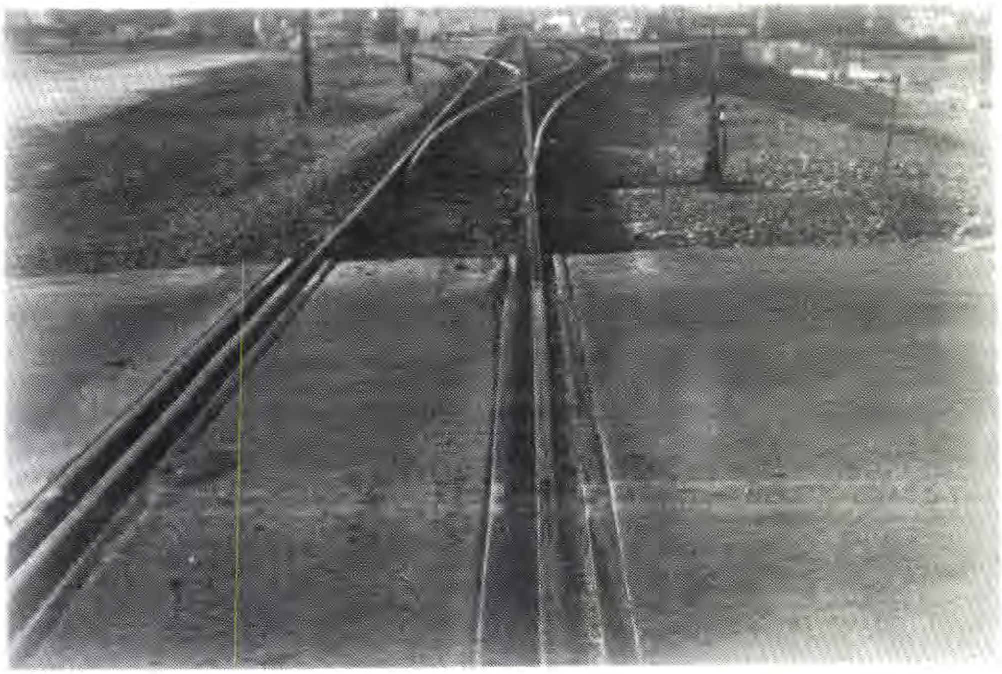
SD90-14-F2

SD Department of Transportation
Office of Research



# Railroad Crossing Study

## Study SD90-14
## Volume II: Appendices

Prepared by
Department of Civil Engineering
SD School of Mines & Technology
Rapid City, South Dakota

January, 1992

## DISCLAIMER

TECHNICAL REPORT STANDARD TITLE PAGE

| | | |
|---|---|---|
| 1. Report No.<br>SD90-14-F2 | 2. Government Accession No. | 3. Recipient's Catalog No. |
| 4. Title and Subtitle<br>Railroad Crossing Study | | 5. Report Date<br>January 31, 1992 |
| | | 6. Performing Organization Code |
| 7. Author(s)<br>Terje Preber, Mohan Ballagere, Krishna Prasad | | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>Civil Engineering Department<br>South Dakota School of Mines & Technology<br>501 East Saint Joseph<br>Rapid City, SD 57701-3995 | | 10. Work Unit No.<br>4-04100 |
| | | 11. Contract or Grant No.<br>310006 |
| 12. Sponsoring Agency Name and Address<br>South Dakota Department of Transportation<br>Office of Research<br>700 East Broadway Avenue<br>Pierre, SD 57501-2586 | | 13. Type of Report and Period Covered<br>Final<br>Aug 1990 to Jan 1992 |
| | | 14. Sponsoring Agency Code |

15. Supplementary Notes

This document is Volume II (Appendices). Volume I (Final Report) is published as SD90-14-F1.

16. Abstract

This report presents the results of the survey of 54 railroad grade crossings in South Dakota. Three basic types of crossings were studied: rubber, asphalt, and timber. The crossings were studied for the effect on roughness of highway and rail traffic, soil conditions, drainage, and age. Construction of five crossings was also observed, in order to evaluate the adequacy of the construction procedures and practices applied in South Dakota.

The results of the study indicate that the main factors leading to the deterioration of railroad crossings include: differential settlement between crossings and the approaches, surfacing material breakdown, inadequate maintenance, and poor construction procedures regarding the foundation materials for the crossings.

Based on the results of the surveys and inspections, conclusions regarding modes of distress and the adequacy of construction practices were formed. Recommendations were given in regard to measures that should be implemented to improve the performance of railroad crossings in South Dakota. The report stresses the need for semiannual cleaning and inspection of crossings, as well as repair and maintenance of items needing attention.

| | | | |
|---|---|---|---|
| 17. Keywords<br>railroad crossing, roughness, maintenance, construction, inspection | | 18. Distribution Statment<br>No restrictions. This document is available (on loan) from the sponsoring agency. | |
| 19. Security Classification (of this report)<br>Unclassified | Security Classification (of this page)<br>Unclassified | 21. No. of Pages<br>273 | 22. Price |

**REPORT**

# RAILROAD CROSSING STUDY

BY

Terje Preber,
Mohan Ballagere,
and Krishna Prasad

Volume II
Appendices

Conducted by
Department of Civil Engineering
South Dakota School of Mines and Technology

In cooperation with the
South Dakota Department of Transportation
Research Project No 4-04100

Department of Civil Engineering
South Dakota School of Mines and Technology
Rapid City, SD 57701
January 25, 1992

## TABLE OF CONTENTS

# APPENDIX A

# FIELD INVESTIGATION

## A-1 CATEGORIZATION

Information on all railroad crossing locations, ADT, and soil conditions at the respective crossings was provided by the South Dakota Department of Transportation. This information was used to categorize and select railroad crossings in accordance with ADT, rail traffic, type of crossing and surfacing material, age, soil type, and drainage conditions.

Categorization based on soil type could not be based on specific information about the subsurface conditions since the borings had to be performed after the crossing had been selected. Location, based on geological features including what soils were to be associated with land forms, flood plains, residual soil and glaciated areas, therefore had to be used for selection.

Originally, traffic volume was to be converted to E18 axle load equivalents, but, due to lack of information on vehicle type breakdown and low traffic volumes on some roads, this was not feasible. Rather, traffic volume alone was used for this portion of the categorization. Whether a crossing was to be considered rural or urban was not only based on location but also by considering speed limit. In order to minimize the number of variables, categorization according to highway traffic was based on two categories for rural (ADT more and less than 1000 vehicles). For urban areas, arterials and collector streets were considered.

Breakdown by type of crossing for rural areas seemed to relate to traffic, as rubber and asphalt crossings were used for both high volume and low volume highways. Timber crossings, however, seem mostly to have been used on low volume state and county highways. In urban areas on arterial streets, rubber crossings appear to be used in almost all cases, while asphalt crossings are most common on collector streets.

Selection of crossings as related to rail traffic proved difficult, as there are few coal lines left. However, two crossings were studied on the Burlington Northern coal line through Aberdeen. Crossings with a wide variety of rail traffic volume, however, were covered by the surveys.

With the number of crossings studied, age spanned over a period of up to 20 years. However, most crossings studied were installed between 1979 and 1990.

**A-2 FIELD SURVEYS**

Based on traffic volume, crossing type and location, railroad crossings were selected and scheduled for investigation. Initially, 25 crossings located in eastern and western South Dakota were surveyed and studied in detail. At the end of the field investigation and survey of the selected crossings, it was decided that the data collected was insufficient for a complete evaluation of the problems associated with the different types of crossings investigated. A complete condition survey of 29 additional crossings was therefore performed on crossings in

Rapid City, Sioux Falls, Blunt, Northville, Redfield, Aberdeen, and Watertown. The condition surveys are described and discussed in Section A-4.

The field investigation for the initial 25 crossings, except for the crossing at Cottonwood, was performed from October, 1990 through March, 1991. The crossings in Rapid City were surveyed during the period of October through December, 1990, while the crossings in Aberdeen and Watertown were surveyed in February, 1991, and crossings in Sioux Falls in March of 1991. The crossing at Cottonwood was surveyed in June of 1991.

The field survey consisted of mapping the surface of the crossings These results are presented in subsequent sections of this chapter. The mapping of the surface of the crossings was performed by dividing the surface into two square foot sections, and measuring the elevation within each of these squares by leveling. The data from the surveys was entered into a data file and contours of the crossing were plotted using a computer program. The main purpose of the surveys was to determine the overall geometry such that surface roughness of the crossings could be evaluated, and also to identify any patterns regarding crossing deterioration and failure. General conditions of the surfacing material and natural drainage were also recorded. Photographs were taken to show details and overall views of the crossings.

Cross-sections were drawn of the pavement at the shoulder of the road (outside the area generally subjected to traffic) in the wheel path of the highway traffic and in between the wheel paths. From the cross-sections so plotted, a roughness number was computed. The roughness number was defined as the height of a ridge or the depth of a depression over its length (in the direction of the highway traffic). A summary of roughness numbers for all crossings is given in Section VII-2.

### A-2.1 Vibration Monitoring

Vibration monitoring to determine dynamic loading conditions during both highway and railroad traffic was performed using the Instantel DS477 monitoring device. The results of the monitoring yielded little useful information, however, the results are discussed in subsequent sections of the report.

The Instantel DS477 records and plots the acceleration, peak velocity and frequency resulting from the highway and railroad traffic. Using the output from the vibration monitoring equipment, values of displacement amplitude of the track were calculated using a computer program. Measurements were taken at a distance of three feet from the wheel path at several locations along the crossing.

### A-2.2 Rail Deflection Measurements

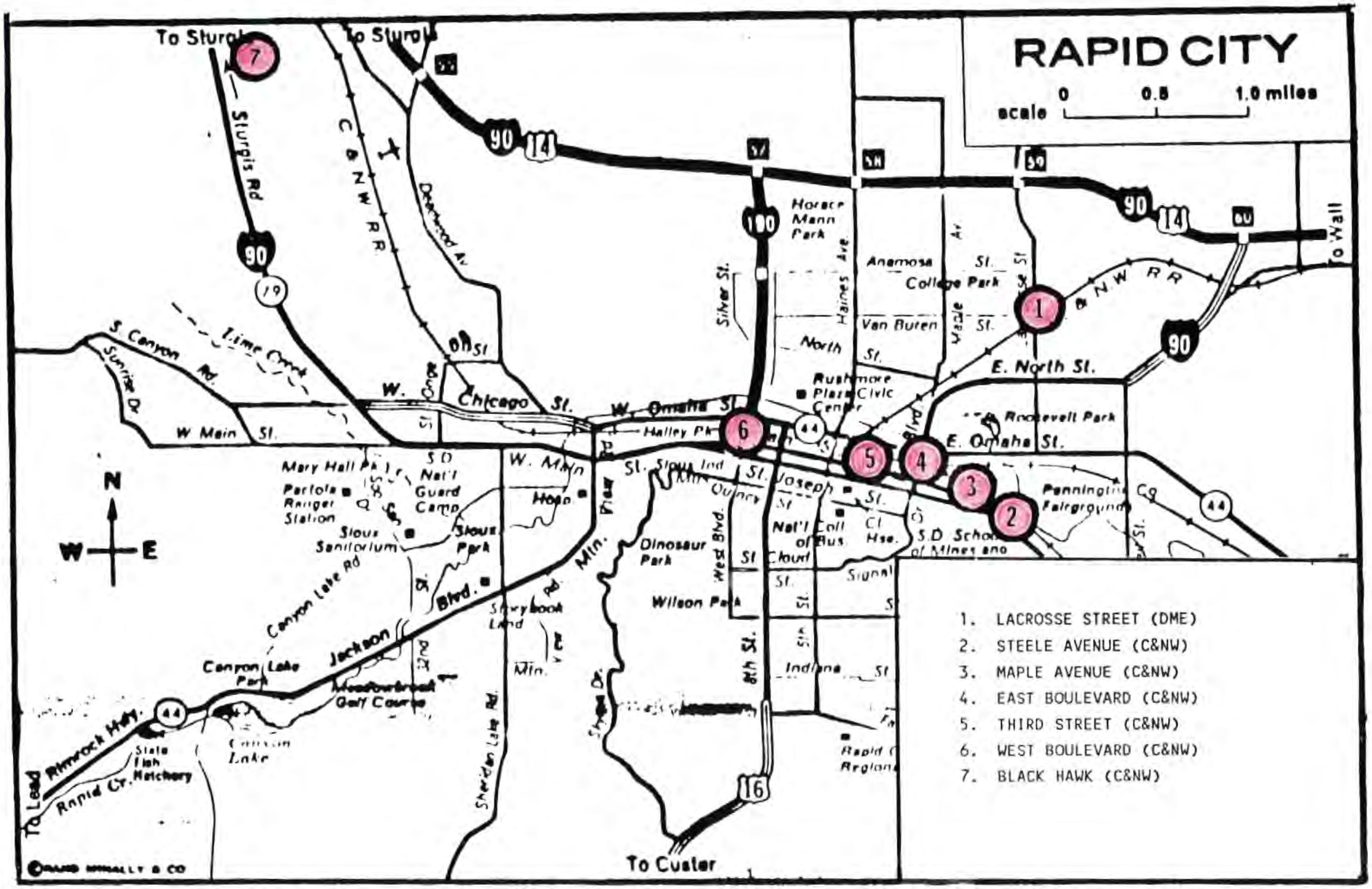
The approach portion of the railroad bed was studied for deflections. Such deflections were measured using a cantilever beam device founded outside the railroad embankment. A pen was attached to the beam and a sheet of paper attached between the tie and the wall of the rail. As the rail deflected, a trace was recorded on the paper. During the measurements it was noted that the rails and ties deflected considerably under the rail traffic, however, no deformations were noted on the ballast between the ties. Deformations were therefore also measured by driving a spike under the rails at the end of the crossing and recording how far the spike was driven into the ballast relative to the rail.

### A-2.3 Soil Conditions

The soil conditions at the location of the crossings surveyed were obtained from borings and laboratory testing performed by crews from the South Dakota Department of Transportation. The soil conditions at the crossings are described under the results of the field surveys and the gradation analysis and water contents obtained from the laboratory testing are shown in Appendix B.

## A-3 RESULTS OF SURVEYS

The crossings are described under the main headings in accordance with the city where located and in the order of which they were surveyed. Each crossing is named in accordance with the name of the street or highway it crosses. The location of each crossing also is shown on the location maps for each city.




LOCATION MAP 1

**A-3.1 Rapid City**

**LaCrosse Street**

Four Lanes - One Track

The crossing at LaCrosse Street is a Redhawk type and was built in 1989. The pavement consists of Portland Cement concrete and the headers are 1/2 inch wood plank with no rubber seals. LaCrosse Street is a four lane artery serving considerable motel business, the Rapid City Mall, and handles traffic from Exit 59 on I-90. The average daily traffic is 10,816 vehicles with a small percentage of trucks. The rail traffic consists of one to two trains per day, each comprised of two to four locomotives and 40 to 50 freight cars. There is no switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded with no bolted joints within 20 feet of the crossing. The crossing is shown in Photos 1 through 4.

The subsurface soils consist of 5 inches of top soil over a dark brown sandy silt extending to a depth of 5 feet. The natural moisture was 22 percent. Based on the soil description, it is likely that the soil has a high organic content and high frost susceptibility. The soil classifies as A-4(3) in the AASHTO and SM in the Unified classification systems. Compressibility of the soil is moderate, and pumping is likely to occur if the soil is saturated.

Photo 1. LaCrosse Street - Settlement of Crossing at RHS of Track and Panel Wear

Photo 2. LaCrosse Street - Debris Collection between Track and Missing Fastener Protective Caps

Photo 3. LaCrosse Street - Rubber Panels Damaged by Snow Plows

Photo 4. LaCrosse Street - Close Up Plow Damage

Rail deflections during train traffic at the ends of the crossing were measured to 0.75 inches. At the time of the survey there was little sign of rail wheel wear on the rubber panels, but, during the spring of 1991, the crossing was reinspected at which time considerable panel wear could be seen along the entire crossing (See Photo 1). Some rail deflection under the rail traffic is therefore likely to occur along the entire crossing.

The results of the survey are shown in Figure A1 through A3. The contour map (Figure A1) shows that the crossing is relatively even, but minor signs of depressions can be seen beginning to form in the driving lanes from 9 to 18 feet and 24 to 30 feet from the west curb. The survey data show that the rail is slightly lower than the panels and the panels tilt towards the rails. This can be seen in Figure A3, which shows cross-sections at one of the wheel paths and in between the wheel paths. In addition, Figure A3 shows that the south panels have settled more than the center and north panels, and that the overall settlement of the crossing in relation to the pavement is on the order of 1/4 to 1/2 of an inch. In addition, the sections on Figure A3 show more settlement and pavement wear under the wheel path than in between the wheel paths. There is a nearly a 1/2 inch difference in the elevation of the pavement at the wheel path as compared to in between wheel paths.

The wood headers are in good shape, although they have settled with the track. Minor chipping can be seen in the concrete on the approaches to the crossing. Snow plow damage is significant,

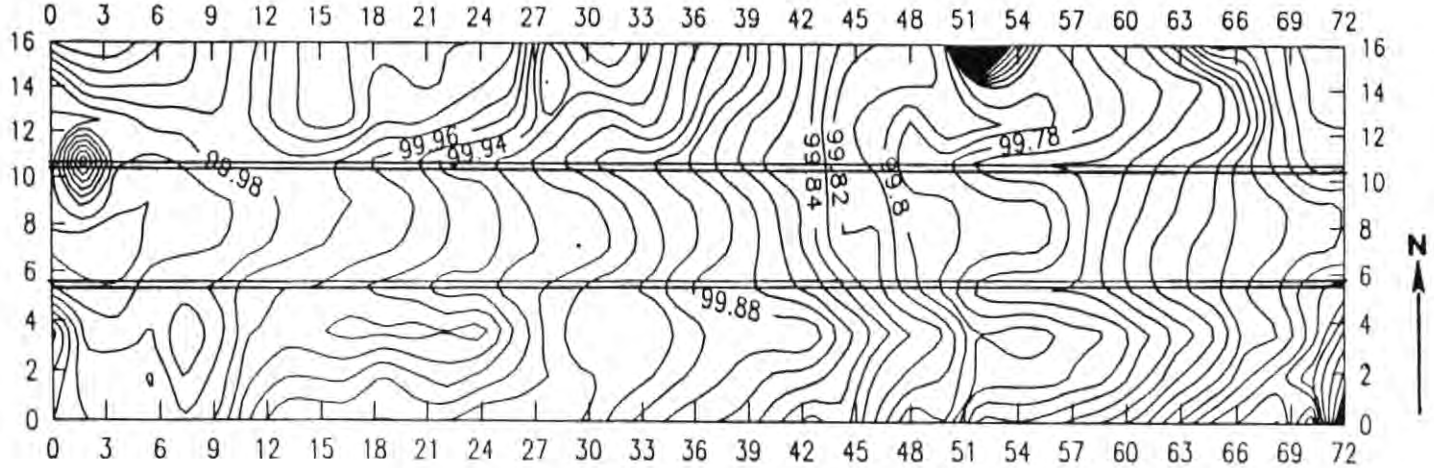



Figure A1 LaCrosse Street, Rapid City (Rubber)

All Distances in Feet

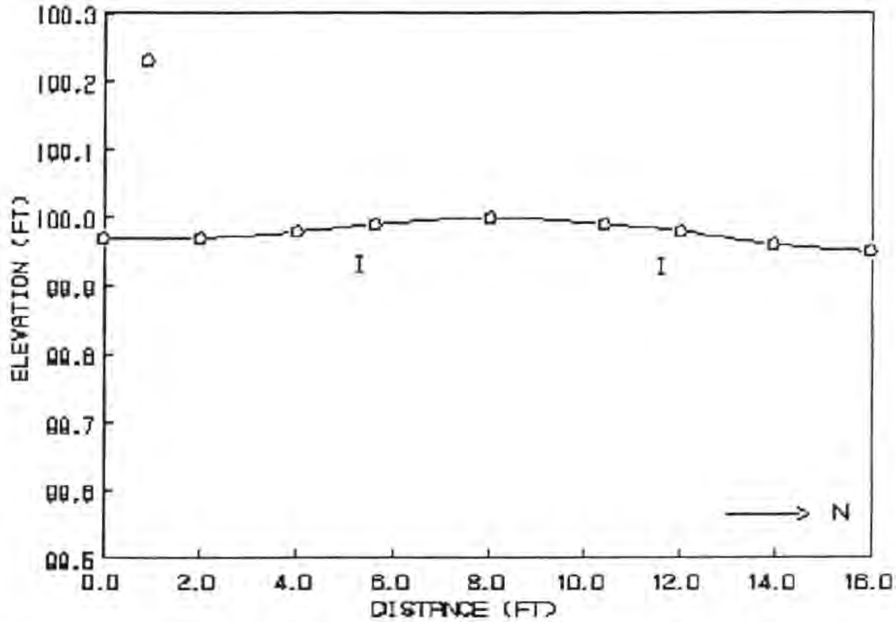



**Figure A2** LaCrosse Street, Rapid City (Rubber) Cross section at curb.

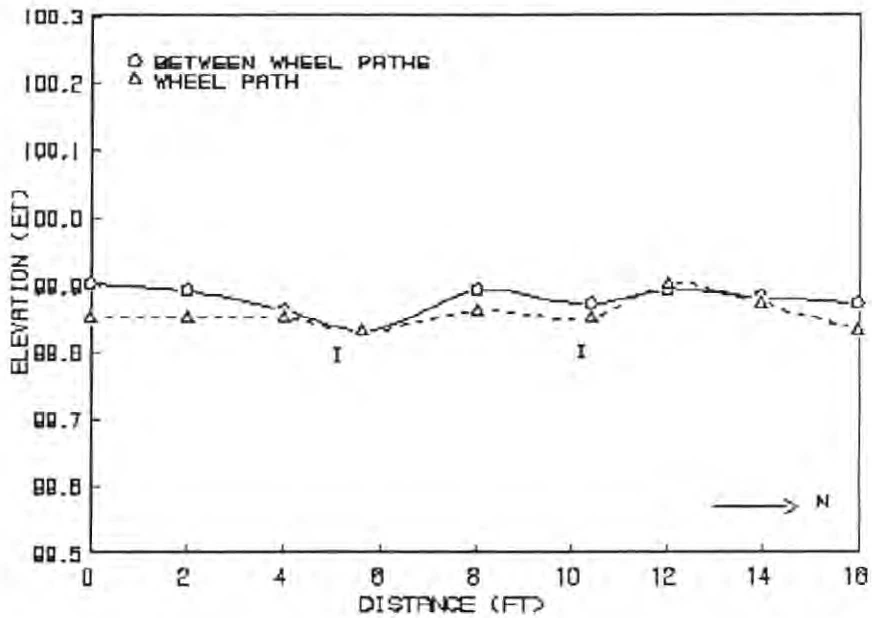



**Figure A3** LaCrosse Street, Rapid City (Rubber) Cross section taken at wheel path and between wheel paths.

as the pattern on the rubber panels has been torn off at the west side of the crossing (See Photos 2, 3 and 4). A significant number of fastener protective caps have also been torn off (See Photo 2).

Drainage at this crossing is good, as there are ditches on both sides of the track beyond the crossing. Nevertheless, there are signs of significant track movements under rail traffic at both the east and west side of the crossing. This is substantiated by the track deflections measured at the crossing (0.75 inches).

**Steele Avenue**

Two Lanes - One Track

The crossing at Steele Avenue is an asphalt type with inner and outer mud rails It was built before 1981, but appears to have been repaved since the time of construction. Steele Avenue is a medium volume road with average daily traffic of 4,728 vehicles serving residential areas small businesses, and the City of Rapid City Municipal Depot. The rail traffic consists of two trains per day, each with two to four locomotives and 40 to 50 freight cars. In addition, the crossing is subjected to considerable rail switching traffic. The rail in the crossing is 115 pound weight and continuously welded with no bolted joints within 20 feet of the crossing. The overall conditions of the crossing are shown in Photos 5 through 7.

The subsurface soils consist of 5 inches of top soil, underlain by silty clay with a small percentage of pebbles and sand. The

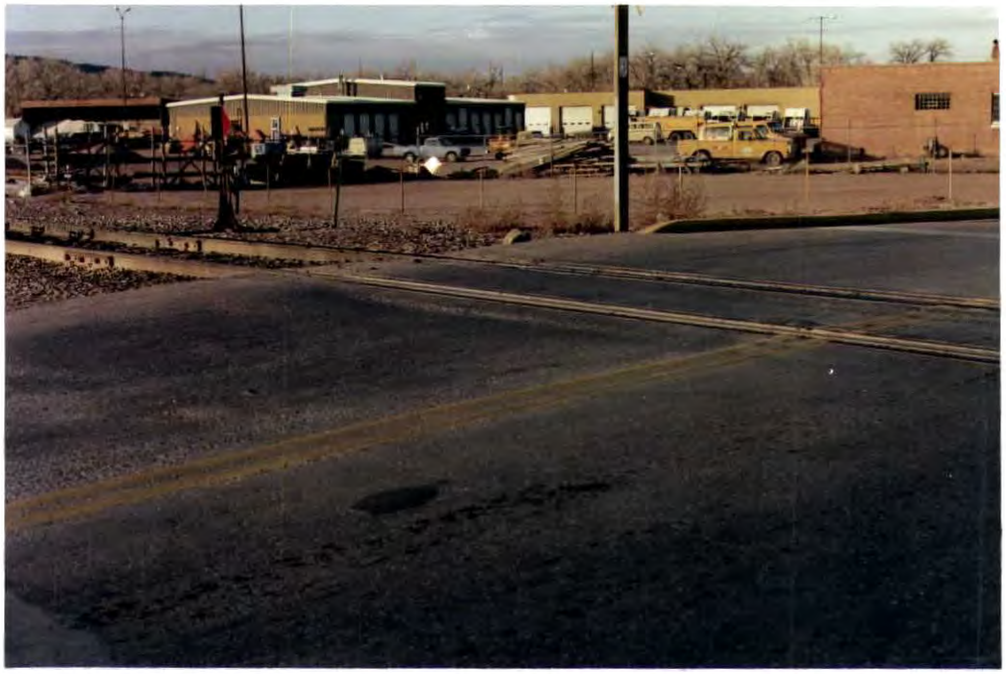


Photo 5. Steele Avenue - Approach Pavement Settlement

Photo 6. Steele Avenue - Yielding of Asphalt and Mud-Filled Track

Photo 7. Steele Avenue - Debris Collection on the Either Side of Rail

gradation analysis shows that 67 percent is smaller than the #200 sieve and the Liquid Limit and Plasticity Indexes are 44 and 26 percent, respectively. The soils classify as A-7-6(13) in the AASHTO and CL in the Unified classification systems. The natural moisture content was 14.9 percent. Based on the laboratory results it is felt that the soils have high frost susceptibility, low bearing capacity under saturated conditions, and moderate compressibility.

The results of the survey are shown in Figures A4 through A6. The contour map (Figure A4) shows a relatively uneven crossing with differenses in elevation in excess of one inch over distances of less than 3 feet. The map also shows that there is some rutting of the asphalt in the wheel paths, especially on the west side of the crossing. Considerable approach pavement settlement can also be seen in Photo 5 and in Figure A6. Pavement distortion was considerably less at the curb, however (Figure A5). The survey data show that the rail is slightly lower than the asphalt adjacent to outer mud rails and that there is a trough in the pavement between the rails (See Figure A6). The approach pavement has settled nearly 1 to 1 1/2 inches with respect to the track. The north rail is uneven and is up to 1 inch higher than the south rail (See Figures A5 and A6). Figure A6 also shows more settlement and pavement wear under the wheel path than in between the wheel paths.

Drainage at this crossing is poor, as there are no ditches and there is evidence of considerable pumping on the rail approaches

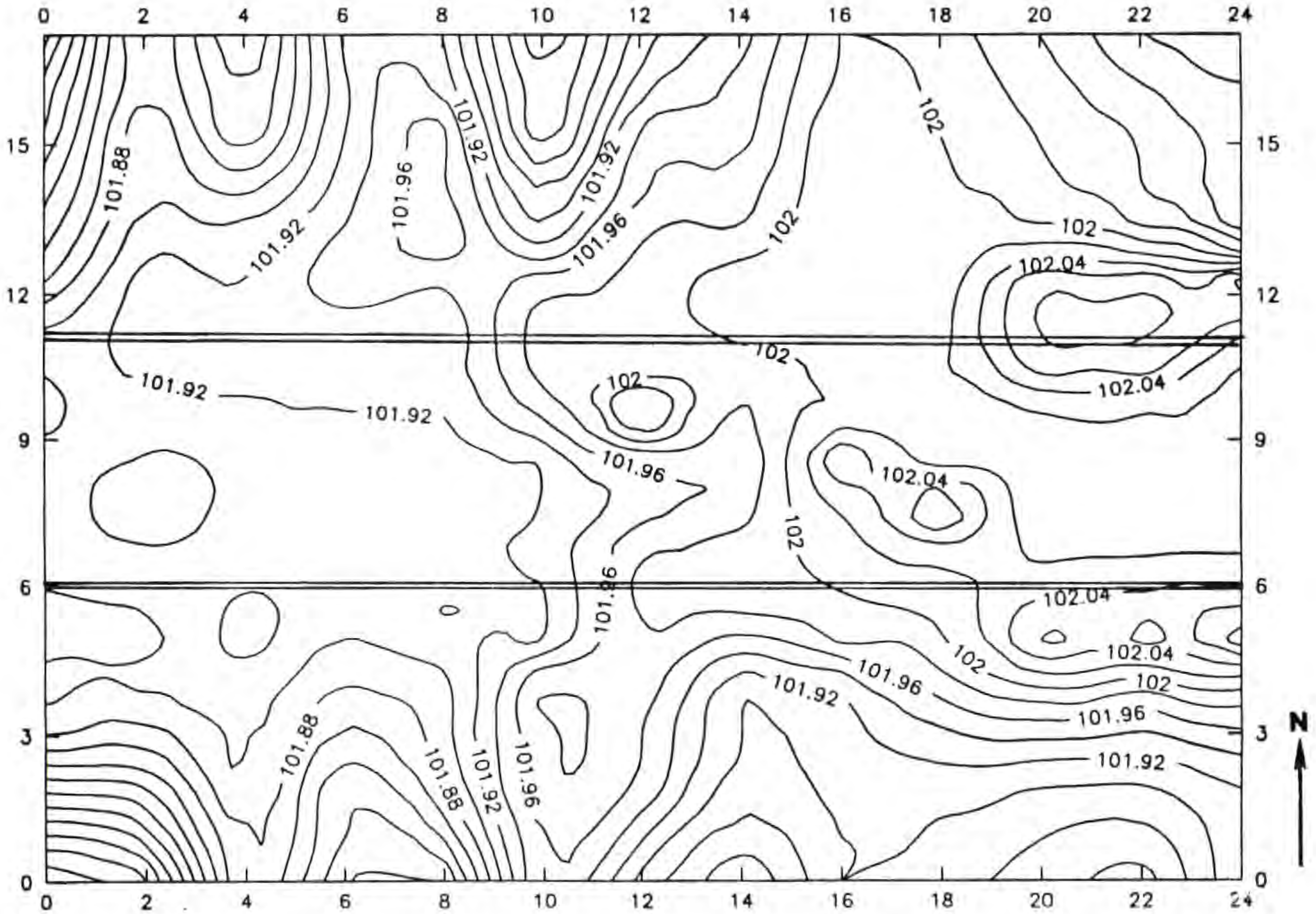



Figure A4 Steele Avenue, Rapid City (Asphalt)

All Distances in Feet

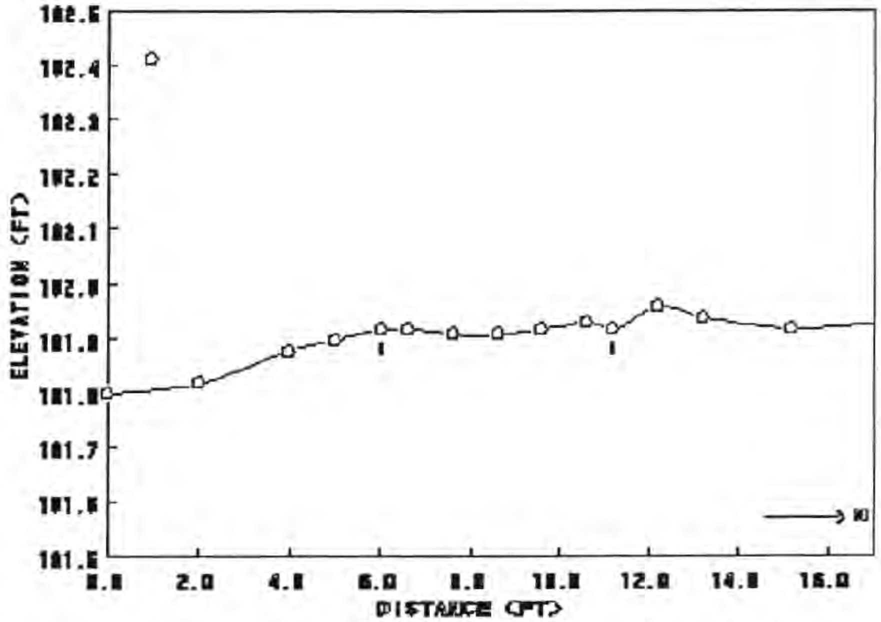


**Figure A5** Steele Avenue, Rapid City (Asphalt)
Cross section at curb.

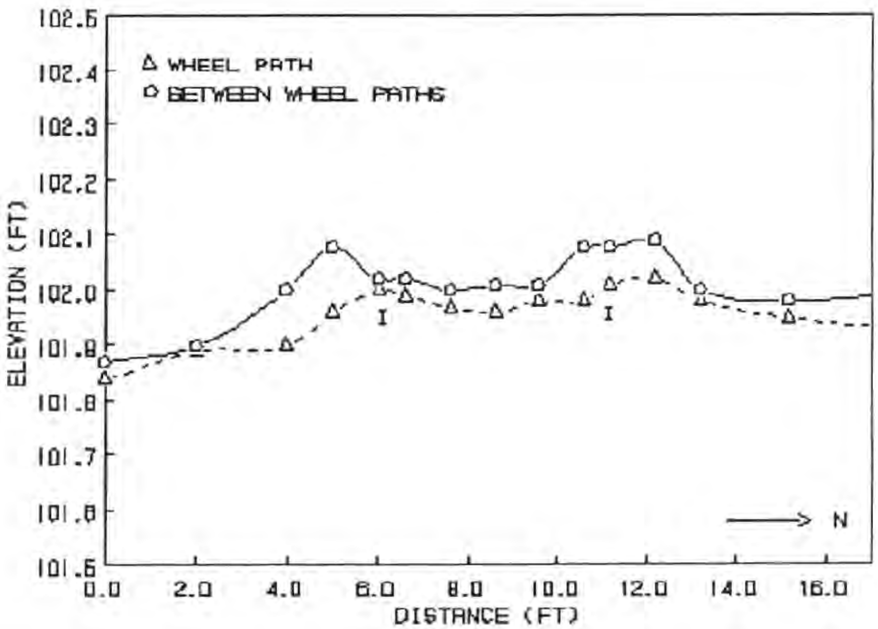



**Figure A6** Steele Avenue, Rapid City (Asphalt)
Cross section taken at wheel path and
between wheel paths.

to the crossing. Rail deflections during rail traffic at the ends of the crossing were measured to 0.25 inches. Significant debris can also be seen on either side of the rails (See Photo 7).

**Maple Avenue**

Two Lanes - Two Tracks

The crossing at Maple Avenue has a Redhawk type surface. The pavement consists of asphalt and the headers are thin rubber strips. The crossing was built in 1987. Maple Avenue has an average daily traffic of 4,505 vehicles. The rail traffic consists of two trains per day, with two to four locomotives and 40 to 50 freight cars. There is heavy switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with no bolted joints within 20 feet of the crossing. Overall conditions of the crossing are shown in Photos 8 through 10.

The subsurface soils at the crossing consist of 1 foot of gravel, underlain by silty sand. The natural moisture content was measured at 15 percent. The silty sand classifies as an A-4(2) in the AASHTO classification and SM in the Unified classification systems. Based on the laboratory tests it was observed that the soil has very high frost susceptibility, low compressibility and high strength unless saturated.

The contour map and profiles of the crossing are presented in Figures A7 through A9. The most pronounced feature shown in Figure A7 is the overall settlement of the crossing with respect

Photo 8. Maple Avenue - Overall View

Photo 9. Maple Avenue - Differential Settlement between Crossing and North Approach

Photo 10. Maple Avenue - Cracking of Southeast Shoulder and Panel Wear

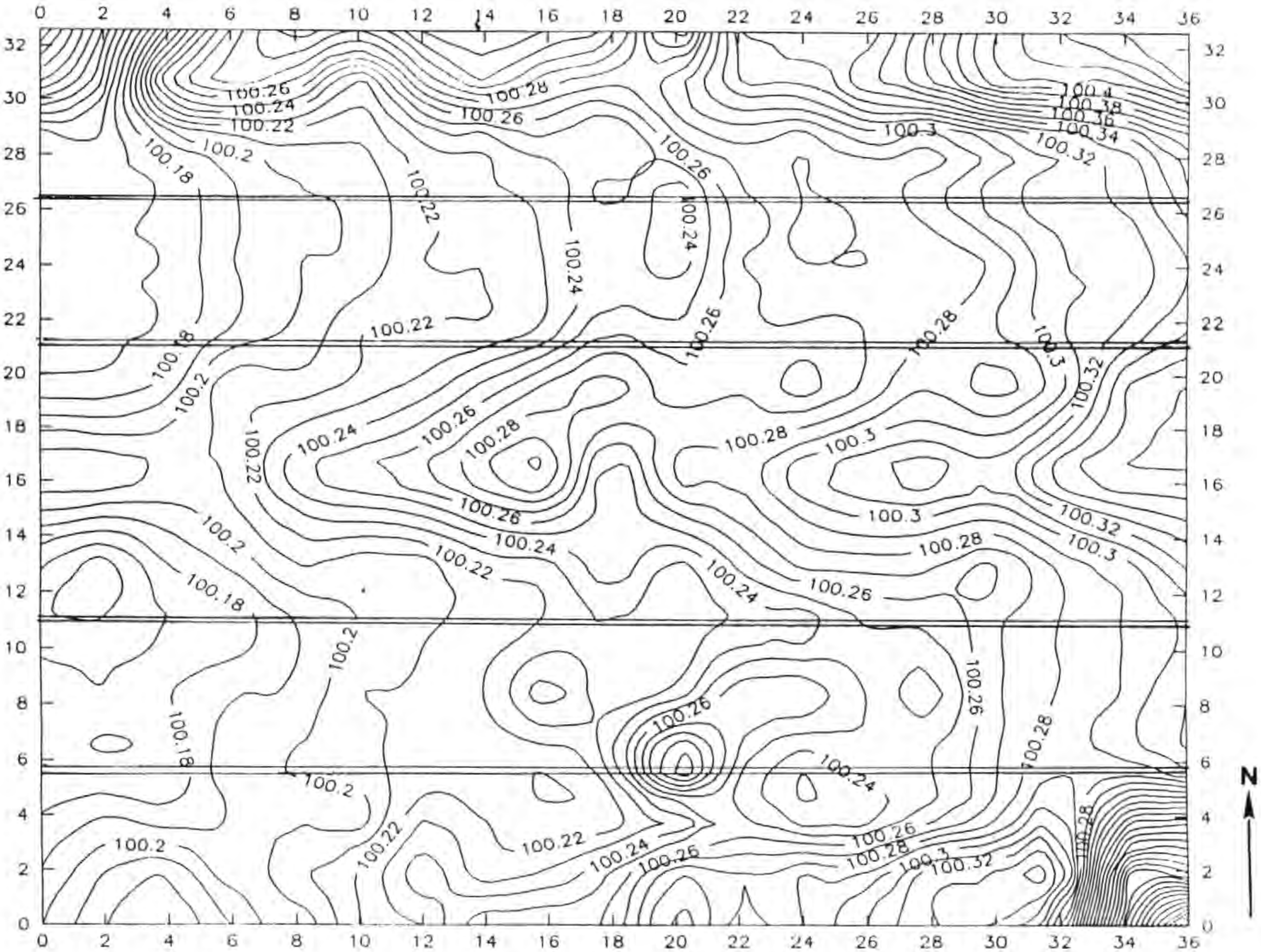


**Figure A7 Maple Avenue, Rapid City (Rubber)**

All Distances in Feet

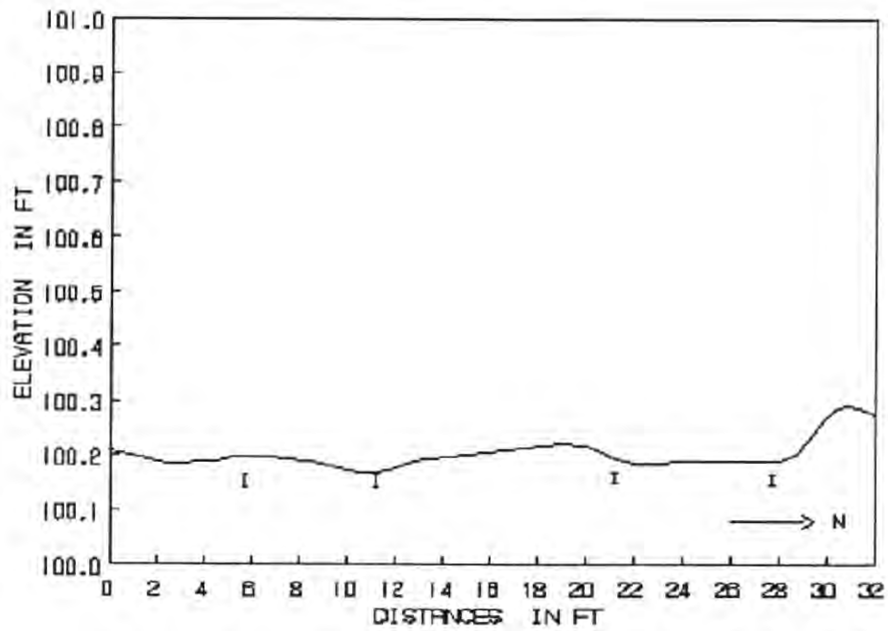



**Figure A8** Maple Avenue, Rapid City (Rubber) Cross section at curb.

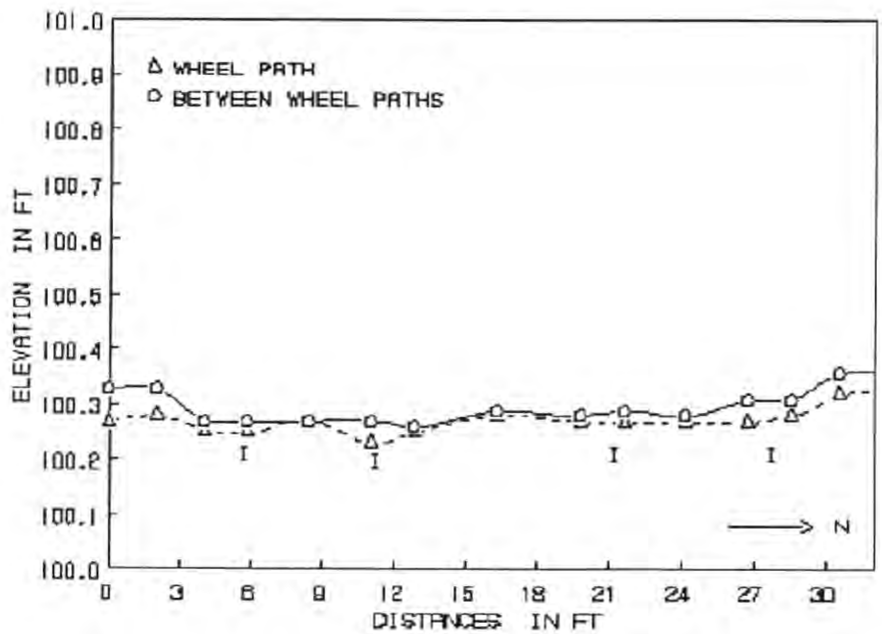



**Figure A9** Maple Avenue, Rapid City (Rubber) Cross section taken at wheel path and between wheel paths.

to the north approach, and the settlement of the southeast shoulder. Evidence of depressions beginning to form along the wheel paths can also be seen, especially in the east lane. Overall settlement of the track is on the order of 1/2 to 1 inch (Figures A8 and A9), but the drop in elevation from the north approach onto the crossing exceeds one inch at some locations. The pavement between the tracks is also slightly higher than the crossing. The surveying data show (Figures A8 and A9) that the rail is slightly lower than the outer panels. Tilting of the outer north panels towards the rail can also be seen (See Figure A8) and there is more settlement along the wheel path than in between wheel paths (Figure A9).

The rubber headers are slightly separated from the pavement along the south side of the track (See Photo 8) and the headers have settled with the track, leaving a sharp drop-off from the pavement to the outer panels at some locations (See Photo 9). Debris is collected between the track and the center panels (See Photo 8).

Drainage at this crossing is good, as there are ditches on both sides of the track and a sump on the west side of the crossing. There is, however, evidence of significant movement under rail traffic on the east side of the track (See Photo 10), and rail deflections during rail traffic at the ends of the crossing were measured to 1/2 of an inch.

**East Boulevard**

Four Lanes - Two Tracks

A ParkCo rubber panel crossing is installed at East Boulevard. The concrete pavement terminates approximately one foot short of the outer rubber panels and the space between the wood headers and the concrete is filled with asphalt. East Boulevard is a four-lane main arterial street built in 1982. The average daily traffic is 16,515 vehicles, with a high percentage of trucks. The rail traffic consists of one to two trains per day with two to four locomotives and 40 to 50 freight cars. There is considerable switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with no bolted joints within 20 feet of the crossing. Photos 11 through 14 show the conditions at East Boulevard.

The boring drilled at the crossing shows that the soil consists of approximately two feet of dark brown silty clay/clayey silt over reddish brown silty clay/clayey silt. The gradation analysis on the soil shows that 81 percent is smaller than the #200 sieve and the Liquid Limit and Plasticity Index are 26 and 9 percent, respectively. The soil classifies as A-4 (6) in the AASHTO and CL in the Unified classification systems. The natural moisture content was 15.9 percent. Based on the laboratory tests the soil classifies as highly frost susceptible and, if subject to saturation, would be likely to pump under repetitive loading. Bearing capacity under saturated condition would also be low, with moderate compressibility.

Considerable panel wear can be seen along the entire crossing (See Photos 11 and 12). Figure A10 shows that the differences in elevation within the crossing on the south track is up to one inch, and elevation differences on the approches are as much as 1.5 inches. This is mainly due to rutting (Photo 11). The south rail has settled approximately 1 inch more than the north rail at the curb (See Figure A12). On the north track (Figure A11), the diffeneces in elvation within the crossing are generally less, but failure of the panels can easily be seen on the east side of the crossing. The rail on the north track has settled about 1 inch compared to the adjacent pavement, and the settlement of the approach pavement in the wheel path is distinctly greater in between wheel paths (See Figure A13).

The wood headers are damaged (See Photo 12). This can be seen over most of the crossing along with loose rubber panels on the entire track. The center panels have popped up on the east side of the north track (See Figure A11 and Photo 11) and failure of the approaches is found along the entire track (See Photos 13 and 14). Debris collection next to the rail and the approach can be seen in Photo 14.

Drainage is poor, as evidenced by mud squeezed in between the rails and the panels. Pumping can also be seen on the west side of the crossing. Rail deflections during rail traffic at the ends of the crossing were measured to 0.6 inches. Further discussion of East Boulevard is presented in Chapter VI.

Photo 11. East Boulevard - Settlement of the Track and Pavement Rutting

Photo 12. East Boulevard - Failed Joint Where Wooden Header is Missing and Damage Due to Traffic

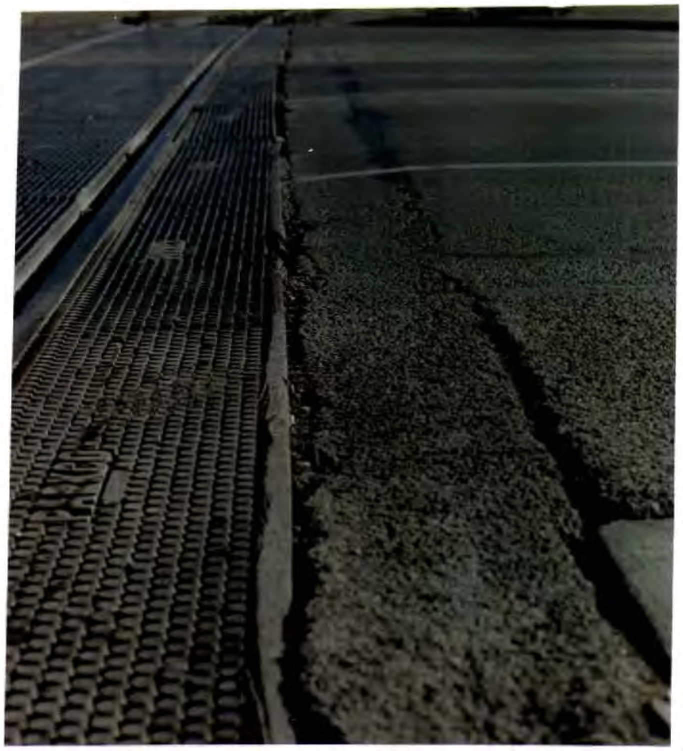


Photo 13. East Boulevard - Failed Joint Along the Shoulder and Damaged Header Board on North Side of Track

Photo 14. East Boulevard - Pavement Cracking on South Side of Track and Debris Collection Next to the Rail

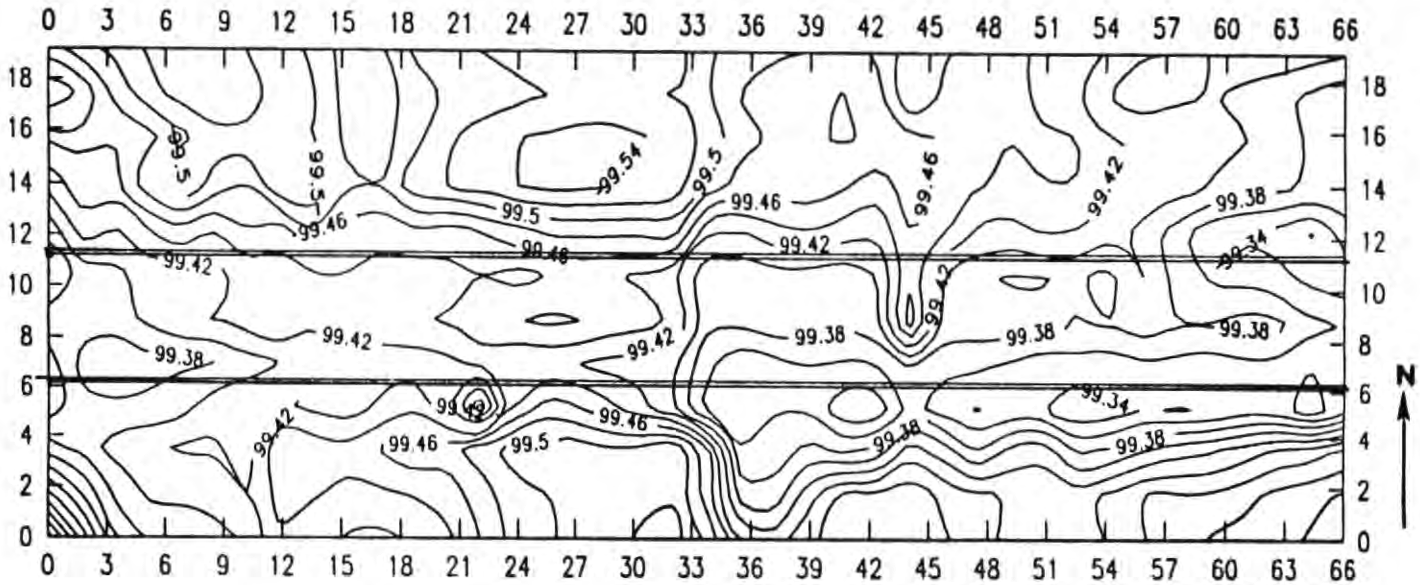



Figure A10 East Boulevard, Rapid City (Rubber)
South Track

All Distances in Feet

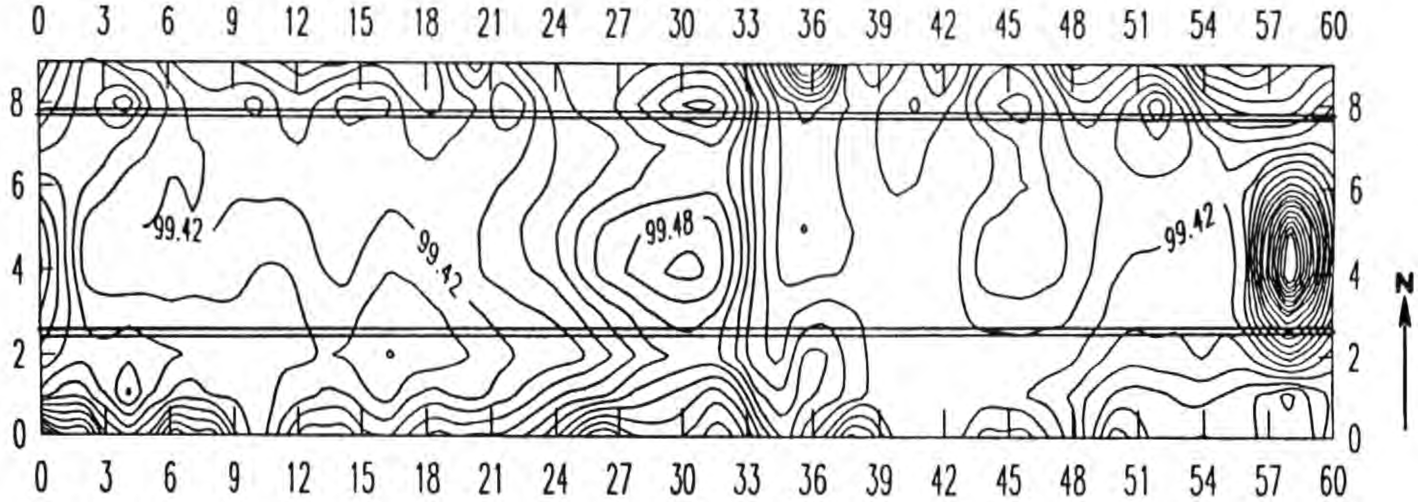



Figure A11 East Boulevard, Rapid City (Rubber)
North Track

All Distances in Feet

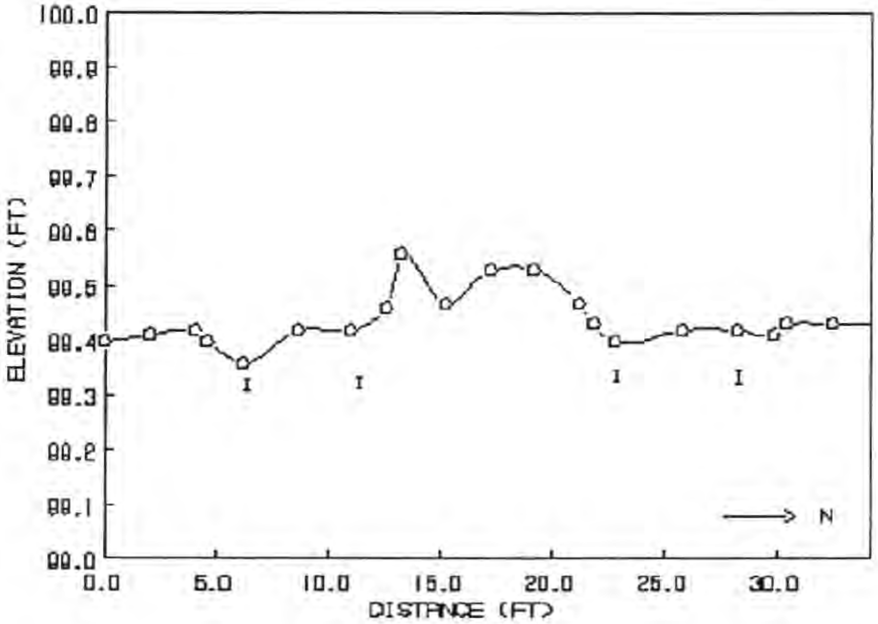



**Figure A12** East Boulevard, Rapid City, (Rubber) Cross section at curb.

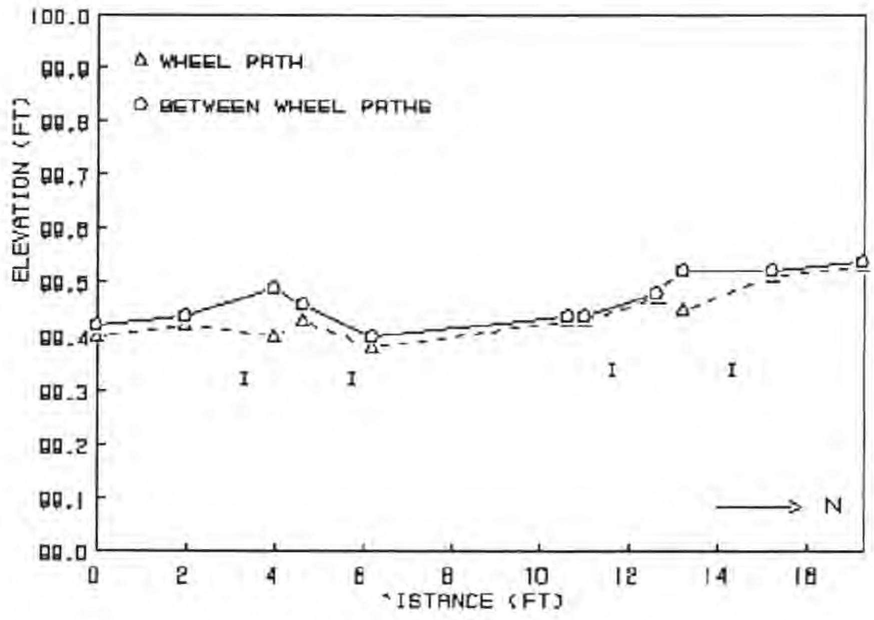



**Figure A13** East Boulevard, Rapid City (Rubber) Cross section taken at wheel path and between wheel paths.

**Third Street**

Two Lanes - Single Track

Third Street is an asphalt ball-up mud rail type crossing with both inner and outer mud rails. The crossing was installed before 1979. The crossing is shown in Photos 15 through 17. Third Street is a two lane street serving small businesses. Daily traffic of 1816 vehicles with only a small percentage of trucks. Rail traffic at the crossing consists of two trains per day with two to five locomotives and 40 to 50 freight cars. The crossing is also subject to considerable switching traffic. The rail in the crossing is 115 pound weight and continuously welded, with no joints within 20 feet of the crossing.

