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EMERGENCY ESCAPE RAMPS FOR RUNAWAY HEAVY VEHICLES

March 1978

Final Report

Prepared for

FEDERAL HIGHWAY ADMINISTRATION

Offices of Research & Development

Washington, D. C. 20590

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16. Abstract (Limit: 200 words)

This report presents a state-of-the practice synopsis of EERRHV technology, findings of a current questionnaire survey, and an overview of existing ramp facilities in regard to design, construction, and practical operational techniques. Several existing emergency escape lanes are described, listing many of the benefits and shortcomings of each.

17. Document Analysis a. Descriptors

Emergency Escape Ramps for Runaway Heavy Vehicles
Emergency Escape Lanes
Truck Runoffs

b. Identifiers/Open-Ended Terms

Gravity ramps - Escape lanes utilizing an inclining grade to gradually stop a runaway vehicle.
Arrester bed - An area of friction material to trap a runaway vehicle.

c. COSATI Field/Group Highway safety, Heavy vehicle hazards

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WASHINGTON, D.C. 20590

ERRATA

Emergency Escape Ramps for Runaway
Heavy Vehicles, FHWA-TS-79-201

The front cover, Item Number 5 on the Report Documentation Page (immediately following the front cover) and the cover sheet reflect a date of this document of March 1978. This is in error. The date should read MARCH 1979.

Form FHWA 121 (Rev. 5-73)

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

DATE: 19 MAR 1979

In reply refer to: HDV-21

SUBJECT: "Emergency Escape Ramps for Runaway Heavy Vehicles," FHWA-TS-79-201

FROM: Chief, Implementation Division
Office of Development
Washington, D.C.

TO: Regional Federal Highway Administrators
Regions 1-3-10
Regional Engineer 15

For the past 20 or so years we have seen the increasing use of downgrade emergency escape ramps for runaway vehicles. Some ramps appear to operate very satisfactorily. In fact, the experiences many jurisdictions have had indicate a significant over-design. National standards have yet to be established.

The magnitude of the runaway vehicle problem is not completely known. The August 21, 1978, issue of "Status Report" (publication of the Insurance Institute for Highway Safety) included an article on the experience of two escape lanes. The article states that the study has, "....uncovered data indicating the brake failure problem for large trucks and tankers may be far greater than official statistics show."

In response to this problem, the Tennessee Department of Transportation, under contract to the Implementation Division, has developed a state-of-the-practice report and slide-tape presentation on emergency escape ramps for runaway heavy vehicles. The authors classify escape ramps into gravity type, arrestor type and a combination of gravity and arrestor type. The report and slide-tape should be of interest to designers and operators of highways in mountainous or hilly terrain.

Copies of the brochure, report and slide-tape are being distributed to the FHWA field offices in the prescribed number and procedure previously agreed upon.

Additional copies of the report are available from the Implementation Division, HDV-21, Washington, D.C. 20590. Loan copies of the slide-tape are available from the National Highway Institute, HHI-4, Washington, D.C. 20590.

Milton P. Criswell

EMERGENCY ESCAPE RAMPS
FOR RUNAWAY HEAVY VEHICLES

A state-of-the-practice report

March, 1978

Prepared By

The Tennessee Department of Transportation
Bureau of Planning and Programming
Office of Research and Planning

In cooperation with the

U. S. Department of Transportation
Federal Highway Administration

Basic Agreement No. D.O.T. - FH-11-9135

ACKNOWLEDGMENTS

In March, 1977 the Research Engineer for the Tennessee Department of Transportation sent an EERRHV survey form to each State, the District of Columbia, and Puerto Rico. Subsequently, the Research Engineer visited most of the States with existing escape ramps for a personal evaluation of representative facilities. Appreciation is extended to those States responding to the survey, and to the Highway Officials who offered their time and expertise in contributing to this report.

Additionally, we are deeply indebted to Mr. J. H. Versteeg, Road Design Engineer for the Oregon State Highway Division. This report utilizes a great deal of information derived from his excellent presentation on emergency escape ramps to the 1976 meeting of the AASHTO Subcommittee on Design held at Phoenix, Arizona.

CREDITS

In addition to the acknowledgements on the preceding page, many thanks go to the following for their guidance and assistance in the production of this report and accompanying slide and tape presentation.

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Use of Metric Units of Measurement

The analyses and compilations in this report were made with English units of measurements. It was decided that showing the dual system of English and metric units would not be practical due to the vast amount of measurements and dimensions contained within the document. To convert English units to metric units the following conversion factors should be used.

Multiply English unit	by	To obtain metric unit
miles (mi)	1.609	kilometers (km)
feet (ft)	0.3048	meters (m)
inches (in)	2.54	centimeters (cm)

The reader is also referred to ASTM E380-76, "Standard for Metric Practice."

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SUMMARY

1. This report presents a state-of-the practice synopsis of EERRHV technology, findings of a current questionnaire survey, and an overview of existing escape ramp facilities in regard to design, construction, and practical operational techniques.

2. The truck escape ramp designs in use today are the (1) Gravity-type ramp, (2) sand and gravel arrester beds, and (3) combination gravity and arrester bed.

3. Contributing factors for the optimization of any escape ramp design include terrain, lengths, dimensions, delineation, approach signs, and service roads.

4. A program of public awareness is vital to assure that all motorists are familiar with the purpose and operations of an EERRHV.

5. Interviews with drivers, motor carriers, highway maintenance foremen, patrolmen, and design and traffic engineers have provided valuable insights to the location, operation, and maintenance of escape ramps.

6. Vehicle removal costs are usually the responsibility of the user, and vehicle removal is usually provided by a private towing firm. Costs are dependent upon degree of entrapment but usually range from $100 for minimum towing efforts to $600 for greater efforts of removal.

7. Funding for the construction of escape ramps is usually 100% state and/or local funds. If escape ramps are designed and approved for construction concurrent with the design of a Federal-aid highway project, there is a possibility of using the same Federal/State funding ratio as applied to the principle project.

8. Escape ramps, along with the utilization of brake-check and trucker awareness of the potential dangers, may well be the most cost-effective and rational alternative for minimizing the high hazards associated with steep grades.

EMERGENCY ESCAPE RAMPS FOR RUNAWAY HEAVY VEHICLES

INTRODUCTION

In recent years, transportation officials across the nation have become increasingly concerned about the potential danger of and the real destruction caused by runaway trucks. Every steep hill, ridge, and mountain range presents a potential hazard over which highway managers and transport personnel have no control. For this reason, state highway officials are experimenting on an individual basis with solutions to this problem, trying to minimize the loss of human lives and property damage which may result when a truck's brakes fail. There are now approximately sixty escape ramps built and another fifteen in the planning stages throughout the country. There is, however, no formal design or construction criteria for guidance in planning these essential safety devices.

The Tennessee Department of Transportation has performed an investigation into the subject of Emergency Escape Ramps for Runaway Heavy Vehicles (EERRHV). The study, financed by a grant from the Federal Highway Administration, presents a valuable source of information on the design, construction, and operation of existing and proposed escape ramps throughout the country.

The objective of the study effort was to develop a "state-of-the-practice" report for use by transportation planners and engineers. The study was conducted by reviewing and analyzing existing emergency escape ramps across the United States and identifying the benefits and shortcomings of each. It was found, for instance, that no one type or style of escape ramp is feasible in all situations; each location and physical condition must be considered individually. Another vital factor in the success of the escape ramp, established by the study, involves informing the motoring public of the function and purpose of the escape ramp.

This report presents the findings of a nationwide study on Emergency Escape Ramps for Runaway Heavy Vehicles. It has been prepared to provide transportation planners and engineers with data on the techniques and schemes used in the development and operation of the presently existing and planned emergency escape ramps.

CONCEPT OF EMERGENCY ESCAPE RAMPS FOR RUNAWAY HEAVY VEHICLES

The ability of Emergency Escape Ramps for Runaway Heavy Vehicles (EERRHV) to safely stop runaway vehicles has been recognized by highway engineers for many years. Through trial and error effective escape ramps have been constructed and usage has proven them effective in saving lives and reducing property damage in runaway truck incidents.

Roadways that show the greatest need for escape ramps generally have long descending grades which, because of a failure to select the proper gear, results in speeds requiring extensive brake usage. This can cause truck brakes to become overheated and ineffective. Traffic accident records can help identify those areas that have a high incidence of runaway trucks.

EARLY PROJECTS

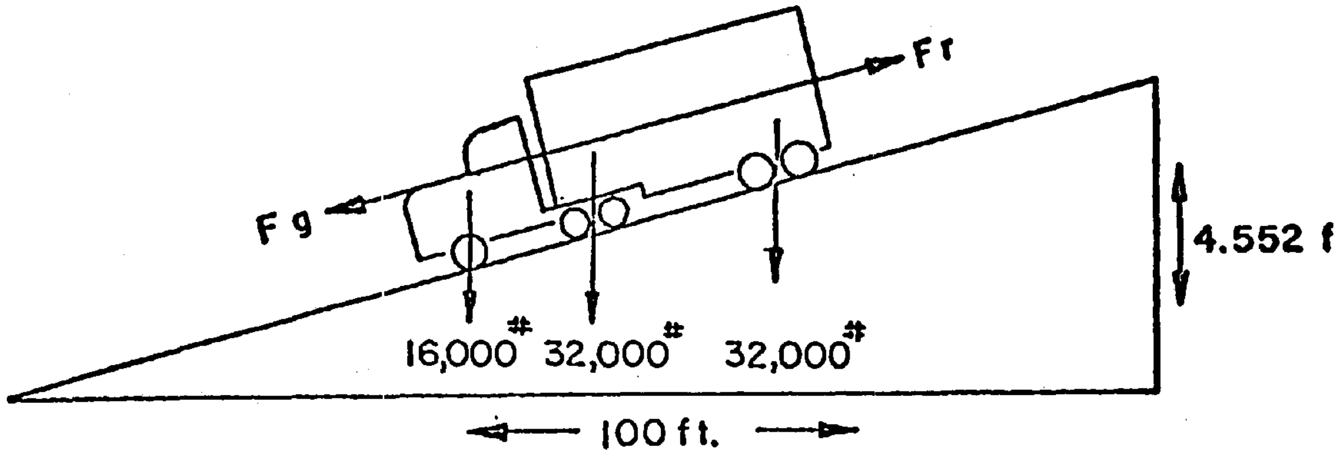
Records indicate the first escape ramp was constructed approximately 22 years ago. California was one of the first western states to construct an escape ramp. In 1956 a ramp was opened on Highway 99, 3.5 miles below the summit of Five Mile Grade (better known as the "grapevine").

The early ramp was built on the gentle up-slope of a hill that had been used for years by runaway trucks. Initially only minor grading and signing was done to allow easier access to the hill but as time went on the ramp was improved and its use very closely observed. This was the basis for studies that established the design guidelines indicating the following stopping distances.

Runaway Speed - MPH		Stopping Distance - Ft.
Radar Recorder	Driver Estimate	Measured from Entrance
20-30	25-40	100-300
30-40	35-50	300-500
40-50	45-65	500-650
50-65	60-80	650-700
65-70	75-90	700-750

In 1969 Utah included a truck escape lane design in the construction plans for the I-80 Freeway. The Utah State Department of Transportation began studying escape ramps initially for the purpose of constructing the runaway truck lane in Parleys Canyon, east of Salt Lake City. They gained empirical proof of the theoretical decelerating abilities of gravel by testing passenger cars in gravel beds constructed for the purpose of the research. Examples of their findings follow:

The semi-trailer truck decelerates on the -4.552% grade at an average rate of 9.715 ft/sec^2 through the truck escape lane a distance of 800'. If the entrance speed to the ramp is 85 mph, the vehicle stops in this section.



$Fg = (32{,}000\#)(\sin \tan^{-1} .04552) = (32{,}000\#)(.04547)$

$Fr = WR$ W = weight R = rolling resistance

$Fr = -(32{,}000\#)(.3472)$

$Ft = Fg = Fr = (32{,}000\#)(.04547-.3472) = -9655.36\#$

$a = F/m = Fg/w$

$a = (-9655.36\#)(32.2 \text{ ft/sec}^2)/(32{,}000\#)$

$a = -9.715 \text{ ft/sec}^2$

Assume an entrance speed of 85 mph

$V_1 = (85 \text{ mi/hr})(5280 \text{ ft/mi})(\text{hr}/3600 \text{ sec})$

$V_1 = 124.667 \text{ ft/sec}$

$x = (V_f^2 - V_1^2)/2a$

x = distance traveled on -4.552% grade is 800 ft.

Note: Rolling resistance is expressed as pounds per 1000 pounds of gross axle weight or as percentage factors. Utah tandem axle maximum gross weight is 32,000 pounds.

Virginia is one of the first eastern states to have constructed truck escape ramps. In attempting to stop runaway trucks on a narrow primary highway with sharp curves and steep grades (max. 8%), two sand pile ramps were built in 1972. Virginia developed a formula that considers speed, friction and resistance. The length of the ramp is based on grade, plus air resistance plus 50 lbs/ton rolling resistance. The design vehicle is a C-50 semi-trailer with a weight of 72,000 pounds. Initial design speed is 90 mph and final design speed is 0.

Pos. Grade %	Resistance	Length Required Lin. Ft.
10	.10	2,080
15	.15	1,500
20	.20	1,175
25	.24	1,000
30	.29	820
35	.33	750

TYPES OF ESCAPE RAMPS

Though no single ramp design standards have been adopted nationally, several states have established design criteria based on computations of their own. Many states have made detailed studies of the use of their existing ramps and have used the results to establish design guidelines.

The truck escape ramp designs in use today are the (1) gravity-type ramp, (2a.) sand or (2b.) gravel arrester beds (level or negative grades) (3) gravity ramps with arrester beds.

1. Gravity ramps have steep ascending grades and are surfaced with asphalt, stone, or gravel. Nevada, Oregon, Pennsylvania, Vermont, Virginia, Washington, and Wyoming are among the states having this type of ramp in use.

   These ramps vary in length from 300' to 3,000'; in width from 12' to 45'; in grades from +5% to +43%; in surfacing depth from 6" to 36". Surfacing materials used are loose gravel, pea gravel or sand. Ramps may have berms or mounds at the end.

2a. Sand arrester beds are used in North Carolina and Virginia to stop runaway trucks. Lengths vary from 85' to 200' with a height of 10' and a top width of 20'. Mounds or ridges are generally built on top of the sand arrester bed high enough to drag the undercarriage of a vehicle.

   Sand arrester beds are economical to construct and only require a small area. Performance is excellent and the maintenance is limited to preventing packing and to maintain the shape of the sand piles and ridges.

2b. Gravel arrester beds are beds of loose gravel that stop the runaway vehicle by rolling friction. The profile grade is generally nearly flat. Lengths vary from 300' to 700', widths are 18'-20' and surfacing is generally 18" of pea gravel.

These arrester beds have been constructed in small areas such as median areas and at the end of interchange ramps. They are effectively being used in Alabama, California, Idaho, Oregon, Pennsylvania, South Dakota, Tennessee, Utah and Wyoming to stop runaway vehicles. They are economical to construct and maintain. The surfacing material must be well drained to prevent freezing and the beds must be loosened periodically to prevent packing.

3. Also in use today is a combination gravity ramp and arrester bed. This type of design relies on the loose surfacing material to assist in bringing the runaway vehicle to a stop. Design lengths have been from 550' to 2,200' and the widths have been some 18' to 50', grades vary from a plus 2.7% to a plus 26%. Surfacing material can be loose gravel or pea gravel with a depth of 12" or more.

In many cases a berm has been constructed at the end of these ramps. Performance results have been excellent. These require the same maintenance as the arrester bed types of ramps. Colorado, Idaho, Oregon, Vermont, and West Virginia have these ramps in use.

DESIRABLE CONDITIONS FOR EERRHV

The following conditions are desirable when constructing an effective escape ramp:

1. The adjacent terrain must have adequate area to physically build the facility.

2. The length of the ramp must be sufficient to safely stop a vehicle. However, the shorter a ramp is that will allow safe stopping for the design speed, the easier it is to locate the ramp at the most desirable location. The best location is in advance of a critical curve or the bottom of the grade, if a community is endangered by the runaway truck.

3. The width of the arresting bed is important as it is possible to have more than one vehicle at a time in the escape ramp. In rare instances there have been as many as three vehicles in one escape ramp at the same time.

4. Access to the ramp must be well marked so that a vehicle traveling at a high rate of speed can safely enter the ramp. It is not uncommon for heavy runaway vehicles to reach speeds of 80 to 90 mph. In areas receiving heavy snow the ramp can be hidden. Ramp approaches should be plowed the same as travel lanes and should be marked with delineators and snow poles.

5. Surfacing materials used in the arrestor bed vary from various gradations of gravel to sand. Regardless of the material used it must be free draining so that freezing will be delayed during

periods of cold weather and will not readily compact. It must be a material that can be readily smoothed out after use and can be maintained with a minimum of effort.

