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DEPARTMENT OF HIGHWAYS
FRANKFORT, KENTUCKY 40601

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M-2-13

Memorandum to: J. R. Harbison, State Highway Engineer
Chairman, Research Committee

Subject: Research Report, "Experimental Guardrail Installation," F 160(10), Mercer County, US 127

Guardrails have become a major item of "highway hardware." Driven, steel, guardrail posts were first introduced in Kentucky on the Kentucky Turnpike (1955). The optional contractor's preference for galvanized rails was first exercised in 1961 (I 75-4(5)90, Madison County). Although aluminum had been accepted for bridge rails and light standards, corrugated aluminum culvert pipe came into test (for durability) in September of 1961. Concurrently, the aluminum industry, through fabricators, introduced deep-beam guardrails in a limited supply and as a market test. A trial installation ensued; approximately 2500 lineal feet of aluminum rail, together with 2500 feet (each) of galvanized steel and painted steel were included in the construction contract referenced above. In addition to first costs, replacement rates, and repainting intervals (ungalvanized steel), general information concerning performance was sought. Corrosion of ungalvanized steel posts at the ground line was suspected to be a serious problem. *(Note: Galvanized posts and rails are now specified without alternates.)*

About the same time that aluminum guardrails came into consideration, aluminum light standards and bridge rails were being specified preferentially (without alternates). This led to the establishment or re-affirmation of a policy by the Bureau of Public Roads (para. 16, PPM 21-6.3, June 28, 1968) regarding non-exclusion of alternate materials unless disqualified by engineering analysis and cost. There was some possibility that unit bids for aluminum rails (installed) might become competitive despite higher material cost. Maintenance costs may be brought into issue in selection of materials if they are found to be significant. Contractors' bids decisively favored galvanized steel over painted steel -- avoiding the cost of field painting and further saving the Department the cost of maintenance repainting. Thus far no galvanized guardrails have required painting (which might be needed in 5 to 10 years in corrosive environments). Indeed, a stable economic situation has emerged. Gross expenditures for guardrail construction have increased greatly -- that is, because of mileage. However, the cost of guardrail per mile of construction has increased because of: 1) greater utilization in terms of lineal feet per mile, 2) closer spacing of posts, and 3) end treatments -- all arising from improved safety standards. As a matter of interest, bid prices and quantities over the past several years have been graphed and included herein. A decline in lineal feet of rail per mile should become evident in the statistics for 1971 inasmuch as current design and safety standards introduce flatter embankment slopes and greater lateral clearance in lieu of guardrails.

A possible complication of the economic picture may arise from replacement rates and salvage value of galvanized steel. Thus far, we have not assembled any data regarding replacement rates; but mere observation of the occurrence interval of damage by vehicles indicates that the eventual replacement will be high -- whereas, the salvage value of galvanized material will be low.

With regard to phasing out existing painted steel, I understand that Maintenance plans to make

major replacements with galvanized material and to use painted material salvaged to make minor replacements where painted steel is to be continued in like kind until finally abandoned. Some painted steel has been reclaimed by steaming and galvanizing.

In summary, it seems that the ultimate feasibility of admitting aluminum as a like alternate to our present galvanized steel barrier would depend upon the establishment of salvage values and dealers in the salvaged materials. The aluminum industry has apparently abandoned hope of competing with the steel barrier system as presently styled. Alternate designs, such as the box-beam barrier system, are claimed to be competitive with the steel barrier currently used.

