exception and both offsets must be recorded. All dimensions for offset and width (columns 60-61) are recorded to the nearest foot. Height or depth (columns 57-59) must be recorded to the nearest tenth foot for guardrail, curbs, and ditches.

Columns 62 and 63 pertain to guardrail only and identify end conditions and safety treatment. Column 62 describes the beginning end; column 63 pertains to the downstream end. Four codes for each are provided, the sixteen combinations of which describe all possible guardrail installations. A guardrail may (1) be isolated (protecting a point hazard, a slope, or combination) and not connected at either end to a bridge or other structure, (2) be located at the approach to a structure, or (3) be located at the downstream end of a structure. Isolated guardrail may be safety treated including post spacing and end treatment in accordance with current accepted safety specifications, or it may not satisfy these specifications (not safety treated). Guardrail connections at a bridge or other structure are classified as "full-beam connection" or "not full-beam connection." A full-beam connection is defined as one transmitting continuous rail strength through the "eight-bolt" connection or other connections assumed by the Texas Highway Department equally acceptable. All one-bolt connections, unconnected guardrail (short gap between rail and structure) and other such connections are classified as "not full-beam." Thus, an isolated guardrail installation over 150 ft in length and having current post spacing specified for safety and turned down ends would be coded as a 1 (column 62), 1 (column 63). An approach guardrail with beginning point safety treated, but connecting to a bridge wingwall with a one-bolt connection would be a 1, 4 in columns 62, 63 respectively.

Guardrail height should be measured in all cases (columns 57-59). Also, each existing guardrail installation should be critically examined to determine if it is, in fact, protecting an object from impact for the 11-degree encroachment angle assumed in the model (See Reference 3). The guardrail installation may meet all safety requirements yet be located such that an encroaching vehicle could pass either end and impact the object which the guardrail was intended to protect. This problem is especially prevalent where short sections of guardrail are installed to protect a point hazard, or at bridge approaches where a vehicle could travel behind the guardrail ending up on a critical slope.

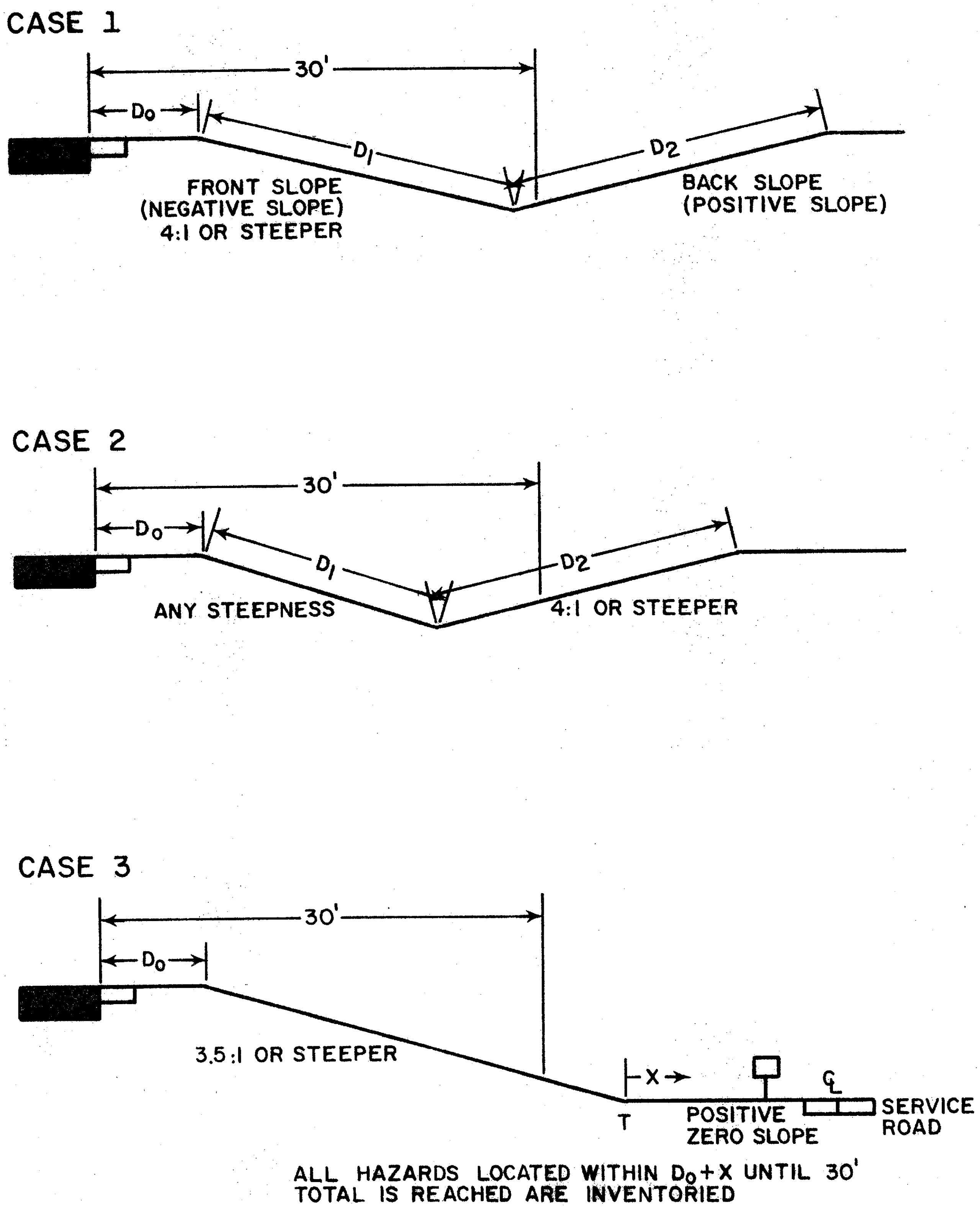
Box 4--Slopes

Slopes of 4:1 or steeper both in the median or on the right of the travel lanes are included in the inventory and categorized as such by a code 3 in column 52. Offset distance (columns 53-56) must be specified for both ends of the slope. The length of slope (see Figure II-3, Section II) is the distance between the point where the slope becomes 4:1 and the point at the downstream end where it becomes flatter than 4:1 or terminates such as would be the case where the slope meets a cross-street under a structure. Slope steepness is recorded to the nearest tenth. Two assumptions are made within the program to compute the hazard index and the program keys on the value of slope steepness to select one of the two subroutines. This feature can govern the lateral distance that must be inventoried for a slope hazard as discussed below.

If the steepness is less than 3.5:1, the program assumes that the vehicle can recover within a lateral travel distance of 30 ft. For slopes 3.5:1 or steeper, the assumption is made that the vehicle cannot be safely returned to the roadway and that it will travel to the toe of the slope. Therefore, hazards located beyond the toe of slope must be included if the sum of the offset distance to the slope, D_0 (columns 53-54) and the distance from the toe of slope to the hazard is 30 ft or less. (See Case 3, Figure III-4).

To facilitate measurement of slope distances without elaborate surveying equipment, the distance, D_1, (columns 61-64) is measured. This measurement is the length along the slope face from the hinge point to the toe of slope. Horizontal distance is computed within the program.

Space is provided (column 65) to record the degree of erosion on the slope face. In most cases, the code 1 (slight or no erosion) will be used, particularly if erosion cuts are present due to a recent rainfall and normal maintenance would be expected to repair slopes. However, if



Roadside Slope Configurations Included in Inventory

Figure III-4

erosion is severe (code 2) this fact should be noted. The program increases the severity index accordingly for badly eroded slopes.

The severity associated with slope traversal, other than vehicle rollover on a steep front slope, is actually dependent on the vehicle g-forces experienced as the vehicle travels through the region at the toe of slope. The combination of front and back slope and ditch configuration, therefore, influence the severity. To quantify this, the steepness of both front and back slope must be recorded. Box 4 provides space to record similar data for both. The second slope may be either a back slope or level terrain such as would be encountered at the toe of a fill section adjacent to a service road. The slope direction is used to key the computer program to various subroutines for analysis purpose. The slope direction convention is that used in roadway alignment--downward (fill section) is negative, upward (cut section) is positive. Level terrain at the bottom of a fill section is coded as a positive slope (Figure III-4). The steepness for a level terrain (columns 67-70) and distance D_2 (columns 71-74) should be recorded by a digit "9" in each space which is interpreted by the program as a level slope.

IV. ROADSIDE HAZARD IMPROVEMENTS

GENERAL

The manner in which improvement alternative information is input to the program is equally as important as the inventory data input. A form, compatible to the inventory form was developed to accomplish this (Figure IV-1). The form has undergone considerable field trial, particularly in the Houston and Austin Districts.

ROADSIDE HAZARD IMPROVEMENT FORM

The roadside hazard improvement form has been designed to provide a system whereby feasible safety improvements for each category of hazard can be coded and evaluated in the cost-effectiveness model. Also included are cost data associated with the improvement selected. The format of the form is similar to that of the hazard inventory form and the general discussion of the left-margin circles, hazard dimensions and hazard location data boxes also applies to the improvement form.

Box 1--Cost Information

The cost-effectiveness model operates on the principle of severity-cost relationship of the existing hazard compared to the same relationship in its improved state. Therefore, costs must be assigned to both conditions. Costs are defined as those which will be borne by the Texas Highway Department. They do not include vehicle damage or personal injury costs incurred in a collision.

The "first cost of improvements" (columns 17-22) represents the initial lump-sum net cost associated with incorporating the improvement.

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

BOX 1

1 2 3 4 Hazard Number — 5 6 7 Highway Number — 8 9 10 County Code — 11 12 13 14 Control Number — 15 16 Section Number — Hazard Description

17 18 19 20 21 22 First Cost of Improvements ($)

Repair Cost per Collision ($): 23 24 25 26 Hazard — 27 28 29 30 Improvement

Normal Maintenance ($/yr): 31 32 33 34 Hazard — 35 36 37 38 Improvement

POINT HAZARD IMPROVEMENTS

BOX 2

[1] 40 [1] 42 Alleviate Hazard — [ ] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — Lateral Offset (ft) 44 45

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — Lateral Offset (ft) 46 47

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — 48 49 50 Length (ft) — 51 52 Width (ft) — 53 54 Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

[2] 40 [1] 42 Curb — [ ] 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — [ ] 43
1. Rigid
2. Semi-rigid

[ ] 44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail — [ ] 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — [ ] 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning — 47 48 End

Median Far Side — Lateral Offset (ft): 49 50 Beginning — 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft): 53 54 55 Beginning — 56 57 58 End

Shorten (ft): 59 60 61 Beginning — 62 63 64 End

SLOPE IMPROVEMENTS

BOX 4

FRONT SLOPE

[3] 40

Hazard Offset D_o (ft): 42 43 Beginning — 44 45 End

Steepness: [.] :1 46 47 Beginning — [.] :1 48 49 End

Distance "D_1" (ft): 50 51 Beginning — 52 53 End

[ ] 54 Slope Direction
1. Positive
2. Negative

2nd or BACK SLOPE

Steepness: [.] :1 55 56 Beginning — [.] :1 57 58 End

Distance "D_2" (ft): 59 60 Beginning — 61 62 End

[ ] 63 Slope Direction
1. Positive
2. Negative

Beginning: 64 65 66 67 68 69 — End: 70 71 72 73 74 75 — Hazard Milepost (Complete If Different From Inventory)

BOX 5

[4] 40 **No Improvement Recommended**

Roadside Hazard Improvement Form

Figure IV-1

It may represent a cost of removal if simple removal was the recommended safety improvement. Where installation of guardrail was the recommended improvement, it would represent the total cost associated with this installation.

Repair costs per collision (excluding vehicle repair costs and personal injury costs) must be estimated both for the existing hazard (columns 23-26) and the recommended improvement (columns 27-30). Either may be zero, depending on the particular hazard. For example, repair cost per collision incurred by a collision of a vehicle and a bridge pier could be zero unless the collision involved a large truck and the pier was severely damaged structurally. The improvement cost, had protection by a barrel attenuation device been recommended, would be the expected replacement costs for the damaged barrel system after collision. Conversely, the hazard repair cost for a rigid sign post may be complete replacement cost of the sign, whereas a recommendation of "removal" would reduce the expected improvement repair cost to zero since future collision would be impossible at that location.

Normal maintenance costs include those maintenance costs for the hazard in its existing state and those estimated for the improved state. As in the case of repair costs, either could be zero. If the recommended improvement was removal, the "improvement normal maintenance costs" would be zero.

In all cost data spaces, zero should be entered where applicable rather than merely leaving the space blank. This also acts as a check system to avoid overlooking data spaces. All data spaces in Box 1 must be completed on each hazard improvement form (spaces 5 through 16 may be duplicated by checking appropriate circle) to avoid rejection by the computer program. Each line of data checked should be completed in full unless otherwise noted.

Box 2--Point Hazards

A code 1 in column 40 signifies that the improvement applies to a point hazard. Four improvement alternatives are available with the appropriate code entered in column 42.

(1) Alleviate Hazard (Code 1, Column 42) which includes removal, making the hazard breakaway, reconstruction of the hazard to a traversable design. The four subdivisions are identified by a code in column 43.

(2) Protect Hazard with Guardrail (Code 2, Column 42). This code may be used for any point hazard that is not located on a critical slope or for a hazard that is not itself a critical slope. When guardrail is recommended, the lateral offset must be specified in columns 44-45.

(3) Protect Hazard with Concrete Median Barrier (Code 3, Column 42). A concrete median barrier may be recommended for either the median location or on the right side. If the barrier is placed in the median, no offset distance need be specified since the dimensions relative to the hazard are built into the computer program. If the barrier is recommended for right-side placement, the offset distance (columns 46-47) must be specified. The computer program assumes a 35-ft length of median barrier both upstream and downstream of the point hazard. This includes a 25-ft section of end treatment. Therefore, length need not be specified on the improvement form.

(4) Protect Hazard with Energy Attenuation System (Code 4, Column 42).

When this improvement is recommended, length (columns 48-50), width (columns 51-52) and offset distance (columns 53-54) must be specified. If, for example, a barrel attenuation system is recommended to protect a median bridge pier, the length of only one barrel system is specified. The program determines if two systems are indeed required (one at each end of the piers) to protect the piers from both directions of traffic flow. The total length of hazard and barrel system(s) is computed within the program.

Box 3--Longitudinal Hazards

A code 2 in column 40 identifies the improvement as a longitudinal improvement. Improvement alternatives are provided for four types of longitudinal hazards:

(1) curb (Code 1, Column 42)

(2) bridge rail (Code 2, Column 42)

(3) guardrail (Code 3, Column 42)

(4) ditch (Code 4, Column 42)

each having several sub-categories as denoted by a code in column 43.

In certain sub-categories, completion of Box A or Box B is required. These data spaces need to be completed only when the appropriate instruction appears adjacent to the selected improvement alternative on the improvement form. Box A pertains only to installation of a longitudinal improvement where none existed previously such as the installation of new guardrail or lateral relocation of a bridge rail if the bridge is widened. When only minor modifications are made to existing longitudinal hazards (examples: lengthening, shortening, or closing up gaps between existing guardrail sections), Box B must be completed. It should be noted that a guardrail may be lengthened (Box B) in three ways: (1) adding guardrail to the beginning end, (2) adding guardrail to the downstream end, or (3) adding length to both ends (columns 53-58). Similarly, guardrail may be shortened in the same ways (columns 59-64). Gaps between guardrail sections may be closed up by lengthening either the upstream or downstream section by the gap length.

Curb--Two improvement alternatives are provided for curbs each being identified by a code in column 43.

Bridge rail--Four improvement alternatives are provided (column 44) for each of two bridge rail types (column 43). "Upgrade to full safety standards" (Code 1, Column 44) is interpreted to include all safety improvements necessary to bring the existing rail up to the highest current safety standards. This may include only minor anchorage modification or it may include complete replacement of existing rail with a new rail system. The costs associated with the improvement will reflect the degree of construction necessary.

If the recommendation is made to move the rail laterally (Code 2, Column 44) bridge widening would be necessary. Again, costs will reflect the degree of construction necessary to accomplish this alternative. As noted on the improvement form, Box A must be completed to designate the offset distance for the proposed bridge rail.

Continuation of guardrail across a bridge rail face (Code 3, Column 44) represents a safety improvement that is being incorporated on many bridges. This feature provides continued beam strength across the bridge in addition to reduced severity of collision with the concrete bridge rail face.

Although it constitutes rather major reconstruction, provision is made to evaluate the safety improvement of decking over the gap between parallel bridges (code 4, column 43). Box A must be completed if this alternative is selected.

Guardrail--Nine safety improvement alternatives are provided for guardrail hazards, each identified by a code number in column 43 under the guardrail general code 2,3 in column 40 and 42 respectively.

In most instances, guardrail will be inventoried as a part of a grouping because it invariably is installed to protect some other hazard, either a point hazard or a critical slope. Therefore, care must be taken in the improvement recommendation to insure that all hazards within that group are accounted for in any recommendation involving guardrail removal. Indiscriminant removal of guardrail will expose hazards located behind it (and therefore previously inaccessible to vehicle impact) so that they now become potential hazards.

Guardrail installation procedures according to the Texas Highway Design procedures are incorporated into the computer program. Therefore, when new guardrail is recommended, its placement and minimum length to protect point hazards or at bridge ends will be in accordance with these specifications. The minimum length of guardrail installation is 150 ft not including safety treatment at the ends and required overlap on the downstream end of the hazard.

Removal of existing guardrail is accomplished by using a code 1 in column 43. Since the improvement form is keyed to the inventory form by hazard number, no dimensions are required on the improvement form.

Full safety standards for guardrail include safety treatment of ends, current post spacing (6 ft-3 in.) and height in accordance with latest safety specifications and full-beam connections at bridge ends. If this recommendation is selected, a code 2 is placed in column 43. Where additional length must be added to provide the 150-ft minimum allowable length, Box B must be completed. This code is <u>not</u> used when closure of short gaps is recommended; a separate code (code 3) is used for this purpose.

When gap closure is required <u>in addition</u> to upgrading (post-spacing, end treatment, etc.), a code 3 is placed in column 43 and Box B is completed.

Guardrail at bridge ends and at other locations are coded separately to facilitate coding improvement alternatives that either recur frequently or are unique to certain problems concerning guardrail. Code 5 pertains to the individual case of installation of guardrail to protect a critical slope that is not associated with a bridge structure, or to protect a point hazard at any location. Codes 6 through 9 apply to improvements of guardrail located at a bridge. When <u>only</u> the anchorage connection of guardrail at the bridge is recommended (no other upgrading of the guardrail is necessary, or recommended) a code 6 is used in column 43. To recommend installation of guardrail (where none exists at the time of inventory) at a bridge approach or at the downstream end of a bridge, a code 7 or 8 is used respectively in column 43. In all cases where installation of new guardrail is recommended, it is assumed that the new installation will comply with the highest current safety specifications and costs must reflect this.

A separate code is provided (code 9) to recommend safety treatment of only the free-end portion of guardrail at either end of a structure. It is noted that this code applies only to the free end of guardrail beginning or terminating at a structure, not to isolated guardrail protecting a point hazard or a slope that is not associated with a structure. Use of the code 9 implies that only the end point of the rail will be safety treated (turned down, buried, anchored, etc.) and that no changes will be made to existing post spacing other than perhaps at the treated section.

The longitudinal hazard category overlaps with the slope hazard category in one respect. If the safety recommendation for an unprotected critical slope is that guardrail should be installed, the hazard inventory form and improvement form are somewhat incompatible with respect to the location on the form where data are recorded. In this particular case, the original hazard is recorded in the "slope" category (Box 4 on the inventory form) and the improvement information is recorded in the "longitudinal hazard" category (Box 3) on the improvement form.

Ditch--Three options are available for safety improvements recommended for ditches. Ditches, under the longitudinal hazard category, include both longitudinally oriented ditches caused by erosion (washout) or designed ditches to carry runoff down fill slopes such as are often found near overpassing structures. Ditches formed by the intersection of roadside slopes are not included in this category and are not coded as an individual hazard. Instead, provision to evaluate the severity of this feature is incorporated in the front and back slope categories in Box 4 on both the inventory and the improvement form.

Box 4--Slope Hazard

Three possible recommendations may be made with respect to slopes. First, the slope may be left in its existing state without guardrail protection. Guardrails may be recommended to protect the slope. Finally, a critical slope may be regraded to a flatter cross-section that an errant vehicle can safely traverse. The latter recommendation of course constitutes rather major reconstruction and can be accomplished only if sufficient right-of-way exists. However, it is emphasized that slope flattening and drainage inlet changes may constitute a very cost-effective safety improvement and should not be overlooked as a feasible improvement alternative. Investigation of this alternative through the cost-effectiveness model alleviates personal bias toward this improvement alternative.