The boring drilled at the crossing shows clay extending to depths of at least 5 feet with natural moisture content of 22 percent. The gradation analysis on the soil shows that 94 percent is smaller than the #200 sieve and the Liquid Limit and Plasticity Indexes are 45 and 27 percent, respectively. The soil classifies as A-7-6(16) in the AASHTO and CL in the Unified classification systems. Based on the soil test results it is felt that the soil is moderately frost susceptible and, if subject to saturation, would be likely to pump under repetitive loading. Bearing capacity under saturated conditions would be low and compressibility would be moderate.

The survey data show (See Figures A14 through A16) that the track is considerably lower than the pavement (also see Photos 15 through 17). The contour map (Figure A14) show that the track has

Photo 15. Third Street - Close View of Approach Settlement

Photo 16. Third Street - Overall View of Track Settlement (See Upper Left)

Photo 17. Third Street - Debris Collection and Uneven Mud Rails

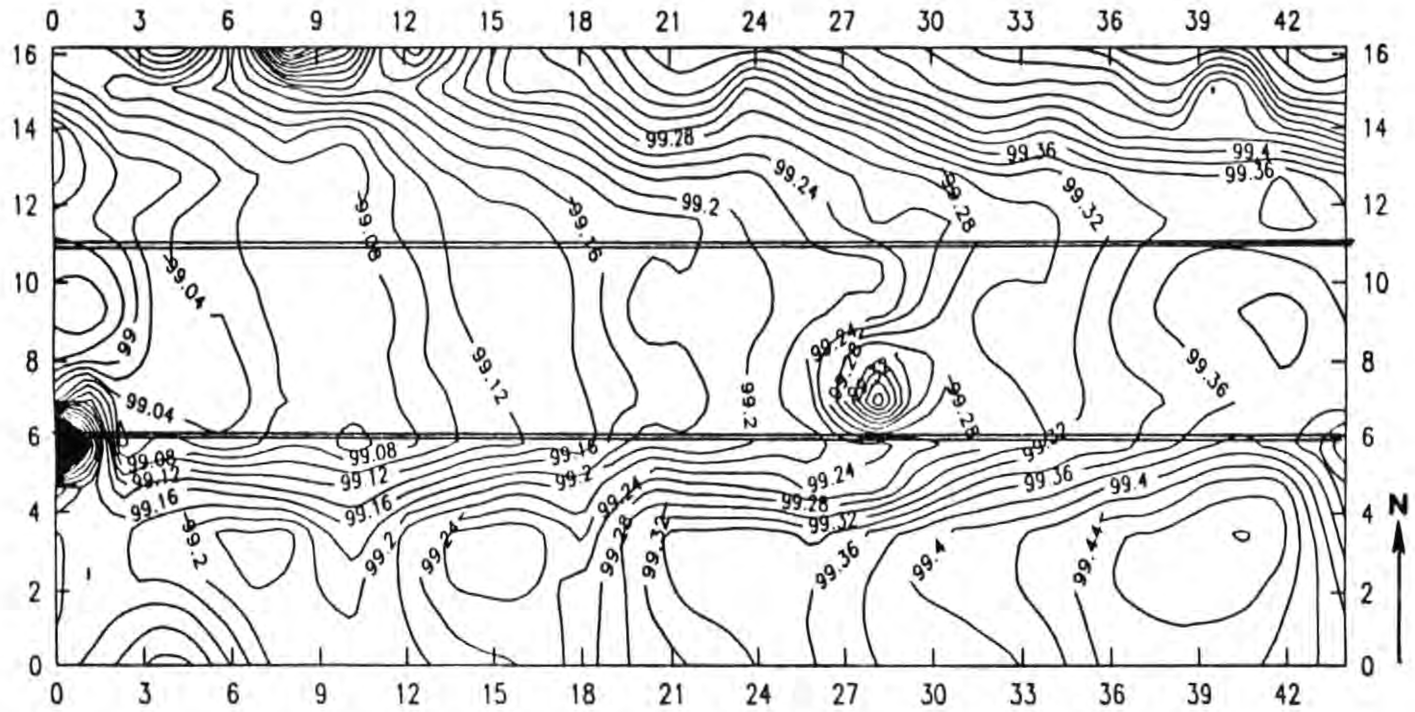


Figure A14 Third Street, Rapid City (Asphalt)

All Distances in Feet

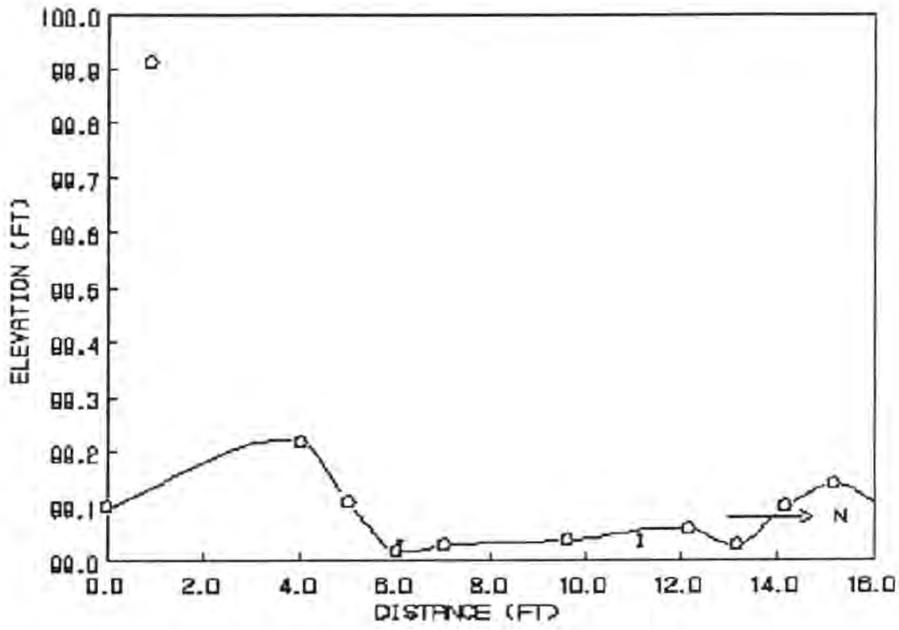



**Figure A15** Third Street, Rapid City (Asphalt) Cross section at curb.

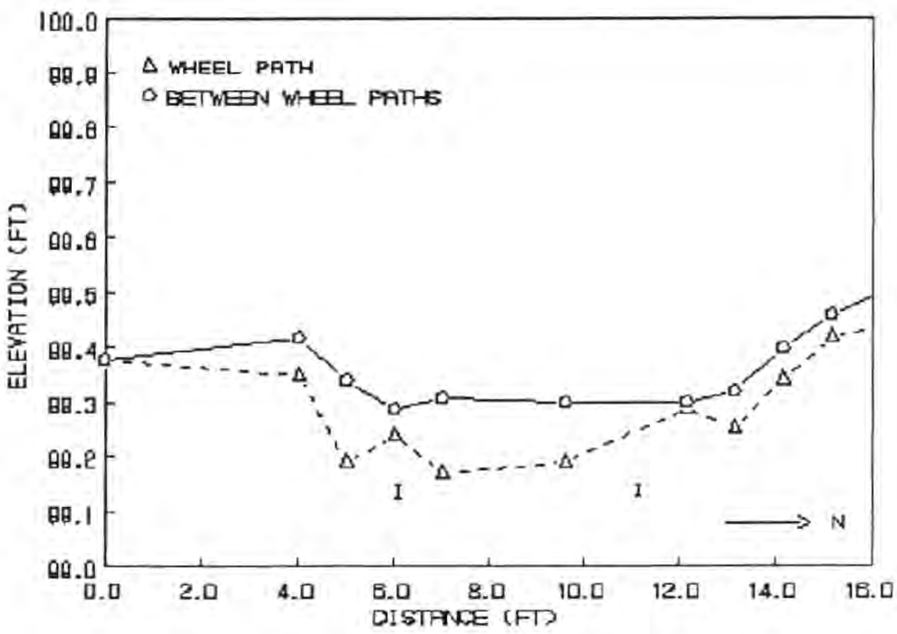



**Figure A16** Third Street, Rapid City (Asphalt) Cross section taken at wheel path and between wheel paths.

settled between two and three inches relative to the approaches along the entire crossing. Evidence of heave in the pavement can also be seen between the tracks to east of the centerline. The overall settlement of the track can also be seen in Figures A15 and A16. Figure A16 also shows that there is more settlement and pavement wear at the wheel path than between the wheel paths.

Pavement cracks are seen all along the track (See Photo 15 through 17) and there is considerable debris collection between the rails.

Drainage at the crossing is poor with evidence of considerable pumping on the approaches to the crossing and between the mud rails and main rails. Deflection at the ends of the crossing during rail traffic was 0.75 inches.

**West Boulevard**

Four Lanes - Single Track

The West Boulevard crossing is a Goodyear rubber type, and was built in 1983. The pavement consists of asphaltic concrete and there appear to be no headers. West Boulevard is a four lane artery with average daily traffic of 14,768 vehicles, a small percentage of which is trucks. The rail traffic consists of two trains per day, each with two to four locomotives and 40 to 50 freight cars. There is only minor switching traffic at this crossing. The rail in the crossing is 115 pound weight and is continuously welded. There are no bolted joints within 20 feet of the crossing. The overall conditions at the crossing are shown in Photos 18 through 21.

The subsurface soils consist of approximately 3 feet of dark brown silty clay over reddish brown clayey silt. The field moisture content was measured at 22.3 percent. The soil classifies as A-4(8) in AASHTO and CL in the Unified classification systems. The gradation analysis on the soils shows that 82 percent is smaller than the #200 sieve and the Liquid Limit and Plasticity Indexes are 27 and 10 percent, respectively. The soil is highly frost susceptible and may have low bearing strength under saturated conditions. Compressibility is felt to be moderate.

Considerable panel wear and loosening of panels was seen during the surveying (See Photos 18 and 20). Settlement of the track with respect to the approach can be seen in Figures A17 and A19. The contours in Figure A17 show the crossing may have been slightly elevated with respect to the road at the time of construction, as the elevation increases towards the crossing from both the north and the south. However, the contour map also shows that the track has settled in excess of one inch with respect to the approaches. The north outer panels on the east side of the crossing have popped out (Figures A18 and Photo 20). From the sections in Figure A19 it can also be seen that there is more settlement and pavement wear under the wheel path than in between the wheel paths. Panel deflection on the west side has also taken place at the wheel paths. The panels in this crossing

Photo 18. West Boulevard - Failed Joint at Wood Header Board

Photo 19. West Boulevard - Settlement of Crossing and Uneven Panels

Photo 20. West Boulevard - Failed Rubber Panel

Photo 21. West Boulevard - Mud Filled Track and General View of Panel Unevenness

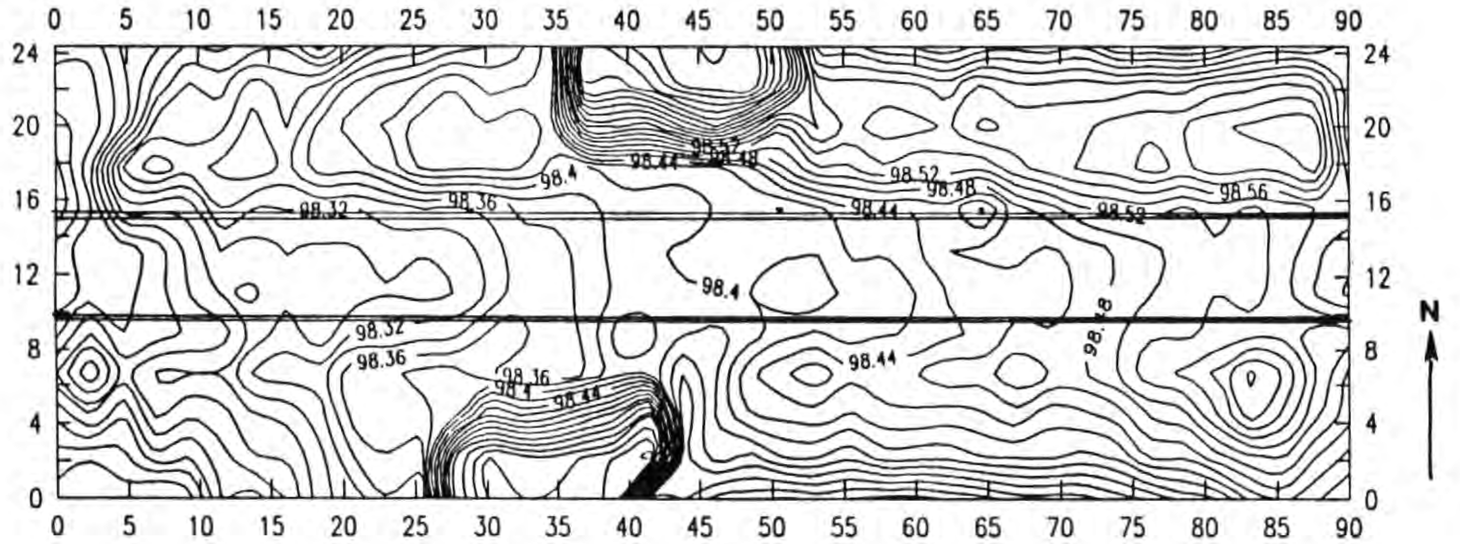



Figure A17 West Boulevard, Rapid City (Rubber)

All Distances in Feet

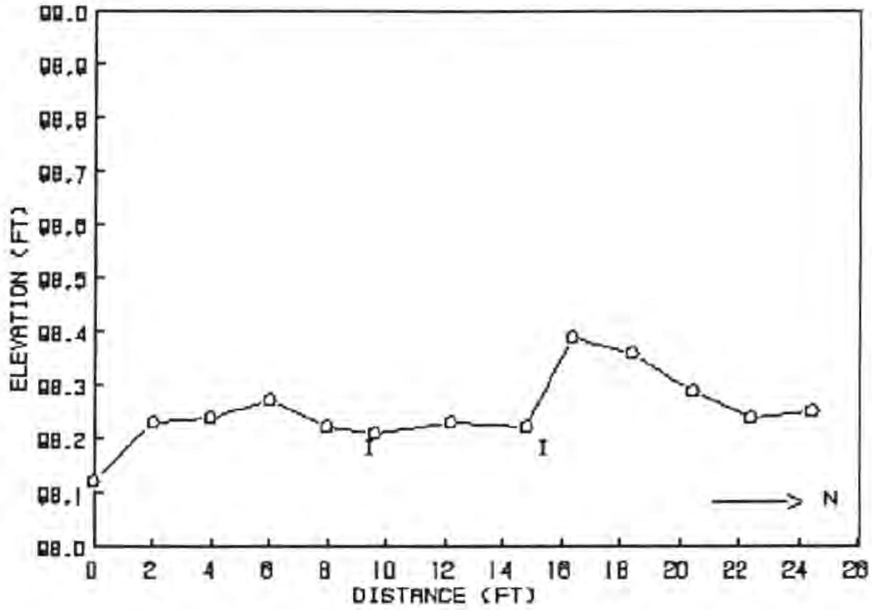



**Figure A18** West Boulevard, Rapid City (Rubber) Cross section at curb.

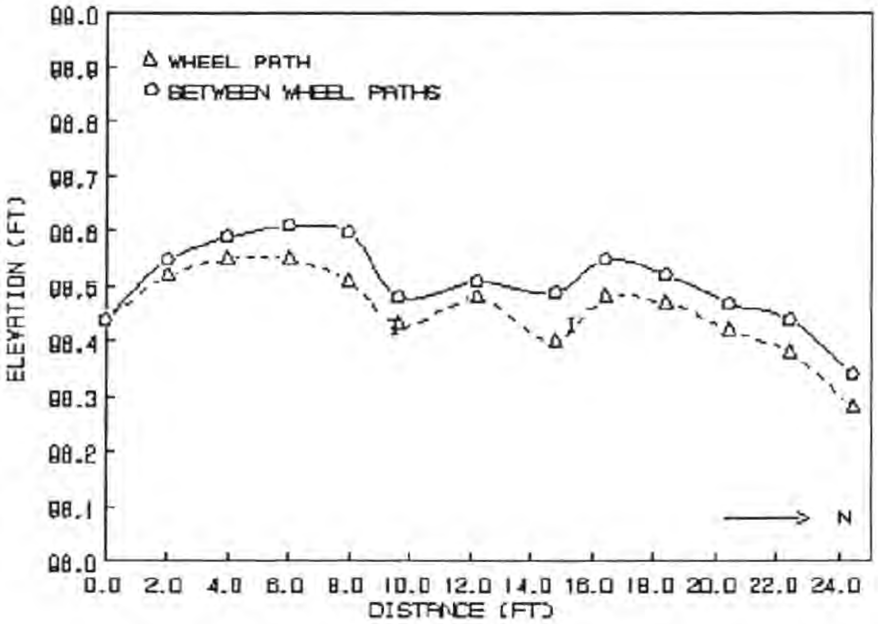



**Figure A19** West Boulevard, Rapid City (Rubber) Cross section taken at wheel path and between wheel paths.

are worn, however, there is little snow plow damage (See Photo 21).

Drainage at this crossing is poor, as evidenced by pumping at portions of the crossing approaches. Deflection of the rails at the end of the crossing were measured to 1/2 an inch under rail traffic.

**Black Hawk**

Two Lanes - Single Track

The crossing near Interstate 90 in Black Hawk is a timber type with individual timbers. The crossing was installed in 1987. The average daily traffic is 500 vehicles per day. The rail traffic consists of two trains per day, carrying two to four locomotives with 40 to 50 freight cars. There is no switching traffic at this crossing. The rail in the crossing is 115 pound continuously welded rail with no bolted joints within 20 feet from the crossing. The crossing is shown in Photos 22 and 23.

The subsurface soils at the crossing are dominantly reddish sandy silt with a field moisture of about 20 percent. The soil classifies as a A-4(8) in the AASHTO classification and ML in the Unified classification systems. Based on the laboratory tests, the soil has high frost susceptibility and relatively low compressibility.

Track movement under railroad loading is evident as the spikes holding the rails have been pulled out of the ties and there is visible damage to the timbers (See Photo 23). The contour map

Photo 22. Black Hawk - Overall View and Damaged Timbers Along the Rails

Photo 23. Black Hawk - Close View of Damaged Timbers and Cracking Along Header

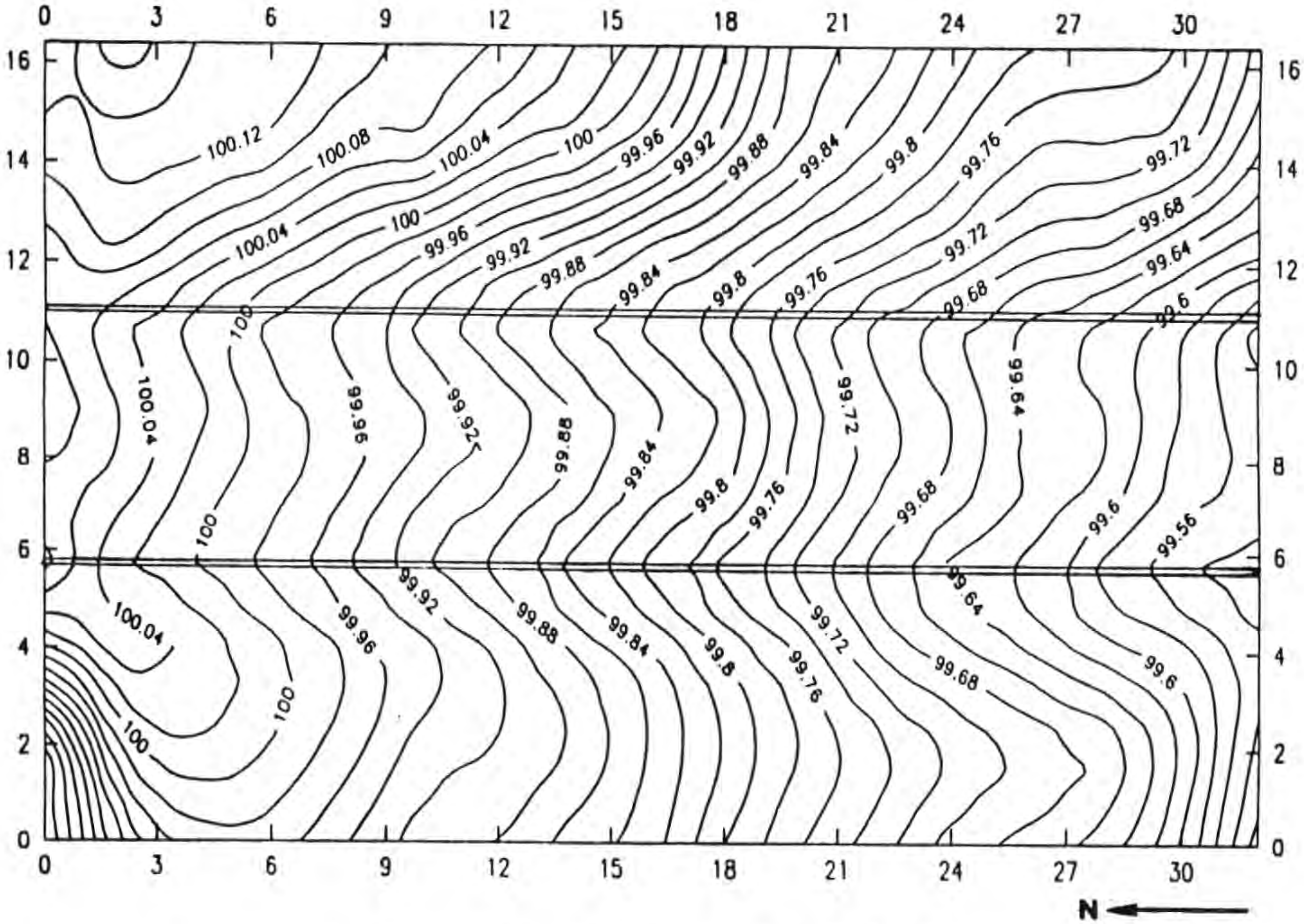



Figure A20 Black Hawk (Timber)

All Distances in Feet

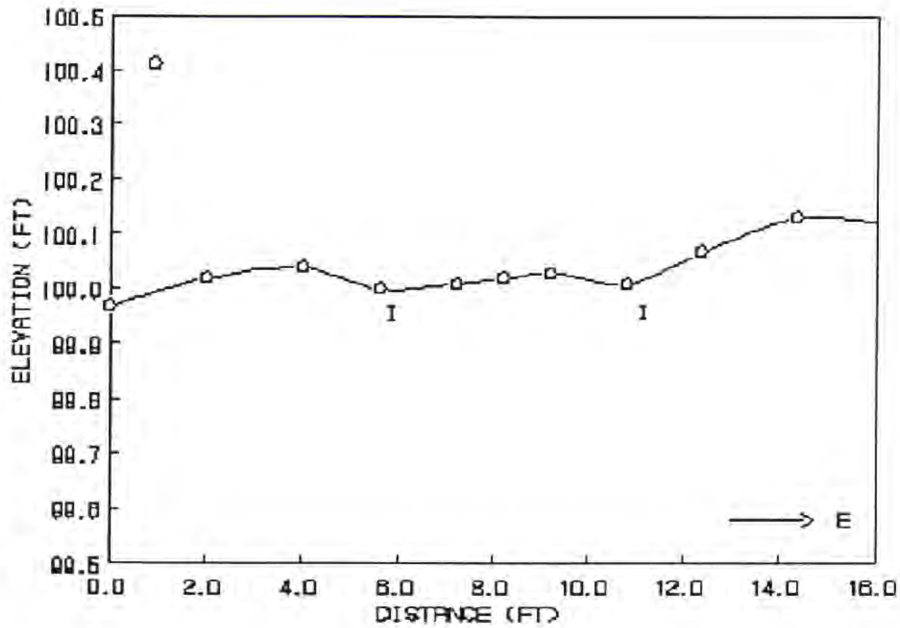



**Figure A21** Black Hawk (Timber)
Cross section at curb.

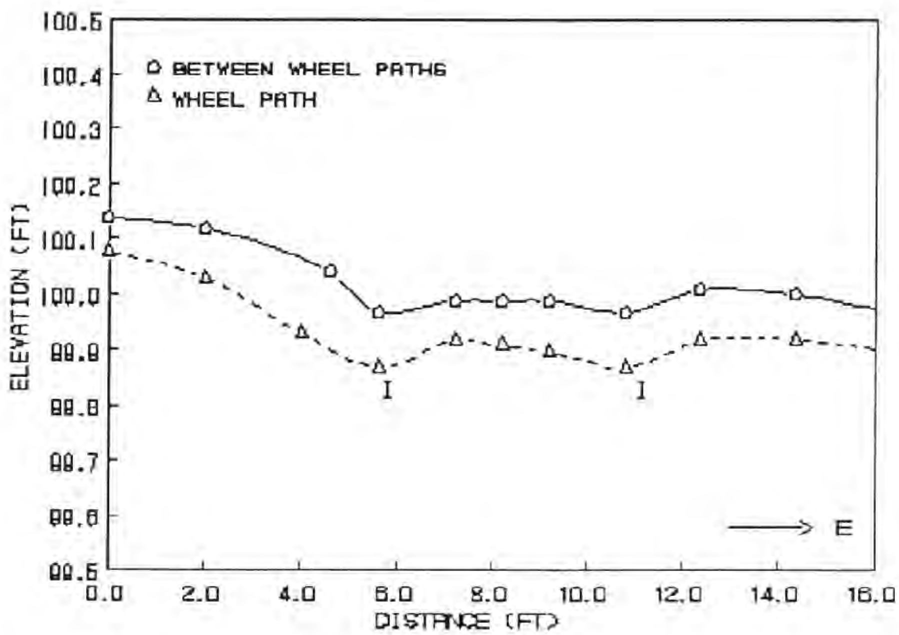



**Figure A22** Black Hawk (Timber)
Cross section taken at wheel path and between wheel paths

with a large percentage of trucks. The rail traffic consists of two trains with up to six locomotives and 100 cars per day and, in addition, there is considerable switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with no bolted joints within 20 feet of the crossing. The conditions at the crossing are shown in Photos 24 through 27.

The boring drilled at the crossing shows that the subsurface soils consist of approximately two feet of dark brown silty clay over 3 feet of black clay. The gradation analysis on the black clay shows that 96 percent passes the #200 sieve and the Liquid Limit and Plasticity Indexes are 68 and 44 percent, respectively. The soil classifies as A-7-6(20) in the AASHTO and CH in the Unified classification systems. The natural moisture content was measured at 33.6 percent. Based on the laboratory tests, the soil classifies as moderately frost susceptible and, if saturated, would be likely to pump under repetitive loading. Bearing capacity under saturated conditions would also be low and soil compressibility would be high.

The results of the survey are shown in Figures A23 through A25. The contour map (Figure A23) shows that the elevation differences within the tracks are less than one half inch, but the south track has settled more than the north track. The survey shows that the rails are at a lower elevation than the panels and the panels also tilt towards the rails (Figure A24). The overall settlement of the crossing in relation to the pavement is on the

Photo 24. Harrison Avenue - Failed Pavement Where Wood Header Board is Missing or Damaged (Track 1)

Photo 25. Harrison Avenue - Cracking From Track Movement Under Rail Traffic (Track 2)

Photo 26. Harrison Avenue - Cracking Along Wood Header Board

Photo 27. Harrison Avenue - Loose Rubber Panels and Misaligned Pavement and Asphalt Header

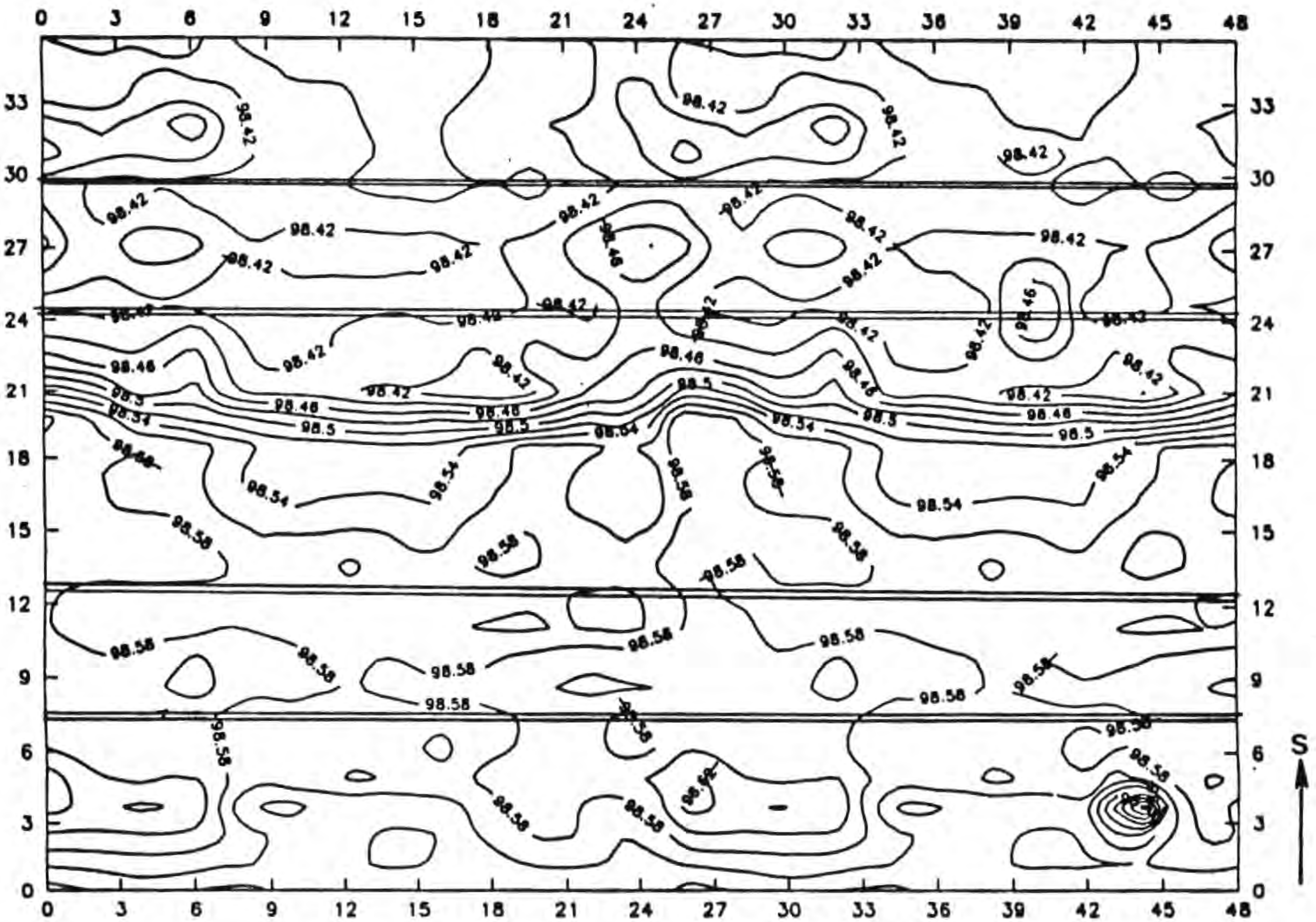



Figure A23 Harrison Avenue, Pierre (Rubber)

All Distances in Feet

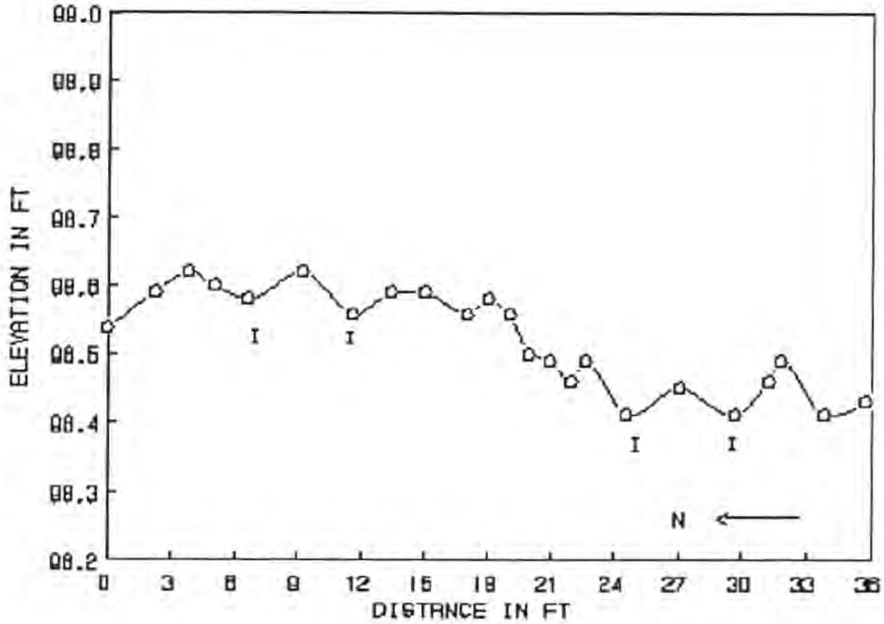



**Figure A24** Harrison Avenue, Pierre (Rubber) Cross section at curb.

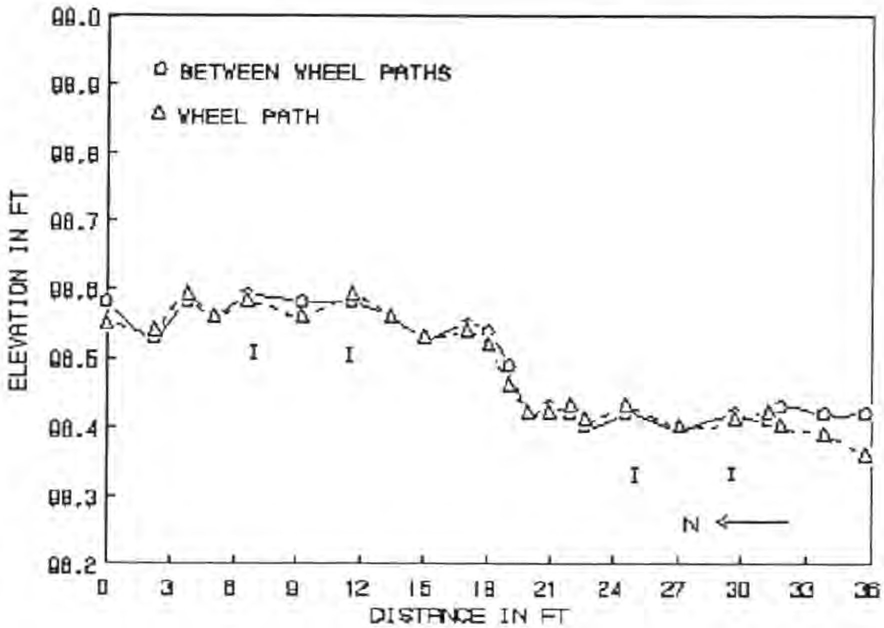



**Figure A25** Harrison Avenue, Pierre (Rubber) Cross section taken at wheel path and between wheel paths.

order of 1/2 inch to 1 inch (See Figures A24 and A25). It can also be seen that there is more panel wear and deformation under the wheel path than in between the wheel paths.

The wooden headers are broken up and torn out all along the tracks (See Photo 24). Chipping and cracking of the asphalt can be observed at many points along the headers (See Photos 25 and 26) and loose sand and gravel has collected next to the rail.

Drainage at this crossing appears to be poor. There were no ditches on either end of the crossing and considerable pumping was observed on approaches to the main track (Photo 27).

**Indian Learning Center**

Two Lanes - Single Track

The crossing at the Indian Learning Center is an asphalt crossing with inner and outer ball-up mud rails. The road serves the Indian Learning Center and small businesses. Average daily traffic consists of 266 vehicles. The rail traffic consists of one to two trains per day with up to six locomotives and 100 freight cars. There is no switching traffic at this crossing. The rail is 115 pound weight and continuously welded. The crossing is shown in Photos 28 and 29.

The subsurface soils at the crossing are dominantly grayish silty clay. The field moisture is 15 percent. The soil classifies as an A-7-6(20) in the AASHTO classification and CH in the Unified classification systems. The gradation analysis on the soil shows that 94 percent is finer than #200 sieve and Liquid Limit and

Photo 28. Indian Learning Center - Overall View

Photo 29. Indian Learning Center - Cracking Along Mud Rails and Settlement of Asphalt in Center Portion of Track

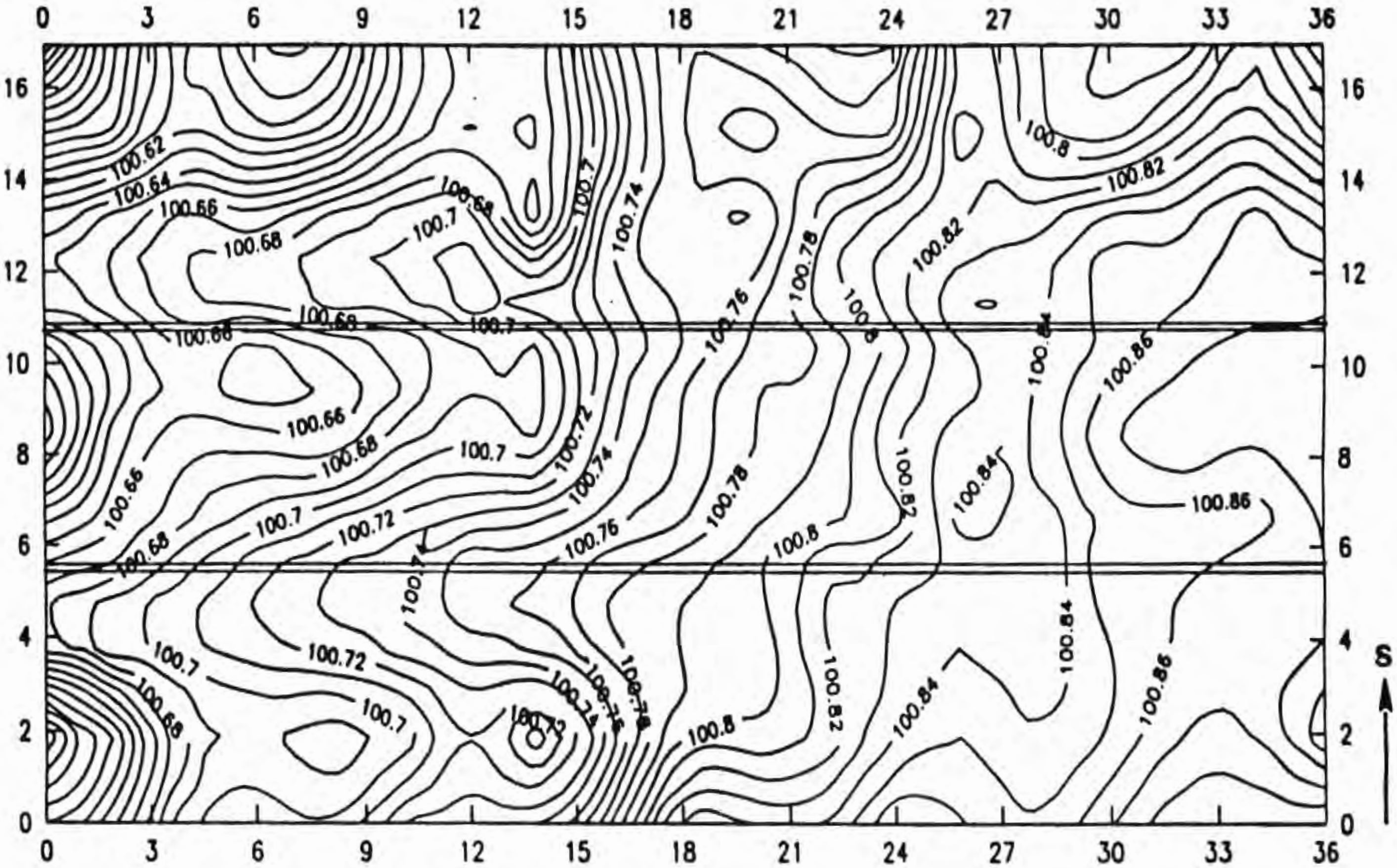



Figure A26 Indian Learning Center, Pierre
(Asphalt)

All Distances in Feet

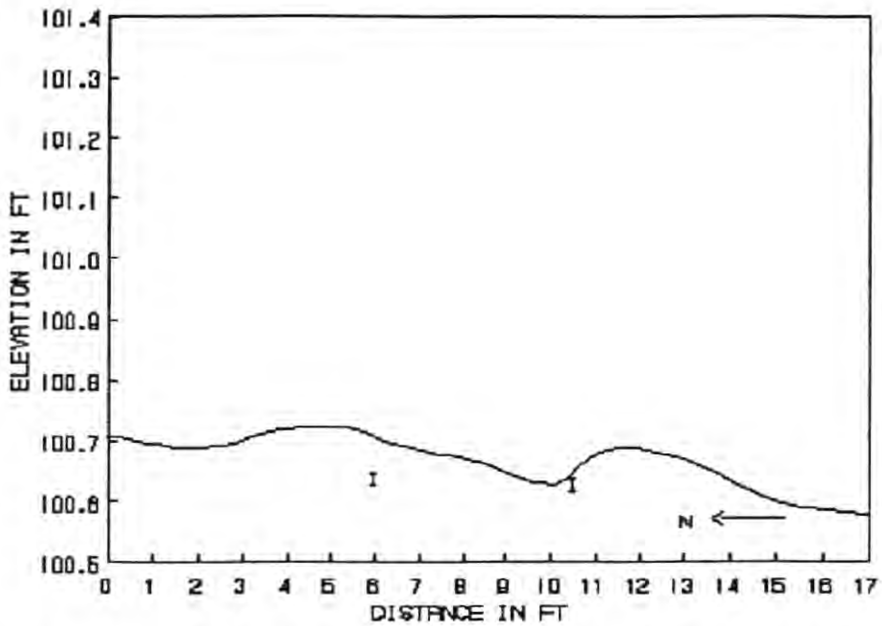



**Figure A27** Indian Learning Center, Pierre (Asphalt) Cross section at curb.

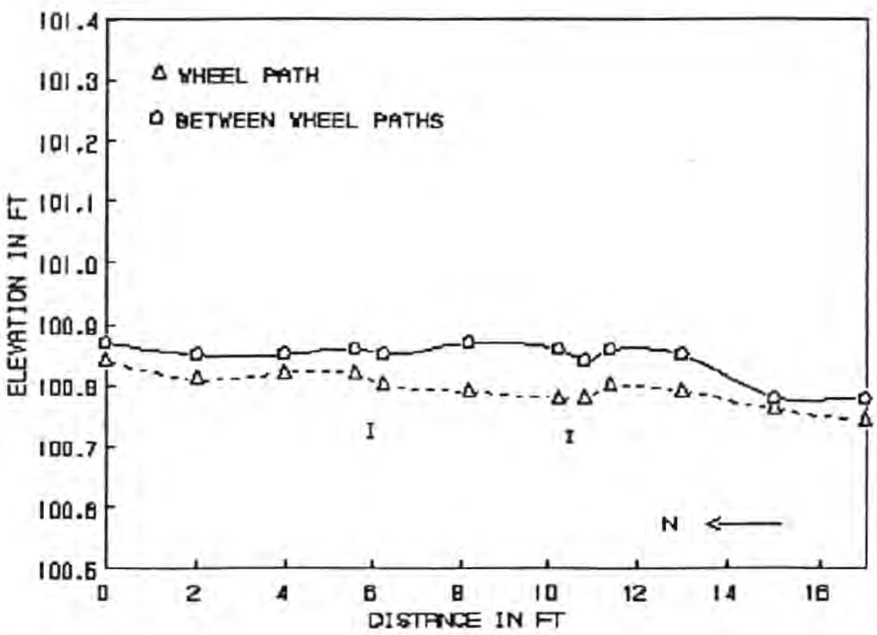



**Figure A28** Indian Learning Center, Pierre (Asphalt) Cross section taken at wheel path and between wheel paths.

Plasticity Indexes are 60 and 38 percent, respectively. It is estimated that the soil has a moderate frost susceptibility, low bearing strength under saturation, and may have a tendency to pump under repetitive loading. Compressibility of the soil is moderate.

The results of the survey are shown on Figures A26 through A28. Figure A26 shows that there is considerable rutting, especially at the approches on the east side of the crossing. The track is tilted towards the south, as the south rail has settled in excess of 1/2 inch in relation to the north rail. The cross section at the wheel path (See Figure A28) is lower than in between the wheel paths, also indicating rutting. Some of the difference in elevation is, however, due to the slope of the crossing, as the elevation of the crossing increases nearly 2 inches from east to west

Drainage at this crossing is poor, as there are no ditches at either end of the track, and there is evidence of pumping on the approaches to the crossing.

**Central Avenue**

Two Lanes - One Track

The crossing at Central Avenue has a SAF&DRI rubber type surface. The pavement is asphalt and the headers are two-inch thick wood plank with no rubber seals. Central Avenue is a two lane road serving small businesses and residential areas. The average daily traffic is 14,796 vehicles with only a small percentage of

Photo 30. Central Avenue - Failure of the Pavement Along the Wood Header

Photo 31. Central Avenue - Overall Settlement of Track.

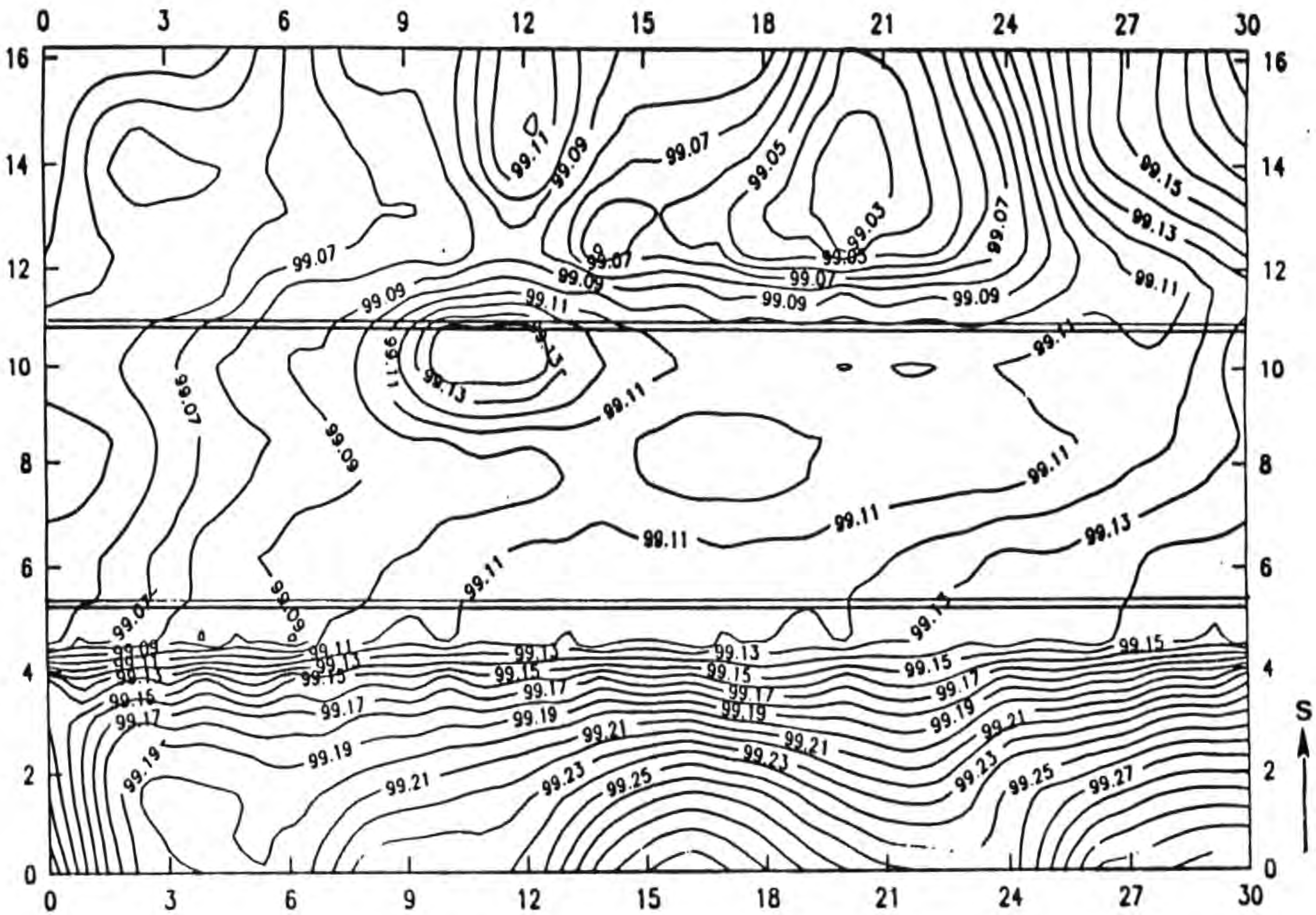



Figure A29 Central Avenue, Pierre (Rubber)

All Distances in Feet

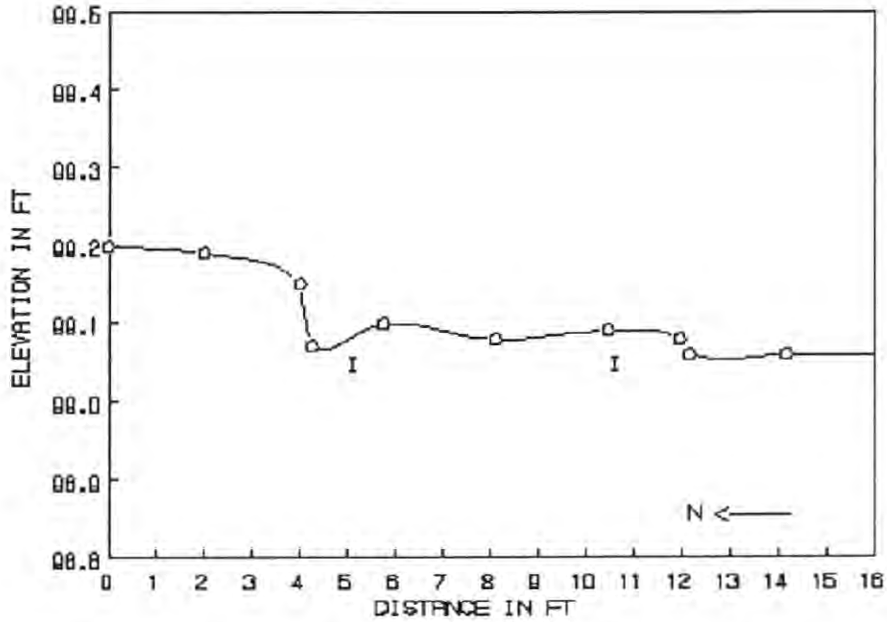



**Figure A30** Central Avenue, Pierre (Rubber)
Cross section at curb.

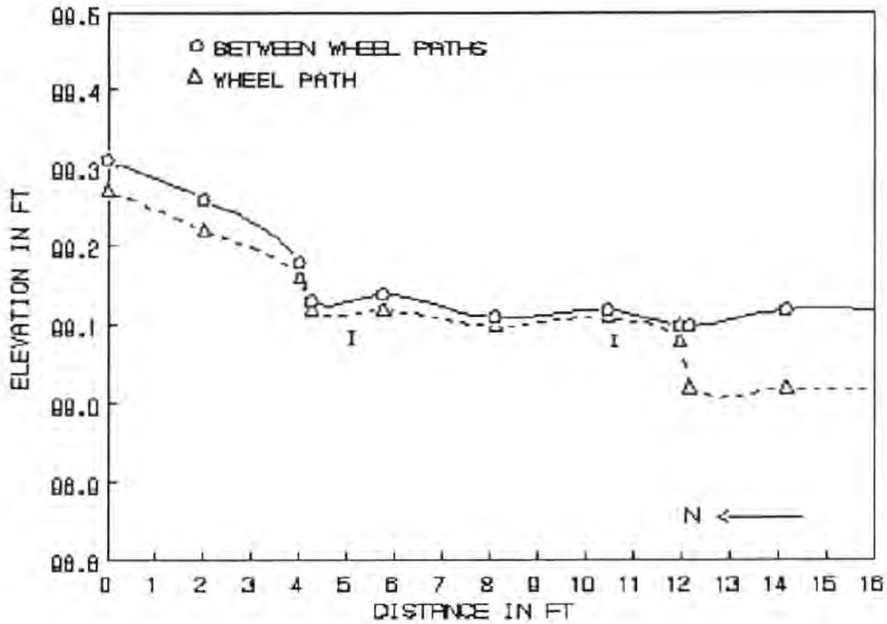



**Figure A31** Central Avenue, Pierre (Rubber)
Cross section taken at wheel path and between wheel paths.

trucks. The rail traffic consists of approximately one train per day. There is no switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded with no bolted joints within 20 feet of the crossing. The condition of the crossing is shown in Photos 30 and 31.

