Over-Embankment Accidents on Rural 2-Lane Conventional Highways

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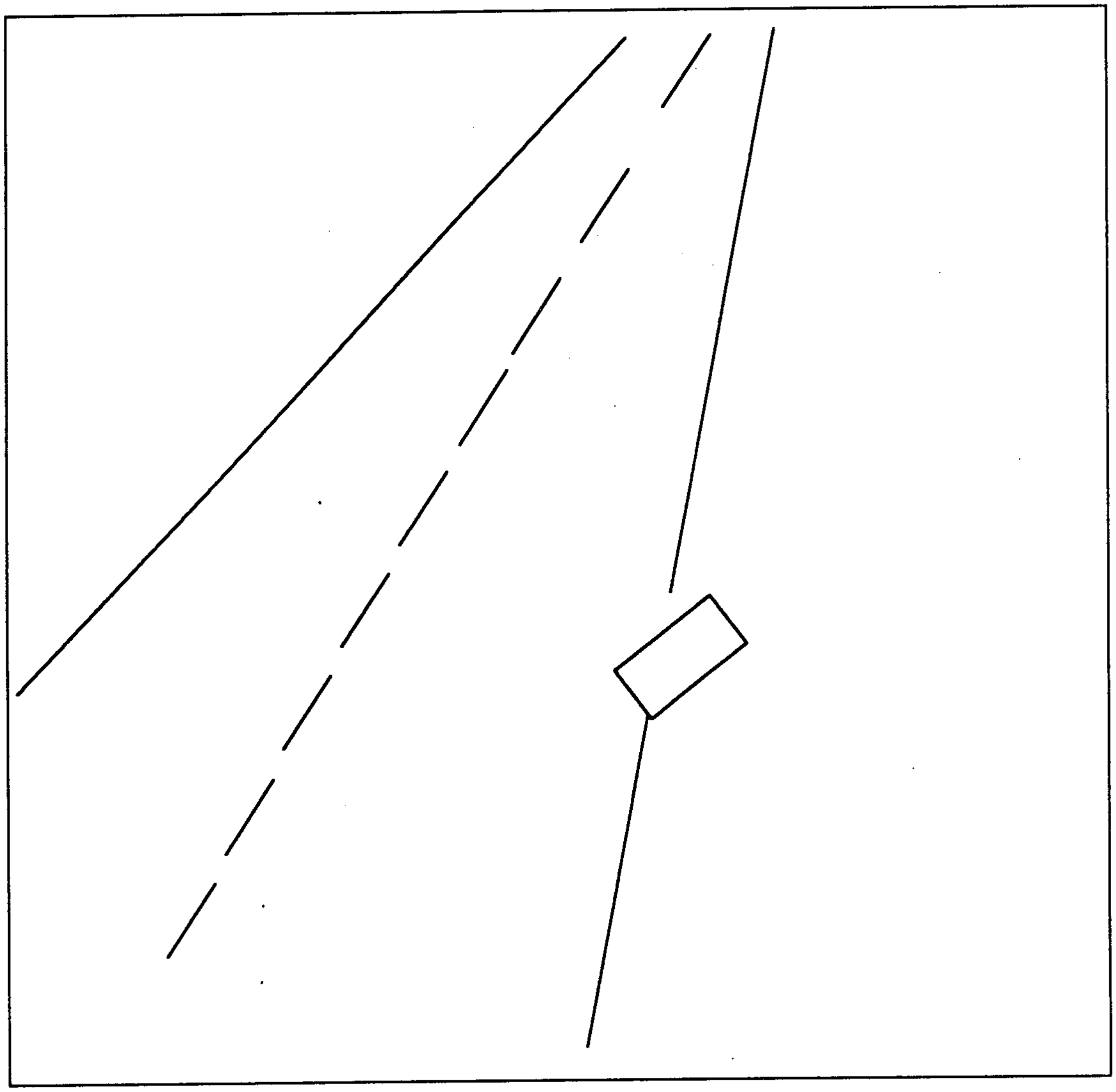

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16. Abstract

This report identifies factors which might be related to vehicles going over the roadway embankment, locations of over-embankment accidents, and roadway/roadside characteristics where these accidents occur. Recommendations which might reduce the potential for over-embankment accidents are provided. The scope of this research was limited to rural 2-lane conventional highways.