6. The arrester bed material should also insure that once a vehicle is stopped it will not roll back. Maintenance is necessary to keep the ramp in the proper condition. The ruts must be smoothed out and the surfacing material loosened frequently. As the material becomes infiltrated with dirt and other fine materials it must be removed and replaced with clean material.

7. Service roads adjacent to the stopping beds should be surfaced so that wreckers and maintenance vehicles may use them without becoming stuck. Wrecker tie-downs need to be constructed either in the stopping bed or along the adjacent service road. The anchors should be close enough together so that equipment on the average wrecker can reach them. Generally a spacing of 300' is sufficient for this purpose.

8. Signing is important to warn the driver of the downgrades ahead so that he may stop and make the necessary checks of his vehicle before proceeding. Signing is also important to inform the driver of the location of an escape ramp.

9 Every effort should be made to inform and educate the motoring public of the uses and purpose of escape lanes; this may be accomplished by proper signing and informative displays at welcome centers, rest areas, and roadside parks.

10. Variations in the design of emergency escape ramps are necessitated by the many topographic restraints on steep downgrades. These topographic limitations dictate the type of escape ramp, and in many cases an arrester bed must be used to slow the runaway truck in the space available.

In the design of arrester beds it is important to use round gravel as large and uniformly graded as is available and as free from fines as possible. The use of uniformly-graded material, washed when possible, will maximize the percentage of voids in the material, thereby providing the optimum drainage and minimizing interlocking and compaction.

The use of such large uniformly-graded gravel will minimize the problems due to moisture retention and freezing as well as minimizing required maintenance which must be performed by scarifying when material compacts.

All of the above maximize the retarding characteristics of the arrester bed.

11. Delineation must be developed that is different from the standard white and yellow delineators now approved. It has been reported on occasion that vehicles not wishing to use the facility have been led into the escape ramp by the delineation. It is suggested that red delineators be considered for this use.

12. If the vehicle leaving the road will drop one front wheel off the pavement before the other front wheel drops off, a squared-off apron should be built so that both front wheels drop off at the same time.

13. A graduated depth of arresting material should be placed over the first 200 or so feet of the ramp so that a vehicle utilizing the ramp will not be stopped too abruptly.

EXISTING FACILITIES

Alabama

Alabama has one emergency escape ramp. It is located on U. S. 31 south of Birmingham in the City of Vestavia Hills. The ramp was built under a special fund known as the "Governor's Death Trap" in 1974.

In a 1977 interview the Division Engineer for the Alabama Highway Department described the U.S. 31 escape ramp as consisting of ¼ to 3/8-inch diameter round gravel, very well graded, not crushed. He added that since I-65 has taken much of the truck traffic off U.S. 31, the ramp is not used as often as prior to the interstate opening. Because of this, the ramp is maintained only routinely by hand labor.

In one simulated runaway truck incident, a 63,000 pound dump truck entered the ramp at 40 miles per hour. The twenty-inch layer of loose gravel stopped the truck within thirty feet. One serious complaint from both truckers and other motorist is that the ramp is sometimes mistaken as a normal roadside area and drivers pull into the ramp, requiring help to exit the facility.

Because of the geographic location of the ramp, freezing weather is not a serious problem for the effectiveness of the facility.

Alaska

Alaska presently has two emergency escape ramps under construction.

Arizona

Arizona does not have any constructed emergency escape ramps. The ADOT has, however, installed an experimental gravel arrester bed to help prevent vehicles from hitting a median bridge column located 28 feet from the traffic lane. Experiments proved unsuccessful in providing alternative devices for standard sand barrel attenuators due to a restricted length.

California

California presently has two emergency escape ramps. One is located near the Oregon State Line on 1-5 and the second located in the metropolitan area of Los Angeles. The State is also credited with constructing the nation's first escape ramp on record. In 1956 an escape ramp was constructed on Highway 99, 3.5 miles below the summit of Five Mile Grade (better known as the "grapevine"). The usage records on this facility are very impressive.

The ramp as developed was 1,150' long. It left the highway on an average downgrade of about 4% for the first 500 feet. The gradient then changed to an upgrade of 17% for a distance of 300 feet, the ramp rising 40 feet in this climb. The ramp was 60' wide as it left the highway, gradually narrowed to 50 feet at the sag and was 18 feet wide at the end.

A layer of 3/8" pea gravel started a short distance from the highway and gradually increased in thickness to 36 inches at the sag and continued at that depth up to the crest. The pea gravel was raked over after each occupancy in order to keep it loosened and uniform to travel through. Approximately every two years portions of gravel that were found to be packing because of contamination were removed and replaced with clean material.

Through the years the ramp averaged one truck each 10 days. In 1967 it was used 30 times; in 1968, 33 times; and 23 times in 1969. In 1970 the 1-5 freeway was completed, bypassing Five Mile Grade, and the truck escape ramp was no longer needed.

The ramp located in the metropolitan Los Angeles area in La Canada is of the arrester bed type. It is unique in that it is located in the median on the Angeles Crest Highway. The median consists of an 18-foot wide curbed bed containing uniformly graded ¼-inch to 3/8-inch gravel. The arrester bed was designed to decelerate an entering vehicle, regardless of vehicle type or weight at approximately 0.6 g's (g=32 ft/sec/sec).

One benefit of this ramp, in addition to providing an emergency facility, is that no additional right-of-way was required. The ramp cost approximately $30,000, which was 100% state funds. The highway passes thru a residential area and shrubbery has been placed in the arrester bed and an irrigation system installed to improve and maintain an aesthetic appearance.

The State is also using an arrester bed design in the northern part of the state located at the end of a freeway exit ramp. A number of accidents have occurred in the past when trucks exiting from the freeway were unable to stop at the end of the ramp and shot across the Kalamth Highway. The bed of loose gravel helped solve the problem of stopping these trucks. No problems have been experienced crossing the highway because of the extremely light traffic.

Colorado

The State of Colorado has a combination gravity- arrester bed escape ramp in operation - on the west side of Rabbit Ears Pass on US-40, and two ramps are being planned at Vail Pass on I-70.

The ramp constructed on US-40, was begun in August, 1976 under a $235,266 contract. The ramp is 1300 feet long and 24 feet wide. It leaves the highway on a -6.5% grade, leveling with 400 feet of a +2.7% grade then ending with 100 feet of 43% ascending grade. The ramp is surfaced with compacted aggregate as it leaves the highway with 12 inches of pea gravel on the remainder.

Hawaii

Hawaii presently has four emergency escape ramps. The first, on Pali Highway, was constructed by the Department of Transportation's maintenance crew following alignment and grade "eye balled" in the field.

There are no standard records kept on the performance of the ramps, but there have been no reported failures in the operation of the facility.

Idaho

The Idaho Transportation Department has seven escape ramps in operation. Two gravity and arrester bed ramps were constructed on south bound U.S. 95 on the Lewiston Hill Relocation Project just north of Lewiston where there is a downgrade of 6.7% for more than five miles. The ramps are 665 feet long with a 20% ascending grade. A 30-inch deep pea gravel bed 30 feet wide was placed on the ascending grade portion of the ramp. The ramp from the highway through the sag vertical and the adjacent service road is surfaced with aggregate base. An additional arrester bed was placed on the old U.S. 95 road bed at the bottom of the grade.

The State has a gravity ramp which has been supplemented with a sand arrester bed south bound on U.S. 95 north of Bonner Ferry. It was constructed in 1962 and is still in service today. It has served well even though it may not meet today's standards, according to Department Officials. A similar installation was made north of White Bird south bound on U.S. 95.

Kentucky

The Kentucky Department of Transportation has plans under development for an emergency escape ramp located on a long hill with a -7% grade. The ramp is planned for a length of 500 feet after it separates from the highway, and a width of 24 feet in the stopping area. The ascending grade is 20% with a short length of 13.5% at the end. The ramp will have 12 inches of loose gravel surfacing and an 8-foot shoulder planted with grass.

Montana

Montana has one emergency escape ramp planned for construction in 1978. The project is located on Highway 287 in the southwestern part of the state just east of Virginia City. The existing highway is on a -6.6% grade. The ramp will be 2,200 feet long and on a descending grade of 7.6% to 4.8% and ending on a -5.5% grade. The ramp bed will be surfaced with 12 inches of loose gravel and will be 24 feet in width. A 10-foot wide adjacent towing lane is to be surfaced with 12 inches of compacted crushed base. The future performance of this truck escape ramp built on a minus 5% grade will be important in developing an escape ramp design standard.

Nevada

State maintenance crews constructed an escape ramp on Highway 27 at Incline City near Lake Tahoe in 1969. The ramp length is approximately 300 feet, 20 feet wide and is surfaced with 36 inches of beach sand. The ascending grade is 27.8%. The ramp has only one recorded use to date. A state truck loaded with asphalt traveled the entire length of the ramp with no injury to the driver.

New York

The New York Department of Transportation has two emergency escape ramps in operation; (1) on State Route 10 near Richmondville, (2) Vickerman Hill Trap, south of Mohawk, New York. A third ramp, the Locke-Horner Arrester, is in the planning stages to be located south of Moravia.

The Vickerman Hill Trap is on Route 28 and was originally proposed to be built under Section 209 (High Hazard Locations) of the 1973 Highway Act. The location is at the end of a 10½% grade (1500 feet long) which is the last and steepest of a series of grades for a distance of over four miles. Plans for this project were completed and submitted to the Federal Highway Administration for their review in April, 1976. The FHWA advised the NY-DOT that they had rejected the project for design reasons. Subsequently, the plans were revised and approved for 209 funding.

The project was let to contract in the fall of 1976 and construction was completed in early 1978. The ramp consists of a 500-foot-long arrester bed of gravel, followed by 200-foot-long section of plastic sand barrels. The entrance of the escape ramp is eighteen feet wide bordered by five-foot-high guardrail which gradually tapers down to a width of twelve feet to help prevent jackknifing.

North Carolina

North Carolina presently has four escape ramps open for use. They are of the sand pile type. Mr. Gene Edmonds, Area Traffic Engineer for the NCDOT gives this description of one location which contains two sand piles:

> We have a truck information station which is approximately 20 miles east of Asheville, North Carolina on US-70, temporary Interstate 40. This station is located at the top of the mountain before descending the steep grade eastward. It was installed to give truckers proper warning of the steep descending grade and the speed limit for trucks.

This is a traffic actuated signal that allows trucks to come in, stop, read the information before descending. Also we have advance warning signs telling truckers that all trucks are required to come into this station and read the information before continuing on. The controller used for the truck information station was a standard 1826 PR Automatic Signal Company Controller. Approximately two miles down the mountain we have another place where trucks can pull out to cool their brakes before descending the complete grade. We have proper warning signs advising truckers that they can, as they pull out ahead, stop and check equipment, cool their brakes, or whatever they feel necessary before continuing on down the mountain. Also at one-mile intervals we have erected the "Hill" symbol sign.

In advance of sandpile #1 we have advance warning signs 1 mile, 2500 feet and 1000 feet to advise them of the sandpile ahead. Since it is still considered to be in experimental stages our legal department has advised us not to sign this as a truck escape ramp, and that is why we use the broad term, "sandpile." We feel that this has been very effective since truckers are familiar with this type of thing in many other states. Sandpile #1 is located approximately 3 miles from the top of the mountain. Approximately 200 feet east of sandpile #1, sandpile #2 was constructed. This was so that while #1 was being maintained there would be a place for trucks to escape, and also so that when #1 or #2 is utilized by a truck there will be another ramp available for another truck, since there is some time involved in getting the trucks out of the sand. We also have sandpiles #1 and #2 lighted so that approaches to them can be seen well at night. In addition, we have installed stop-action cameras which are traffic actuated and will hopefully give us some information concerning speed and what happens to the truck as it goes through the sandpile. The routine maintenance on the sandpiles occurs approximately every 1-6 weeks, and is done by a bulldozer. Between maintenance times, if a truck utilizes a sandpile, we handwork it with shovels.

Oregon

Oregon is considered to be one of the leaders in the development of emergency escape ramps. The road design engineer for the Oregon State Highway Division, J. H. Versteeg, presented a report on the State's emergency ramps to the 1976 meeting of the AASHTO Subcommittee on Design held at Phoenix, Arizona. His anaylsis of Oregon's escape ramp projects is included here:

Interstate 80-N, the major east-west route in Oregon, crosses the summit of the Blue Mountains between Pendleton and La Grande. The average daily traffic volumes are 4,500, 26% of which are classified as heavy vehicles.

The westbound, downhill, lanes have seven miles of 6% grade for most of that distance. There are eight curves to the bottom of the hill.the sharpest being a 5°7' curve.

Two escape ramps were constructed; one located about two miles from the beginning of the downgrade and the other located about 4 miles from the beginning of the downgrade.

The profile of the lower escape ramp consists of a -5.4% approach grade, a 400' sag vertical curve and a +17% grade extending about 800 feet. The upper ramp is shorter but has similar grades. The lower ramp is 43' wide with a usable width of 30 feet. The service road is 14' wide with wrecker hold-down anchors spaced at 300 feet. Edges of the ramp are marked with guide posts.

The taper from the highway was initially constructed with 16" of plant mix aggregate base - sag vertical and the ramp had 30" of pea gravel surfacing. After some use, it was realized that there were two minor problems with the ramp operation. The first problem consisted of slow speed trucks with hot brakes drifting into the sag in order to stop - then becoming trapped in the loose pea gravel. This problem has been eliminated by removal of the pea gravel in the sag and replacing it with crushed aggregate base material. The area from the highway to the sag vertical has been paved to ease the truck removal from the escape ramp. The second problem was caused by too many trucks parking at the beginning of the ramp just to cool their brakes. This blocked the ramp from use by other runaway trucks. This problem has almost been eliminated by "No Parking" signs near the entrance at the right of the service road.

After this change in surfacing, use-records indicate that those trucks able to stop in the sag do not get trapped. The trucks that are traveling faster and must use the higher part of the ramp to stop actually go very little further up the 17% grade and are easily removed from the escape ramp.

A series of signs have been installed; first, warning the truckers of the 6% downgrade, second, advising them of a brake test area to give them the opportunity to stop and inspect their rigs before proceeding down the mountain, and third, directing them to the ramps. Also the "No Parking" signs have been installed to prevent blockage of the ramp by sightseers or truckers parked to cool their brakes.

Trucks using the ramp in cold winter weather have been successfully stopped without damage to the truck or injury to the driver. They do go further up the ramp if the pea gravel is frozen or covered with snow. Ruts that have not been smoothed out from previous incidents and then refrozen have caused minor problems.

The fastest of the trucks reported in the lower ramp was traveling an estimated 90 mph. The maximum horizontal travel with the pea gravel not frozen was about 450 feet and vertical rise was 37 feet.

One driver, interviewed after successfully using the truck escape ramp, reported that he expected to decelerate quite rapidly and braced himself against the steering wheel but was surprised when the truck decelerated smoothly.

After witnessing a runaway truck (loaded with sheet steel) use the escape ramp, one observer commented on the simplicity and effectiveness of the ramp. Though the driver had no idea of his actual speed, the truck's course was straight and the semi-trailer remained in alignment with the tractor's path. Even after attempting to back out the tractor was only tire deep in the pea gravel.

In the 18-month period from September 1973 to March 1975, there were four different days on which three trucks used the ramps and one day with four trucks, three of which were in the lower ramp at the same time. During the same 18 months of use the following information was obtained. (The use-totals, unfortunately, include four-wheelers, sightseers and other uninvited guests.)

1. Ramp Use: Upper - 18. Lower - 176. Approximately 91% using lower ramp.

2. There were 136 trucks, one pick-up and 57 cars. Approximately 70% of the vehicles using the ramps were trucks.

3. Speeds of the vehicles using the ramps ranged from 20 to 90 mph with the average speed of 50 mph.

4. Reasons for using the ramp:

   Trucks: The majority were hot brakes; next, brake failure; third, driver error.

   Cars: Most cars were sightseers.

Many of the trucks which have entered these ramps at low speeds of 20 to 30 miles per hour probably could have negotiated the remainder of the downgrade without incident.

We believe that a number of those traveling at higher speeds would have lost control before they got to the bottom of the grade with probably property damage, injuries and possibly loss of lives.

The $200,000 cost of constructing the truck escape ramps appears to have been already paid off in property damage savings alone. Many more thousands of dollars will probably be saved in the future.

A section of the Willamette Highway some 60 miles easterly of Eugene, Oregon, has a history of a large number of truck accidents. There is a stretch of approximately 3-1/2 miles of a 5 to 6% downgrade having an ADT of 1,900 with 27% trucks. During the 4-1/2 years from 1970 to the middle of 1974 there were some 25 truck related accidents which resulted in 2 deaths and 11 injuries. Since that reporting period there has been at least one other truck related fatality. Trucks losing brakes on this section often reach speeds of 70 miles per hour.