Respectfully submitted,

Jas. H. Havens
Director of Research

Attachments

cc's: Research Committee
Assistant State Highway Engineer, Research and Development
Assistant State Highway Engineer, Planning and Programming
Assistant State Highway Engineer, Pre-Construction
Assistant State Highway Engineer, Construction
Assistant State Highway Engineer, Operations
Assistant Pre-Construction Engineer
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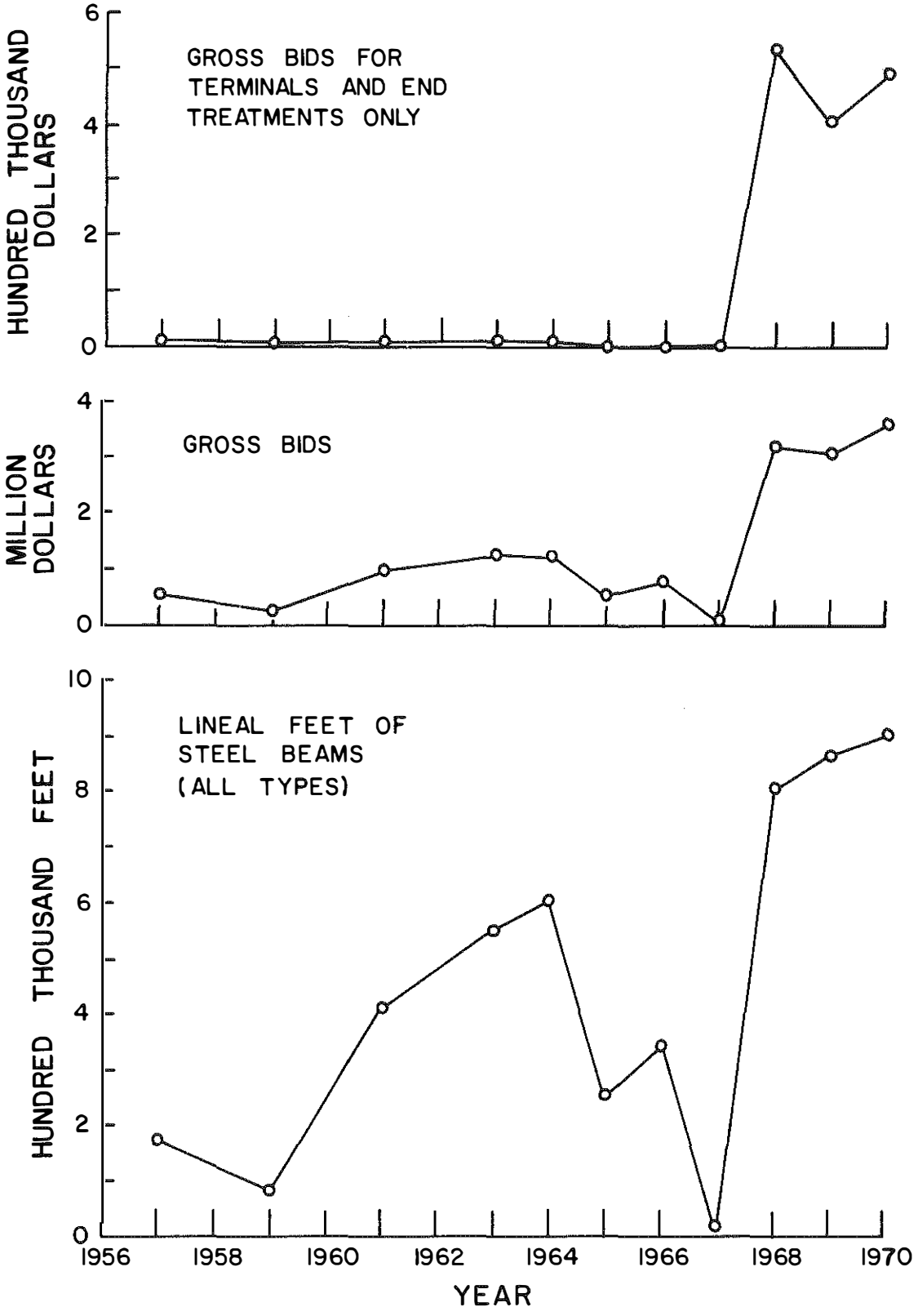
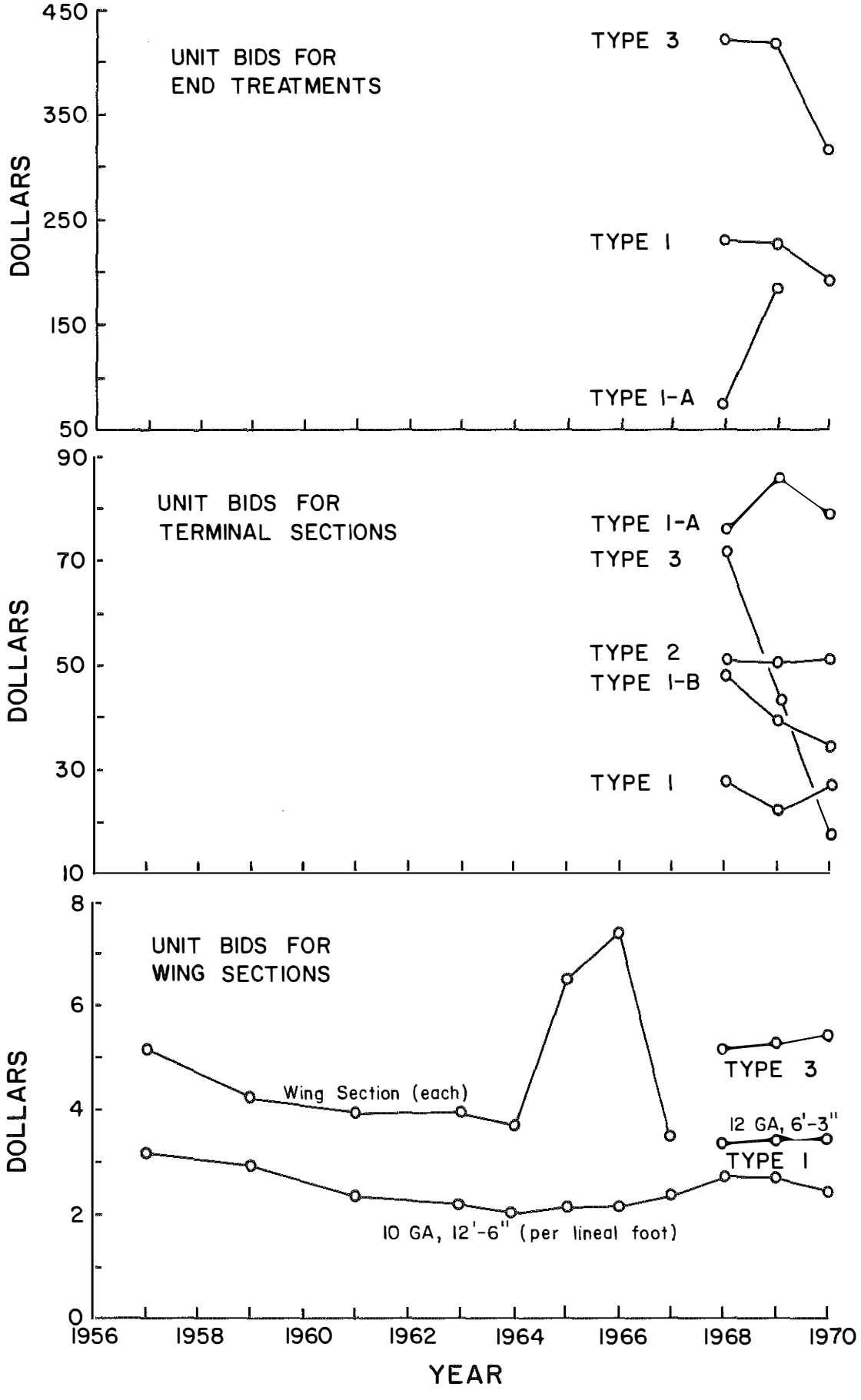
Director, Division of Construction
Director, Division of Design
Director, Division of Maintenance
Director, Division of Materials
Director, Division of Photogrammetry
Director, Division of Traffic
Director, Division of Planning
Director, Division of Right of Way
Director, Division of Roadside Development
Director, Division of Rural Roads
Division Engineer, Federal Highway Administration
Chairman, Department of Civil Engineering, University of Kentucky
Associate Dean for Continuing Education, College of Engineering, University of Kentucky
All District Engineers