It was determined that only 11% of the over-embankment accidents occurred at concentrated locations (less than 0.5-mile apart). Most of these locations had numerous curves with little or no shoulders and trees or water in the roadside environment.

Countermeasures that might reduce the potential for over-embankment accidents in general include installing new guardrail, lengthening existing guardrail, extending embankment guardrail near cut-slope areas and burying guardrail into the cut-slope, providing additional signing and striping, improving the shoulder, installing rumble strips, installing audible edge stripes, or cleaning up the roadside environment to provide a clear recovery area. Individual locations should be investigated to determine whether a safety project is warranted and to determine what countermeasures, if any, should be applied.

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INTRODUCTION

In 1992, approximately 21% of all fatal accidents and 14% of all injury accidents on rural 2-lane conventional highways in California involved vehicles going over the embankment. In most of these accidents, the vehicle overturned.

The objectives of this research are to identify factors which might cause vehicles to go over the embankment, the location of over-embankment accidents, roadway and roadside characteristics where these accidents occur, and to provide recommendations which might reduce the potential for over-embankment accidents. The scope of this research was limited to rural 2-lane conventional highways.

BACKGROUND

Research regarding over-embankment accidents by the California Department of Transportation (Caltrans) began in the 1960's. The first study[1] compared the severity of over-embankment accidents with that of hitting guardrail on freeways. The over-embankment accidents investigated did not include accidents where the vehicle hit a fixed object or where the vehicle went into the water. The results of this study and an updated study[2] led to the development of the "equal severity curve" as well as guidelines for the placement of embankment guardrail. These guidelines have been effective in reducing the number and severity of over-embankment accidents on freeways. However, as the following graph shows, in 1992 the percentage of over-embankment accidents on rural 2-lane conventional highways involving fatalities was nearly two times higher than that on multi-lane urban freeways.