To overcome this problem, two truck escape ramps are being constructed at a total cost of $200,000. (Editor's note: These ramps are presently in operation.) The first one is located approximately halfway down the grade and the second one is near the bottom just prior to the last curve. These ramps are the "gravity" type design, one having 700' of 10% ascending grade and the other has 600' of 13% ascending grade. The 700' ramp with the 10% grade will have one pea gravel barrier at the upper end, while the 600' ramp will have five similar pea gravel barriers. The ramp area from the highway and on through the sag vertical curve will be surfaced with 16 inches of crushed rock. The remainder of the ramp will be surfaced with 16 inches of pea gravel. Wrecker anchors will be constructed to assist in removing trucks from the ramp.

Design attention is currently being focused on a problem area in southern Oregon. Truck escape ramps are needed on the northbound lanes of the 1-5 Freeway below the Siskiyou Summit, between the California State Line and Ashland. It is estimated there is an average of one runaway a month on this section. The ADT is 8,500 with 2,300 classified as heavy trucks.

There is approximately 7 miles of northbound freeway with minus grades from 5% to 6.5%. The roadside terrain does not lend itself to the design of a gravity type ramp. Other types of designs were considered such as arrester beds and sand piles that could be constructed on a 6% minus grade. Although some research has been done on sand and pea gravel beds, additional studies must be completed before design standards can be developed. Also the legal questions concerning liability must be resolved.

Driver interviews have been helpful in getting firsthand information for escape ramps in this area. Recently some 50 truck drivers were interviewed. Forty-one said a brake check area would be beneficial at the summit and 21 of those said its use should be mandatory for loaded trucks. Thirty-nine said they would use an escape ramp if they could see it soon enough. Hot brakes caused by too much use was reported to be the main cause of problems, followed by driver error and brake failure.

Pennsylvania

The Pennsylvania DOT has installed nine emergency escape ramps throughout the state. Various types of ramps are used, utilizing a number of design techniques and materials.

One particularly interesting runoff facility is the truck escape ramp at the bottom of Indiana Pike (U.S. 422 - Pa. 28, Pa. 66). This project constitutes a milestone in community involvement with PennDOT in that it was developed in cooperation with a civic organization, the Kittanning Jaycees.

The Jaycees contacted the county maintenance superintendent for PennDOT inquiring about the feasibility of installing a truck escape lane at Indiana Pike. Subsequently, a feasibility study was conducted for the project. After considering the right-of-way limitations of the site, a runaway truck arrester bed was recommended. Although arrester beds had never been installed before in Pennsylvania, they had been used successfully in Virginia and North Carolina. Design data from both states provided the basis for designing the arrester bed on the Indiana Pike.

When the feasibility study was completed, the Jaycees were informed that PennDOT could not undertake the entire arrester bed project due to the other financial obligations. It was suggested to the Jaycees that if they could raise the money to purchase the 1700 tons of pea gravel, PennDOT would install the arrester bed, build the approach road, and erect all necessary signing. The Jaycees then decided to undertake the fund raising project and raised approximately $2,300 through their "Buy-A-Ton" campaign. This enabled them to purchase approximately 600 tons of pea gravel. In order to expedite the project, PennDOT supplied the remaining 1,400 tons with other funds.

This act of cooperation between the Kittanning Jaycees and PennDOT aided in implementing a safeguard to the community for which both organizations are to be complimented.

PUERTO RICO

The Highway Authority of the Commonwealth of Puerto Rico has constructed four emergency escape ramps. These ramps were placed where long or steep downgrades exist. There are, however, no records available to this investigator on the usage of these ramps.

SOUTH DAKOTA

South Dakota has one emergency escape ramp open for use. It is located on US-16 south of Rapid City. Two other ramps are in the planning stages on US-385 south of Deadwood-Lead on Strawberry Hill.

TENNESSEE

Tennessee has one emergency escape ramp in operation. It is located on eastbound I-24 descending Monteagle Mountain. This eastbound lane utilizes the alignment of former US-41 which had been a problem for truckers for many years.

The ramp, opened in July 1976, is 550 feet long, fifty feet wide and is surfaced with 36 inches of pea gravel. A five-foot berm is placed at the end to stop any vehicle that may overrun the ramp.

Before and after accident studies for the 1.42 mile section of I-24 show that during seventeen months before the opening of the escape ramp 21 accidents were reported, involving six fatalities and $243,000 in property damage. In the seventeen months following the opening of the ramp there were 22 accidents with two fatalities and $116,300 in property damages; only 50% of these accidents, however, involved a truck running into the escape lane, indicating that losses could have been decreased further if all trucks in trouble were able to utilize the ramp. It is anticipated that as truckers become more familiar with the escape ramp, usage will increase, thus improving the facility's safety record.

UTAH

The Utah State Department of Transportation has two emergency escape lanes in operation. One of these is on I-80 at Parley's Canyon. This ramp and studies relating to its operation have been used as a model for escape ramps in other states.

Interstate 80 was constructed in 1969 and replaced US-40, where numerous truck accidents had occurred. During the design stage of this section of I-80, the Utah Motor Transport Association requested that designs include some method that would permit truck drivers to regain control of trucks in the event drivers had lost control. This prompted the Utah DOT to investigate the possibilities of an emergency escape lane.

After research of existing escape ramp technology and usage, the Department designed a ramp 2480 feet long and 18 feet wide with a ten-foot shoulder.

VERMONT

Vermont has planned three emergency escape lanes. There are two lanes to be located on Vermont Route 9 near Searsburg. The third ramp was constructed on Route 9, near Woodford.

The latter ramp is recently constructed; there are no usage records at this time.

VIRGINIA

The Virginia Department of Highways and Transportation has constructed eight emergency escape ramps throughout the state. The Department has used sand and pea gravel arrester beds for its escape ramps as well as gravity ramps. They have found that sand arrester beds can usually be constructed shorter than gravel arrester beds.

WASHINGTON

Washington constructed a ramp in 1972 west of Clarkston on Alpowa grade at a cost of $80,000. It is 1,300 feet long, varies from 30 to 45 feet wide and has a 20% ascending grade at the end. The original surfacing was crushed top course over ballast. Later, upgraded river rock was added after a truck rolled back down steep grade and overturned. The ramp has been very enthusiastically received throughout the community.

WEST VIRGINIA

The steep and rugged terrain of West Virginia, and the constant heavy hauling by the coal and timber industries presented a need long ago for emergency escape ramps to these industries as well as the West Virginia Department of Highways.

The Department has constructed two escape ramps on US-48 east of Morgantown. In addition, two other escape ramps are planned.

WYOMING

Wyoming has 3 emergency escape ramps in operation at this time. The ramps are constructed at locations which had high accident rates. They have been well received by the truckers and are credited with safely entrapping several runaway vehicles.

The success of the truck runoffs has been credited to adequate signing at the top of the hills requesting all trucks to stop for brake checks, the signs every half mile down the mountain advising of the distance to the runoff, the articles published in local newspapers and trucker association magazines, and the fact that the trucker is looking straight into the runoff and has time to consider the alternative.

Diagrams and layout sheets of several emergency escape ramps are included in Appendix C of this report.

CONCLUSION

Escape ramps, along with the utilization of brake-check areas and truckers' awareness of the potential dangers of runaway vehicles, may well be the most cost-effective and rational alternatives for minimizing the high hazards associated with steep grades. Recognizing this point, however, is only the initial step in solving the problem. From this point it is the responsibility of transportation planners, both public and private, and engineers to effectively use the concept to minimize the loss of lives and property.

Certain critical performance data are needed for the design of escape lanes for runaway trucks. Typically, ramps have been designed to combine the energy absorbing characteristics of a pea gravel roadbed with an ascending grade to stop trucks that have lost their brakes on long downgrades. Most of these have been designed very liberally having adequate length to stop a truck under any circumstance. Frequently, terrain is such that it is not feasible to obtain an upgrade to assist in decelerating the vehicle.

Additional research is needed on arrester beds to quantify what is necessary to stop high speed runaway trucks. Arrester beds have typically employed a deep bed of pea gravel or sand to decelerate the vehicle. From calculations based on reported speeds and measured stopping distances, the coefficients of rolling resistance are usually found in the range of 0.25 to 0.35; however, values both smaller and greater than this range have been determined. Very often the speeds are not reliably reported and the stopping distances are estimated. Field testing is needed so that designers can confidently predict minimum values of rolling resistance for various configurations of arrester beds. This investigator proposes the testing of a design using pea gravel arrester beds with additional transverse ridges of pea gravel about 18 inches high, spaced adjacent to each other along the bed.

A scientific accessment is needed of the effect of freezing on the efficiency of the various arrester bed materials.

Because of the question of liability, highway administrators are reluctant to build truck escape lanes where available lengths and grades are not favorable without more positive assurance that they will work satisfactorily. As the state-of-the-practice evolves for emergency escape ramps and use proves the effectiveness of the facilities this will become evident to public officials, the trucking industry, and the motorist. Success records of existing ramps are already impressive and, as more ramps are built and placed into operation, their benefits will show them to be the most cost-effective method of controlling runaway trucks.

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APPENDIX B Summary of Known Existing and Planned EERRHV

SURVEY RESULTS

State	No.	Location	Type	Surface	Length[1]	% Grade	Date
Alabama	1	US-31, South of Birmingham	A	Gravel	300'	-4½	1974
Alaska	2*	North of Skagway	G	Gravel		+17	1977
California	2	N/B 1-5 at Klamath Siskiyou County	A	Gravel	250'	±5	1974
		S/B CA-2 at La Canada Los Angeles County	A	Gravel	595'	neg.	1972
Colorado	1 7*	Rabbit Ears Pass	C	Gravel	1300'	-6.5 +2.7	1976
Hawaii	4	Pali Highway	G	Gravel	2900'	-7.5 +15	1968
		Likelike Highway	C	Gravel	175'	-8.3 +15.5	1975
		Likelike Highway	A	Gravel	200'	-7.3 -5.0	1975
		Pali Highway - no plans available					
Idaho	7	US-95, Bonners Ferry	C	Sand	577'	-6 +26.7	1962
		US-95, Lewiston #1**	C	Gravel	300' 300'	-6.0 +20	1977
		US-95, Lewiston #2	C	Gravel	300' 300'	-7.0 +20	1977
		US-95, Lewiston #3	A	Gravel	400'	0	1977
		US-95, White Bird #1	C	Gravel	400'	+20	1977
		US-95, White Bird #2	C	Gravel Arrester bed added	350'	+20	1973 1977
		US-95, White Bird #3	A	Gravel	900'	-6.5	*
Montana	1	Highway 287	A	Gravel	2200'	-5.5	1978*

A - Arrester Bed
G - Gravity Ramp
C - Combination of A and G
*Under design or construction during 1977 survey period

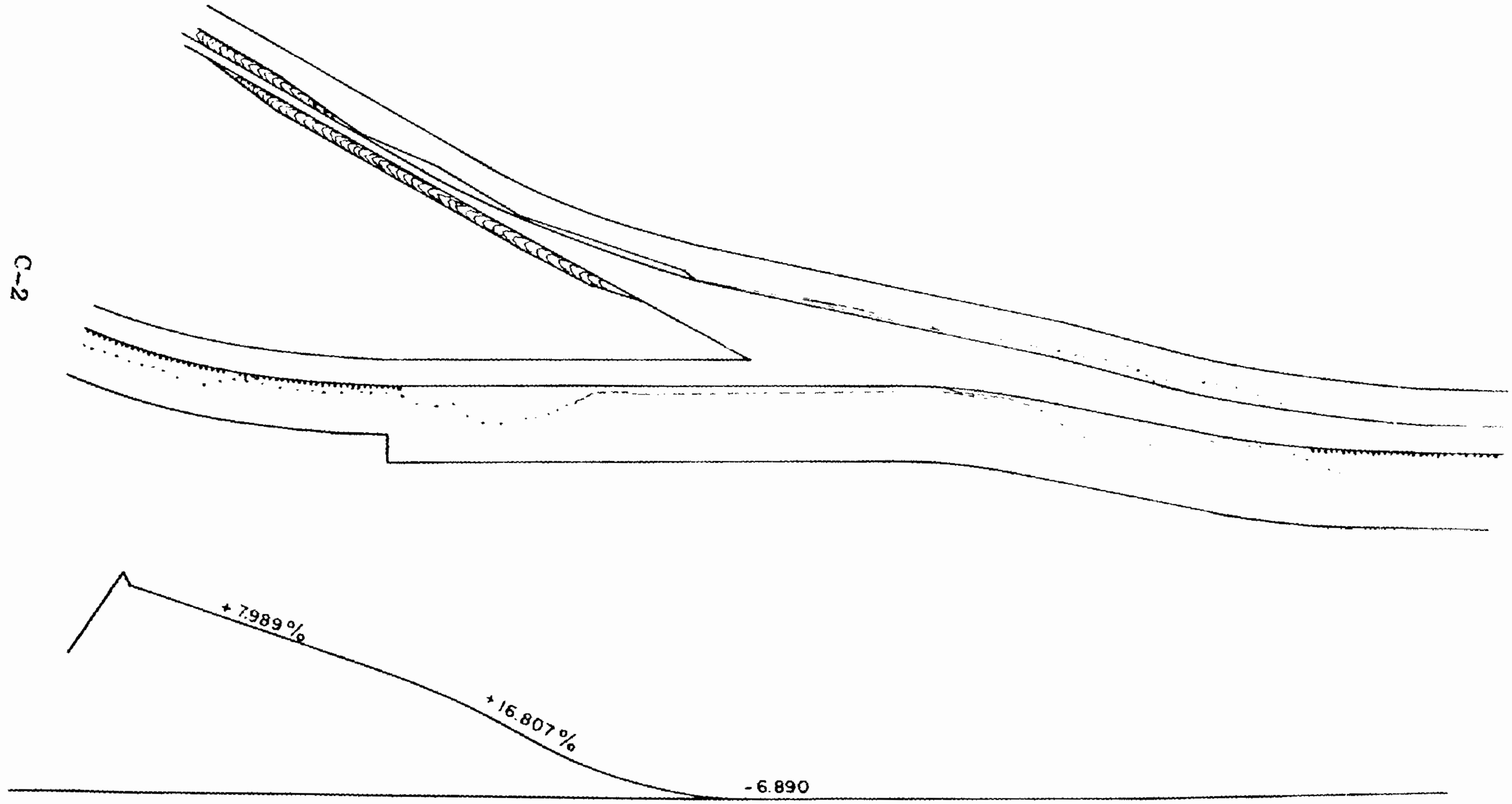
**Where more than one escape ramp exists on a downgrade they are numbered accordingly, with #1 being the ramp nearest the top of the summit.

[1]note: 100 feet=30.48m

State	No.	Location	Type	Surface	Length	% Grade	Date
Nevada	1	Highway 27	C	Sand	300'	+27.8	1969
New York	2	NY-10, at Richmondville	G	Gravel	3000'	+5, +10½	1964
		NY-28, Vickerman Hill	A	Gravel	700'	-7, -10	1978
		Locke-Homer	A	Planned			*
N. Carolina	4	US-421, Wilkes County	A	Sand	210'	0	N/A
		US-421, Wilkes County	A	Sand	370'	-6, +5	N/A
		US-70 (2)	A	Sand	340'	-6, +4	1974
Oregon	5	I-80 N. W/B #1	G	Gravel	1200'	-5.4 +17	1973
		I-80 N. W/B #2 Emigrant Hill	G	Gravel	1000'	-5.4 +17	1973
		OR-58, near Willamette Pass W/B #1	A	Gravel	1300'	0	1976
		OR-58, near Willamette Pass W/B #2	C	Gravel	2300'	+13	1976
		I-5, N. of Siskiyou Summit N/B	A	Gravel	1900'	-5½	1977
Pennsylvania	9	US-219, Boot Jack Hill, #1	G	Hard Surface	1900'	-8.3 +6, +15	1968
		US-219, Boot Jack Hill, #2	G	Hard Surface	1900'	-7.3 +6, +13	1968
		US-422, Kittanning	A	Gravel	250'	+2	1976
		US-40, Uniontown	G	Hard Surface	1125'	+20	1966
		US-30, Sideling Hill	G	Hard Surface	1560'	-9, +12 +18	1969
		US-30, Franklin County	G	Hard Surface	1200'	+7.5 +21.5	1974
		PA-93, Nesquehoning	G	Gravel	1500'	+5	1975
		PA-115, Wilkes Barre	C	Gravel	371'	Avg. +8.7 Max.+18	1976
		PA-115, Wilkes Barre	C	Gravel	430'	Avg. +5.2 Max.+11	1976
Puerto Rico	4	Located on Route 52	N/A		N/A		N/A
S. Dakota	1	US-16, S. of Rapid City	A	Gravel	700'	-5.5	1976