HUNDRED THOUSAND DOLLARS
6
4
2
0
GROSS BIDS FOR TERMINALS AND END TREATMENTS ONLY
MILLION DOLLARS
4
2
0
GROSS BIDS
HUNDRED THOUSAND FEET
10
8
6
4
2
0
LINEAL FEET OF STEEL BEAMS (ALL TYPES)
1956
1958
1960
1962
1964
1966
1968
1970
YEAR


UNIT BIDS FOR
END TREATMENTS
TYPE 3
TYPE 1
TYPE 1-A
450
350
250
150
50
DOLLARS
UNIT BIDS FOR
TERMINAL SECTIONS
TYPE 1-A
TYPE 3
TYPE 2
TYPE 1-B
TYPE 1
90
70
50
30
10
DOLLARS
UNIT BIDS FOR
WING SECTIONS
Wing Section (each)
TYPE 3
12 GA, 6'-3"
TYPE 1
10 GA, 12'-6" (per lineal foot)
8
6
4
2
0
DOLLARS
1956
1958
1960
1962
1964
1966
1968
1970
YEAR

Research Report
311

EXPERIMENTAL GUARDRAIL INSTALLATION
[F 160(10), Mercer County, US 127]
Final Report

by

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and

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DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

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INTRODUCTION

This is the final report on a limited investigation comparing the performance of painted steel, galvanized steel and aluminum guardrails. A previous report *(1)* was issued in 1964. The final inspection of the project was made in November 1969.

The project consisted of approximately 2500 lineal feet of each type of guardrail (see Figure 1 and Table 1). The painted steel and galvanized steel were installed in November 1962. The aluminum guardrails were installed in February 1963. All rails are the deep-beam type and were installed in accordance with special provisions which covered material requirements and erection procedures. The special provisions were included in the first report.

The initial costs of the three types of guardrails, installed, according to the contractor's bid price were:

Painted steel guardrail	$2.20 per lineal foot
Galvanized steel guardrail	$2.20 per lineal foot
Aluminum guardrail	$3.12 per lineal foot
Painted end sections	$3.50 each
Galvanized end sections	$3.50 each
Aluminum end sections	$6.00 each

Maintenance of the painted steel guardrails consisted of repainting and replacement of damaged sections. The cost of repainting was approximately $0.30 per lineal foot. The aluminum and galvanized steel have had no maintenance costs except replacement of damaged sections.

PERFORMANCE SURVEY

Aluminum Guardrails

There was no apparent corrosion or discoloration. Two sections had been damaged by vehicles, one slightly and the other sufficiently to require replacement. A 30-foot section of the guardrail had been replaced with salvaged steel. It had been painted by brush with aluminum paint and the condition was poor. Daubs of aluminum paint appeared on the aluminum rails near posts which were painted in the spring of 1967. Aluminum guardrail is shown in Figures 2 through 9.

The following is a summarization of the field notes made during the November 1969 inspection:

Section 1 Sta 432+50 to 434+25	The end section had been badly damaged. The remainder of the section was in good condition.
Section 2 Sta 449+00 to 450+50	Condition was good.
Section 3 Sta 458+45 to 459+00	Guardrail at Sta 459+00 had been struck by a vehicle. Damage was slight. The remainder of the section was in good condition.
Section 4 Sta 460+00 to 462+62.5 (right)	Condition was good.
Section 5 Sta 460+00 to 462+62.5 (left)	Condition was good.

Painted Steel

The painted steel guardrails had been repainted once since installation in 1962. The Division of Maintenance estimated the life of the paint (described in the special provisions contained in the first report) to be five years.

These guardrails were rusted throughout and needed repainting again. The paint was very thin and peeling in areas. Rust was especially prevalent in the scarred areas and the center portion of the guardrail.

A section of guardrail at Sta 500+00 was damaged by a truck in 1964 and had not been repaired. All sections were of uniform condition and will not be summarized here by individual sections. The condition of the sections was poor. Figures 8 through 11 are of the painted steel guardrails.

Guardrail Posts

The guardrail posts (all steel) were repainted with aluminum paint in the spring of 1967. The edges showed rust, and in a few places rust could be seen under the recent coat of paint. A small amount of corrosion was also evident at the ground level of the posts. Generally, the posts were in good condition. Guardrail posts are shown in Figures 12 through 14.

ECONOMIC ANALYSIS

The following information was obtained from maintenance records for this project:

1. The unpainted aluminum guardrail had required no maintenance and was in good condition.

2. The unpainted galvanized steel was corroding in the places which had been scarred. However, no maintenance had been performed.

3. The painted, ungalvanized steel guardrail had been repainted once at a cost of approximately $800.00. It was in need of a second repainting, which would cost an additional $800.00.

Based on this information and the initial cost figures presented above, an economic analysis has been performed to evaluate the three types of guardrail treatment. The least ambiguous and most accurate method to analyze alternatives from an economic basis is the net present value method *(2)*. This method as applied herein evaluates all costs - past, current, and future -- on the basis of a single time frame of reference, usually (and in this case) the current year. The elements of cost in this case were the initial construction expenditures and maintenance costs. Cost figures for extraordinary maintenance such as replacement due to damage caused by collision were excluded since they were extraneous to this analysis.

Table 1 lists the costs per lineal foot for the three types of guardrails. These cost figures have been inversely discounted to the year 1970 for comparative purposes. Based on an examination of recent annual summaries of unit price bids, an interest rate of 7½ percent per annum was used. From the table, it can be seen that, from a purely economic standpoint, the galvanized steel sections are superior.

CONCLUSIONS

Eight years after the installation of the guardrails, it was evident that the painted steel guardrails were in much poorer condition than the other two types. The painted steel needed repainting, whereas the galvanized steel and aluminum guardrails needed no maintenance. Significant differences between the aluminum and galvanized steel guardrails had not then been observed. The galvanized steel guardrails had slight rust and discoloration, whereas none was present on the aluminum guardrails. Rust on galvanized steel guardrails was very isolated and occurred only in small, scarred areas. The galvanized steel had a distinct cost advantage over the aluminum guardrail. The galvanized steel also had a cost advantage over the painted steel guardrail when maintenance costs were considered.