The hazard associated with traversing a slope is dependent primarily upon two factors: the steepness of the front slope, and the relative difference between steepness of front and back slopes. The cross-section of the ditch formed between front and back slopes also influences the vehicle g-forces; however, the severity indices incorporated in the computer program are based on a vee ditch.

Therefore, in recommending a slope improvement, both front slope steepness (columns 46-49) and back slope steepness (columns 55-58) must be specified unless the back slope is, in fact, level terrain such as would be encountered adjacent to a service road at the toe of a fill section. The distance, D_1, (columns 50-53) must be estimated because until detailed cross-section data are prepared, the toe-of-slope for the newly proposed slope will not be known. The distance, D_2, for the second slope also must be estimated.

The lateral offset of the toe-of-slope at the beginning and end of the slope is computed within the computer program by trigonometric relationships using the hazard offset, D_0, slope steepness, and distance D_1. A linear relationship is then assumed for the toe-of-slope offset between the beginning and end positions from which the critical slope steepness between expected operations (3.5:1) is determined.

It is probable that the beginning and end points of the slope will change after the slope is flattened. Therefore, these data must be entered in columns 64-75 for this recommendation only. If guardrail is recommended as a safety improvement, the slope end points will remain unchanged and the columns 64-75 may be left blank.

Box 5--No Improvement Recommended

The computer program is developed on a one-for-one relationship between hazard inventory and hazard improvement. That is, for each hazard inventoried, there must be a corresponding improvement recommendation even if the recommendation is that "no improvement" is recommended. Provision for this is made through a code 4 in column 40 on the improvement form. Some examples are used to illustrate the use of this code.

Many times a grouping of hazards is inventoried in which guardrail is protecting one or more hazards. Each individual hazard within the grouping must be inventoried. If the safety improvement recommendation for the whole grouping is that only the guardrail be upgraded to full safety standards and nothing be done to the hazards behind the guardrail, the improvement form for each of the hazards behind the guardrail would be merely a code 4 in column 40.

From strictly a safety improvement viewpoint, it would appear unnecessary to even inventory hazards located behind a guardrail if it was obvious that removal of the guardrail was not a viable alternative. However, it is strongly recommended that <u>every</u> hazard be inventoried. If, at a later date, the guardrail is removed, the grouping evaluation would be incomplete because no data would be available concerning objects located behind it. Also, reasons other than safety evaluation may require a detailed inventory of particular hazard types along a section of highway and retrieval programs could be adapted to locate the information from the inventory data.

The "no improvement" code is not intended to be used as a "catch-all" for these hazards which appear to have no feasible improvement possibility. It is provided to reduce the field time required in completing the forms while maintaining the computer program requirements that an improvement form be provided for each hazard form. If no improvement form is provided, an error message will be printed out on the data output.

It is noted that the basic requirement is that an improvement form must be provided for each hazard inventory form. It should be noted also that <u>more than one</u> improvement form may be provided for each hazard inventory form. The arrangement of data input and data output that can be expected is discussed in Section V of this report.

V. DATA INPUT/OUTPUT

DATA DECK ARRANGEMENT

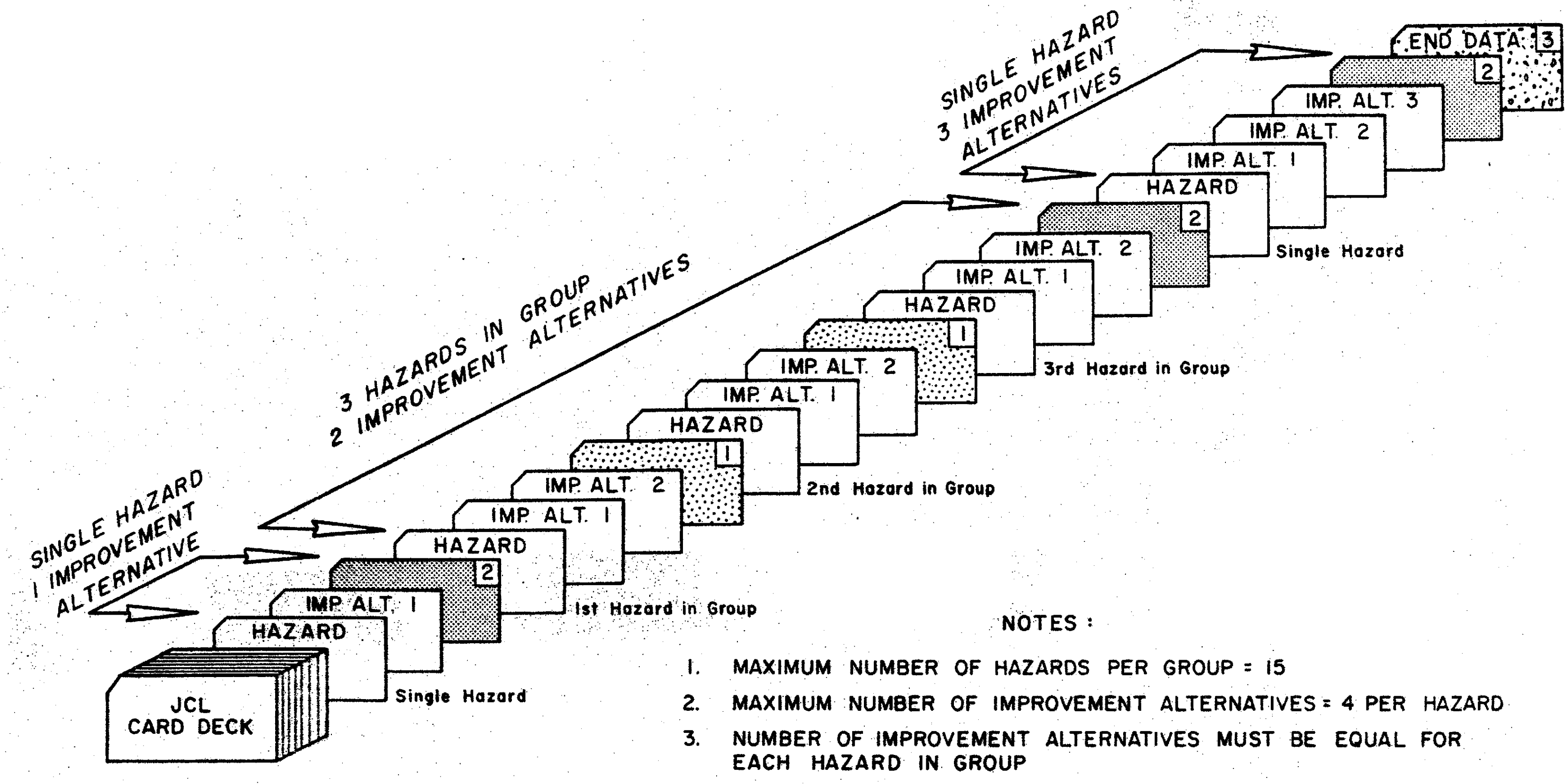
Correct type, location, and amount of data on an inventory or improvement form are imperative to successful computer operation. It is equally important that the data deck be correctly oriented including insertion of "key" cards after the improvement card or between successive inventory/improvement groups of cards within a grouping as illustrated in Figure V-1.

Three key cards (sometimes referred to as "kicker" cards) are used to signify the end of a inventory/improvement set; the end of an inventory/improvement set within a grouping; and the end of the entire data block being input to the computer. As illustrated in Figure V-1, a key card having the digit 1 in column 80 is used to separate each set of hazard inventory and its improvements from the next successive set within a grouping. A key card having a digit 2 in column 80 is used to signify the end of all improvements either with a single hazard or the end of a grouping. A code 3 in column 80 signifies the end of all input data after which execution terminates.

The computer program is capable of evaluating a grouping containing a maximum of 15 hazards and 4 improvement alternatives per hazard. Four alternatives were ample in all cases during field testing; in only rare instances were more than two alternatives required.

In any hazard/improvement set, the improvement card (or cards) follows immediately behind the hazard card to which it applies. A maximum of four improvements is allowed per hazard. Particular care must be exercised in

DATA INPUT ILLUSTRATION



Arrangement of Data Cards

Figure V-1

arranging the sequence of improvement cards within a grouping. The program evaluates the improvements in a prescribed sequence. For example, using Figure V-1 to illustrate, in the grouping of 3 hazards with 2 improvement alternatives, the evaluation procedure for the first improvement considers improvement alternative 1 with the first hazard, alternative 1 with the second hazard and alternative 1 with the third hazard as a single grouping evaluation. A grouping cost effectiveness is computed. The process is then repeated using improvement alternative 2 with each of the three hazards and a grouping cost effectiveness is again computed. Therefore, compatible alternatives must be in the proper sequence throughout the grouping deck arrangement.

Since a grouping cost-effectiveness is computed in the above described manner, it should be noted that within each grouping, the same number of improvement alternatives must be specified for each hazard, even if for one hazard in the grouping, a "No Improvement" alternative is recommended. For example, if in a three-hazard grouping, two improvement alternatives are recommended, two improvement alternative cards must be inserted behind each of the three hazard inventory cards. If two improvement alternative cards were inserted for the first two hazards and only one for the third hazard, the omission error would be detected during data reading, and no computer execution would occur on either of the two improvement alternatives even though the error applied only to the second improvement alternative. An error message, therefore, would be printed on the output data and no grouping cost-effectiveness would be computed for either improvement alternative.

ERROR MESSAGES

Since computer program execution is highly dependent on precise data input both in type and location, error messages have been incorporated into the program to "flag" input errors. Due to the complexity of the program and extensive branching within subroutines from several key data sources, it is expected that errors will occur. To avoid program termination (which would normally occur for each data error), the program has been developed to bypass the erroneous data, print out an error message, and continue with the next data input.

Thirty-six error messages have been incorporated. They are listed in Table V-1. In most cases, the message is self-explanatory. Each error message is identified on the data output by reference number. The list of messages is printed out for each computer run. Also printed out is the location within the program or subroutine in which the data error affected the program execution. The message indicates the type of error and provides direction to remedy the data error.

The program will automatically terminate if 100 error messages are printed during any run.

A message, "Hazard Improvement Non Cost-Effective," will appear in the data output. This is not an error message, and is not included in the 100-maximum count for automatic program termination. It indicates that the recommended improvement produces, for all intents and purposes, no safety benefit over the hazard currently existing. Under certain circumstances it indicates that the recommended improvement in fact produces a more hazardous situation than the existing one. The message may be obtained under two circumstances as shown below.

The simplified cost-effectiveness ratio is determined by:

$$\text{Cost-Effectiveness} = \frac{\text{Cost}}{H_B - H_A}$$

where H_A = Hazard Index after Improvement

H_B = Hazard Index before Improvement (Existing)

If H_A is greater than H_B, the denominator becomes negative. This means that the recommended alternative, is in fact, more hazardous than the existing situation. Obviously, it is impractical to incur costs to produce a more critical situation than currently exists; therefore, the flag message "Hazard Improvement Not Cost-Effective" is printed out when this occurs and the cost-effectiveness ratio is not computed.

When H_A is only slightly less than H_B, the denominator becomes very small numerically, hence the cost-effectiveness ratio becomes very large. Based on statistical logic, a lower cut-off level has been incorporated into the model such that when the numerical value of $H_B - H_A$ is less than 0.02, the flag message is printed out and the cost-effectiveness ratio is not computed. The 0.02 level indicates a 55-percent probability of no hazard reduction.

A second message, "No Improvement Hazard Grouping" merely indicates that for that particular hazard, the recommended safety improvement was "No Improvement Recommended" (code 4, column 40, improvement form). It is not counted as an error message for program termination.

If a data error occurs within a grouping, a group cost-effectiveness cannot be determined. Therefore, an error message will be printed out and the message, "End Group" will also appear where the grouping cost-effectiveness value would normally appear. The message "Group" denotes that the cost-effectiveness value represents a total grouping value.

TABLE V-1

ERROR OR FLAG MESSAGES

MESSAGE NAME	SUBROUTINES	DESCRIPTION OF MESSAGE
1	INVTRY	End milepost at hazard not specified
2	PTHAZ	Unmatched point hazard and improvement codes
3	PTHAZ, LGHAZ	Non-existing improvement classification specified in col 42 of improvement form
4	DITCH	Non-existing ditch improvement code classification
5	RAILNG	Guardrail installation not necessary--- Re-examine roadway group hazard
6	HAZARD	Non-existing hazard classification specified in column 52 of inventory form
7	PTHAZ, LGHAZ	Non-existing point hazard improvement code (column 40)
8		Available for later use
9	PTRAIL	Distance between guardrail and obstacle less than 2.0 ft
10		Available for later use
11	CURB	Non-existing curb improvement class. Specified in col 43 of improvement form
12	BRIDGE	Non-existing bridgerail imprvmnt class. Specified in col 43 of improvement form
13	BRIDGE	Non-existing bridgerail imprvmnt class. Specified in col 44 of improvement form
14	RAIL	Non-existing guardrail imprvmnt class. Specified in col 43 of improvement form
15	RAIL6	Guardrail end-treatment adjacent to bridge incorrectly specified
16		Available for later use
17	SLOPE1	Non-existing slope direction class. Specified on inventory form

TABLE V-1

ERROR OR FLAG MESSAGES, Continued

MESSAGE NAME	SUBROUTINES	DESCRIPTION OF MESSAGE
18	RAIL5	No slope recommendation specified on improvement form
19	ZERO, DITCH	Programming error---vehicle not permitted to penetrate guardrail
20	PTHAZ, LGHAZ	No improvement needed-- flat slopes and /or lateral offset greater than 30 ft.
21	ZERO	Program error in subroutine zero--refer to flow charts
22		Available for later use
23	MAIN PROGRAM	Stop computer program---100 error or flag messages
24	INVTRY	Unmatched hazard numbers on inventory and improvement form
25	INSTGR, RAILING	Guardrail installation not necessary-- re-examine roadway site
26	INSTGR	No improvement hazard exposed--- re-examine roadway site
27	INVTRY	End of data and program
28	INVTRY	Unequal number of improvement alternatives per hazard in group
29	RAIL1	Program error in subroutine raill-- refer to flow charts
30	MAIN PROGRAM	Hazard improvement not cost-effective.
31	INVTRY	Hazards on right side and left side of roadway cannot be grouped together
32	HAZARD	Guardrail end treatment code not specified on inventory form
33	HAZARD	Guardrail end treatment code not defined--value greater than 4

TABLE V-1

ERROR OR FLAG MESSAGES, Continued

MESSAGE NAME	SUBROUTINES	DESCRIPTION OF MESSAGE
34	HAZARD	Improvement costs not specified
35	HAZARD	Guardrail hazard maintenance costs not specified
36	HAZARD	Guardrail improvement maintenance costs not specified

SEVERITY INDICES

The severity index is the relative measure of an obstacle's ability to produce a given outcome on the vehicle and/or occupants when a collison occurs. The severity indices selected for the NCHRP 20-7 Project represented an "average" set of values based on limited data and were, to a large degree, determined subjectively. To adapt the NCHRP 20-7 results to the needs of the Texas Highway Department, a two-part questionnaire was developed to subjectively determine severity indices for common types of roadside hazards expected in the state. The first part of the questionnaire consisted of ninety-eight hazard comparison statements to which an "agree" or "disagree" response was requested. The second part consisted of an evaluation of fifty-two roadside hazards and conditions; the respondent was requested to numerically rate the potential hazard of each on a one-to-ten rating scale.

The questionnaire was administered to individuals employed by the State of Texas in professions related to highway safety. These professions included the areas of design, operations, maintenance, law enforcement, and administration. The results were evaluated and a base severity index on the one-to-ten scale was determined.

The cost-effectiveness ratio is extremely sensitive to the severity index. A severity index reduction from 10 to 8 represents a much greater safety improvement than a reduction from 5 to 3 although the numerical reduction is the same. Therefore, to provide a relative weighting system, cost values supplied by the Texas Highway Department were used and the one-to-ten scale was expanded to a one-to-one-hundred scale according to the following relationship:

$$0 < SI_B < 4,\ SI_A = SI_B$$

$$4 < SI_B < 7,\ SI_A = 7SI_B - 24$$

$$7 < SI_B < 10,\ SI_A = 25SI_B - 150$$

where

SI_B = Base Severity Index (one-to-ten scale)

SI_A = Adjusted Severity Index (one-to-one-hundred scale)

The severity indices used in the computer model represent the adjusted severity indices. A detailed explanation of the adjustment methodology is presented in Report 11-3, Documentation Manual.

CASE EXAMPLES OF DATA INPUT/OUTPUT

Three hypothetical sets of inventory and improvement data input are presented to illustrate the procedure for use of the two data forms. Typical output data are shown for each example.

Test Case 1 (Bridge Piers in Median)

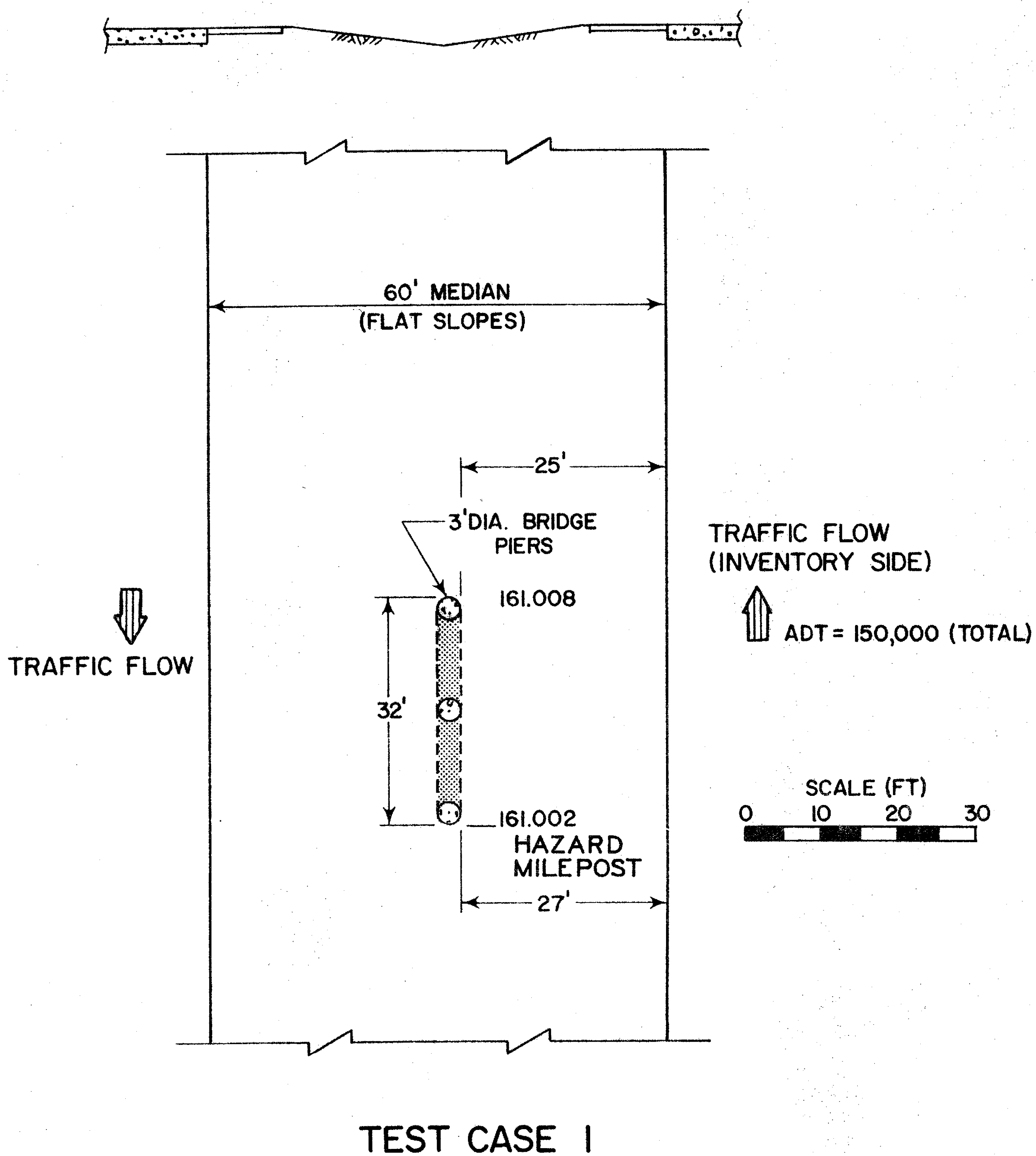
The location and geometry of the set of three bridge piers assumed to be a rectangular point hazard (3 ft x 32 ft) are shown in Figure V-2. Typical hazard inventory data for this point hazard are shown in Figure V-3 with four possible improvement recommendations listed in the "Recommendations" section at the bottom of the form. Figures V-4 through V-7 illustrate the manner in which improvement forms would be completed to evaluate each of the four improvement recommendations. Figure V-8 presents the cost effectiveness data output obtained from the program for these four recommendations.