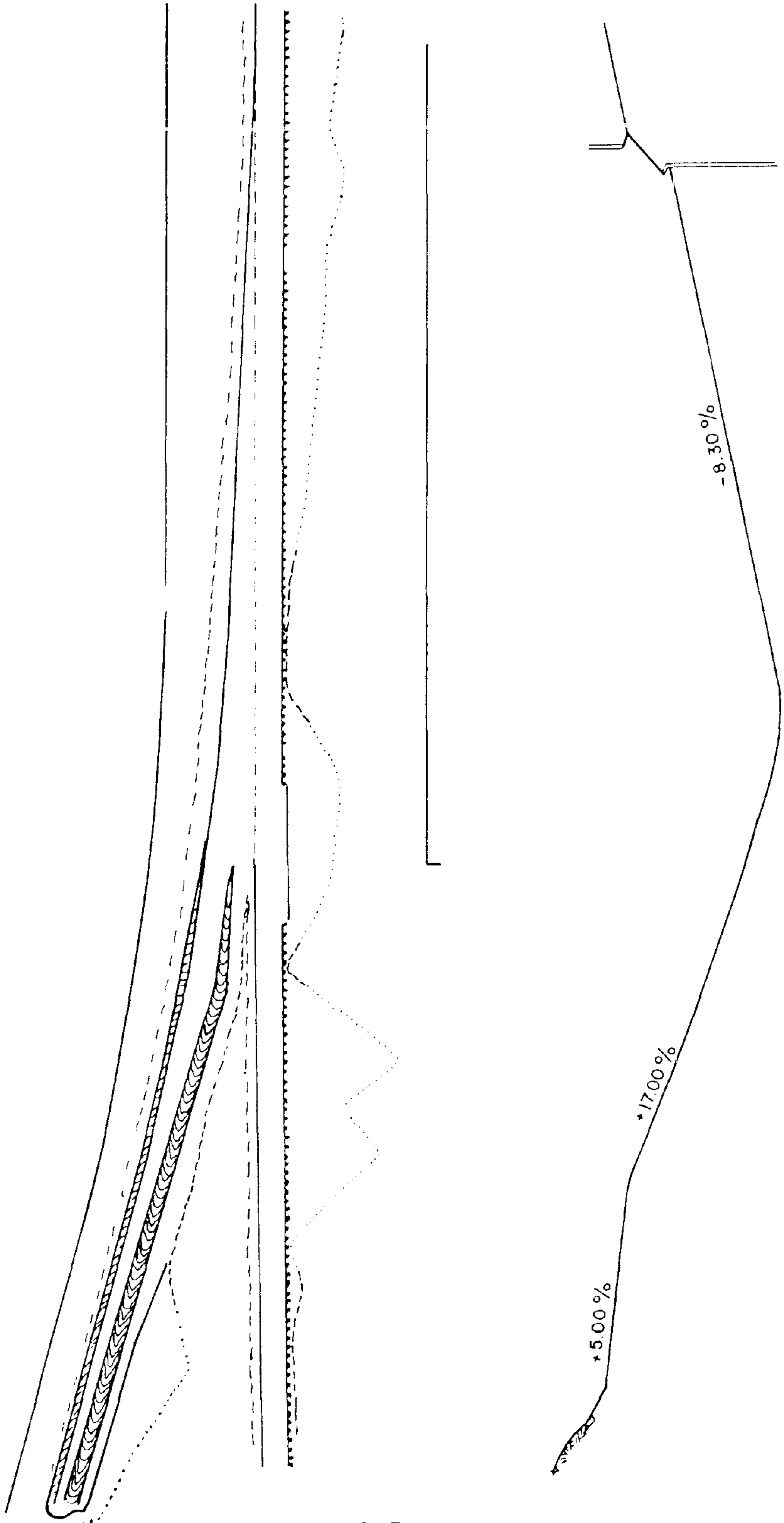
APPENDIX C Diagrams and Layouts of Emergency Escape Ramps

The following diagrams and layouts of various emergency escape ramps, in general, represent as-built statements of constructed projects. No effort has been made to convert each lineal dimension to its metric (SI) equivalent. Readers interested in converting English units to their metric (SI) equivalent are referred to ASTM E380-76, "Standard for Metric Practice."



ALASKA No 1
North of Scagway

State	No.	Location	Type	Surface	Length	% Grade	Date
Tennessee	1	I-24-E, at Monteagle Mountain, S/B	A	Gravel	550'	-6	1976
Utah	2	I-80, Parley's Canyon	A	Gravel	2480'	-1.5	1969
		US-91, near Brigham City	G	Gravel	1200'	+4.5 +2.75	1968
Vermont	3	SR-9, near Woodford	G	Gravel	500'	-7, +15	1977
		SR-9, near Searsburg #1	A	Gravel	100' 450'	-8 +1	*
		SR-9, near Searsburg #2	G	Gravel	515'	-8, +20	*
Virginia	9	I-77, Bland County N/B	G	Gravel	1400'	+20	1974
		I-77, Carroll Co. S/B	G	Gravel	1350'	+2	1977
		I-77, Carroll Co. S/B	G	Gravel	1350'	+23.4	1977
		I-77, Carroll Co. S/B	G	Gravel	1400'	+20.7	1977
		VA-58, Patrick Co. E/B	G	Gravel	550'	+20	1973
		I-81, Botetourt Co. S/B	A	Sand	200'	(-) N/A	1975
		VA-52, Carroll Co. S/B	A	Sand	200'	(-) N/A	1972
		VA-52, Carroll Co. S/B	A	Sand	200'	(-) N/A	1972
		VA-33, Rockingham Co. W/B	A	Sand	100'	(-) N/A	1975
Washington	1	US-12, Alpowa Summit	G	Gravel		-4.6 +3.2, +19.6	1972
West Virginia	2	US-48, E. of Morgantown Preston County E/B	C	Gravel	1300'	+10	1974
		US-48, E. of Morgantown Monongalia Co. W/B	C	Gravel	1300'	+10	1976
Wyoming	3	US-16, W. of Buffalo, E/B, #1	G	Gravel	610'	-6, +25	1972
		US-16, W. of Buffalo, E/B #2	A	Gravel	800'	-2.5	1972
		US-16, E. of Tensleep, W/B	G	Gravel	2300'	Avg.+3.8 Max.+7.6	1971



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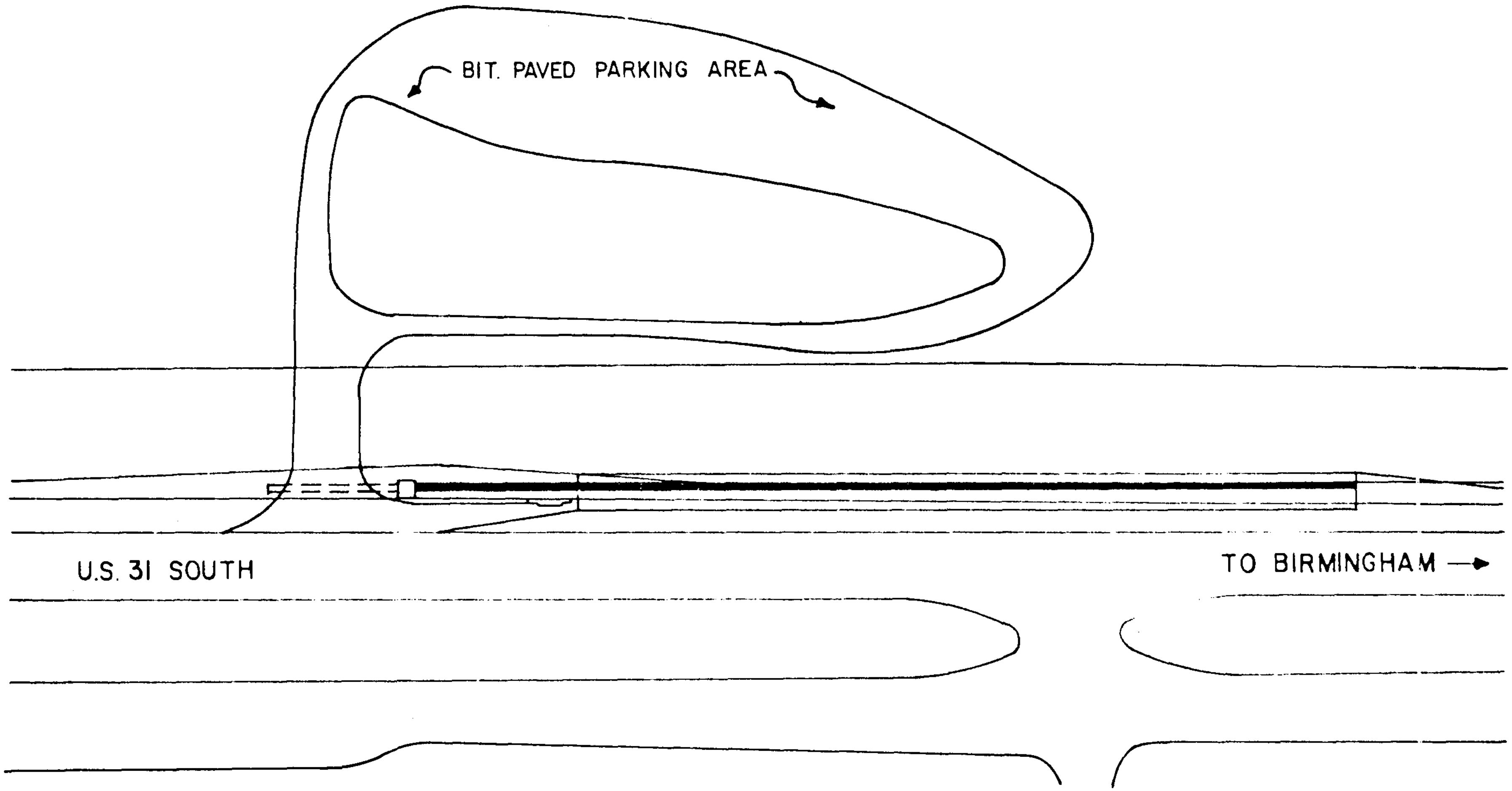
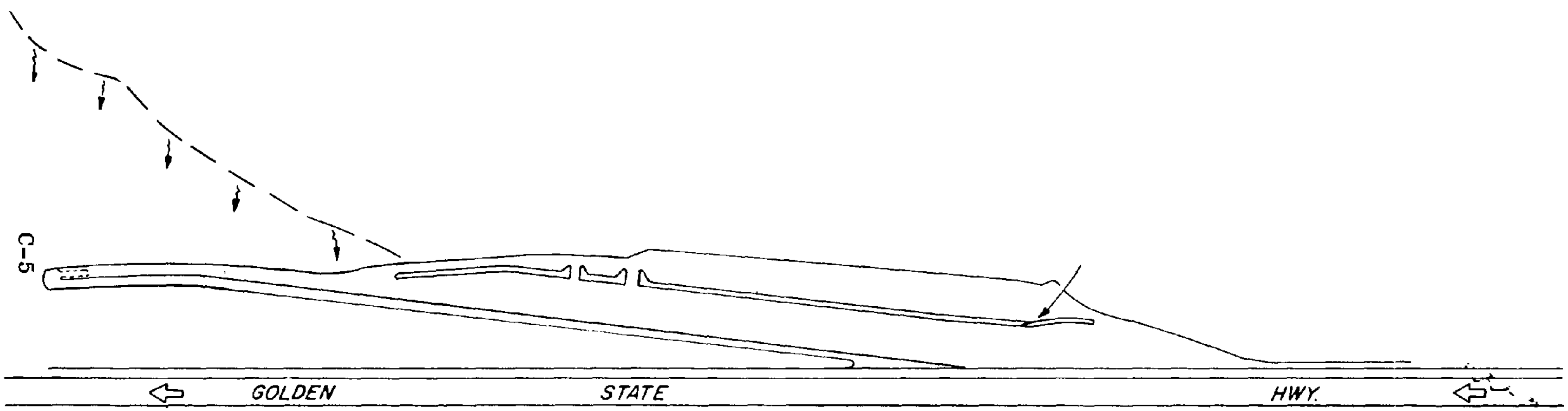
North of Scagway