TABLE 1

SUMMARY OF GUARDRAIL INSTALLATIONS

F 160(10), MERCER COUNTY, U.S. 127
Harrodsburg-Lawrenceburg Road, Sta 431+60 to Sta 650+50

PAINTED STEEL GUARDRAIL

Northbound Lanes

Station	500+00	to 502+50		250.0 l.f.
	513+50	to 519+12.5		562.5 l.f.
	519+87.5	to 521+25		137.5 l.f.
	551+25	to 553+12.5		187.5 l.f.
	571+25	to 577+50		625.0 l.f.
	597+87.5	to 603+87.5		600.0 l.f.
	613+75	to 616+00		225.0 l.f.
	624+75	to 626+62.5		187.5 l.f.
			Total	2775.0 l.f.

GALVANIZED STEEL GUARDRAIL

Northbound Lanes

Station	627+25	to 632+50		525.0 l.f.

Southbound Lanes

Station	534+50	to 539+75		525.0 l.f.
	552+62.5	to 553+62.5		100.0 l.f.
	567+37.5	to 575+12.5		775.0 l.f.
	598+50	to 604+00		550.0 l.f.
			Total	2475.0 l.f.

ALUMINUM GUARDRAIL

Southbound Lanes

Station	432+50	to Radius		75.0 l.f.
	432+50	to Approach		25.0 l.f.
	432+50	to 434+25		175.0 l.f.
	449+00	to 450+50		150.0 l.f.
	458+45	to 459+20		75.0 l.f.
	460+00	to 462+62.5	(left)	262.5 l.f.
	460+00	to 462+62.5	(right)	262.5 l.f.
	471+00	to 472+00		100.0 l.f.
	478+00	to 486+75		875.0 l.f.
	493+25	to 504+00		75.0 l.f.
	513+50	to 516+37.5		287.5 l.f.
	521+37.5	to 523+00		162.5 l.f.
			Total	2525.0 l.f.