The boring drilled at the crossing shows that the soil consists of approximately two feet of light brown clayey silt over 4 feet of dark brown sandy clay. The sandy clay classifies as A-7-6(15) in the AASHTO and CH in the Unified classification systems. The natural moisture content was 21.6 percent. The soil is likely to be highly frost susceptible. Bearing capacity under saturated conditions would also be low and compressibility would be moderate.

The survey data show that the track has settled up to 1 1/2 inches with respect to the northern approach. This is clearly seen on the contour map (Figure A29), and also in Figures A30 and A31. An half inch high ridge can be seen on the contour map near the south rail on the east side of the crossing, which may be an indication of pumping. The panels are cupped between the rails and have settled more in the center than at the rails. There is little evidence of differential distortion of the panels at the wheel path and in between the wheel paths, but there is considerable rutting on the south side of the crossing (Figure A31 and Photo 30). The wooden header boards are broken on the south side of the crossing (See Photo 30). Panels in between the rails have been damaged and appear to be loose along most of the crossing.

The crossing is located on an embankment, hence natural drainage is good. No evidence of pumping can be seen at the crossing and rail deflections were approximately 3/4 inch.

Sale Barn Road, Ft Pierre

Two Lanes - Two Tracks

The crossing at Second Avenue is timber. The timbers are partial depth and are supported on shims, and the outer timbers serve as headers. The age of the crossing is unknown but is estimated at approximately 20 years. The crossing serves the stockyards and a silo complex. The average daily traffic is 756 vehicles per day with a high percentage of trucks. The rail traffic consists of one to two trains per day with up to 6 locomotives and 100 freight cars. There is also switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with no bolted joints within 20 feet from the crossing.

The subsurface soil at the crossing is predominantly grayish clay extending to a depth of at least 6 feet, with a field moisture of 37.8 percent. The soil classifies as A-7-5(20) in the AASHTO classification and CH in the Unified classification systems. The gradation analysis on the soil shows that 91 percent is finer than #200 sieve and the Liquid Limit and Plasticity Indexes are 89 and 58 percent, respectively. The soil has moderate frost

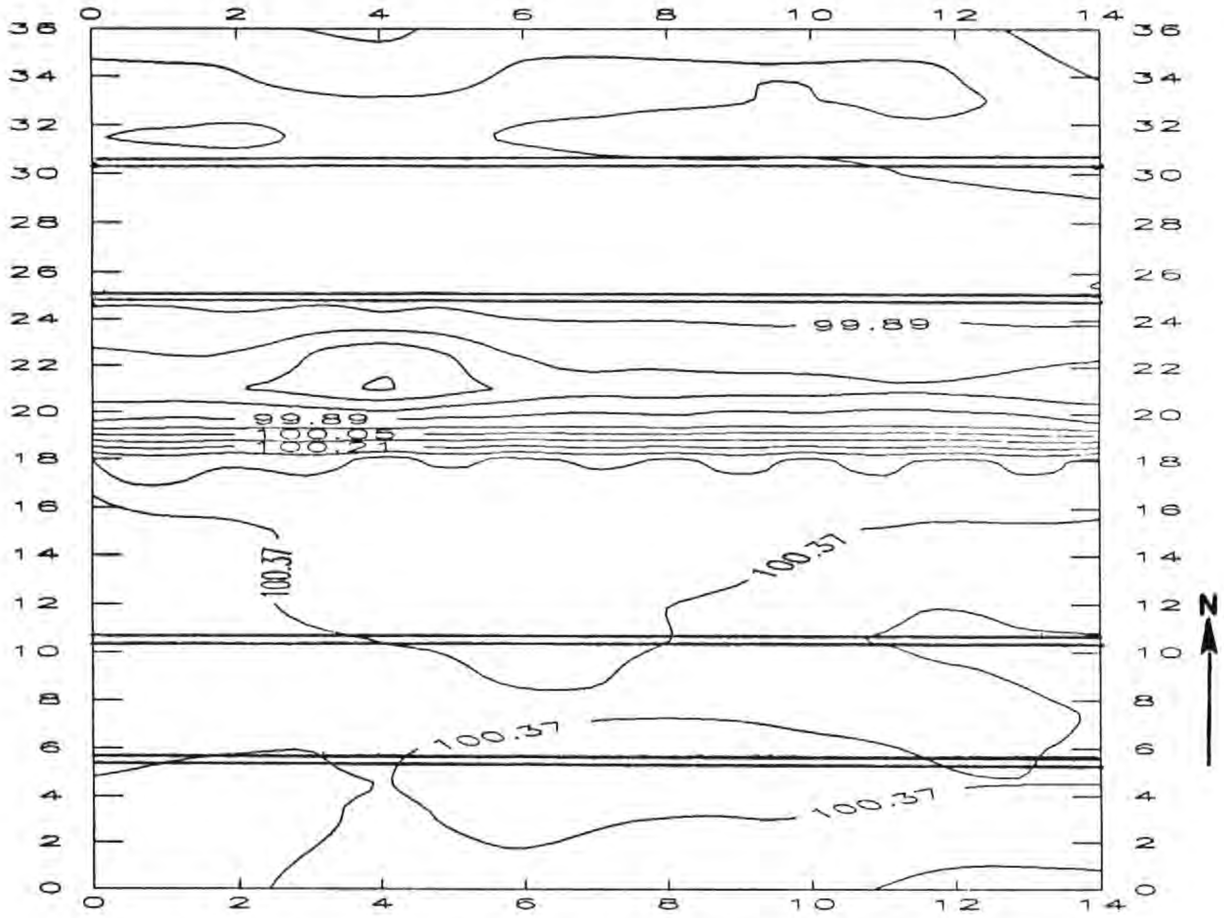



Figure A32 Sale Barn Road, at Ft. Pierre (Timber)

All Distances in Feet

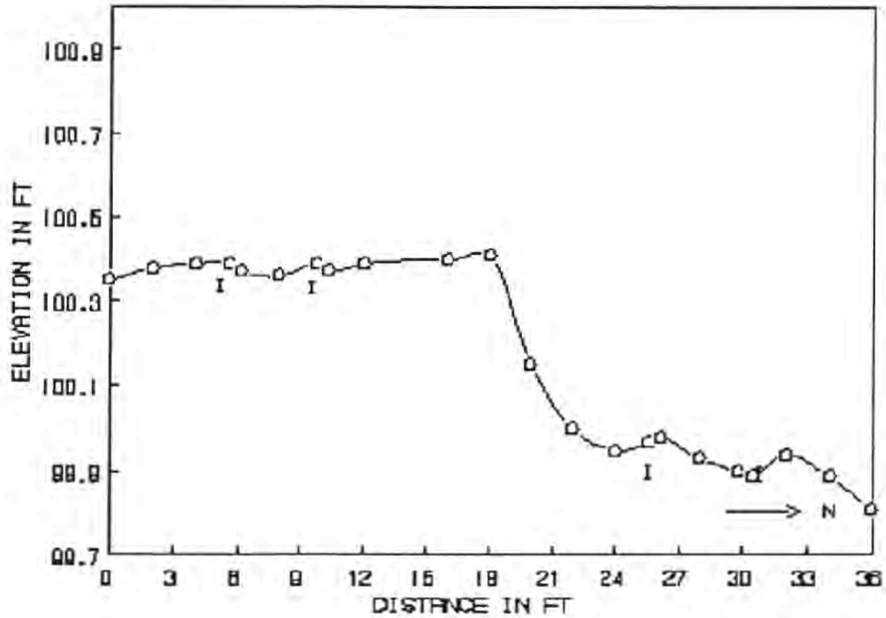



**Figure A33** Sale Barn Road at Ft.Pierre (Timber)
Cross section at curb.

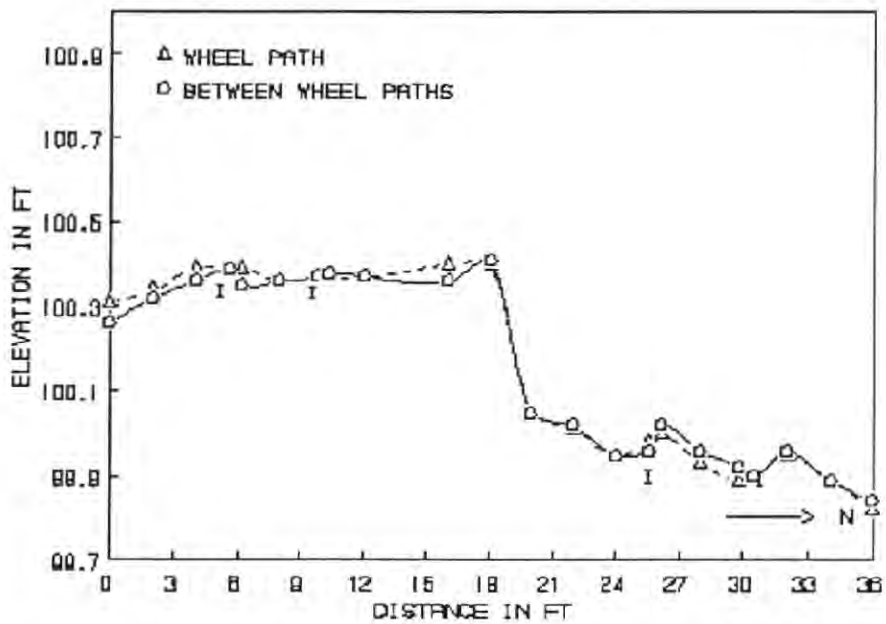



**Figure A34** Sale Barn Road at Ft.Pierre (Timber)
Cross section taken at wheel path and between wheel paths.

susceptibility but low bearing strength under saturation, and is likely to pump under repetitive loading. Compressibility of this soil is high.

There are three tracks at this crossing, but, only the two northernmost tracks were surveyed (the main track and the most used side spur). The results of the survey are shown in Figures A32 through A34, where a two to three inch difference in elevation between the main rail and the side spur can be seen, thus creating an extremely rough crossing. There is very little difference in the elevation at and between the wheel paths.

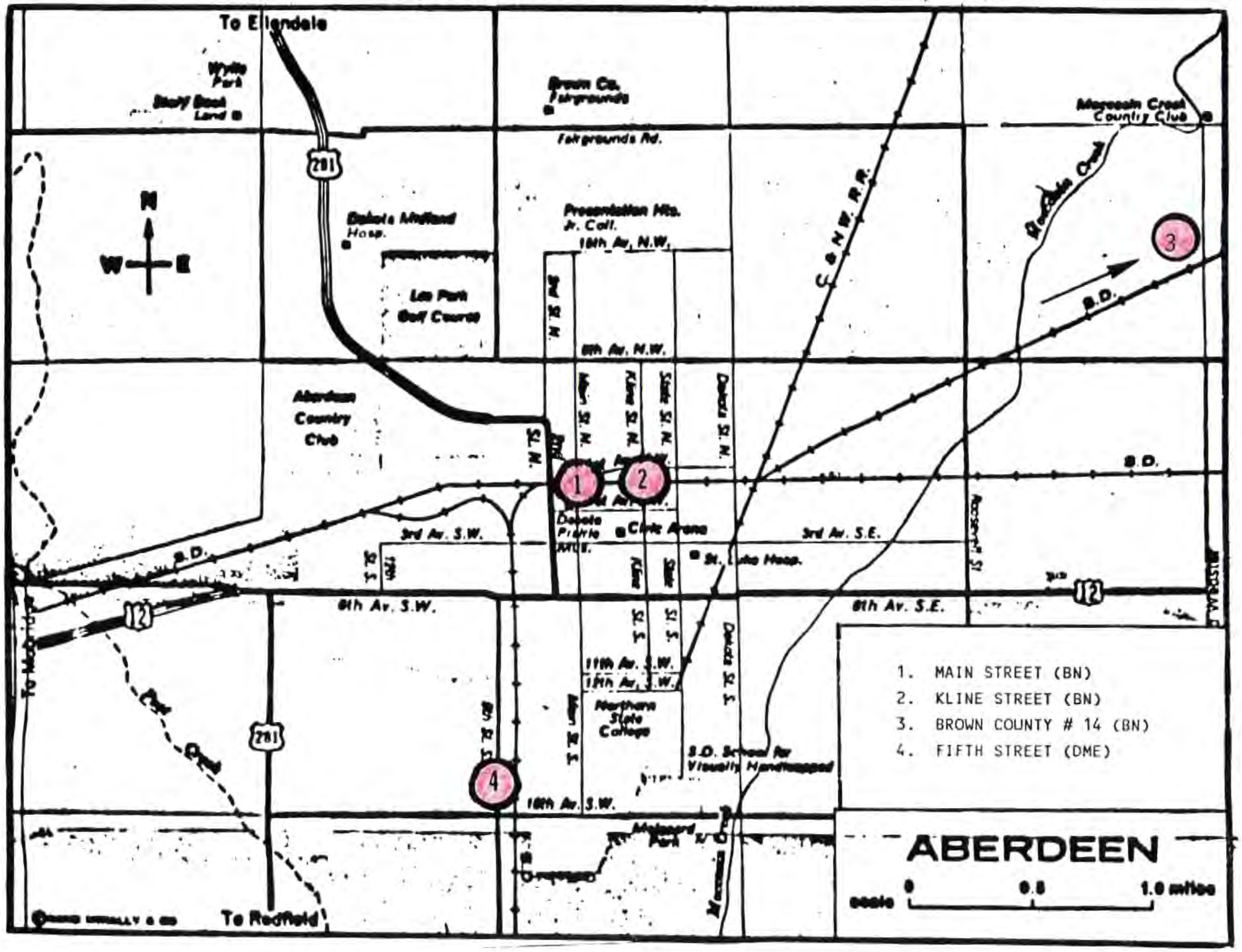
Drainage at this crossing is poor, as there are no ditches at either end of the crossing. Significant amounts of debris are also present on and in between the timber panels. Pumping is very evident as mud is squeezed up around the ties in the crossing.

**A-3.3 Aberdeen**

**Main Street**

Four Lanes - One Track

The crossing at Main Street was built in 1984 and has a Hi-Rail rubber type surface. There are no headers. The adjoining pavement is asphalt. Main Street is a four lane artery serving the business community in Aberdeen. The average daily traffic is 6,050 vehicles with rail traffic consisting of three trains per day, including coal freight trains with 100 cars and up to six heavy locomotives. There is also considerable switching




LOCATION MAP 3

Photo 32. Main Street - Settlement of Track and Cracked Shoulder

Photo 33. Main Street - Failure of Pavement at Approaches

Photo 34. Main Street - Separation of Panels at Rail and Mud-Filled Track.

Photo 35. Main Street - Separation of Panels

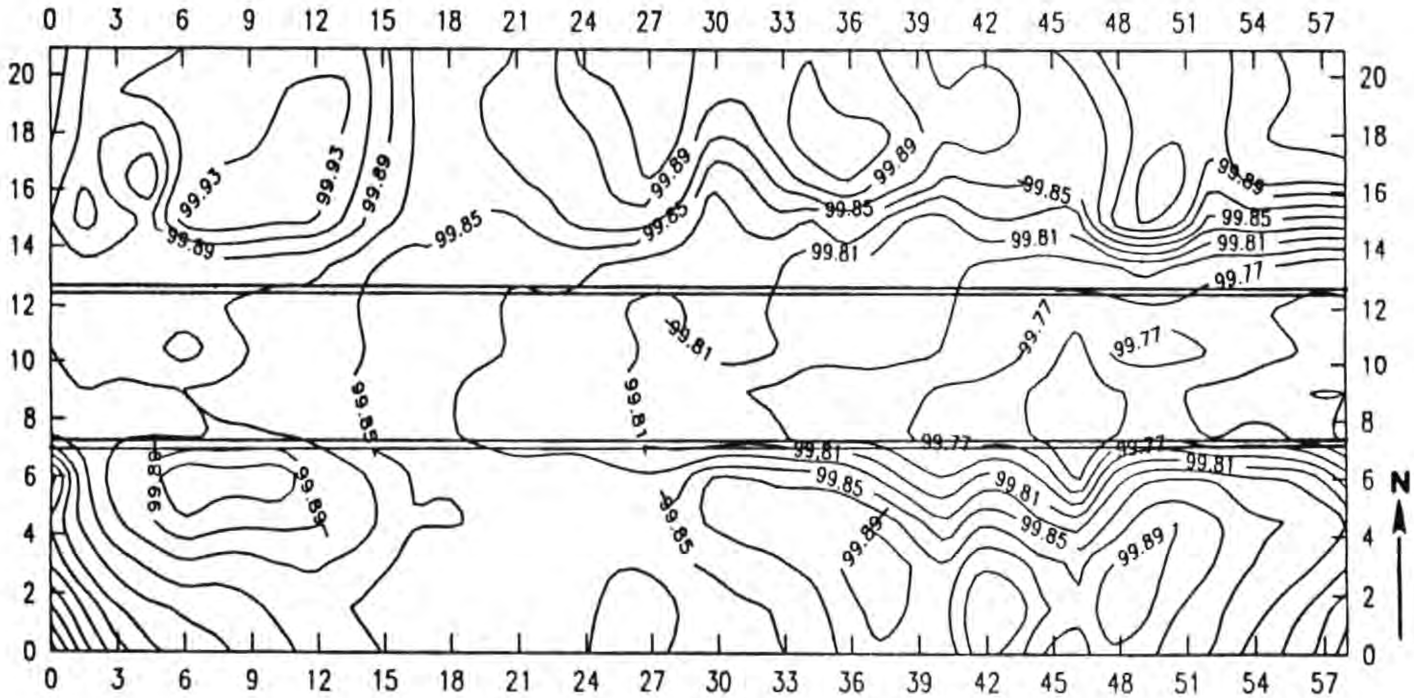



Figure A35 Main Street, Aberdeen (Rubber)

All Distances in Feet

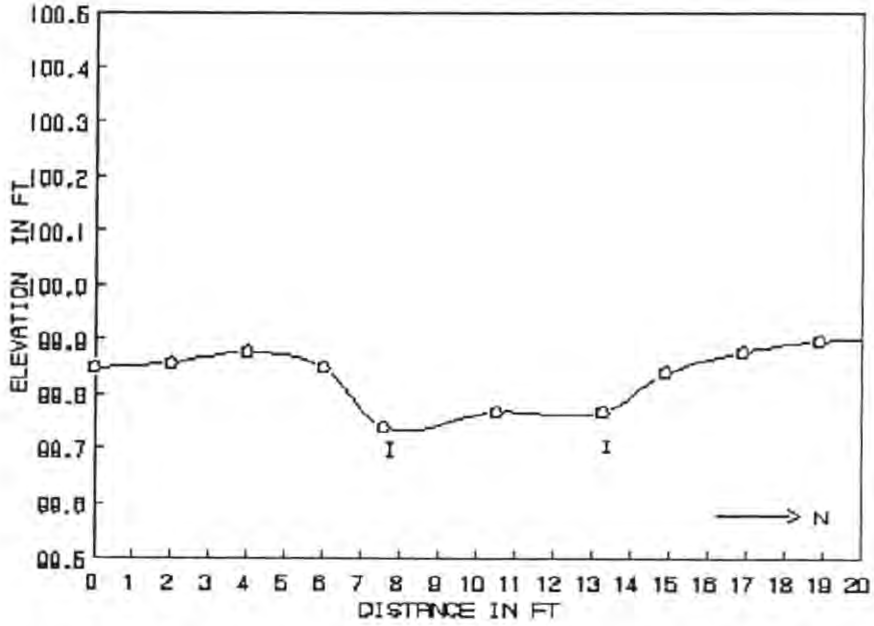



**Figure A36** Main Street, Aberdeen (Rubber)
Cross section at curb.

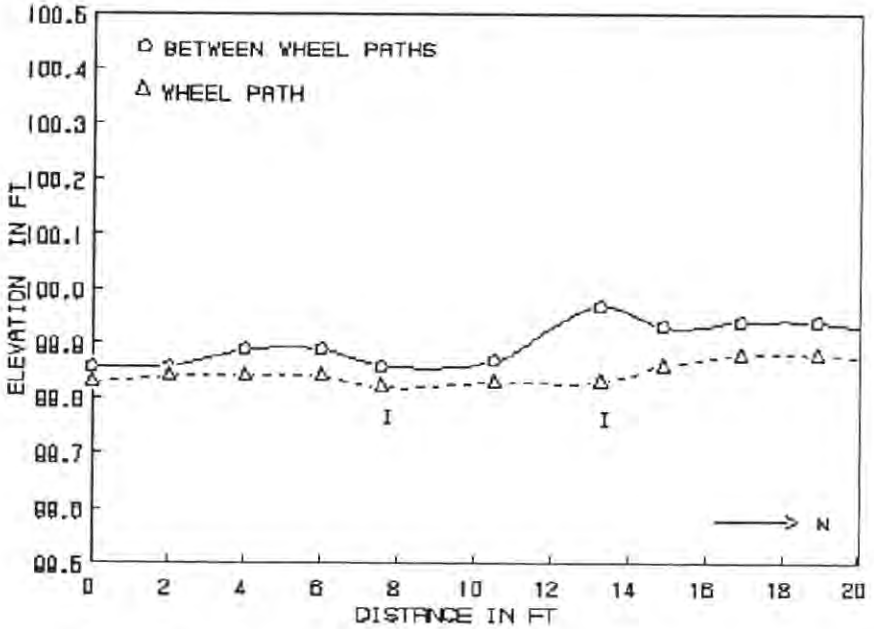



**Figure A37** Main Street, Aberdeen (Rubber)
Cross section taken at wheel path and between wheel paths.

traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with no bolted joints within 20 feet of the crossing. The crossing is shown in Photos 32 through 35.

The subsurface soils at the crossing consist of an upper 4 feet of silty clayey sand over 2 feet of light brown silty clay. The sand field moisture content was measured at 11 percent. The soil classifies as an SM-SC in the Unified and A-1-b(0) in the AASHTO classification systems. Based on the results of the classification tests the sand has slight frost susceptibility, low compressibility, and high strength.

The results of the survey at the crossing are shown in Figures A35 through A37. The contour map shown in Figure A35 show little difference in elevation wihthin the crossing itself, but the track settlement relative to the approaches is evident on the east side of the crossing. Rutting is also evident on the approaches at the north side of the crossing, and considerable rutting can also be seen on Figure A37. The overall settlement of the crossing relative to the approaches can also be seen at the shoulder (See Figure A36) where the pavement has been unaffected by traffic. At this location, the crossing is nearly two inches lower than the pavement approach. The south rail is from 1/4 to 1/2 inch lower than the north rail. The large differences in elevation from the south to the north rail in between the wheel paths (Figure A37), however, are not realistic and it is most likely the result of a surveying error. Evidence of track settlement can also be seen in Photo 32 and cracking and tilting of the approaches are seen in Photo 33.

The Hi-Rail crossing consists of full-depth rubber panels which do not use fasteners. The outer panels are held in place under the ball of the rail and are laterally confined by the pavement. The outer panels are thus subject to lateral movement under traffic and the center panels are subject to movement along the direction of the track. Evidence of such movement can be seen in Photos 34 and 35. Snow plow damage is insignificant.

Surface drainage at this crossing is poor, as the surrounding terrain is level. Pumping can also be seen in the rail approaches to the crossing, and cracks extend from the end of the panels onto the asphalt shoulder (Photo 32).

**Kline Street**

Two Lanes - One Track

The crossing at Kline Street has a General Tire type rubber surface. The approach pavement is asphalt, and the headers are 2 inch wood boards. The crossing was installed in 1986. Kline Street is a two lane street serving the Aberdeen downtown business district. The average daily traffic is 5,167 vehicles with rail traffic consisting of three trains per day, including coal freight with up to 100 cars and six locomotives. There is also considerable switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with

Photo 36. Kline Street - Panel and Header Failure

Photo 37. Kline Street - Settlement of Pavement Approach

Photo 38. Kline Street - Close-up View of Shoulder Settlement

Photo 39. Kline Street - Panel Distortion and Track Settlement.

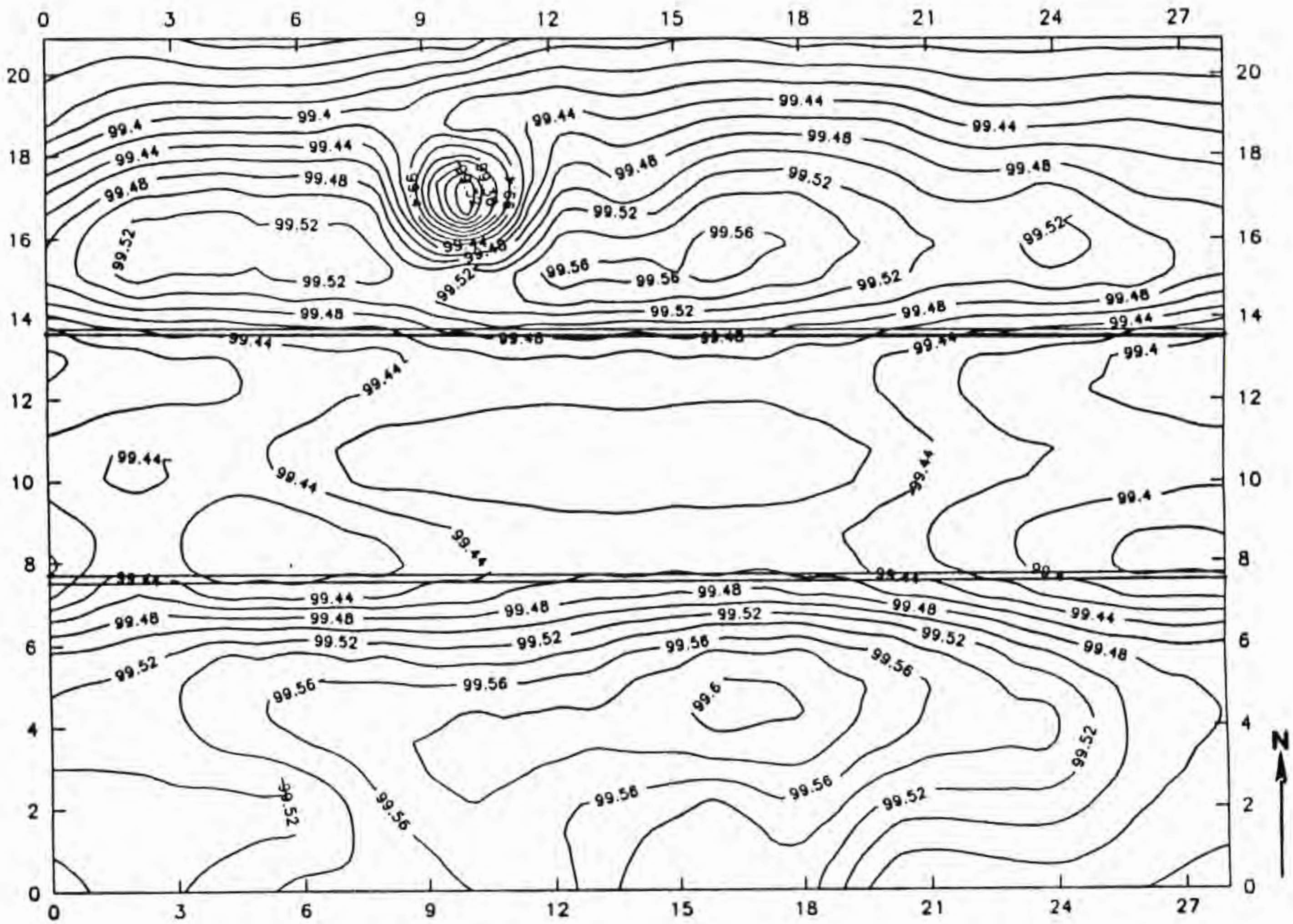



Figure A38 Kline Street, Aberdeen (Rubber)

All Distances in Feet

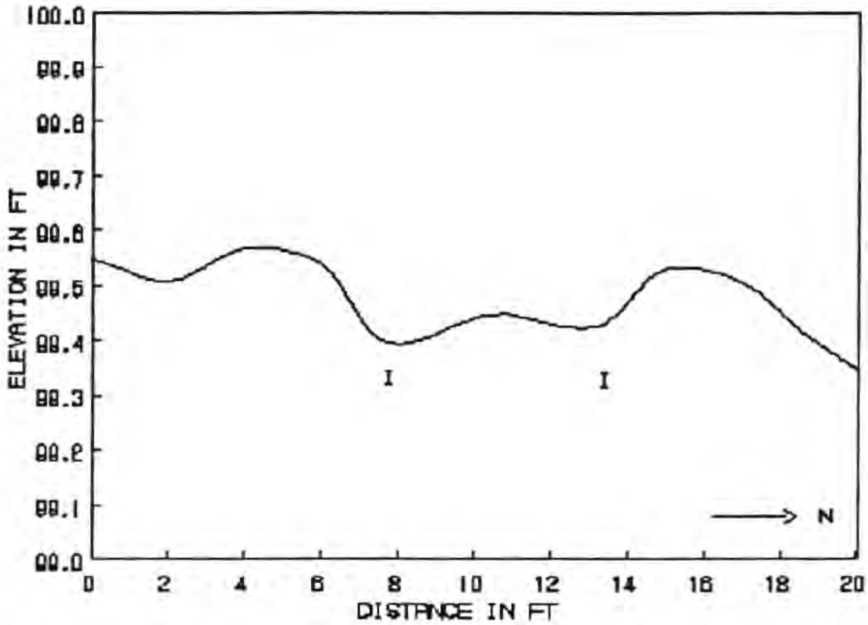



**Figure A39** Kline Street, Aberdeen (Rubber)
Cross section at curb.

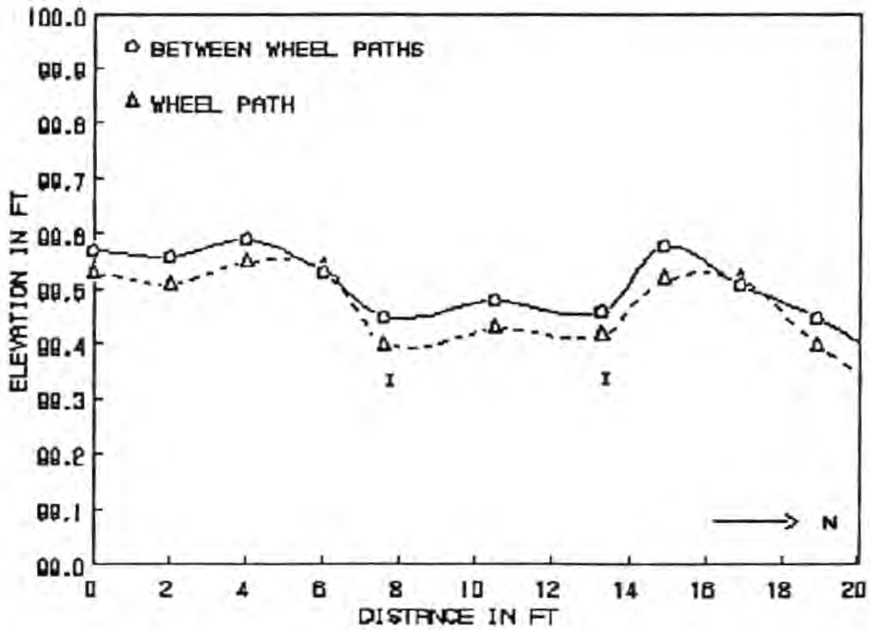



**Figure A40** Kline Street, Aberdeen (Rubber)
Cross section taken at wheel path and between wheel paths.

Photos 36 and 38). Heavy amounts of debris have collected between the rails and the center panels (Photo 37). The panels at this crossing show considerable wear and are distorted (See Photo 37 and 39). Fresh scarring, as would have occurred from snow plow damage, could not be seen.

Surface drainage at this crossing is poor. Nevertheless, no evidence of pumping could be seen and rail deflection at the approaches was less than 0.31 inches.

**Brown County #14**

Two Lanes - Single Track

The timber crossing on Brown County #14 Street was installed before 1980. Full depth timbers were used and the outer timber serve as headers. The rail traffic consists of one train per week. There is no switching traffic at this crossing. The rail in the crossing is 100 pound weight and continuously welded, with no bolted joints within 20 feet of the crossing. The condition at the crossing is shown in Photos 40 through 42.

The subsurface soils consist of an approximate 5 foot layer of black clay silt and light brown silty clay. The field moisture content of the silt was 30.7 percent. The soil classifies as A-7-5(13) in AASHTO and OL or ML in the Unified classification systems. The gradation analysis on the soil shows that 78 percent is smaller than the #200 sieve and the Liquid Limit and Plasticity Indexes are 48 and 18 percent, respectively. The clayey silt is highly frost susceptible and is likely to exhibit

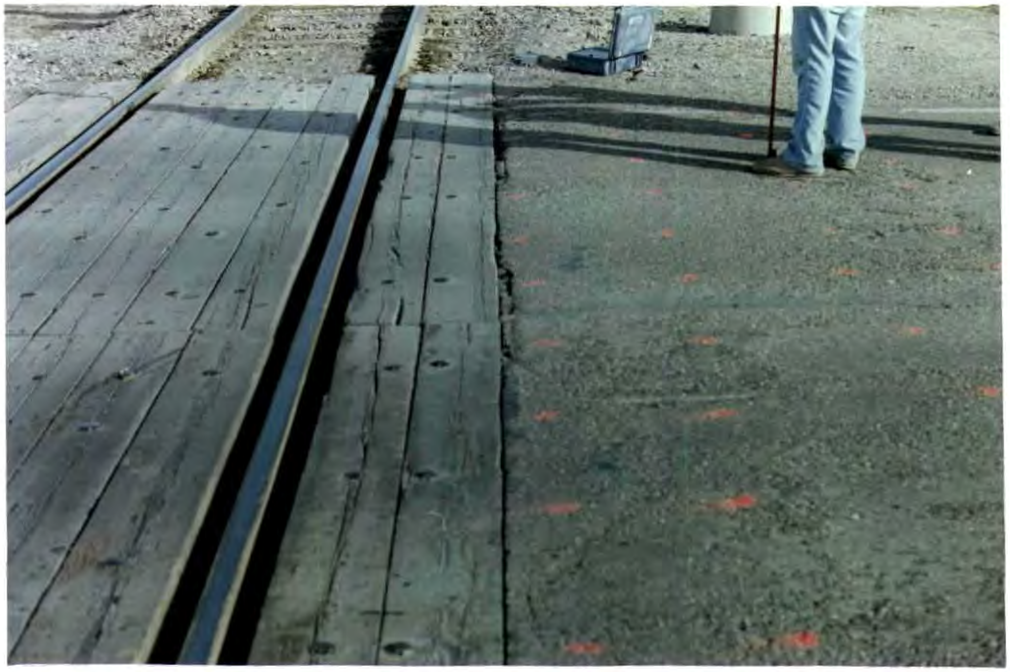


Photo 40. Brown County # 14 - Asphalt Breakdown Next to Timber

Photo 41. Brown County # 14 - Exposed Nails

Photo 42. Brown County # 14 - Pulled Out Nail

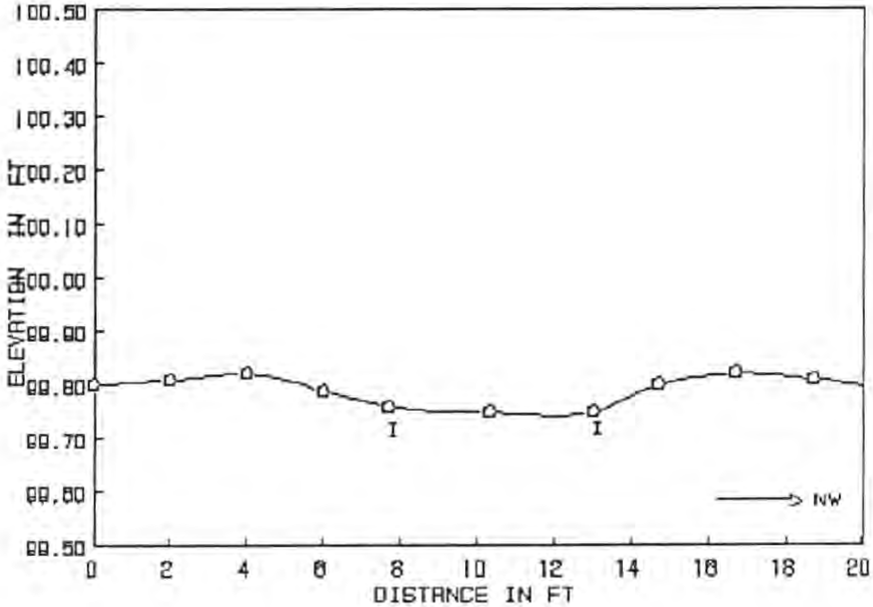



**Figure A42** Brown County # 14, Aberdeen (Timber) Cross section at curb.

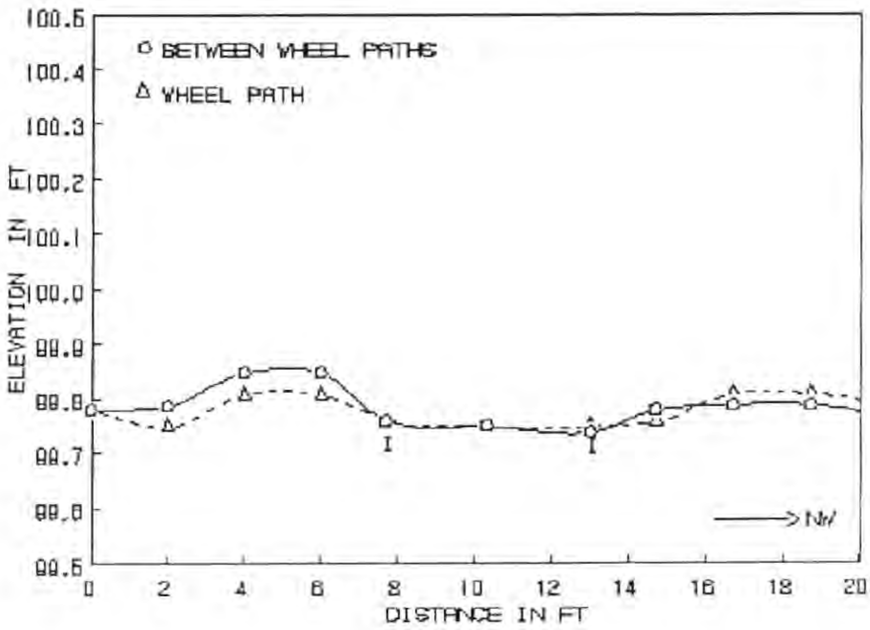



**Figure A43** Brown County # 14, Aberdeen (Timber) Cross section taken at wheel path and between wheel paths.

low bearing strength under saturated conditions. As the soil appears organic in nature, compressibility would also be high.

The topographic map and cross sections for the crossing are shown in Figures A41 through A43. The topographic map shows that the track has settled relative to the approaches, and that the slope of approach onto the track on the southeast side of the crossing is quite abrupt. The survey shows that the overall settlement of the track is from 1/2 to 1 inch relative to the pavement approaches. Both the contour map and the cross sections (Figures A42 and A43), indicate that differential elevations between the rails are less than one quarter inch. Rutting, however, has taken place in the pavement outside the crossing and can be seen both on the contour map and in Figure A43. There is no evidence of rutting from wear on the timber crossing itself.

Overall views of the crossing are shown in Photos 40 and 41. Photo 40 shows slight breakdown of the asphalt next to the outer timber. Fasteners with large heads were used at this crossing (See Photo 41), and the protruding heads contribute to the roughness of the crossing. There is minor snow plow damage, as some of the timbers are torn as nails have been pulled out (Photo 42).

Surface drainage at this crossing is poor, as evidence of pumping can be seen at the ends of the crossing.

**Fifth Street West**

Two Lanes - Single Track

The asphalt crossing at Fifth Street West was built in 1971 and was replaced in the summer following the survey. There were no mud rails at this crossing. The crossing is in an eight degree curve on the track (See Photo 46). Fifth Street West is a two-lane road with daily traffic of 460 vehicles. The rail traffic consists of one train per week, which includes switching traffic to a nearby grain elevator. The rail in this crossing is 115 pound weight with bolted joints within the crossing. Conditions are shown in Photos 43 through 46.

The boring drilled at the crossing shows that the soils consist of approximately four feet dark brown to black clay over tan sand. The gradation analysis on the clay shows that 88 percent is smaller than the #200 sieve and the Liquid Limit and Plasticity Indexes are 63 and 38 percent, respectively. The soil classifies as A-7-6(20) in the AASHTO and CH in the Unified classification systems. The natural moisture content was 29 percent. Based on the laboratory tests, the soil classifies as highly frost susceptible and, if subject to saturation, would be likely to pump under repetitive loading. Bearing capacity under saturated conditions would also be low and compressibility would be moderate (See also discussion in Chapter V).

The results of the survey data are presented in Figures A44 through A46 and the condition of the crossing is shown in photos 43 through 46. The contour map shows that the crossing is very

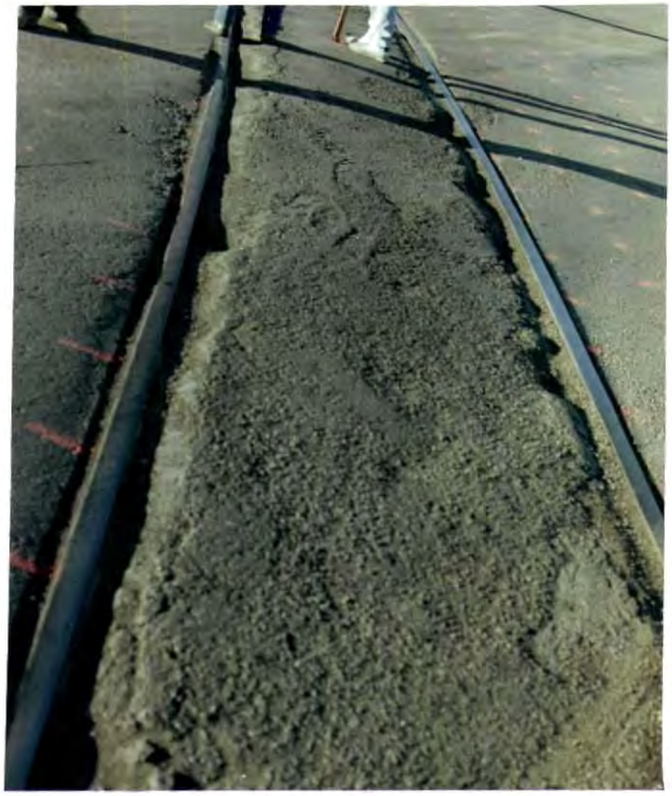


Photo 43. Fifth Street - Overall Condition

Photo 44. Fifth Street - Pumping

Photo 45. Fifth Street - Close-up View of Failed Asphalt

Photo 46. Fifth Street - Cracked Approaches and Failed Center Section

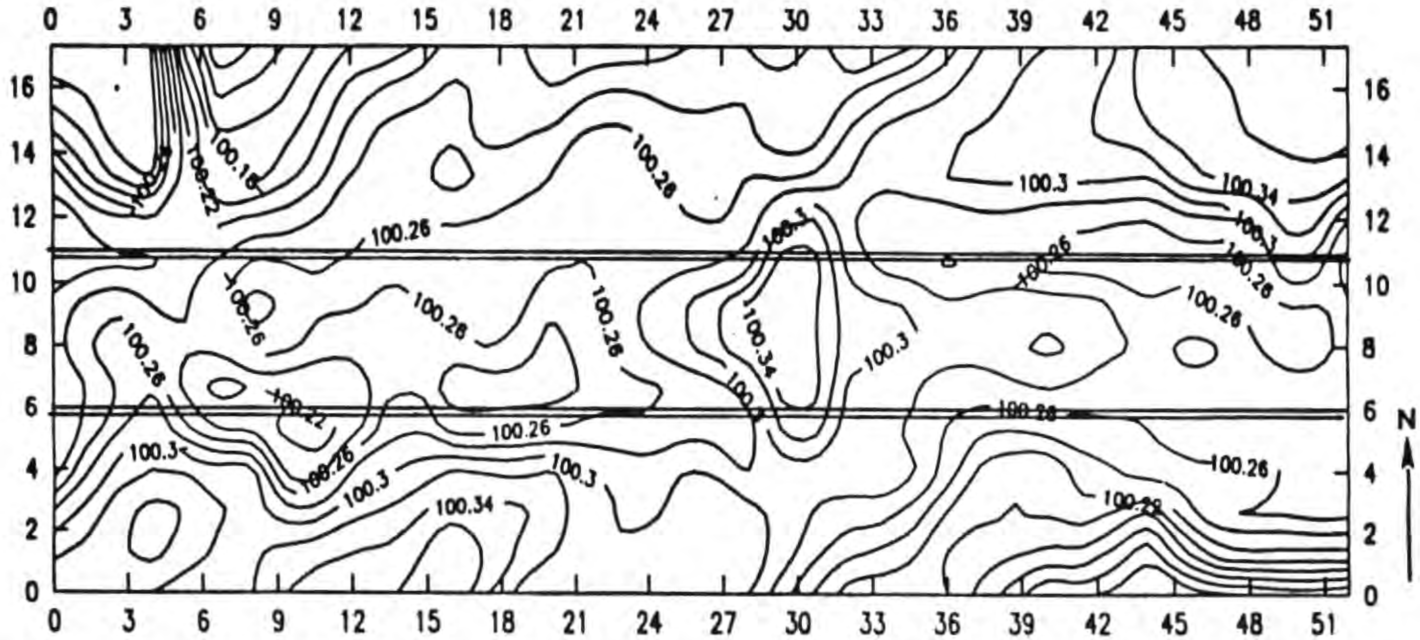



Figure A44 Fifth Street, Aberdeen (Asphalt)

All Distances in Feet

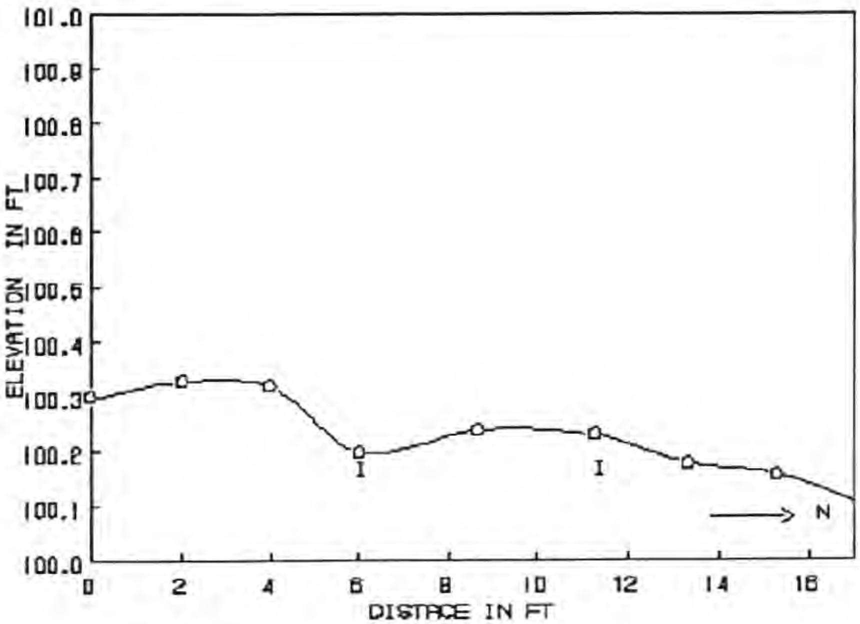



**Figure A45** Fifth Street West, Aberdeen (Asphalt) Cross section at curb.

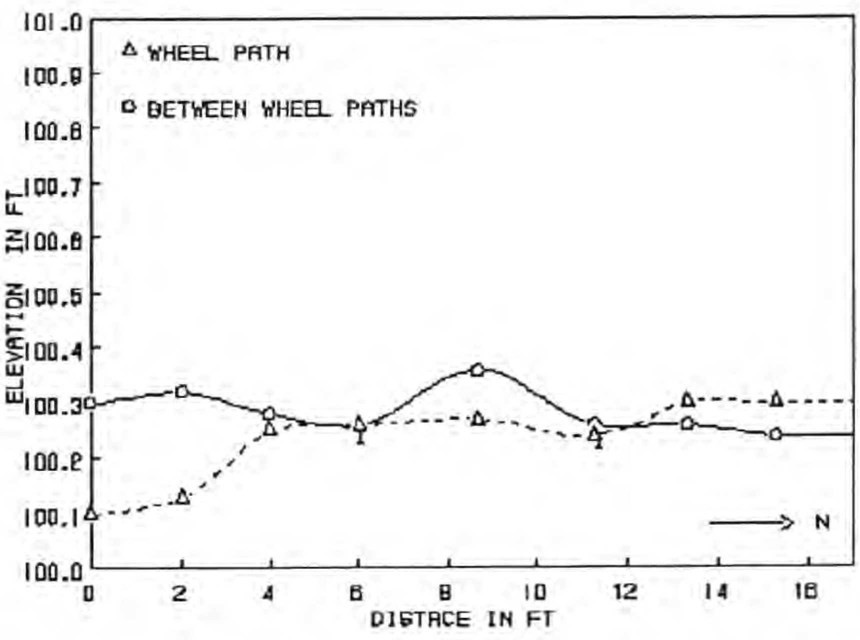



**Figure A46** Fifth Street West, Aberdeen (Asphalt) Cross section taken at wheel path and between wheel paths.

uneven, with differential elevations in excess of one inch over a distance of approximately five feet. The survey shows considerable bulging of pavement in between and outside the rails. Overall, the rails are from 1 to 2 inches beneath the pavement. Figure A45 shows that the elevations of the crossing at the wheel path and in between the wheel paths are vastly different, hence considerable rutting has taken place (Figure A46).

Drainage at this crossing is poor and severe pumping can be seen at the ends of the crossing and between the rails (See Photos 44, 45 and 46).

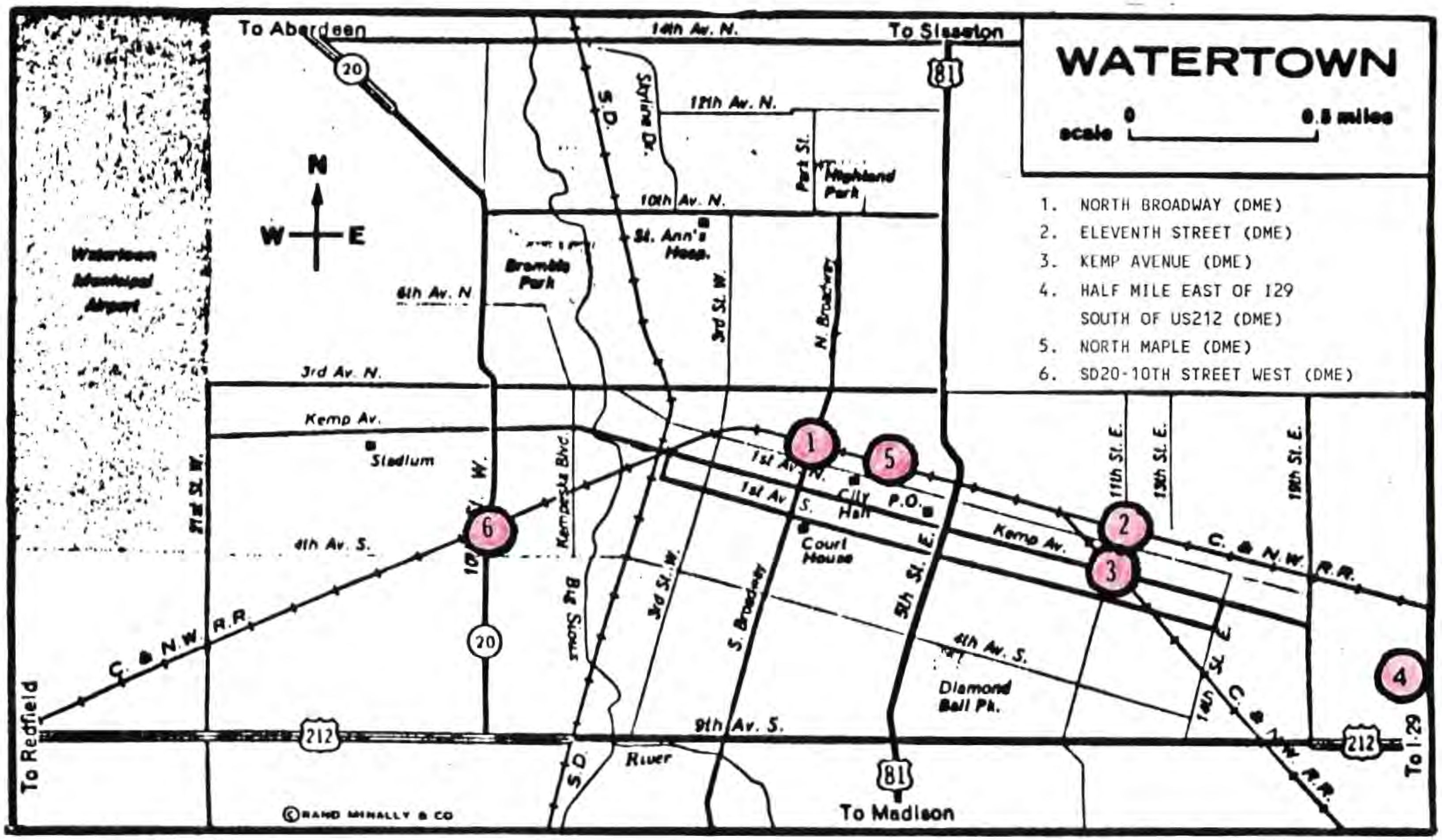
**A-3.4 Watertown**

**North Broadway**

Two Lanes - Single Track

The North Broadway crossing is a SAF&DRI rubber type, built in 1980. The pavement is asphalt and there are no headers. North Broadway is a four lane artery serving the business and government offices. The average daily traffic is 6,097 vehicles with rail traffic consisting of two trains per week, each with two to four locomotives and 40 to 50 freight cars. There is considerable switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with no bolted joints within 20 feet of the crossing.

The subsurface soils at the crossing consist of 2 feet of dark brown clayey silt over 4 feet of black clayey silt. The field




LOCATION MAP 4

moisture of the black silt is 29.7 percent. The soil classifies as ML in the Unified and A-6-(8) in the AASHTO classification systems. As the soil is organic in nature it is likely to be highly compressible and have low bearing strength. When saturated, the soil is likely to pump under repetitive loading, and the frost susceptibility of the soil is high.

Contours and cross-sections of the crossing are shown in Figures A47 through A49, and the surface conditions of the crossing are shown in Photos 47 through 50. Overall settlement of the crossing is difficult to evaluate, since, as can be seen on the contour map, the elevations of the crossing are highly variable (Figure A47). The contour map also show considerable evidence of rutting. The north approach slopes sharply towards the crossing, with a drop in elevation of up to 3 inches. The cross-section at the curb shows an overall settlement of the track of between 1 to 2 inches. In the driving lanes (See Figure A49) the rubber portion of the crossing is quite even, while the approaches between wheel paths drop sharply on to the crossing. Rutting in the wheel path is evident, especially on the south side of the crossing.