Test Case 2 (Group Hazards in Median)

Figure V-9 illustrates the location of five hazards in a grouping. Each cluster of trees is considered to be a point hazard within the group. The group also includes a guardrail, a critical slope, and a raised drop inlet. Each hazard within the group is inventoried individually. Although several alternatives exist, only two are discussed for illustrative purposes. Figures V-10 through V-24 illustrate the data input to determine the group cost-effectiveness value for the two selected improvement alternatives. Figure V-25 presents cost-effectiveness data output for Test Case 2.

Test Case 3 (Group Hazards at Bridge)

Figure V-26 illustrates a typical grouping of hazards that may be encountered at an overcrossing structure. The grouping considered includes an approach guardrail, a sidewalk curb, a bridge rail, and a slope at each end of the bridge. These hazards along the right side of the travel lane constitute a grouping. Similar hazards along the median side of the same travel lanes would be coded as a different grouping. It should be noted that the subject group contains all hazards associated with the structure both upstream from, on, and downstream from the bridge. To illustrate, only one improvement alternative is specified for each hazard in the grouping and a total grouping cost-effectiveness value is determined. The process would be duplicated for other selected improvement alternatives. Figures V-27 through V-36 illustrate the input data. Figure V-37 presents cost-effectiveness data output for Test Case 3.



Location of Hazards--Bridge Piers in Median (Test Case 1)

Figure V-2

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by G.D Weaver Page____of____

BOX 1

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

Hazard Number (1–4)	Highway Number (5–7)	County Code (8–10)	Control Number (11–14)	Section No (15–16)	Recording Direction (17) 1. With Milepost 2. Against Milepost	ADT (Total Both Directions 1000's) (18–20)	Date Mo. Yr. (21–24)
0100	010	230	0026	12	1	150	0873

Hazard Description: Bridge Piers

CLASSIFICATION

Identification Code (25–26)	Descriptor Code (27–28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (30–32) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number (33–36)
11	01	2	060	

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard	161.002 (37–42)	(43–48)

BOX 2

POINT HAZARDS

52	Hazard Offset, D_o (ft) (54–55)	Width (W)(ft) (56–57)	Length (L)(ft) (58–59)	Drop Inlets Only: Height (ft) (60–62) or	Depth (ft) (63–65)
1	26	03	32	00.0	00.0

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

2 (52) — Hazard Offset, D_o (ft.): Beginning (53–54), End (55–56); Height (ft.) or Depth (ft.) (57–59); Width (W)(ft.) (60–61)

END TREATMENT — Guardrail Only

62:
1. Not Beginning at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated
3. Beginning at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full-Beam Connection

63:
1. Not Ending at Structure – Safety Treated
2. Not Ending at Structure – Not Safety Treated
3. Ending at Structure – Full-Beam Connection
4. Ending at Structure – Not Full-Beam Connection

BOX 4

SLOPES

FRONT SLOPE

3 (52) — Hazard Offset, D_o (ft.): Beginning (53–54), End (55–56); Steepness: Beginning (57–58) :1, End (59–60) :1; Distance "D_f" (ft.): Beginning (61–62), End (63–64); Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts>1ft.); Slope Direction (66) 1. Positive 2. Negative

2nd or BACK SLOPE (Except for Level Terrain)

Steepness: Beginning (67–68) :1, End (69–70) :1; Distance "D_2" (ft.): Beginning (71–72), End (73–74); Slope Face Erosion Code (75) 1. Slight or None 2. Severe (Ruts>1ft.); Slope Direction (76) 1. Positive 2. Negative

Recommendations:
(1) Remove Piers - Replace with single span
(2) Protect piers with guardrail
(3) Protect piers with concrete median barrier
(4) Install Barrel Attenuator System (L = 50 ft)

Hazard Inventory--Test Case 1

Figure V-3

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

BOX 1

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form ○

(✓) [0][1][0][0] Hazard Number (1 2 3 4) — [0][1][0] Highway Number (5 6 7) — [2][3][0] County Code (8 9 10) — [0][0][2][6]–[1][2] Control Number (11 12 13 14) / Section Number (15 16) — Hazard Description: *Piers- Remove*

(✓) [2][2][5][0][0][0] First Cost of Improvements ($) (17 18 19 20 21 22)

Repair Cost per Collision ($): [0][0][0][0] Hazard (23 24 25 26); [0][0][0][0] Improvement (27 28 29 30)

Normal Maintenance ($/yr): [0][0][0][0] Hazard (31 32 33 34); [0][0][0][0] Improvement (35 36 37 38)

BOX 2

POINT HAZARD IMPROVEMENTS

(✓) [1] (40) [1] (42) Alleviate Hazard — [1] (43)
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ [1] (40) [2] (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] Lateral Offset (ft) (44 45)

○ [1] (40) [3] (42) Protect Hazard with Concrete Median Barrier (CMB) — [ ][ ] Lateral Offset (ft) (46 47)

○ [1] (40) [4] (42) Protect Hazard with Energy Attenuation System — [ ][ ][ ] Length (ft) (48 49 50); [ ][ ] Width (ft) (51 52); [ ][ ] Offset (ft) (53 54)

BOX 3 (crossed out)

LONGITUDINAL HAZARD IMPROVEMENTS

○ [2] (40) [1] (42) Curb — [ ] (43)
1. Remove and Regrade
2. Install Wedge Modification

○ [2] (40) [2] (42) Bridgerail — [ ] (43)
1. Rigid
2. Semi-rigid

[ ] (44)
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

○ [2] (40) [3] (42) Guardrail — [ ] (43)
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

○ [2] (40) [4] (42) Ditch — [ ] (43)
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

○ Box A (INSTALL GUARDRAIL)
- Right or Median Near Side — Lateral Offset (ft): [ ][ ] Beginning (45 46) – [ ][ ] End (47 48)
- Median Far Side — Lateral Offset (ft): [ ][ ] Beginning (49 50) – [ ][ ] End (51 52)

BOX B (CHANGES TO EXISTING GUARDRAILS)
- Lengthen (ft): [ ][ ][ ] Beginning (53 54 55) – [ ][ ][ ] End (56 57 58)
- Shorten (ft): [ ][ ][ ] Beginning (59 60 61) – [ ][ ][ ] End (62 63 64)

BOX 4 (crossed out)

SLOPE IMPROVEMENTS

FRONT SLOPE

○ [3] (40) — Hazard Offset D_h (ft): [ ][ ] Beginning (42 43) – [ ][ ] End (44 45); Steepness: [.]:1 Beginning (46 47), [.]:1 End (48 49); Distance "D_1" (ft): [ ][ ] Beginning (50 51) – [ ][ ] End (52 53); [ ] (54) Slope Direction: 1. Positive 2. Negative

2nd or BACK SLOPE

○ Steepness: [.]:1 Beginning (55 56), [.]:1 End (57 58); Distance "D_2" (ft): [ ][ ] Beginning (59 60) – [ ][ ] End (61 62); [ ] (63) Slope Direction: 1. Positive 2. Negative

○ Hazard Milepost (Complete If Different From Inventory): Beginning [ ][ ][.][ ][ ][ ] (64 65 66 67 68 69); End [ ][ ][.][ ][ ][ ] (70 71 72 73 74 75)

BOX 5 (crossed out)

○ [4] (40) No Improvement Recommended

Improvement Alternative No. 1--Test Case 1
(Remove Piers, Replace with Single Span Bridge)

Figure V-4

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

BOX 1

0100	010	230	0026 – 12	Piers-Install Guardrail
1 2 3 4 Hazard Number	5 6 7 Highway Number	8 9 10 County Code	11 12 13 14 Control Number – 15 16 Section Number	Hazard Description

003600	0000	0050	0000	0150
17 18 19 20 21 22 First Cost of Improvements ($)	23 24 25 26 Repair Cost per Collision ($) – Hazard	27 28 29 30 Repair Cost per Collision ($) – Improvement	31 32 33 34 Normal Maintenance ($/yr) – Hazard	35 36 37 38 Normal Maintenance ($/yr) – Improvement

POINT HAZARD IMPROVEMENTS

BOX 2

[1] 40 [1] 42 Alleviate Hazard [ ] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) [23] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) [ ] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System [ ] 48 49 50 Length (ft) [ ] 51 52 Width (ft) [ ] 53 54 Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

[2] 40 [1] 42 Curb [ ] 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail [ ] 43
1. Rigid
2. Semi-rigid

[ ] 44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail [ ] 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch [ ] 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning – 47 48 End

Median Far Side — Lateral Offset (ft): 49 50 Beginning – 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft): 53 54 55 Beginning – 56 57 58 End

Shorten (ft): 59 60 61 Beginning – 62 63 64 End

SLOPE IMPROVEMENTS

BOX 4

FRONT SLOPE

[3] 40

Hazard Offset D_o (ft): 42 43 Beginning – 44 45 End

Steepness: [.]:1 46 47 Beginning; [.]:1 48 49 End

Distance "D_1" (ft): 50 51 Beginning – 52 53 End

[ ] 54 Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: [.]:1 55 56 Beginning; [.]:1 57 58 End

Distance "D_2" (ft): 59 60 Beginning – 61 62 End

[ ] 63 Slope Direction 1 Positive 2 Negative

Beginning: 64 65 66 67 68 69; End: 70 71 72 73 74 75 — Hazard Milepost (Complete If Different From Inventory)

BOX 5

[4] 40 No Improvement Recommended

Improvement Alternative No. 2--Test Case 1
(Protect Piers with Guardrail)

Figure V-5

Form. B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

BOX 1

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

Hazard Number	1 2 3 4	0 1 0 0
Highway Number	5 6 7	0 1 0
County Code	8 9 10	2 3 0
Control Number	11 12 13 14	0 0 2 6
Section Number	15 16	1 2
Hazard Description		Piers - Install CMB
First Cost of Improvements ($)	17 18 19 20 21 22	0 0 1 5 0 0
Repair Cost per Collision ($) — Hazard	23 24 25 26	0 0 0 0
Repair Cost per Collision ($) — Improvement	27 28 29 30	0 0 0 0
Normal Maintenance ($/yr) — Hazard	31 32 33 34	0 0 0 0
Normal Maintenance ($/yr) — Improvement	35 36 37 38	0 0 5 0

BOX 2

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard [ ] 43

1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — [2][7] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — [ ][ ][ ] 48 49 50 Length (ft); [ ][ ] 51 52 Width (ft); [ ][ ] 53 54 Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb [ ] 43

1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail [ ] 43

1. Rigid
2. Semi-rigid

[ ] 44

1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail [ ] 43

1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch [ ] 43

1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning — 47 48 End

Median Far Side — Lateral Offset (ft): 49 50 Beginning — 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft): 53 54 55 Beginning — 56 57 58 End

Shorten (ft): 59 60 61 Beginning — 62 63 64 End

BOX 4

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40

Hazard Offset D_h (ft): 42 43 Beginning — 44 45 End

Steepness: [.]:1 46 47 Beginning; [.]:1 48 49 End

Distance "D_1" (ft): 50 51 Beginning — 52 53 End

Slope Direction [ ] 54: 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: [.]:1 55 56 Beginning; [.]:1 57 58 End

Distance "D_2" (ft): 59 60 Beginning — 61 62 End

Slope Direction [ ] 63: 1. Positive 2. Negative

Beginning: 64 65 66 67 68 69 — End: 70 71 72 73 74 75 — Hazard Milepost (Complete If Different From Inventory)

BOX 5

[4] 40 No Improvement Recommended

Improvement Alternative No. 3—Test Case 1
(Protect Piers with Concrete Median Barrier)

Figure V-6

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

BOX 1

0100	010	230	0026–12	Piers-Install Barrels
1 2 3 4 Hazard Number	5 6 7 Highway Number	8 9 10 County Code	11 12 13 14 Control Number – 15 16 Section Number	Hazard Description

005000	0000	0300	0000	0100
17 18 19 20 21 22 First Cost of Improvements ($)	23 24 25 26 Repair Cost per Collision ($) – Hazard	27 28 29 30 Repair Cost per Collision ($) – Improvement	31 32 33 34 Normal Maintenance ($/yr) – Hazard	35 36 37 38 Normal Maintenance ($/yr) – Improvement

BOX 2

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard — [ ] 43: 1. Remove 2. Make Breakaway and/or Relocate 3. Reconstruct Inlet to Safe Design 4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — [ ][ ] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — [050] 48 49 50 Length (ft) [10] 51 52 Width (ft) [22] 53 54 Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb — [ ] 43: 1. Remove and Regrade 2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — [ ] 43: 1. Rigid 2. Semi-rigid — [ ] 44: 1. Upgrade to Full Safety Standards 2. Move Laterally (Complete Box A Below) 3. Install Guardrail Along Bridgerail Face 4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail — [ ] 43: 1. Remove Existing Guardrail 2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable) 3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below) 4. Close-up Gap Between Existing Guardrail (Complete Box B Below) 5. Install Guardrail to Protect Slope Near Bridge -- May Include Point Hazards (Complete Box A Below) 6. Anchor Existing Guardrail to Bridgerail 7. Install Guardrail at Bridge Approach (Complete Box A Below) 8. Install Guardrail Departing Bridge (Complete Box A Below) 9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — [ ] 43: 1. Reshape to Safe Cross Section 2. Replace with Storm Drain 3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL): Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning, 47 48 End; Median Far Side — Lateral Offset (ft): 49 50 Beginning, 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS): Lengthen (ft): 53 54 55 Beginning, 56 57 58 End; Shorten (ft): 59 60 61 Beginning, 62 63 64 End

BOX 4

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40 — Hazard Offset D_0 (ft): 42 43 Beginning, 44 45 End; Steepness: 46 47 Beginning :1, 48 49 End :1; Distance "D_1" (ft): 50 51 Beginning, 52 53 End; [ ] 54 Slope Direction: 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: 55 56 Beginning :1, 57 58 End :1; Distance "D_2" (ft): 59 60 Beginning, 61 62 End; [ ] 63 Slope Direction: 1. Positive 2. Negative

Hazard Milepost (Complete If Different From Inventory): Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 5

[4] 40 No Improvement Recommended

Improvement Alternative No. 4--Test Case 1
(Install Barrel Attenuation System)

Figure V-7

COST EFFECTIVENESS PROGRAM

HIGHWAY NO = 10
COUNTY NO = 230
DISTRICT NO = 19
CONTROL NO = 26
SECTION NO = 12

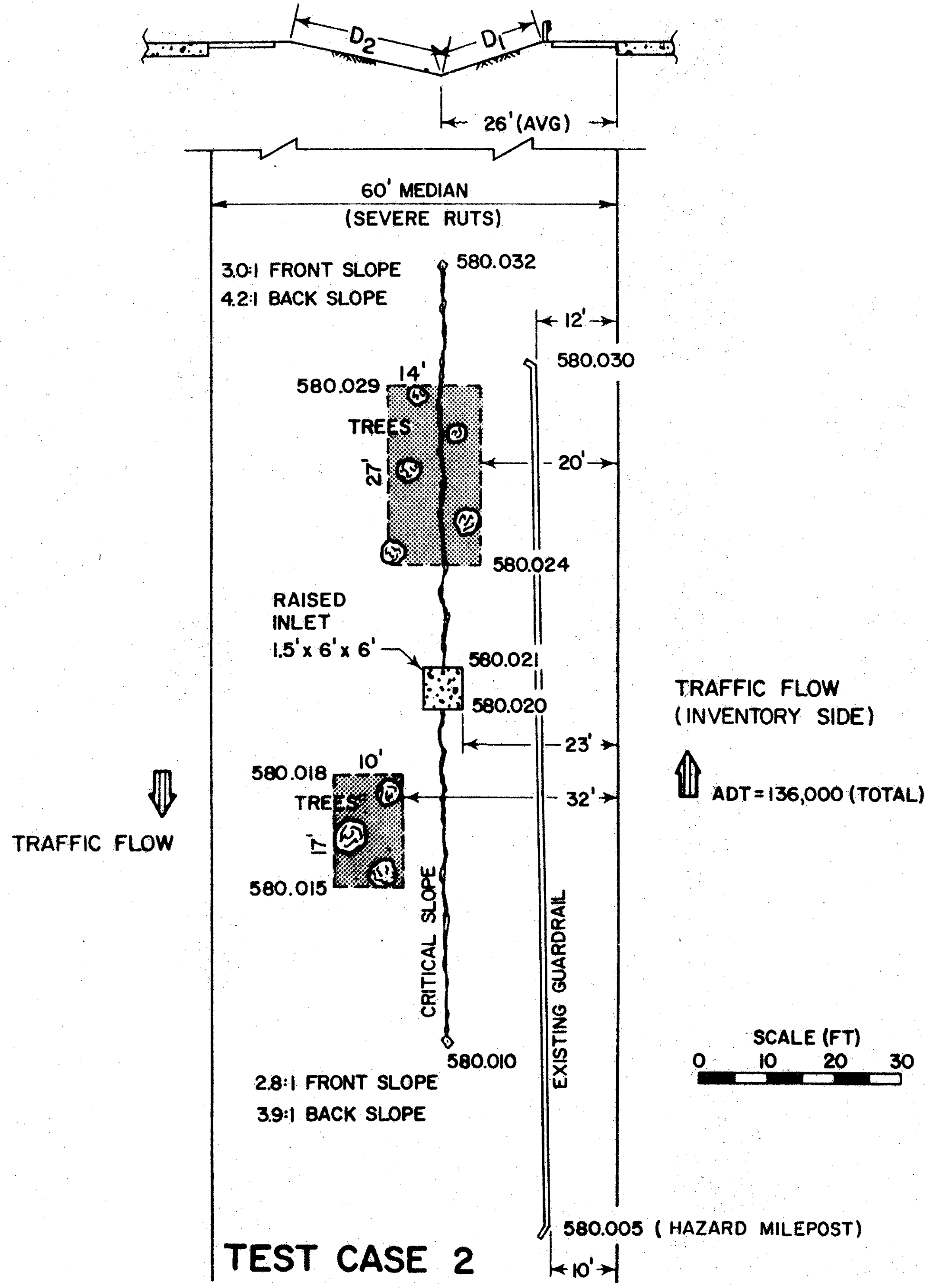
RECORDING DIRECTION = 1
ADT (1000) = 150
LIFE = 20(YRS)
INTEREST = 6.0(PERCENT)
DATE = 8-73

HAZARD										IMPROVEMENT						
HAZARD NO	IDENT CODE	DESC CODE	END TREATMENT BEG	END TREATMENT END	SEVERITY INDEX	OFFSET CODE	GROUP NO	MILE-POST BEG	MILE-POST END	IMPR ALT	IMPR CODE	SEVERITY INDEX	FIRST COST ($)	PRESENT WORTH ($)	ANNUAL COST ($/YR)	COST EFFECTIVE VALUE
100	11	1	0	0	82.5	2	0	161.002	161.008	1	1-1-0-0	0.0	225000	224999	19616	8225
100	11	1	0	0	82.5	2	0	161.002	161.008	2	1-2-0-0	3.7	3600	5372	468	271
100	11	1	0	0	82.5	2	0	161.002	161.008	3	1-3-0-0	2.6	1500	2073	180	82
100	11	1	0	0	82.5	2	0	161.002	161.008	4	1-4-0-0	1.0	5000	6350	553	242

TEST CASE 1
(bridge piers in median)

Typical Cost Effectiveness Program Output--Test Case 1

Figure V-8



Location of Hazards--Group Hazards in Median (Test Case 2)

Figure V-9

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Page ____ of ____

BOX 1

( ) Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

(✓)

Hazard Number (1–4)	Highway Number (5–7)	County Code (8–10)	Control Number (11–14)	Section No (15–16)	Recording Direction (17) 1 With Milepost 2 Against Milepost	ADT (Total Both Directions (000's)) (18–20)	Date Mo. Yr. (21–24)
0101	020	163	0123	02	1	136	0873