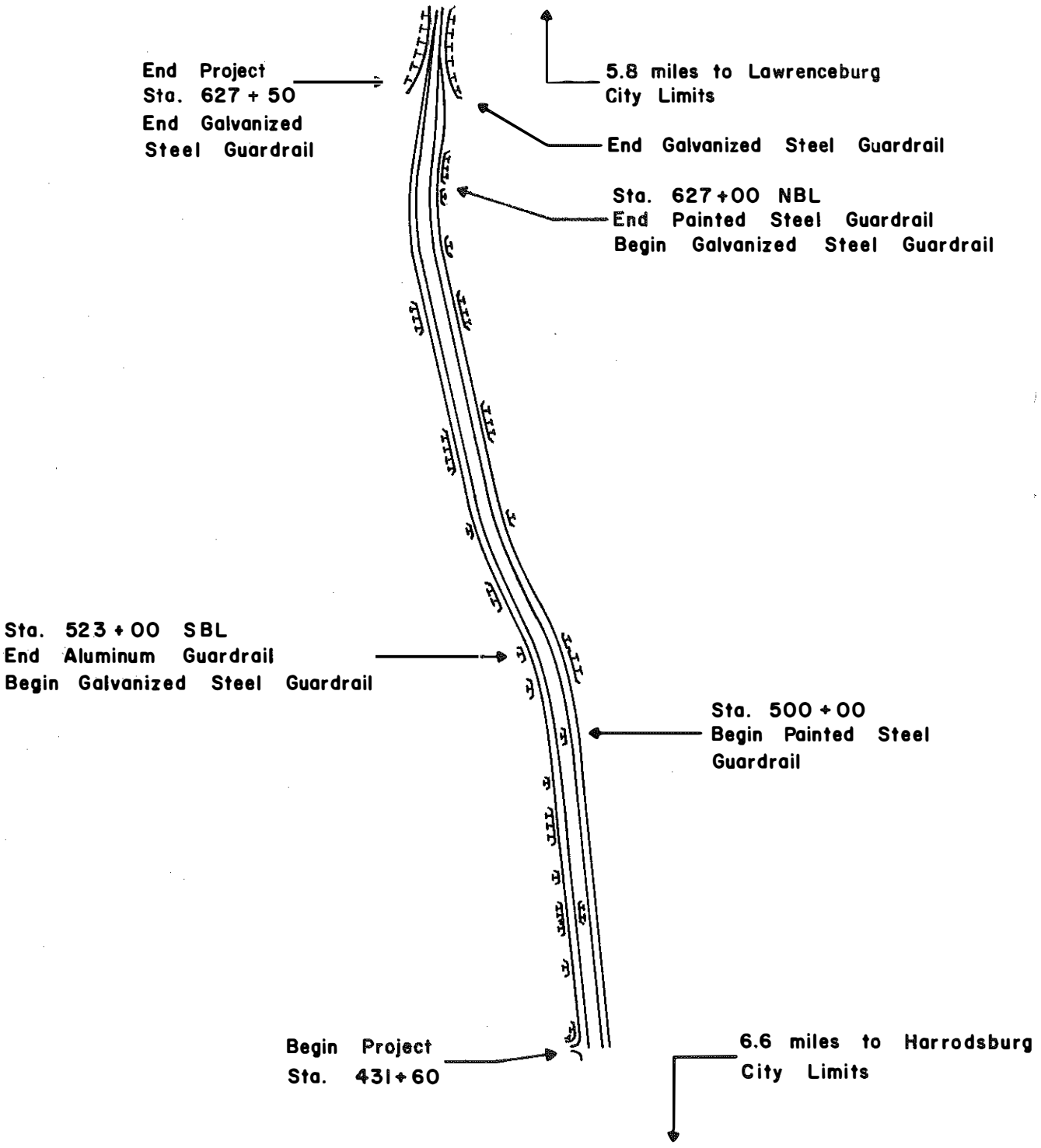

Figure 1. Map Showing Location of Guardrail Installations

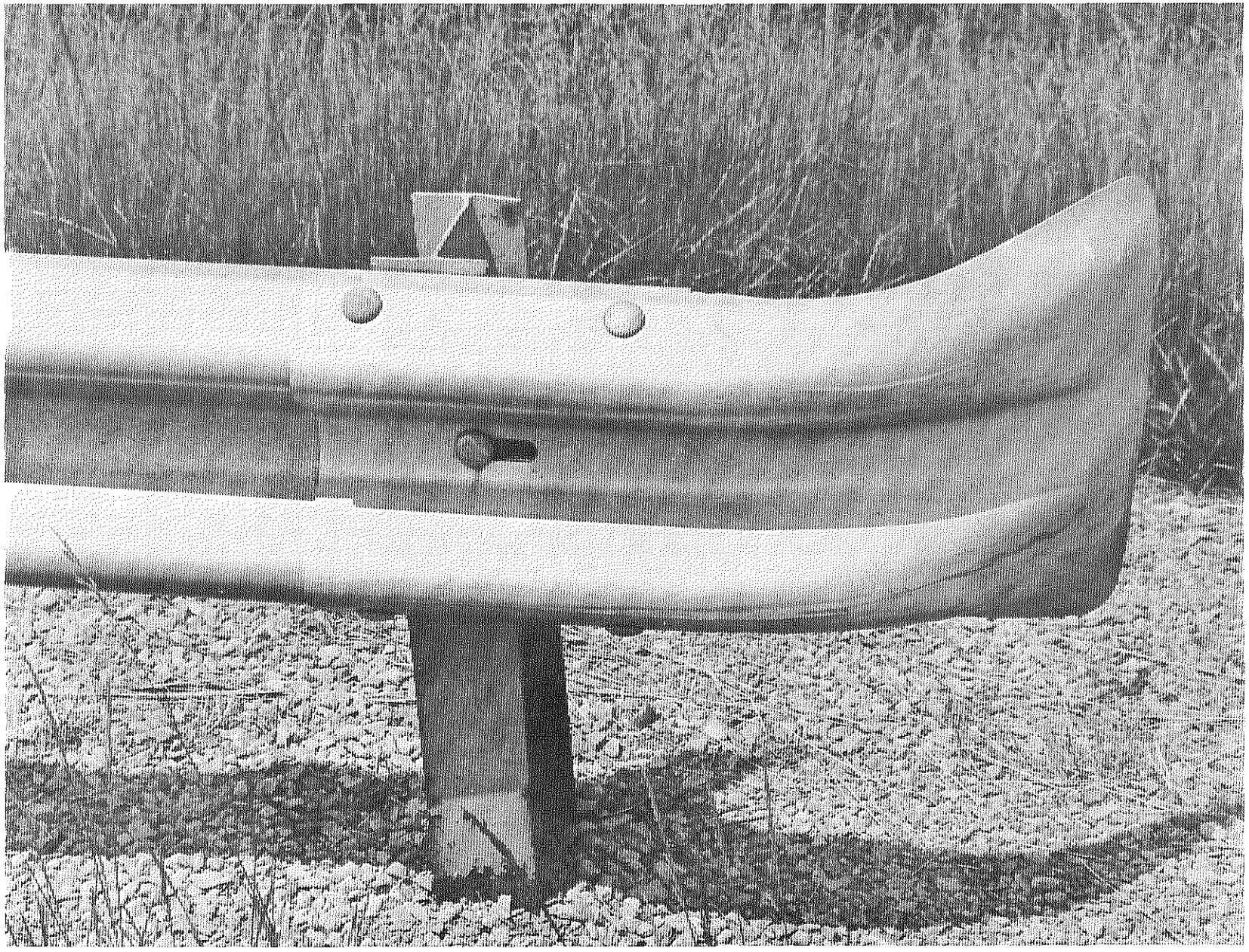

Figure 3. Aluminum End Section

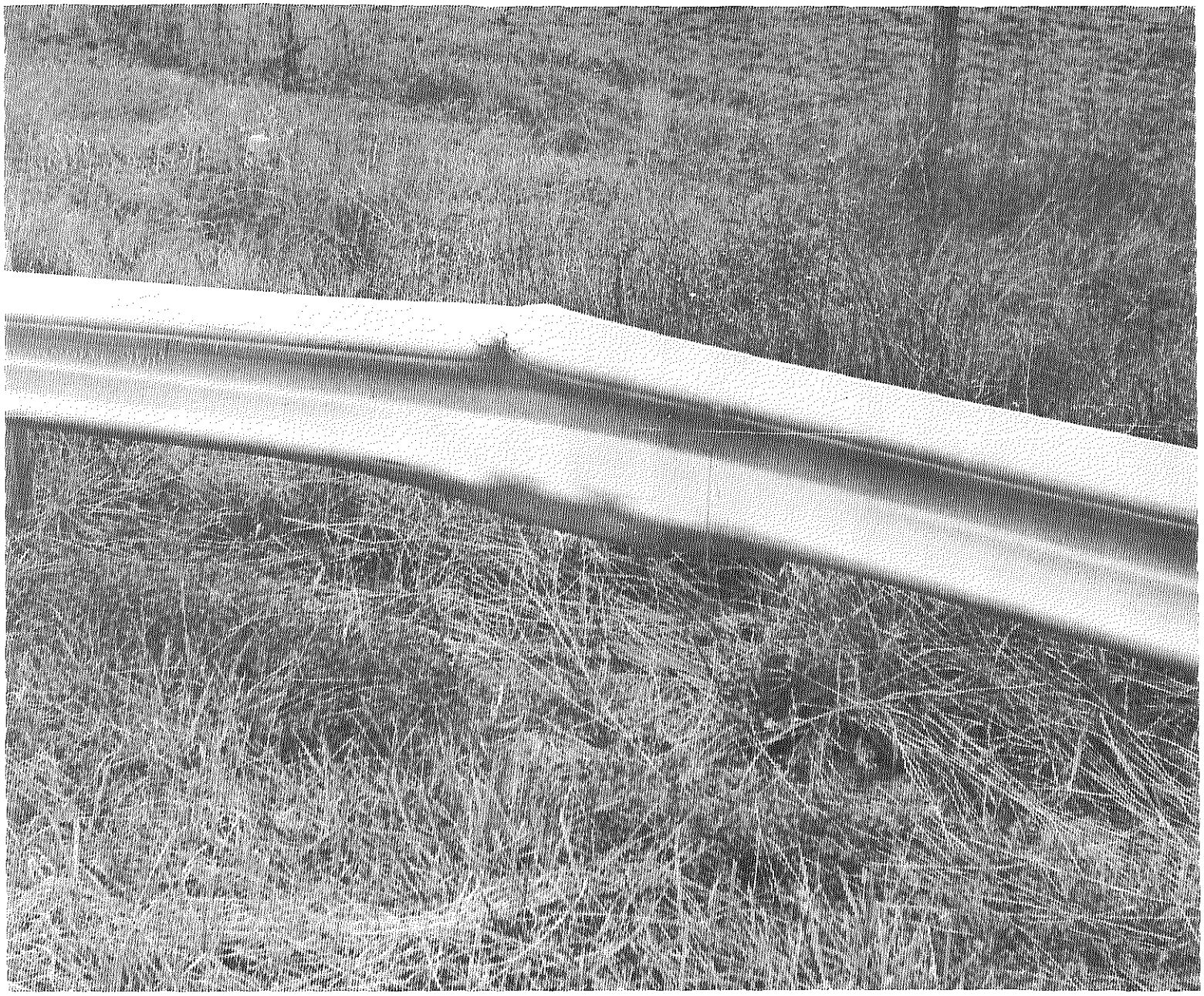