The panels in the crossing are considerably worn and the combination of snow plow damage and wear can be clearly seen in Photos 47 and 48. The space between the rails and the panels is variable and it is likely that some panels are loose (See Photo 50).

Photo 47. North Broadway - Rubber Pad Damage by Snow Plows and Wear

Photo 48. North Broadway - Debris Collection on the Track and Also Next to Rail

Photo 49. North Broadway - Overall View

Photo 50. North Broadway - Relative Settlement between Panels

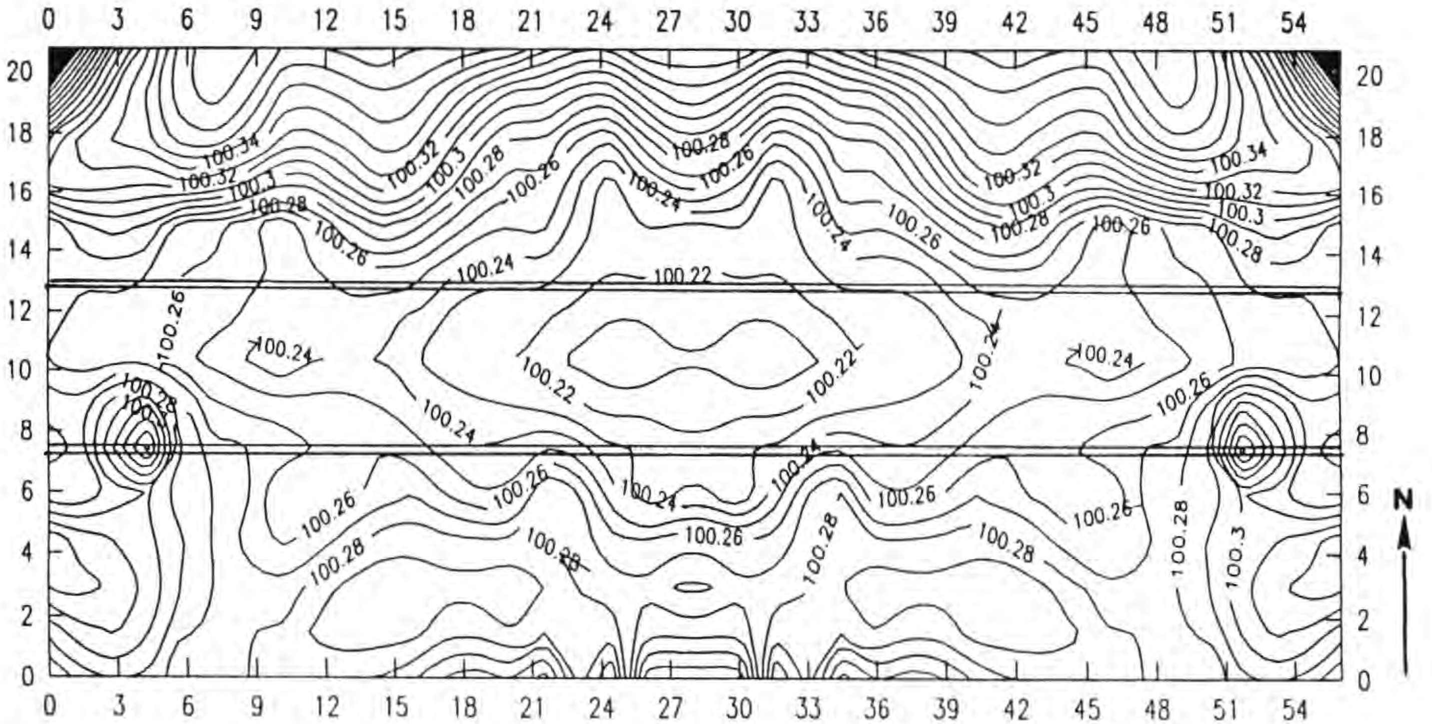



Figure A47 North Broadway, Watertown (Rubber)

All Distances in Feet

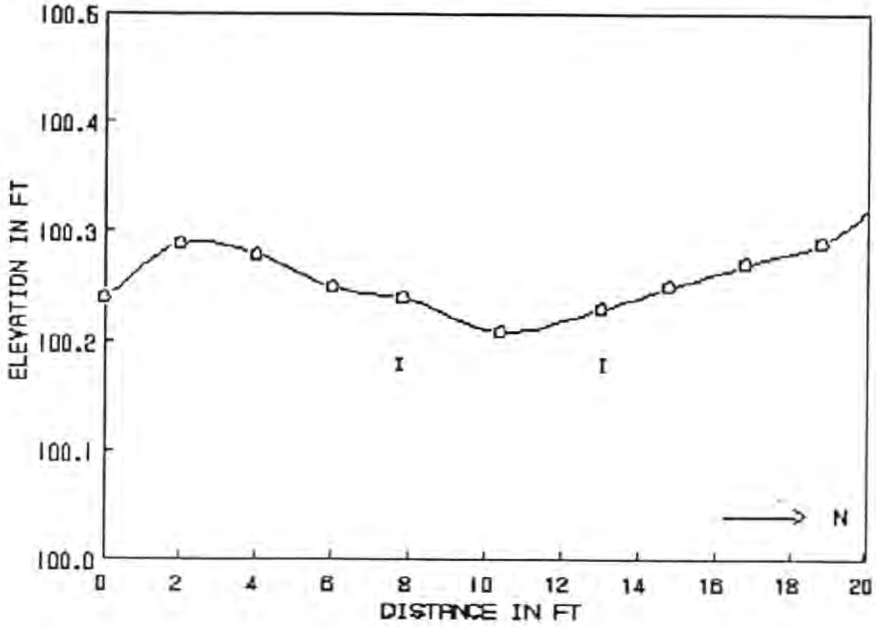



**Figure A48** North Broadway, Watertown (Rubber)
Cross section at curb.

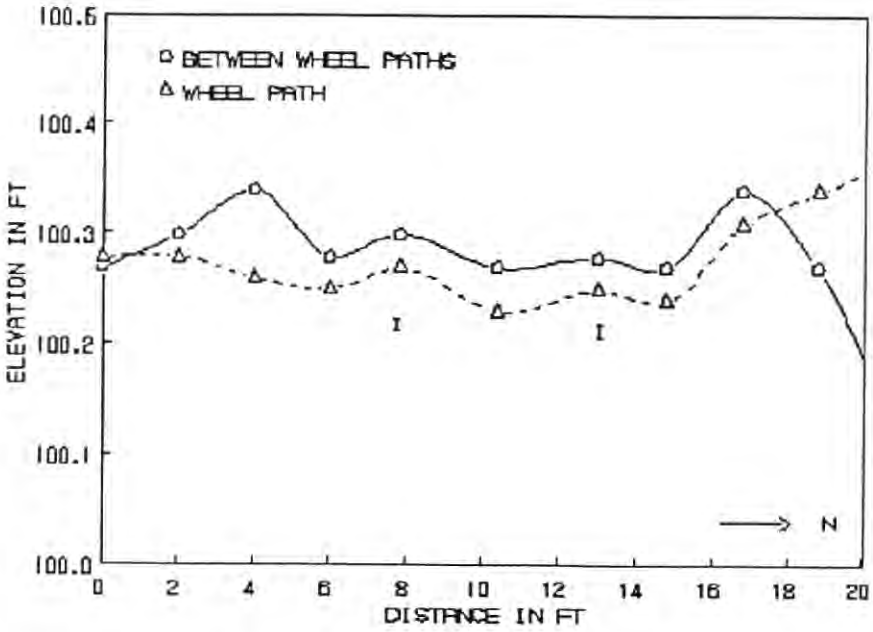



**Figure A49** North Broadway, Watertown (Rubber)
Cross section taken at wheel path and between wheel paths.

Drainage at this crossing is fair, as shallow ditches are present at both ends of the crossing. No evidence of pumping under the track can be seen at either end of the crossing, and there was no detectable rail deflection at the ends of the crossing during train traffic.

**North Maple**

Two Lanes - Two Tracks

At North Maple Avenue a SAF&DRI rubber crossing has been installed for the main track and a single ball-up mud rail type crossing was used for the side spur. An overall view of the crossing is shown in Photo 54. The crossing was built in 1979.

North Maple is a two lane street serving the business community and residential areas. The average daily traffic is 3,192 vehicles with rail traffic consisting of two trains per week, each with 40 to 50 freight cars and two to four locomotives. There is also switching traffic at this crossing. The rail in both the rubber and asphalt crossing is 115 pound weight and continuously welded, however, there are bolted joints near the crossing (See Photo 54). The weight of the rail in the side spur could not be identified.

The boring drilled at the crossing shows that the subsurface soils are predominantly black silty clay. The gradation analysis on the soil shows that 83 percent passes the #200 sieve. The Liquid Limit and Plasticity Indexes are 41 and 17 percent, respectively. The soil classifies as A-7-6(10) in the AASHTO and

Photo 51. North Maple - Failed Joints (Without Header Board) All Along the Track

Photo 52. North Maple - Pavement Cracking

Photo 53. North Maple - Debris Collected on Side Spur

Photo 54. North Maple - Overall View of Main Track and Side Spur

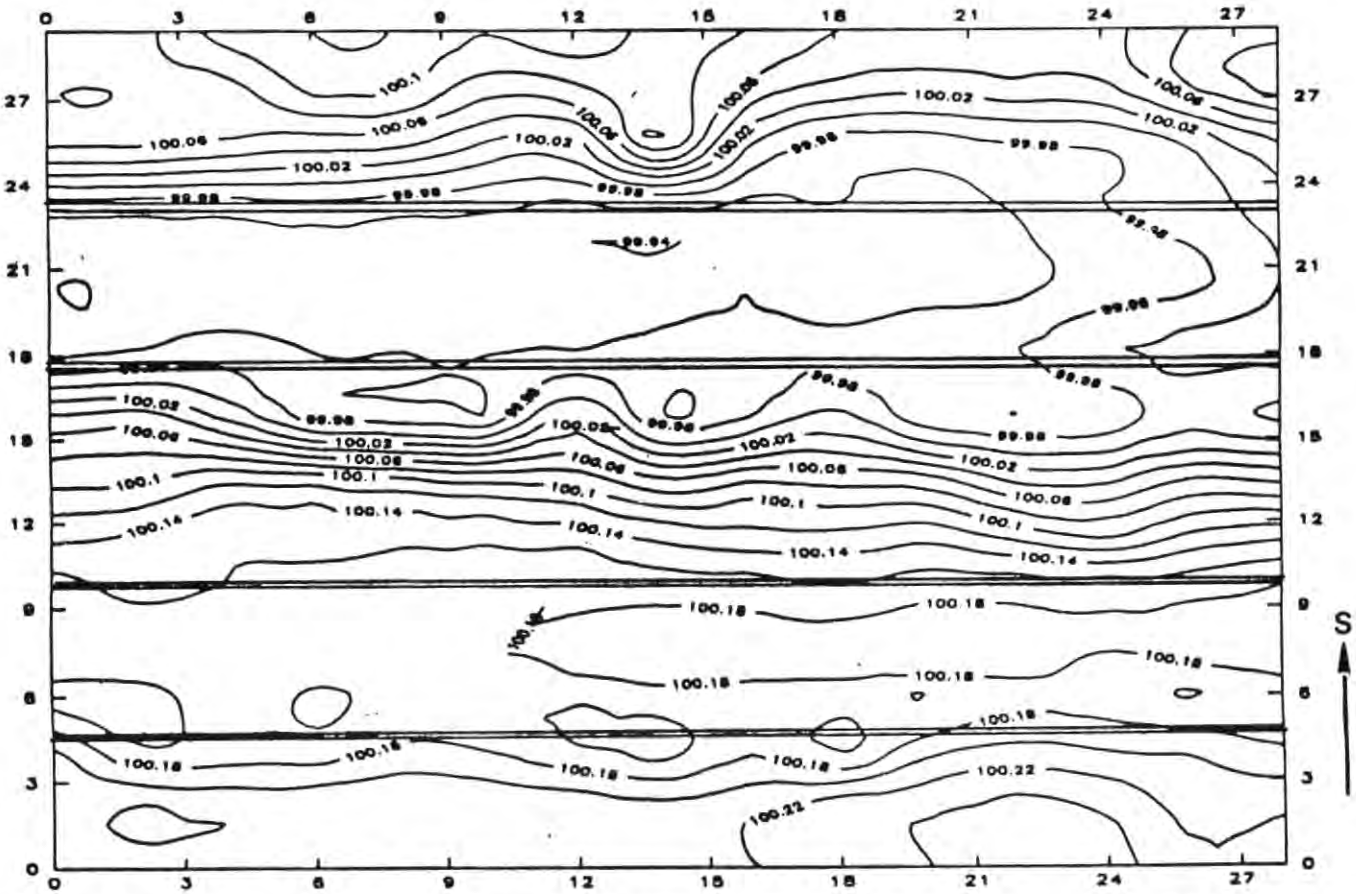



Figure A50 North Maple, Watertown (Rubber and Asphalt)

All Distances in Feet

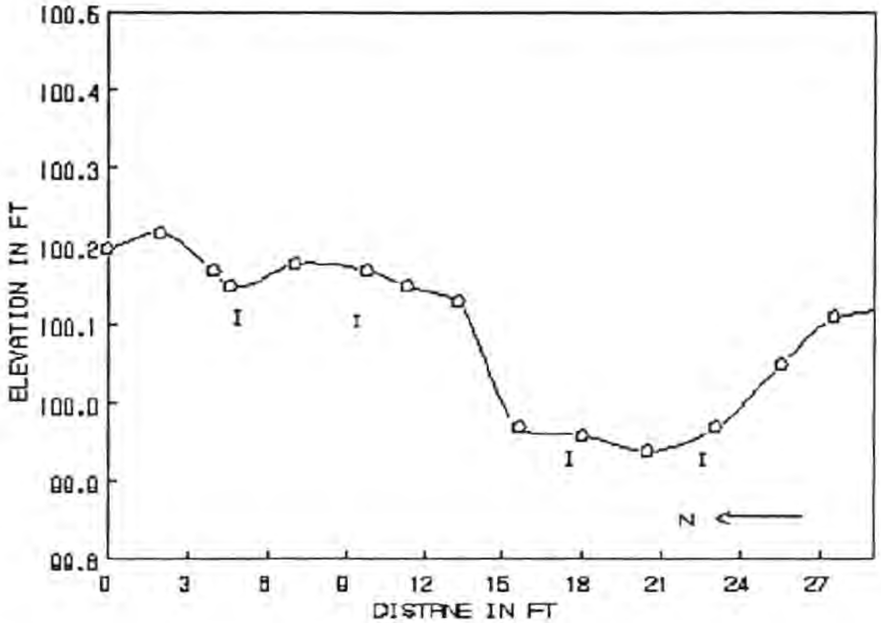



**Figure A51** North Maple Street, Watertown
(Rubber and Asphalt)
Cross section at curb.

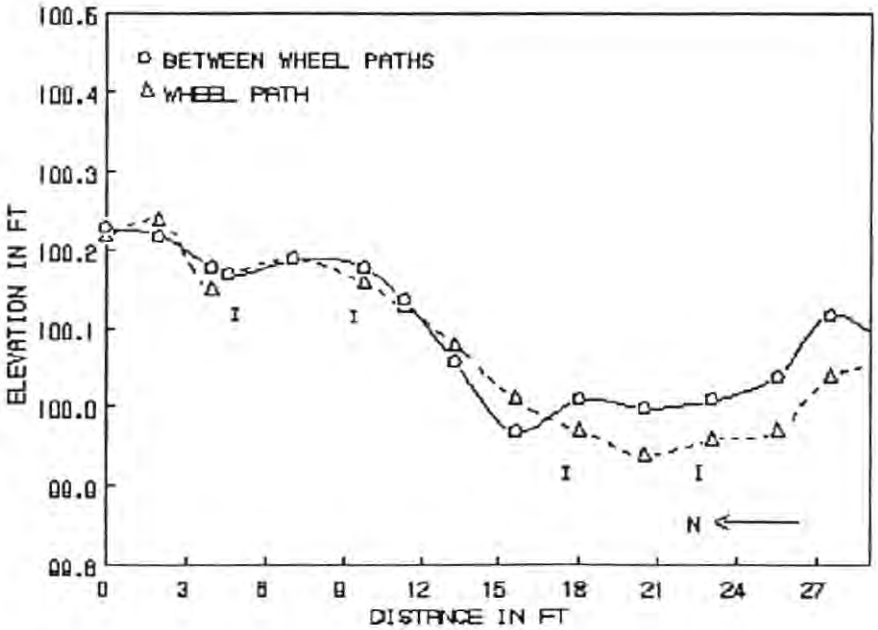



**Figure A52** North Maple Street, Watertown
(Rubber and Asphalt)
Cross section taken at wheel path and between wheel paths.

CL in the Unified classification systems. The natural moisture content was 34.5 percent. Based on the laboratory tests the soil classifies as highly frost susceptible and, if subject to saturation, would be likely to pump under repetitive loading. Bearing capacity under saturated conditions would also be low, and soil compressibility would be moderate.

The results of the survey are shown in Figures A50 through A52. As can be seen on the contour map (Figure A50), the road is sloping toward the south, however, the main track appears to have settled up to two inches relative to the side spur. This can also be seen in Figures A51 and A52. Rutting at this crossing is insignificant, which can be seen both on the contour map and in the cross section in Figure 52. Elevation is differences within the crossings is less than one half inch. The roughness of the crossing can mainly be contributed to the large settlement of the main track and to the rails protruding from the asphalt at the side spur (See Photos 51 and 53).

Damage to the rubber panels was observed in the west lane and on the west side of the east lane. Asphalt chipping can be seen along the entire crossing (See Photo 51), and pavement failures were seen at the south side of the crossing on the east side (See Photo 52). Collection of debris between the rails is evident.

Drainage at this crossing is fair, as ditches are present at both ends of the crossing. No evidence of pumping could be seen at either track.

**Eleventh Street North**

Two Lanes - One Track

At Eleventh Street North, an Omni type of rubber crossing has been installed. The pavement approaches are asphalt and there are no headers. The crossing was built in 1986. Eleventh Street North is a two-lane street serving business and residential areas. The average daily traffic is 600 vehicles with very little truck traffic. The rail traffic consists of two trains per week. There is minor switching traffic at this crossing in conjunction with rail traffic to a nearby industrial plant. The rail in the crossing is 115 pound weight and is continuously welded, with no bolted joints within 20 feet of the crossing. Overall surface conditions of the crossing are shown in Photos 55 through 57.

The boring taken at the crossing revealed that the soil consists of approximately 4 feet of black clayey silt/silty clay over 2 feet of brown sandy clay. The field moisture of the silt was 18.7 percent. The soil classifies as A-7-6(10) in the AASHTO and ML/CL in the Unified classification systems. The gradation analysis show that 68 percent of the soil passes the #200 sieve and the Liquid Limit and Plasticity Indexes are 41 and 16 percent, respectively. Based on classification tests, the soils are highly frost susceptible and have low bearing strength under saturated conditions, while compressibility is thought to be moderate.

Photo 55. 11th Street - Failed Joint Along Outer Panel and Debris Collected Next to Rail

Photo 56. 11th Street - Overall Settlement of the Track

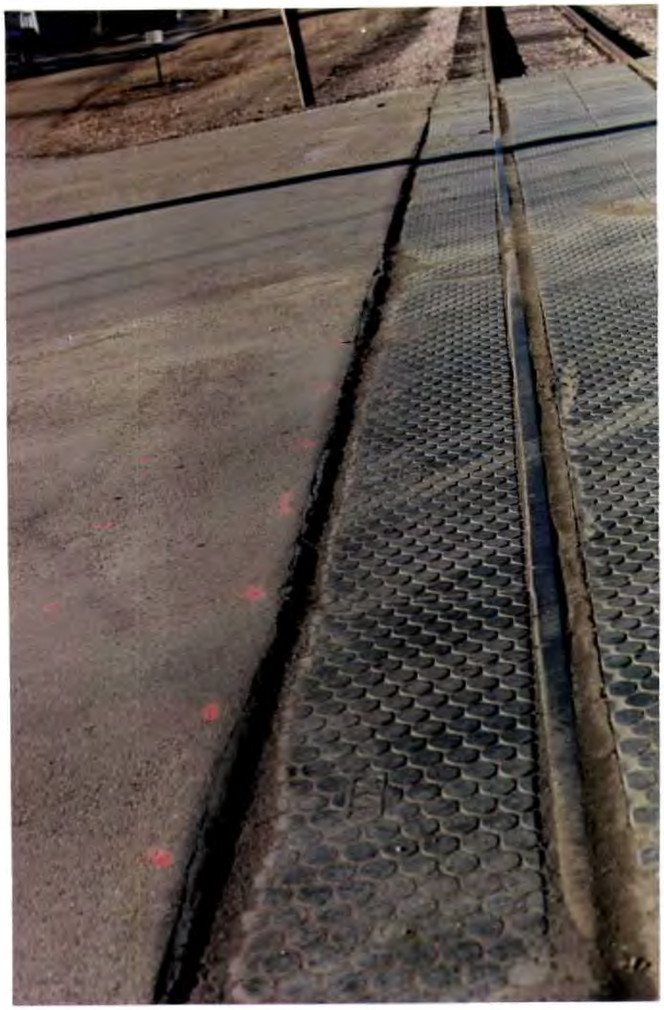


Photo 57. 11th Street - Close-up of Approach Settlement

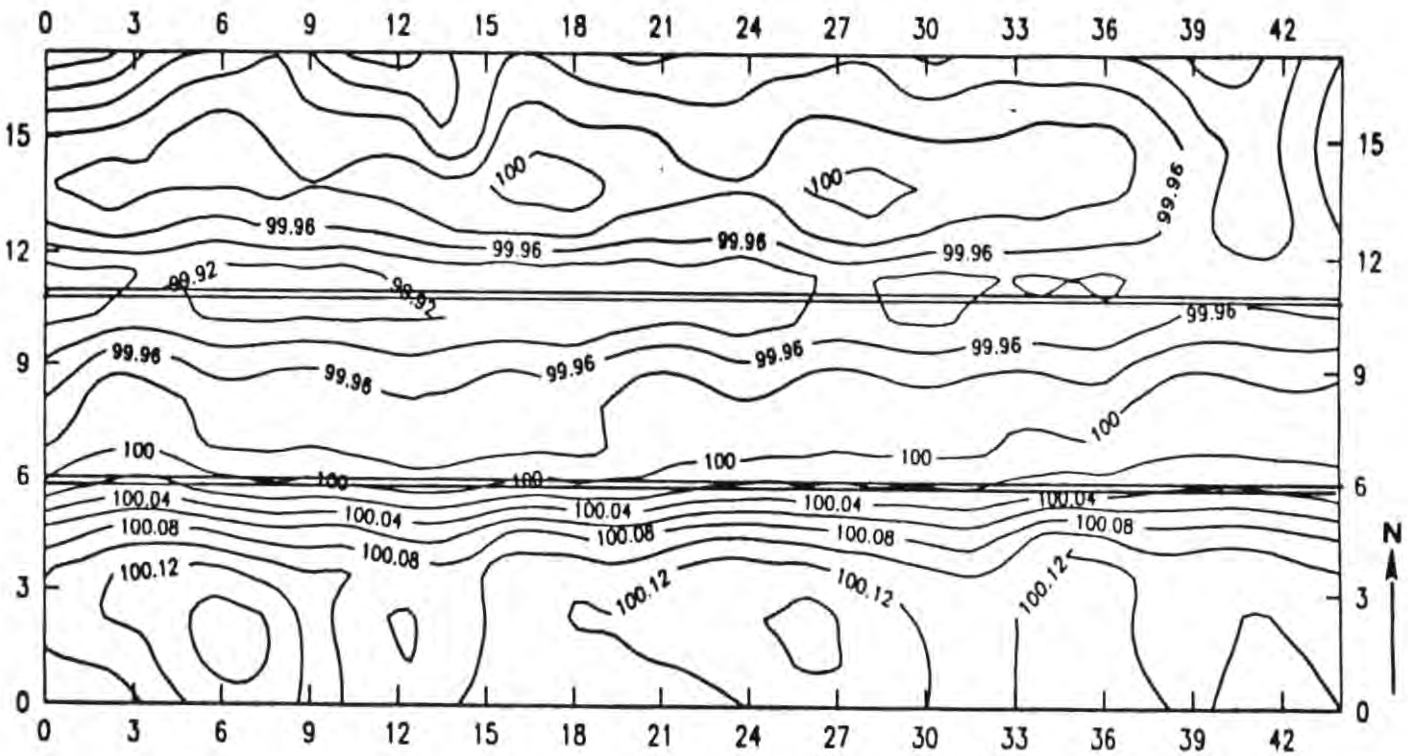



Figure A53 Eleventh Street North, Watertown (Rubber)

All Distances in Feet

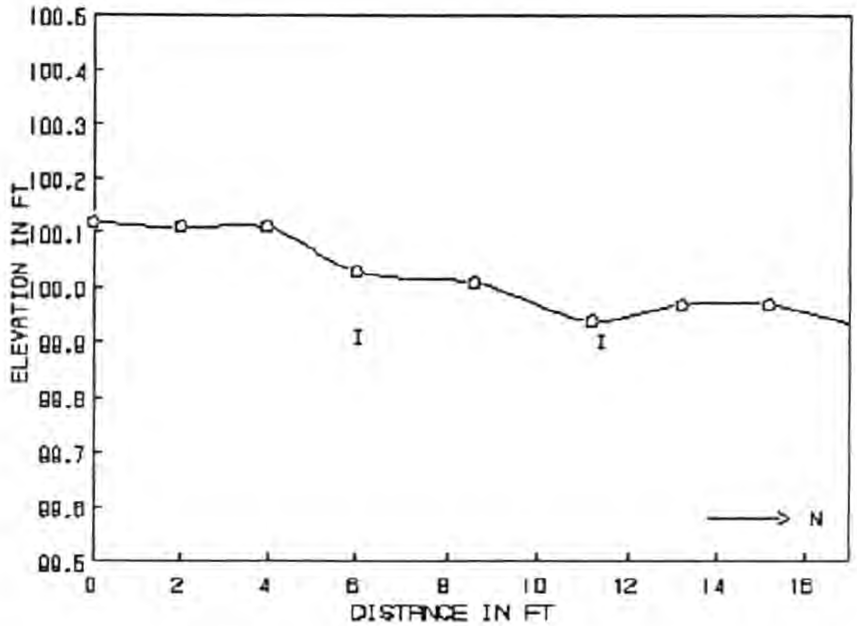



**Figure A54** Eleventh Street North, Watertown (Rubber)
Cross section at curb.

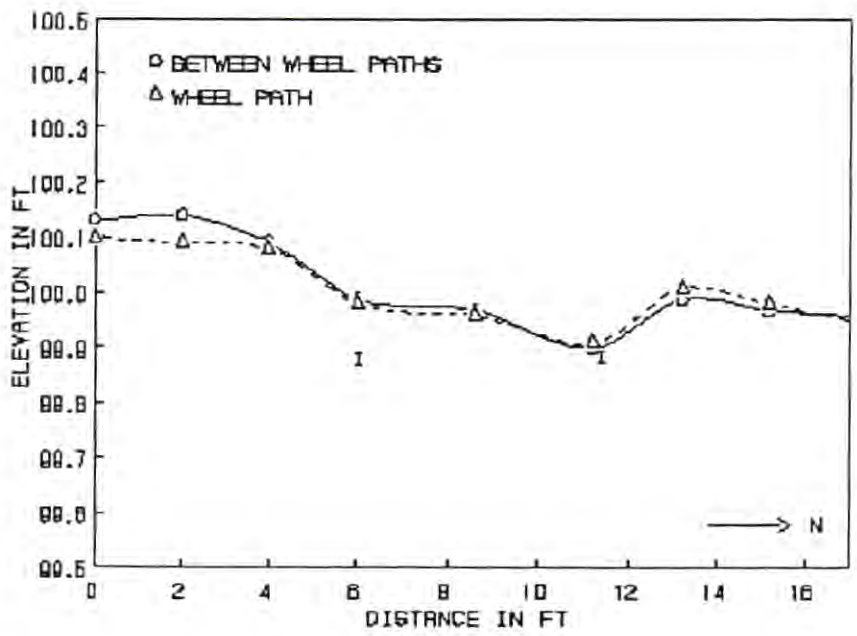



**Figure A55** Eleventh Street North, Watertown (Rubber)
Cross section taken at wheel path and
between wheel paths.

The results of the crossing survey are shown in Figures A53 through A55. The street is sloping slightly to the south, with a difference in elevation of two inches from north to south. As can bee seen from both the contour map (Figure A53) and the cross sections (Figures A54 and A55), The crossing has settled approximately one inch relative to the approach pavement. The cross-section at the shoulder is slightly less than in the driving lanes. The south rail has also settled between 1/2 and 1 inch relative to the north rail. Rutting in the wheel path is minor, as can be seen both from the contour map and the cross section in Figure A55.

The visual inspection of the crossing indicates that there is a sharp drop-off from the pavement to the crossing (See Photos 56 and 57). The abrupt change in elevation was not evident during a second inspection in September of 1991, indicating that frost heave may have occurred at the time of the survey in February of 1991. The inspection also revealed that cracks were opening between the asphalt and the outer rubber panels (See Photo 55). The space between the rails and the panels was also completely filled with mud (See Photos 55, 56 and 57).

Drainage at this crossing is fair, as ditches are present at both ends of the crossing. No pumping under the track was evident at either end of the crossing. Deflection under rail traffic was 3/8 of an inch.

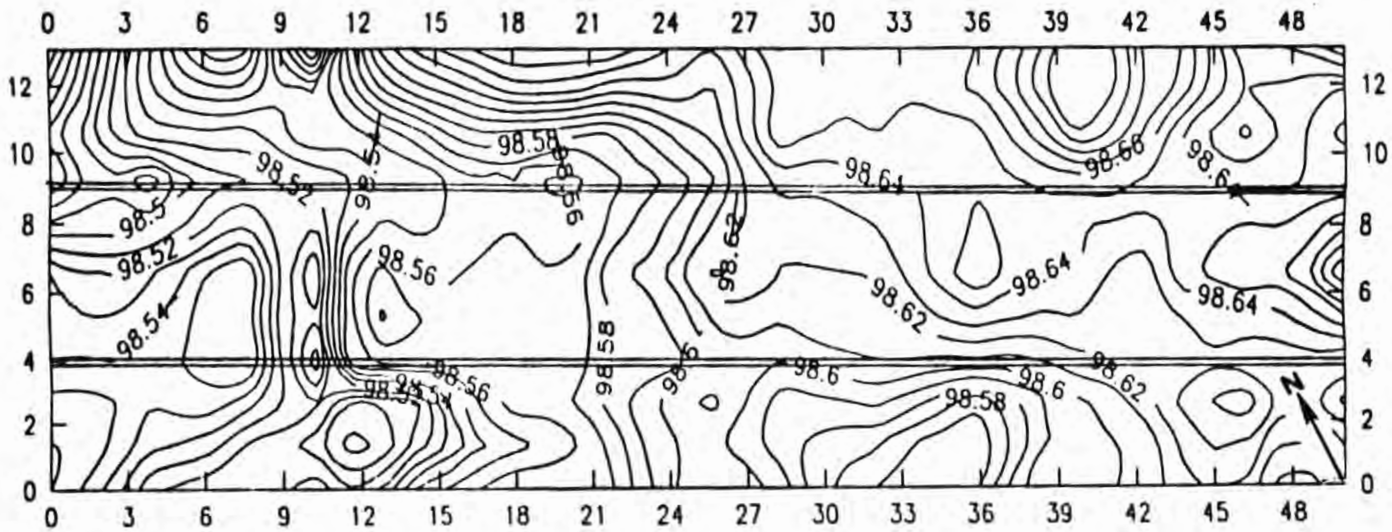



Figure A56 Kemp Avenue, Watertown (Asphalt)

All Distances in Feet

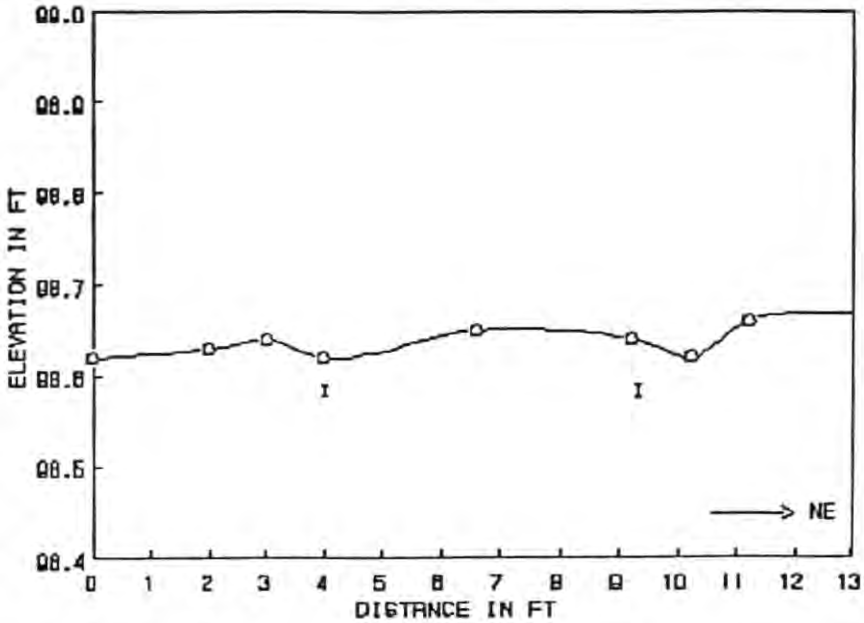



**Figure A57** Kemp Avenue East, Watertown (Asphalt)
Cross section at curb.

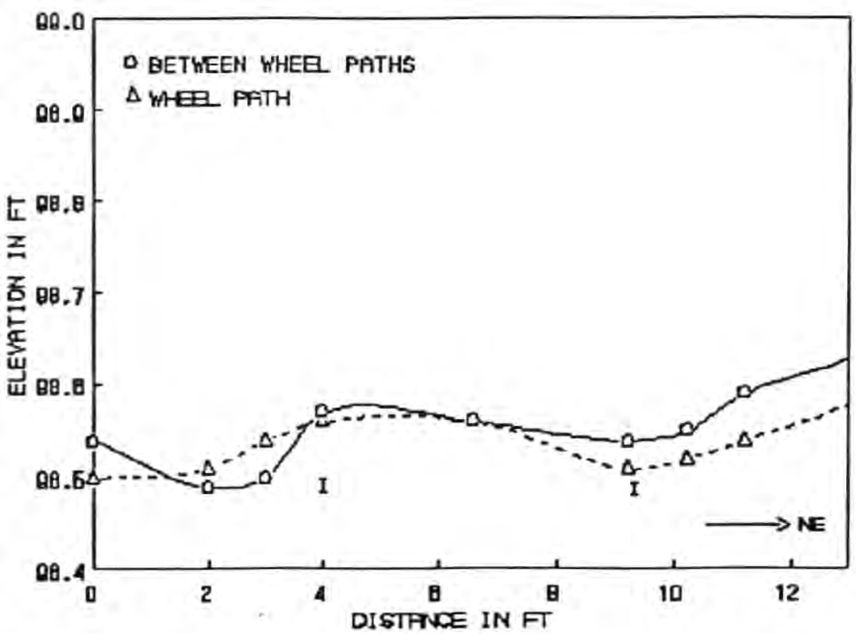



**Figure A58** Kemp Avenue East, Watertown (Asphalt)
Cross section taken at wheel path and between wheel paths.

Photo 58. Kemp Avenue - General Condition

Photo 59. Kemp Avenue - Failed Approach and Asphalt Along Mud Rail

Photo 60. Kemp Avenue - Pavement Failure at End of Tie

Photo 61. US 212 - Spalling off of Asphalt on Timbers

Photo 62. US 212 - Overall Condition With Failed Asphalt Over Header Timber

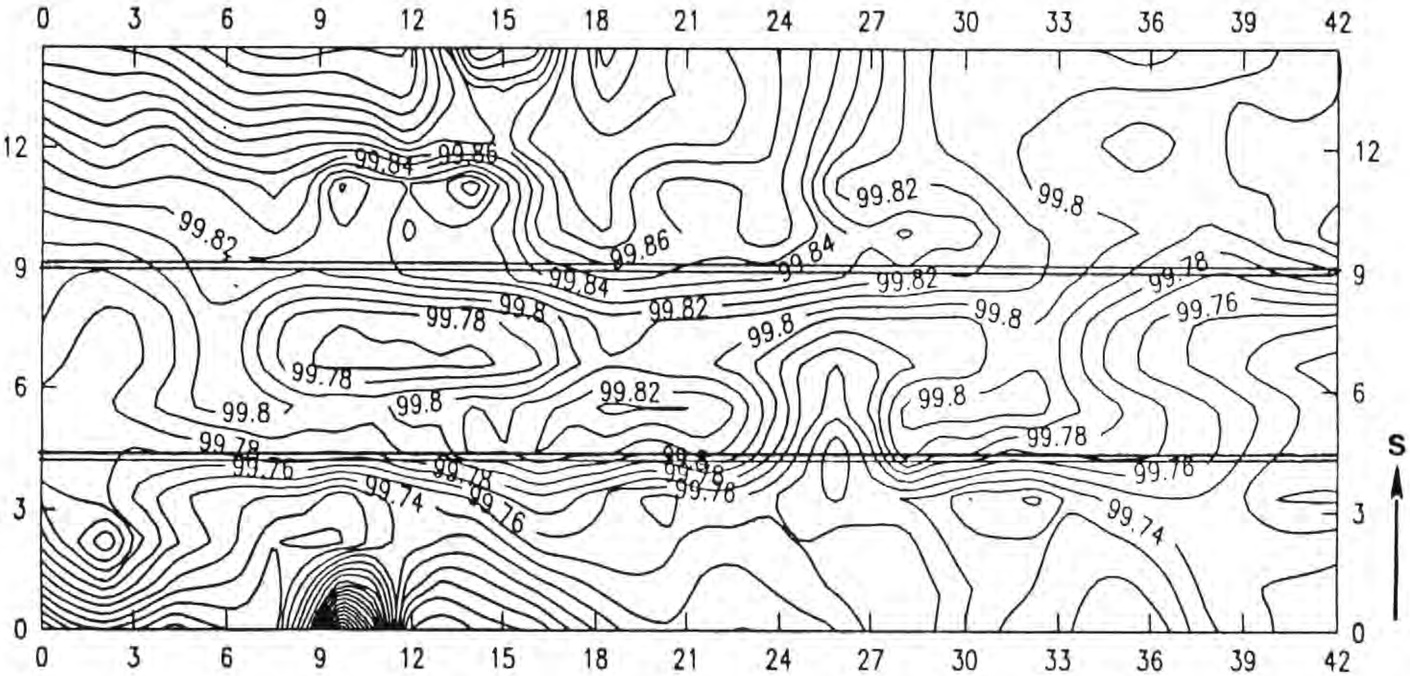



Figure A59 Half Mile East of Watertown, South of US212 (Timber)

All Distances in Feet

Photo 63. US 212 - Bolts Exposed by Timber Wear

is non plastic. The sand has low frost susceptibility, low compressibility and high strength.

The results of the crossing survey are shown in Figures A59 through A61. The contours of the crossing (See Figure A59) indicate that the crossing is rough, but, the overall settlement relative to the pavement is minimal. The contour map also indicates that the timbers in center portion of the crossing between the rails are worn down as much as one half inch relative to the timbers adjacent to the rails. The rails are also elevated approximately one inch above the timbers in the crossing. The crossing is smoother at the shoulder, indicating that the roughness observed at the wheel paths and between the wheel paths is primarily due to pavement wear and rutting (See Figure A60 and A61).

The photographs show that the crossing had once been paved but the asphalt is nearly worn down (See Photo 61). The eastern rail is uneven indicating either tie or spike failure. The timbers are worn down and the spikes are protruding up to 1/2 inch above the timbers (See Photos 61 and 63). The spaces between the timbers and the pavement and the spaces between the timbers and the rails are completely filled with sand. Both surface and subsurface drainage at this crossing is good and there is no evidence of pumping.

Photo 64. SD 20 and 10th Street West - Cracking Along Approach

Photo 65. SD 20 and 10th Street West - Cracked Approach and Asphalt Failure at Rail

Photo 66. SD 20 and 10th Street West - Cracking of Center Portion

Photo 67. SD 20 and 10th Street West - Overall View

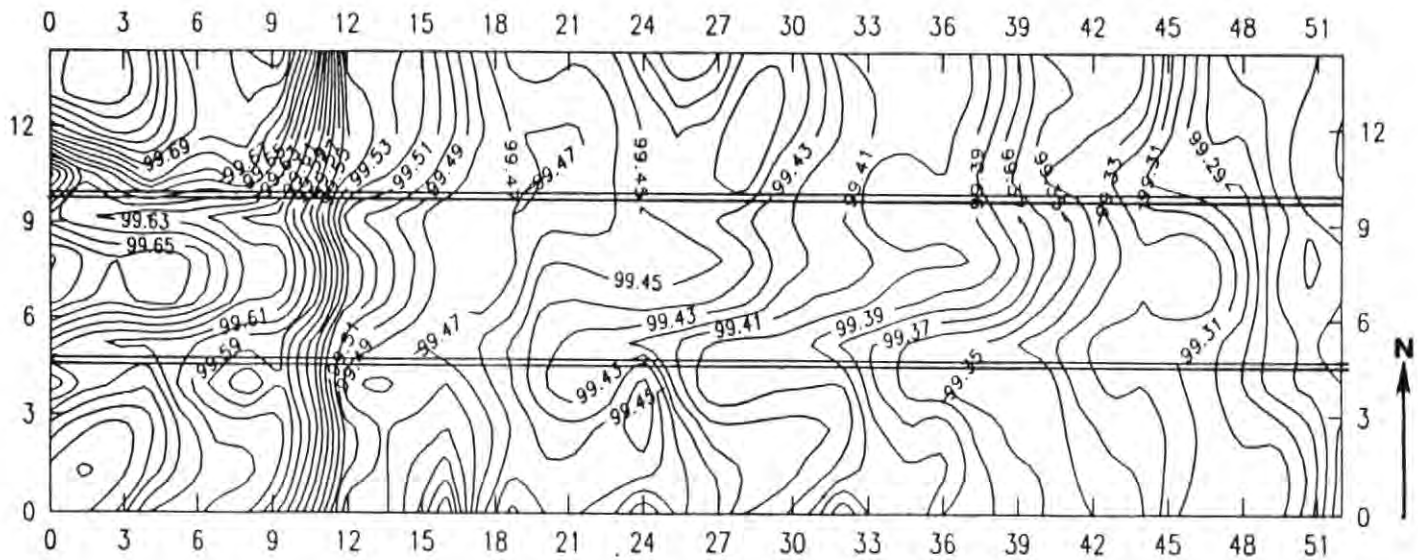



Figure A62 SD20 & 10th Street, Watertown (Asphalt)

All Distances in Feet

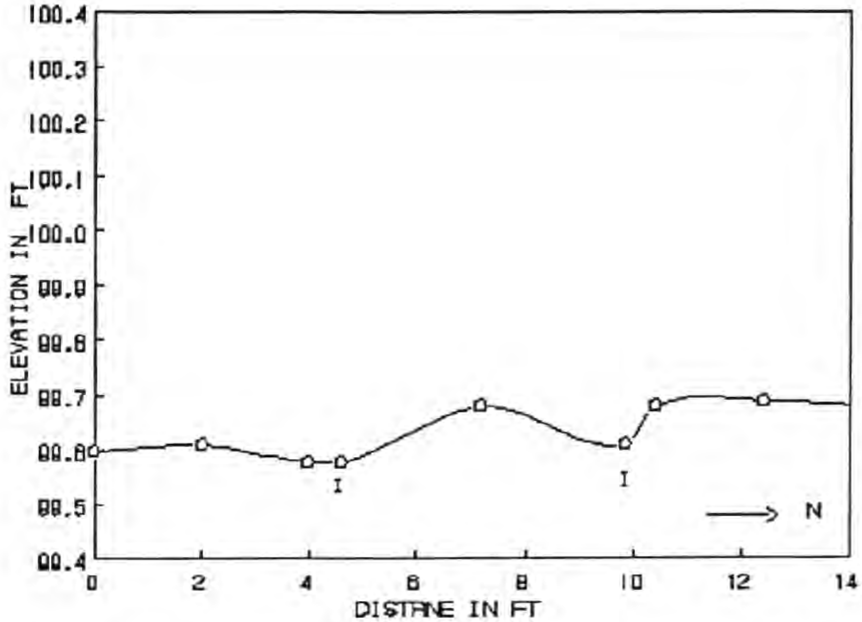



**Figure A63** SD20 & 10th Street, Watertown (Asphalt) Cross section at curb.

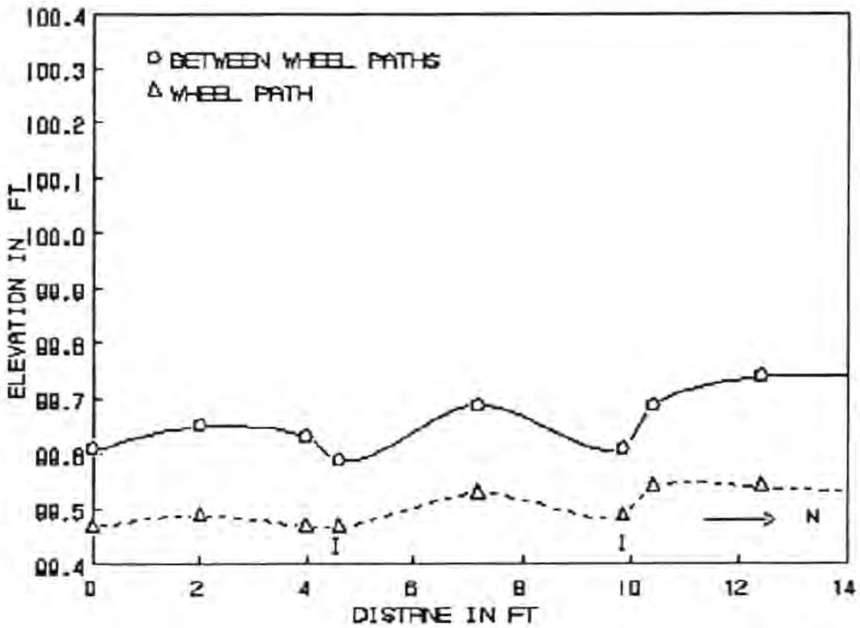



**Figure A64** SD20 & 10th Street, Watertown (Asphalt) Cross section taken at wheel path and between wheel paths.

**SD 20 & 10TH STREET WEST**

Four Lanes - One Track

The crossing at SD 20 & 10TH Street West is an asphalt type crossing. The crossing was built in 1987. The average daily traffic is 9,895 vehicles, with a high percentage of trucks. The rail traffic consist of two trains per week with only switching traffic. The rail in this crossing is 90 pound weight with bolted joints at each end of the crossing. Overall conditions of the crossing are shown in Photos 64 through 67.

The subsurface soils at the crossing consist of an upper 2 feet of black silty soil with a natural water content of 30.7 percent. Underlying the silty soil is silty well-graded sand. Classification tests were not run on this soil, however, based on the soil description, it is likely that the soil has a high organic content. The soil, is also likely to exhibit high frost susceptibility. It is also likely that the silty soil has been over-excavated beneath the crossing and the ballast is resting on the silty sand. The sand classifies as well-graded silty sand (SW-SM) in the Unified and A1-b in the AASHTO classification systems. The sand, based on its classification, should have low frost susceptibility, low compressibility, and high strength. However, if the upper black silt was not fully over-excavated under the crossing and street approach to the crossing, frost heave of the approach is likely to occur in the winter and pumping would be likely under the track.

The results of the survey are shown in Figures A62 through A64. Based on the topographic map and the cross-sections, the rails have settled approximately one inch relative to the pavement. It should be noted that there is a four inch elevation difference between the east and west ends of the crossing. The cross section in Figure A64 should therefore be analyzed from the overall shape and not on an elevation basis. The cross-section shows that rutting has occurred in the wheel paths, and the crossing is actually smoother at the wheel paths than the area between the wheel paths.

The photo of the crossing indicates that chipping of the pavement has occurred along the rails. Cracks can be seen at the approach pavement on the south side, extending from the east (See Photos 64 and 65). Significant debris has collected in between the mud rail and the main rail.

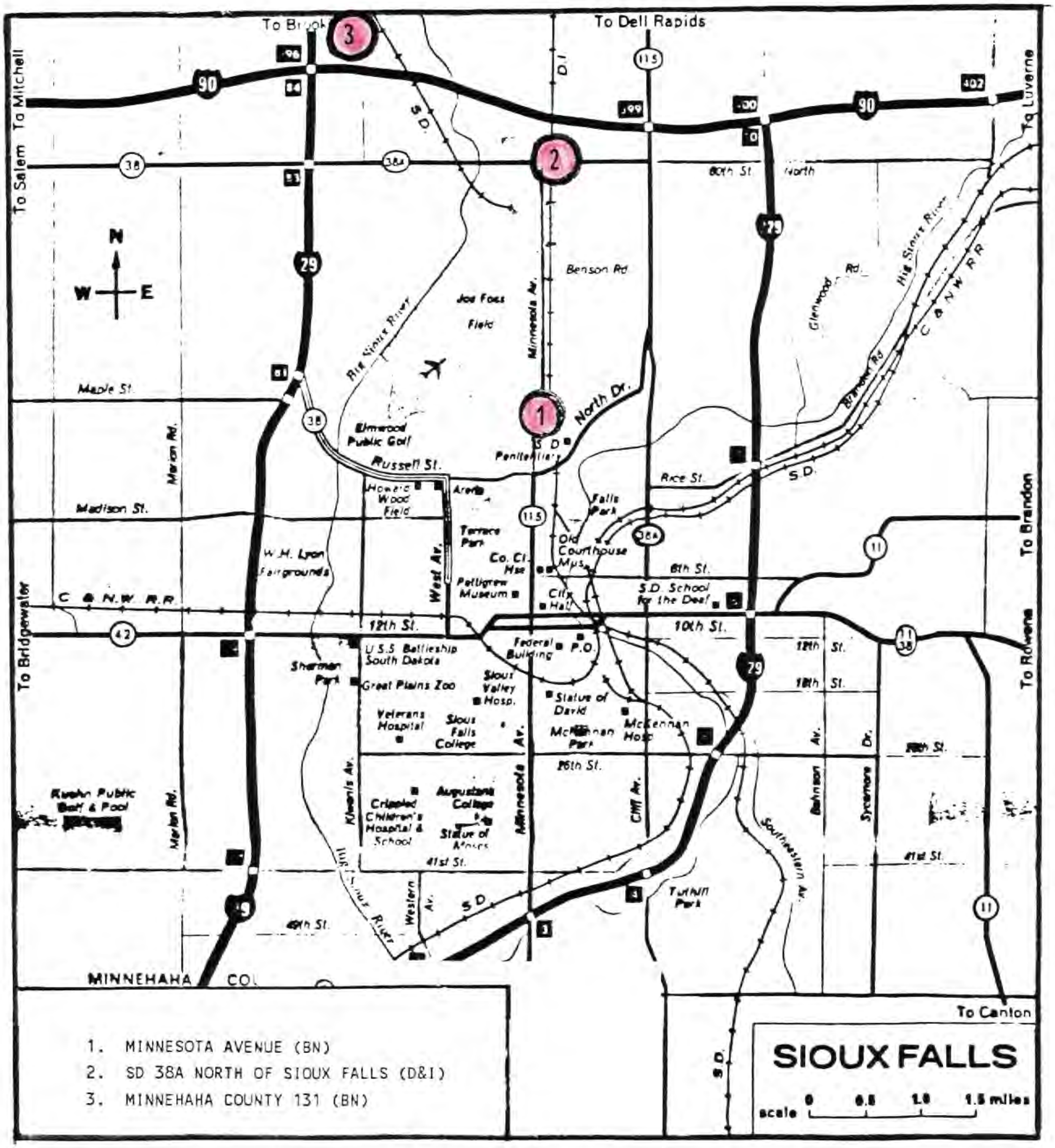
Both surface and subsurface drainage at this crossing is good, however, evidence of pumping can be seen at both ends of the crossing. The deflection under rail traffic was 3/4 of an inch.