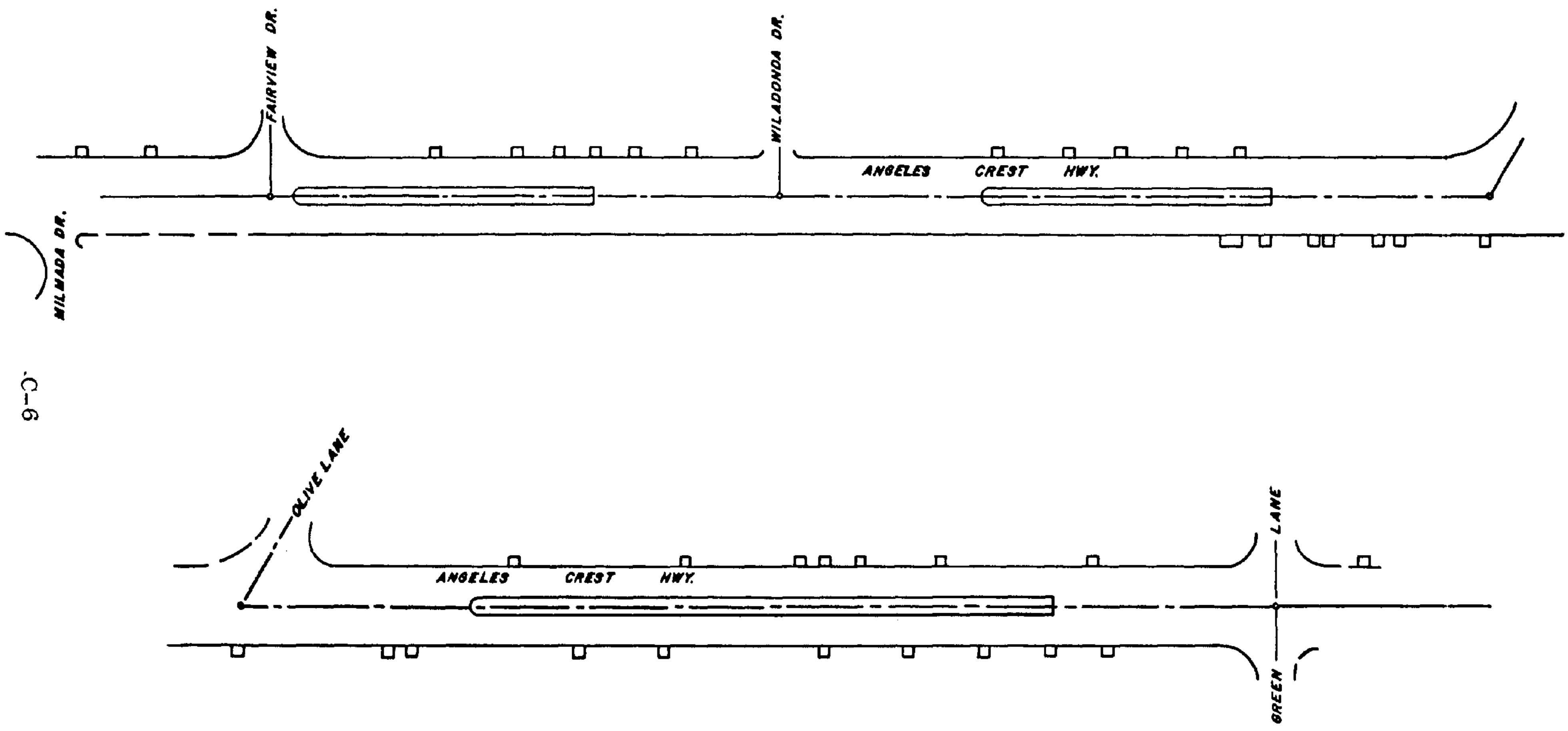
ALABAMA U.S. 31

South of Birmingham

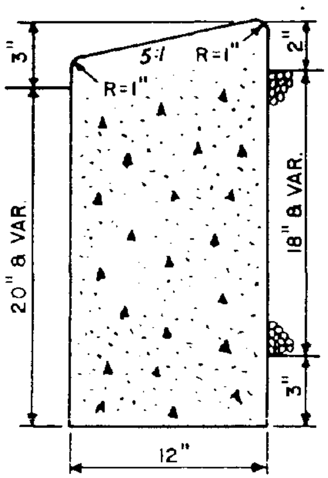


CALIFORNIA

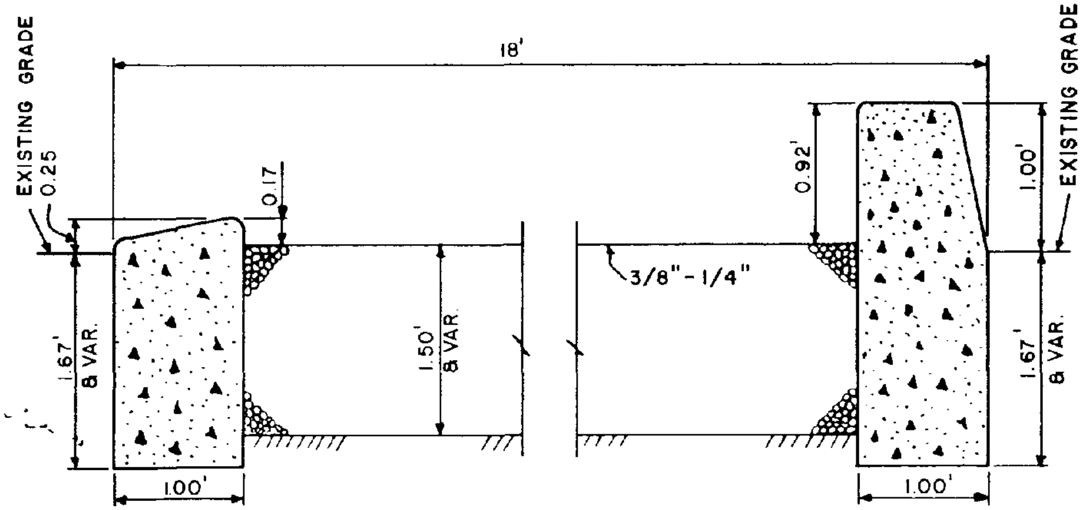
Highway 99



CALIFORNIA
CA - 2 at La Canada

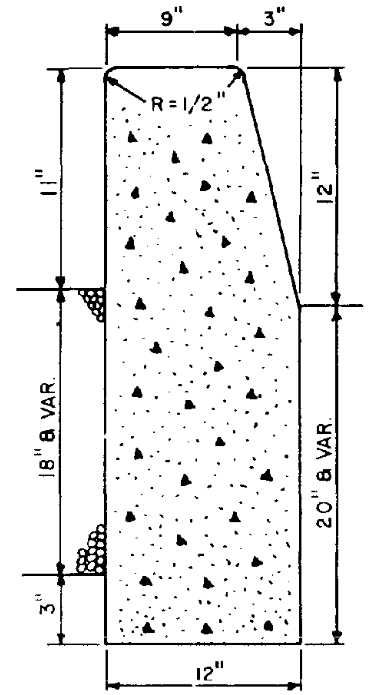


SPECIAL LOW CURB



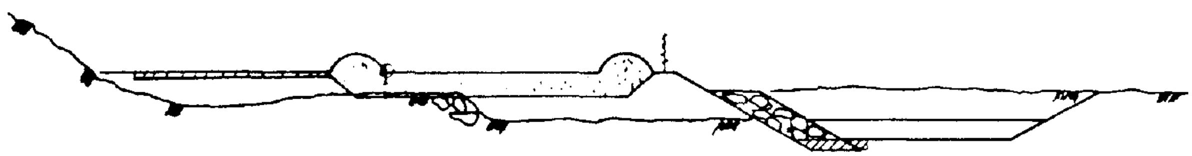
TYPICAL SECTION

ARRESTER BED MEDIAN



SPECIAL HIGH CURB

CA .2 - CALIFORNIA



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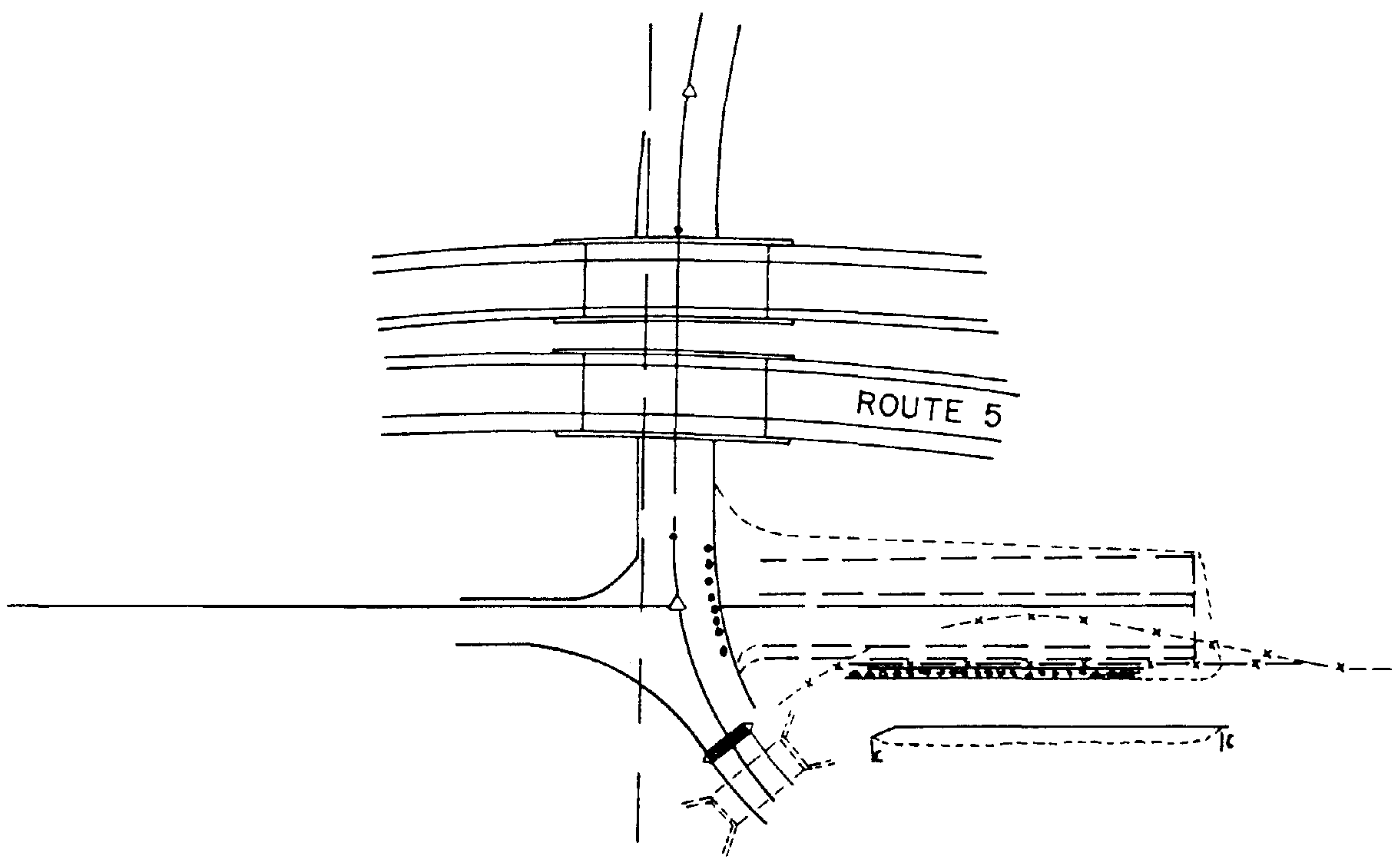
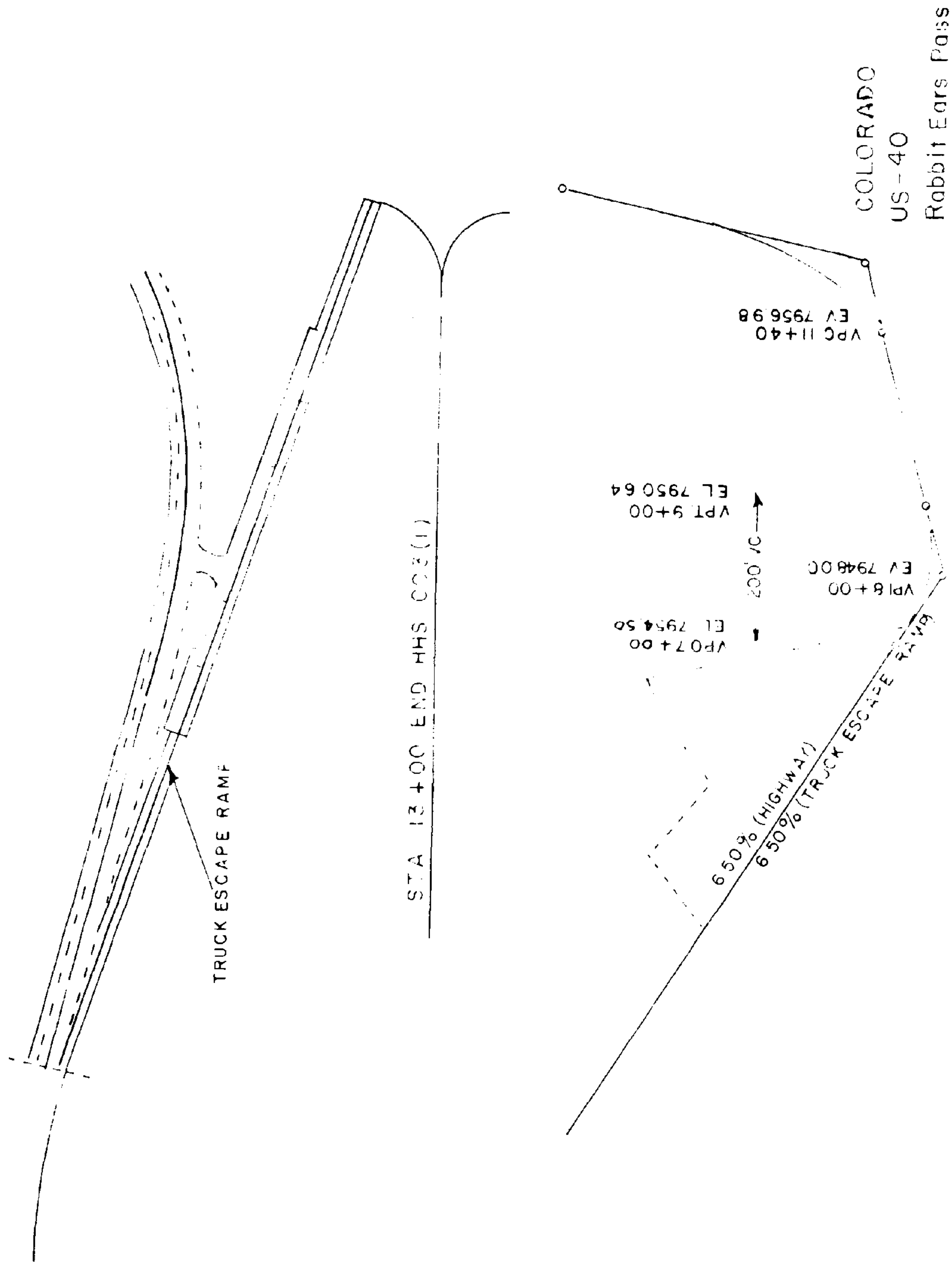
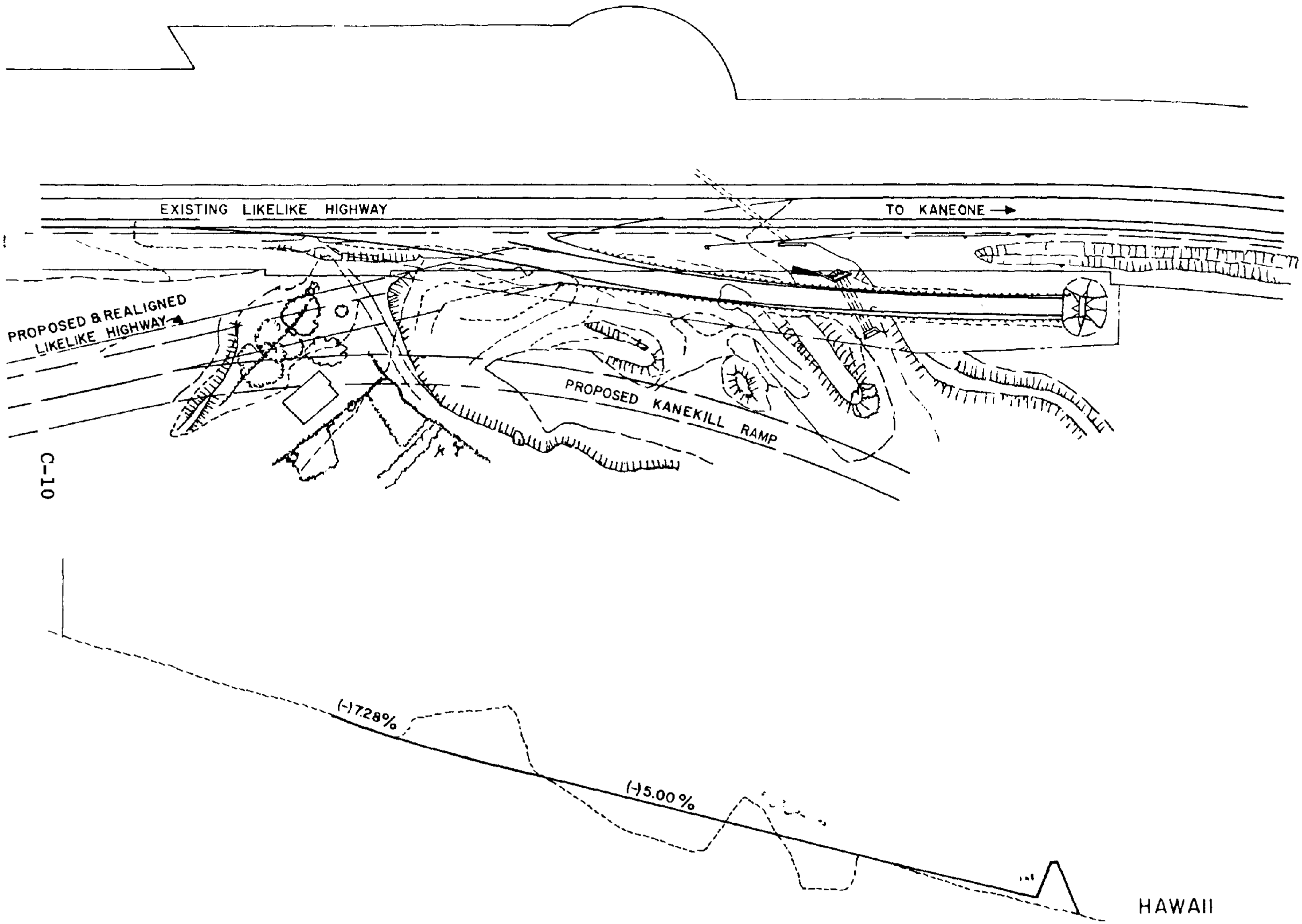


PLAN VIEW

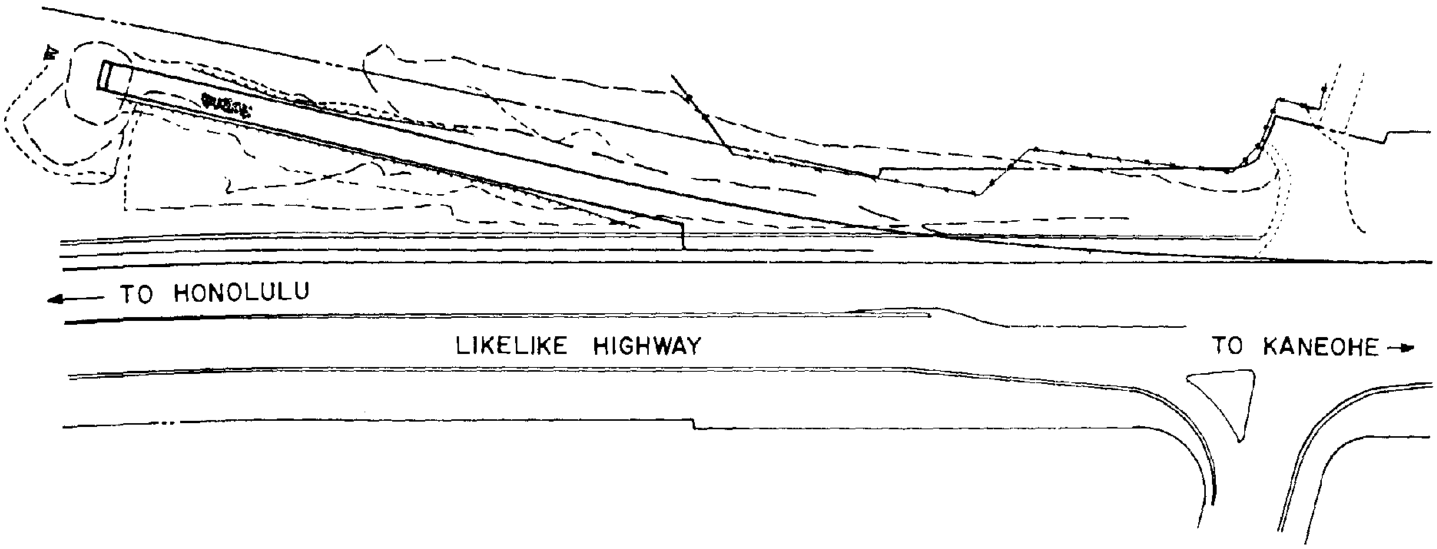
CALIFORNIA

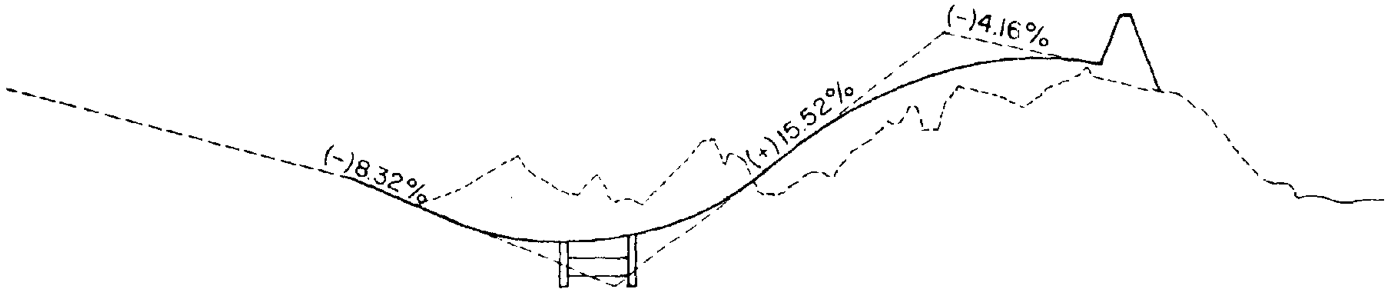
CA-5 Siskiyou County


COLORADO
US-40
Rabbit Ears Pass
VPC 11+40
EV 7956.98
VPT 9+00
EL 7950.64
200' VC
VPI 8+00
EV 7948.00
VPC 7+00
EL 7954.50
6.50% (HIGHWAY)
6.50% (TRUCK ESCAPE RAMP)
STA 13+00 END HHS CC3(1)
TRUCK ESCAPE RAMP