Figure 4. Damaged Section of Aluminum Guardrail

Figure 5. Section of Galvanized Steel Guardrail

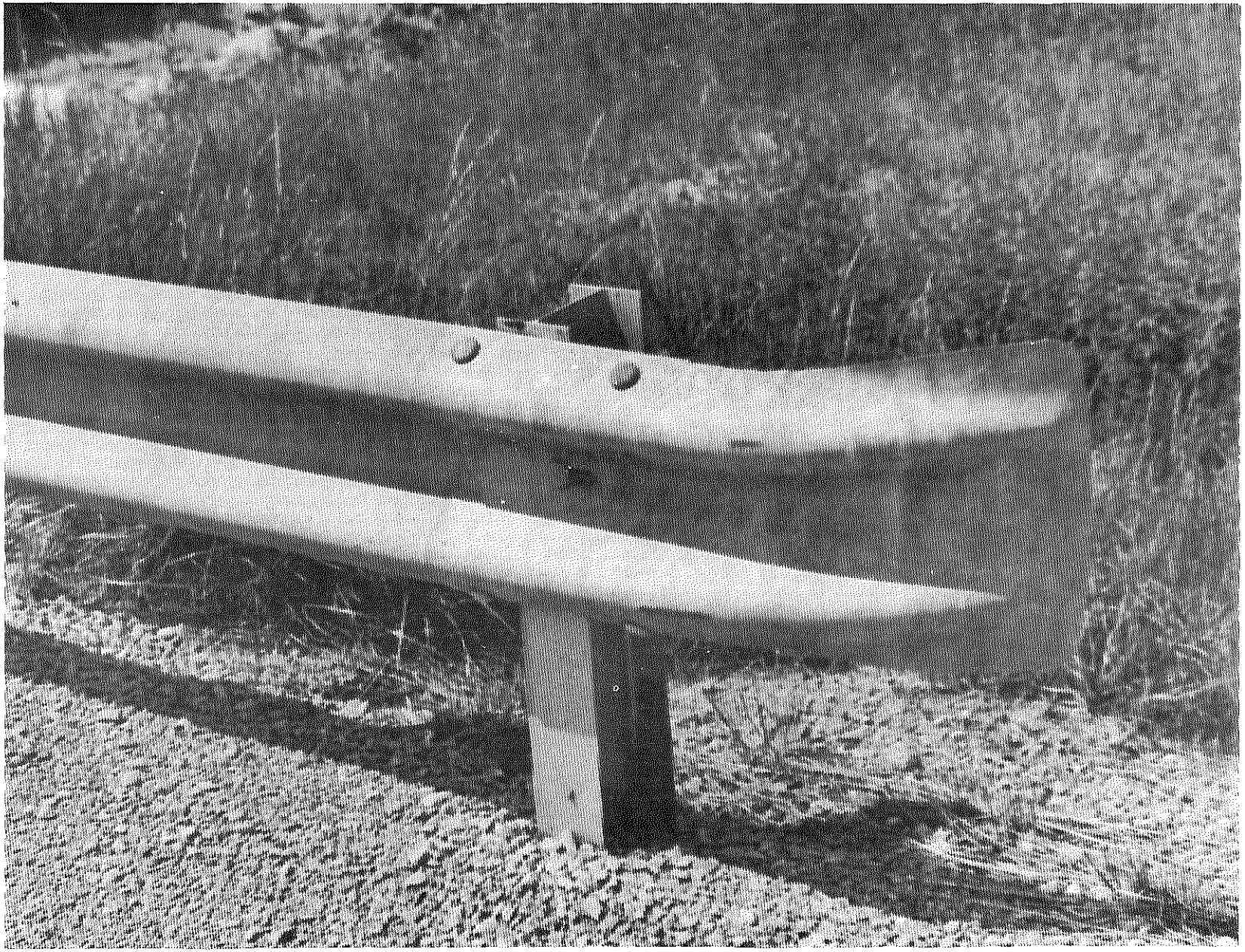

Figure 6. Galvanized Steel End Section

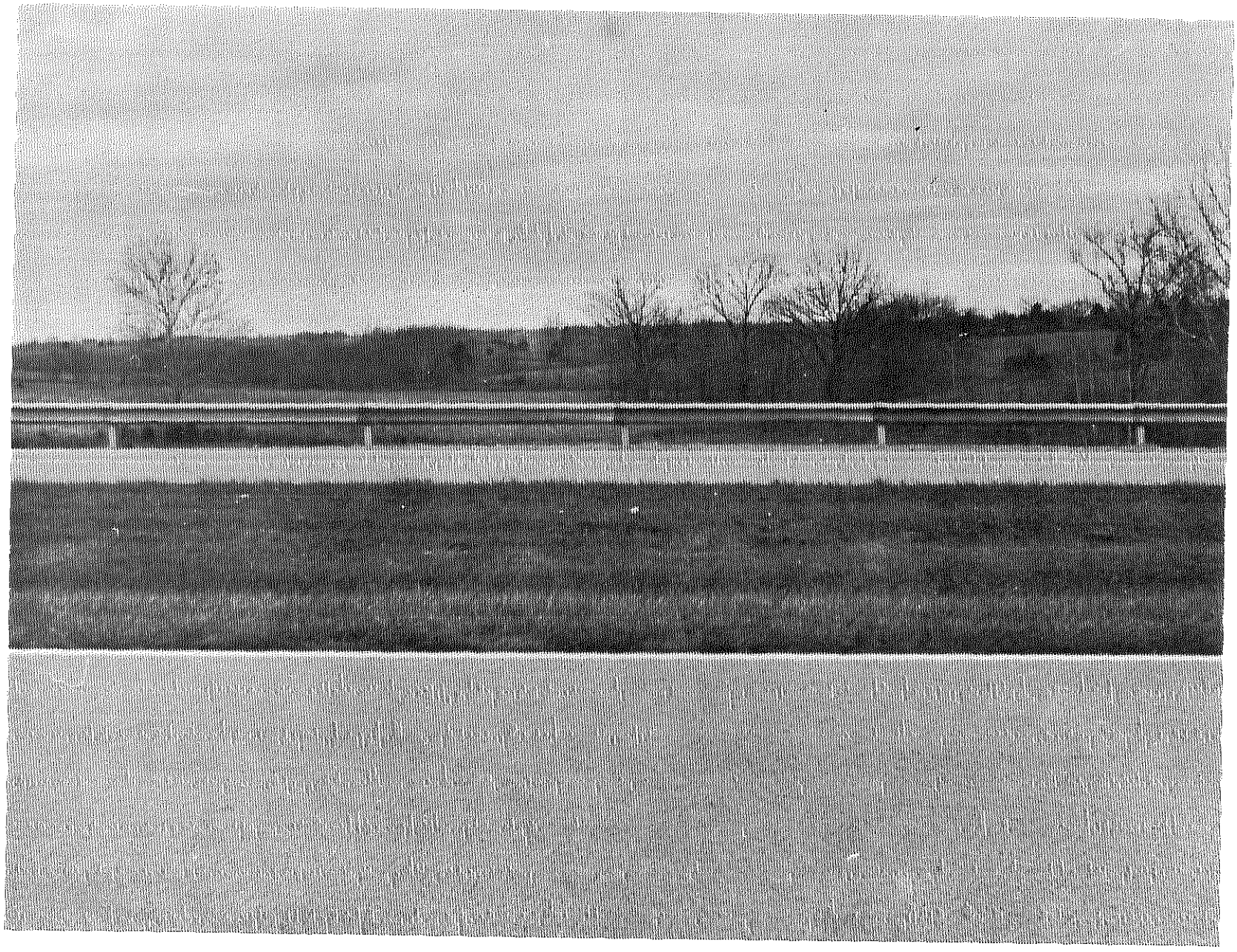

Figure 7. **Galvanized Steel Guardrail