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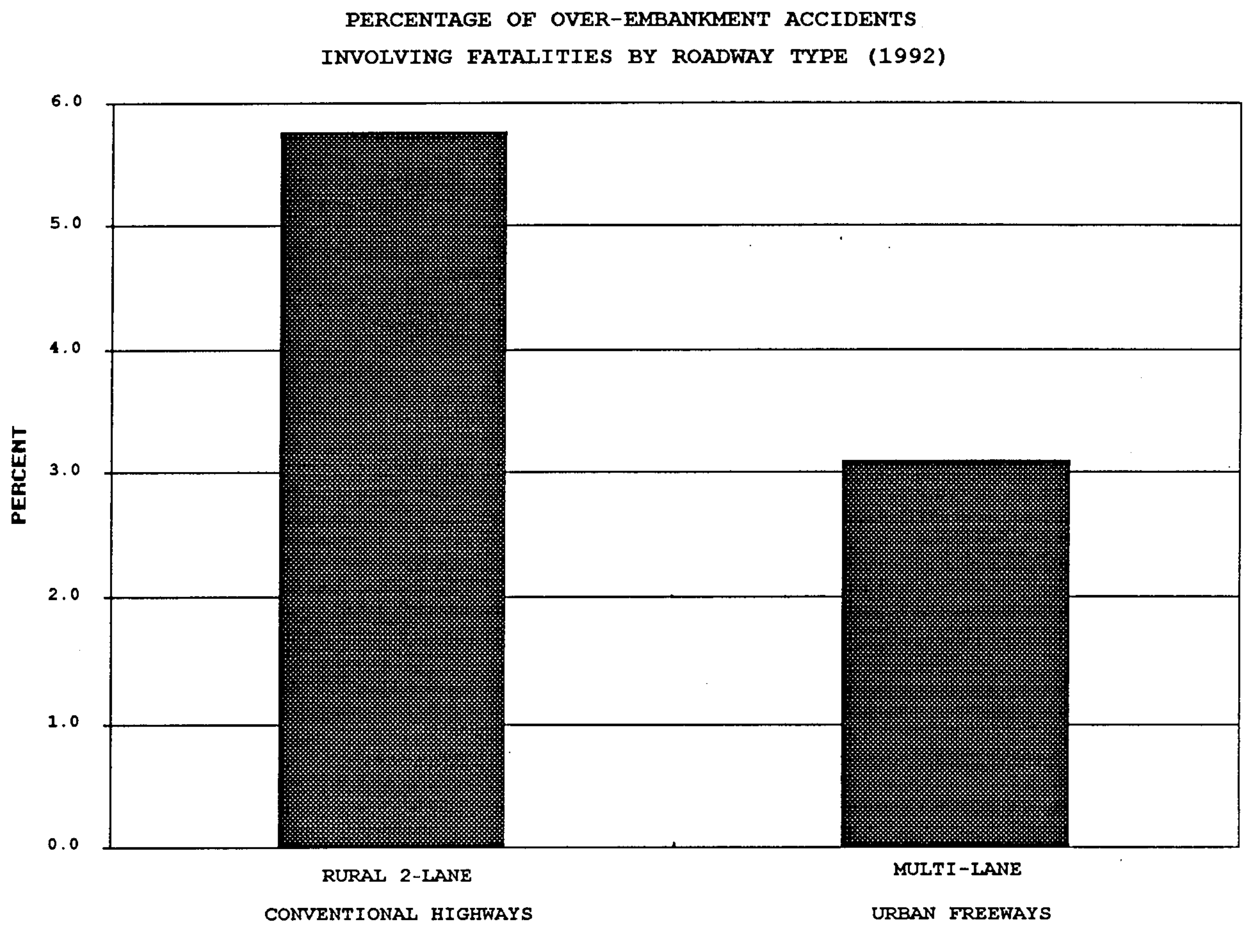

One of the reasons for this disparity is that many potential roadside hazards along freeways have been eliminated. This was done in the 1970's under the Clean Up the Roadside Environment Program (CURE). The CURE program involved an overall effort to reduce the potential for accidents by providing a clear recovery area with the removal of fixed objects or by making them more forgiving. The priority of this program was to place guardrail around fixed objects and on embankments with critical slopes. The CURE program was very successful at reducing the fatal accident rate on freeways. However, in 1992 the fatal accident rate for rural conventional highways was approximately six times higher than that for multi-lane freeways. In response to this, the 1993 CURE program for rural conventional highways was implemented. The guidelines[3] for the new CURE program provided suggestions to reduce various types of accidents, including over-embankment accidents. As part of the implementation process for the new CURE program, this research was conducted to identify countermeasures that might reduce the potential for over-embankment accidents.

A literature search regarding over-embankment accidents was performed. Thirteen reports were identified which involved the analysis of vehicles going over the embankment. Four of these reports were case studies of overturn accidents, five were investigations of overturn accidents using computer simulation models, and the remainder were statistical studies of run-off-road and overturn accidents. Three of the studies had objectives similar to the objectives of this study: “Study Of Fatal Rollover Crashes In Georgia", "Survey Of Single-Vehicle Fatal Rollover Crash Sites In New Mexico", and "Running Off The Road: A Study Of Car Encroachment, Accidents

And Road Conditions In Finland In 1971-75". These studies looked at roadside features and other factors, which were related to rollover and run-off-road accidents.

WORKPLAN

The following methodology was used for achieving the objectives of this study:

1. A list of accident locations involving vehicles going over the embankment was developed, using the Traffic Accident Surveillance and Analysis System (TASAS) database. A list of locations of accident concentrations was also developed.

2. The locations of accident concentrations were ranked by accident rates from high to low. Only locations with high fatal accident rates and high fatal + injury accident rates were included in the final list. For each of the locations in the final list, additional data regarding roadway characteristics and the roadside environment were obtained from the photolog (a visual record of California highways on laser disc format).