**A-3.5 Sioux Falls**

**Industrial Spur - Minnesota Avenue**

Four Lanes - One Track

At Minnesota Avenue south of the airport a SAF&DRI type of rubber crossing was installed in 1983. This crossing has Portland Cement Concrete pavement approaches and rubber headers. There is a six inch wide gap between the header and the concrete pavement




LOCATION MAP 5

Photo 68. Minnesota Avenue - Failing Asphalt Header

Photo 69. Minnesota Avenue - Collection of Debris Along the Rail

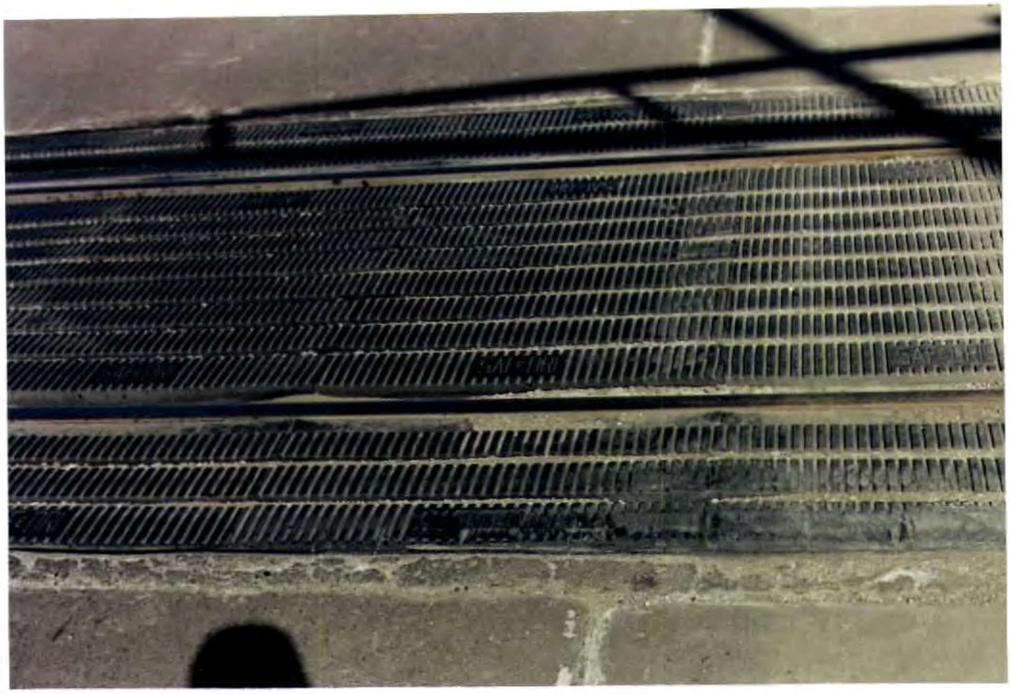


Photo 70. Minnesota Avenue - Worn and Damaged Panels

Photo 71. Minnesota Avenue - Overall View of Crossing (Note Mud-Filled Panels)

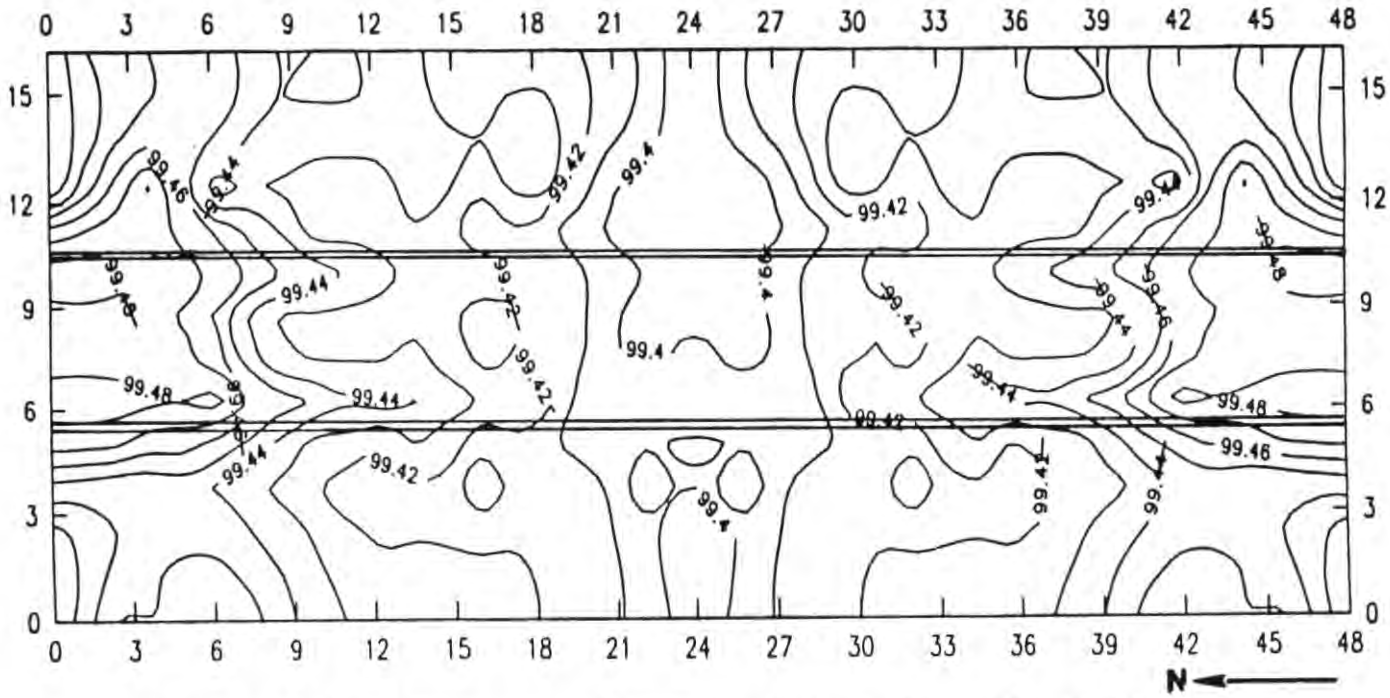



Figure A65 Minnesota Avenue, Sioux Falls (Rubber)

All Distances in Feet

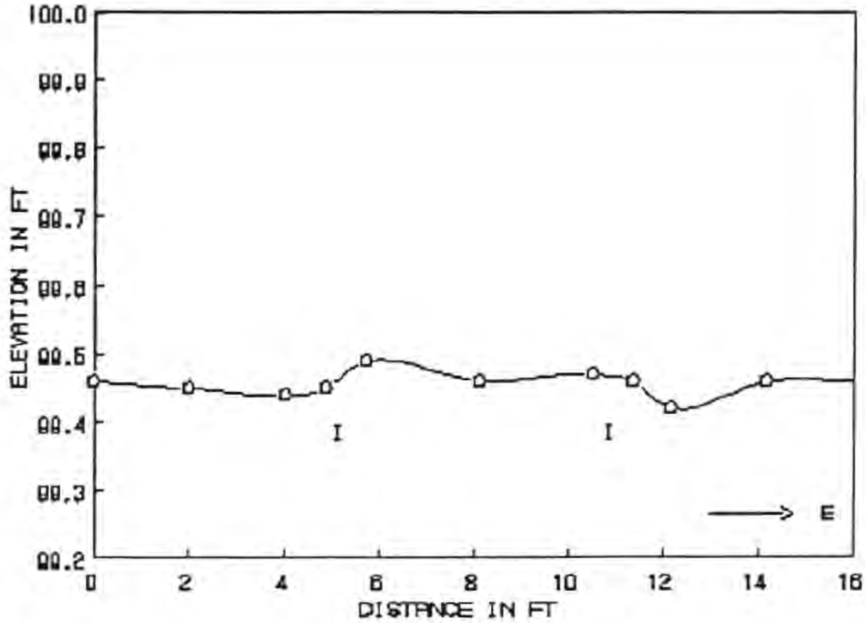



**Figure A66** Minnesota Avenue, Sioux Falls (Rubber) Cross section at curb.

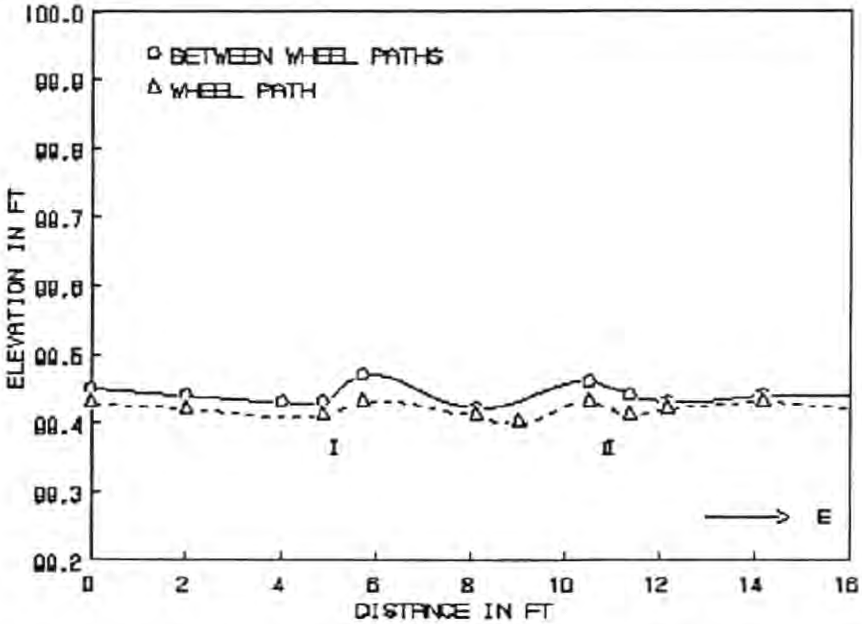



**Figure A67** Minnesota Avenue, Sioux Falls (Rubber) Cross section taken at wheel path and between wheel paths.

approach which is filled with asphalt. Minnesota Avenue is a four lane artery serving the local businesses and the airport. The average daily traffic is 5,000 vehicles with considerable truck traffic. The rail traffic consists of one train per day with one locomotive and approximately 15 cars. There is no switching traffic at this crossing. The rail in the crossing is 115 pound weight and continuously welded, with no bolted joints within 20 feet of the crossing.

The boring drilled at the crossing shows that the subsurface soil consists of one feet of medium brown sandy clay over three feet of black clay. Under the black clay is grayish brown sandy clay. The gradation analysis on the soil shows that 77 percent is passing #200 sieve and the Liquid Limit and Plasticity Indexes are 60 and 23 percent, respectively. The soil classifies as A-7-6(20) in the AASHTO and CH in the Unified classification systems. The natural moisture content is 31.7 percent. Based on the laboratory tests, the soil is highly frost susceptible and, if subject to saturation, would be likely to pump under repetitive loading. Bearing capacity under saturated conditions would also be low. As the soil is organic in nature, it is assumed that it is highly compressible.

The results of the survey at Minnesota Avenue are presented in Figures A65 through A67. The contour map in Figure A65 shows very little differential settlement between the track and the approaches. However, the cross sections (Figures A66 and A67) show that the outer panels are at the same elevation as the approach pavement, however, the rails and the panels between the tracks are elevated approximately 1/2 to 3/4 inches above the approaches. The panels between the tracks appear to have settled towards the center of the crossing, as can be seen both on the contour map and in Figures A66 and A67. There is little difference between the cross-sections taken at the shoulder as compared with the cross-sections taken at the wheel path and in between the wheel paths. No evidence of rutting was observed.

The conditions of the crossing are shown in Photos 68 through 71. Overall, the crossing is in fair condition, but the coarse, textured SAF&DRI pattern contributes to crossing roughness. The asphalt filler between the rubber headers and the concrete pavement approaches are deteriorating, as can be seen in Photo 69. The course textured crossing is also susceptible to accumulation of sand and debris, which is evident in Photo 69. In Photos 70 and 71 the panels show considerable wear. Snow plow damage is evident as well, but overall damage is minor and does not contribute to crossing roughness.

Surface drainage at the crossing is poor, as the terrain at both ends of the crossing is at approximately the same elevation as the crossing. Nevertheless, no evidence of pumping under the track could be seen at either end of the crossing.

Photo 72. SD 38A - Approach Pavement Rutting

Photo 73. SD 38A - Panel Damage by Snow Plows

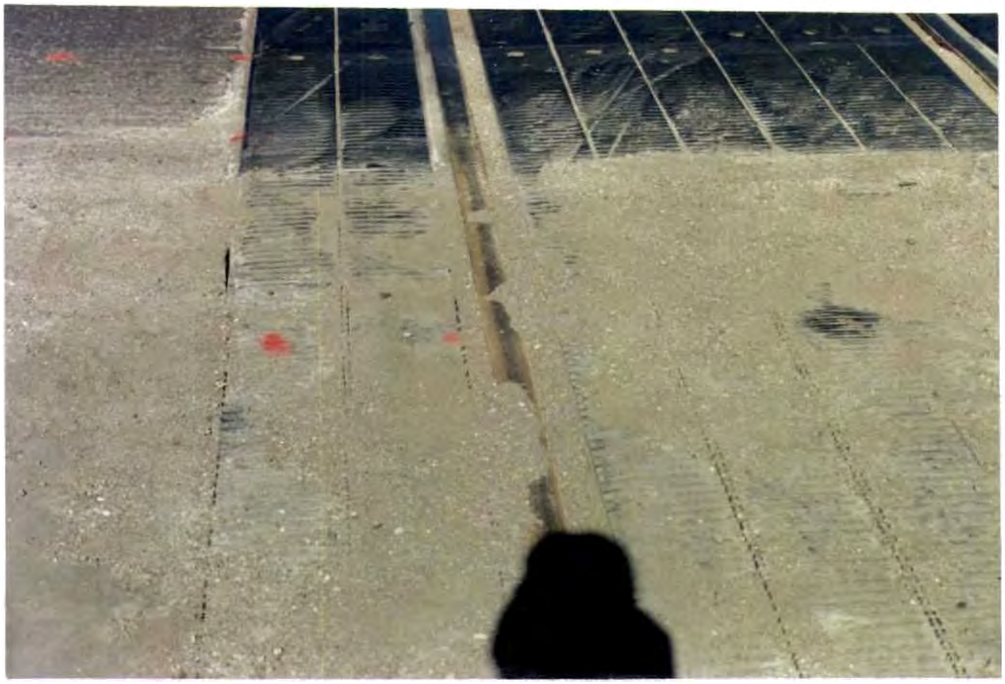


Photo 74. SD 38A - Debris Collected on the Track

Photo 75. SD 38A - Overall View

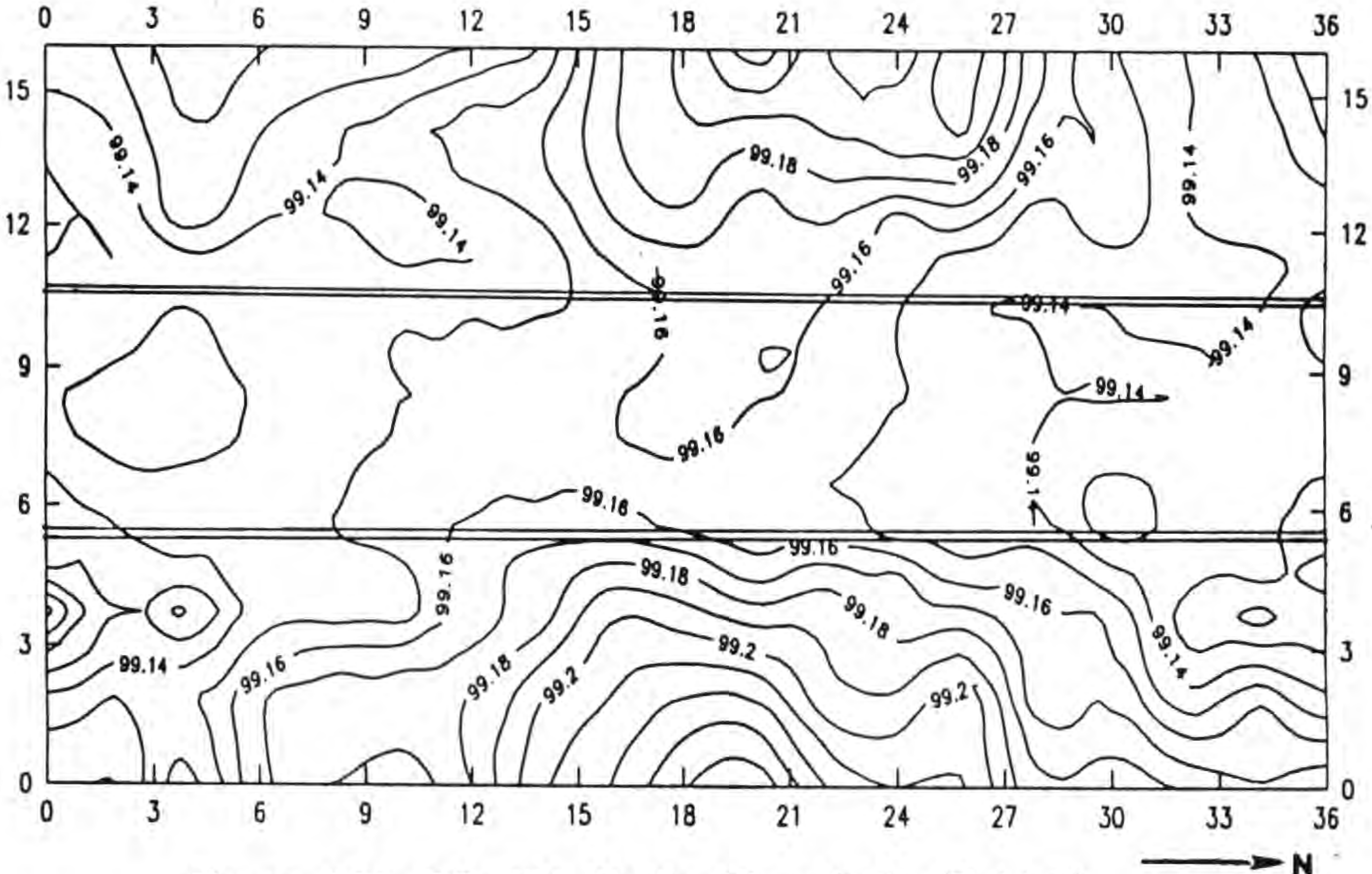



Figure A68 SD 38A North, Sioux Falls (Rubber)

All Distances in Feet

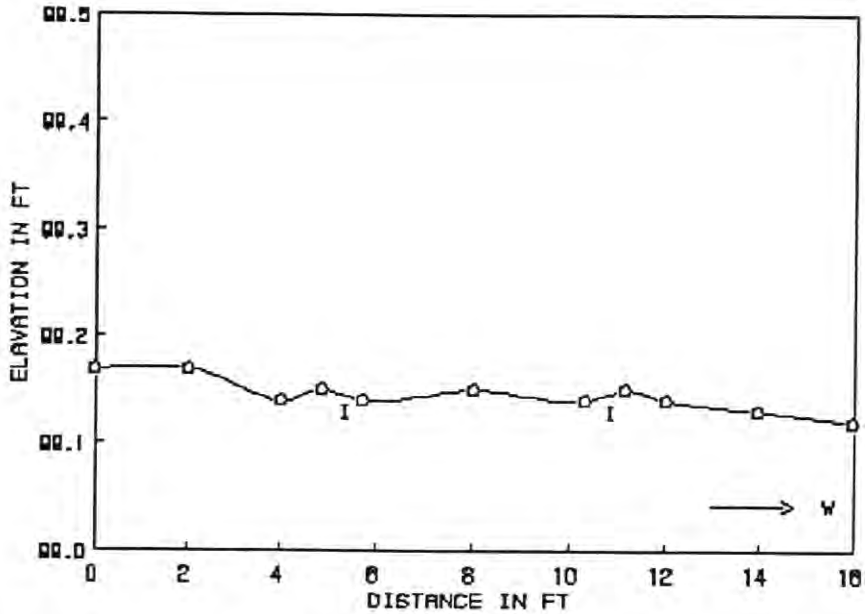



**Figure A69** SD 38A North, Sioux Falls (Rubber)
Cross section at curb.

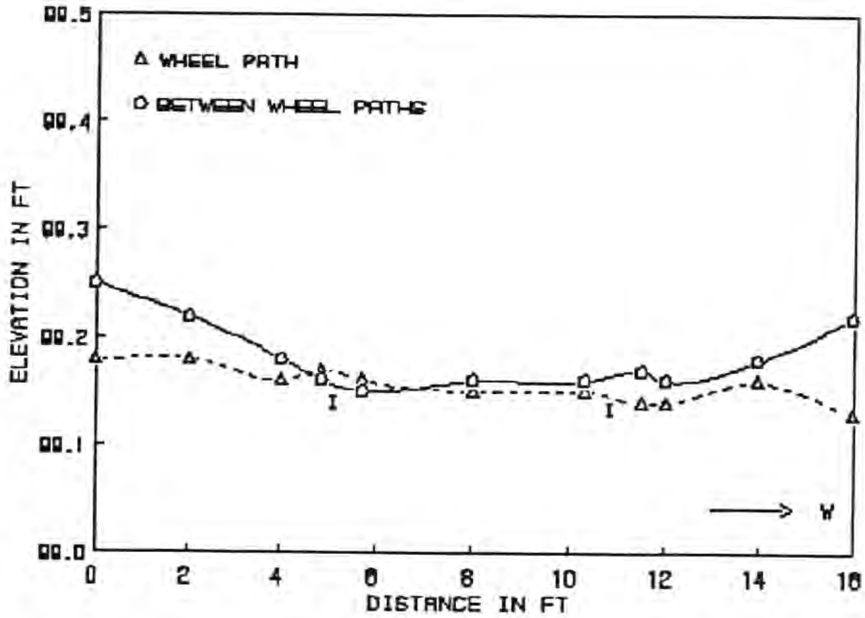



**Figure A70** SD 38A North, Sioux Falls (Rubber)
Cross section taken at wheel path and between wheel paths.

**SD 38A North of Airport**

Two Lanes - One Track

The SAF&DRI crossing at SD 38A North of Airport was installed in 1975. The pavement is a Portland Cement Concrete and was poured up to the rubber headers. Highway 38A is a two-lane artery serving the northwest commercial area and the airport. The average daily traffic is 6,376 vehicles with a high percentage of trucks. The rail traffic consists of one to two trains per day with 50 cars. There is no switching traffic at this crossing. The rail in the crossing is continuously welded 115 pound weight, with no bolted joints within 20 feet of the crossing.

The subsurface soil at the crossing consists of an upper one to two foot thick layer of dark brown silty clay over black clay. The black clay classifies as a A-7-6(20) in the AASHTO classification and CH in the Unified classification systems. The gradation analysis on the clay shows 98 percent is finer than #200 sieve and the Liquid Limit and Plasticity Indexes are 63 and 36 percent, respectively. The natural moisture content was 21.6 percent. Based on the laboratory tests, the soil is moderately frost susceptible.

The results of the survey at the crossing are presented in Figures A68 through A70. As may be seen from Figure A70, the overall settlement of the crossing is approximately 1/2 inch below the pavement approaches. The contour map (Figure A68) show that the differential elevations within the crossing are less than one quarter inch. Also, at the shoulders, very little overall settlement is evident (See Figure A69), while the elevations of the approaches at and in between the wheel paths indicate wear and rutting. Evidence of rutting can also be seen in Photo 72. There is significant snow plow damage at this crossing, as can be seen in Photo 73. It is unlikely that the snow plow damage contributes to crossing roughness, but panel wear may be accelerated by the damage. Debris from sanding of the highway is collected in between the panels and the rails and in the grooves of the panels. This can slow surface drainage on the crossing (Photos 74 and 75). The debris does not appear to be periodically removed from the crossing, as the debris was also present during a reinspection of the crossing in July of 1991.

The surface drainage near the crossing is good, as the track outside the crossing is constructed on an embankment. No evidence of pumping could be seen at either the south or north end of the crossing.

**Minnehaha County 131 North of Sioux Falls**

Two Lanes - One Track

The crossing on County 131 was installed in 1989 and is comprised of timber panels. There are no headers, as the asphalt pavement is butting against the panels. The average daily traffic is 198 vehicles per day. The rail traffic consists of four trains per week with 50 to 60 cars. The track is continuously welded, consisting of 115 pound weight rail with no bolted joints within 20 feet of the crossing.

Photo 76. Minnehaha County 131 - Rutted Pavement and Plow Damage

Photo 77. Minnehaha County 131 - Mud Along Rails and Scarring From Snow Plows

Photo 78. Minnehaha County 131 - Timber Panel Misalignment (RHS of the Photo)

Photo 79. Minnehaha County - Overall View of Crossing

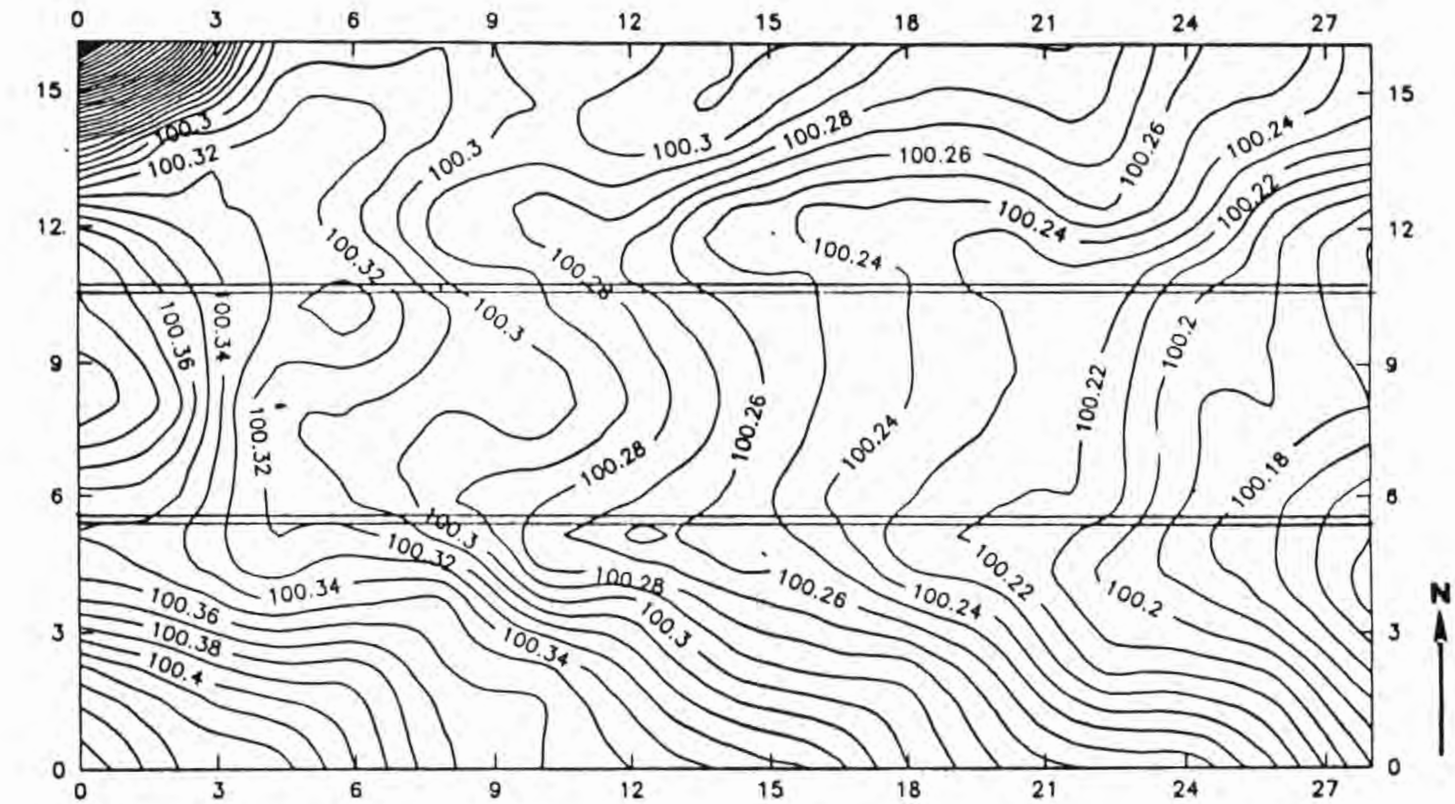



Figure A71 Minnehaha County 131 North of Sioux Falls (Timber)

All Distances in Feet

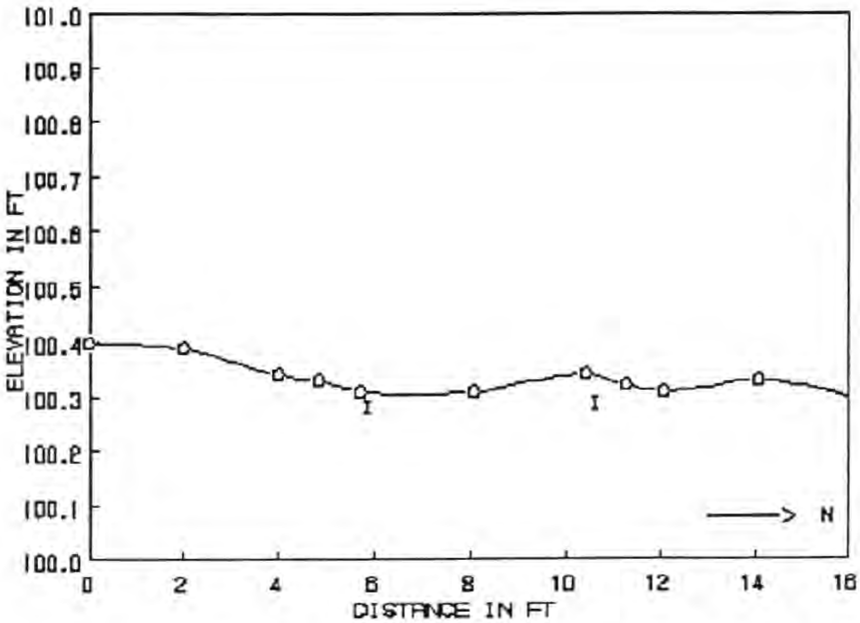



**Figure A72** Minnehaha County 131 North of Sioux Falls (Timber)
Cross section at curb.

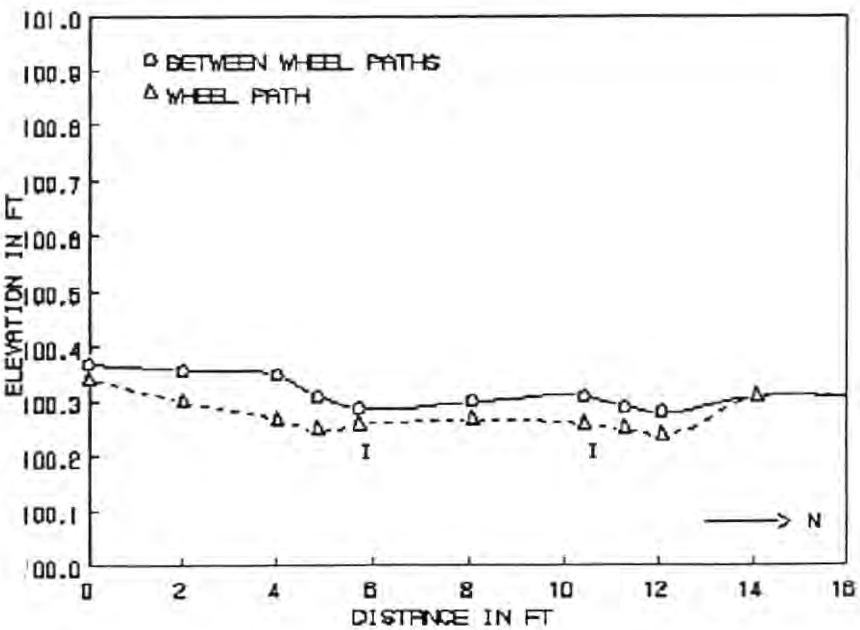



**Figure A73** Minnehaha County 131 North of Sioux Falls (Timber)
Cross section taken at wheel path and between wheel paths.

The boring drilled at the crossing shows that the subsurface soils consist of an upper 4 feet of dark brown silty clay over dark brown clayey sand. The gradation analysis on the clay shows that 69 percent of the soil is passing the #200 sieve and the Liquid Limit and Plasticity Indexes are 58 and 36 percent, respectively. The soil classifies as A-7-6(18) in AASHTO and CH in the Unified classification systems. The natural moisture content was 32.7 percent. Based on the laboratory tests, the soil has moderate frost susceptibility and moderate compressibility.

The results of the survey are shown in Figures A71 through A73. The contour map indicates that the track has settled relative to the approaches, however, the crossing is at the low point in a vertical curve, hence the contour tend to overemphasize the actual overall settlement. As can be seen fron the cross sections in Figures A72 and A73, the settlement of the track is less than 3/4 inches relative to the approach pavement. The cross-section at the shoulder differs only slightly from the cross-sections in the driving lanes (Figures A72 and A73). Some rutting of the pavement approaches can be seen when comparing the cross-sections at the wheel paths to those between the wheel paths. Evidence of rutting can also be seen in Photo 76.

The panels are showing some signs of deterioration (See Photo 78), as the lamination has failed in some of the panels. Slight misalignment of some of the panels can also be seen. There is evidence of track deflection under rail traffic, as the asphalt shoulder sections are cracking (See Photo 79). The spaces between the panels and the rails are mud-filled and may have contributed to shifting of the panels. There is some scarring from snow plows (See Photos 76 and 77), however, overall snow plow damage is insignificant at this time.

The surface drainage at the crossing is good, as there are ditches on both sides of the track at the ends of the crossing. No evidence of pumping could be seen at any location on the crossing.

**A-3.6 Cottonwood on US 14**

Four Lane - One Track

The crossing at US 14 east of Cottonwood is an asphalt type with inner and outer ball-up mud rails. The construction date of the crossing is not known. US 14 is a two-lane rural highway, serving traffic between Wall and Pierre. Average daily traffic is 564 vehicles, with a high percentage of trucks. The rail traffic consists of two trains per day, comprised of two to four locomotives and 40 to 50 freight cars. There is no switching traffic at this crossing. The rail in this crossing is 115 pound weight and continuously welded, however, there are bolted joints at each end. The mud rail is also jointed at several locations within the crossing.

The crossing was surveyed in July of 1991 and the results are shown in Figures A74 through A76. The cross-sections taken in the driving lanes and at the shoulder of the highway are quite

Photo 80. Cottonwood - Shoulder and Road Settlement

Photo 81. Cottonwood - Failure of Asphalt Near Mud Rail

Photo 82. Cottonwood - Rail and Mud Rail Settlement

Photo 83. Cottonwood - Close-up View of Pavement Cracks

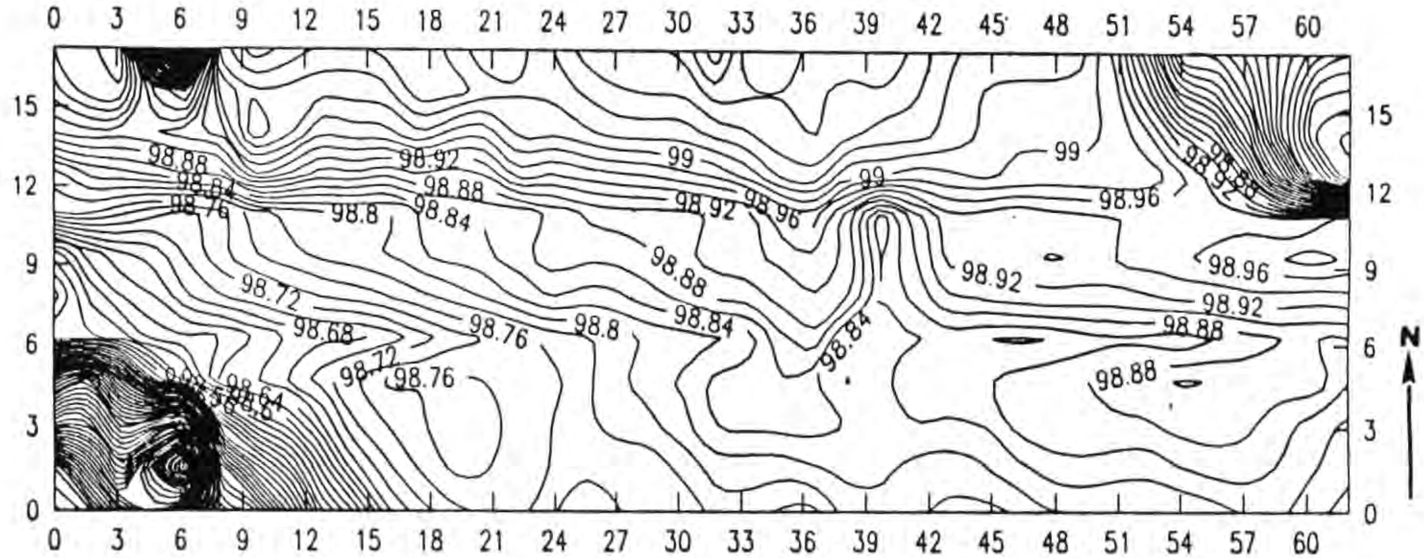



Figure A74 Cottonwood (Asphalt)

All Distances in Feet

similar, indicating that the crossing has settled approximately one inch relative to the approaches (See Figures A75 and A76). There is considerable rutting in the wheel paths, as can be seen when comparing the cross-sections in Figure A76. At some locations the ruts are nearly two inches deep. The rutting and pavement wear can also be seen in Photos 80 and 81.

No borings were drilled at this crossing. Visual inspection of the crossing indicates that the asphalt is crumbling at the inner mud rail on the north side of the crossing (See Photo 83). The mud rails have also been pushed toward the main rail, as depicted at the east shoulder in Photo 82. Settlement of the rails in relation to the asphalt pavement can be seen in this photo as well.

Surface drainage at the crossing is good, as the track is on an embankment at both the east and west ends of the crossing. Only minor signs of pumping were visible at the ends of the crossing. Rail deflections taken in September of 1991 were less than 3/8 of an inch.

## A-4 CONDITION SURVEYS

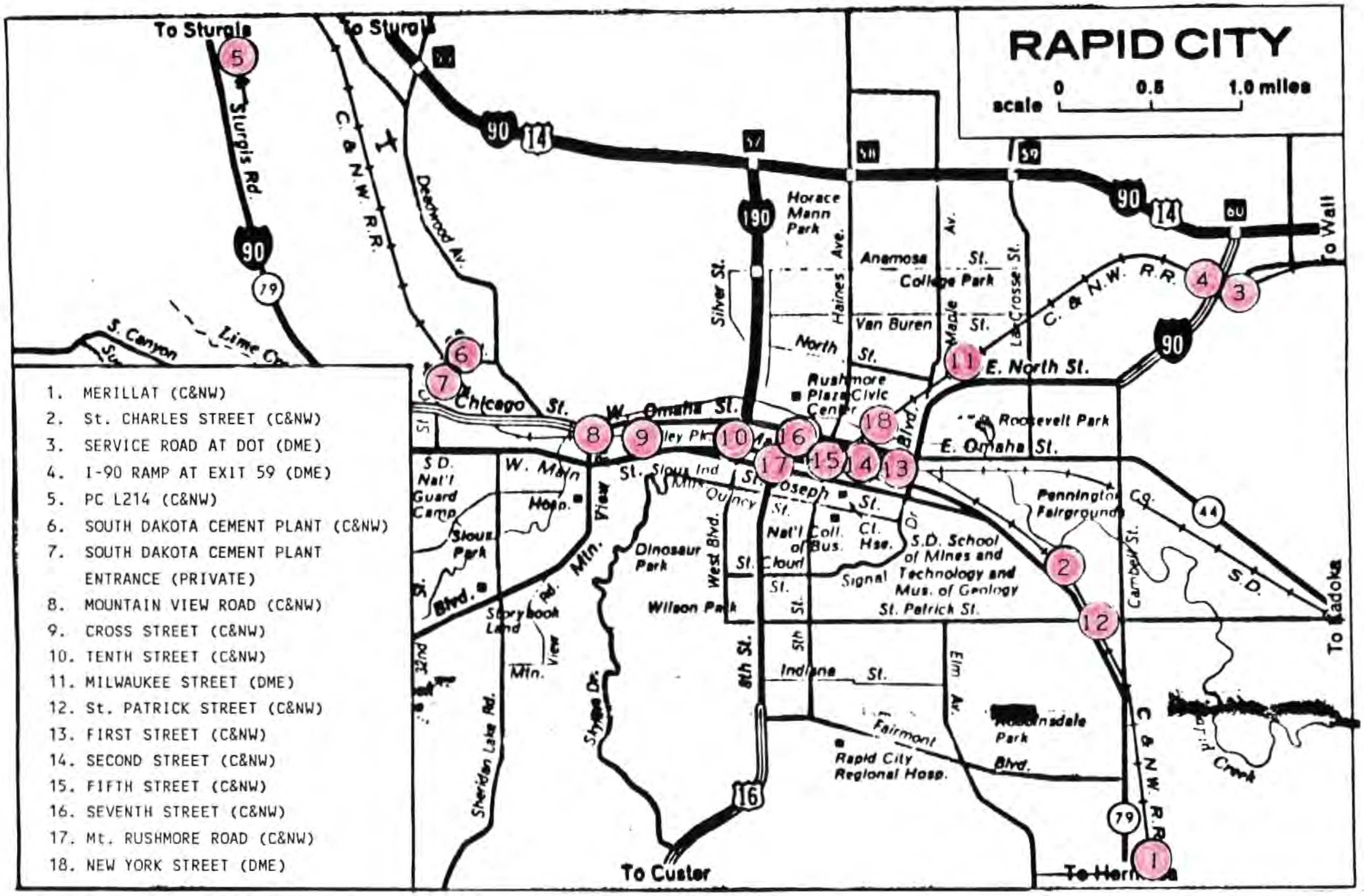
Following the survey of the originally designated 25 crossings, it was felt that the database for types of distress and failure modes connected with the different types of crossings inspected, especially with the many different types of rubber crossings, was inadequate. In order to obtain more information regarding failure and distress modes, an additional 29 crossings were inspected. The railroad crossings described in the following sections were not surveyed, however, a complete conditions survey including deflection and settlement measurements was obtained at selected locations. In addition, photographic records of the conditions at and near the crossings were obtained. In total, 29 crossings in Aberdeen, Rapid City, Watertown, Sioux Falls, Blunt, Redfield, Summit, and Northville were inspected. Each crossing is designated by street name. The crossings inspected are described under the main heading in accordance with the city where located.

### A-4.1 Rapid City

**Merillat**

Two Lanes - Two Tracks (main track and side spur)

The crossing at Merillat is asphalt with ball-up mud rails. The main spur has both inner and outer mud rails, while the side spur has only an inner mud rail. Based on information obtained, this crossing was built in 1983. The crossing is at the entrance to a wood products manufacturing plant and is subject to heavy truck traffic with the same truck traffic crossing the side spur as




LOCATION MAP 6

Photo 84. Merillat - Main Track Settlement

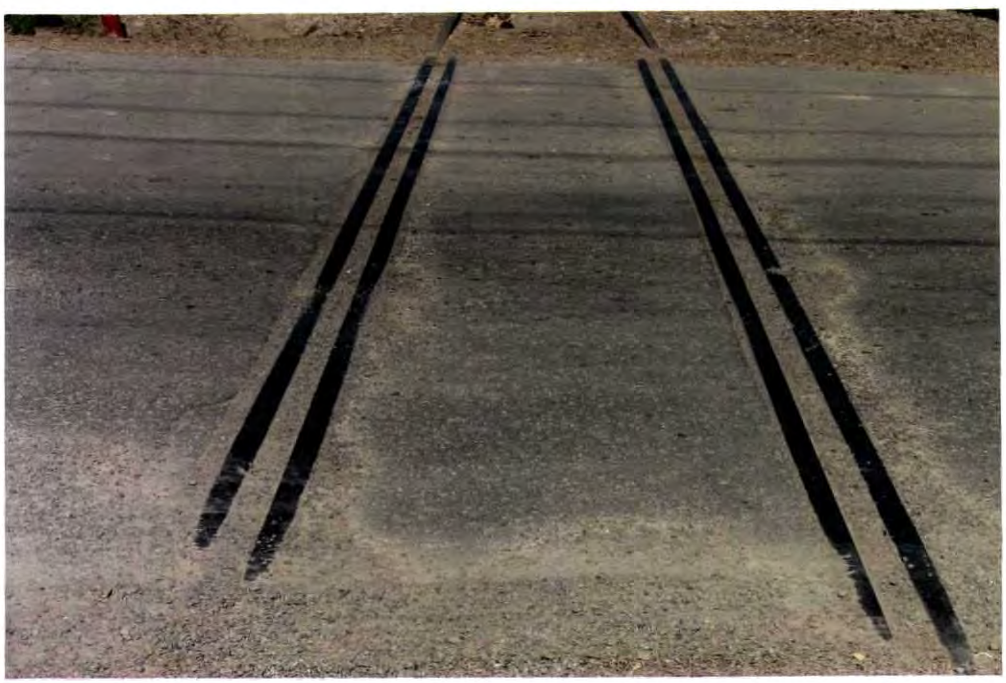


Photo 85. Merillat - Side Spur

Photo 86. Merillat - Main Track Pavement Approaches

Photo 87. St. Charles Street - Pumping between Rails

well as the main track. Average daily traffic is not known but most of the traffic consists of heavy trucks. Average daily train traffic on the main track is two trains, usually comprised of two locomotives and 40 to 50 freight cars. Traffic on the side track is less than one train per week. At this crossing, the difference between a crossing with a high volume and low volume rail traffic is evident. The main track has settled up to 1.5 inches in relation to the mud rails (See Photo 84), while little or no differential settlement is evident on the side spur (See Photo 85). The inner mud rail also appears to have been pushed away from the main rail. The tracks are mud-filled and it is likely that the mud rails on the main track have been raised by mud being forced under them. The main track also appears to have settled 1.5 to 2 inches in relation to the pavement, and the pavement approaches to the crossing have failed (Photos 85 and 86). There is 115 pound rail throughout the crossing with no bolted joints close to the crossing.

Natural drainage is poor with little terrain relief. Nevertheless, there is little or no evidence of pumping at the rail approaches to the crossing.

**St. Charles Street**

Two Lanes - One Track

The St. Charles Street crossing is an asphalt type with inner and outer ball-up mud rails. The crossing was built in 1979. St. Charles Street is a medium volume road with average daily traffic of 3,240 vehicles serving residential areas and small businesses.

Photo 88. St. Charles Street - Pumping on East Side of Crossing

Photo 89. St. Charles Street - Apron and Center Settlement

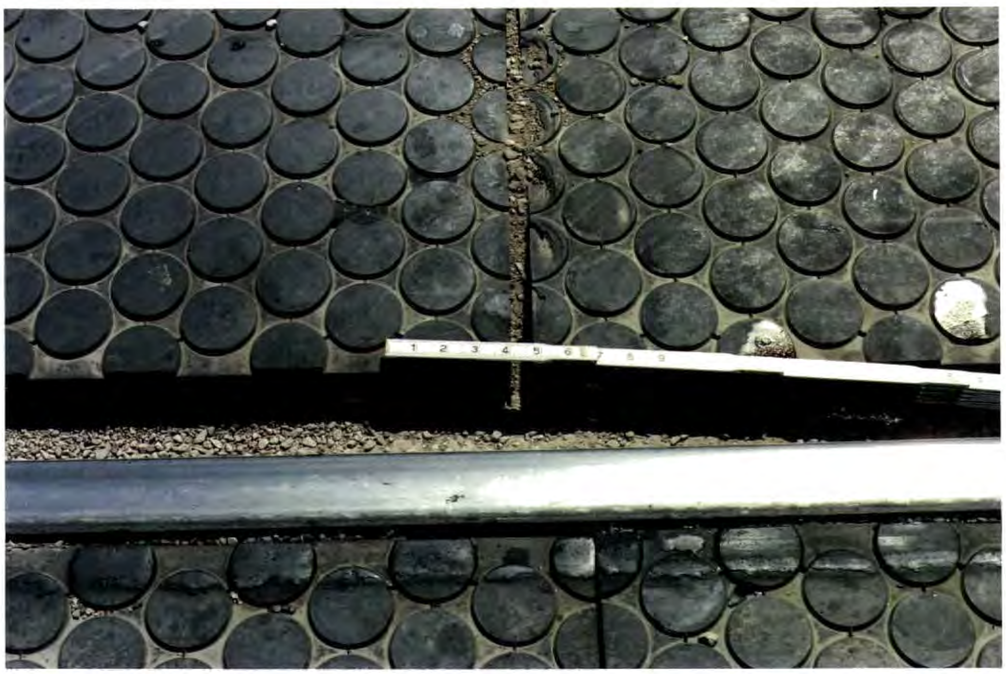


Photo 90. Service Road at DOT - Panel Wear and Panel Separation

Drainage at this location should be good since the railroad embankment is from 4 to 6 feet above the terrain to the north, and approximately two to three feet above St. Joseph Street to the south. Nevertheless, evidence of water pooling can be seen between the rails at the end of the crossing, especially on the east side. Evidence of water pooling can be seen on Photo 88.

This crossing is among the roughest surveyed in the Rapid City area. Based on the information obtained from the condition survey, it is believed that the ties under the crossing are deteriorated. The ballast may also have become infiltrated with fines, as is evidenced by water pooling between the rails and observation of the ballast at the approaches to the crossing.

**Service Road at DOT**

Two Lanes - One Track

The crossing at the Service Road at DOT is an Omni full depth rubber type. The road pavement consists of Portland Cement concrete and the headers consist of 6 to 8 inches of bituminous asphalt. The crossing was built in 1987. The service road at DOT is a medium volume road with average daily traffic of 3,310 vehicles serving essentially small businesses. Heavy truck traffic is high and rail traffic is comprised of two trains per day, each consisting of two to four locomotives and 40 to 50 cars. The rail in the crossing is 115 pound weight and continuously welded rail, with no joints within a distance of 20 feet of the crossing.

Photo 91. Service Road at DOT - Crossing Settlement

Photo 92. Service Road at DOT - Panel Buckling and Panel Separation

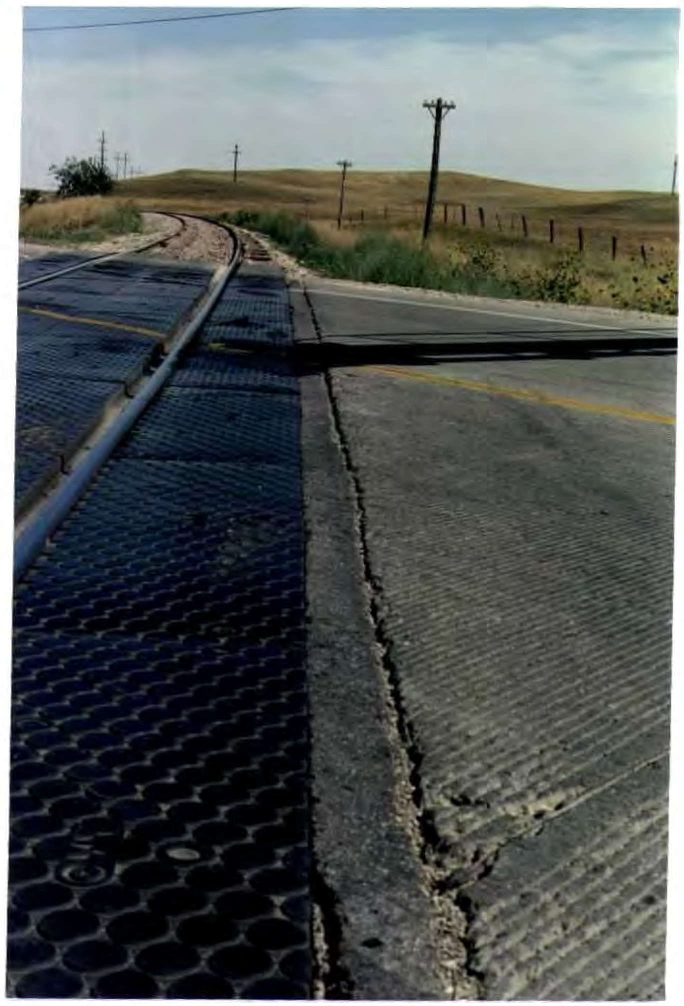


Photo 93. Service Road at DOT - Header Failure

There is some evidence of track settlement and movements, especially at the south rail as the rubber panels are worn down by the railroad traffic (See Photo 90). In addition, minor wear of the rubber panels can be seen along the entire crossing. The entire track section in the crossing has also settled in relation to the pavement, as can be seen by the difference in elevation between the concrete pavement and the headers (See Photo 91 and 92). The differential settlement between the pavement was measured to be between 1/4 to 1.5 inches. The headers are in poor condition (See Photo 93) and should be considered failed in some places. Snow plow damage is locally severe in some places (See Photos 91 and 93), with some panels gouged to depths of more than one inch. The panels have shifted both vertically and horizontally. Vertical misalignment is up to as much as 1/4 to 3/8 inch, while gaps up to 3/4 inch can be seen between panels (See Photo 90). Some of the misalignment may be related to installation and uneven panel thickness. The gaps between the rubber panels and the rails are being filled with sand and gravel (See Photo 90). It should also be noted that the rubber panels appear to be buckling (See Photos 92 and 93). The panels do not appear to be restrained laterally at the ends of the crossing.

The drainage at this location appears to be good, with the crossing elevation well above the surrounding terrain. There is no evidence of pumping or of water pooling at either end of the crossing.

**I-90 Ramp at Exit 59**

Four Lanes - One Track

This crossing consists of SAF&DRI panels in the eastbound lanes and Redhawk in the westbound lanes. The road pavement consists of Portland Cement concrete with 10 to 12 inch wide header strips of asphalt in the eastbound lanes, and 1 to 2 inches of asphalt against rubber molding in the westbound lanes. The crossing was built in 1987. It is likely that the panels across the westbound lanes may have been replaced, as the SAF&DRI panels on the east shoulders of the westbound lanes are severely damaged by snowplows, while the adjacent Redhawk panels show little damage (See Photo 94). The road is subjected to heavy traffic with average daily traffic on the order of 10,000 vehicles per day. Heavy truck traffic is high, and the speed limit is 55 miles per hour. Rail traffic is comprised of two trains per day, each consisting of two to four locomotives and 40 to 50 cars. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet from the crossing.

The rubber panels are not full depth but are resting on wood shims attached to the ties. The outer panels are up to one half inch lower than the top of the rails, yet wear from the railroad traffic is still visible. It is therefore likely that up to one half inch of vertical deformation has taken place under railroad traffic. No panel movement is visible under highway traffic. The asphalt headers have failed and have contributed to the considerable roughness in the eastbound lane (See Photos 95 and

Photo 94. I-90 Loop at Exit 59 - Snow Plow Damage

Photo 95. I-90 Loop at Exit 59 - Wear and Rubber Separation on Saf & Dri Panels

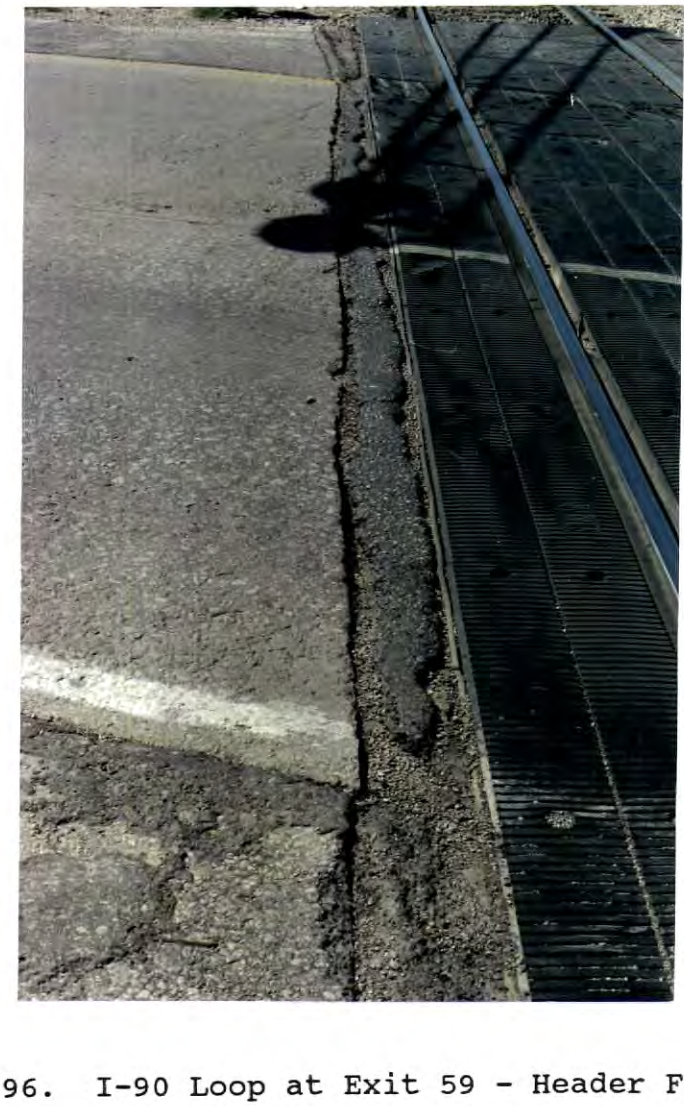


Photo 96. I-90 Loop at Exit 59 - Header Failure

96). The headers are also in poor shape in the westbound lanes and the rubber molding is separating from the rubber panels. However, since the headers here are narrower than in the eastbound lanes, roughness is not so severe. Rubber is peeling off of the SAF&DRI panels, not only in areas which have been damaged from snow plows, but also in areas affected by general wear and railroad traffic (See Photo 95). The space between the rail and the center panels is also completely filled with debris and may have contributed to the panel distress. Snow plow damage is severe along the entire crossing but it appears that the SAF&DRI portion of the crossing has been most severely damaged (See Photo 94). The west portion of the crossing appears to have settled the most. As much as 1.5 inches of differential settlement was measured at the north approach in the westbound lanes. The rubber panels in the westbound lanes also showed as much as 1/4 inch vertical separation. Spacing between the panels horizontally was as much as 3/8 inch, with debris-filled panel openings.

Drainage at the east end of the crossing should be excellent, as the end of the crossing is on a 10 foot high embankment. The west end of the crossing is from one to two feet above the terrain, however, evidence of water pooling between the tracks is fully visible at this location.