with Discoloration at the Joints**

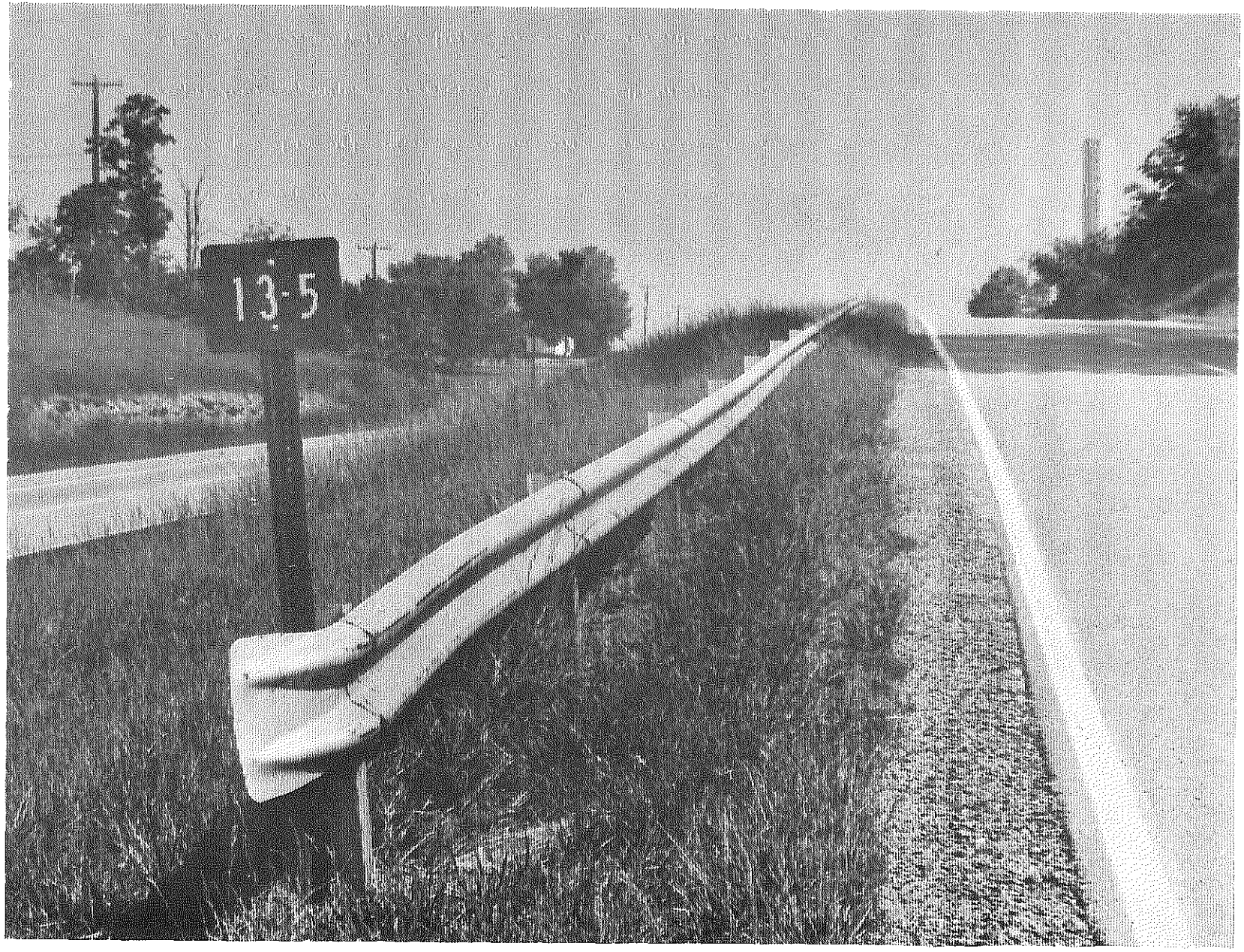

Figure 8. Section of Painted Steel Guardrail

Figure 9. Painted Steel End Section

Figure 10. Closeup of Painted Steel Guardrail Showing Severe Rusting