3. General information regarding over-embankment accidents was obtained from the TASAS database and from a sample of written accident reports. The accident reports included collision diagrams and narratives by the officer responsible for investigating the accident.

4. The data was analyzed, conclusions were made, and countermeasures that might reduce the potential and severity of over-embankment accidents were provided.

FINDINGS

TASAS DATA

Data for state highways is transmitted from the Statewide Integrated Traffic Records System (SWITRS) database to Caltrans on a weekly basis. SWITRS is a centralized collection of computerized data on all traffic accidents in California. Caltrans is responsible for coding additional information from the collision reports, including objects struck and location of accident. These accident records are then entered into the TASAS database. For this project, a special TASAS computer run was done to identify accidents where the vehicle went down the embankment. The roadway type was limited to rural 2-lane conventional highways. The time base was from January 1, 1992 to December 31, 1996.

The TASAS data files were downloaded to a Macintosh computer as ASCII text files. Headers, page breaks, blank lines, and other impertinent information were removed from the data files. The data files were then formatted so that various fields of data could be easily analyzed using an EXCEL spreadsheet.

The TASAS data was used for providing general information about over-embankment accidents and for determining where concentrations of such accidents occurred.

GENERAL INFORMATION

Over-Embankment Accidents on Rural 2-Lane Conventional Highways:

Year	Fatal	Injury	PDO	Total
1992	84	825	455	1364
1993	54	741	448	1243
1994	87	762	527	1376
1995	79	795	506	1380
1996	67	772	524	1363
1992-1996	371	3895	2460	6726

Primary Collision Factor for Total Over-Embankment Accidents (1992-1996):

Primary Collision Factor	Number of Accidents	Percentage
Influence of Alcohol	1262	18.8
Following too Close	18	0.3
Failure to Yield	83	1.2
Improper Turn	1106	16.5
Speeding	1554	23.1
Other Violations	1872	27.9
Improper Driving	73	1.1
Other Than Driver	357	5.3
Unknown	55	0.8
Fell Asleep	340	5.1

Type of Weather for Total Over-Embankment Accidents (1992-1996):

Type of Weather	Number of Accidents	Percentage
Clear	4641	69.1
Cloudy	1239	18.4
Raining	507	7.5
Snowing	209	3.1
Fog	106	1.6
Other	15	0.2

Type of Lighting for Total Over-Embankment Accidents (1992-1996):

Lighting	Number of Accidents	Percentage
Daylight	3995	59.6
Dusk/Dawn	252	3.8
Dark-Street Light	101	1.5
Dark-No Street Light	2350	35.0
Dark-Street Light Not Operating	6	0.1
Dark-Not Stated	0	0

Road Surface Condition for Total Over-Embankment Accidents (1992-1996):

Road Surface Condition	Number of Accidents	Percentage
Dry	5031	74.8
Wet	1100	16.4
Snowy, Icy	522	7.8
Slippery	38	0.6
Not Stated	35	0.5

In addition to the above information, the following were observed for 1992-1996:

- The percentages of over-embankment accidents which involved drunk driving were 19% for total accidents, 43% for fatal accidents, and 23% for injury accidents. These percentages are substantially higher than the percentages for all highway accidents. The percentages for all highway accidents which involved drunk driving were 7% for total accidents, 25% for fatal accidents, and 10% for injury accidents.

- The percentages of over-embankment accidents occurring to the left of the centerline were 44% for total accidents, 48% for fatal accidents, and 45% for injury accidents.

- The percentages of over-embankment accidents which involved a vehicle overturning were 56% for total accidents, 70% for fatal accidents, and 65% for injury accidents. For total accidents, 6% were fatal accidents and 65% were injury accidents.

- The percentage of over-embankment accidents, which were the same type as those used to develop the "equal severity curve", was 67%. Of these, 4% were fatal accidents and 56% were injury accidents.

- The percentages of over-embankment accidents, which included a vehicle overturning and hitting a tree, were 4% for total accidents, 7% for fatal accidents, and 5% for injury accidents. For total accidents, 8% were fatal accidents and 64% were injury accidents.