**Intersection of Sturgis Road and Pennington County L214**

Two Lanes - One Track

The crossing on PC L214 is comprised of individual timbers. The timbers are not full depth and are resting on wood shims. The crossing was installed in 1989. PC L214 serves a small subdivision and several small businesses, some of which require large truck shipments. The road is subjected to relatively light traffic. The average daily traffic is listed as 30, however, traffic seems considerably higher. Rail traffic is comprised of two trains per day, each consisting of two to five locomotives and 40 to 50 cars. The rail in the crossing is 115 pound weight per yard and bolted joints are located at the ends of the crossing.

The timbers and the rail are mismatched, with the timbers sitting as much as one inch above the top of the rail (See Photos 97 and 98). Track movement under rail traffic is evident, as the spikes holding the rails have been pulled out as much as one inch. Severe damage to the timbers from the train wheels is also visible (See Photo 99). Several of the spikes holding the timbers in place are loose, as can be seen by loose and missing washers (Photo 98). Some of the spikes appear to have been pulled out by snowplows, as evidenced by damaged spikes and washers. Some of the timbers can be seen moving under motor vehicle traffic. The asphalt approach and asphalt contact with the timbers are good, with little chipping or differential settlements. Some of the timbers are warped (See Photo 98) and

Photo 97. PC L 214 - Mismatched Timber and Rail, and Pulled Out Spike

Photo 98. PC L 214 - Warped Timber, Loose Washers, and Joint Within the Crossing

Photo 99. PC L 214 - Rail Traffic Damage to Timbers

not all timbers are the same thickness, contributing considerably to crossing roughness.

The spaces between the timbers on the outside of the rails are being filled with mud and debris. The timber joints in this crossing are not staggered, which also makes roughness due to timber warping and uneven thickness more noticeable.

Drainage at this crossing is good, with ditches present at both sides of the railroad embankment at the crossing ends. Some erosion is taking place on the road shoulder approaching the crossing.

**South Dakota Cement Plant**

Two Lanes - Two Tracks

The crossing at the South Dakota Cement Plant is a Redhawk rubber panel type crossing. The road pavement consists of Portland Cement concrete and the headers consist of only rubber molding. The crossing was built in 1985. The road into the South Dakota Cement Plant has daily traffic of 2,200 vehicles consisting mostly of heavy trucks. Rail traffic is comprised of two trains per day, each carrying two to five locomotives and 40 to 50 cars. In addition, rail switching traffic takes place in conjunction with daily rail traffic. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet of the crossing.

The crossing appears to have settled between 1/2 and 1 inch in relation to the concrete pavement. The outer panels at the south

Photo 100. South Dakota Cement Plant - Outer Panel Settlement

Photo 101. South Dakota Cement Plant - Panel Wear and Crossing Settlement

Photo 102. South Dakota Cement Plant - Snow Plow Damage

Photo 103. South Dakota Cement Plant - Panels Torn off by Snow Plows

Photo 104. South Dakota Cement Plant - Erosion on the Main Track

Photo 105. South Dakota Cement Plant - Side Spur

end of the crossing are also up to 1 inch lower than the rest of the crossing (See Photo 100). Evidence of track movement can be seen on the panels, especially at the rail approaches to the crossing. The crossing itself appears to be quite even, with little or no differential movement between the rubber panels. Snow plow damage is severe, as the panels are scarred, and pieces of torn off panel surfaces are laying next to the crossing (See Photos 101, 102 and 103). The concrete pavement approach to the crossing is in good shape, with only minor chipping next to the outer rubber panels.

Drainage at this location is poor, as can be seen by dried mud in between the rails at both ends of the crossing. At the north end of the crossing, the surrounding terrain is flat with no ditches. On the south side, however, there is a one foot deep gully on the east side of the track. Runoff from the crossing at this location has caused considerable erosion next to the crossing (See Photo 104).

The side spur (See Photo 105) appears to be in good shape, with little or no differential settlement between the concrete approaches and the rubber panels. The spaces between the rails and the inner rubber panels are completely filled with mud and the panels have sustained damage similar to the main track crossing from snow plows.

**South Dakota Cement Plant - Plant Entrance**

Two Lanes - One Track

The crossing at the entrance to the South Dakota Cement Plant has a Redhawk type surface. The road pavement consists of Portland Cement concrete and the headers consist of only rubber molding seals. The crossing was built in 1985. The road into the South Dakota Cement Plant has a daily traffic of 2,200 vehicles, most of these being heavy trucks. Rail traffic at the entrance to the plant includes daily switching traffic, using a light switching engine, and one pickup run per day by the train. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet from the crossing.

As can be seen by Photo 106, the elevation of the rails is from 1/2 to 1 inch below the rubber panels. The difference in elevation is especially noticeable between the rails and the rubber panels between the rails. The photo also shows that the space between the center panels and the rails is packed with soil. In addition, the outer panels are worn down from 1/4 to 1/2 inch by rail traffic. Settlements between the concrete apron and the outer rubber panels is generally less than 1/2 inch. Snow plow damage is minor, however, some rubber has been peeled off of the panels down to the steel on the east side of the crossing (See Photo 107).

Drainage is poor and there are no ditches at either end of the crossing. It also appears that the crossing is serving as a path for water to drain from the west to the east side of the road.

Photo 106. Entrance to Cement Plant - Rail Settlement

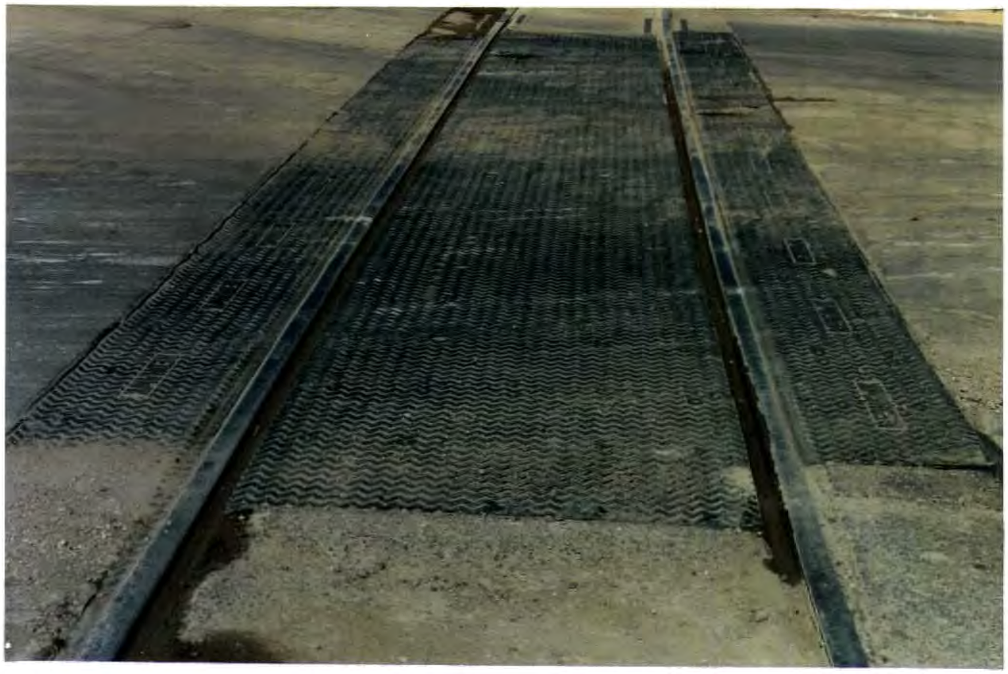


Photo 107. Entrance to Cement Plant - Plow Damage and Drainage

This is evidenced by the wet soil between the rails and the center rubber panels (See Photo 107).

**Mountain View Road**

Four Lanes - One Track

The crossing at Mountain View Road has a Goodyear type surfacing. The road pavement consists of asphaltic concrete and the headers are 2 inch wide wood plank with no rubber seals. The crossing was built in 1984. Mountain View Road is a four lane main artery with a daily traffic load of 15,130 vehicles, a small percentage of which is heavy trucks. Rail traffic at the crossing consists of two trains per day, each with two to five locomotives and 40 to 50 freight cars. Daily switching traffic is comprised of minor cross-town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet from the crossing.

There is evidence of considerable track movement on both track approaches to the crossing. This can be concluded from evidence of pumping at the west end of the crossing (See Photo 108), and from wear on the rubber panels caused by the rail car wheels. The entire crossing has settled from 1 to 2 inches in relation to the pavement (See Photo 109), and there is considerable unevenness within the crossing itself, as the panels are bent and warped and have shifted both horizontally and vertically in relation to each other. The outer rubber panels are nearly flush with the top of the rails, while the center panels are up to one

Photo 108. Mt. View Road - Pumping and Track Movements

Photo 109. Mt. View Road - Crossing Settlement

Photo 110. Mt. View Road - Differential Elevation between Center and Outer Panels

Photo 111. Mt. View Road - Panel Wear and Snow Plow Damage

Photo 112. Mt. View Road - Cracking of Apron

inch above the rails (See Photo 110). Since the track is completely mud-filled, the higher elevation of the center panels may be attributed to lifting by mud squeezed down by the rail wheel flanges. The approach aprons are severely cracked parallel to the track and at a distance of 6 to 12 inches from the outer rubber panels (See Photo 112) and considerable patching has been done. The wood headers are worn down or deteriorated. There is some damage from snow plows (See Photo 111). Overall, snow plow damage is not as severe as has been seen on other rubber crossings, however, most fastener protective caps have been torn off, such that the fastener heads are fully exposed to corrosion, wear and snowplows.

Drainage to the east is good, while drainage to the west is poor. This is evidenced by the mud in between the rails and pumping on the west side of the crossing, and the relatively clean ballast between the rails on the east side.

**Cross Street**

Two Lanes - One Track

The crossing at Cross Street is a ball-up mud rail type with asphalt surfacing. Both inner and outer mud rails are present. The pavement leading up to the crossing also consists of asphaltic concrete and there are no headers. The crossing was built before 1979. Cross Street is a two-lane street serving small business and city parks and is also a connecting street between Omaha and West Main Street. Daily traffic is 3,616 vehicles, with only a small percentage of these being heavy

Photo 113. Cross Street - Cracking of Apron Parallel to Track

Photo 114. Cross Street - Main Rail Settlement in Relation to Mud Rails

Photo 115. Cross Street - Evidence of Water Pooling between Rails on West End

trucks. Rail traffic at the crossing consist of two trains per day with two to five locomotives and 40 to 50 freight cars. Daily switching traffic consists of minor cross-town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight and continuously welded with no joints within a distance of 20 feet of the crossing.

There is considerable evidence of pumping at both the east and west ends of the crossing and between the mud rails and the main rails, as can be seen by broken up clay between the rails (See Photo 113). Pumping appears to have been more severe on the west side of the crossing. The asphalt pavement between the rails is sagging, with the lowest elevation approximately 1 inch below the mud rails. The asphalt in the entire center section is below the top of the mud rails. On the approaches, the asphalt is from slightly above to flush with the mud rails on the south side, while the asphalt is generally below the mud rails on the north side. The main rail is form one to two inches below the mud rails (See Photo 114) which makes the crossing very rough. The asphalt approahes have failed, as can be seen by cracking parallel to the track at a distance of 12 to 16 inches from the outer mud rail (See Photo 113). This distance corresponds to the location of the end of the railroad ties. Crossing maintenance and patching appears to have been minimal.

There are ditches at both sides of the crossing, as the track is located on an embankment which is six to ten feet high. Nevertheless, drainage from the track appears to be poor. There is evidence of considerable water pooling between the rails at both the east and west ends of the crossing indicating that water is not draining onto the slopes of the embankments at each side of the crossing (See Photo 115).

**Tenth Street (West Boulevard)**

Four Lanes - One Track

The crossing at Tenth Street has a Goodyear type rubber surface. This crossing was surveyed in the winter of 1990-91 but is included in this section since the conditions have deteriorated during the past year. The road pavement consists of asphaltic concrete, and the headers are 2 inch wide wood planks with no rubber seals. The crossing was built in 1983. Tenth Street is a four lane main artery with daily traffic of 13,882 vehicles, with some heavy truck traffic. Rail traffic at the crossing consists of two trains per day, each with two to five locomotives and 40 to 50 freight cars. Daily switching traffic consists of minor cross-town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet from the crossing.

Track movement does not appear to be significant on the west half of the crossing, but considerable wear from the rail traffic can be seen on the east side of the crossing. The crossing appears to have settled from 1 to 2 inches in relation to the pavement aprons (See Photos 116 and 117). The center panels are from 3/8 to 1/2 of an inch above the outer panels at most locations, but

Photo 116. Tenth Street - Apron Tilting and Crossing Settlement

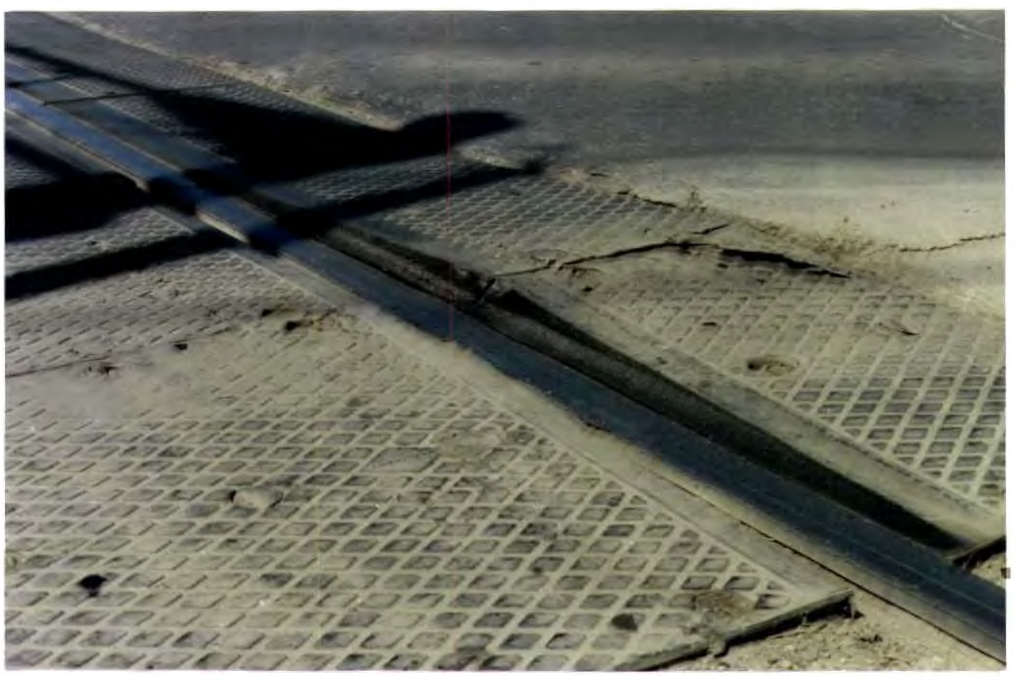


Photo 117. Tenth Street - Loose Rubber Panels

Photo 118. Tenth Street - Loose Rubber Panel

Photo 119. Tenth Street - Disintegrating Wood Headers

locally the difference in elevation is close to 1 inch. The space between the center panels and the rails is completely packed with soil. The rubber panels are coming loose at several locations (See Photos 117 and 118) and considerable gaps can be seen between panels. The loosening of the panel in Photo 117 was not observed in the past inspection. Panel displacement is especially noticeable in the two east lanes where panels also can be seen moving under motor vehicle traffic. A considerable number of fastener protective caps are missing with the number having increased dramatically since the previous inspection. The space around the fastener heads is mud-filled. The pavement approach to the crossing is fairly level but some rutting is evident close to the headers. The wood headers are worn and at some locations the headers are completely disintegrated (See Photo 116 and 119). Referring to the initial survey (See Photo 118) the approach was in considerably better shape at that time. Snow plow damage at this crossing is minimal.

Drainage at the crossing is poor, as the surrounding terrain is at the level of the crossing, and evidence of pumping can be seen around the ties and the rails at the east end of the crossing.

**Milwaukee Street**

Two Lanes - One Track

The crossing at Milwaukee Street has a ParkCo type rubber surfacing. The road pavement consists of asphaltic concrete and the headers consist of 2 inch wide wood planks with no rubber molding. The crossing was built in 1980. Milwaukee Street is a

Photo 120. Milwaukee Street - Rubber Panel Wear and Track Settlement

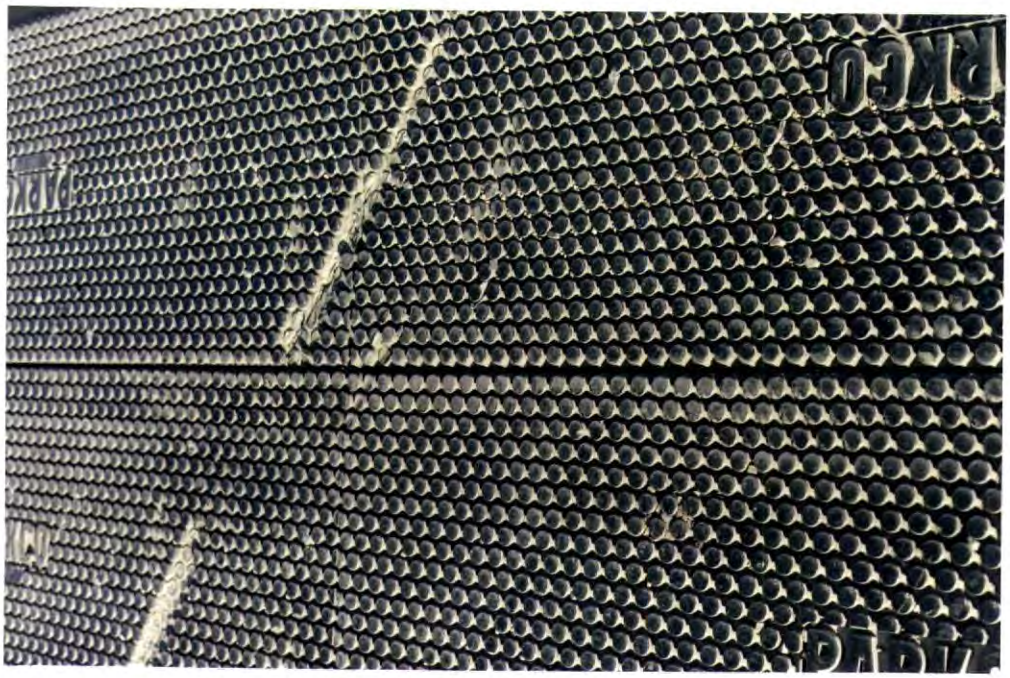


Photo 121. Milwaukee Street - Snow Plow Damage

Photo 122. Milwaukee Street - Disintegrated Headers

Photo 123. Milwaukee Street - Pumping at East End of Crossing

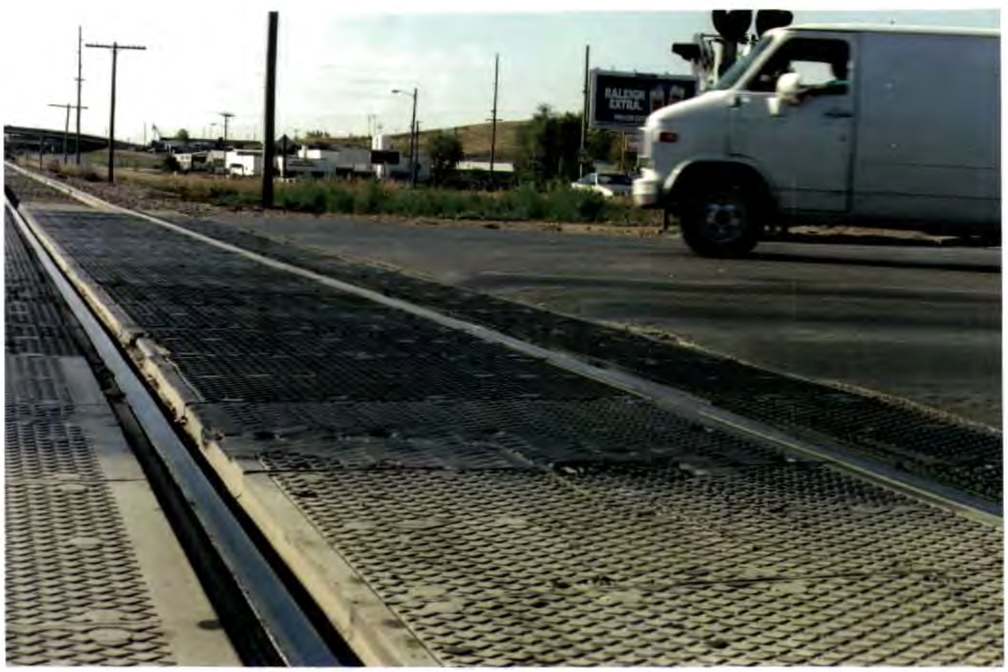


Photo 124. St. Patrick Street - Crossing Settlement on West Side

two-lane street, with average daily traffic of 5,900 vehicles but with little truck traffic. Rail traffic at the crossing consists of one to two trains per day, each with mostly two to four locomotives and 40 to 50 freight cars. There is no switching traffic. The rail in the crossing is 115 pound weight, with bolted joints within a distance of 5 feet from the crossing on both the east and west sides.

There is evidence of significant track deflection along most of the crossing, as the panels are severely worn by railroad traffic (See Photo 120). Some sand and mud has collected between the center panels and the rails, but this crossing is cleaner than most of those inspected. There are some gaps and vertical displacement between the panels. However, panel displacement at this crossing is on the order of 3/8 inch or less horizontally and less than 1/4 inch vertically. The horizontal gaps are filling with debris. There is no evidence of loose panels, as little or no panel deflection or movement could be seen under motor vehicle traffic. Overall settlement of the crossing relative to the pavement is up to 1 inch at the south side of the crossing, but less at the north side. The wood headers are severely disintegrated at most locations (See Photos 120 and 122) and are missing at other locations. The headers have also been raised up to 1 inch above the pavement on the southwest shoulder where they are not exposed to significant traffic.

The asphalt approaches are cracked and are breaking up in the areas where the headers are missing or have disintegrated. The asphalt approaches at the shoulders are also breaking up. There is some snowplow damage but scars from the snowplows do not cover large areas (See Photo 121).

Drainage at this crossing appears to be poor, although there is one foot deep ditches on both sides of the track at both the east and west ends of the crossing. Nevertheless, there is evidence of water pooling between the rails and along the tracks on both sides of the crossing. Pumping at the east end of the crossing is especially noticeable where the track and ties have settled considerably (See Photo 123).

**St. Patrick Street**

Four Lanes - One Track

The crossing at St. Patrick Street is a Goodyear type rubber surfacing. The road pavement consists of asphaltic concrete and the headers consist of 2 inch wide wood planks with no rubber seals. The crossing was built in 1984. St. Patrick Street is a four-lane main artery with daily traffic of 14,557 vehicles, a high percentage of which are heavy trucks. Rail traffic at the crossing consists of two trains per day, each with two to five locomotives and 40 to 50 freight cars. Daily switching traffic consists of cross-town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight with bolted joints within and at each side of the crossing.

The crossing appears to have settled from 1 to 1 1/2 inches in relation to the road pavement on the west side of the crossing,

Photo 125. St. Patrick Street - Apron Settlement Relative to Crossing on East Side and Panel Wear

Photo 126. St. Patrick Street - Panel Scarring From Railroad Traffic

Photo 127. St. Patrick Street - Header Failure and Panel Wear

Photo 128. St. Patrick Street - Pumping and Rail Deflection at North End of Crossing

Photo 129. First Street - Asphalt Contact With Mud Rail

but is from 1/2 inch above to 1 inch below the pavement on the east side (See Photos 125 and 127). Considerable pavement wear is evident on both approaches, especially in the wheel path. There is also evidence of considerable rail deflection under rail traffic, as the outer rubber panels have up to 1/2 inch deep scars along the rails (See Photo 126). The rubber panels are worn down to the steel at several locations (See Photos 125 and 127). There is only minor panel separation and very little vertical shifting between panels. The space between the center panels and the rails contain only small amounts of debris. Snow plow damage is extensive and the combination of plow damage and wear have exposed the steel in the panels at several locations (See Photos 127). A considerable number of fastener protective caps have been lost. The wood headers are badly deteriorated and mud and debris have been forced in between the rubber panels and the headers (See Photo 127).

Drainage at the site is poor, as there are no ditches on either side of the crossing. Evidence of pumping and subgrade softening can be seen at either end of the crossing, but is especially noticeable at the north end of the crossing. Significant evidence of water pooling was also noted (See Photo 128). Rail deflections during rail traffic at the north end of the crossing ranged from 1/2 inch on the west rail to 1 inch on the east rail. Significant tie movement was also noticeable. At this location, the loading on the spikes caused by repetitive deflection has also caused the spikes to be pulled out of the ties as much as two inches and some spikes are missing altogether.

**First Street**

Two Lanes - One Track

The crossing at First Street is a ball-up mud rail type with asphalt surfacing. Both inner and outer mud rails are present. The pavement leading up to the crossing also consists of asphaltic concrete and there are no headers. The crossing was built in 1990. First Street is a two-lane street serving small businesses and is also a connector street between Omaha and West Main Street. Average daily traffic is 2,345 vehicles, with only a small percentage of these being heavy trucks. Rail traffic at the crossing consists of two to three trains per day, each with of two to five locomotives and 40 to 50 freight cars. Daily switching traffic consists of minor cross-town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet of the crossing.

There is little evidence of track movement and the mud rails are close to or at the same elevation as the main rail. The asphalt contact with the mud rails is also good, with not more than a 1/4 to a 1/2 inch difference between the elevation of the mud rails and the asphalt contact (See Photo 129). There is no cracking of the apron on either side of the crossing. The spaces between the mud rails and the main rail are filled with loose mud and debris

Photo 130. First Street - Mud Filled Spaces between Rails and Curved Apron and Asphalt between Rails

(See Photo 130). The drainage at the location of the First Street crossing appears poor, as there is no difference in elevation between the crossing and the surrounding terrain. Nevertheless, there is no evidence of pumping or standing water between the tracks at either the east or the west end of the crossing. This probably reflects the low age of the crossing.

**Second Street**

Two Lanes - Two Tracks

At Second Street only the south rail was inspected. The crossing is a ball-up Mud Rail type with asphalt surfacing. Both inner and outer mud rails are present. The road pavement leading up to the crossing also consists of asphaltic concrete and there are no headers. The crossing was built in 1979. Second Street is a two-lane street serving small businesses and is also a connector street between Omaha and West Main Street. Average daily traffic is 1,548 vehicles, with only a small percentage of these being heavy trucks. Rail traffic at the crossing consists of two trains per day, each with two to five locomotives and 40 to 50 freight cars. Daily switching traffic consists of cross-town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet of the crossing.

Settlement of the crossing is evidenced by cracking and tilting of the asphalt approach towards the track at both the north and south sides of the crossing (See Photo 131). The cracking is approximately 18 inches from the rails, which corresponds to the

Photo 131. Second Street - Crossing Settlement and Tilted Aprons

Photo 132. Second Street - Settlement of Main Rail and Mud Rail Below Asphalt

Photo 133. Second Street - Cracking of Apron and Pumping at Shoulder and Mud Rail Below Asphalt

location of the end of the ties. Overall, the crossing is about 1 inch lower than the street pavement level. In addition, the main track is from 1/2 to 1 inch lower than the mud rails (See Photo 132). The asphalt in the driving lanes is rutted and the asphalt between the rails is up to 1/2 of an inch below the mud rails. At the shoulders, however, the mud rails are as much as 2 inches below the asphalt (See Photo 132 and discussion in Chapter IV). The spaces between the mud rails and the main rails are filled with mud and debris.

Drainage at the Second Street crossing is poor, as there are no ditches and the surrounding terrain is at the elevation of the crossing and the track. Evidence of pumping below the track and shoulder is present at both the east and west ends of the crossing (See Photo 133), and broken up clay is seen in between the mud rails and the main rail. Evidence of pooling water was also seen between the rails at both ends of the crossing.

The crossing at Second Street was rebuilt in October and November of 1991. The reconstruction and settlement records taken after the reconstruction are discussed in Chapter IV.

**Fifth Street**

Four Lanes - Four Tracks

The crossing at Fifth Street has a Redhawk type rubber surface. In addition to the main track, three side spurs are located at the crossing. Only the main track was inspected. The road pavement consists of Portland Cement concrete and the headers

Photo 134. Fifth Street - Mud Packed Space between Rail and Center Rubber Panel

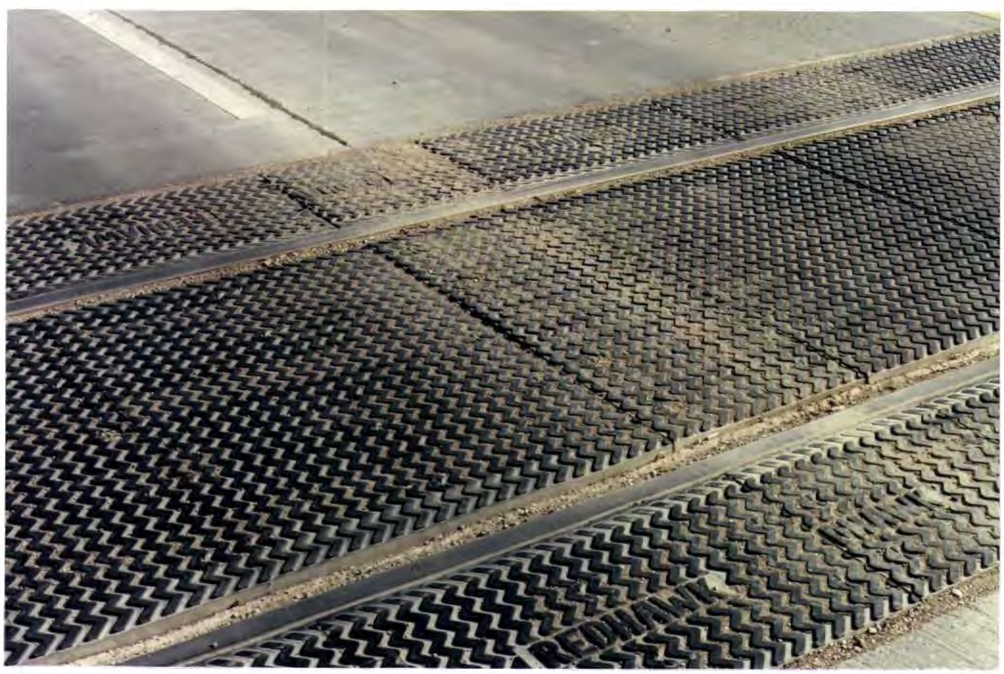


Photo 135. Fifth Street - Vertical Offset between Panels

consist of rubber strips and felt. The crossing was built in 1985. Fifth Street has an average daily traffic of 9,760 vehicles, with truck traffic essentially consisting of that serving local businesses. Rail traffic is comprised of two trains per day, each with two to five locomotives and 40 to 50 cars. In addition, rail switching traffic takes place in conjunction with daily rail traffic to the nearby grain elevators. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet of the crossing.

Some track deflection under rail traffic is evidenced by wear on the outer rubber panels. Settlement of the crossing in relation to the concrete aprons is about one half inch, and is quite uniform for the entire crossing. Soil and debris, seen tightly packed in between the rail and the center panels, is being forced down between the rail and the center panels (See Photo 134). Soil and debris is also being forced in between the headers and the concrete approach. There is little separation (maximum of 1/4 inch) laterally between the panels but a considerable difference in vertical elevation was observed (See Photo 135), both on the center panels and outer panels. There is very little, if any, significant snow plow damage.

Natural drainage at the crossing is poor, as the track is at the level of the surrounding terrain. Nevertheless, there is very little evidence of pumping at the approaches to the crossing and no evidence of standing water between the rails.

**Seventh Street**

Two Lanes - Two Tracks

The Seventh Street crossing consists of the main track plus one side spur. The side spur is subjected to very little rail traffic and, at the time of the inspection, it was evident that the side spur had not been used in a long time, as grass was growing between the mud rail and the main rail (See Photo 136). The main track crossing is a ball-up mud rail type with asphalt surfacing. Both inner and outer mud rails are present. The side track has an inner side mud rail only. The pavement consists of asphaltic concrete and there are no headers. The crossing was built before 1979. Seventh Street is a two-lane street serving small businesses and is also a connector street between Omaha and West Main Street. Average daily traffic is 2,252 vehicles, with only a small percentage of these being heavy trucks. Rail traffic at the crossing consists of two trains per day, each with two to five locomotives and 40 to 50 freight cars. Daily switching traffic consists of cross-town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet of the crossing. There is, however, a switch at the east end of the crossing.

On the main track the main rail is from 1/4 to 1/2 of an inch below the mud rails (See Photo 137). The asphalt between the rails is from 1/2 to 1 1/2 inch below the mud rails. At the outside mud rails the asphalt is up to 2 1/2 inches below the mud

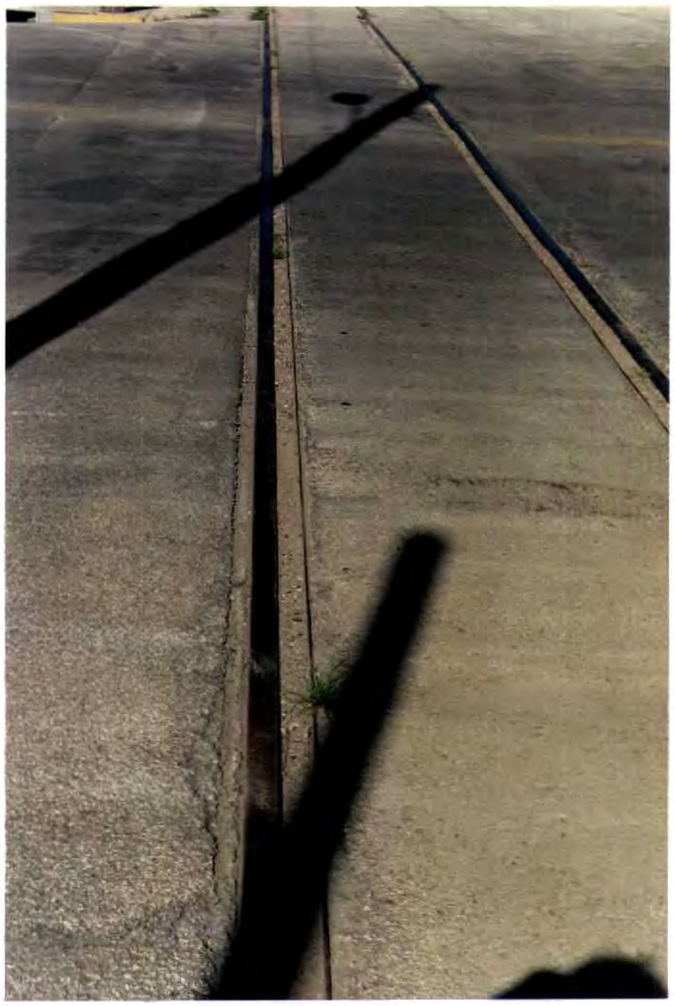


Photo 136. Seventh Street - Side Track

Photo 137. Seventh Street - Main Rail Settled Below Mud Rails

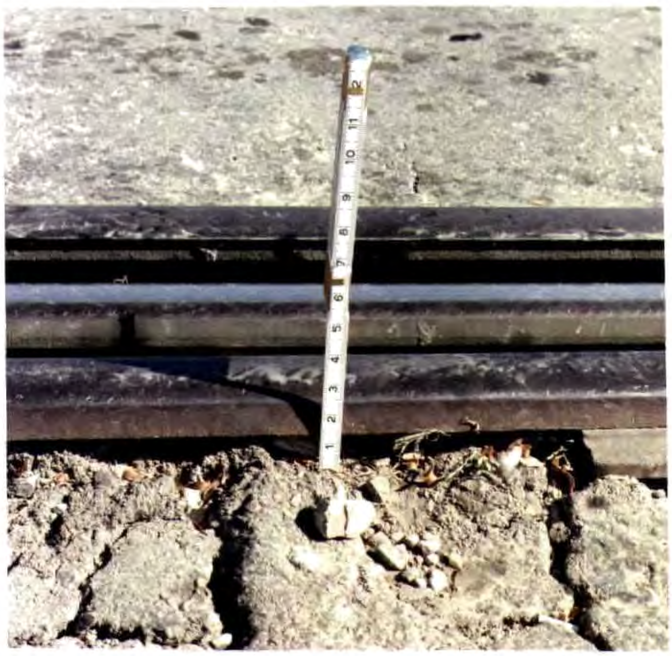


Photo 138. Seventh Street - Asphalt Below Outer Mud Rail


Photos 139 and 140. Seventh Street - Aprons Failing Parallel to Track

Photo 141. Seventh Street - Pumping and Tie Settlement

rail (See Photo 138). The approach is failing at a distance of 18 to 24 inches from the rails, which corresponds to the location of the end of the ties (See Photos 139 and 140). The approach is also tilted down towards the rails and it is estimated that the crossing has settled between 1 and 2 inches in relation to the street elevation. The space between the mud rails and the main rail is completely filled with mud and debris.

Natural drainage at this crossing is poor, as the track is at the elevation of the surrounding terrain. Evidence of pumping is clearly seen at both ends of the crossing where the ties have been pushed well below the elevation of the top of the ballast (See Photo 141).

The side spur shows little or no distress (See Photo 136). The side spur crossing shows no vertical differential movement between the pavement and the crossing, and the asphalt pavement is at the elevation of the mud rail. There is no cracking of the asphalt at the approaches (at the estimated end of the ties).

**Mount Rushmore Road (8th Street)**

Four Lanes - One Track

The crossing at Mount Rushmore Road has a Goodyear type rubber surface. The road pavement consists of asphaltic concrete and the headers consist of 2 inch wide wood planks with no rubber molding or seals. The crossing was built in 1980. Mount Rushmore Road is a four-lane main artery with an average daily traffic of 10,277 vehicles, with some heavy truck traffic. Rail

Photo 142. Mt. Rushmore Road - Cracking of Headers, Tilt of Apron, and Dropoff From Apron to Crossing

Photo 143. Mt. Rushmore Road - Worn Wood Headers

traffic at the crossing consists of two trains per day, each with two to five locomotives and 40 to 50 freight cars. Daily switching traffic consists of minor cross town hauling of freight cars to and from the train depots. The rail in the crossing is 115 pound weight and continuously welded, with no joints within a distance of 20 feet of the crossing.

The crossing is quite even, although significant panel wear can be seen near the rails. Some panels are loose, as they can be seen moving under traffic. The track has settled considerably in relation to the road. Considering the tilt of the apron towards the outer panels and the differential elevation (drop-off) at the headers, total settlement is in excess of 2 inches at some locations. The drop off may be seen at the center left of Photo 142, where the shadow of the mast hits the header and the outer panels. Cracking of the apron is especially evident on both the south and north sides of the crossing, approximately 1 1/2 feet from the headers. Rail deflection under train traffic varies along the crossing, as the outer panels show signs of different levels of wear (See Photo 143). The rail also appears uneven. No portion of the headers are missing, but considerable wear can be seen at some locations (See Photo 143). This photo also shows a sharp drop-off from the approach to the crossing. The space between the headers and the rubber panels is being filled with debris, and the space between the rails and the center panels is becoming filled with hard packed soil. Snow plow damage is minimal and is confined to minor scarring and missing fastener protective caps.

Natural drainage at the crossing is poor, as there are no ditches along the track, and the natural terrain is at the level of the crossing. There are some signs of water pooling between the tracks at both ends of the crossing, and there is evidence of track pumping at the west end of the crossing.

**New York Street**

Two Lanes - One Track

The crossing at New York Street is asphalt with no mud rails and no headers. The crossing was built in 1979. New York Street is a two-lane street serving small businesses and is also a connector street between East Boulevard and Fifth Street. Average daily traffic is 5,328 vehicles, with only a small percentage of these being heavy trucks. Rail traffic at the crossing consists of one to trains per day, each with two to four locomotives and 40 to 50 freight cars. There is little or no switching traffic. The rail in the crossing is 115 pound weight, with bolted joints on the shoulders at both ends of the crossing.

The rails are between 1/2 and 1 inch below the pavement in the driving lanes but have settled up to 3 inches below the pavement on the south shoulder (See Photos 144 and 145). The asphalt on both the inside and outside of the rails is severely broken up (See Photo 146). Settlement of the track under rail traffic is

Photo 144. New York Street - Rail Settlement Relative to Pavement

Photo 145. New York Street - Rail Settlement Near South Shoulder

Photo 146. New York Street - Pumping South of Joint on West Rail

considerable, as the bottom of the freight cars have been scarring the asphalt at the south shoulder.

Natural drainage at this location should be good, as the track is on an embankment 6 to 10 feet above the surrounding terrain. Nevertheless, evidence of severe pumping can be seen, as soil has squeezed under the asphalt and lifted the pavement (See Photo 146).

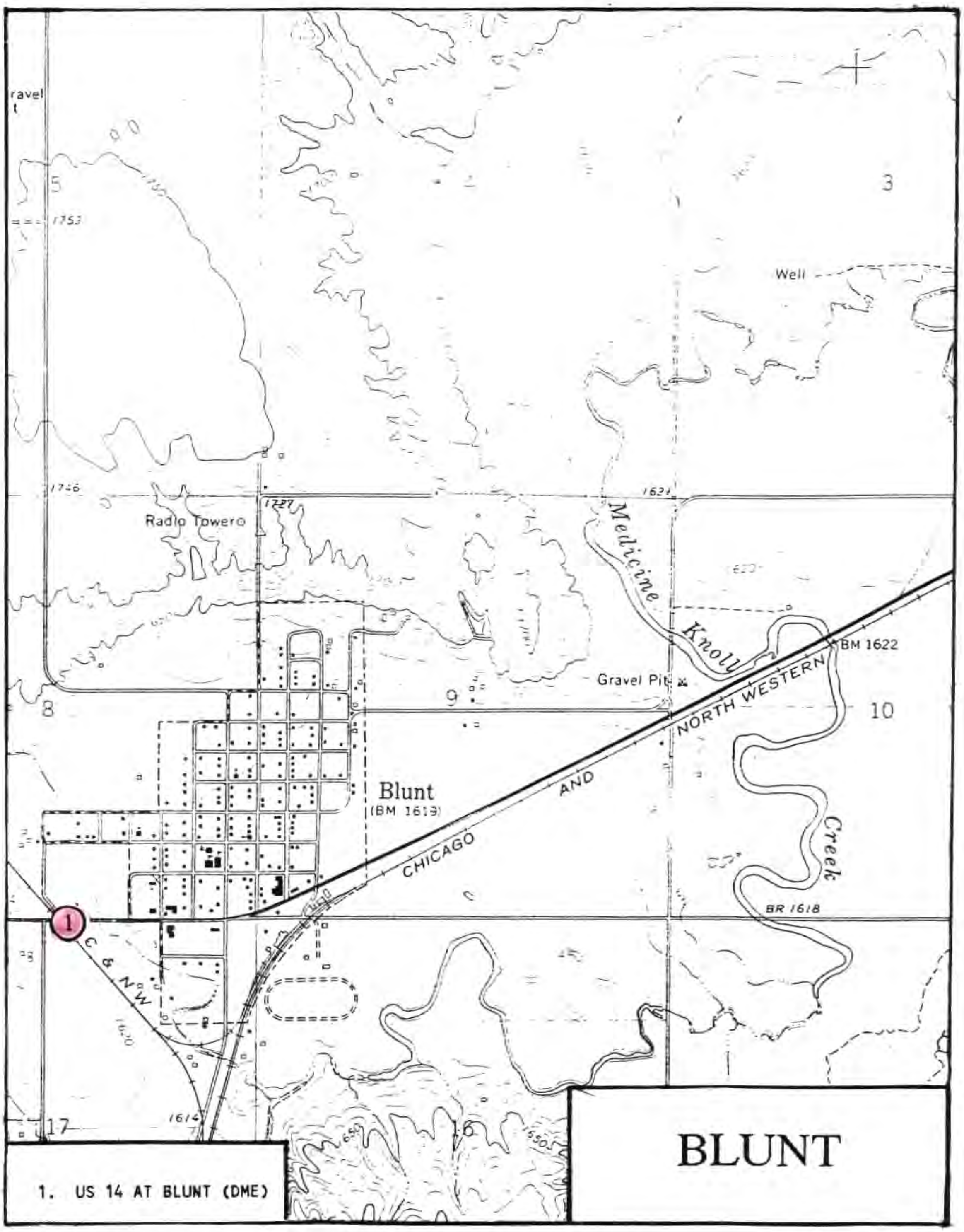
**A-4.2 Blunt**

**Highway 14 East of Blunt**

Two Lanes - One Track

The crossing at Blunt is a Redhawk type rubber surface with concrete pavement right up to the pads. The crossing is on US Highway 14 and average daily traffic is 1,172 vehicles. The percentage of trucks is not known. Rail traffic is light and consists of 2 trains per week with two locomotives and 30 cars. The rail is welded (115 lb) and no joints are located close to the crossing. The crossing was built in 1984.

The crossing appears to have settled about 1/2 inch to 3/4 of an inch overall in relation to the pavement, as there is an abrupt drop off from the concrete pavement onto the crossing on both sides. The rail is also from 1/4 to 3/8 of an inch below the center panels along most of the crossing (See Photos 147 and 148). There is considerable amounts of soil and debris between the rail and the center panels which is being forced down between the rail and the panels. Minor vertical displacement between




LOCATION MAP 7

Photo 147. US Highway 14 at Blunt - Rail Below Center Panels

Photo 148. US Highway 14 at Blunt - Settlement at Concrete Apron and Uneven Panels

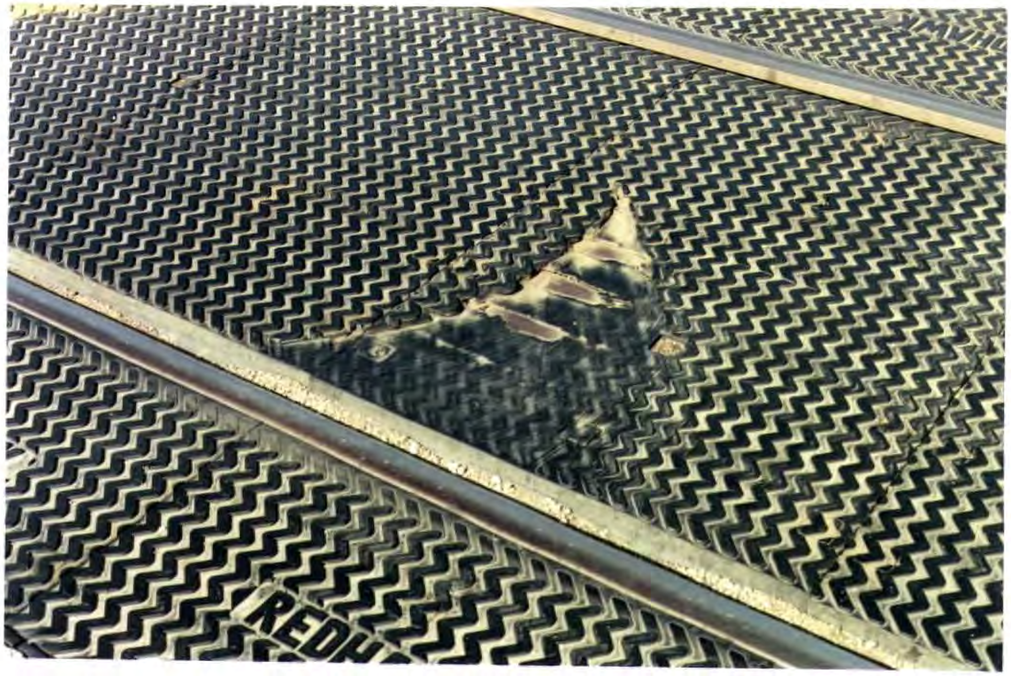


Photo 149. US Highway 14 at Blunt - Snowplow Damage, Rubber Torn Off Down to the Steel

Photo 150. Northville - Rutting and Lack of Apron Settlement

panels can be seen (See Photo 148), however, shifting of the panels laterally is negligible. The panels show very little wear from motor vehicle traffic. There are no significant signs of rail wheel wear on the outer panels next to the rails, indicating very little deflection of the rail under rail traffic and good rail attachment to the ties. There is minor chipping of the concrete next to the outer panels in the middle of the road on the east side of the crossing. Snowplow damage is severe locally in the eastbound lane where the rubber has been torn off down to the steel (See Photo 149).

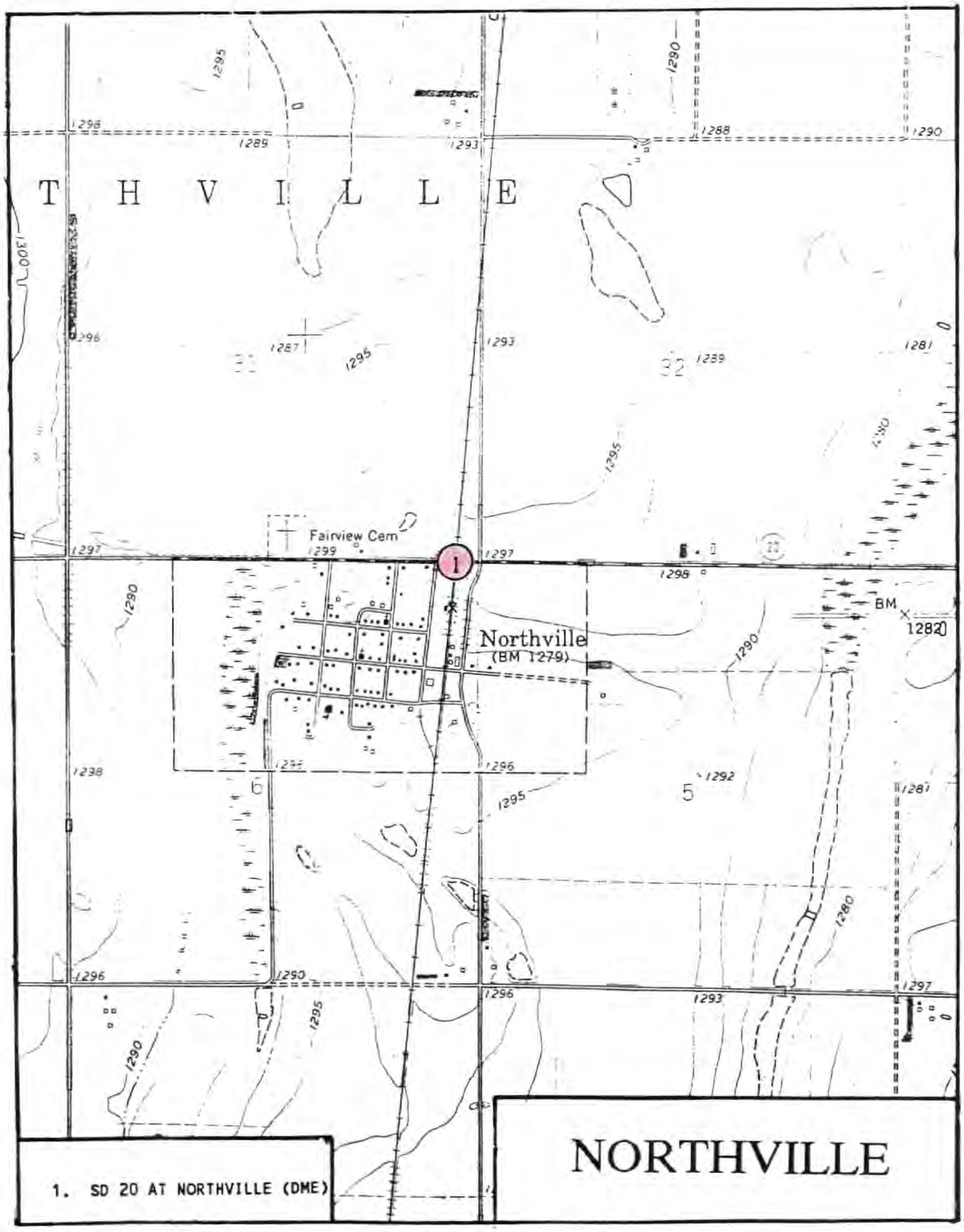
The drainage is good with the track elevated well above surrounding terrain. There is no evidence of pumping at each end of the crossing.

**A-4.3 Northville**

**SD Highway 20 at Northville**

Two Lanes - One Track

This crossing is located on SD-20 just north of Northville and has asphalt surfacing with rubber mud rails (See Photo 150). The crossing was built in 1987. SD-20 is a low volume rural highway with average daily traffic of 455 vehicles. Train traffic consists of 2 trains per week with one locomotive and approximately 10 cars. The track is composed of 115 pound weight rail with bolted joints at a distance of approximately 20 feet from each end of the crossing.




LOCATION MAP 8

Photo 151. Northville - Rutting between the Rails

Photo 152. Northville - Cracking of Apron at the End of the Ties

The mud rails are not even and are essentially following the surface cross-section of the pavement. In Photo 150 it can be seen that the mud rails generally follow the rutting in the pavement, however, the portion of the pavement between the rails has been rutted to well below the mud rail (See Photo 151). The aprons show evidence of failure (See Photo 152), yet there is very little difference in the elevation of the crossing and the road. The lack of settlement of the crossing in relation to the pavement can be seen in Photo 150, where cracks in the apron are located to the right in the photo. There is no evidence of any track problems on either side of the crossing, neither of water pooling. The spikes on the ties next to the crossing are tight, indicating that the track is deflecting negligibly next to the crossing. There is some gravel in the mud rail although most of the rail is clear.

Drainage is good with the track several feet above the surrounding terrain. The water table in the area is high, evidenced by reeds all along the road. This crossing has been said to be rough in the winter, hence frost heaving of the highway aprons is likely to have been taking place. This may explain the severe cracking and breaking up of the apron near the tracks, despite the lack of differential settlements between the apron and the crossing at the time of inspection. At the time of inspection, the crossing is too even for differential settlement to have caused such breakup and cracking along the crossing.