Hazard Description: *Guardrail*

CLASSIFICATION

(✓)

Identification Code (25–26)	Descriptor Code (27–28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (30–32) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number (33–36)
06	02	2	060	0333

LOCATION

	Beginning	(Except for Point Hazard) End
Reference Milepost	___.___	___.___
Odometer Reading at Hazard	___.___	___.___
Milepost at Hazard	580.005 (37–42)	580.030 (43–48)

BOX 2

~~POINT HAZARDS~~

( )

1 (52) | Hazard Offset, D_0 (ft) (54–55) | Width (W)(ft) (56–57) | Length (L)(ft) (58–59) | Drop Inlets Only: Height (ft) (60–62) or Depth (ft) (63–65)

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

(✓)

(52)	Hazard Offset, D_0 (ft) Beginning (53–54)	Hazard Offset, D_0 (ft) End (55–56)	Height (ft) or Depth (ft) (57–59)	Width (W)(ft) (60–61)
2	10	12	02.3	01

END TREATMENT — Guardrail Only

62: 2

1. Not Beginning at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated
3. Beginning at Structure – Full–Beam Connection
4. Beginning at Structure – Not Full Beam Connection

63: 2

1. Not Ending at Structure – Safety Treated
2. Not Ending at Structure – Not Safety Treated
3. Ending at Structure – Full–Beam Connection
4. Ending at Structure – Not Full–Beam Connection

BOX 4

~~SLOPES~~

( )

FRONT SLOPE

3 (52) | Hazard Offset, D_0 (ft) Beginning (53–54), End (55–56) | Steepness Beginning (57–58) :1, End (59–60) :1 | Distance "D_1" (ft) Beginning (61–62), End (63–64) | Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts > 1ft) | Slope Direction (66) 1. Positive 2. Negative

2nd or BACK (Except for Level Terrain) SLOPE

Steepness Beginning (67–68) :1, End (69–70) :1 | Distance "D_2" (ft) Beginning (71–72), End (73–74) | Slope Face Erosion Code (75) 1 Slight or None 2 Severe (Ruts > 1ft) | Slope Direction (76) 1 Positive 2 Negative

Recommendations: *Improvement Alternative #1 – Upgrade to Full Safety Standards*
Improvement Alternative #2 – Remove Existing Guardrail

Inventory of Hazard No. 1 in Grouping (Guardrail)--Test Case 2

Figure V-10

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

0101	020	163	0123–02	Guardrail – Upgrade
1 2 3 4 Hazard Number	5 6 7 Highway Number	8 9 10 County Code	11 12 13 14 Control Number, 15 16 Section Number	Hazard Description

000650	0200	0150	0150	0100
17 18 19 20 21 22 First Cost of Improvements ($)	23 24 25 26 Repair Cost per Collision ($) Hazard	27 28 29 30 Repair Cost per Collision ($) Improvement	31 32 33 34 Normal Maintenance ($/yr) Hazard	35 36 37 38 Normal Maintenance ($/yr) Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard [ ] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — [ ][ ] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — [ ][ ][ ] 48 49 50 Length (ft); [ ][ ] 51 52 Width (ft); [ ][ ] 53 54 Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb [ ] 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail [ ] 43
1. Rigid
2. Semi-rigid

[ ] 44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail [2] 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch [ ] 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

Right or Median Near Side — Lateral Offset (ft): [ ][ ] 45 46 Beginning – [ ][ ] 47 48 End

Median Far Side — Lateral Offset (ft): [ ][ ] 49 50 Beginning – [ ][ ] 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft): 050 (53 54 55 Beginning) – 000 (56 57 58 End)

Shorten (ft): 000 (59 60 61 Beginning) – 000 (62 63 64 End)

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40

Hazard Offset D_o (ft): [ ][ ] 42 43 Beginning – [ ][ ] 44 45 End

Steepness: [.]:1 46 47 Beginning; [.]:1 48 49 End

Distance "D_1" (ft): [ ][ ] 50 51 Beginning – [ ][ ] 52 53 End

[ ] 54 Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: [.]:1 55 56 Beginning; [.]:1 57 58 End

Distance "D_2" (ft): [ ][ ] 59 60 Beginning – [ ][ ] 61 62 End

[ ] 63 Slope Direction 1. Positive 2. Negative

Beginning [ ][ ][ ] . [ ][ ][ ] 64 65 66 67 68 69 — End [ ][ ][ ] . [ ][ ][ ] 70 71 72 73 74 75 — Hazard Milepost (Complete If Different From Inventory)

BOX 4

[4] 40 No Improvement Recommended

BOX 5

Improvement Alternative No. 1, Hazard No. 1--Test Case 2
(Upgrade Guardrail to Full Safety Standards)

Figure V-11

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

0 1 0 1 — Hazard Number (1 2 3 4)
0 2 0 — Highway Number (5 6 7)
7 6 3 — County Code (8 9 10)
0 1 2 3 — Control Number (11 12 13 14)
0 2 — Section Number (15 16)
Guardrail - Remove — Hazard Description

BOX 1

0 0 0 5 0 0 — First Cost of Improvements ($) (17 18 19 20 21 22)

Repair Cost per Collision ($): 0 2 0 0 — Hazard (23 24 25 26); 0 0 0 0 — Improvement (27 28 29 30)

Normal Maintenance ($/yr): 0 1 5 0 — Hazard (31 32 33 34); 0 0 0 0 — Improvement (35 36 37 38)

POINT HAZARD IMPROVEMENTS

1 (40) 1 (42) Alleviate Hazard — ☐ (43)
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

1 (40) 2 (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ Lateral Offset (ft) (44 45)

1 (40) 3 (42) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ Lateral Offset (ft) (46 47)

1 (40) 4 (42) Protect Hazard with Energy Attenuation System — ☐☐☐ Length (ft) (48 49 50); ☐☐ Width (ft) (51 52); ☐☐ Offset (ft) (53 54)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

2 (40) 1 (42) Curb — ☐ (43)
1. Remove and Regrade
2. Install Wedge Modification

2 (40) 2 (42) Bridgerail — ☐ (43)
1. Rigid
2. Semi-rigid

☐ (44)
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

2 (40) 3 (42) Guardrail — 1 (43)
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

2 (40) 4 (42) Ditch — ☐ (43)
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

Right or Median Near Side — Lateral Offset (ft): ☐☐ Beginning (45 46) — ☐☐ End (47 48)

Median Far Side — Lateral Offset (ft): ☐☐ Beginning (49 50) — ☐☐ End (51 52)

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft): ☐☐☐ Beginning (53 54 55) — ☐☐☐ End (56 57 58)

Shorten (ft): ☐☐☐ Beginning (59 60 61) — ☐☐☐ End (62 63 64)

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

3 (40)

Hazard Offset D_0 (ft): ☐☐ Beginning (42 43) — ☐☐ End (44 45)

Steepness: ☐.☐ :1 Beginning (46 47); ☐.☐ :1 End (48 49)

Distance "D_1" (ft): ☐☐ Beginning (50 51) — ☐☐ End (52 53)

☐ (54) Slope Direction
1. Positive
2. Negative

2nd or BACK SLOPE

Steepness: ☐.☐ :1 Beginning (55 56); ☐.☐ :1 End (57 58)

Distance "D_2" (ft): ☐☐ Beginning (59 60) — ☐☐ End (61 62)

☐ (63) Slope Direction
1. Positive
2. Negative

Beginning: ☐☐☐.☐☐☐ (64 65 66 67 68 69) End: ☐☐☐.☐☐☐ (70 71 72 73 74 75) Hazard Milepost (Complete If Different From Inventory)

BOX 4

4 (40) No Improvement Recommended

BOX 5

Improvement Alternative No. 2, Hazard No. 1--Test Case 2
(Remove Existing Guardrail)

Figure V-12

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G.D Weaver* Page ___ of ___

( ) Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

(✓) 0102 (1 2 3 4 Hazard Number) — 020 (5 6 7 Highway Number) — 163 (8 9 10 County Code) — 0123–02 (11 12 13 14 Control Number; 15 16 Section No) — 1 (17 Recording Direction: 1. With Milepost, 2. Against Milepost) — 136 (18 19 20 ADT (Total Both Directions 1000's)) — 08 73 (21 22 23 24 Date, Mo. Yr.)

Hazard Description: *Slope*

CLASSIFICATION

(✓) 07–01 (25 26 Identification Code; 27 28 Descriptor Code) — 2 (29 Offset Code: 1. Right, 2. Median) — 060 (30 31 32 Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)) — 0333 (33 34 35 36 Grouping Number)

LOCATION

	Beginning	(Except for Point Hazard) End
Reference Milepost	___.___	___.___
Odometer Reading at Hazard	___.___	___.___
Milepost at Hazard	580.010 (37 38 39 40 41 42)	580.032 (43 44 45 46 47 48)

BOX 1

~~POINT HAZARDS~~

( ) 1 (52) — Hazard Offset, D_o (ft.) (54 55) — Width (W)(ft.) (56 57) — Length (L)(ft.) (58 59) — Drop Inlets Only: Height (ft.) (60 61 62) or Depth (ft.) (63 64 65)

BOX 2

~~LONGITUDINAL HAZARDS~~ (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

( ) 2 (52) — Hazard Offset, D_o (ft): Beginning (53 54), End (55 56) — Height (ft.) or Depth (ft.) (57 58 59) — Width (W)(ft.) (60 61)

END TREATMENT — Guardrail Only

62:
1. Not Beginning at Structure – Safely Treated
2. Not Beginning at Structure – Not Safely Treated
3. Beginning at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full-Beam Connection

63:
1. Not Ending at Structure – Safely Treated
2. Not Ending at Structure – Not Safely Treated
3. Ending at Structure – Full-Beam Connection
4. Ending at Structure – Not Full-Beam Connection

BOX 3

SLOPES

FRONT SLOPE

(✓) 3 (52) — Hazard Offset, D_o (ft.): Beginning 11 (53 54), End 12 (55 56) — Steepness: Beginning 2.8:1 (57 58), End 3.0:1 (59 60) — Distance "D_1" (ft.): Beginning 16 (61 62), End 17 (63 64) — 2 (65 Slope Face Erosion Code: 1. Slight or None, 2. Severe (Ruts > 1 ft.)) — 2 (66 Slope Direction: 1. Positive, 2. Negative)

2nd or BACK (Except for Level Terrain) SLOPE

Steepness: Beginning 3.9:1 (67 68), End 4.2:1 (69 70) — Distance "D_2" (ft.): Beginning 23 (71 72), End 24 (73 74) — 2 (75 Slope Face Erosion Code: 1. Slight or None, 2. Severe (Ruts > 1 ft.)) — 1 (76 Slope Direction: 1. Positive, 2. Negative)

BOX 4

Recommendations: *Improvement Alternative #1 - Install Guardrail (Far Side of Median)*
Improvement Alternative #2 - No Improvement.

Inventory of Hazard No. 2 in Grouping (Slope)--Test Case 2

Figure V-13

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

0102 (1 2 3 4 Hazard Number) — 020 (5 6 7 Highway Number) — 163 (8 9 10 County Code) — 0123-02 (11 12 13 14 Control Number; 15 16 Section Number) — Slope - Install Guardrail (Hazard Description)

001600 (17 18 19 20 21 22 First Cost of Improvements ($))

Repair Cost per Collision ($): 0000 (23 24 25 26 Hazard) — 0100 (27 28 29 30 Improvement)

Normal Maintenance ($/yr): 0000 (31 32 33 34 Hazard) — 0100 (35 36 37 38 Improvement)

BOX 1

POINT HAZARD IMPROVEMENTS

1 (40) 1 (42) Alleviate Hazard — ☐ (43) 1. Remove 2. Make Breakaway and/or Relocate 3. Reconstruct Inlet to Safe Design 4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

1 (40) 2 (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (44 45) Lateral Offset (ft)

1 (40) 3 (42) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (46 47) Lateral Offset (ft)

1 (40) 4 (42) Protect Hazard with Energy Attenuation System — ☐☐☐ (48 49 50 Length (ft)) ☐☐ (51 52 Width (ft)) ☐☐ (53 54 Offset (ft))

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

2 (40) 1 (42) Curb — ☐ (43) 1. Remove and Regrade 2. Install Wedge Modification

2 (40) 2 (42) Bridgerail — ☐ (43) 1. Rigid 2. Semi-rigid — ☐ (44) 1. Upgrade to Full Safety Standards 2. Move Laterally (Complete Box A Below) 3. Install Guardrail Along Bridgerail Face 4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

2 (40) 3 (42) Guardrail — 5 (43) 1. Remove Existing Guardrail 2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable) 3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below) 4. Close-up Gap Between Existing Guardrail (Complete Box B Below) 5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below) 6. Anchor Existing Guardrail to Bridgerail 7. Install Guardrail at Bridge Approach (Complete Box A Below) 8. Install Guardrail Departing Bridge (Complete Box A Below) 9. Safety Treat Guardrail Free-End Only

2 (40) 4 (42) Ditch — ☐ (43) 1. Reshape to Safe Cross Section 2. Replace with Storm Drain 3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)
Right or Median Near Side — Lateral Offset (ft): 00 (45 46 Beginning) – 00 (47 48 End)
Median Far Side — Lateral Offset (ft): 52 (49 50 Beginning) – 52 (51 52 End)

BOX B (CHANGES TO EXISTING GUARDRAILS)
Lengthen (ft): ☐☐☐ (53 54 55 Beginning) – ☐☐☐ (56 57 58 End)
Shorten (ft): ☐☐☐ (59 60 61 Beginning) – ☐☐☐ (62 63 64 End)

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

3 (40) — Hazard Offset D_o (ft): ☐☐ (42 43 Beginning) – ☐☐ (44 45 End) — Steepness: ☐.☐:1 (46 47 Beginning) ☐.☐:1 (48 49 End) — Distance "D_1" (ft): ☐☐ (50 51 Beginning) – ☐☐ (52 53 End) — ☐ (54) Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: ☐.☐:1 (55 56 Beginning) ☐.☐:1 (57 58 End) — Distance "D_2" (ft): ☐☐ (59 60 Beginning) – ☐☐ (61 62 End) — ☐ (63) Slope Direction 1. Positive 2. Negative

Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) — End ☐☐☐.☐☐☐ (70 71 72 73 74 75) — Hazard Milepost (Complete If Different From Inventory)

BOX 4

4 (40) No Improvement Recommended

BOX 5

Improvement Alternative No. 1, Hazard No. 2--Test Case 2
(Install Guardrail to Protect Slope)

Figure V-14

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box if Columns 5 Thru 16 Are To Be Duplicated From Previous Form

BOX 1

0 1 0 2	0 2 0	1 6 3	0 1 2 3 — 0 2	*Slope - No Improvement*
1 2 3 4 Hazard Number	5 6 7 Highway Number	8 9 10 County Code	11 12 13 14 Control Number — 15 16 Section Number	Hazard Description

0 0 0 0 0 0	0 0 0 0	0 0 0 0	0 1 0 0	0 1 0 0
17 18 19 20 21 22 First Cost of Improvements ($)	Repair Cost per Collision ($): 23 24 25 26 Hazard	Repair Cost per Collision ($): 27 28 29 30 Improvement	Normal Maintenance ($/yr): 31 32 33 34 Hazard	Normal Maintenance ($/yr): 35 36 37 38 Improvement

BOX 2

POINT HAZARD IMPROVEMENTS

1 (40) 1 (42) Alleviate Hazard — ☐ (43)
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

1 (40) 2 (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (44 45) Lateral Offset (ft)

1 (40) 3 (42) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (46 47) Lateral Offset (ft)

1 (40) 4 (42) Protect Hazard with Energy Attenuation System — ☐☐☐ (48 49 50) Length (ft); ☐☐ (51 52) Width (ft); ☐☐ (53 54) Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

2 (40) 1 (42) Curb — ☐ (43)
1. Remove and Regrade
2. Install Wedge Modification

2 (40) 2 (42) Bridgerail — ☐ (43)
1. Rigid
2. Semi-rigid

☐ (44)
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

2 (40) 3 (42) Guardrail — ☐ (43)
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge — May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

2 (40) 4 (42) Ditch — ☐ (43)
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)
- Right or Median Near Side — Lateral Offset (ft): ☐☐ (45 46) Beginning — ☐☐ (47 48) End
- Median Far Side — Lateral Offset (ft): ☐☐ (49 50) Beginning — ☐☐ (51 52) End

BOX B (CHANGES TO EXISTING GUARDRAILS)
- Lengthen (ft): ☐☐☐ (53 54 55) Beginning — ☐☐☐ (56 57 58) End
- Shorten (ft): ☐☐☐ (59 60 61) Beginning — ☐☐☐ (62 63 64) End

BOX 4

SLOPE IMPROVEMENTS

FRONT SLOPE

3 (40) — Hazard Offset D_0 (ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End; Steepness: ☐.☐ :1 (46 47) Beginning, ☐.☐ :1 (48 49) End; Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End; ☐ (54) Slope Direction: 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: ☐.☐ :1 (55 56) Beginning, ☐.☐ :1 (57 58) End; Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End; ☐ (63) Slope Direction: 1. Positive 2. Negative

Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) — End ☐☐☐.☐☐☐ (70 71 72 73 74 75) — Hazard Milepost (Complete If Different From Inventory)

BOX 5

4 (40) No Improvement Recommended

Improvement Alternative No. 2, Hazard No. 2--Test Case 2
(No Improvement Recommended)

Figure V-15

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Page ___ of ___

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

Hazard Number (1–4)	Highway Number (5–7)	County Code (8–10)	Control Number (11–14)	Section No. (15–16)	Recording Direction (17) 1. With Milepost 2. Against Milepost	ADT (Total Both Directions 1000's) (18–20)	Date Mo. Yr. (21–24)
0103	020	163	0123	02	1	136	0873

Hazard Description: *Trees*

BOX 1

CLASSIFICATION

Identification Code (25–26)	Descriptor Code (27–28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only) (30–32)	Grouping Number (33–36)
02	00	2	060	0333

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard (37–42 / 43–48)	580.015	

BOX 2

POINT HAZARDS

52	Hazard Offset, D_o (ft) (54–55)	Width (W)(ft) (56–57)	Length (L)(ft) (58–59)	Drop Inlets Only: Height (ft.) (60–62) or	Drop Inlets Only: Depth (ft.) (63–65)
1	32	10	17	000	000

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

52: 2

Hazard Offset, D_o (ft.): Beginning (53–54), End (55–56); Height (ft.) or Depth (ft.) (57–59); Width (W)(ft.) (60–61)

END TREATMENT Guardrail Only

62:
1. Not Beginning of Structure – Safety Treated
2. Not Beginning of Structure – Not Safety Treated
3. Beginning of Structure – Full-Beam Connection
4. Beginning of Structure – Not Full-Beam Connection

63:
1. Not Ending of Structure – Safety Treated
2. Not Ending of Structure – Not Safety Treated
3. Ending of Structure – Full-Beam Connection
4. Ending of Structure – Not Full-Beam Connection

BOX 4

SLOPES

FRONT SLOPE

52: 3

Hazard Offset, D_o (ft): Beginning (53–54), End (55–56); Steepness: Beginning (57–58) :1, End (59–60) :1; Distance "D_1" (ft.): Beginning (61–62), End (63–64); Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts > 1 ft.); Slope Direction (66) 1. Positive 2. Negative

2nd or BACK SLOPE (Except for Level Terrain)

Steepness: Beginning (67–68) :1, End (69–70) :1; Distance "D_2" (ft): Beginning (71–72), End (73–74); Slope Face Erosion Code (75) 1. Slight or None 2. Severe (Ruts > 1 ft.); Slope Direction (76) 1. Positive 2. Negative

Recommendations: *Improvement Alternative #1 - No Improvement*
Improvement Alternative #2 - Remove Trees

Inventory of Hazard No. 3 in Grouping (Trees)--Test Case 2

Figure V-16

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box if Columns 5 Thru 16 Are To Be Duplicated From Previous Form

0103 (1 2 3 4 Hazard Number) 020 (5 6 7 Highway Number) 163 (8 9 10 County Code) 0123 (11 12 13 14 Control Number) 02 (15 16 Section Number) Trees - No Improvement (Hazard Description)

000000 (17 18 19 20 21 22 First Cost of Improvements ($))

Repair Cost per Collision ($): 0000 (23 24 25 26 Hazard) 0000 (27 28 29 30 Improvement)

Normal Maintenance ($/yr): 0050 (31 32 33 34 Hazard) 0050 (35 36 37 38 Improvement)