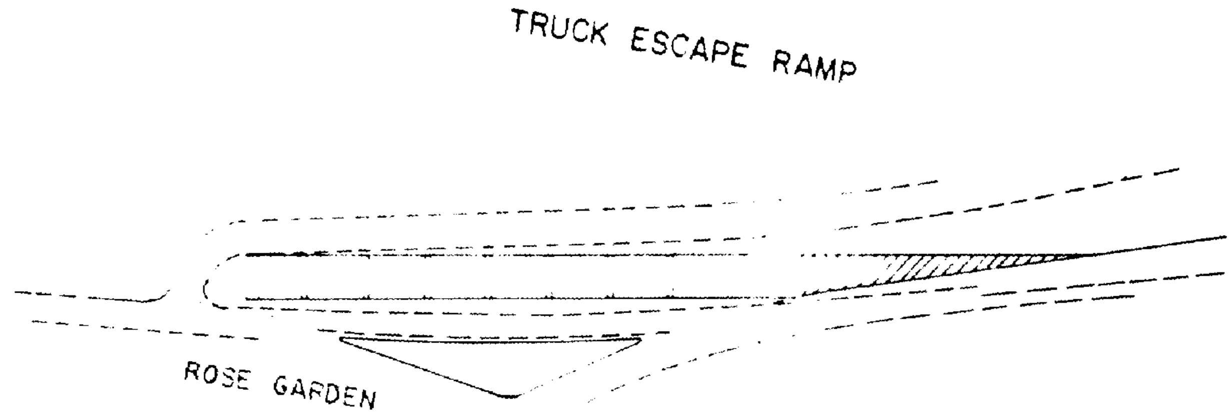
HAWAII
Likelike Highway



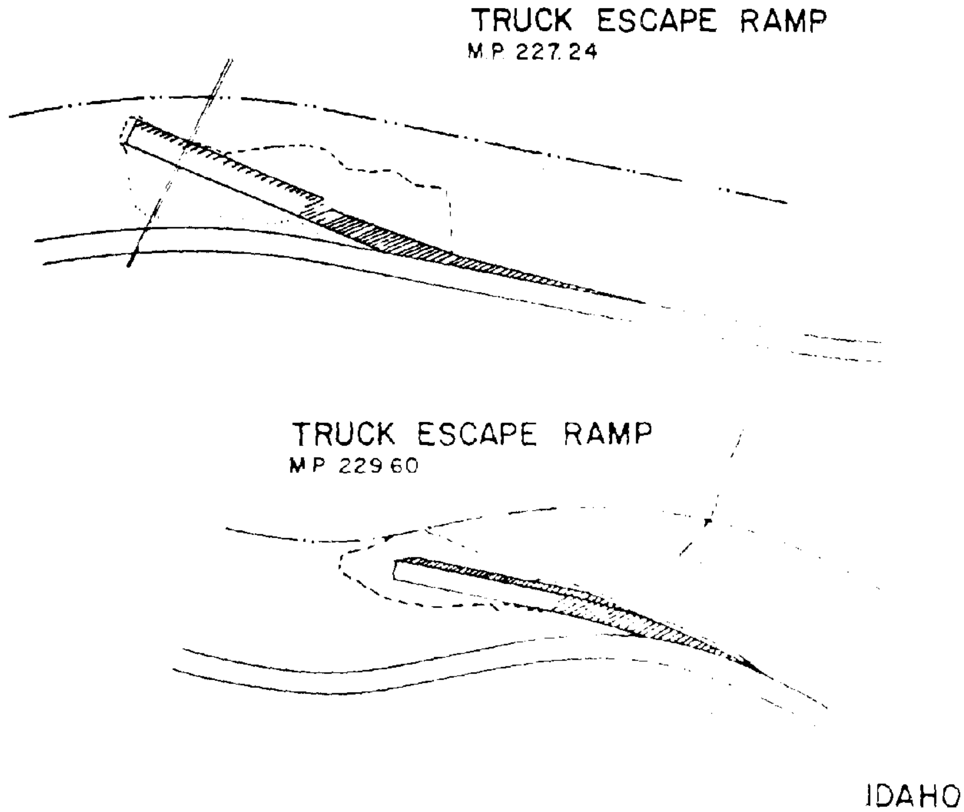


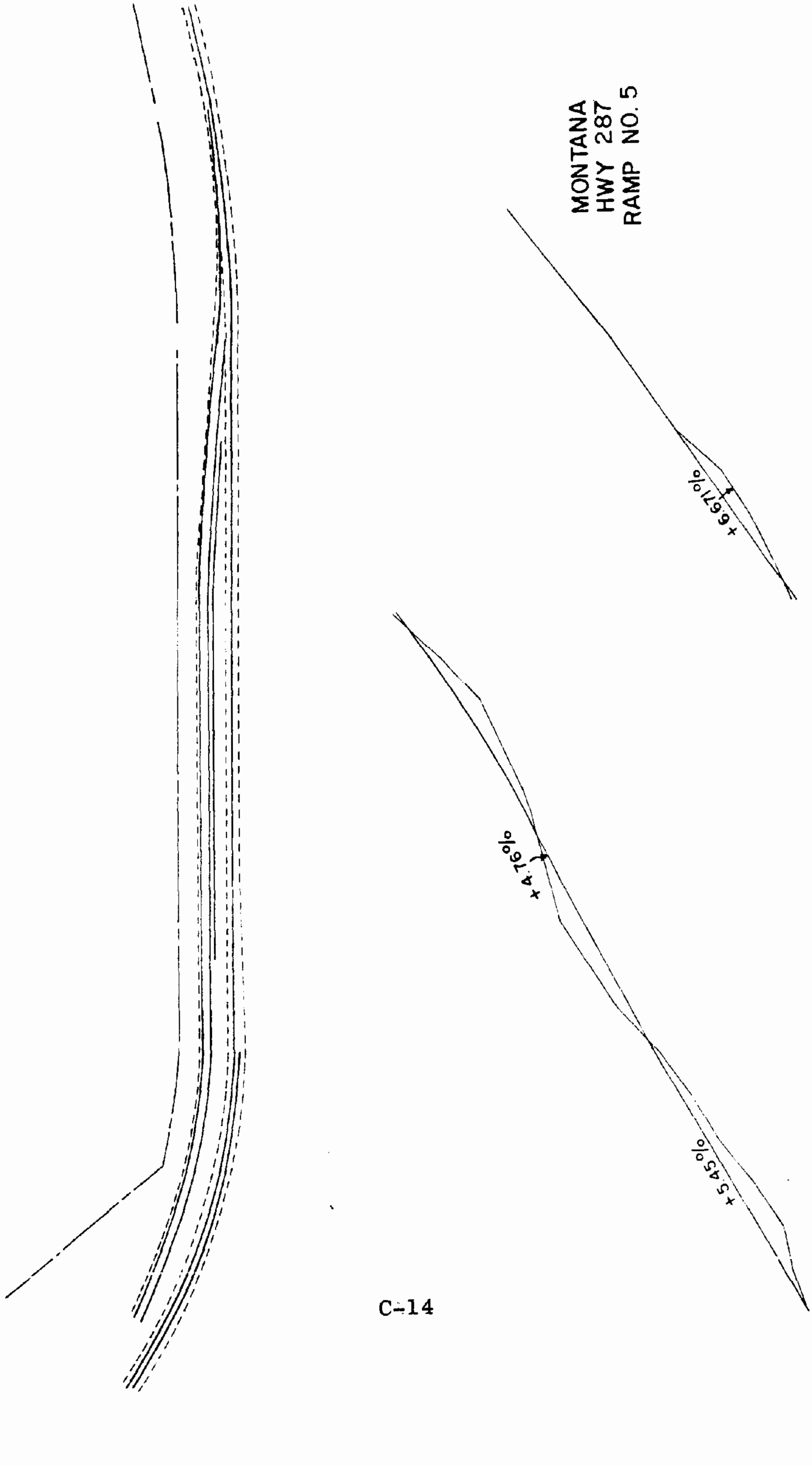
HAWAII

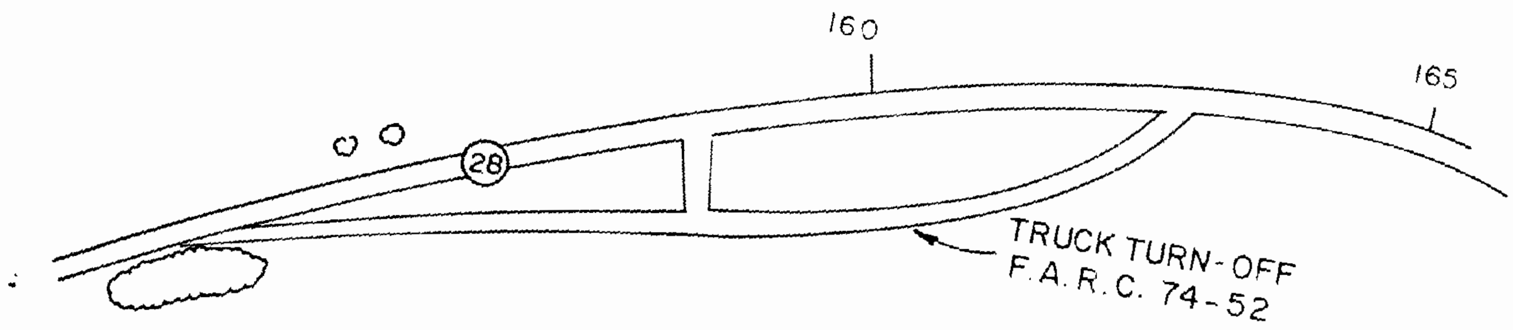
Likeliki Highway

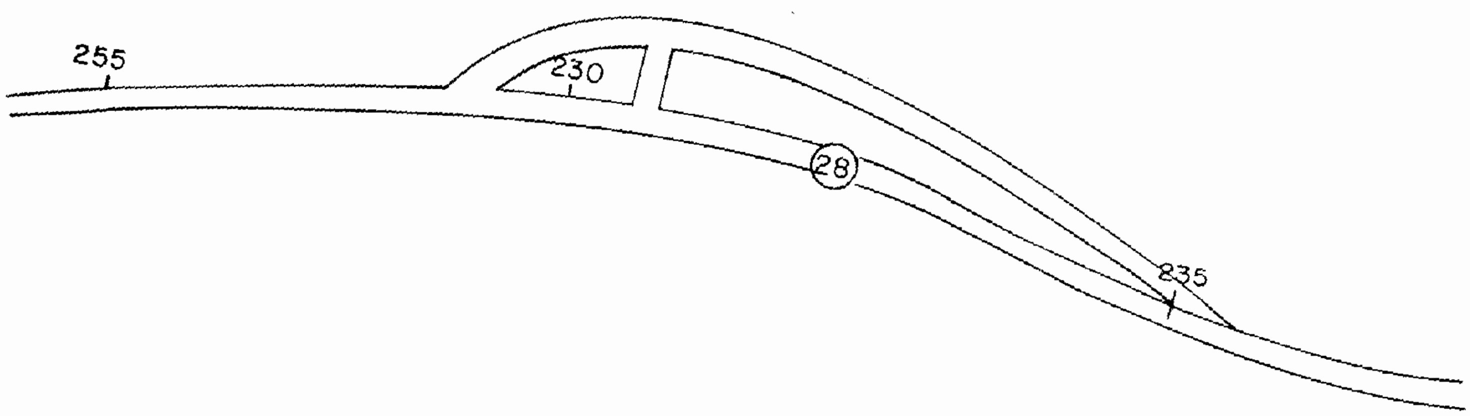


IDAHO

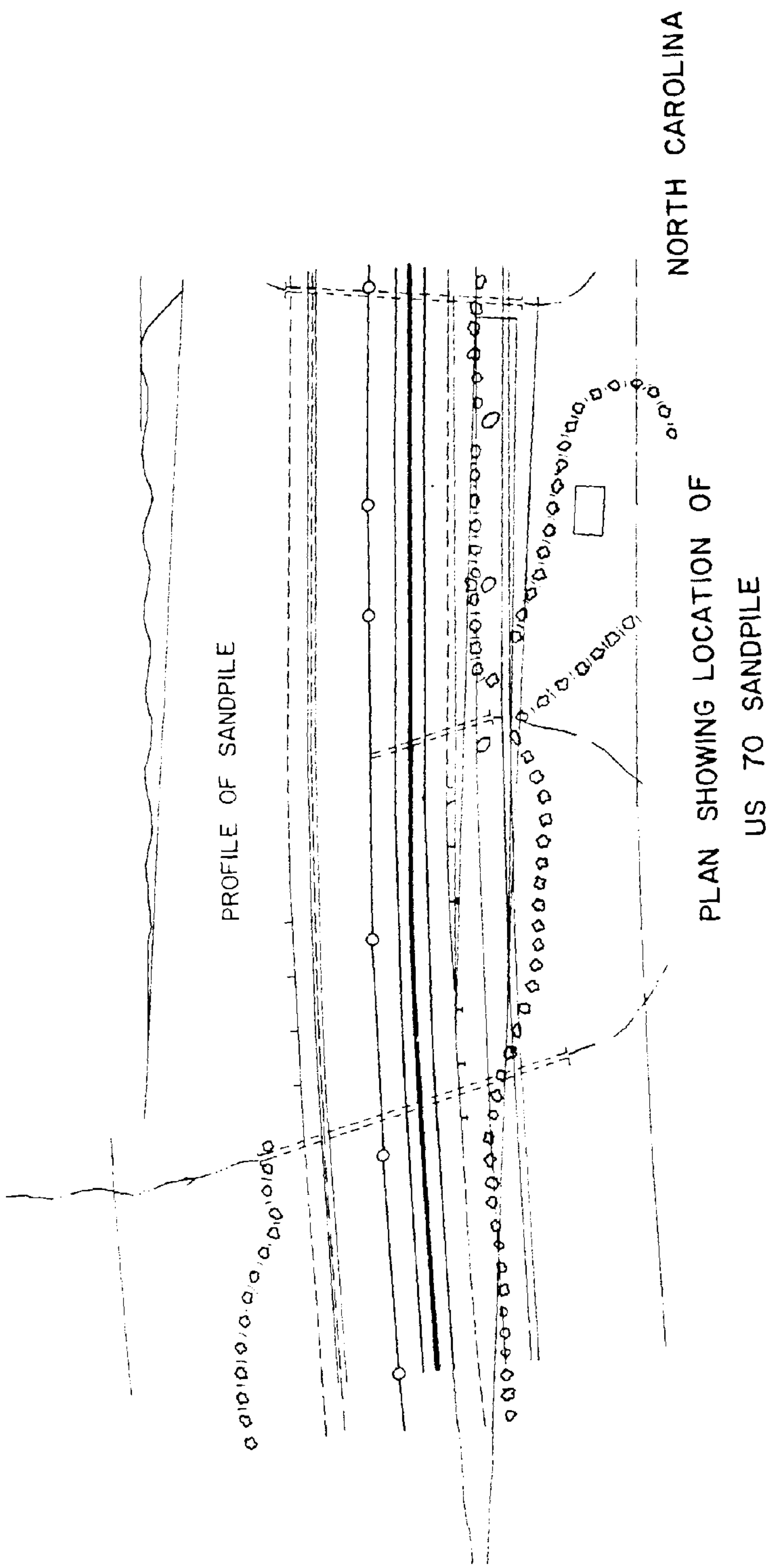

TRUCK ESCAPE RAMP
M.P. 227.24
TRUCK ESCAPE RAMP
M.P. 229.60
IDAHO


MONTANA
HWY 287
RAMP NO. 5
+6.67%
+4.76%
+5.45%



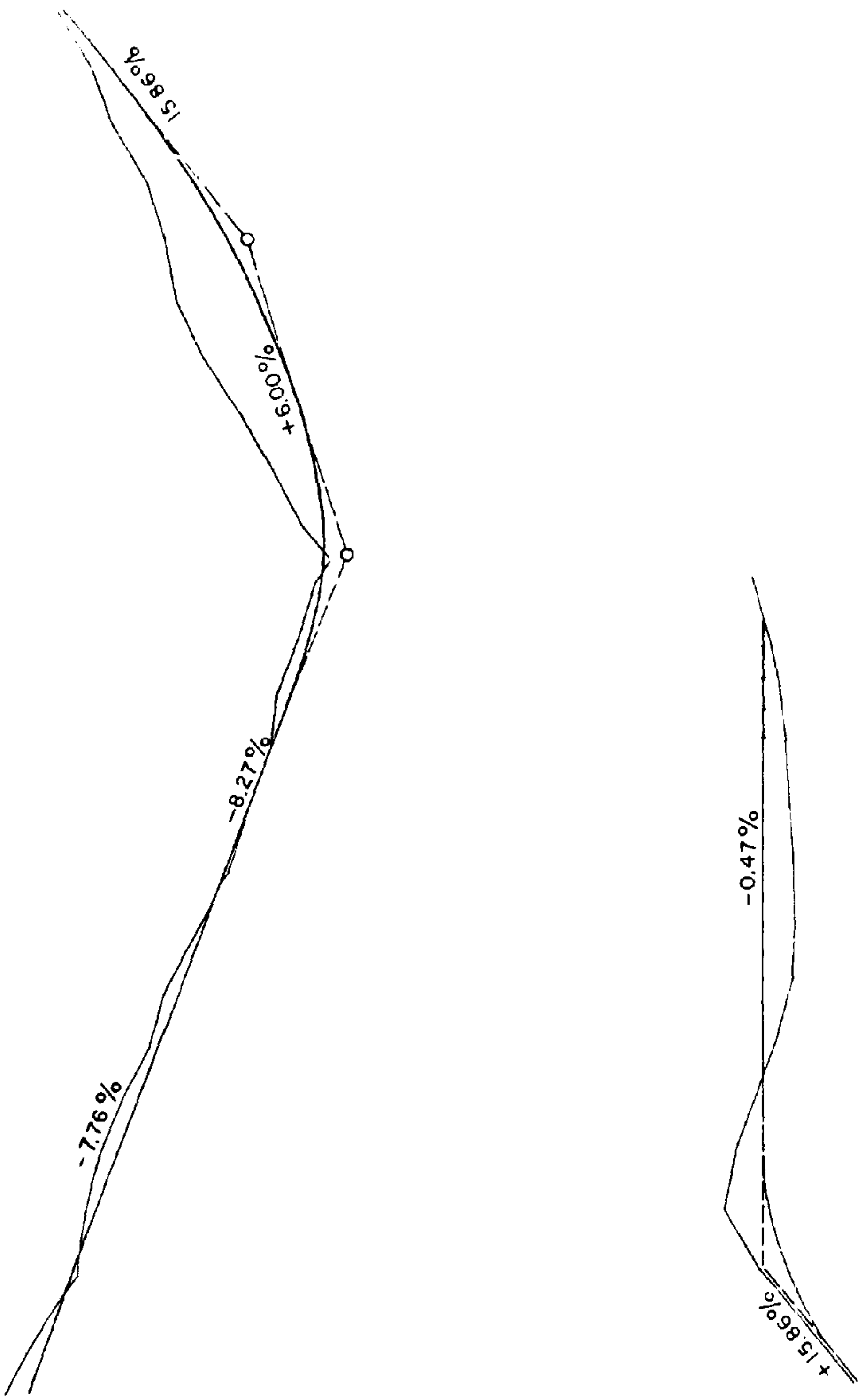


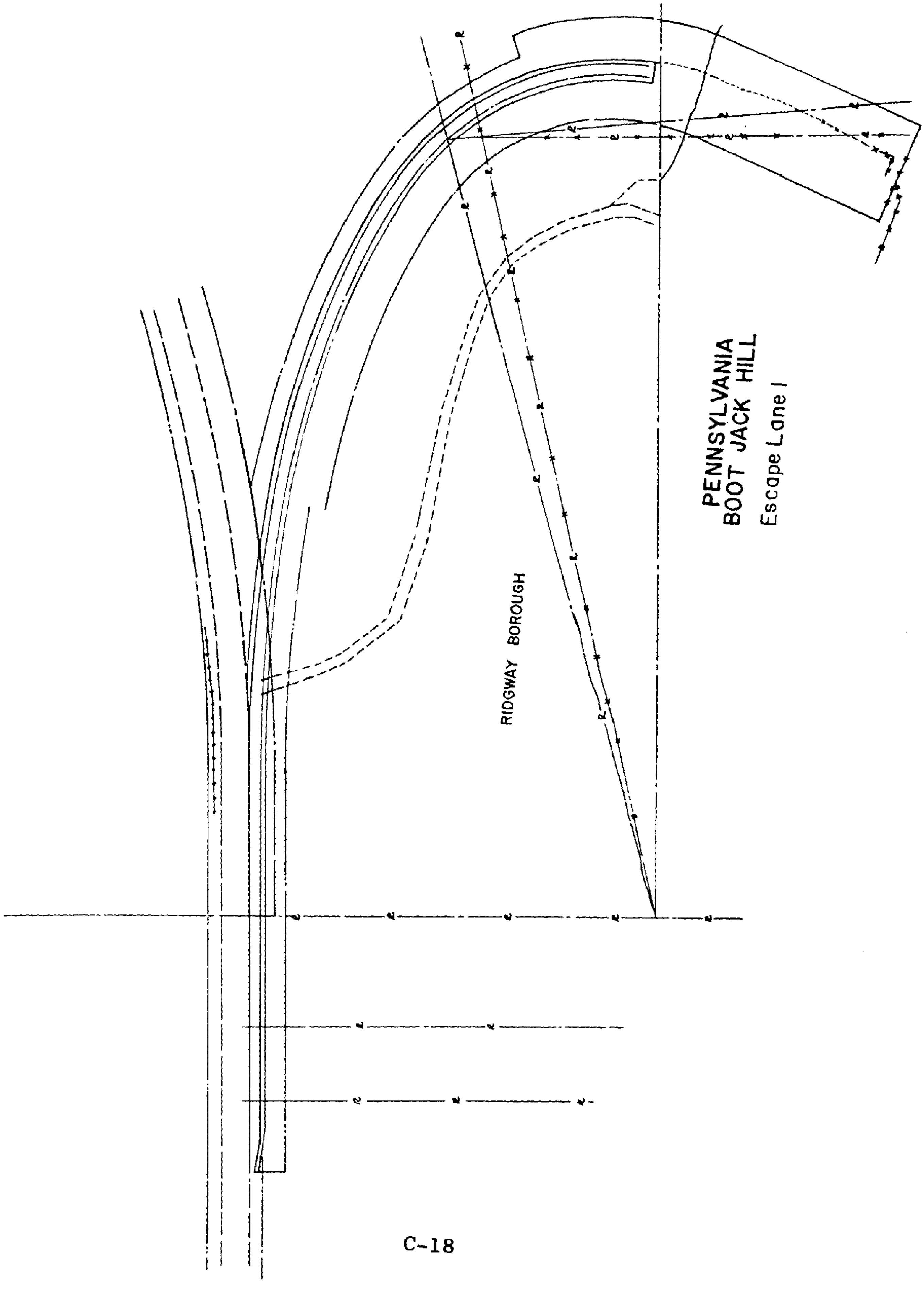
NEW YORK
Vickerman Hill
Truck Escape Lane