### A-4.4 Aberdeen

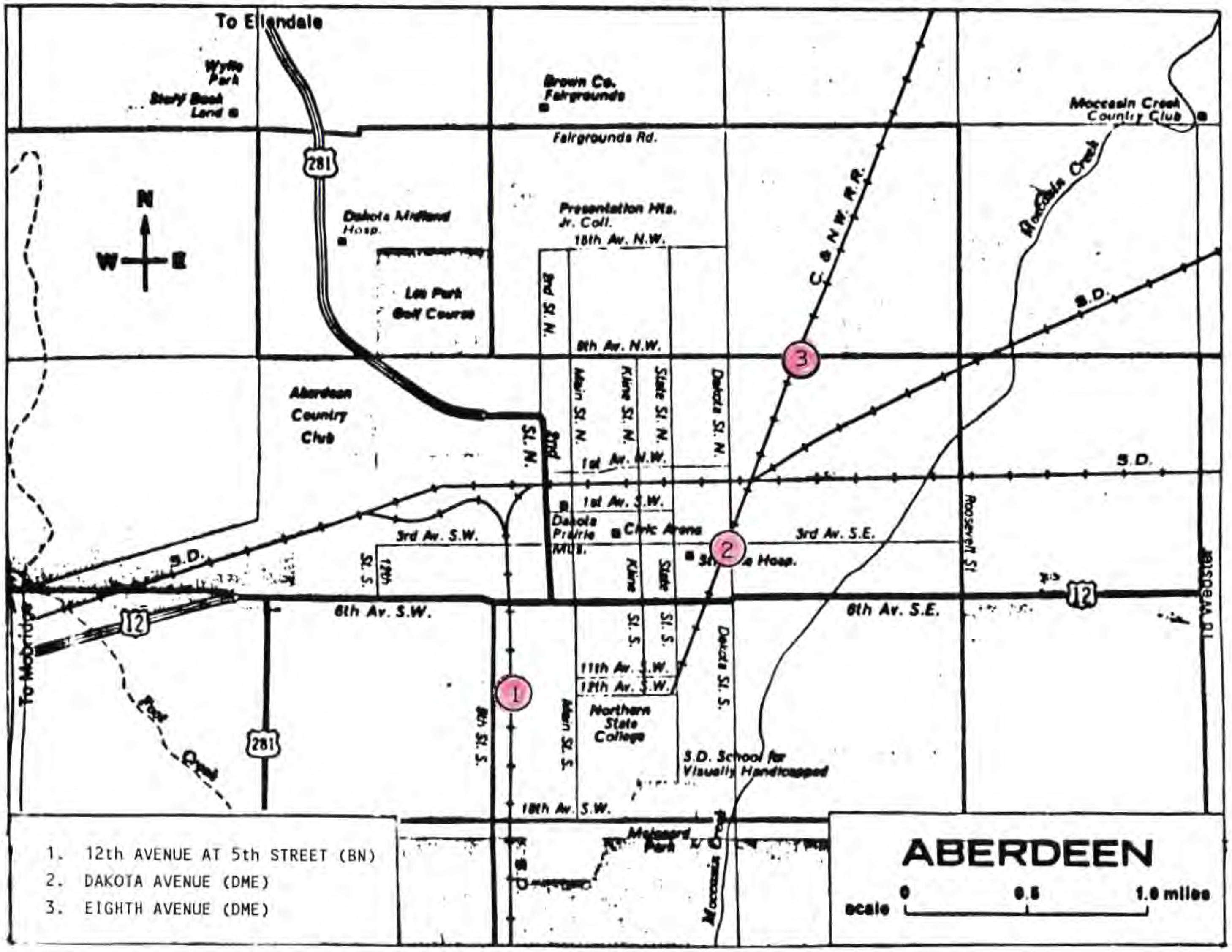
**Crossing at Intersection of 12th Avenue and 5th Street**

Two Lanes - One Track

This crossing is essentially an asphalt crossing with individual timbers as mud rails on the inside and outside of the track. The crossing was built in 1979. Average daily traffic is approximately 300 vehicles per day with minimal truck traffic. Railroad traffic consists of one train per day with up to 6 locomotives and 100 cars. The track consists of 115 pound weight rail, however, there is a bolted joint in middle of the crossing.

The crossing appears to have been repaired, as the timbers used for headers have been paved over with asphalt, but the asphalt is now spalling off (See Photo 153). The track has settled at least 1 inch in relation to the adjoining street pavement and the timber header/mud rail is tilting towards the rail (See Photo 154). The timbers are getting quite worn (see Photo 155) and the asphalt outside the timber header is failing. The rail is completely mud-filled and is pushing the timbers up on the rail side (See Photo 156). Deflection under rail traffic at the track approach was approximately measured to 1/4 inch and the timbers and rail in the crossing deflected about 1/8 of one inch during rail traffic. Some movement of the timbers could also be seen under heavy motor vehicle traffic.

Surface drainage at the site is fair as there are shallow ditches on all sides of crossing. There is no evidence of track pumping and no evidence of water pooling in between the tracks at the




LOCATION MAP 9

Photo 153. Aberdeen at 12th Avenue - Asphalt Spalling off Headers

Photo 154. Aberdeen at 12th Avenue - Timber Headers Tilting Towards Rail

Photo 155. Aberdeen at 12th Avenue - Timber Wear

Photo 156. Aberdeen at 12th Avenue - Mud between Rails and Timber

approaches to the crossing. Subsurface drainage at the site is good since the natural soil, which is revealed by a deep excavation nearby, consists of silty fine sand.

**Dakota Street**

Three Lanes - One Track

The crossing has a Redhawk type rubber surface with two inch wide wood planks as headers. The pavement is Portland Cement concrete. The crossing was built in 1987. South Dakota Street has average daily traffic of approximately 1,400 vehicles per day. The percentage of trucks is not known. Rail traffic consisted of 3 trains per day, however, the track is now only used intermittently. There is 115 pound weight rail in the crossing and no bolted joints within or close to the crossing.

The overall settlement of the crossing in relation to the concrete aprons is less than 1/2 inch (See Photo 157), except for the northwest section where the concrete pavement slab has settled such that it is flush with the rubber panels in the crossing. The center panels appear to be elevated slightly above the rails. The panels also show a slight vertical shifting in relation to each other, as vertical displacement was measured to less than 1/16 of an inch. There is no separation of the panels, at least none that cannot be attributed to installation. The spaces next to the rails are completely mud-filled. There is no sign of wear of the panels from the rail traffic, indicating that there is very little relative movement between the rails and the

Photo 157. Aberdeen at Dakota Street - Crossing Settlement And Center Panels Higher than the Rail

Photo 158. Aberdeen at Dakota Street - Snow Plow Damage

panels. There is considerable snow plow damage on the curb side in the south bound lane (See Photo 158).

The natural surface drainage is poor at the site but a drain pipe was installed in the crossing leading into a storm sewer. No evidence of pumping of the track can be seen on the track approaches. There is no evidence of pooling water in between the tracks.

**Eighth Avenue**

Two Lanes - One Track

At this location a Hi-Rail type rubber crossing has been installed. There are no headers, as the asphalt pavement has been lain right up to the outer panels. The crossing was built in 1986. The average daily traffic is 5,110 vehicles. The track is only used intermittently. There is 115 pound weight rail in the crossing to well beyond the crossing (20 feet) at both sides.

There is very little overall differential settlement between the asphalt aprons and the crossing and the rails are at no point 1/4 inch higher or lower than the rubber panels. Overall settlement of the crossing in relation to the road is less than 1/2 inch. There is some problem with panel separation, with the outer panaels moving as much as an inch away from the rail (See Photo 159), and the opening is becoming mud-filled. The asphalt is placed right up to the panels and show distress at some locations (See Photo 160). The space between the rails and the center panels is filled with mud. The asphalt approach is uneven, at

Photo 159. Aberdeen at 8th Avenue - Lateral Displacement of Outer Rubber Panels

Photo 160. Aberdeen at 8th Avenue - Asphalt Apron Failure at Rubber Panels

Photo 161. Aberdeen at 8th Avenue - Lateral Movement of Outer Panels and Snow Plow Damage

some locations 1 inch below the track, and at other locations 1 inch above the track. In the driving lanes, however, the approach is mostly even with the rubber panels. The snow plow damage to this crossing is minor in relation to most rubber crossings (See Photo 161).

Natural surface drainage is excellent, with the surrounding terrain being several feet below the track. There is no evidence of pumping at the rail approaches to the crossing and no evidence of water pooling in the ballast between the rails. It should be noted that a smaller ballast with maximum one inch size rock has been used at this crossing.

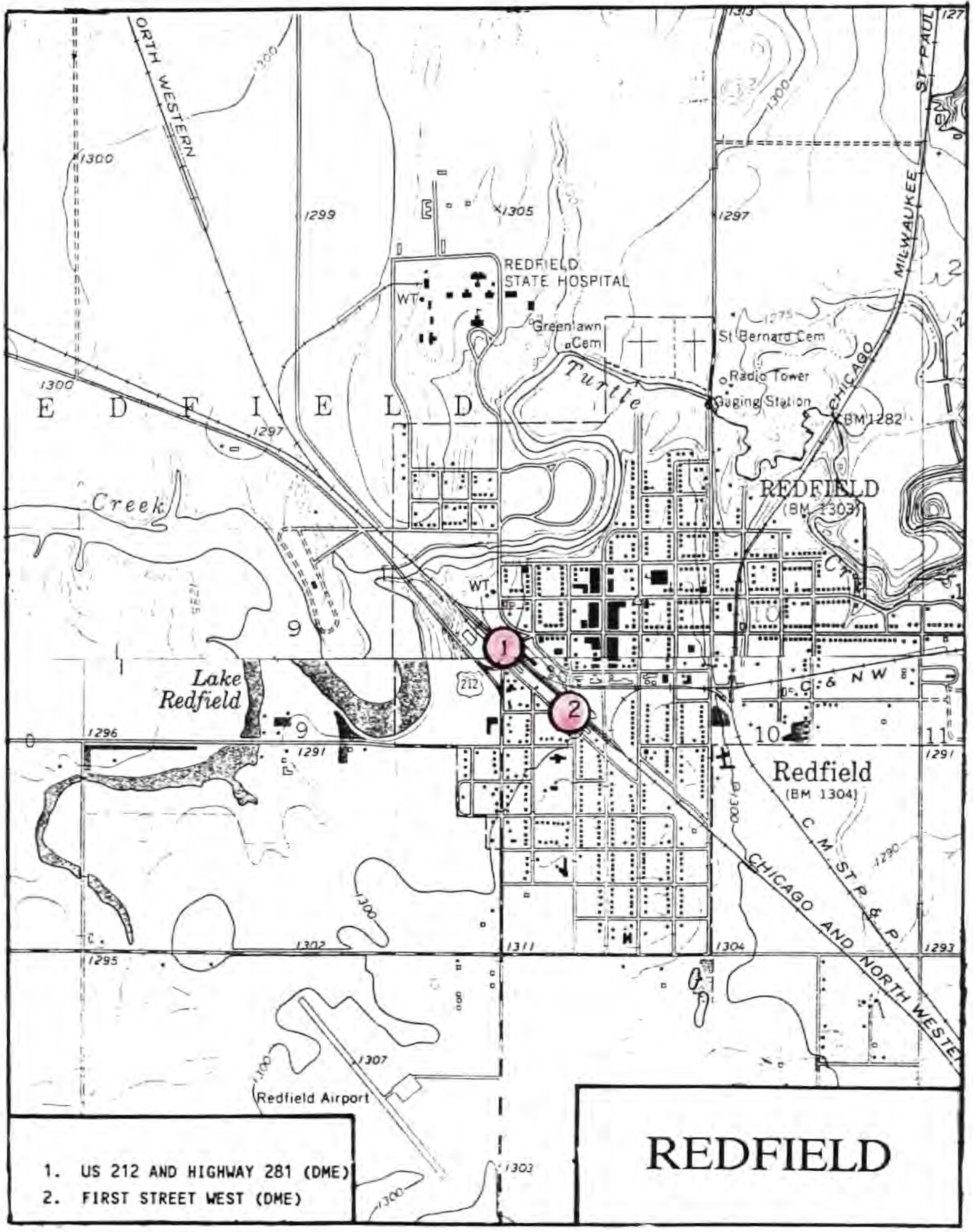
**A-4.5 Redfield**

**Crossing at US 212 and Highway 281**

Two Lanes - Two Tracks

The US 212 and Highway 281 crossing is a SAF&DRI (Course Grid) rubber type surfacing, and was built in 1982. The road pavement is asphaltic concrete and there are no headers. Highway 281 is a major artery with average daily traffic of 4,660 vehicles, a considerable percentage of which is truck traffic. There are bolted joints on both sides of the crossing. Rail traffic consists of two trains per week with four locomotives and 40 to 50 cars.

The asphalt approach on the sides of the crossing has settled in excess of 1 inch in relation to the outer panels, although some of the difference in elevation can be attributed to asphalt




LOCATION MAP 10

Photo 162. US 212 and Highway 281 at Redfield - Asphalt Apron Settlement and Rutting

Photo 163. US 212 and Highway 281 at Redfield - Mud-Filled Rail and Lateral Panel Shifting

rutting (See Photo 162). With the coarse grid SAF&DRI crossing it is not possible evaluate track deflections under rail traffic, since there are grooves on both sides of the rail. The rails and the crossing are fairly even but there is some settlement on each side of the crossing. As can be seen in Photo 163 there is considerable panel unevenness and some of the panels are shifted. The spaces between the rails and the inner and outer panels are completely filled with sand. Snow plow damage is local with the most serious damage confined to the outer edges of the outer panels.

Natural surface drainage is poor, since there are no ditches on either side of the crossing. Subsurface drainage appears good, however, as the near-surface soils consist of medium to fine sand. There is no evidence of pumping next to the track and no evidence of water pooling in between the rails.

**1st Street West**

Two Lanes - Five Tracks

The crossing at 1st Street West is of the ball-in mud rail type with both inside and outside mud rails. There is one main track and four side tracks. The age of the crossing is not known, however, the crossing is scheduled for reconstruction. The average daily traffic is approximately 300 vehicles per day, including seasonal truck traffic. Rail traffic consists of two trains per week with four locomotives and 40 to 50 cars, but the tracks are used for extensive switching traffic, especially during the harvest season. A switching engine is kept at the

Photo 164. Redfield at 1st Street West - Track and Rail Settlement

Photo 165. Redfield at 1st Street West - Overall View of Track Settlement and Crossing Condition

Photo 166. Redfield at 1st Street West - Track Settlement and Evidence of Pumping

depot. The rail weight varies from track to track and there are numerous bolted joints both within the crossing and at each end of the crossing.

The rail has settled up to 2 to 3 inches in relation to the pavement, as can be seen from Photos 164 and 165. The crossing is up to 6 inches higher at the center than the track at the ends. The track is also very uneven, with settlements relative to the pavement varying considerably along the crossing. Evidence of track deflections under train loads can also be seen, as there are scars in the asphalt on the outside of the rails from the railroad cars (See Photo 166). The asphalt is broken up on the aprons and the aprons have settled considerably towards the rails at most locations. The spaces between the mud rails and the main rail are completely filled with soil, yet there is very little difference in elevation between the main rail and the mud rails. There is no evidence of ballast on either side of the crossing for a distance of at least 30 feet.

Surface drainage at the location is poor and there is evidence of pooling water runoff from the crossing and the sides of the crossing. There is evidence of pumping underneath the asphalt near the rails where the asphalt has been lifted up and is, at some locations, several inches above the rail. There is little evidence of pumping at the main track but there has been maintenance performed on and near the crossing recently.

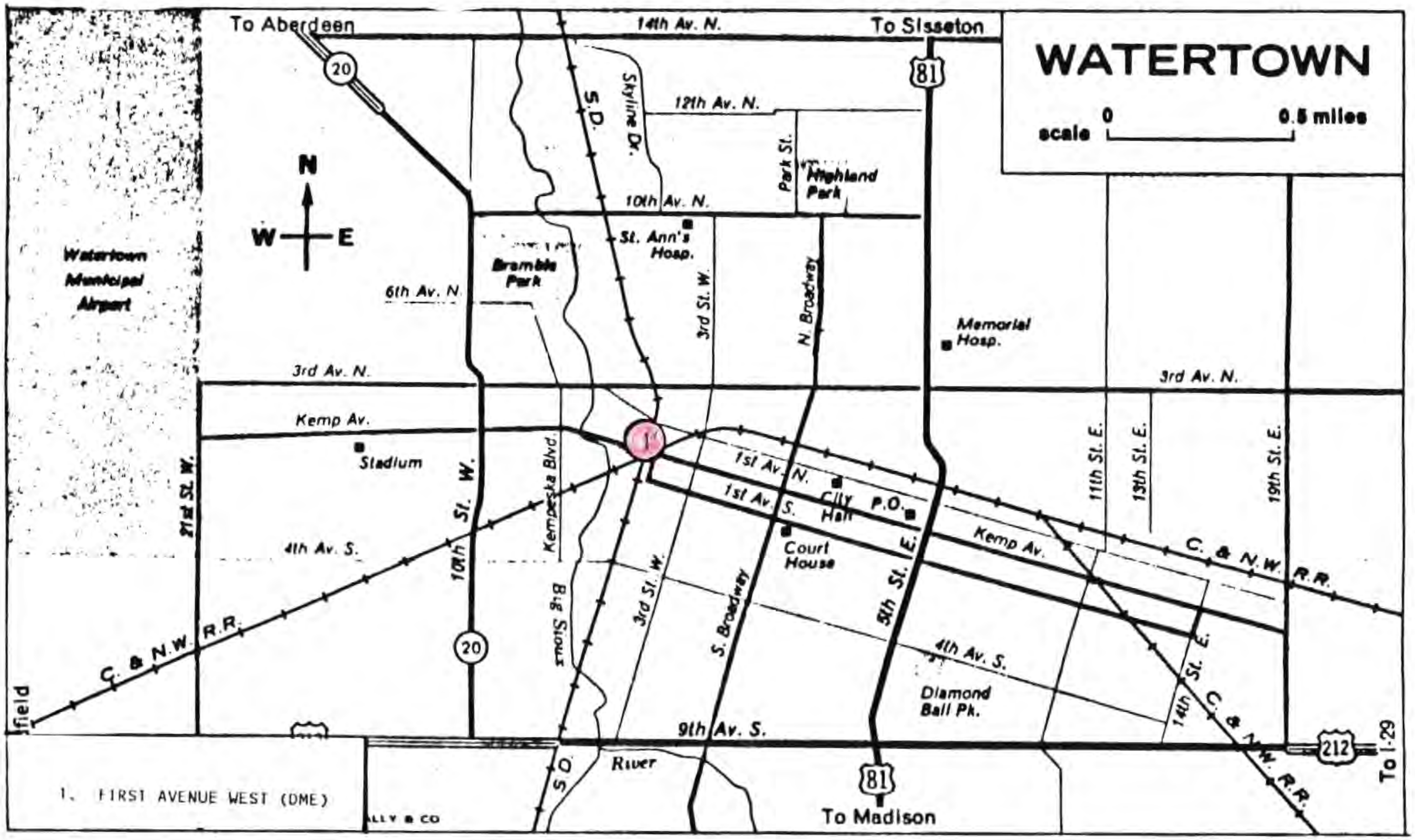
**A-4.6 Watertown**

**First Avenue West**

Two Lanes - One Track

This is a Redhawk type rubber crossing, with no visible headers. The crossing was rebuilt in 1986. The road pavement consists of asphaltic concrete. The average daily traffic on First Avenue is approximately 1,500 vehicles with a small percentage of trucks. The rail traffic consists of one train per week with up to four locomotives and 40 to 50 cars, however, the train both arrives and leaves Watertown on this track. The track consists of 115 pound weight and continuously welded rail, with no bolted joints inside or outside the crossing.

There is no evidence of track deflection under rail traffic, as there are no visible signs of wear on the outside panels next to the rails (See Photo 167). Rail deflections at the ends of the crossing ranged from 1/16 to 1/32 of an inch. The overall settlement of the crossing in relation to the asphalt pavement is up to 1/2 inch on the east side of the crossing and 3/4 inch on the west side, with most of the differential movement in the south (eastbound) lane. Panel separation laterally is up to 1/4 inch and the space between the panels is filled with fine sand. Vertical shifting of the panels is minor and may all be contributed to installation (See Photo 168). The asphalt contact between the rubber panels is good, however, minor breakage can be seen at some locations, especially at the east side of the




LOCATION MAP 11

Photo 167. Watertown at First Street West - Settlement and Overall Condition

Photo 168. Watertown at First Street West - Minor Vertical Shifting of Panels

Photo 169. Watertown at First Street West - Condition of Asphalt Apron

crossing (See Photo 169). Snow plow damage is minor and panel wear is minimal.

Natural surface drainage at the crossing is good, as the embankment is from 6 to 10 feet above the surrounding terrain. Hence there is neither any evidence of track pumping nor any signs of water pooling between the tracks at the approaches to the crossing.

**A-4.7 Sioux Falls**

**SD 38A NW of Airport**

Two Lanes - One Track

The crossing at SD 38A northwest of the airport is a ParkCo type rubber crossing with 6 inch wide asphalt headers. The road pavement is Portland Cement concrete. The crossing was originally built in 1975, but has been repaired at several occasions since. The average daily traffic is 5,100 vehicles, with a high percentage of trucks. Train traffic consists of two trains per week with approximately 50 to 60 cars. The track consists of 115 pound weight rail with bolted joints within a few feet of the crossing at both the north and south ends.

The settlement of the crossing in relation to the concrete pavement is less than 1/2 inch. There is little wear on the rubber panels along the rails, hence track deflection under rail traffic appears to be minor. The headers are failed and appear to have been patched and repaired several times (See Photo 170). Lateral panel separation is less than 1/4 inch and vertical


LOCATION MAP 12

Photo 170. Highway 38A Northwest of Airport - Failed and Patched Headers

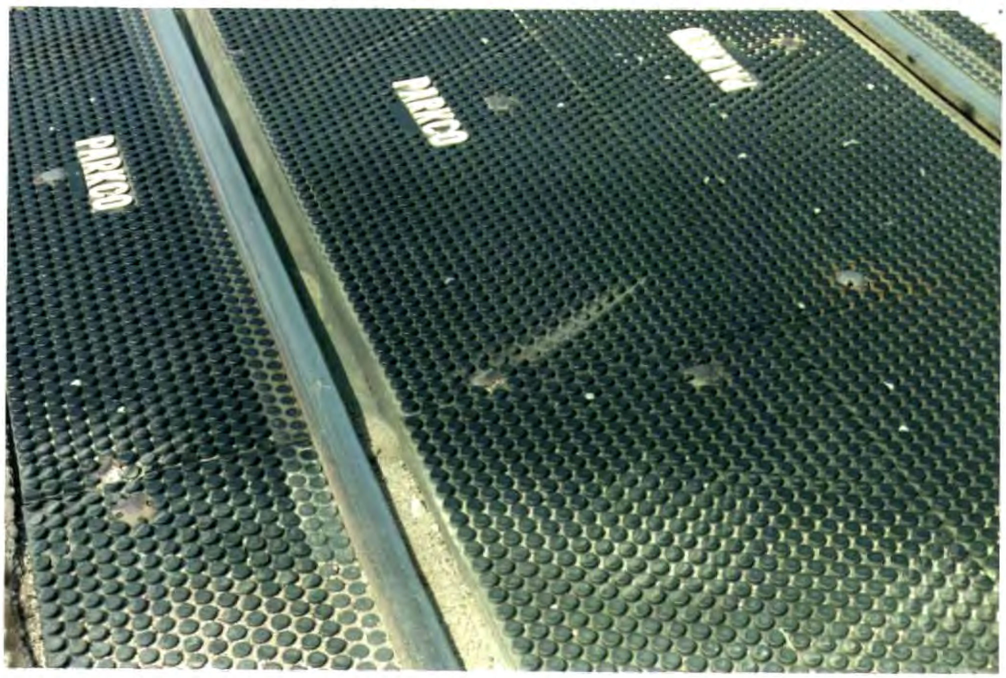



Photo 171. Highway 38A Northwest of Airport - Minor Scarring from Snow Plows

offset between the panels is insignificant. The spaces between the rails and the center panels contain some debris but no hard-packed soil. Snow plow damage is minor and is confined to minor scarring (See Photo 171).

Drainage at the crossing is good, as the railroad and road embankments are a minimum of 5 feet above surrounding terrain. There is no evidence of pumping at the ends of the crossing and no evidence of pooling water in between the rails. There are track settlements, however, at the bolted joints, especially at the north end of the crossing where the ties are failing.

**1/2 Mile East of Minnehaha County 131**

Two Lanes - One Track

This crossing is located on a gravel road approximately 1/2 mile east of Minnehaha County 131 and 1/2 mile north of SD 38A. It is a timber panel crossing which was installed in 1989. Average daily traffic is less than 50 light vehicles. Railroad traffic consists of two trains per week three locomotives and 50 to 60 cars. The rail weight could not be determined, however, there are no bolted joints neither within or near the crossing.

The crossing is on the sloping portion of a hill. On the uphill portion of the crossing the outer timber panels are approximately 3/4 inch lower than the asphalt header, however, the gap is filled with gravel (See Photo 172). On the downhill side of the crossing the pavement is from 1/2 to 3/4 of an inch below the outer timber panels. Thus, overall movement of the crossing

Photo 172. 1/2 Mile East of Minnehaha County 131 - Crossing and Apron Vertical Movements

Photo 173. 1/2 Mile East of Minnehaha County 131 - Frayed Timber Panels

Photo 174. 1/2 Mile East of Minnehaha County 131 - Snow Plow Damage

Photo 175. 1/2 Mile East of Minnehaha County 131 - Uneven Timber Panels

relative to the road is difficult to estimate. There is evidence of rail deflections at the approaches to the crossing, as the timber panels have become frayed from the rail traffic (See Photo 173). The timber panels are in good shape although some snow plow damage has occurred (See Photo 174). The track is completely filled with fine sand and silt and some of the inner timber panels adjacent to the rails appear to be slightly higher than the rails and the outer timber panels. This can be seen on in the upper portion of Photo 175.

Natural surface drainage at this crossing is good, as there are ditches on all sides of the crossing and provisions were made for drainage from the north end to the south end of the crossing. There is no evidence of pumping or of water pooling in between the rails.

# APPENDIX B

# GRADATION CURVES

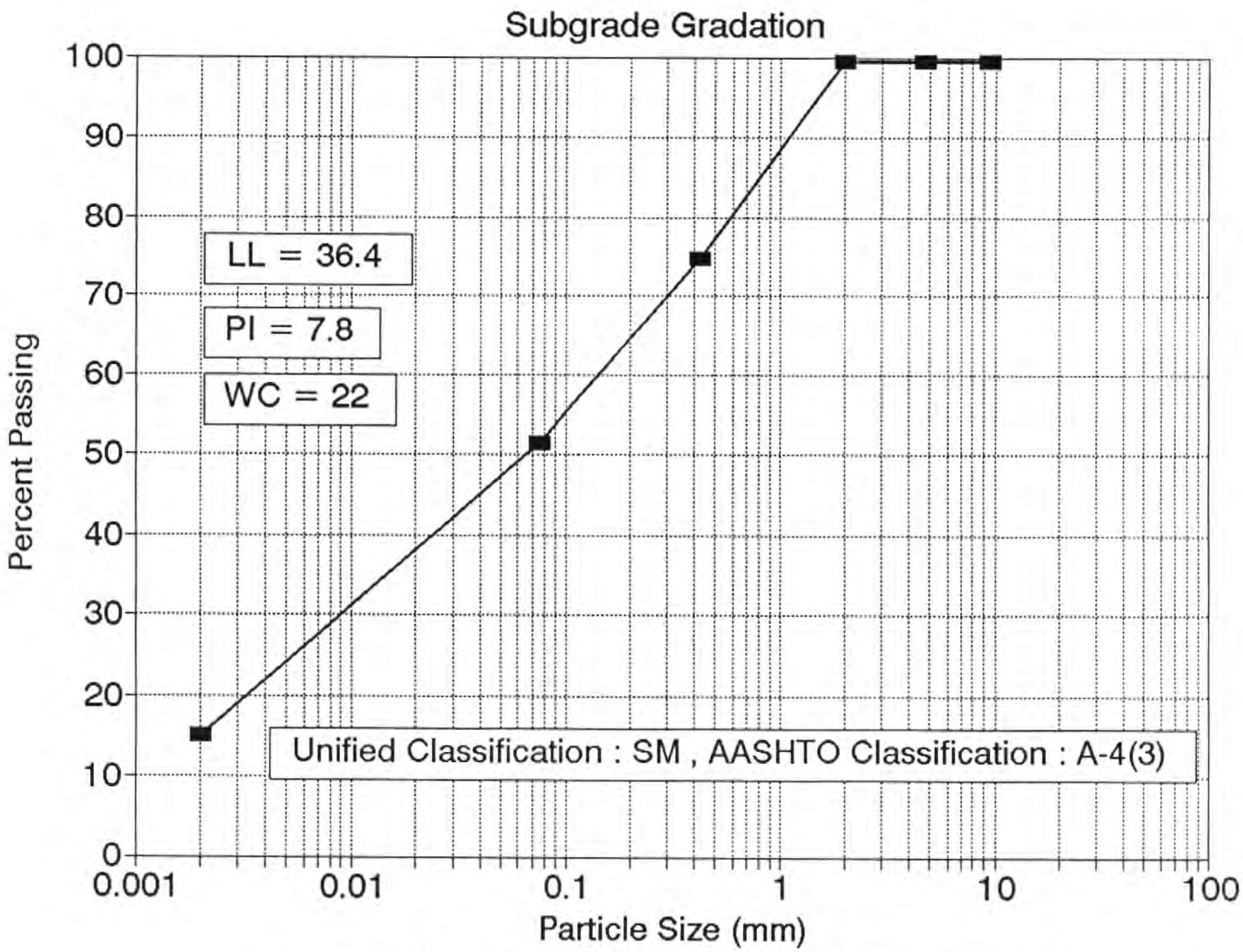



Figure B1 LaCrosse Street , Rapid City (Rubber)

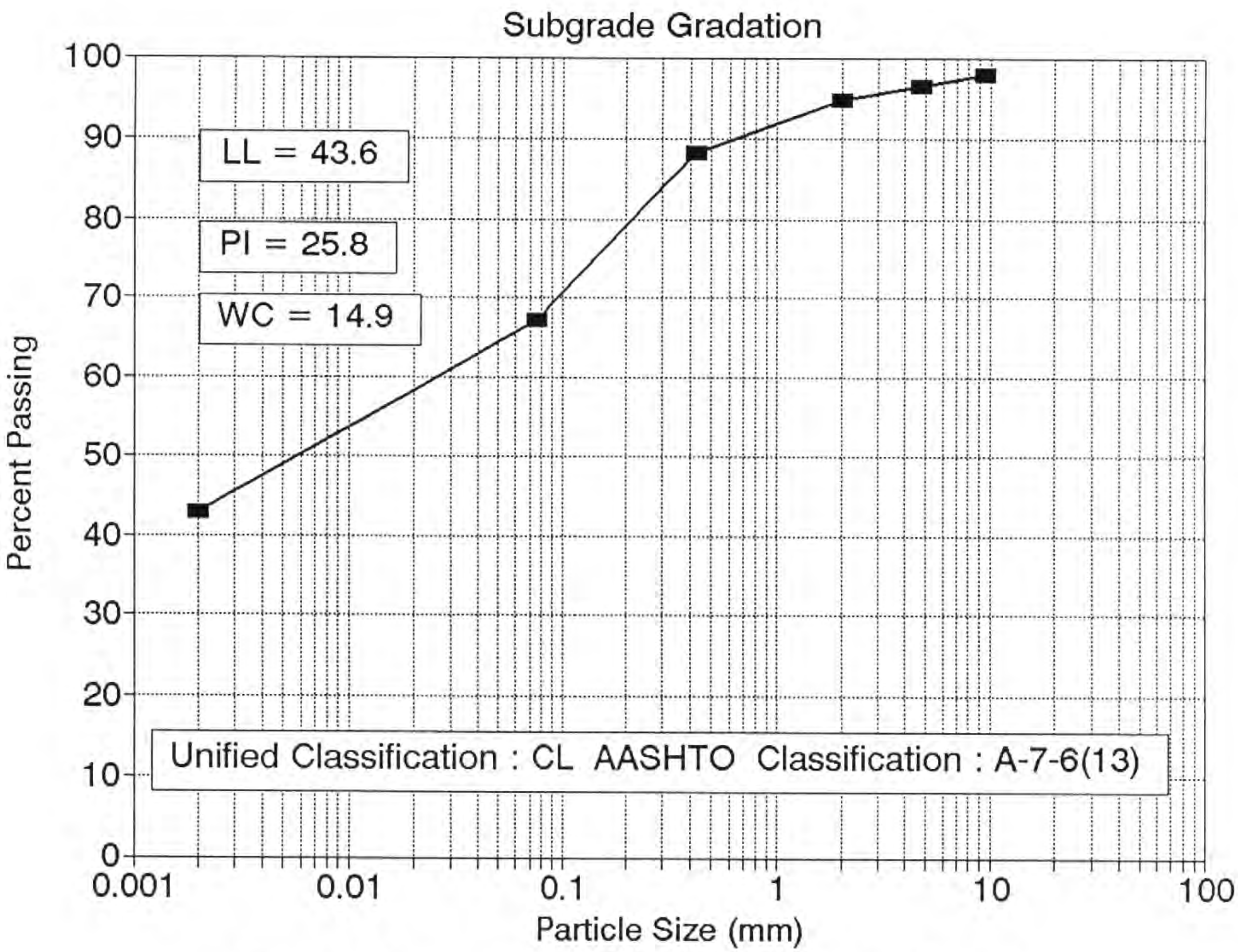



Figure B2 Steele Avenue, Rapid City (Asphalt)

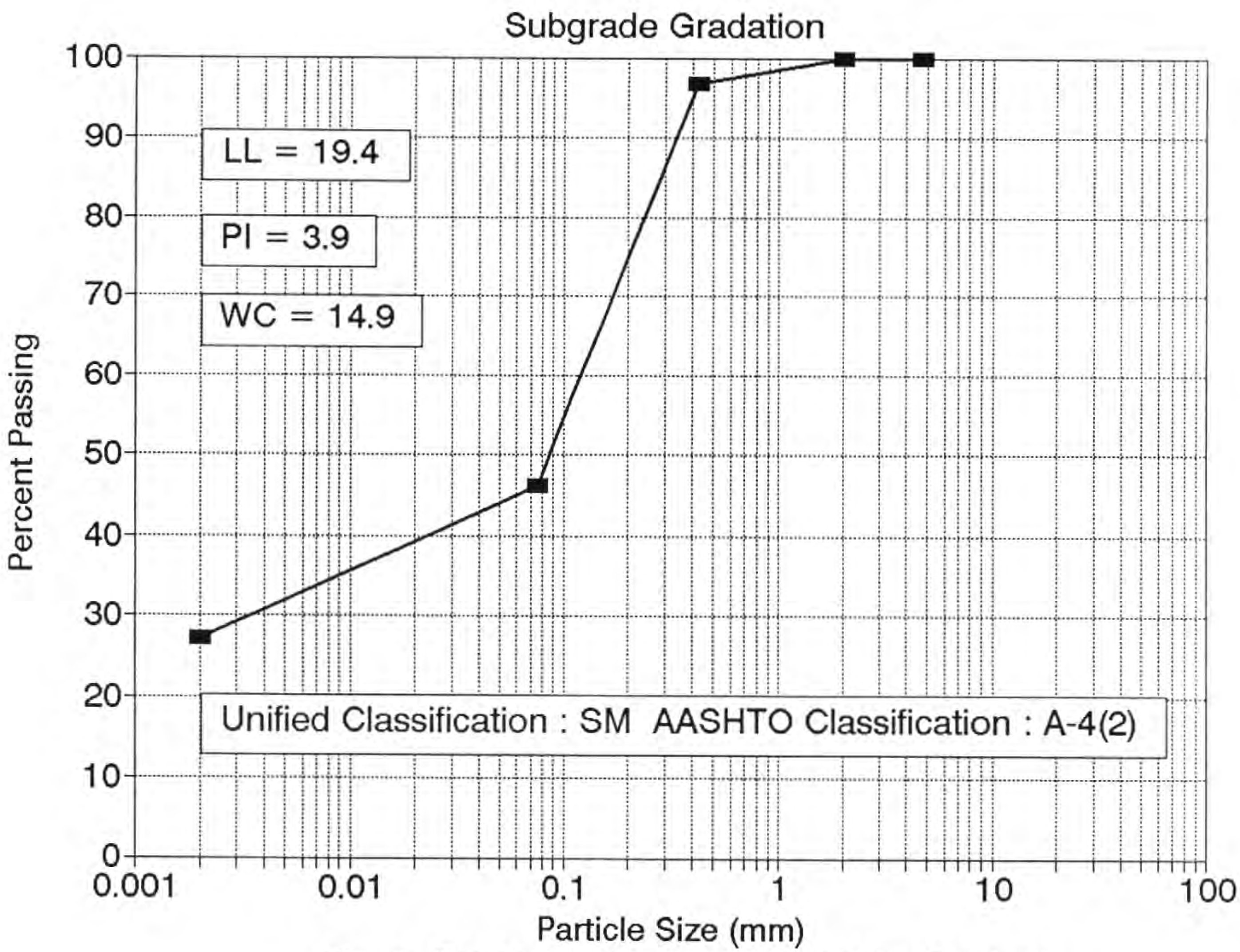



Figure B3 Maple Avenue, Rapid City (Rubber)

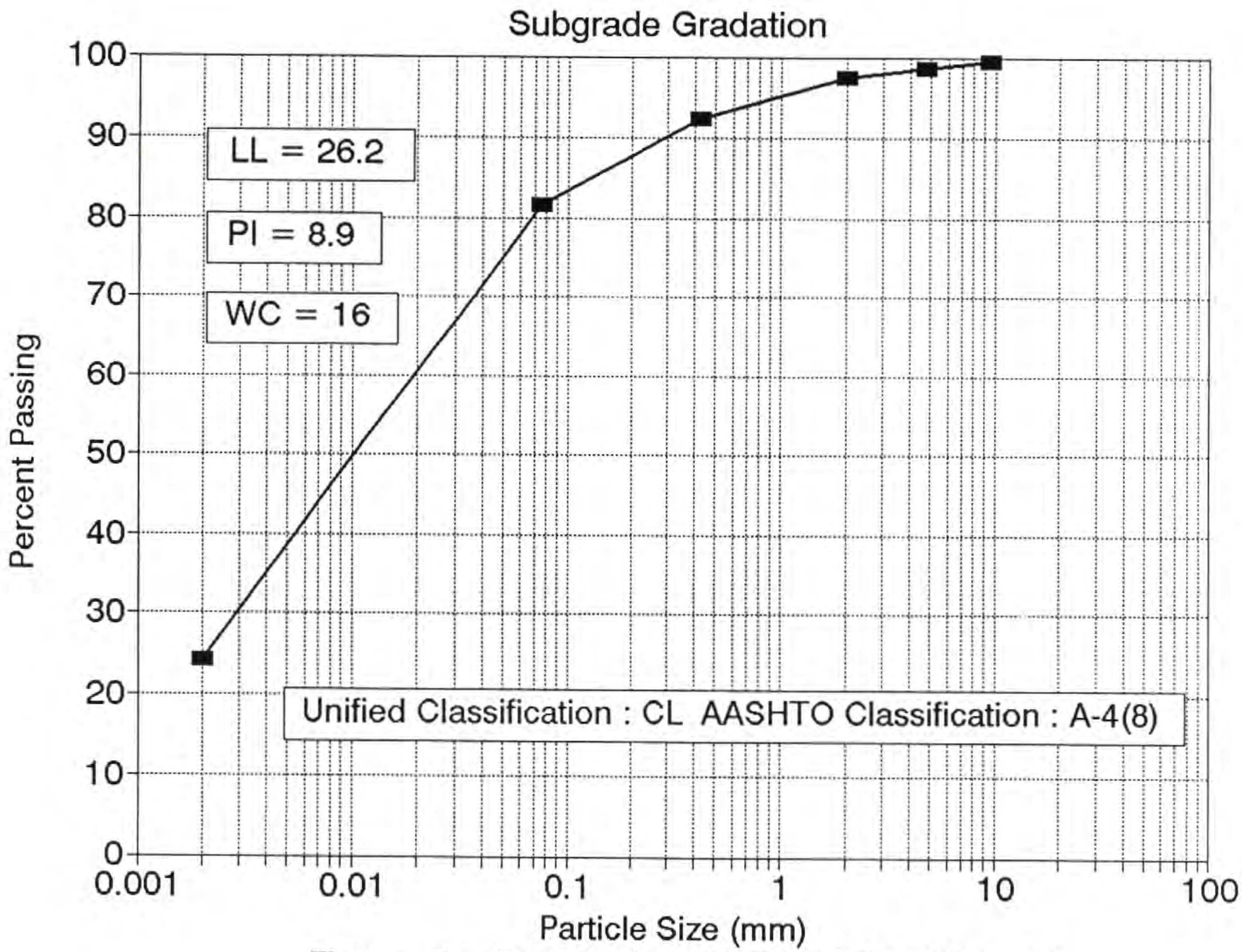



Figure B4 East Boulevard, Rapid City (Rubber)

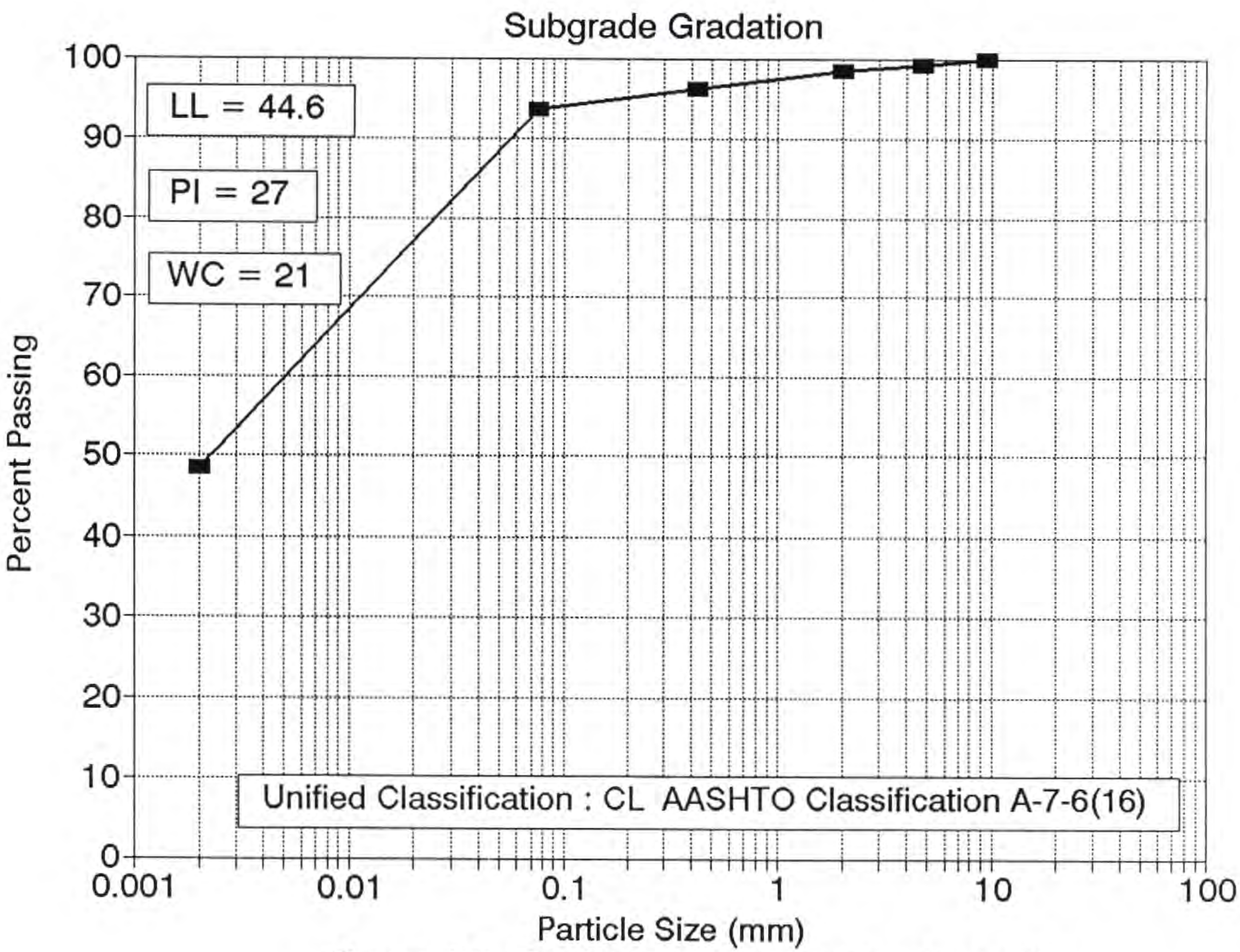



Figure B5 Third Street , Rapid City (Asphalt)

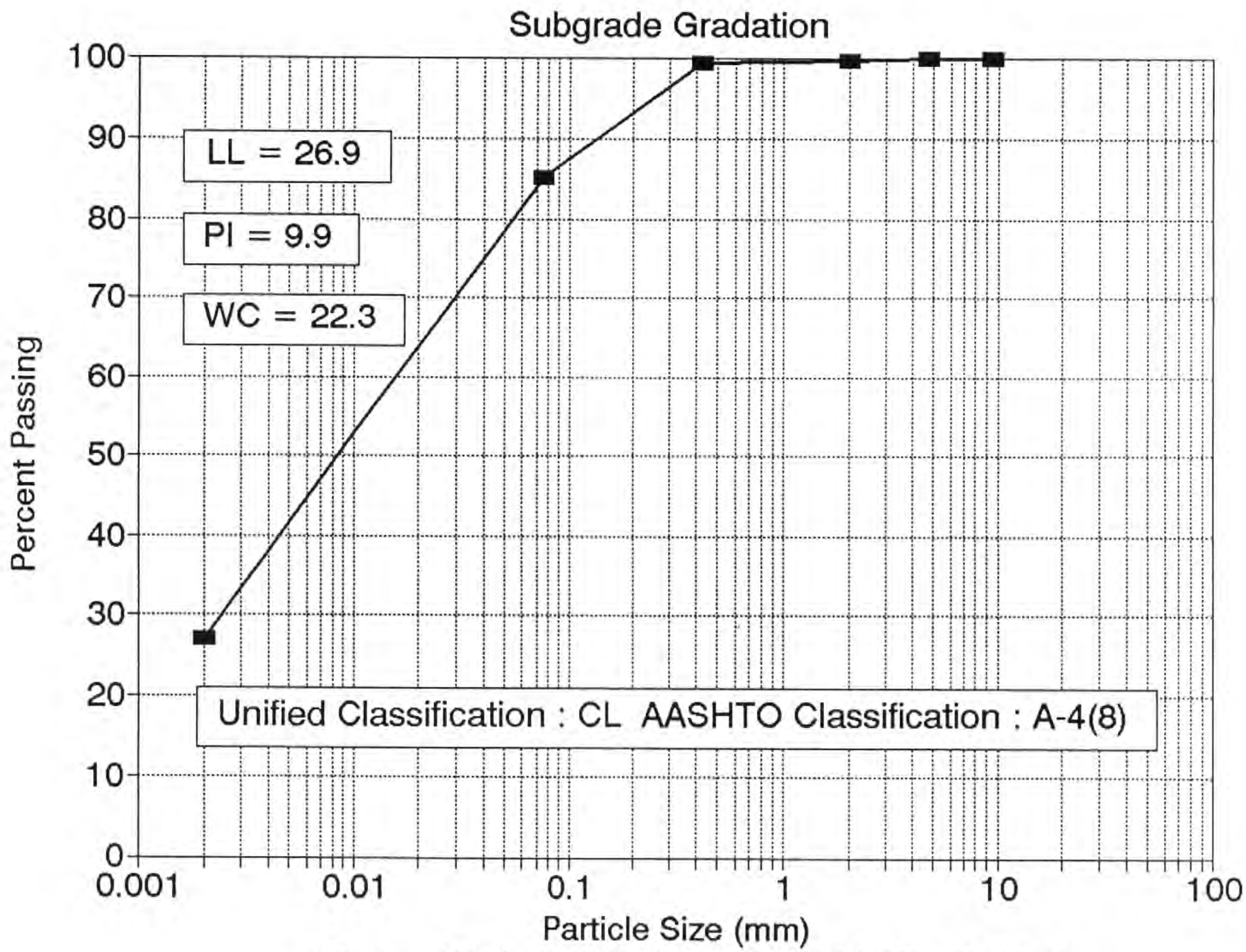


Figure B6 West Boulevard, Rapid City (Rubber)

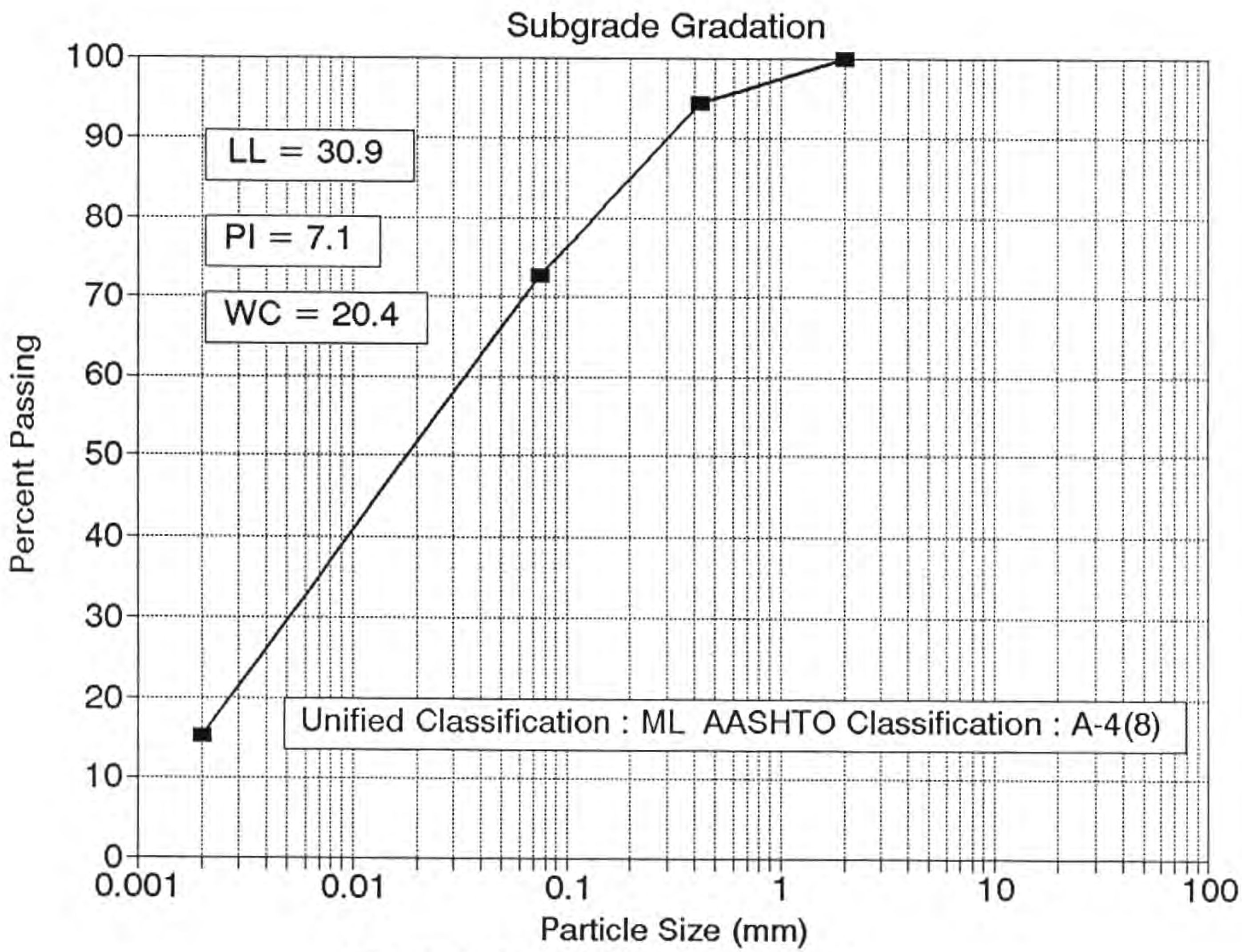



Figure B7 Black Hawk (Timber)

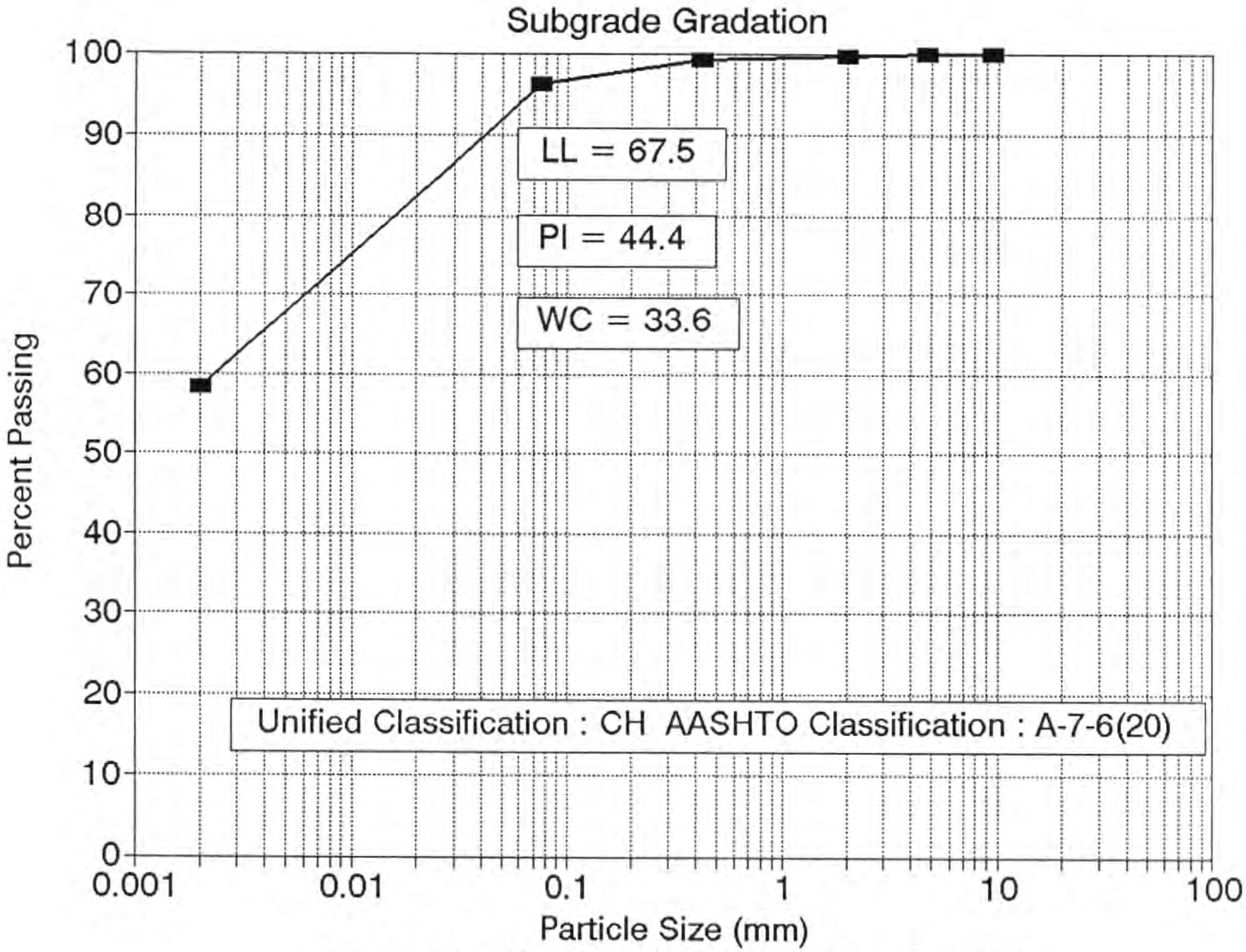



Figure B8 Harrison Avenue, Pierre (Rubber)