Figure 11. Painted Steel Guardrail in Poor Condition

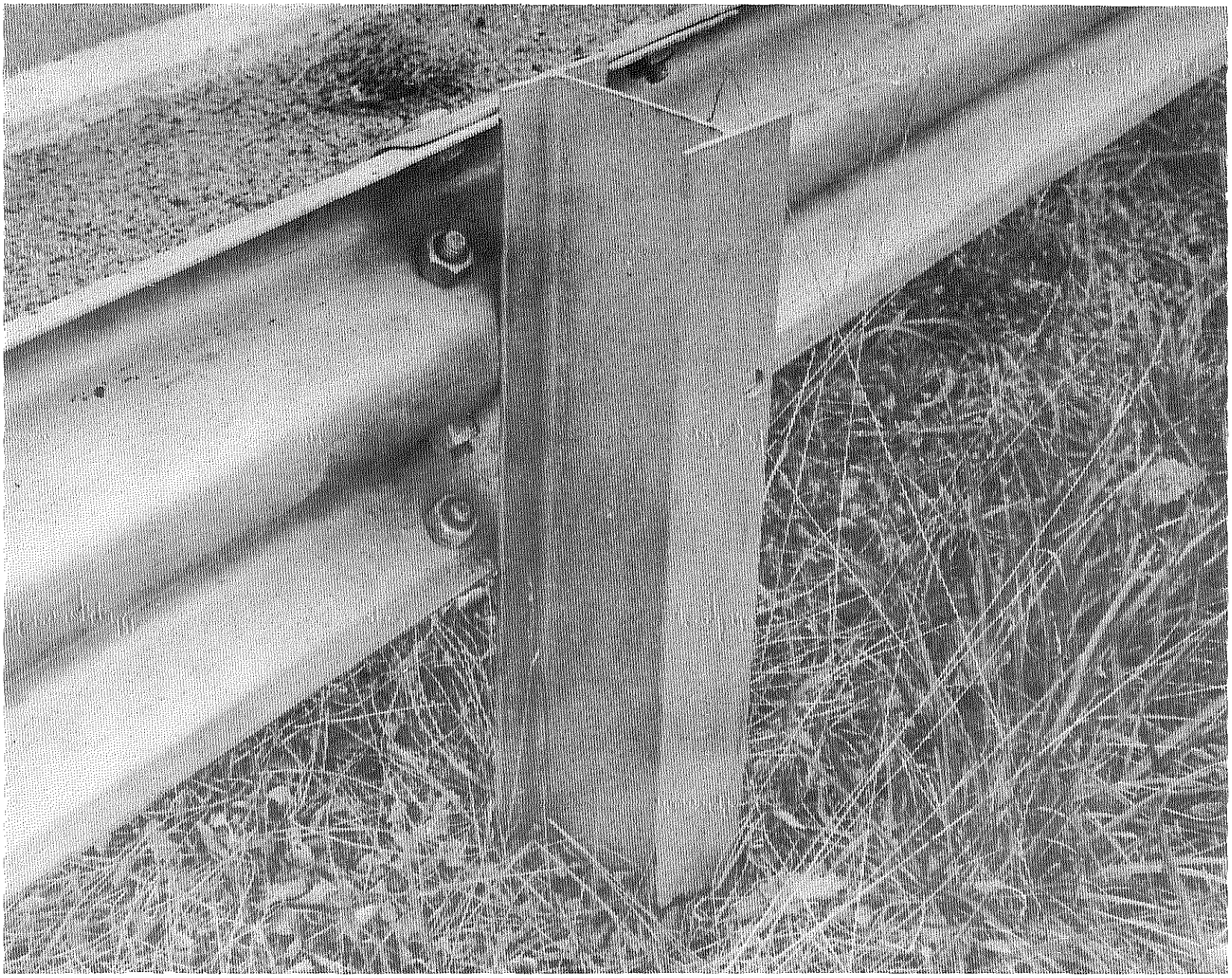

Figure 12. Guardrail Post

Figure 13. Guardrail Post Exposed below Painted Portion

Figure 14. Closeup of Guardrail Post Exposed below Painted Portion