BOX 1

POINT HAZARD IMPROVEMENTS

1 (40) 1 (42) Alleviate Hazard — [ ] (43) 1. Remove 2. Make Breakaway and/or Relocate 3. Reconstruct Inlet to Safe Design 4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

1 (40) 2 (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — Lateral Offset (ft) (44 45)

1 (40) 3 (42) Protect Hazard with Concrete Median Barrier (CMB) — Lateral Offset (ft) (46 47)

1 (40) 4 (42) Protect Hazard with Energy Attenuation System — Length (ft) (48 49 50); Width (ft) (51 52); Offset (ft) (53 54)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

2 (40) 1 (42) Curb — [ ] (43) 1. Remove and Regrade 2. Install Wedge Modification

2 (40) 2 (42) Bridgerail — [ ] (43) 1. Rigid 2. Semi-rigid — [ ] (44) 1. Upgrade to Full Safety Standards 2. Move Laterally (Complete Box A Below) 3. Install Guardrail Along Bridgerail Face 4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

2 (40) 3 (42) Guardrail — [ ] (43)
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

2 (40) 4 (42) Ditch — [ ] (43) 1. Reshape to Safe Cross Section 2. Replace with Storm Drain 3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)
Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning; 47 48 End
Median Far Side — Lateral Offset (ft): 49 50 Beginning; 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)
Lengthen (ft): 53 54 55 Beginning; 56 57 58 End
Shorten (ft): 59 60 61 Beginning; 62 63 64 End

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

3 (40) — Hazard Offset D_o (ft): 42 43 Beginning; 44 45 End — Steepness: [.]:1 46 47 Beginning; [.]:1 48 49 End — Distance "D_1" (ft): 50 51 Beginning; 52 53 End — [ ] (54) Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: [.]:1 55 56 Beginning; [.]:1 57 58 End — Distance "D_2" (ft): 59 60 Beginning; 61 62 End — [ ] (63) Slope Direction 1. Positive 2. Negative

Hazard Milepost (Complete if Different From Inventory): Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 4

4 (40) No Improvement Recommended

BOX 5

Improvement Alternative No. 1, Hazard No. 3--Test Case 2
(No Improvement Recommended)

Figure V-17

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

Hazard Number	1 2 3 4	0 1 0 3
Highway Number	5 6 7	0 2 0
County Code	8 9 10	1 6 3
Control Number	11 12 13 14	0 1 2 3
Section Number	15 16	0 2
Hazard Description		Trees- Remove
First Cost of Improvements ($)	17 18 19 20 21 22	0 0 0 1 7 5
Repair Cost per Collision ($) — Hazard	23 24 25 26	0 0 0 0
Repair Cost per Collision ($) — Improvement	27 28 29 30	0 0 0 0
Normal Maintenance ($/yr) — Hazard	31 32 33 34	0 0 5 0
Normal Maintenance ($/yr) — Improvement	35 36 37 38	0 0 0 0

BOX 1

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard — [1] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — [ ][ ] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — [ ][ ][ ] 48 49 50 Length (ft) — [ ][ ] 51 52 Width (ft) — [ ][ ] 53 54 Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb — [ ] 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — [ ] 43
1. Rigid
2. Semi-rigid

[ ] 44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail — [ ] 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge--May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — [ ] 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL) — Right or Median Near Side: Lateral Offset (ft) 45 46 Beginning, 47 48 End; Median Far Side: Lateral Offset (ft) 49 50 Beginning, 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS) — Lengthen (ft): 53 54 55 Beginning, 56 57 58 End; Shorten (ft): 59 60 61 Beginning, 62 63 64 End

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40 — Hazard Offset D_o (ft): 42 43 Beginning, 44 45 End — Steepness: [.]:1 46 47 Beginning, [.]:1 48 49 End — Distance "D_1" (ft): 50 51 Beginning, 52 53 End — [ ] 54 Slope Direction: 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: [.]:1 55 56 Beginning, [.]:1 57 58 End — Distance "D_2" (ft): 59 60 Beginning, 61 62 End — [ ] 63 Slope Direction: 1. Positive 2. Negative

Hazard Milepost (Complete if Different From Inventory): Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 4

[4] 40 No Improvement Recommended

BOX 5

Improvement Alternative No. 2, Hazard No. 3--Test Case 2
(Remove Trees)

Figure V-18

Form A (Aug. '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G.D Weaver* Page ____ of ____

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

(✓)

0104	020	163	0123-02	1	136	0873
1 2 3 4 Hazard Number	5 6 7 Highway Number	8 9 10 County Code	11 12 13 14 Control Number / 15 16 Section No.	17 Recording Direction 1. With Milepost 2. Against Milepost	18 19 20 ADT (Total Both Directions 1000's)	Mo. Yr. 21 22 23 24 Date

Hazard Description: *Raised Drop Inlet*

BOX 1

CLASSIFICATION

(✓)

10-01	2	060	0333
25 26 Identification Code / 27 28 Descriptor Code	29 Offset Code 1. Right 2. Median	30 31 32 Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)	33 34 35 36 Grouping Number

LOCATION

	Beginning	(Except for Point Hazard) End
Reference Milepost	___.___	___.___
Odometer Reading at Hazard	___.___	___.___
Milepost at Hazard	580020 (37 38 39 40 41 42)	(43 44 45 46 47 48)

BOX 2

POINT HAZARDS

(✓)

1	23	06	06	015	000
52	54 55 Hazard Offset, D_o(ft.)	56 57 Width (W)(ft.)	58 59 Length (L)(ft.)	Drop Inlets Only: 60 61 62 Height (ft.) or	63 64 65 Depth (ft.)

BOX 3

~~LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)~~

○ 2 (52)

Hazard Offset, D_o(ft.): 53 54 Beginning; 55 56 End

57 58 59 Height (ft.) or Depth (ft.)

60 61 Width (W)(ft.)

END TREATMENT — Guardrail Only

62:
1. Not Beginning at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated
3. Beginning at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full-Beam Connection

63:
1. Not Ending at Structure – Safety Treated
2. Not Ending at Structure – Not Safety Treated
3. Ending at Structure – Full-Beam Connection
4. Ending at Structure – Not Full-Beam Connection

BOX 4

~~SLOPES~~

FRONT SLOPE

○ 3 (52)

Hazard Offset, D_o(ft.): 53 54 Beginning; 55 56 End

Steepness: 57 58 Beginning __.__ :1; 59 60 End __.__ :1

Distance "D_1" (ft.): 61 62 Beginning; 63 64 End

65 Slope Face Erosion Code
1. Slight or None
2. Severe (Ruts > 1 ft.)

66 Slope Direction
1. Positive
2. Negative

2nd or BACK (Except for Level Terrain) SLOPE

Steepness: 67 68 Beginning __.__ :1; 69 70 End __.__ :1

Distance "D_2" (ft.): 71 72 Beginning; 73 74 End

75 Slope Face Erosion Code
1. Slight or None
2. Severe (Ruts > 1 ft.)

76 Slope Direction
1. Positive
2. Negative

Recommendations: ~~*Improvement Alternative #1- No Improvement*~~
~~*Improvement Alternative #2- Reconstruct Inlet to Safe Design.*~~

Inventory of Hazard No. 4 in Grouping (Raised Drop Inlet)--Test Case 2

Figure V-19

Form B (AUG '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

BOX 1

Hazard Number (1 2 3 4)	Highway Number (5 6 7)	County Code (8 9 10)	Control Number (11 12 13 14)	Section Number (15 16)	Hazard Description
0 1 0 4	0 2 0	1 6 3	0 1 2 3	0 2	Inlet - No Improvement

First Cost of Improvements ($) (17 18 19 20 21 22)	Repair Cost per Collision ($) Hazard (23 24 25 26)	Repair Cost per Collision ($) Improvement (27 28 29 30)	Normal Maintenance ($/yr) Hazard (31 32 33 34)	Normal Maintenance ($/yr) Improvement (35 36 37 38)
0 0 0 0 0 0	0 0 0 0	0 0 0 0	0 0 5 0	0 0 5 0

BOX 2

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard — [ ] 43: 1. Remove 2. Make Breakaway and/or Relocate 3. Reconstruct Inlet to Safe Design 4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grate, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — Lateral Offset (ft) 44 45

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — Lateral Offset (ft) 46 47

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — 48 49 50 Length (ft); 51 52 Width (ft); 53 54 Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb — [ ] 43: 1. Remove and Regrade 2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — [ ] 43: 1. Rigid 2. Semi-rigid — [ ] 44: 1. Upgrade to Full Safety Standards 2. Move Laterally (Complete Box A Below) 3. Install Guardrail Along Bridgerail Face 4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail — [ ] 43: 1. Remove Existing Guardrail 2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable) 3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below) 4. Close-up Gap Between Existing Guardrail (Complete Box B Below) 5. Install Guardrail to Protect Slope Near Bridge -- May Include Point Hazards (Complete Box A Below) 6. Anchor Existing Guardrail to Bridgerail 7. Install Guardrail at Bridge Approach (Complete Box A Below) 8. Install Guardrail Departing Bridge (Complete Box A Below) 9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — [ ] 43: 1. Reshape to Safe Cross Section 2. Replace with Storm Drain 3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL) — Right or Median Near Side: Lateral Offset (ft) 45 46 Beginning, 47 48 End; Median Far Side: Lateral Offset (ft) 49 50 Beginning, 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS) — Lengthen (ft) 53 54 55 Beginning, 56 57 58 End; Shorten (ft) 59 60 61 Beginning, 62 63 64 End

BOX 4

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40 — Hazard Offset O_h (ft) 42 43 Beginning, 44 45 End; Steepness [.]:1 46 47 Beginning, [.]:1 48 49 End; Distance "D_1" (ft) 50 51 Beginning, 52 53 End; Slope Direction [ ] 54: 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness [.]:1 55 56 Beginning, [.]:1 57 58 End; Distance "D_2" (ft) 59 60 Beginning, 61 62 End; Slope Direction [ ] 63: 1. Positive 2. Negative

Hazard Milepost (Complete If Different From Inventory) — Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 5

[4] 40 **No Improvement Recommended**

Improvement Alternative No. 1, Hazard No. 4--Test Case 2 (No Improvement Recommended)

Figure V-20

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

Hazard Number (1-4)	Highway Number (5-7)	County Code (8-10)	Control Number (11-14)	Section Number (15-16)	Hazard Description
0104	020	163	0123	02	Inlet-Reconstruct

First Cost of Improvements ($) (17-22)	Repair Cost per Collision ($) Hazard (23-26)	Repair Cost per Collision ($) Improvement (27-30)	Normal Maintenance ($/yr) Hazard (31-34)	Normal Maintenance ($/yr) Improvement (35-38)
002000	0000	0000	0050	0050

BOX 1

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard [3] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — Lateral Offset (ft) 44 45

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — Lateral Offset (ft) 46 47

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — Length (ft) 48 49 50; Width (ft) 51 52; Offset (ft) 53 54

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb — 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — 43
1. Rigid
2. Semi-rigid

44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail — 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge--May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)
Right or Median Near Side — Lateral Offset (ft): Beginning 45 46, End 47 48
Median Far Side — Lateral Offset (ft): Beginning 49 50, End 51 52

BOX B (CHANGES TO EXISTING GUARDRAILS)
Lengthen (ft): Beginning 53 54 55, End 56 57 58
Shorten (ft): Beginning 59 60 61, End 62 63 64

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40 — Hazard Offset D_h (ft): Beginning 42 43, End 44 45; Steepness: Beginning 46 47 :1, End 48 49 :1; Distance "D_1" (ft): Beginning 50 51, End 52 53; Slope Direction 54 (1. Positive 2. Negative)

2nd or BACK SLOPE

Steepness: Beginning 55 56 :1, End 57 58 :1; Distance "D_2" (ft): Beginning 59 60, End 61 62; Slope Direction 63 (1. Positive 2. Negative)

Hazard Milepost (Complete If Different From Inventory): Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 4

[4] 40 No Improvement Recommended

BOX 5

Improvement Alternative No. 2, Hazard No. 4--Test Case 2
(Reconstruct Inlet to Safe Design)

Figure V-21

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by G.D. Weaver Page ___ of ___

Check Box If Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

(✓)

0105 (1 2 3 4 Hazard Number) 020 (5 6 7 Highway Number) 163 (8 9 10 County Code) 0123-02 (11 12 13 14 Control Number; 15 16 Section No) 1 (17 Recording Direction 1. With Milepost 2 Against Milepost) 136 (18 19 20 ADT (Total Both Directions 1000's)) 0873 (21 22 23 24 Date Mo. Yr.)

Hazard Description: Trees

BOX 1

CLASSIFICATION

(✓)

02-00 (25 26 Identification Code; 27 28 Descriptor Code) 2 (29 Offset Code 1. Right 2. Median) 060 (30 31 32 Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)) 0333 (33 34 35 36 Grouping Number)

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard	580.024 (37 38 39 40 41 42)	(43 44 45 46 47 48)

POINT HAZARDS

BOX 2

(✓)

1 (52) 20 (54 55 Hazard Offset, D_o (ft)) 14 (56 57 Width (W)(ft)) 27 (58 59 Length (L)(ft))

Drop Inlets Only: 00.0 (60 61 62 Height (ft.)) or 00.0 (63 64 65 Depth (ft.))

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 3

2 (52) Hazard Offset, D_o (ft): ☐☐ (53 54 Beginning) ☐☐ (55 56 End) ☐☐.☐ (57 58 59 Height (ft.) or Depth (ft.)) ☐☐ (60 61 Width (W)(ft.))

END TREATMENT — Guardrail Only

☐ (62)
1. Not Beginning at Structure - Safety Treated
2. Not Beginning at Structure - Not Safety Treated
3. Beginning at Structure - Full-Beam Connection
4. Beginning at Structure - Not Full-Beam Connection

☐ (63)
1. Not Ending at Structure - Safety Treated
2. Not Ending at Structure - Not Safety Treated
3. Ending at Structure - Full-Beam Connection
4. Ending at Structure - Not Full-Beam Connection

SLOPES

BOX 4

FRONT SLOPE

3 (52) Hazard Offset, D_o (ft.): ☐☐ (53 54 Beginning) ☐☐ (55 56 End)

Steepness: ☐.☐ :1 (57 58 Beginning) ☐.☐ :1 (59 60 End)

Distance "D_1" (ft.): ☐☐ (61 62 Beginning) ☐☐ (63 64 End)

☐ (65 Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts>1ft.))

☐ (66 Slope Direction 1. Positive 2. Negative)

2nd or BACK (Except for Level Terrain) SLOPE

Steepness: ☐.☐ :1 (67 68 Beginning) ☐.☐ :1 (69 70 End)

Distance "D_2" (ft.): ☐☐ (71 72 Beginning) ☐☐ (73 74 End)

☐ (75 Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts>1ft))

☐ (76 Slope Direction 1 Positive 2 Negative)

Recommendations: Improvement Alternative #1 - No Improvement
Improvement Alternative #2 - Remove Trees

Inventory of Hazard No. 5 in Grouping (Trees)--Test Case 2

Figure V-22

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

BOX 1

Hazard Number	1 2 3 4	0 1 0 5
Highway Number	5 6 7	0 2 0
County Code	8 9 10	1 6 3
Control Number	11 12 13 14	0 1 2 3
Section Number	15 16	0 2
Hazard Description		Trees – No Improvement
First Cost of Improvements ($)	17 18 19 20 21 22	0 0 0 0 0 0
Repair Cost per Collision ($) – Hazard	23 24 25 26	0 0 0 0
Repair Cost per Collision ($) – Improvement	27 28 29 30	0 0 0 0
Normal Maintenance ($/yr) – Hazard	31 32 33 34	0 0 5 0
Normal Maintenance ($/yr) – Improvement	35 36 37 38	0 0 5 0

BOX 2

POINT HAZARD IMPROVEMENTS

[1] (40) [1] (42) Alleviate Hazard — [ ] (43)
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] (40) [2] (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — Lateral Offset (ft) (44 45)

[1] (40) [3] (42) Protect Hazard with Concrete Median Barrier (CMB) — Lateral Offset (ft) (46 47)

[1] (40) [4] (42) Protect Hazard with Energy Attenuation System — Length (ft) (48 49 50); Width (ft) (51 52); Offset (ft) (53 54)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

[2] (40) [1] (42) Curb — [ ] (43)
1. Remove and Regrade
2. Install Wedge Modification

[2] (40) [2] (42) Bridgerail — [ ] (43) 1. Rigid 2. Semi-rigid — [ ] (44)
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] (40) [3] (42) Guardrail — [ ] (43)
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] (40) [4] (42) Ditch — [ ] (43)
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL) — Right or Median Near Side: Lateral Offset (ft) Beginning (45 46), End (47 48); Median Far Side: Lateral Offset (ft) Beginning (49 50), End (51 52)

BOX B (CHANGES TO EXISTING GUARDRAILS) — Lengthen (ft) Beginning (53 54 55), End (56 57 58); Shorten (ft) Beginning (59 60 61), End (62 63 64)

BOX 4

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] (40) — Hazard Offset D_0 (ft) Beginning (42 43), End (44 45); Steepness Beginning (46 47) :1, End (48 49) :1; Distance "D_1" (ft) Beginning (50 51), End (52 53); Slope Direction (54) 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness Beginning (55 56) :1, End (57 58) :1; Distance "D_2" (ft) Beginning (59 60), End (61 62); Slope Direction (63) 1. Positive 2. Negative

Beginning (64 65 66 67 68 69) End (70 71 72 73 74 75) Hazard Milepost (Complete If Different From Inventory)

BOX 5

[4] (40) No Improvement Recommended

Improvement Alternative No. 1, Hazard No. 5--Test Case 2
(No Improvement Recommended)

Figure V-23

Form B (AUG '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

0105	020	763	0123-02	Trees - Remove
1 2 3 4 Hazard Number	5 6 7 Highway Number	8 9 10 County Code	11 12 13 14 Control Number; 15 16 Section Number	Hazard Description

002250	0000	0000	0050	0000
17 18 19 20 21 22 First Cost of Improvements ($)	23 24 25 26 Repair Cost per Collision ($) Hazard	27 28 29 30 Repair Cost per Collision ($) Improvement	31 32 33 34 Normal Maintenance ($/yr) Hazard	35 36 37 38 Normal Maintenance ($/yr) Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

[1] (40) [1] (42) Alleviate Hazard [1] (43)
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] (40) [2] (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — Lateral Offset (ft) (44 45)

[1] (40) [3] (42) Protect Hazard with Concrete Median Barrier (CMB) — Lateral Offset (ft) (46 47)

[1] (40) [4] (42) Protect Hazard with Energy Attenuation System — Length (ft) (48 49 50); Width (ft) (51 52); Offset (ft) (53 54)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

[2] (40) [1] (42) Curb — (43)
1. Remove and Regrade
2. Install Wedge Modification

[2] (40) [2] (42) Bridgerail — (43)
1. Rigid
2. Semi-rigid

(44)
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] (40) [3] (42) Guardrail — (43)
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] (40) [4] (42) Ditch — (43)
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)
Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning; 47 48 End
Median Far Side — Lateral Offset (ft): 49 50 Beginning; 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)
Lengthen (ft): 53 54 55 Beginning; 56 57 58 End
Shorten (ft): 59 60 61 Beginning; 62 63 64 End

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] (40) Hazard Offset D_1 (ft): 42 43 Beginning; 44 45 End — Steepness: 46 47 Beginning :1; 48 49 End :1 — Distance "D_2" (ft): 50 51 Beginning; 52 53 End — Slope Direction (54): 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: 55 56 Beginning :1; 57 58 End :1 — Distance "D_2" (ft): 59 60 Beginning; 61 62 End — Slope Direction (63): 1. Positive 2. Negative

Hazard Milepost (Complete If Different From Inventory): Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 4

[4] (40) No Improvement Recommended

BOX 5

Improvement Alternative No. 2, Hazard No. 5--Test Case 2
(Remove Trees)