- The percentages of over-embankment accidents, which included a vehicle overturning and going into water, were 5% for total accidents, 14% for fatal accidents, and 5% for injury accidents. For total accidents, 13% were fatal accidents and 51% were injury accidents.

- For all types of over-embankment accidents, the percentage of total DUI accidents involving fatalities was approximately 2.6 to 4.6 times greater than the percentage of total non-DUI accidents involving fatalities.

CALIFORNIA HIGHWAY PATROL (CHP) ACCIDENT RECORDS

The CHP officer in charge of investigating an accident is required to prepare a traffic collision report which provides important details of the accident. Traffic collision reports are forwarded to Caltrans for coding additional information into the TASAS database, such as the location of the accident. The TASAS database provides many important details regarding accidents. However, to gain a better understanding as to the possible causes of over-embankment accidents and events leading up to them, a sample of traffic collision reports was reviewed. A total of 512 collision reports were reviewed. Each of these reports was examined, with special attention given to the collision diagrams and comments prepared by the officer in charge of the investigation.

After reviewing the reports, it was observed that over-embankment accidents might be related to the length of embankment guardrail where the accidents occurred. Many of the over-embankment accidents involved the driver over-steering the vehicle to the left to prevent it from running off of the right-hand side of the roadway. As a result, the vehicle is over-steered across the roadway into the opposing lane and over the embankment on the other side of the roadway beyond the left-hand shoulder. This type of over-correction by the driver was found to be a factor in approximately 15% of over-embankment accidents.

PHOTOLOG

The Caltrans photolog was used to review roadway segments and the roadside environment where high concentrations of over-embankment accidents occurred. There are many curves along these roadway segments, many of them with small radii. Most of the embankments are steep and are adjacent to rivers or streams. Over half of the areas have trees and boulders in the roadside environment.

LOCATIONS OF ACCIDENT CONCENTRATION

Locations of accident concentrations were defined as locations that had at least 6 over-embankment accidents, occurring less than 0.5-mile apart. For each location of accident concentration, the number of total, fatal, and injury over-embankment accidents were determined. In addition to the number of over-embankment accidents, the number of total, fatal, and injury accidents of all types were also determined. The locations were ranked based on the percentage of fatal and injury over-embankment accidents to fatal and injury accidents of all types. Locations having less than 50% over-embankment accidents were not included in the ranking. For the locations that were ranked, additional information regarding the roadway and the roadway environment was obtained using the photolog. The information included a qualitative description of the number of curves, the length of guardrail, shoulder widths, and characteristics of the roadside environment (steep embankments, trees, water, fixed objects, etc.). The information is summarized in the table on the following page.