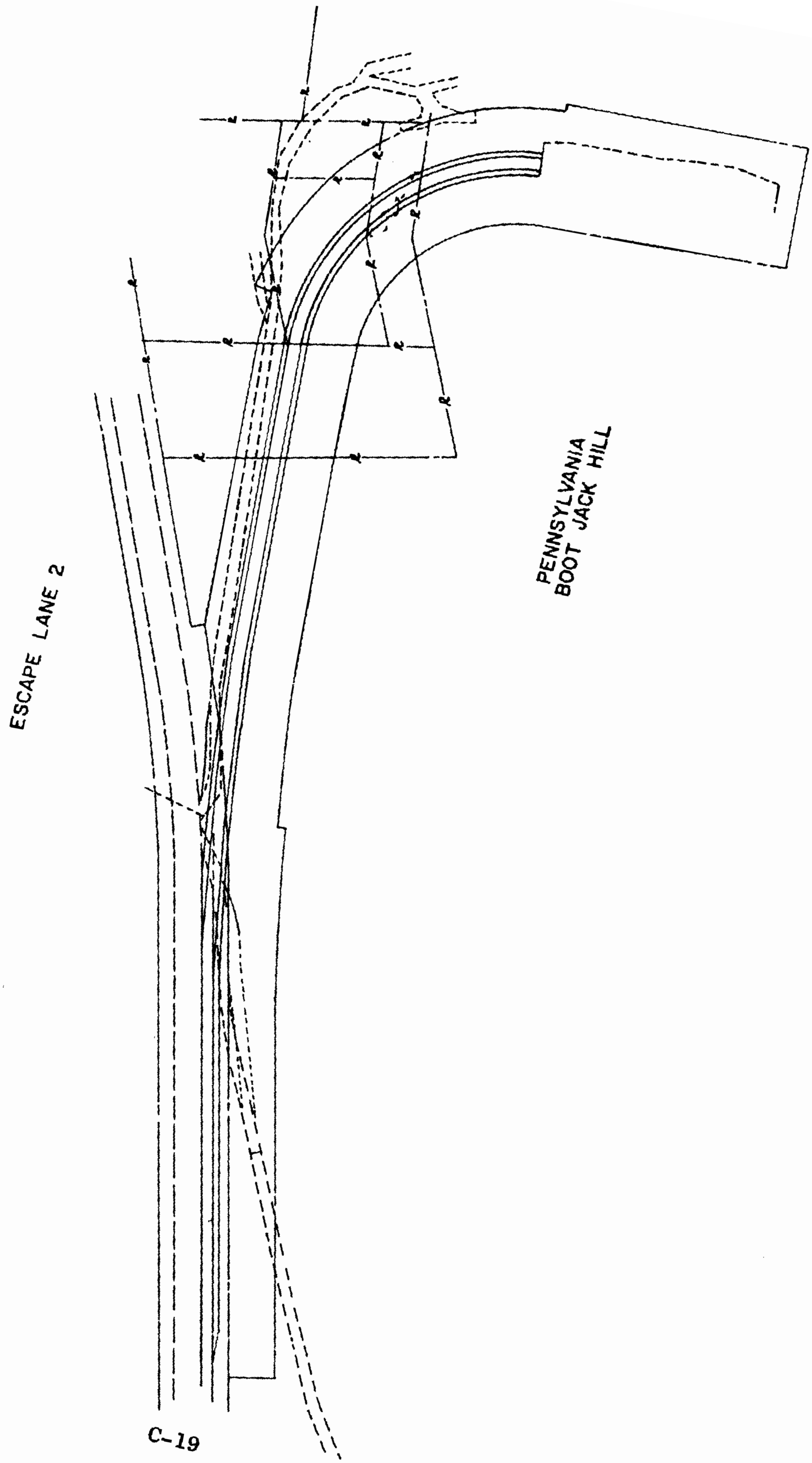

NORTH CAROLINA
PLAN SHOWING LOCATION OF
US 70 SANDPILE
PROFILE OF SANDPILE

PROFILE ESCAPE LANE I

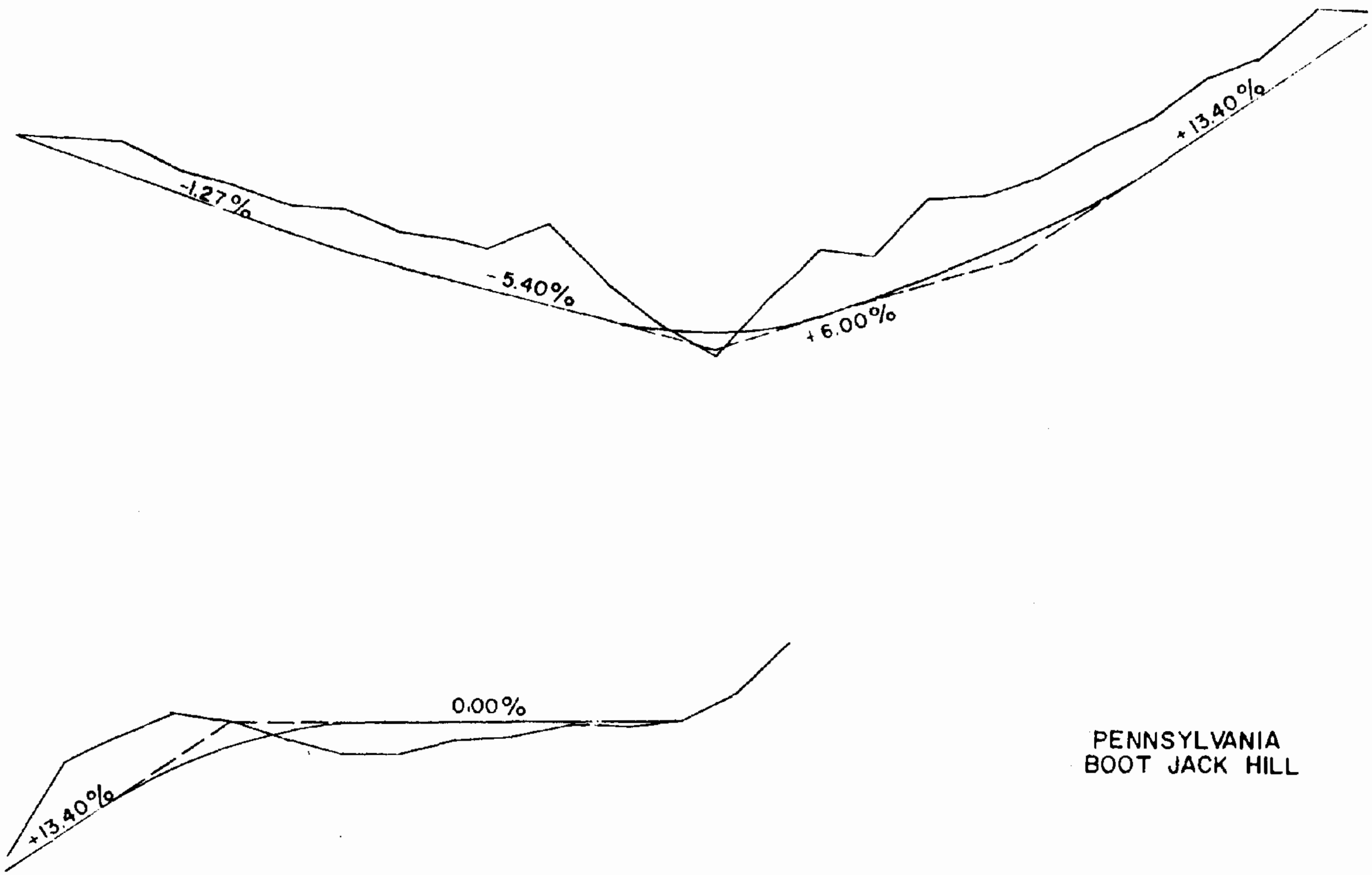
PENNSYLVANIA
BOOT JACK HILL



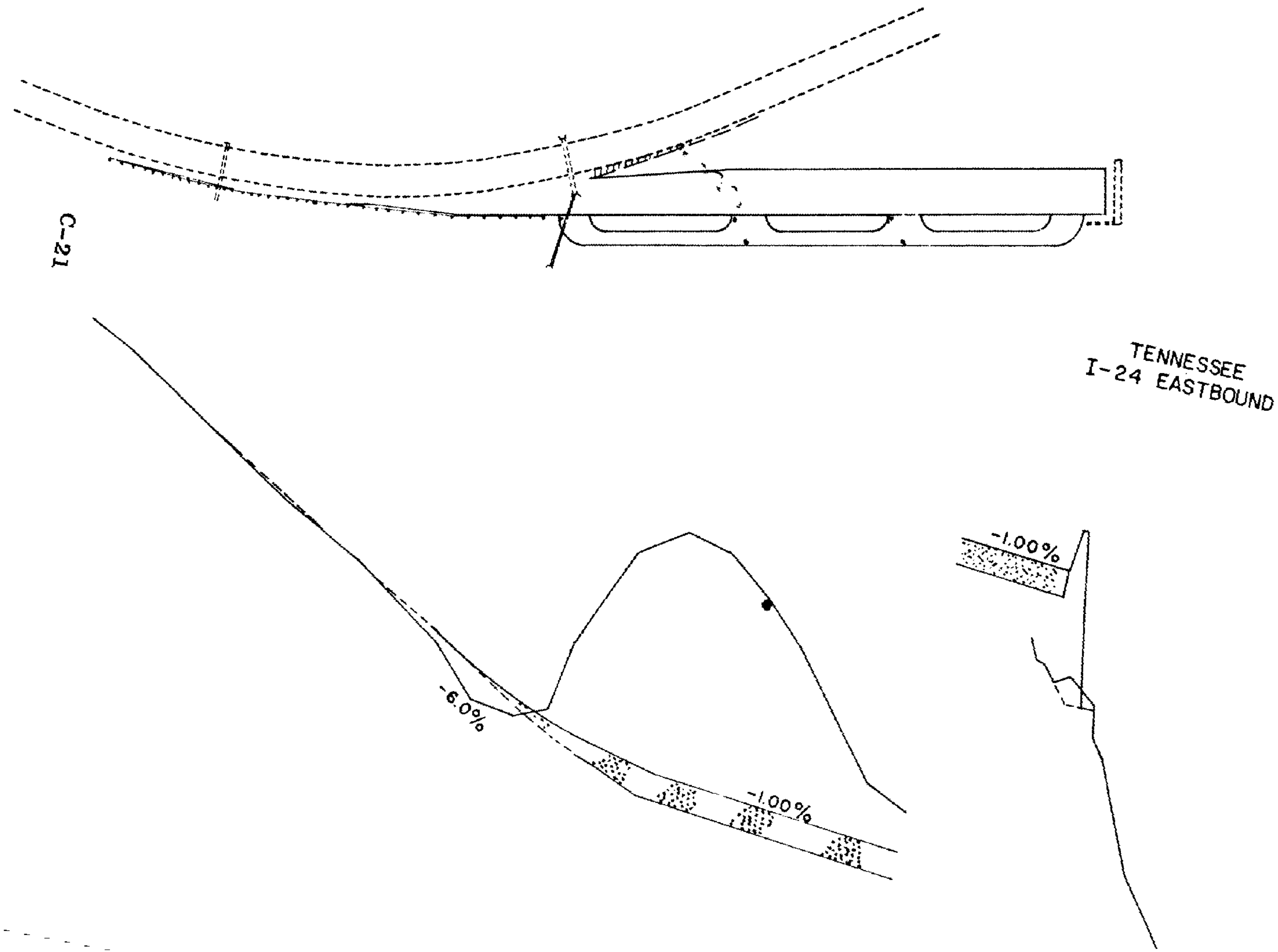

PENNSYLVANIA
BOOT JACK HILL
Escape Lane I
RIDGWAY BOROUGH

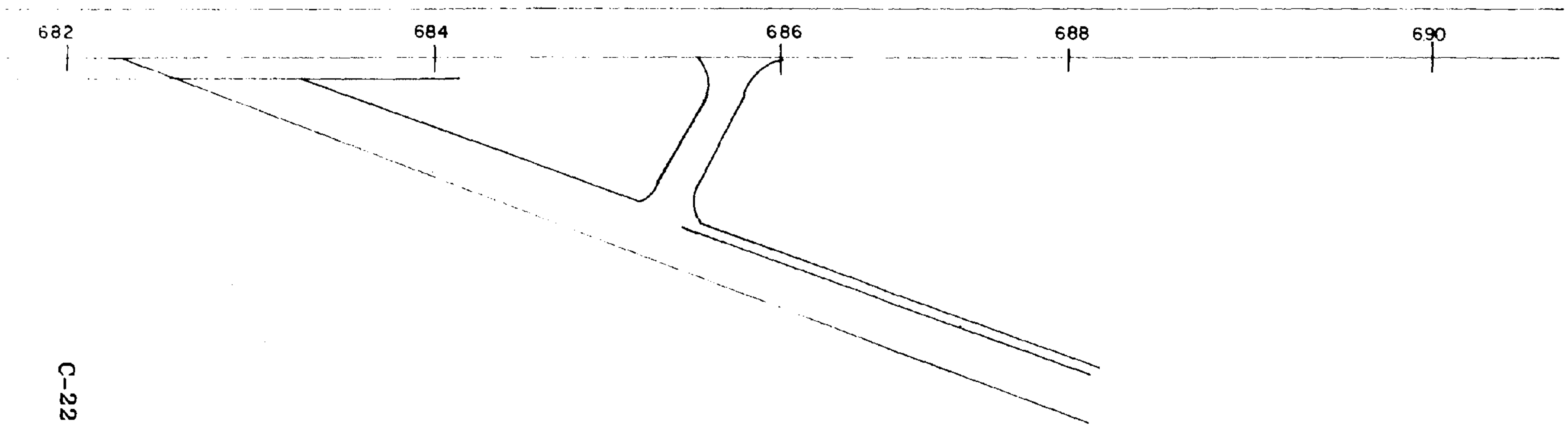

ESCAPE LANE 2
PENNSYLVANIA