Figure V-24

C O S T   E F F E C T I V E N E S S   P R O G R A M

HIGHWAY NO = 20
COUNTY NO = 163
DISTRICT NO = 15
CONTROL NO = 123
SECTION NO = 2

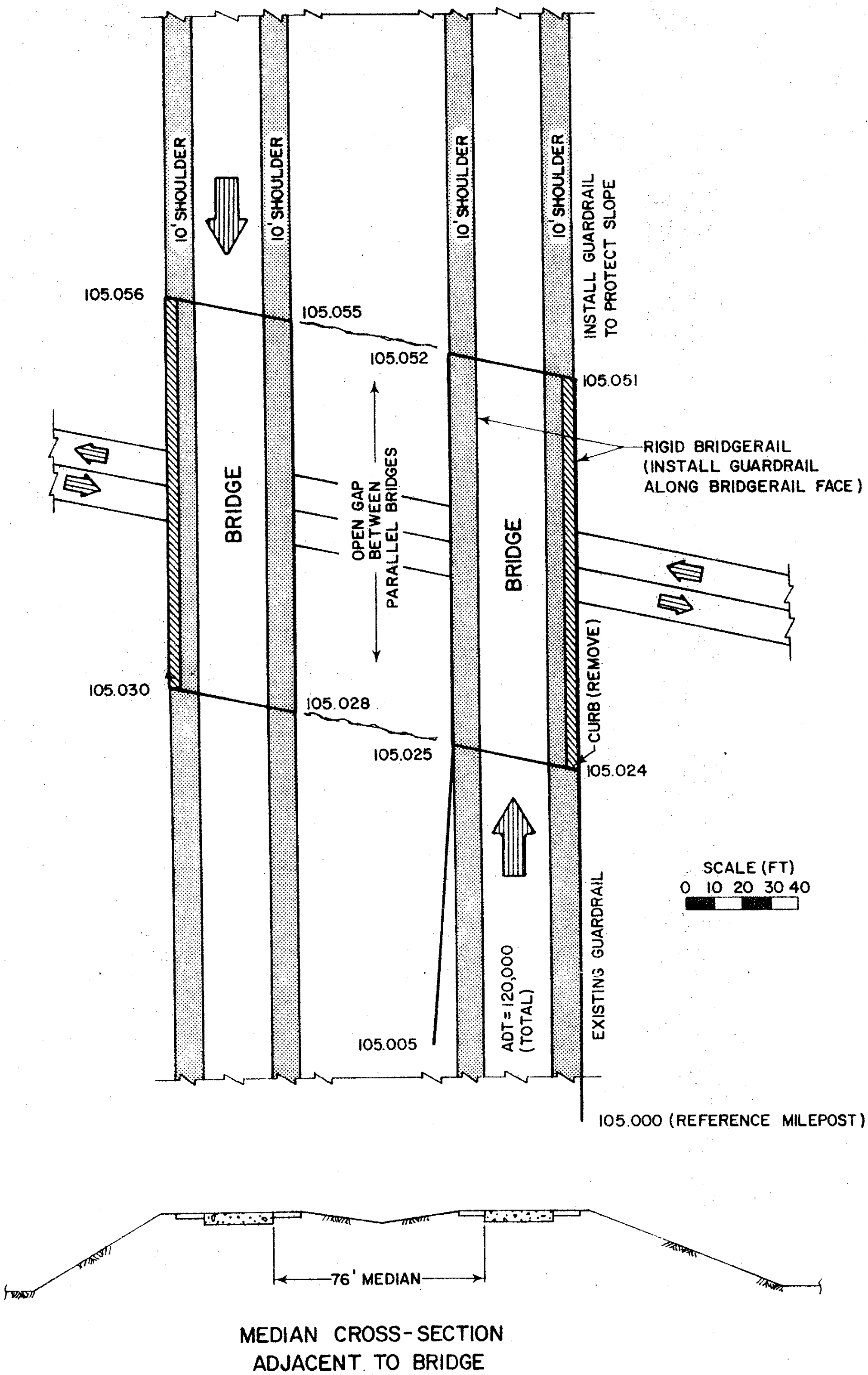
RECORDING DIRECTION = 1
ADT (1000) = 136
LIFE = 20(YRS)
INTEREST = 6.0(PERCENT)
DATE = 8-73

H A Z A R D										I M P R O V E M E N T							
HAZARD NO	IDENT CODE	DESC CODE	END TREATMENT BEG	END TREATMENT END	SEVERITY INDEX	OFFSET CODE	GROUP NO	MILE-POST BEG	MILE-POST END	IMPR ALT	IMPR CODE	SEVERITY INDEX	FIRST COST ($)	PRESENT WORTH ($)	ANNUAL COST ($/YR)	COST EFFECTIVE VALUE
101	6	2	2	2	17.3	2	333	580.005	580.030	1	2-3-2-0	3.7	650	56	4	GROUP
105	2	0	0	0	50.0	2	333	580.024	580.029	1	4-0-0-0	50.0	0	56	4	GROUP
104	10	1	0	0	82.5	2	333	580.020	580.021	1	4-0-0-0	82.5	0	56	4	GROUP
102	7	1	0	0	8.0	2	333	580.010	580.032	1	2-3-5-0	3.7	1600	2803	244	GROUP
103	2	0	0	0	50.0	2	333	580.015	580.018	1	4-0-0-0	50.0	0	2803	244	73
101	6	2	2	2	17.3	2	333	580.005	580.030	2	2-3-1-0	0.0	500	-1375	-119	GROUP
105	2	0	0	0	50.0	2	333	580.024	580.029	2	1-1-0-0	0.0	250	-1125	-98	GROUP
104	10	1	0	0	82.5	2	333	580.020	580.021	2	1-1-0-0	0.0	2000	874	76	GROUP
102	7	1	0	0	8.0	2	333	580.010	580.032	2	4-0-0-0	8.0	0	874	76	GROUP
103	2	0	0	0	50.0	2	333	580.015	580.018	2	1-1-0-0	0.0	175	1049	91	31

TEST CASE 2
(group hazards in median)

Typical Cost-Effectiveness Program Output--Test Case 2

Figure V-25



TEST CASE 3

Location of Hazards--Group Hazards at Bridge (Test Case 3)

Figure V-26

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by G.D. Weaver Page ___ of ___

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

Hazard Number (1-4)	Highway Number (5-7)	County Code (8-10)	Control Number (11-14)	Section No (15-16)	Recording Direction (17) 1. With Milepost 2. Against Milepost	ADT (Total Both Directions 1000's) (18-20)	Date Mo. Yr. (21-24)
0250	035	097	2561	08	1	120	1273

Hazard Description: Guardrail

BOX 1

CLASSIFICATION

Identification Code (25-26)	Descriptor Code (27-28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (30-32) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number (33-36)
06	02	1	000	0111

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard	105.000 (37-42)	105.024 (43-48)

BOX 2

POINT HAZARDS

1 (52) Hazard Offset, D_o (ft) (54-55); Width (W)(ft.) (56-57); Length (L)(ft.) (58-59); Drop Inlets Only: Height (ft.) (60-62) or Depth (ft.) (63-65)

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

52	Hazard Offset, D_o (ft.) Beginning (53-54)	End (55-56)	Height (ft.) or Depth (ft.) (57-59)	Width (W)(ft.) (60-61)	End Treatment, Guardrail Only (62)	(63)
2	11	10	02.3	01	1	4

END TREATMENT — Guardrail Only

62:
1. Not Beginning at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated
3. Beginning at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full-Beam Connection

63:
1. Not Ending at Structure – Safety Treated
2. Not Ending at Structure – Not Safety Treated
3. Ending at Structure – Full-Beam Connection
4. Ending at Structure – Not Full-Beam Connection

BOX 4

SLOPES

FRONT SLOPE

3 (52) Hazard Offset, D_o (ft.) Beginning (53-54), End (55-56); Steepness Beginning (57-58) :1, End (59-60) :1; Distance "D_1" (ft.) Beginning (61-62), End (63-64); Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts > 1 ft.); Slope Direction (66) 1. Positive 2. Negative

2nd or BACK (Except for Level Terrain) SLOPE

Steepness Beginning (67-68) :1, End (69-70) :1; Distance "D_2" (ft.) Beginning (71-72), End (73-74); Slope Face Erosion Code (75) 1. Slight or None 2. Severe (Ruts > 1 ft.); Slope Direction (76) 1. Positive 2. Negative

Recommendations: Improvement Alternative #1 — Anchor Existing Guardrail to Bridgerail. (Only) (No other improvements to guardrail)

Inventory of Hazard No. 1 in Grouping (Guardrail)--Test Case 3

Figure V-27

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form ✓

BOX 1

Hazard Number (1–4)	Highway Number (5–7)	County Code (8–10)	Control Number (11–14)	Section Number (15–16)	Hazard Description
0250	035	097	2561	08	Guardrail - Anchor

First Cost of Improvements ($) (17–22)	Repair Cost per Collision ($) Hazard (23–26)	Repair Cost per Collision ($) Improvement (27–30)	Normal Maintenance ($/yr) Hazard (31–34)	Normal Maintenance ($/yr) Improvement (35–38)
000325	0350	0225	0150	0075

BOX 2 (crossed out)

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard — [ ] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — [ ][ ] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — [ ][ ][ ] 48 49 50 Length (ft); [ ][ ] 51 52 Width (ft); [ ][ ] 53 54 Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb — [ ] 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — [ ] 43
1. Rigid
2. Semi-rigid

[ ] 44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

✓ [2] 40 [3] 42 Guardrail — [6] 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — [ ] 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

Right or Median Near Side — Lateral Offset (ft): [ ][ ]–[ ][ ] 45 46 Beginning, 47 48 End
Median Far Side — Lateral Offset (ft): [ ][ ]–[ ][ ] 49 50 Beginning, 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft): [ ][ ][ ]–[ ][ ][ ] 53 54 55 Beginning, 56 57 58 End
Shorten (ft): [ ][ ][ ]–[ ][ ][ ] 59 60 61 Beginning, 62 63 64 End

BOX 4 (crossed out)

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40 — Hazard Offset D_h (ft): [ ][ ]–[ ][ ] 42 43 Beginning, 44 45 End; Steepness: [.]:1 46 47 Beginning, [.]:1 48 49 End; Distance "D_1" (ft): [ ][ ]–[ ][ ] 50 51 Beginning, 52 53 End; [ ] 54 Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: [.]:1 55 56 Beginning, [.]:1 57 58 End; Distance "D_2" (ft): [ ][ ]–[ ][ ] 59 60 Beginning, 61 62 End; [ ] 63 Slope Direction 1. Positive 2. Negative

Hazard Milepost (Complete If Different From Inventory): Beginning [ ][ ][.][ ][ ][ ] 64 65 66 67 68 69; End [ ][ ][.][ ][ ][ ] 70 71 72 73 74 75

BOX 5 (crossed out)

[4] 40 No Improvement Recommended

Improvement Alternative No. 1, Hazard No. 1--Test Case 3
(Anchor Guardrail to Bridge)

Figure V-28

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G.D Weaver* Page ____ of ____

BOX 1

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

Hazard Number (1–4)	Highway Number (5–7)	County Code (8–10)	Control Number (11–14)	Section No (15–16)	Recording Direction (17) 1. With Milepost 2. Against Milepost	ADT (Total Both Directions 1000's) (18–20)	Date Mo. Yr. (21–24)
0251	035	097	2561	08	1	120	1273

Hazard Description: *Sidewalk Curb*

CLASSIFICATION

Identification Code (25–26)	Descriptor Code (27–28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (30–32) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number (33–36)
05	03	1	000	0111

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard	105024 (37–42)	105051 (43–48)

BOX 2 (crossed out)

POINT HAZARDS

1 (52)	Hazard Offset, D_o (ft.) (54–55)	Width (W)(ft.) (56–57)	Length (L)(ft.) (58–59)	Drop Inlets Only: Height (ft.) (60–62) or Depth (ft.) (63–65)

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

52	Hazard Offset, D_o (ft.) Beginning (53–54)	End (55–56)	Height (ft.) or Depth (ft.) (57–59)	Width (W)(ft.) (60–61)
2	06	06	010	04

END TREATMENT — Guardrail Only

62:
1. Not Beginning at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated
3. Beginning at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full Beam Connection

63:
1. Not Ending at Structure – Safety Treated
2. Not Ending at Structure – Not Safety Treated
3. Ending at Structure – Full-Beam Connection
4. Ending at Structure – Not Full-Beam Connection

BOX 4 (crossed out)

SLOPES

FRONT SLOPE

3 (52); Hazard Offset, D_o (ft.): Beginning (53–54), End (55–56); Steepness: Beginning (57–58) :1, End (59–60) :1; Distance "D_1" (ft.): Beginning (61–62), End (63–64); Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts>1ft.); Slope Direction (66) 1. Positive 2. Negative

2nd or BACK (Except for Level Terrain) SLOPE

Steepness: Beginning (67–68) :1, End (69–70) :1; Distance "D_2" (ft.): Beginning (71–72), End (73–74); Slope Face Erosion Code (75) 1. Slight or None 2. Severe (Ruts>1ft.); Slope Direction (76) 1. Positive 2. Negative

Recommendations: *Improvement Alternative #1 - Remove and Regrade*

Inventory of Hazard No. 2 in Grouping (Curb)--Test Case 3

Figure V-29

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form ✓

Hazard Number (1–4)	Highway Number (5–7)	County Code (8–10)	Control Number (11–14)	Section Number (15–16)	Hazard Description
0251	035	097	2561	0B	Curb - Remove

First Cost of Improvements ($) (17–22)	Repair Cost per Collision ($) — Hazard (23–26)	Repair Cost per Collision ($) — Improvement (27–30)	Normal Maintenance ($/yr) — Hazard (31–34)	Normal Maintenance ($/yr) — Improvement (35–38)
000750	0000	0000	0000	0000

BOX 1

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard [ ] 43
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — [ ][ ] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — 48 49 50 Length (ft); 51 52 Width (ft); 53 54 Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb [1] 43
1. Remove and Regrade
2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail [ ] 43
1. Rigid
2. Semi-rigid

[ ] 44
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail [ ] 43
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch [ ] 43
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)
- Right or Median Near Side — Lateral Offset (ft): 45 46 Beginning; 47 48 End
- Median Far Side — Lateral Offset (ft): 49 50 Beginning; 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS)
- Lengthen (ft): 53 54 55 Beginning; 56 57 58 End
- Shorten (ft): 59 60 61 Beginning; 62 63 64 End

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40 — Hazard Offset D_0 (ft): 42 43 Beginning; 44 45 End — Steepness: 46 47 Beginning :1; 48 49 End :1 — Distance "D_1" (ft): 50 51 Beginning; 52 53 End — [ ] 54 Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: 55 56 Beginning :1; 57 58 End :1 — Distance "D_2" (ft): 59 60 Beginning; 61 62 End — [ ] 63 Slope Direction 1. Positive 2. Negative

Hazard Milepost (Complete If Different From Inventory): Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 4

[4] 40 No Improvement Recommended

BOX 5

Improvement Alternative No. 1, Hazard No. 2—Test Case 3
(Remove Curb and Regrade)

Figure V-30

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G.D Weaver* Page ___ of ___

BOX 1

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

Hazard Number (1-4)	Highway Number (5-7)	County Code (8-10)	Control Number (11-14)	Section No (15-16)	Recording Direction (17) 1. With Milepost 2. Against Milepost	ADT (Total Both Directions 1000's) (18-20)	Date Mo. Yr (21-24)
0252	035	097	2561	08	1	120	1273

Hazard Description: *Bridgerail*

CLASSIFICATION

Identification Code (25-26)	Descriptor Code (27-28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (30-32) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number (33-36)
12	05	1	000	0111

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard	105.024 (37-42)	105.051 (43-48)

BOX 2

POINT HAZARDS

[1] (52) Hazard Offset, D_o(ft.) (54-55); Width (W)(ft) (56-57); Length (L)(ft) (58-59); Drop Inlets Only: Height (ft.) (60-62) or Depth (ft.) (63-65)

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

(52)	Hazard Offset, D_o(ft.) Beginning (53-54)	Hazard Offset, D_o(ft.) End (55-56)	Height (ft.) or Depth (ft.) (57-59)	Width (W)(ft) (60-61)
2	10	10	02.3	01

END TREATMENT — Guardrail Only

62	63
1. Not Beginning at Structure – Safety Treated	1. Not Ending at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated	2. Not Ending at Structure – Not Safety Treated
3. Beginning at Structure – Full-Beam Connection	3. Ending at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full-Beam Connection	4. Ending at Structure – Not Full-Beam Connection

BOX 4

SLOPES

FRONT SLOPE

[3] (52) Hazard Offset, D_o(ft.): Beginning (53-54), End (55-56); Steepness: Beginning (57-58) :1, End (59-60) :1; Distance "D_1" (ft.): Beginning (61-62), End (63-64); Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts>1ft.); Slope Direction (66) 1. Positive 2. Negative

2nd or BACK (Except for Level Terrain) SLOPE

Steepness: Beginning (67-68) :1, End (69-70) :1; Distance "D_2" (ft.): Beginning (71-72), End (73-74); Slope Face Erosion Code (75) 1 Slight or None 2 Severe (Ruts>1ft); Slope Direction (76) 1. Positive 2. Negative

Recommendations: *Improvement Alternative #1 – Install Guardrail Along Bridgerail Face*

Inventory of Hazard No. 3 in Grouping (Bridgerail)--Test Case 3

Figure V-31

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

0252 (1 2 3 4 Hazard Number) 035 (5 6 7 Highway Number) 097 (8 9 10 County Code) 2561-08 (11 12 13 14 Control Number; 15 16 Section Number)

Hazard Description: *Bridgerail - Install Guardrail on Face*

BOX 1

000250 (17 18 19 20 21 22 First Cost of Improvements ($))

Repair Cost per Collision ($): 0425 (23 24 25 26 Hazard) 0050 (27 28 29 30 Improvement)

Normal Maintenance ($/yr): 0225 (31 32 33 34 Hazard) 0050 (35 36 37 38 Improvement)

POINT HAZARD IMPROVEMENTS

BOX 2

1 (40) 1 (42) Alleviate Hazard — ☐ (43)
1. Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

1 (40) 2 (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (44 45) Lateral Offset (ft)

1 (40) 3 (42) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (46 47) Lateral Offset (ft)

1 (40) 4 (42) Protect Hazard with Energy Attenuation System — ☐☐☐ (48 49 50 Length (ft)) ☐☐ (51 52 Width (ft)) ☐☐ (53 54 Offset (ft))

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

2 (40) 1 (42) Curb — ☐ (43)
1. Remove and Regrade
2. Install Wedge Modification

2 (40) 2 (42) Bridgerail — 1 (43) 1. Rigid 2. Semi-rigid — 3 (44)
1. Upgrade to Full Safety Standards
2. Move Laterally (Complete Box A Below)
3. Install Guardrail Along Bridgerail Face
4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

2 (40) 3 (42) Guardrail — ☐ (43)
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge--May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

2 (40) 4 (42) Ditch — ☐ (43)
1. Reshape to Safe Cross Section
2. Replace with Storm Drain
3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)
- Right or Median Near Side — Lateral Offset (ft): ☐☐ (45 46 Beginning) – ☐☐ (47 48 End)
- Median Far Side — Lateral Offset (ft): ☐☐ (49 50 Beginning) – ☐☐ (51 52 End)

BOX B (CHANGES TO EXISTING GUARDRAILS)
- Lengthen (ft): ☐☐☐ (53 54 55 Beginning) – ☐☐☐ (56 57 58 End)
- Shorten (ft): ☐☐☐ (59 60 61 Beginning) – ☐☐☐ (62 63 64 End)

SLOPE IMPROVEMENTS

BOX 4

FRONT SLOPE

3 (40)

Hazard Offset D_o (ft): ☐☐ (42 43 Beginning) – ☐☐ (44 45 End)

Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End)

Distance "D_1" (ft): ☐☐ (50 51 Beginning) – ☐☐ (52 53 End)

☐ (54) Slope Direction: 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End)

Distance "D_2" (ft): ☐☐ (59 60 Beginning) – ☐☐ (61 62 End)

☐ (63) Slope Direction: 1. Positive 2. Negative

Beginning: ☐☐☐.☐☐☐ (64 65 66 67 68 69) End: ☐☐☐.☐☐☐ (70 71 72 73 74 75) Hazard Milepost (Complete If Different From Inventory)

BOX 5

4 (40) No Improvement Recommended

Improvement Alternative No. 1, Hazard No. 3--Test Case 3
(Install Guardrail Along Bridgerail Face)

Figure V-32

Form A (Aug. '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by G.D Weaver Page ____ of ____

BOX 1

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

Hazard Number (1-4)	Highway Number (5-7)	County Code (8-10)	Control Number (11-14)	Section No (15-16)	Recording Direction (17) 1. With Milepost 2. Against Milepost	ADT (Total Both Directions 1000's) (18-20)	Date Mo. Yr. (21-24)
0253	035	097	2561	08	1	120	1273

Hazard Description: Slope

CLASSIFICATION

Identification Code (25-26)	Descriptor Code (27-28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (30-32) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number (33-36)
07	02	1	000	0111

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard	104.992 (37-42)	105.024 (43-48)

BOX 2

POINT HAZARDS

52	Hazard Offset, D_0 (ft) (54-55)	Width (W)(ft) (56-57)	Length (L)(ft) (58-59)	Drop Inlets Only: Height (ft.) (60-62) or Depth (ft.) (63-65)
1				

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

52	Hazard Offset, D_0 (ft.) Beginning (53-54)	End (55-56)	Height (ft.) or Depth (ft.) (57-59)	Width (W)(ft.) (60-61)	End Treatment Guardrail Only (62)	(63)
2						

END TREATMENT — Guardrail Only

62:
1. Not Beginning at Structure - Safety Treated
2. Not Beginning at Structure - Not Safety Treated
3. Beginning at Structure - Full-Beam Connection
4. Beginning at Structure - Not Full Beam Connection

63:
1. Not Ending at Structure - Safety Treated
2. Not Ending at Structure - Not Safety Treated
3. Ending at Structure - Full-Beam Connection
4. Ending at Structure - Not Full-Beam Connection

BOX 4

SLOPES

FRONT SLOPE

52	Hazard Offset, D_0 (ft.) Beginning (53-54)	End (55-56)	Steepness Beginning (57-58)	Steepness End (59-60)	Distance "D_1" (ft.) Beginning (61-62)	End (63-64)	Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts>1ft)	Slope Direction (66) 1 Positive 2. Negative
3	14	12	3.1:1	2.6:1	72	61	2	2

2nd or BACK (Except for Level Terrain) SLOPE

Steepness Beginning (67-68)	Steepness End (69-70)	Distance "D_2" (ft.) Beginning (71-72)	End (73-74)	Slope Face Erosion Code (75) 1 Slight or None 2 Severe (Ruts>1ft)	Slope Direction (76) 1 Positive 2 Negative
9.9:1	9.9:1	99	99	1	1

Recommendations: Improvement Alternative #1 - No Improvement Recommended.