DIST	NO	F	CO		MILE1		MILE2	MILES	TOTAL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS	CURVES	SHOULDER	COMMENTS
7	1		VEN		0.68		4.65	3.97	21	4	13	moderate	5'	ocean, steep embankment, 0.09 mi guardrail
7	2		LA		49.02		49.72	0.70	9	0	9	many	1'	trees, steep embankment
7	2		LA		56.61		57.08	0.47	12	0	12	many	4-5'	trees, steep embankment
8	2		SBD		3.06		4.67	1.61	17	2	8	many	1'	steep embankment
10	4		SJ		5.16		8.24	3.08	40	5	22	moderate	1'	
8	18		SBD		59.41		60.61	1.20	12	1	6	many	3'	trees, steep embankment
3	20		COL		26.94		29.70	2.76	7	2	3	some	2-4'	trees, 0.07 mi guardrail
1	20		LAK		2.93		4.63	1.70	8	1	4	many		embankment into lake
1	20		MEN		12.61		31.68	19.07	45	3	30	many	2' paved	trees, 0.35 mi guardrail
3	20		NEV		30.10		30.59	0.49	9	1	7	many	1-2'	trees, steep embankment
3	20		NEV		38.53		38.99	0.46	7	0	6	many	4'	trees, steep embankment
7	23		LA		3.60		5.00	1.40	8	0	6	many	3-4'	trees
4	29		NAP		39.33		40.24	0.91	17	1	15	many	2'	trees, steep embankment
4	29		NAP		44.52		45.06	0.54	7	0	7	many	3'	trees, steep embankment, 0.10 mi guardrail
3	32		BUT		11.30		12.65	1.35	8	1	2	none	4'	
6	33		KER		2.57		3.80	1.23	7	0	5	moderate	1'	
2	36		TEH		76.76		78.22	1.46	12	1	3	many	0-1' paved	trees, steep embankment
6	41		MAD		19.51		20.90	1.39	9	2	6	moderate	1'	trees
5	41		SLO		46.25		48.20	1.95	12	0	8	moderate.	1'	steep embankment, 0.13 mi guardrail
2	44		SHA	R	25.67	R	27.01	1.34	7	1	4	many	2'paved	trees
3	49		ED		34.58		35.21	0.63	8	0	5	many	0-1'	trees, steep embankment
10	49		MPA		32.42		42.70	10.28	11	3	4	many	1'	trees, 0.06 mi guardrail
3	49		NEV/YUB		28.81		0.90	4.71	8	4	2	many	2'	trees, 0.42 mi guardrail
10	49		TUO		23.69		26.03	2.34	9	2	1	many	1-3'	trees, steep embankment, 0.67 mi guardrail
3	50		ED		32.57		33.42	0.85	9	2	5	many	0-1'	trees, 0.22 mi guardrail
6	58		KER		16.70		16.93	0.23	10	0	5	moderate	2'	
2	70		PLU		21.06		23.47	2.41	11	1	8	many	0-1' paved	deep ravine, river, 0.22 mi guardrail
2	70		PLU		30.55		32.26	1.71	9	0	7		0-1' paved	deep ravine, river, 0.50 mi guardrail
8	74		RIV		3.39		5.25	1.86	17	2	13	many	3-4'	trees, rocks, steep embankment, 0.21 mi guardrail
8	74		RIV		8.61		9.20	0.59	15	1	8	many	3-4'	0.12 mi guardrail
8	79		RIV		33.30		33.88	0.58	9	0	8	moderate	2'	construction zone
4	84		SM		11.72		14.46	2.74	9	1	5	many	2'	trees, 0..07 mi guardrail
3	84		YOL		12.70		14.10	1.40	7	1	4	few	0-1'	canal, trees
10	88		AMA		43.20		45.00	1.80	18	0	13	many	1-2'	trees
3	89		ED		15.24		15.47	0.23	7	0	4	many	2-3'	trees, rocks, very steep embankment
3	89		ED		22.48		25.08	2.60	17	1	7	many	3-4'	trees, rocks, steep embankment, 0.17 mi guardrail
1	101		DN		7.75		9.65	1.90	8	1	4	many	4' paved	trees
1	101		DN		17.96		18.56	0.60	8	1	4	many	2' paved	trees
1	101		MEN		94.59		96.13	1.54	7	1	5	many	2-4' paved	trees, ravine, steep embankment, 0.26 mi guardrail
11	111		IMP		29.64		30.2	0.56	7	0	3			
4	116		SON		42.68		43.66	0.98	7	2	4	many	2'	0.48 mi guardrail
7	126		LA		0.01		1.00	0.99	14	1	8	few	3-4'	trees
7	126		VEN		27.41		28.15	0.74	7	0	6	moderate	5'	trees, 0.17 mi guardrail
1	128		MEN		39.34		42.61	3.27	10	1	3	many	2' paved	trees
10	132		STA		3.35		4.30	0.95	14	2	7	moderate	5'	trees, water
8	138		SBD		18.48		19.00	0.52	6	0	4	many	2-3'	
2	147		PLU		8.08		9.13	1.05	7	0	7	many	0-1'	trees
3	160		SAC		0.51		3.98	3.47	32	2	19	few	0-1'	trees, river, 0.23 mi guardrail
3	160		SAC	L	3.91	L	6.16	2.25	18	4	9	few	0-1'	trees, river, 0.08 mi guardrail
3	160		SAC		13.00		15.52	2.52	9	2	5	few	0-1'	trees, river, 0.08 mi guardrail
3	160		SAC		19.70		20.86	1.16	8	1	5	many	0-1'	trees, river, 0.01 mi guardrail
3	160		SAC		23.30		24.06	0.76	13	1	5	few	1-2'	trees
6	178		KER		18.00		20.81	2.81	19	2	12	many	0-1'	rocks, river, steep embankment
6	180		FRE		76.00		76.59	0.59	9	0	6	moderate	0-5'	trees
5	198		MON		12.46		18.20	5.74	19	2	11	many	0-1'	trees, steep embankment, 0.04 mi guardrail
1	199		DN		7.01		7.74	0.73	6	2	3	many	4' paved	trees, steep embankment, river, 0.18 mi guardrail
1	199		DN		9.12		10.89	1.77	12	0	11	many	2'paved	trees, steep embankment, river, rocks, 0.25 mi guardrail
1	254		HUM		0.48		1.28	0.80	9	0	7	many	1' paved	trees
1	299		HUM		29.87		36.24	6.37	27	2	13	many	2'paved	steep embankment
9	395		MNO		8.97		9.43	0.46	6	1	3	moderate	5'	0.10 mi guardrail
								124.57	730	71	439			