BOOT JACK HILL

PROFILE ESCAPE LANE 2



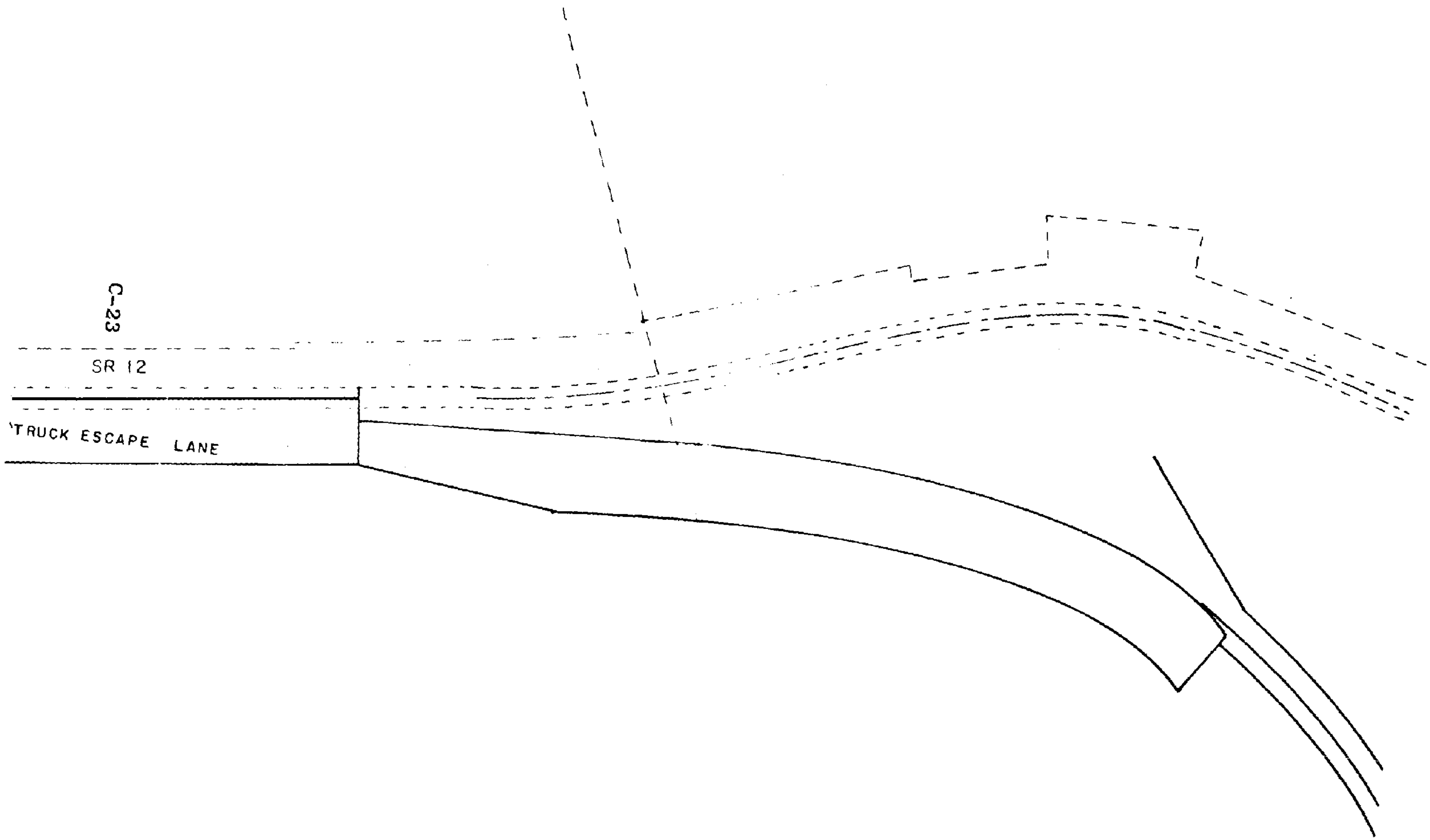
PENNSYLVANIA
BOOT JACK HILL


TENNESSEE
I-24 EASTBOUND
-1.00%
-6.0%
-1.00%

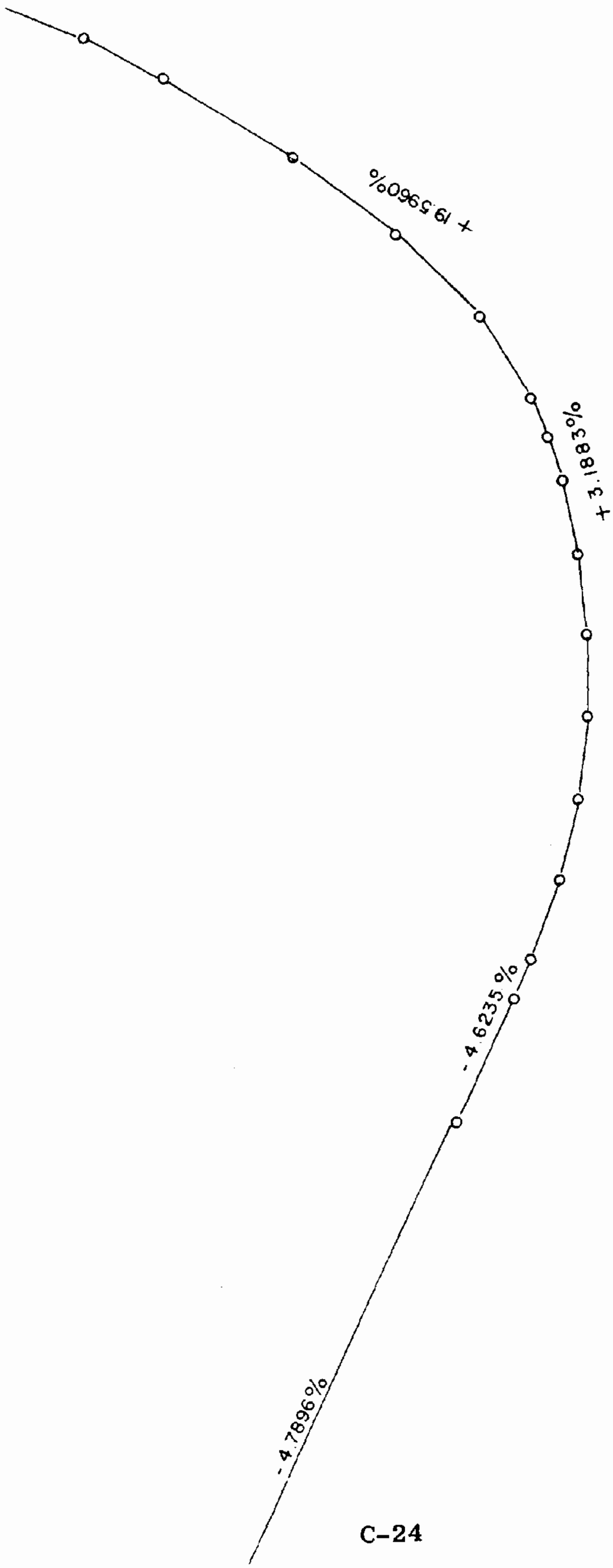


VERMONT
SR 9

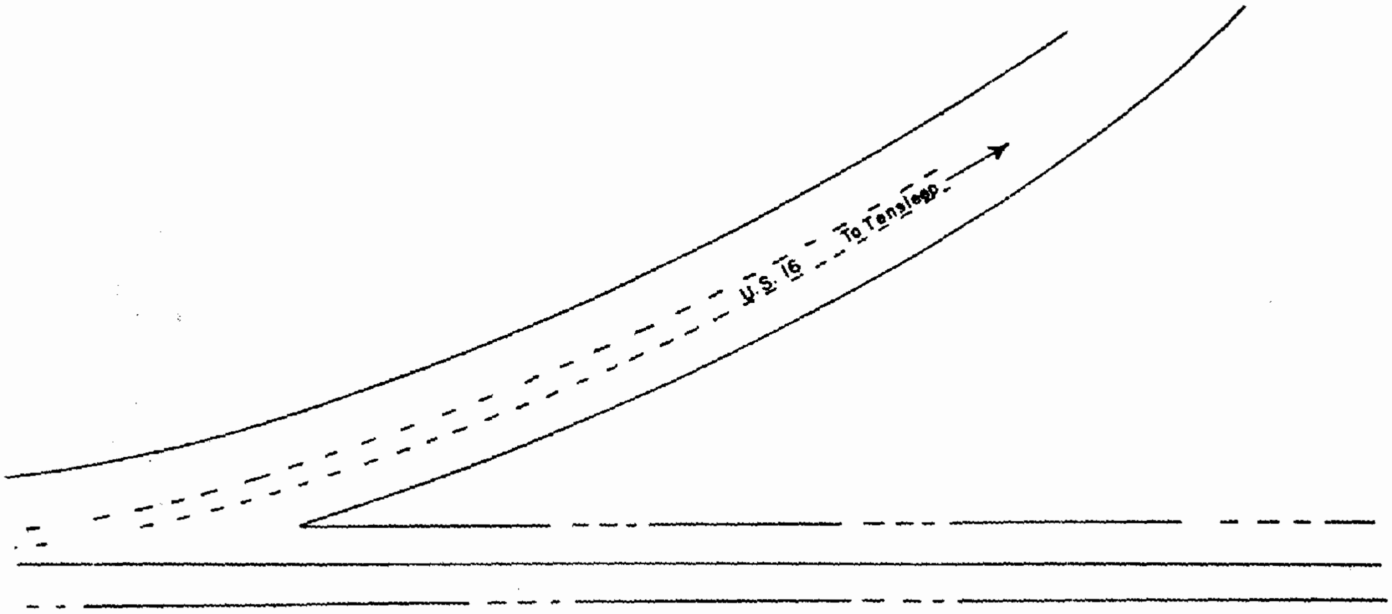
C-23

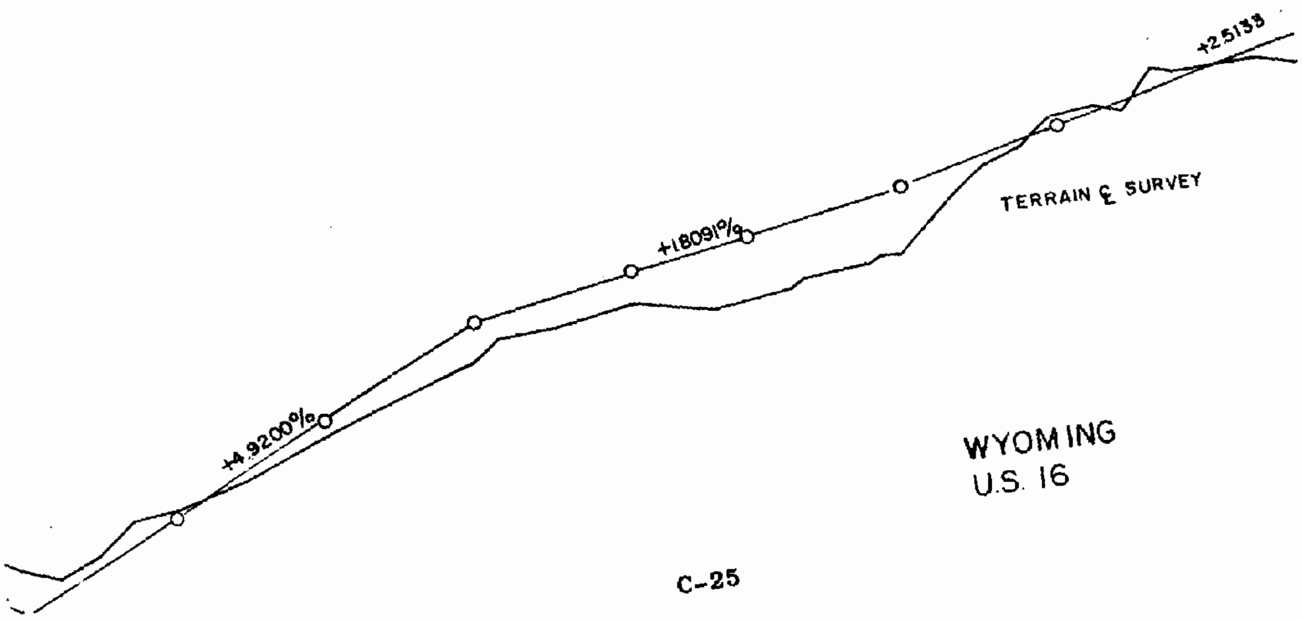


WASHINGTON
US 12 Eastbound



WASHINGTON SR12
Truck Escape Lane
Profile





WYOMING
U.S. 16