Inventory of Hazard No. 4 in Grouping (Slope)--Test Case 3

Figure V-33

Form 8 (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

0253	035	097	2567 — 08	*Slope - No Improvement*
1 2 3 4 Hazard Number	5 6 7 Highway Number	8 9 10 County Code	11 12 13 14 Control Number / 15 16 Section Number	Hazard Description

000000	0000	0000	0000	0000
17 18 19 20 21 22 First Cost of Improvements ($)	Repair Cost per Collision ($): 23 24 25 26 Hazard	Repair Cost per Collision ($): 27 28 29 30 Improvement	Normal Maintenance ($/yr): 31 32 33 34 Hazard	Normal Maintenance ($/yr): 35 36 37 38 Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

[1] 40 [1] 42 Alleviate Hazard — [ ] 43: 1. Remove 2. Make Breakaway and/or Relocate 3. Reconstruct Inlet to Safe Design 4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

[1] 40 [2] 42 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — [ ][ ] 44 45 Lateral Offset (ft)

[1] 40 [3] 42 Protect Hazard with Concrete Median Barrier (CMB) — [ ][ ] 46 47 Lateral Offset (ft)

[1] 40 [4] 42 Protect Hazard with Energy Attenuation System — 48 49 50 Length (ft); 51 52 Width (ft); 53 54 Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

[2] 40 [1] 42 Curb — [ ] 43: 1. Remove and Regrade 2. Install Wedge Modification

[2] 40 [2] 42 Bridgerail — [ ] 43: 1. Rigid 2. Semi-rigid — [ ] 44: 1. Upgrade to Full Safety Standards 2. Move Laterally (Complete Box A Below) 3. Install Guardrail Along Bridgerail Face 4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

[2] 40 [3] 42 Guardrail — [ ] 43:
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Near Bridge — May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

[2] 40 [4] 42 Ditch — [ ] 43: 1. Reshape to Safe Cross Section 2. Replace with Storm Drain 3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL) — Right or Median Near Side: Lateral Offset (ft) 45 46 Beginning, 47 48 End; Median Far Side: Lateral Offset (ft) 49 50 Beginning, 51 52 End

BOX B (CHANGES TO EXISTING GUARDRAILS) — Lengthen (ft): 53 54 55 Beginning, 56 57 58 End; Shorten (ft): 59 60 61 Beginning, 62 63 64 End

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

[3] 40 — Hazard Offset D_h (ft): 42 43 Beginning, 44 45 End; Steepness: 46 47 Beginning :1, 48 49 End :1; Distance "D_1" (ft): 50 51 Beginning, 52 53 End; [ ] 54 Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: 55 56 Beginning :1, 57 58 End :1; Distance "D_2" (ft): 59 60 Beginning, 61 62 End; [ ] 63 Slope Direction 1. Positive 2. Negative

Hazard Milepost (Complete If Different From Inventory): Beginning 64 65 66 67 68 69; End 70 71 72 73 74 75

BOX 4

[4] 40 **No Improvement Recommended**

BOX 5

Improvement Alternative No. 1, Hazard No. 4--Test Case 3
(No Improvement Recommended)

Figure V-34

Form A (Aug '73)

ROADSIDE HAZARD INVENTORY

Inventory Conducted by G.D. Weaver Page ___ of ___

Check Box if Columns 5 Thru 24 Are to be Duplicated from Previous Inventory Form

Hazard Number (1-4)	Highway Number (5-7)	County Code (8-10)	Control Number (11-14)	Section No (15-16)	Recording Direction (17) 1. With Milepost 2. Against Milepost	ADT (Total Both Directions 1000's) (18-20)	Date Mo. Yr. (21-24)
0254	035	097	2561	08	1	120	1273

Hazard Description: Slope

BOX 1

CLASSIFICATION

Identification Code (25-26)	Descriptor Code (27-28)	Offset Code (29) 1. Right 2. Median	Median Width (ft) (30-32) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number (33-36)
07	02	1	000	0111

LOCATION

	Beginning	End (Except for Point Hazard)
Reference Milepost		
Odometer Reading at Hazard		
Milepost at Hazard	105051 (37-42)	105086 (43-48)

BOX 2

POINT HAZARDS

1 (52)

Hazard Offset, D_o(ft) (54-55): ___ Width (W)(ft) (56-57): ___ Length (L)(ft) (58-59): ___ Drop Inlets Only: Height (ft) (60-62) or Depth (ft) (63-65): ___

BOX 3

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

2 (52)

Hazard Offset, D_o(ft): Beginning (53-54) ___ End (55-56) ___ Height (ft) or Depth (ft) (57-59): ___ Width (W)(ft) (60-61): ___

END TREATMENT — Guardrail Only

62:
1. Not Beginning at Structure – Safety Treated
2. Not Beginning at Structure – Not Safety Treated
3. Beginning at Structure – Full-Beam Connection
4. Beginning at Structure – Not Full-Beam Connection

63:
1. Not Ending at Structure – Safety Treated
2. Not Ending at Structure – Not Safety Treated
3. Ending at Structure – Full-Beam Connection
4. Ending at Structure – Not Full-Beam Connection

BOX 4

SLOPES

FRONT SLOPE

3 (52)

Hazard Offset, D_o(ft) Beginning (53-54)	End (55-56)	Steepness Beginning (57-58)	End (59-60)	Distance "D_1" (ft) Beginning (61-62)	End (63-64)	Slope Face Erosion Code (65) 1. Slight or None 2. Severe (Ruts>1ft.)	Slope Direction (66) 1. Positive 2. Negative
12	15	2.5:1	3.2:1	59	68	2	2

2nd or BACK (Except for Level Terrain) SLOPE

Steepness Beginning (67-68)	End (69-70)	Distance "D_2" (ft) Beginning (71-72)	End (73-74)	Slope Face Erosion Code (75) 1. Slight or None 2. Severe (Ruts>1ft.)	Slope Direction (76) 1. Positive 2. Negative
9.9:1	9.9:1	99	99	1	1

Recommendations: Improvement Alternative #1- Install Guardrail Departing Bridge.

Inventory of Hazard No. 5 in Grouping (Slope)--Test Case 3

Figure V-35

Form B (AUG. '73)

ROADSIDE HAZARD IMPROVEMENTS

Check Box If Columns 5 Thru 16 Are To Be Duplicated From Previous Form

Hazard Number (1-4)	Highway Number (5-7)	County Code (8-10)	Control Number (11-14)	Section Number (15-16)	Hazard Description
0254	035	097	2561	08	Slope - Install Guardrail

First Cost of Improvements ($) (17-22)	Repair Cost per Collision ($) Hazard (23-26)	Repair Cost per Collision ($) Improvement (27-30)	Normal Maintenance ($/yr) Hazard (31-34)	Normal Maintenance ($/yr) Improvement (35-38)
000325	0000	0150	0075	0075

BOX 1

POINT HAZARD IMPROVEMENTS

1 (40) 1 (42) Alleviate Hazard — (43) 1. Remove 2. Make Breakaway and/or Relocate 3. Reconstruct Inlet to Safe Design 4. Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grate, Etc.)

1 (40) 2 (42) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — Lateral Offset (ft) (44-45)

1 (40) 3 (42) Protect Hazard with Concrete Median Barrier (CMB) — Lateral Offset (ft) (46-47)

1 (40) 4 (42) Protect Hazard with Energy Attenuation System — Length (ft) (48-50), Width (ft) (51-52), Offset (ft) (53-54)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

2 (40) 1 (42) Curb — (43) 1. Remove and Regrade 2. Install Wedge Modification

2 (40) 2 (42) Bridgerail — (43) 1. Rigid 2. Semi-rigid — (44) 1. Upgrade to Full Safety Standards 2. Move Laterally (Complete Box A Below) 3. Install Guardrail Along Bridgerail Face 4. Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A Below)

2 (40) 3 (42) Guardrail — (43) 8
1. Remove Existing Guardrail
2. Upgrade to Full Safety Standards (Complete Box B Below, if Applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B Below)
4. Close-up Gap Between Existing Guardrail (Complete Box B Below)
5. Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards (Complete Box A Below)
6. Anchor Existing Guardrail to Bridgerail
7. Install Guardrail at Bridge Approach (Complete Box A Below)
8. Install Guardrail Departing Bridge (Complete Box A Below)
9. Safety Treat Guardrail Free-End Only

2 (40) 4 (42) Ditch — (43) 1. Reshape to Safe Cross Section 2. Replace with Storm Drain 3. Protect with Guardrail (Complete Box A Below)

Box A (INSTALL GUARDRAIL)

	Lateral Offset (ft) Beginning (45-46)	Lateral Offset (ft) End (47-48)	Lateral Offset (ft) Beginning (49-50)	Lateral Offset (ft) End (51-52)
Right or Median Near Side	12	12		
Median Far Side			00	00

BOX B (CHANGES TO EXISTING GUARDRAILS)

Lengthen (ft) Beginning (53-55)	Lengthen (ft) End (56-58)	Shorten (ft) Beginning (59-61)	Shorten (ft) End (62-64)

BOX 3

SLOPE IMPROVEMENTS

FRONT SLOPE

3 (40) — Hazard Offset O_h (ft): Beginning (42-43), End (44-45); Steepness: Beginning (46-47) :1, End (48-49) :1; Distance "D_1" (ft): Beginning (50-51), End (52-53); Slope Direction (54): 1. Positive 2. Negative

2nd or BACK SLOPE

Steepness: Beginning (55-56) :1, End (57-58) :1; Distance "D_2" (ft): Beginning (59-60), End (61-62); Slope Direction (63): 1. Positive 2. Negative

Hazard Milepost (Complete If Different From Inventory): Beginning (64-69), End (70-75)

BOX 4

4 (40) No Improvement Recommended

BOX 5

Improvement Alternative No. 1, Hazard No. 4--Test Case 3
(Install Guardrail Departing Bridge)

Figure V-36

COST EFFECTIVENESS PROGRAM

HIGHWAY NO = 35
COUNTY NO = 97
DISTRICT NO = 25
CONTROL NO = 2561
SECTION NO = 8

RECORDING DIRECTION = 1
ADT (1000) = 120
LIFE = 20(YRS)
INTEREST = 6.0(PERCENT)
DATE = 12-73

H A Z A R D										I M P R O V E M E N T						
HAZARD NO	IDENT CODE	DESC CODE	END TREATMENT BEG	END TREATMENT END	SEVERITY INDEX	OFFSET CODE	GROUP NO	MILE-POST BEG	MILE-POST END	IMPR ALT	IMPR CODE	SEVERITY INDEX	FIRST COST ($)	PRESENT WORTH ($)	ANNUAL COST ($/YR)	COST EFFECTIVE VALUE
251	5	3	0	0	3.7	1	111	105.024	105.051	1	2-1-1-0	0.0	750	749	65	GROUP
252	12	5	0	0	82.5	1	111	105.024	105.051	1	2-2-1-3	3.3	250	-1302	-113	GROUP
250	6	2	1	4	17.3	1	111	105.000	105.024	1	2-3-6-0	3.8	325	-1923	-167	GROUP
254	7	2	0	0	8.0	1	111	105.051	105.086	1	2-3-8-0	3.2	325	-592	-51	GROUP
253	7	2	0	0	8.0	1	111	104.992	105.024	1	4-0-0-0	8.0	0	737	64	7

TEST CASE 3
(group hazards at bridge)

Typical Cost-Effectiveness Program Output--Test Case 3

Figure V-37

REFERENCES

1. Glennon, John C., and Tamburri, F. N., "Objective Criteria for Guardrail Installation," Highway Research Record No. 174, 1967.

2. Texas Department of Public Safety, Motor Vehicle Traffic Accidents, 1970.

3. Glennon, John C., "A Cost-Effectiveness Priority Approach for Roadside Safety Improvement Programs on Freeways," NCHRP Project 20-7, Task Order 1/1, Research Report 625-2F, Texas Transportation Institute, February, 1972 (Will be published by NCHRP in 1974, tentatively as NCHRP report no. 148).

4. Hutchinson, John W., and Kennedy, Thomas W., "Medians of Divided Highways - Frequency and Nature of Vehicle Encroachments," University of Illinois Engineering Experiment Station Bulletin 487, 1966.

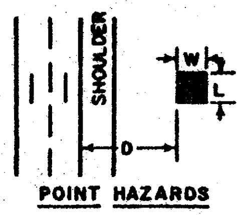
APPENDIX

Included in this Appendix are photographs of roadside hazards depicting the identification and descriptor codes for hazard inventory purposes. Table II-1 is reprinted in the Appendix as (Table A-1) to permit easy code reference.

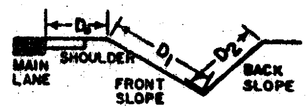
It should be noted that all hazards having identification or descriptor codes enclosed in a diamond in Table A-1 are inventoried as point hazards. If the identification code is so designated, all descriptor codes within that major classification apply to point hazard codes. In some categories, only certain descriptor codes apply to point hazards (ex. bridge piers, and open gap between parallel bridges).

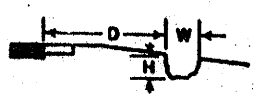
TABLE A-1

Hazard Classification Codes



IDENTIFICATION CODE	DESCRIPTOR CODES
◇01 Utility Poles	(00)
◇02 Trees	(00)
◇03 Rigid Signpost	(01) single-pole-mounted (02) double-pole-mounted (03) triple-pole-mounted (04) cantilever support (05) overhead sign bridge
◇04 Rigid Base Luminaire Support	(00)
05. Curbs	(01) mountable design (02) non-mountable design less than 10 inches high (03) barrier design greater than 10 inches high
06. Guardrail or Median Barrier	(01) w-section with standard post spacing (6 ft-3 in.) (02) w-section with other than standard post spacing (03) approach guardrail to bridge--decreased post spacing (3 ft-1 in.) adjacent to bridge (04) approach guardrail to bridge--post spacing not decreased adjacent to bridge (05) post and cable (06) median fence (07) median barrier (CMB design or equivalent)
07. Roadside Slope	(01) sod cut slope (02) sod fill slope (03) concrete-faced cut slope (04) concrete-faced fill slope (05) rubble rip-rap cut slope (06) rubble rip-rap fill slope
08. Washout Ditch (Does <u>not</u> include ditch formed by intersection of front and back slopes)	(00)
◇09 Culverts	(01) headwall (or exposed end of pipe culvert) (02) gap between culverts on parallel roadways (03) sloped culvert with grate (04) sloped culvert without grate
◇10 Inlets	(01) raised drop inlet (tabletop) (02) depressed drop inlet (03) sloped inlet
11. Roadway Under Bridge Structure	◇01 bridge piers (02) bridge abutments
12. Roadway Over Bridge Structure	◇01 open gap between parallel bridges (02) closed gap between parallel bridges (03) rigid bridgerail--smooth and continuous construction (04) semi-rigid bridgerail--smooth and continuous construction (05) other bridgerail--penetration likely; severe snagging likely; severe pocketing and snagging likely; or, vaulting likely (06) elevated gore abutment
13. Retaining Wall	(00)

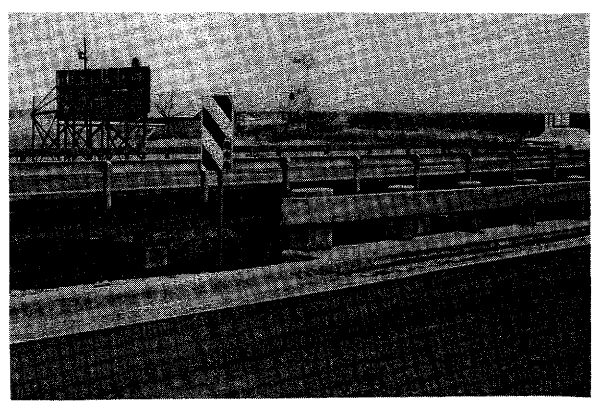




◇ Denotes Point Hazard

a. Mountable Curb Design
(Code 05-01)

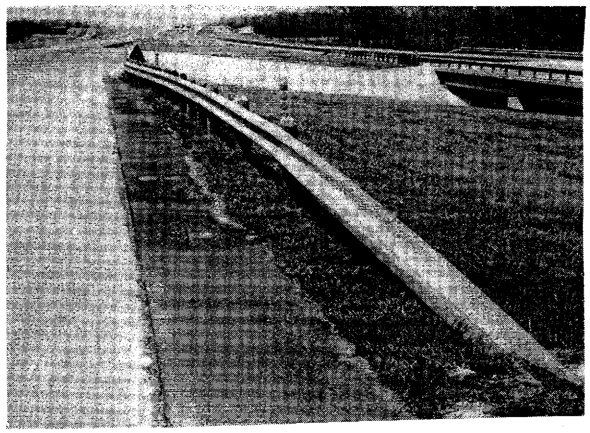
b. Non-mountable Curb Design
Less than 10 inches High
(Code 05-02)



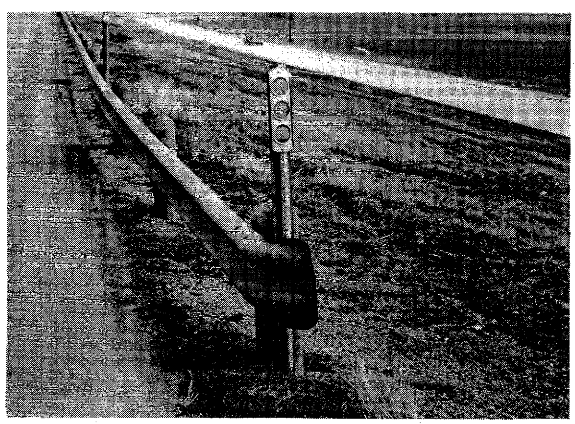
c. Barrier Curb Greater
than 10 inches High
(Code 05-03)

Curb Hazards (Identification Code 05)

Figure A-1



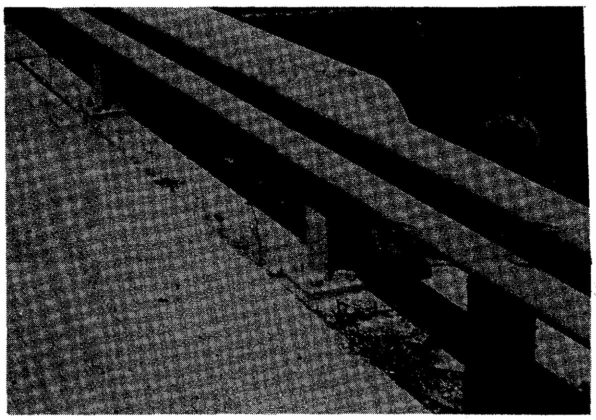
a. Safety-Treated Guardrail End (Turned Down)