These locations of accident concentrations comprise 11% of the total over-embankment accidents, 11% of injury over-embankment accidents, and 19% of the fatal over-embankment accidents. As can be seen from this list, almost all of the locations have curves with little or no shoulder. Many locations have trees in the roadside environment. Despite the presence of guardrail at many of the locations, over-embankment accidents still occurred.

CONCLUSIONS

1. Most of the over-embankment accidents occurred at random locations. Only 11% of the over-embankment accidents occurred at concentrated locations (less than 0.5-mile apart). These accidents occurred along 125 miles of rural 2-lane conventional highway.

2. Most of the locations with concentrations of accidents were in areas with trees or water. Approximately 48 percent of the fatal accidents and 36 percent of the injury accidents involved trees or water.

3. Most of the locations with concentrations of accidents had numerous curves with little or no shoulder.

4. Over-embankment accidents on rural 2-lane conventional highways have a DUI involvement nearly 3 times greater than that for all roads.

5. Nearly half of the over-embankment accidents occurred on the opposite side of the roadway that the vehicle was traveling. Many of these over-embankment accidents involved over-correction by the driver.

6. Less than 1% of the fatal over-embankment accidents were caused by the vehicle *only* going down the embankment. Many of the fatal over-embankment accidents involved rollovers, hitting fixed objects, and going into the water.

RECOMMENDATIONS

1. The locations that were identified as having concentrations of over-embankment accidents should be investigated further to determine whether a safety project is warranted. Countermeasures might include installing new guardrail, lengthening existing guardrail, extending embankment guardrail near cut-slope areas and burying guardrail into the cut-slope, providing additional signing and striping, improving the shoulder, installing rumble strips, installing audible edge stripes, or cleaning up the roadside environment to provide a clear recovery area.

2. Since over-embankment accidents on rural 2-lane conventional highways have a DUI involvement nearly 3 times higher than that for all roads, a program of enforcement should be initiated which would concentrate on locations having the highest DUI involvement.

3. Since the "equal severity curve" does not apply to accidents which involve trees, water and other fixed objects, it will not apply to almost 50% of the locations having concentrations of fatal over-embankment accidents. At locations such as these, it is recommended that measures be taken to reduce the potential for over-embankment accidents and to make the roadside environment more forgiving. Such measures might include those listed above.

REFERENCES

1. Glennon, J. C., and Tamburri, T. N., "Objective Criteria for Guardrail Installations," California Division of Highways, July 1966.

2. Tye, E. J., "Highway Research Report, Embankment Guardrail," California Department of Transportation, March 1980.

3. "Guidelines for CURE Projects on Rural Conventional Highways," California Department of Transportation, November 1993.