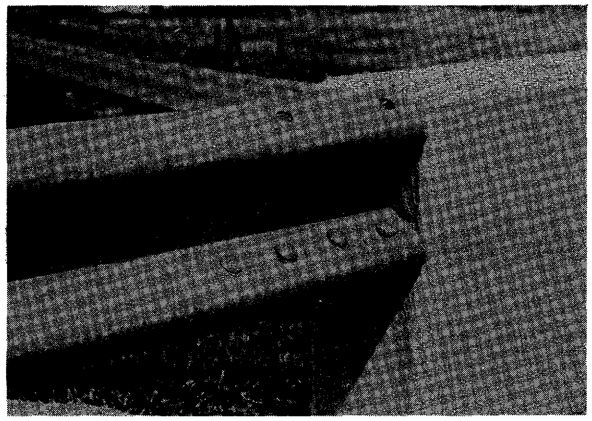
b. Blunt Guardrail End--Not Safety Treated

Guardrail End Treatment

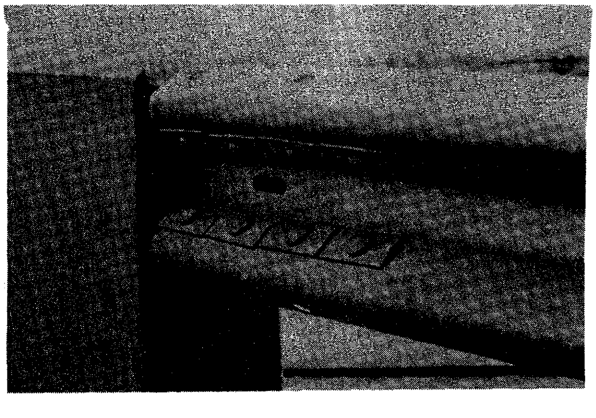
Figure A-2



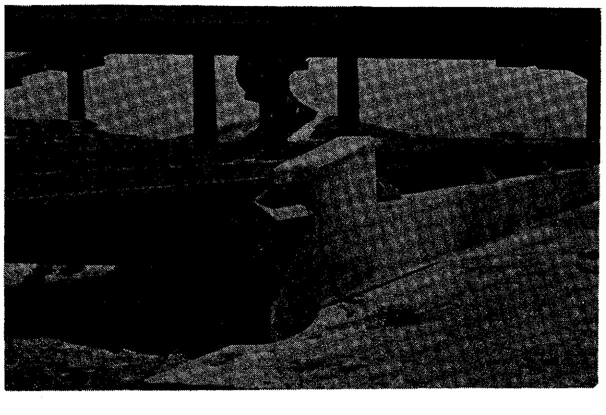
a. Full Beam Strength Developed Because Rail is Carried Across Bridge



b. Full Beam Strength Developed Through 8-Bolt Connection



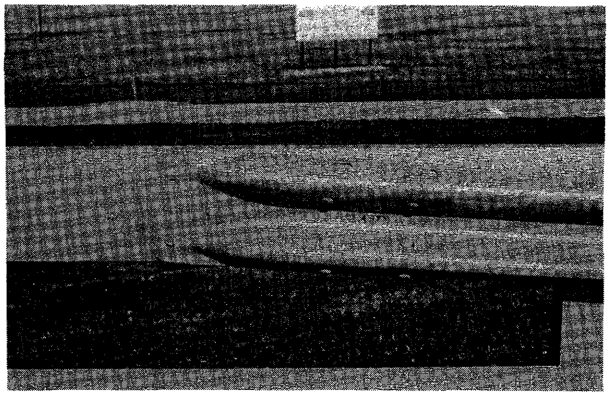
c. Full Beam Strength Developed Through 8-Bolt Connection With Washers



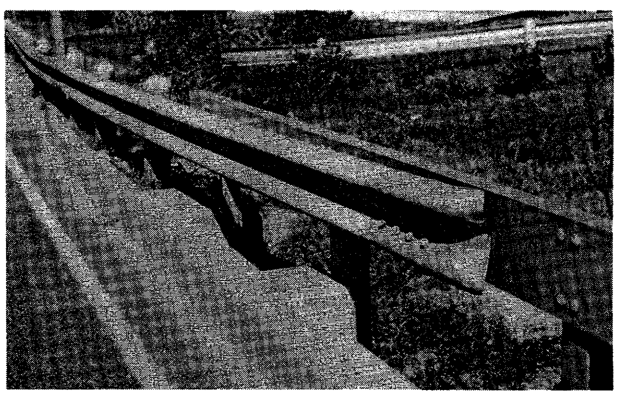
d. Construction of 8-Bolt Connection Anchor Bracket

Approach Guardrail--Full Beam Strength Connection

Figure A-3



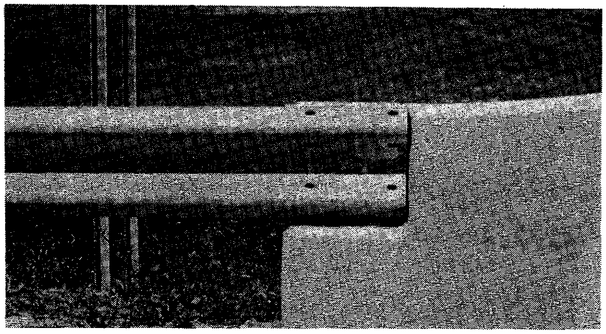
a. Michigan End Shoe--Develops Full Beam Strength



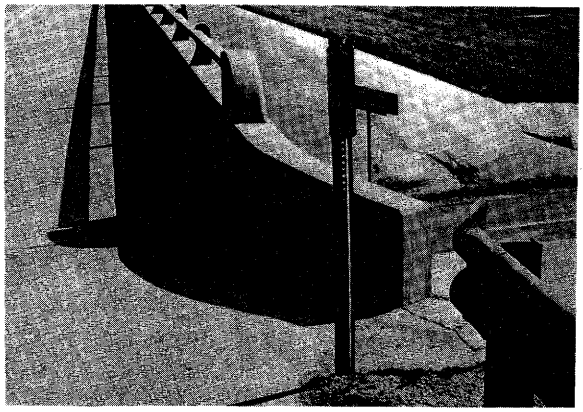
b. Shop Fabrication--Develops Full Beam Strength

Approach Guardrail--Full-Beam Strength Connection

Figure A-4



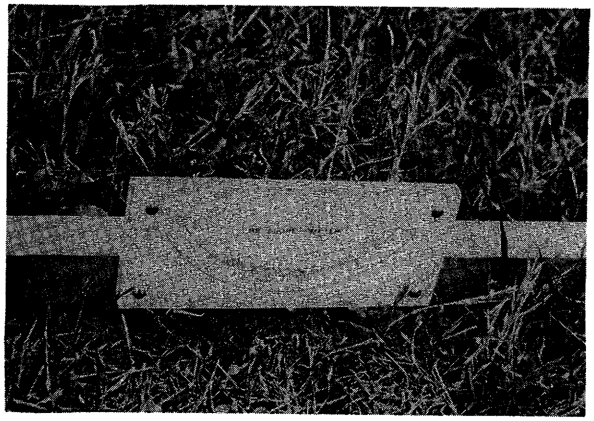
a. One-Bolt Guardrail/Bridge Connection. Does Not Develop Beam Strength.



b. Approach Guardrail Not Connected to Bridge Leaving Open Gap and Exposed Wingwall.

Approach Guardrail--Not Full Beam Strength Connection

Figure A-5

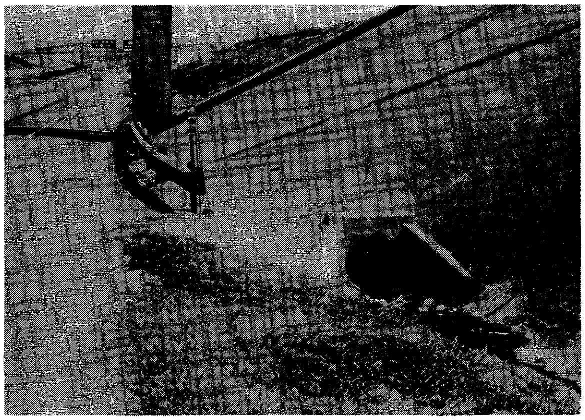


a. BB Slope-ometer

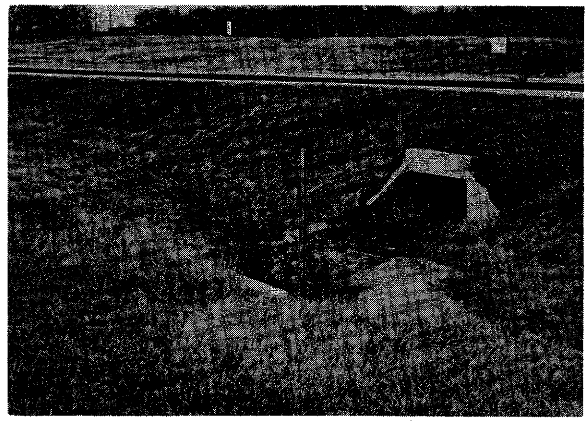
b. Use of BB Slope-ometer to Measure Roadside Slope Ratio

Roadside Slope Measurement

Figure A-6

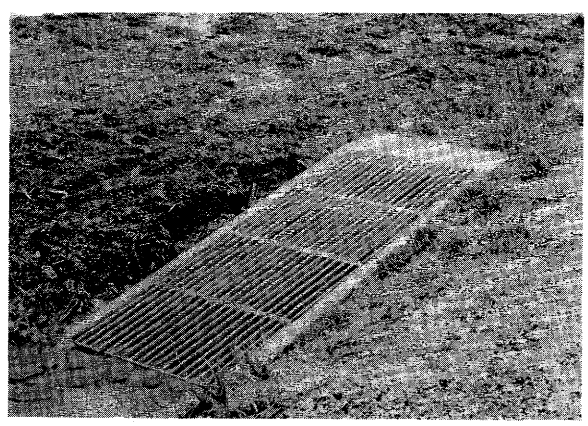


a. Culvert Headwall
(Code 09-01)



b. Culvert Headwall
(Code 09-01)

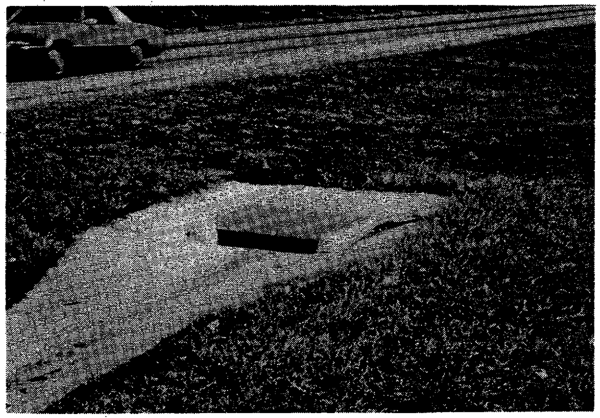
c. Gap between Culvert Headwalls on Parallel Roads
(Code 09-02)



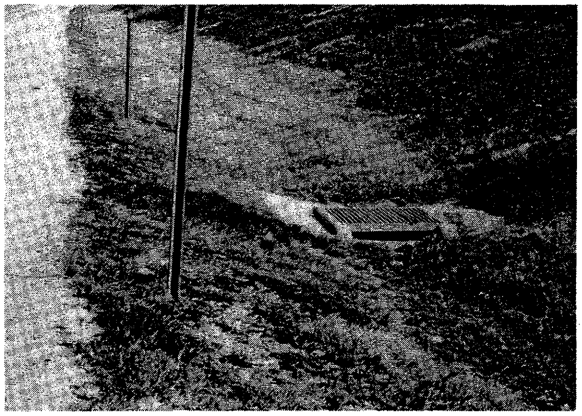
d. Culvert with Sloped Grate
(Code 09-03)

Culvert Hazards (Identification Code 09)

Figure A-7



a. Raised Drop Inlet (Table-top) in Median
(Code 10-01)

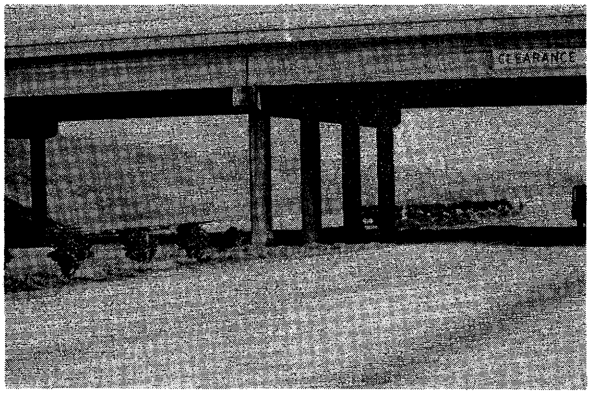


b. Raised Drop Inlet (Table-top) Alongside Outer Travel Lane
(Code 10-01)

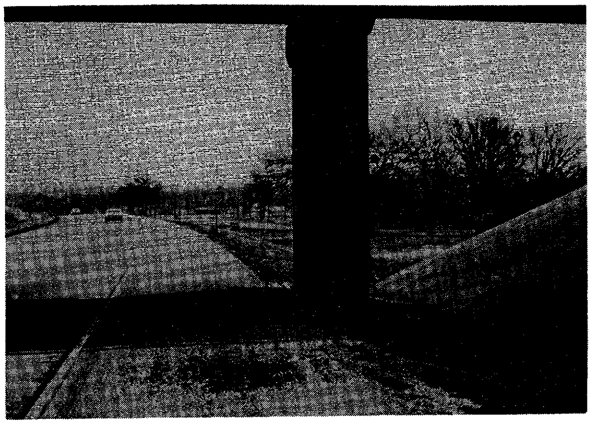
c. Curb Inlet
(Inventoried as Non-Mountable Curb Less than 10 Inches High)
(Code 05-02)

Inlet Hazards (Identification Code 10)

Figure A-8



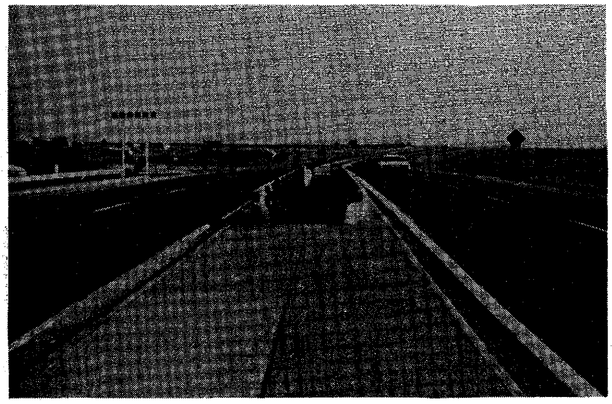
a. Bridge Piers Without Guardrail Protection
(Code 11-01)



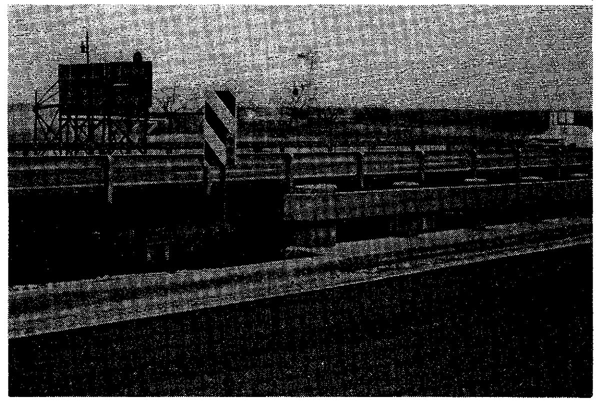
b. Bridge Abutment Behind Unprotected Piers
(Code 11-02)

Hazards Associated with Roadway Under Bridge Structure
(Identification Code 11)

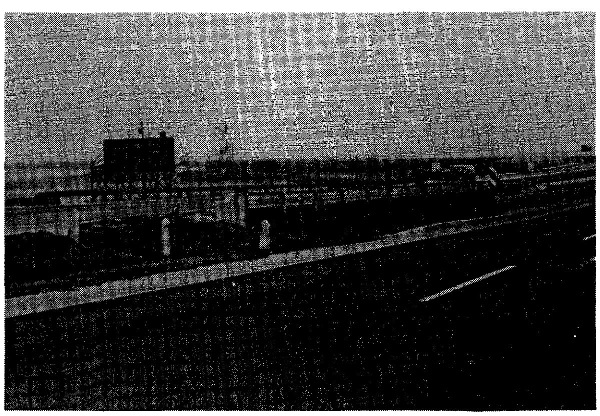
Figure A-9



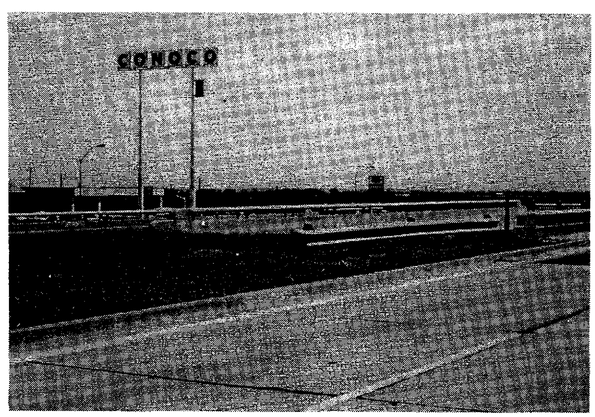
a. Unprotected Open Gap Between Parallel Bridges
(Code 12-01)



b. Open Gap Between Parallel Bridges
(Code 12-01)



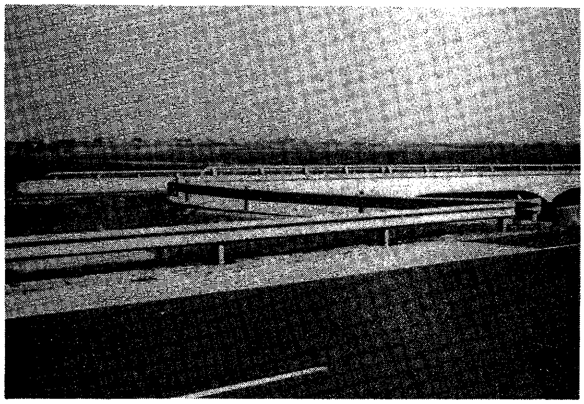
c. Semi-protected Open Gap Between Parallel Bridges. Vehicle can Easily Enter Gap
(Code 12-01)



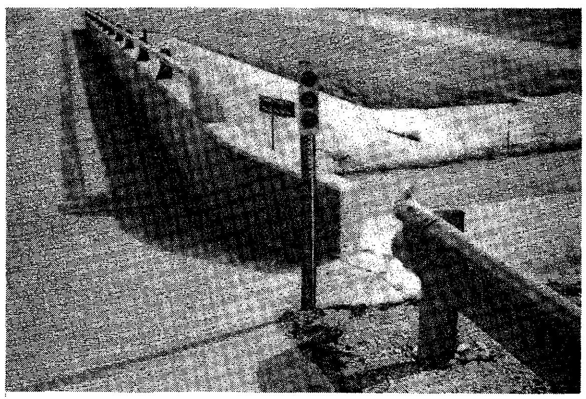
d. Open Gap Semi-protected by Short Guardrail Section. Vehicle can Easily Enter Gap
(Code 12-01)

Hazards Associated with Roadway Over Bridge Structure
(Identification Code 12)

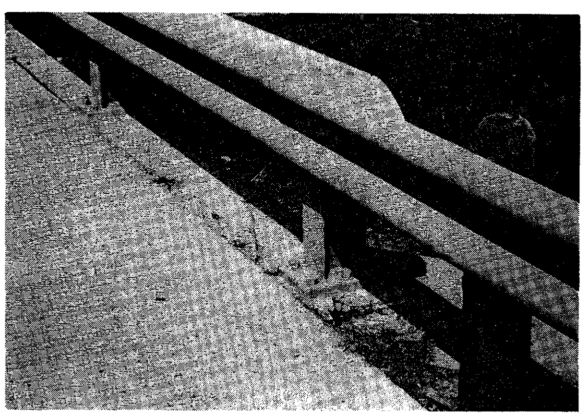
Figure A-10



a. Closed Gap Between Parallel Bridges (Code 12-02)



b. Rigid Bridgerail--Smooth and Continuous Construction (Code 12-03)



c. Semi-Rigid Bridgerail--Smooth and Continuous Construction (Code 12-04)

Hazards Associated with Roadway Over Bridge Structure
(Identification Code 12)
Figure A-11