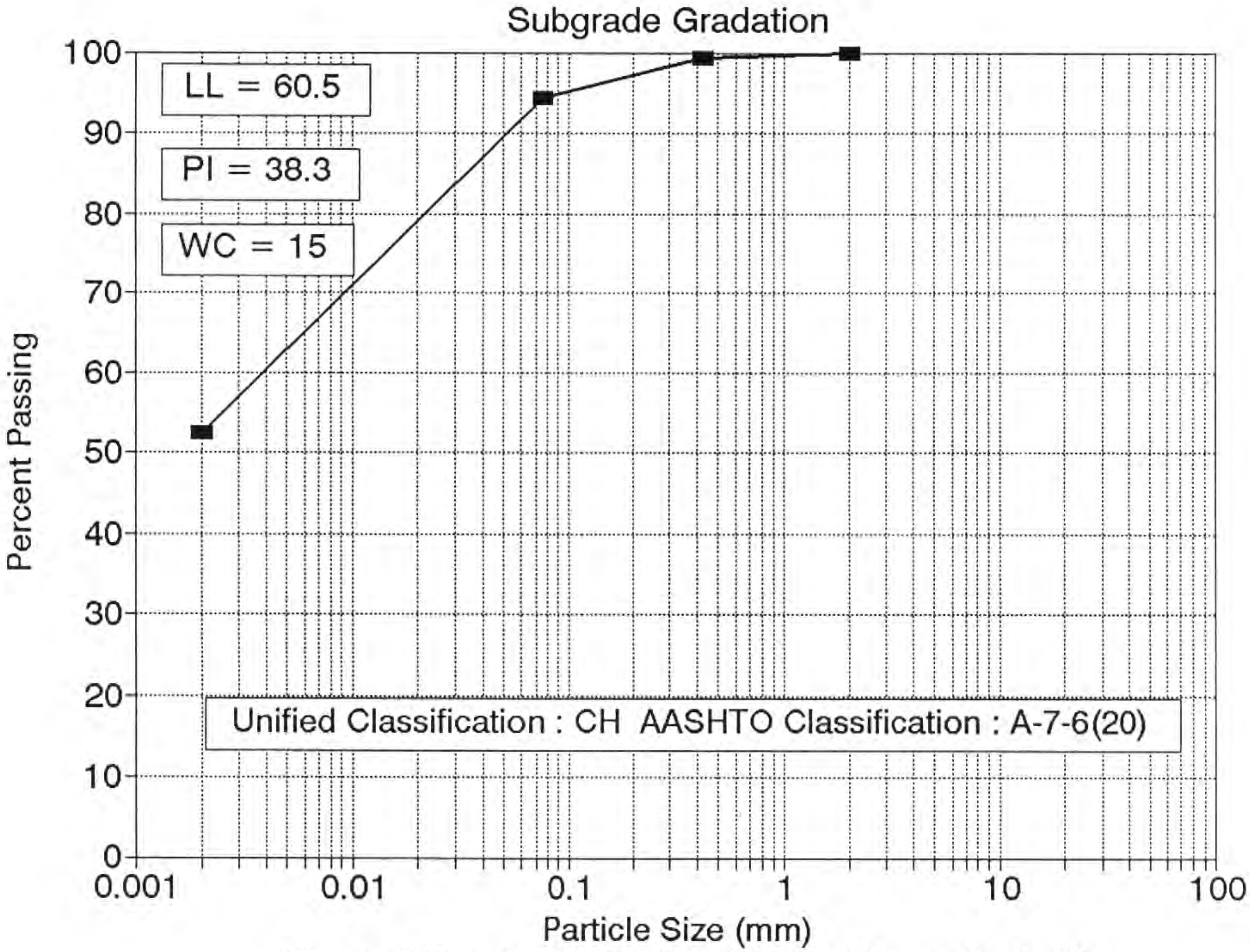



Figure B9 Indian Learning Center, Pierre (Asphalt)

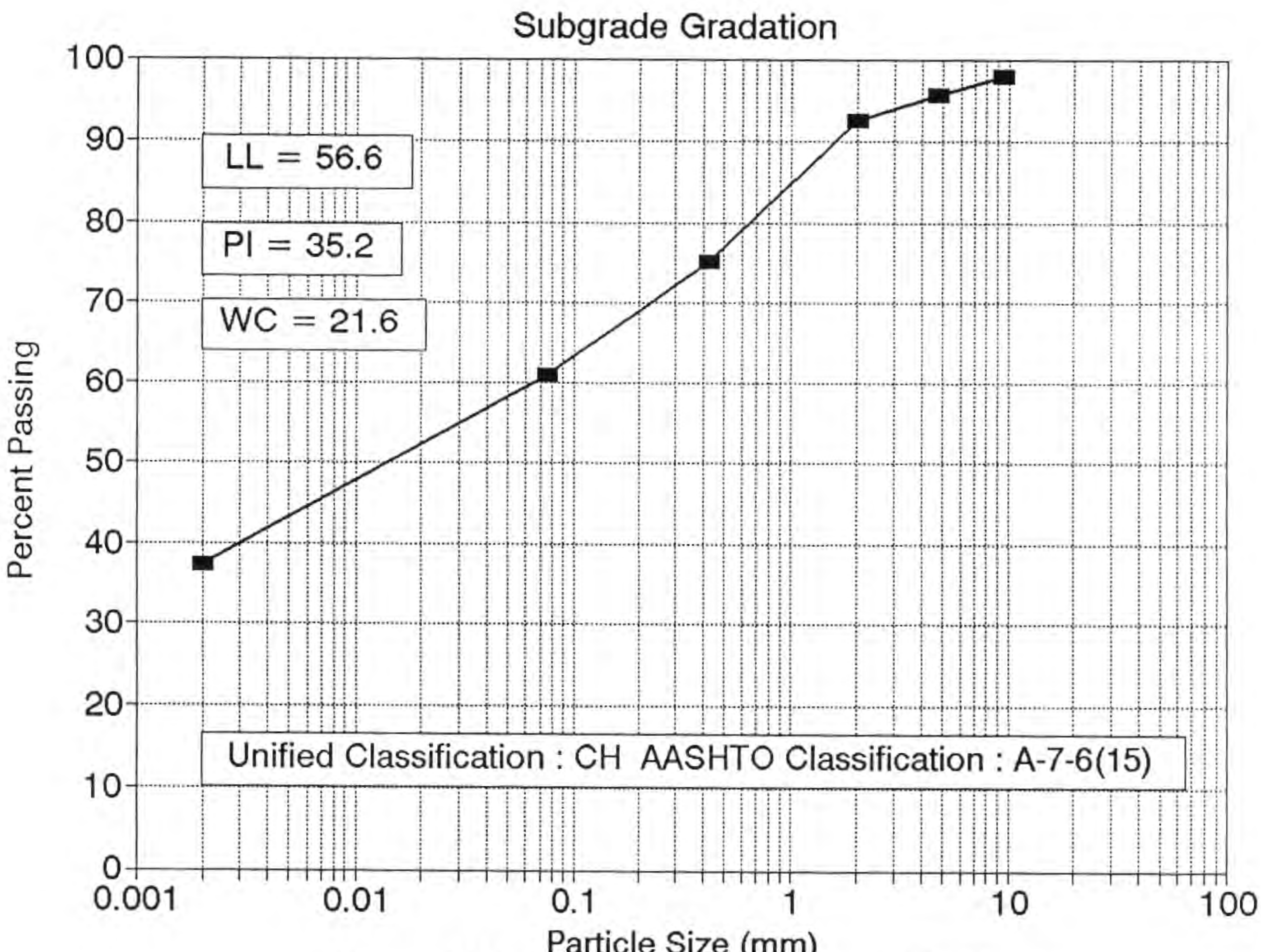



Figure B10 Central Avenue, Pierre (Rubber)

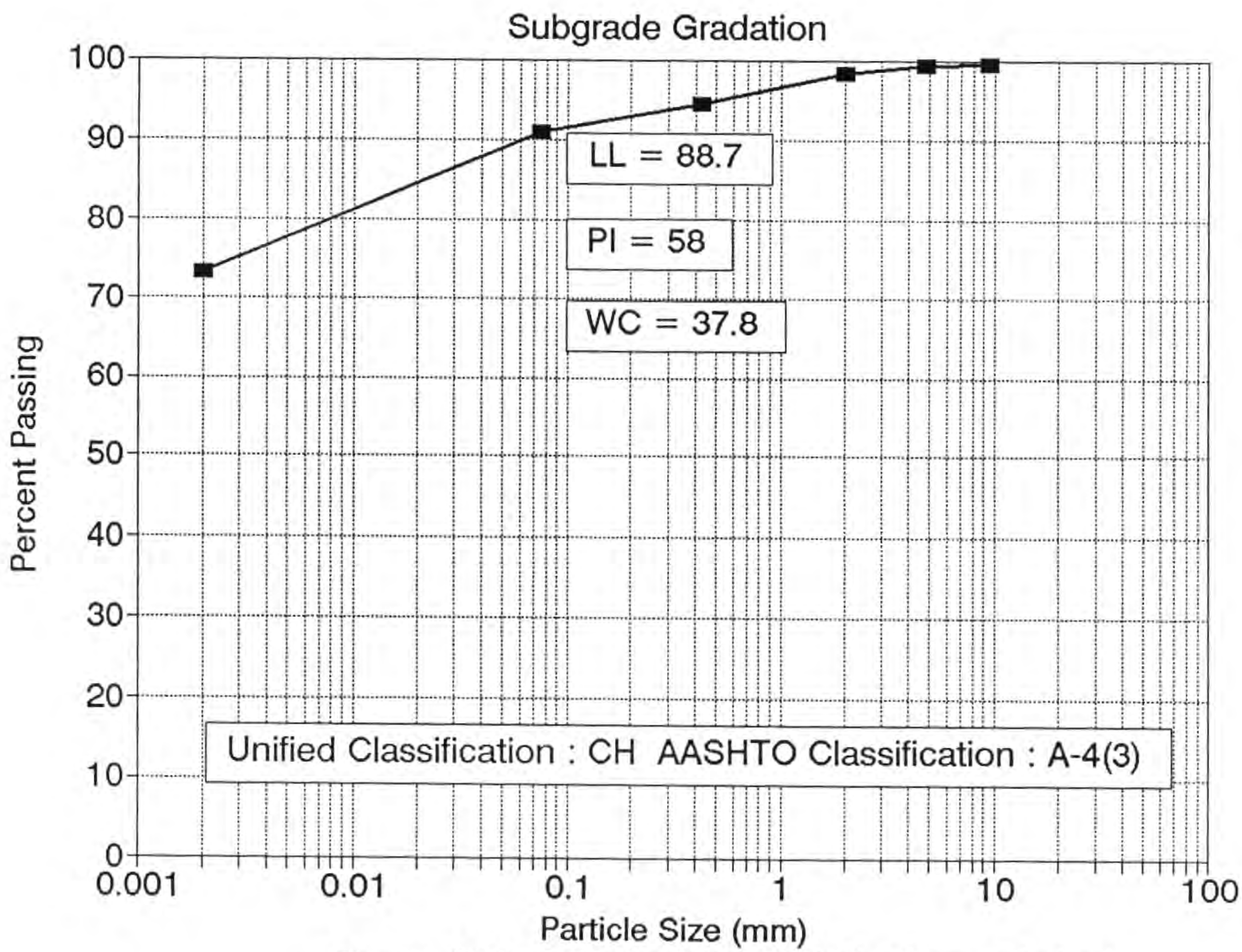



Figure B11 Sale Barn Road at Ft. Pierre (Timber)

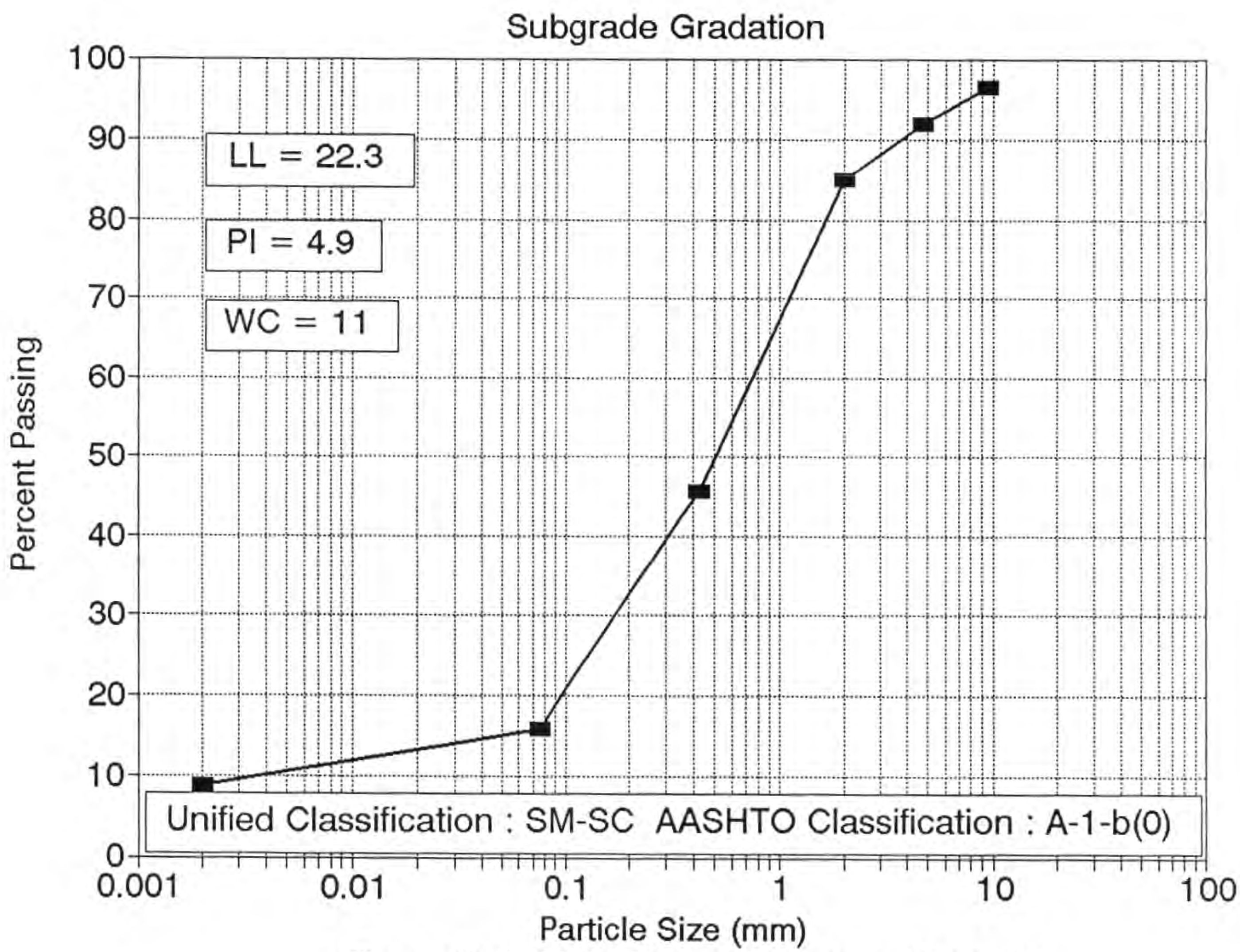


Figure B12 Main Street, Aberdeen (Rubber)

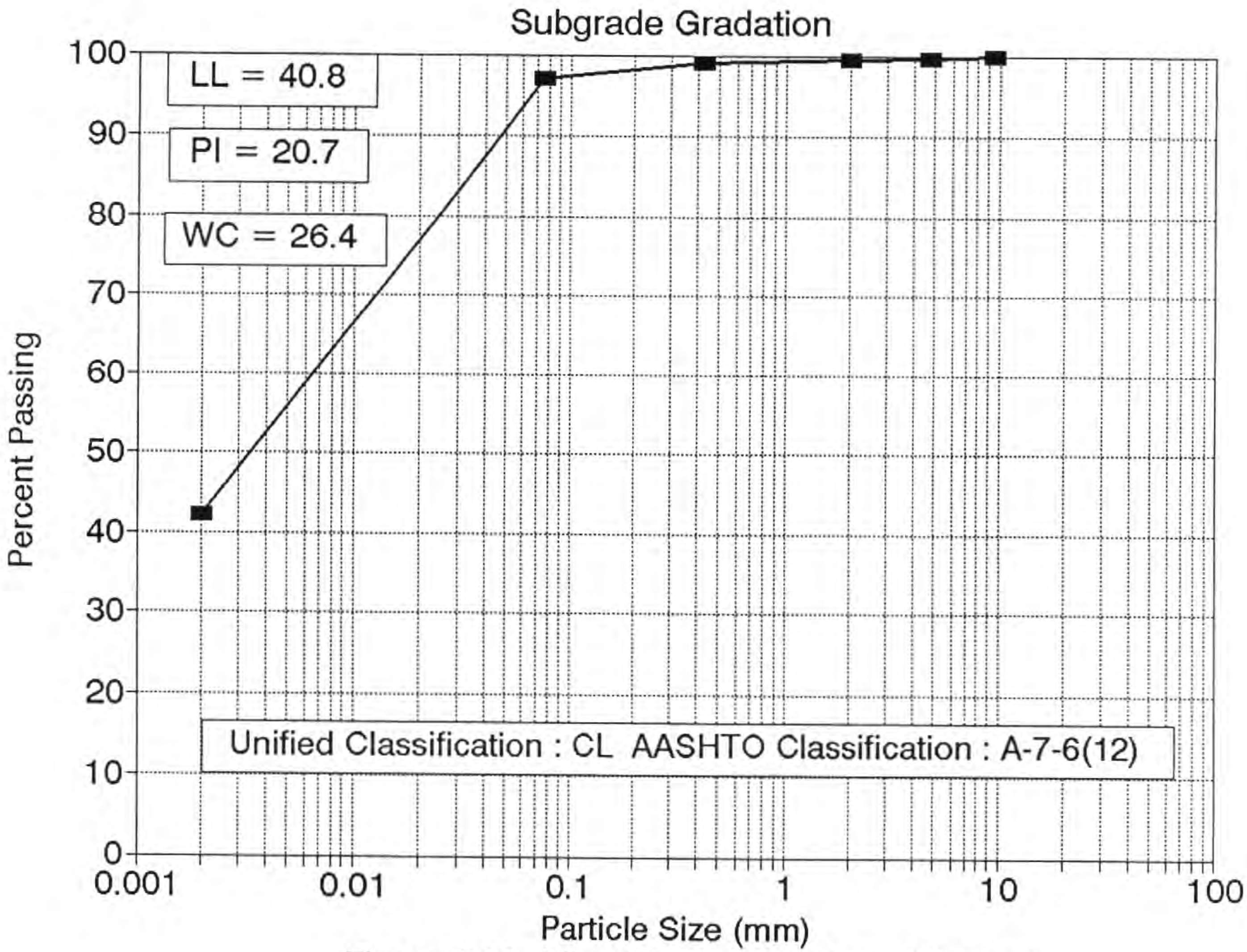



Figure B13 Kline Street, Aberdeen (Rubber)

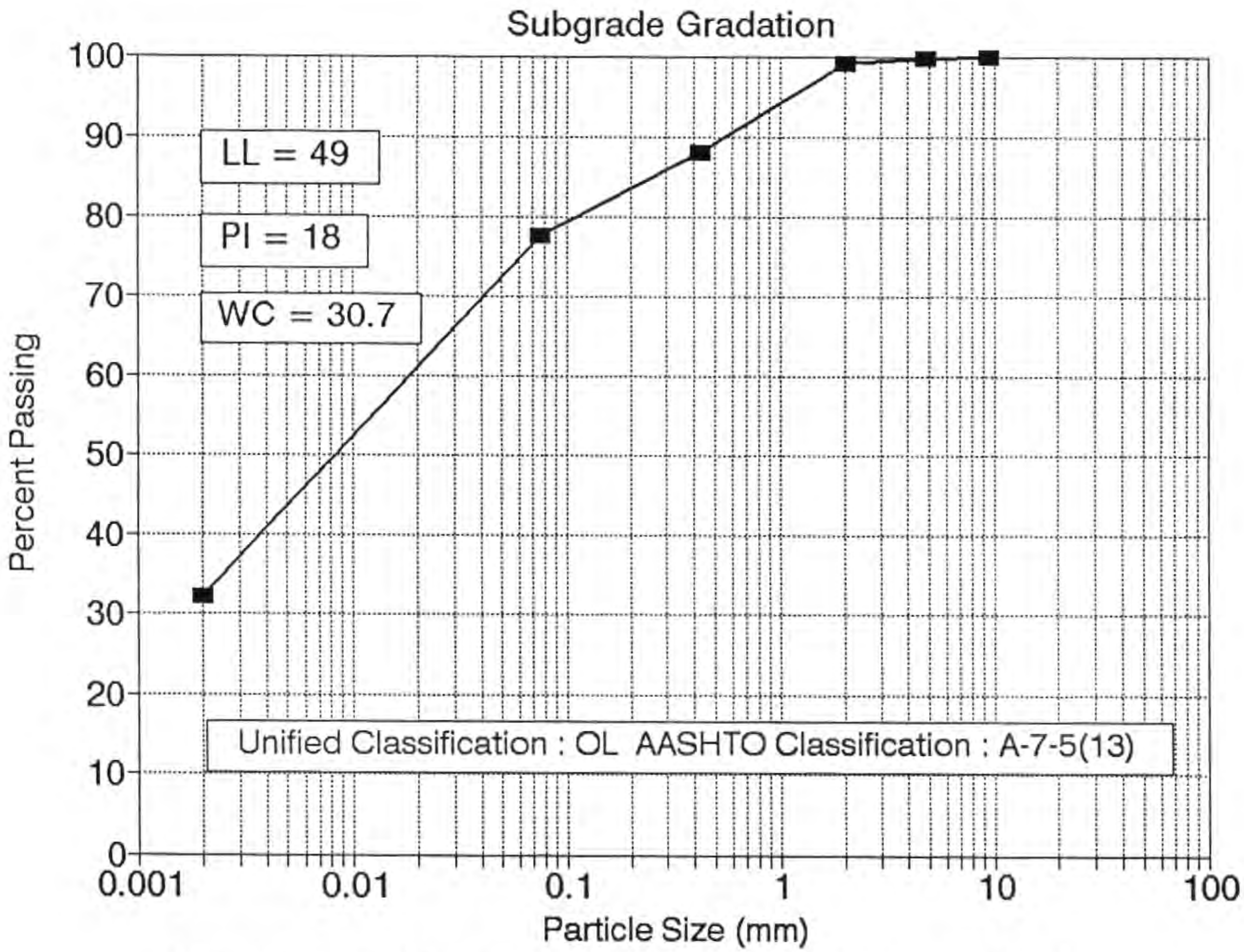



Figure B14 Brown County # 14, Aberdeen (Timber)

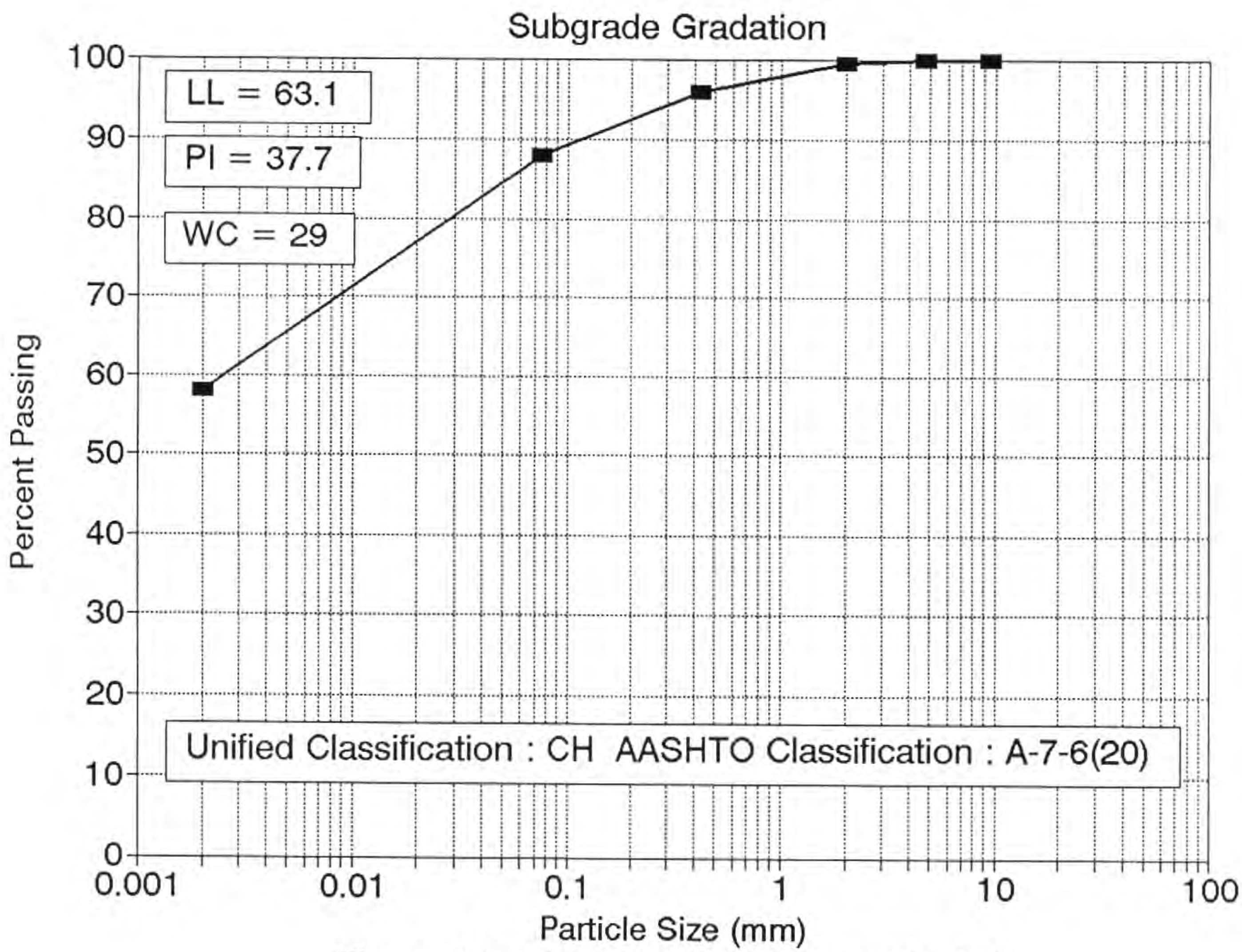


Figure B15 Fifth Street, Aberdeen (Asphalt)

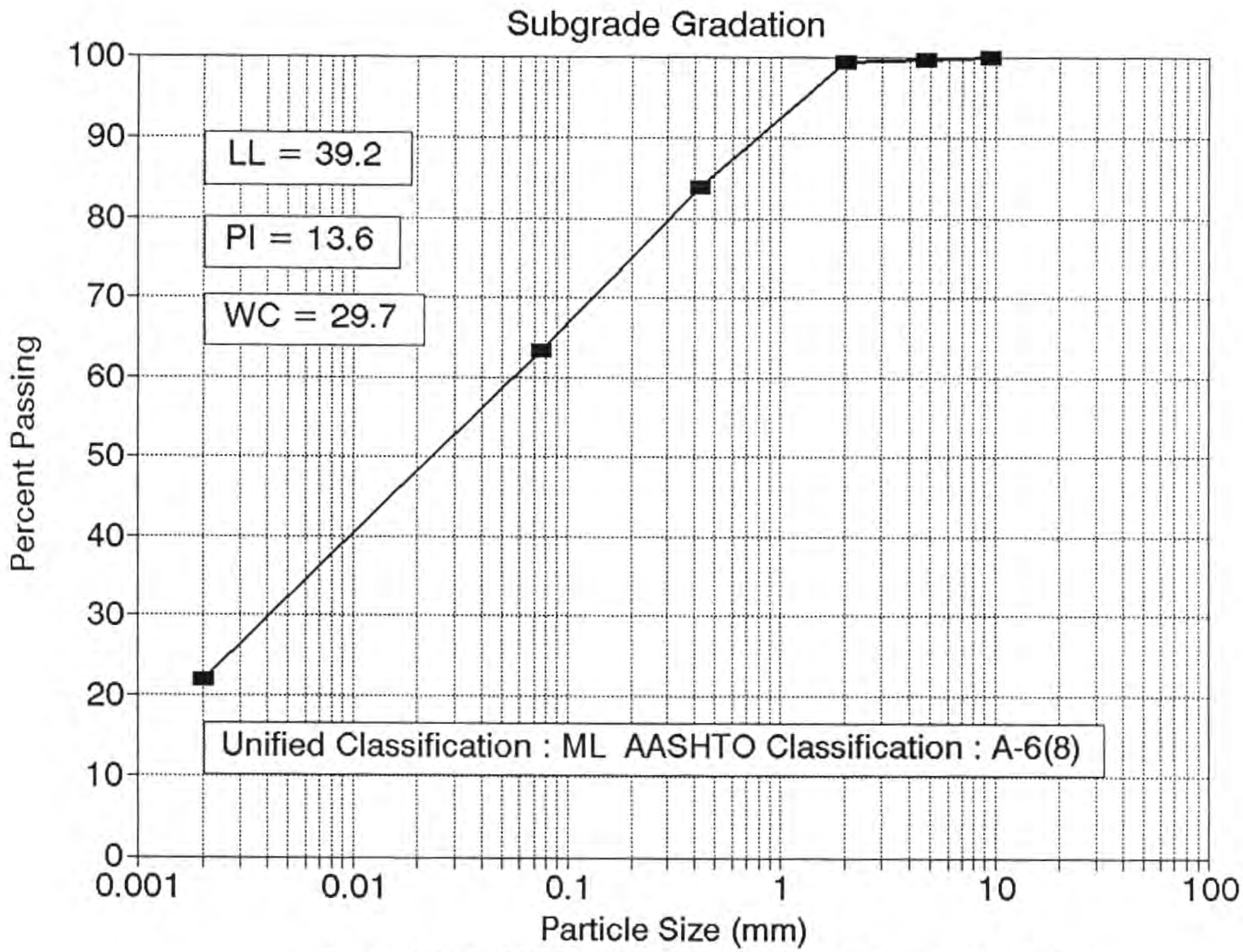



Figure B16  North Broadway, Watertown (Rubber)

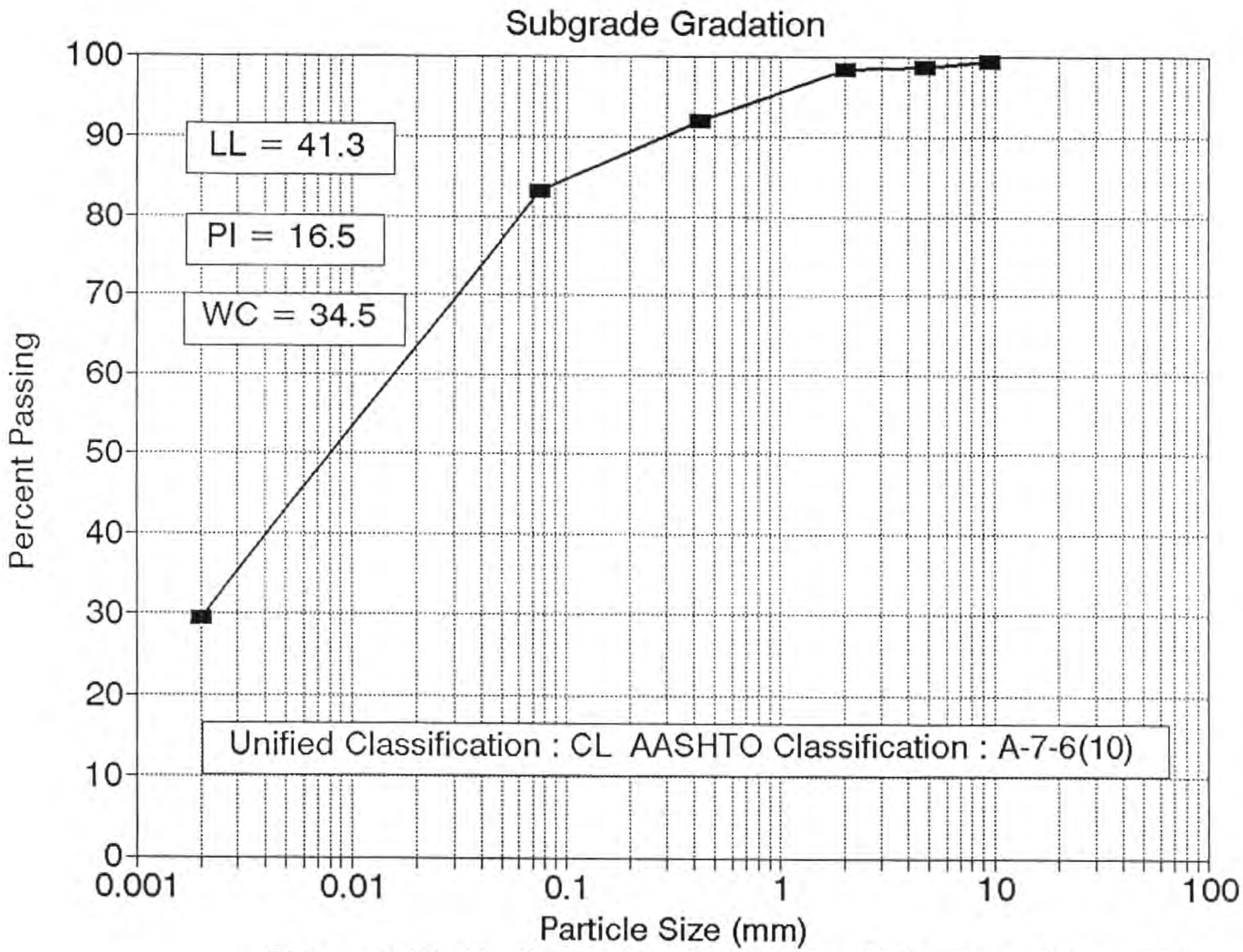



Figure B17 North Maple, Watertown (Rubber and Asphalt)

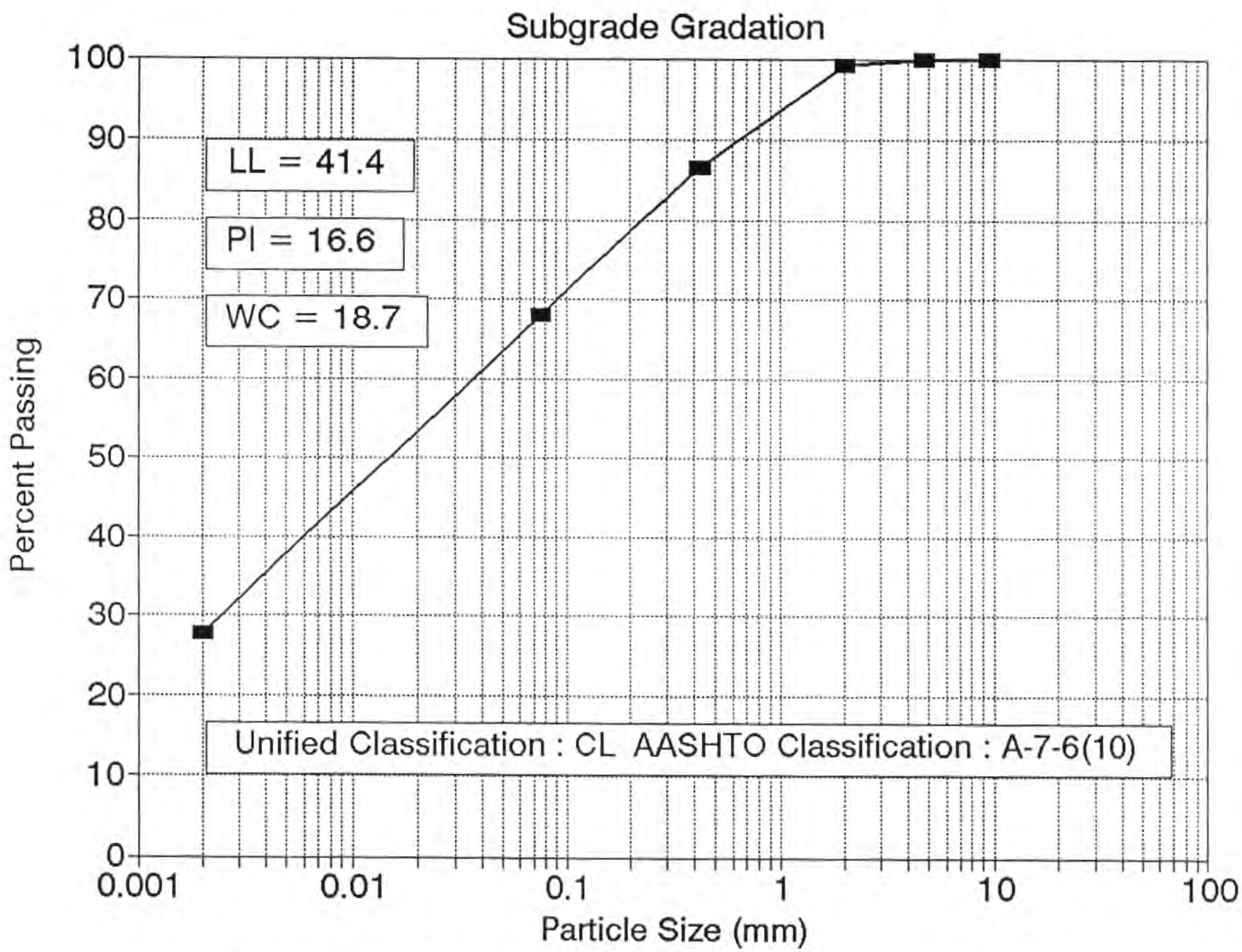



Figure B18 Eleventh Street North , Watertown (Rubber)

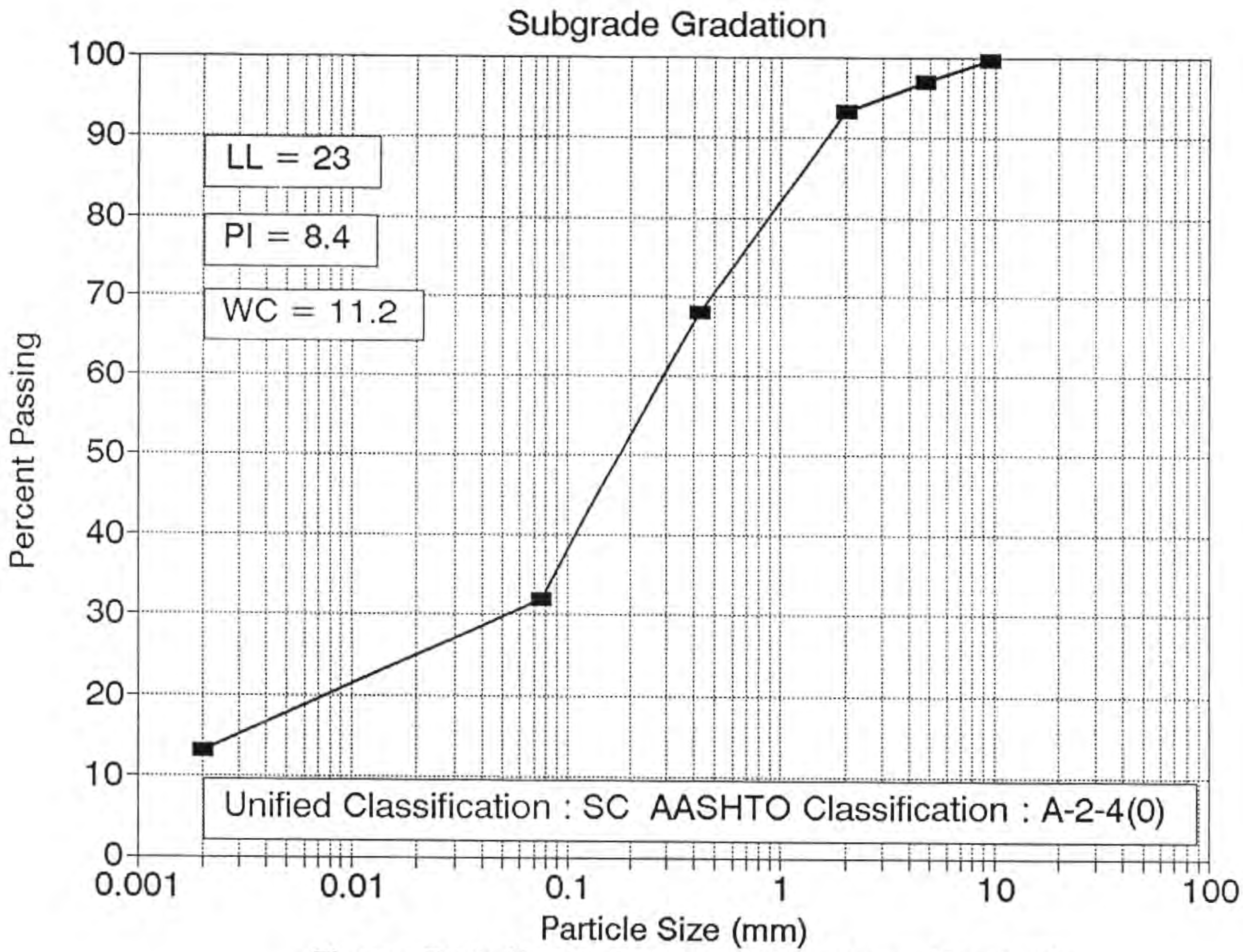



Figure B19 Kemp Avenue, Watertown (Asphalt)

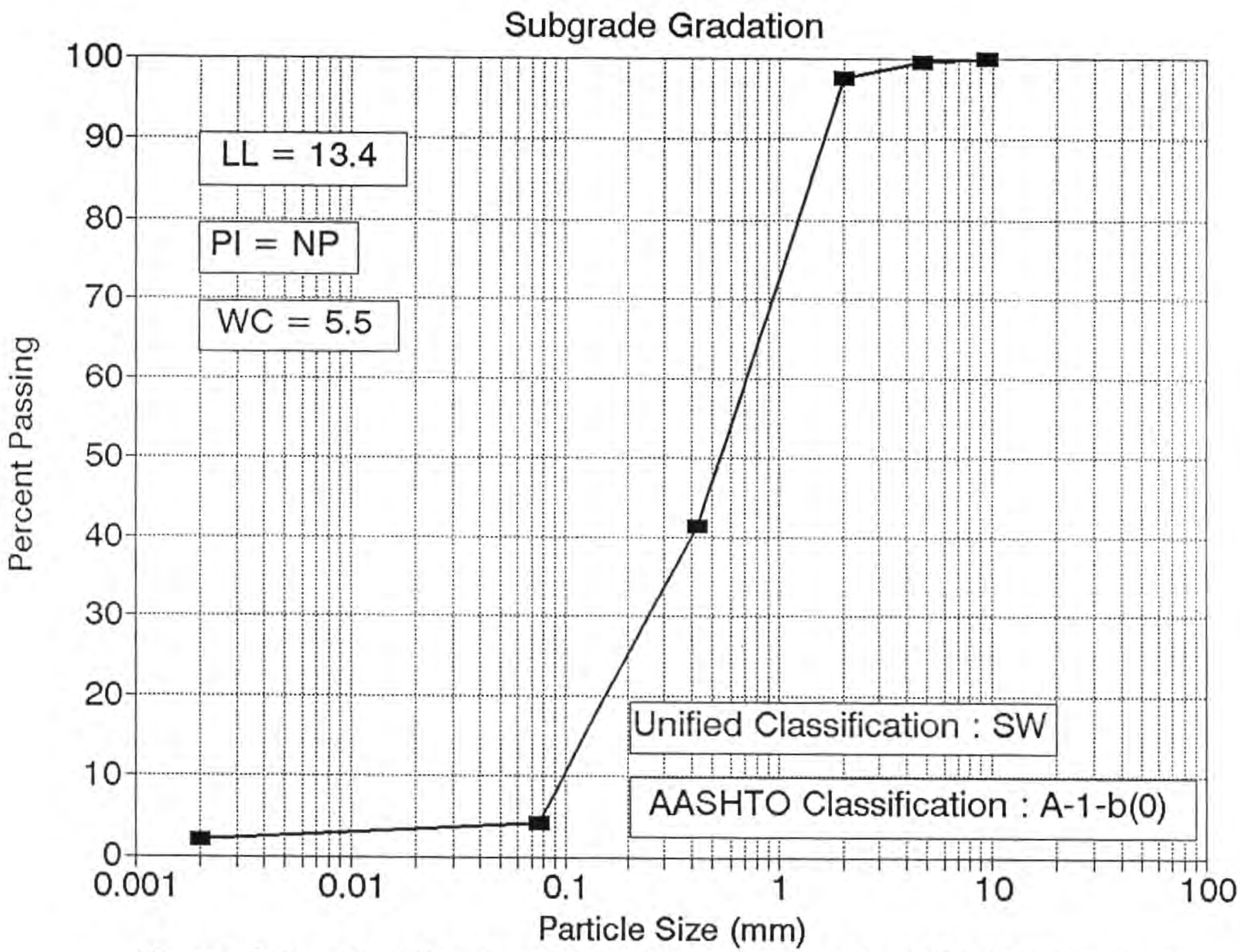


Figure B20 1.2 Miles East of Watertown, South of US212 (Timber)

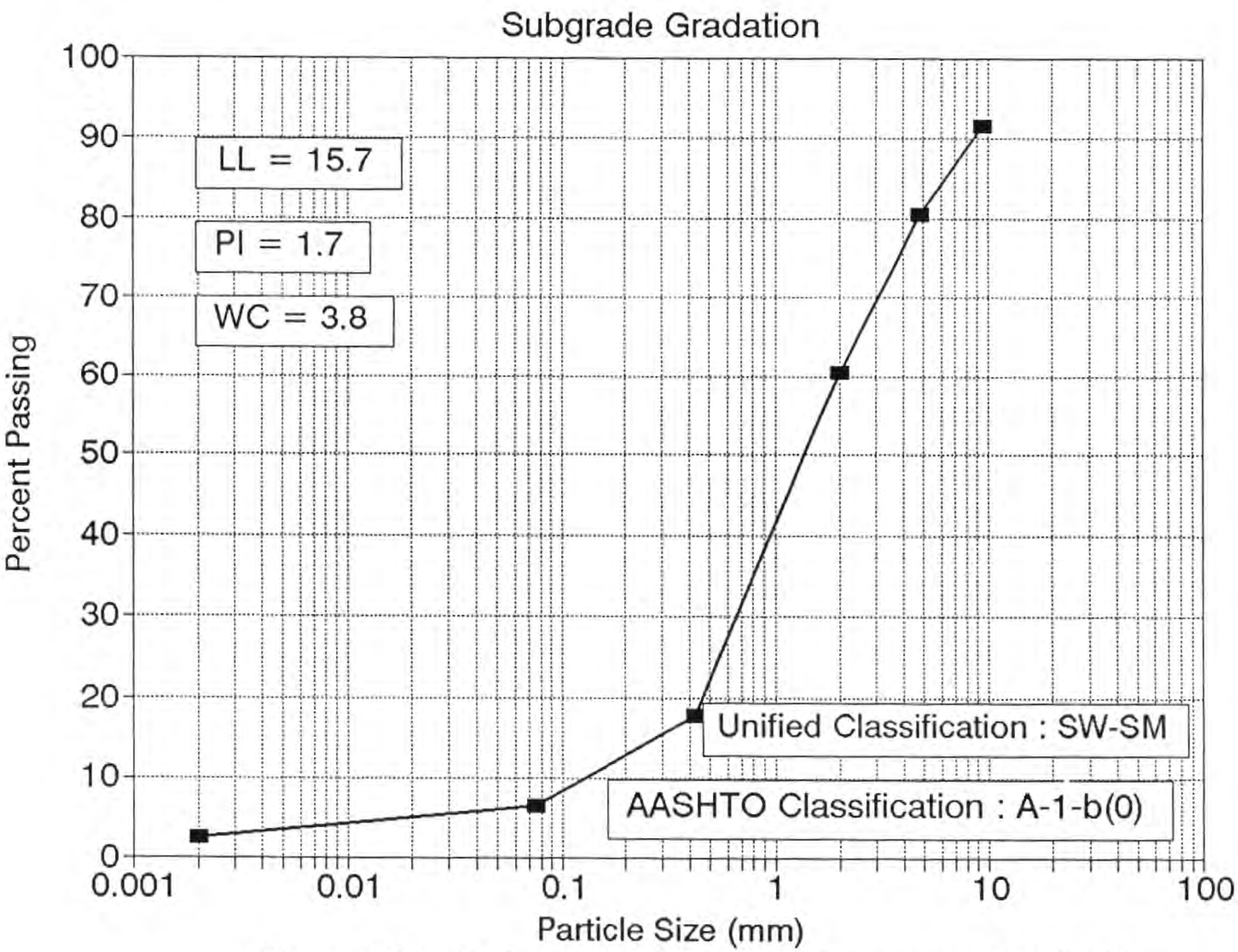



Figure B21 SD20 and 10th Street, Watertown (Asphalt)

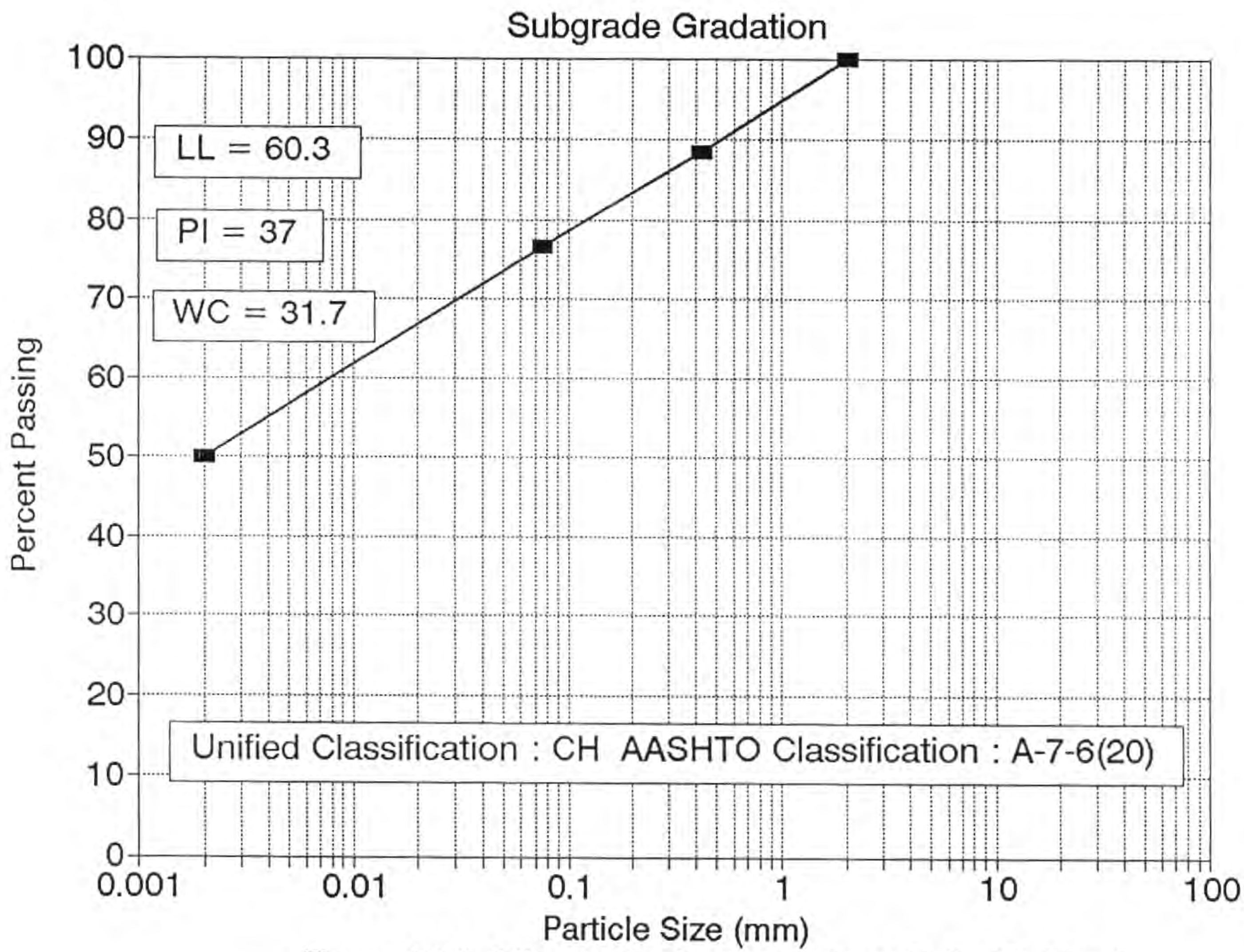



Figure B22  Minnesota Avenue, Sioux Falls (Rubber)

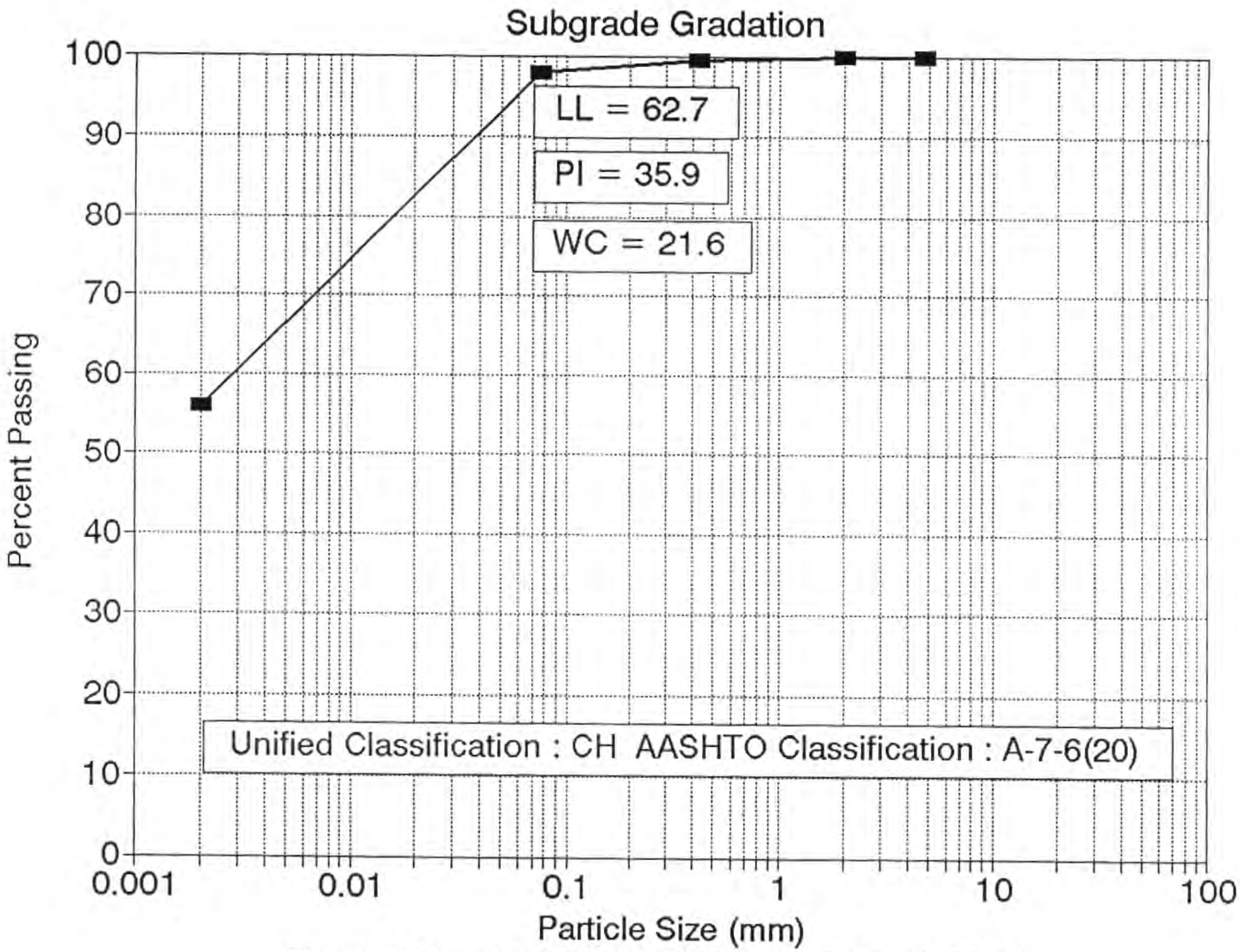



Figure B23 SD 38A North, Sioux Falls (Rubber)

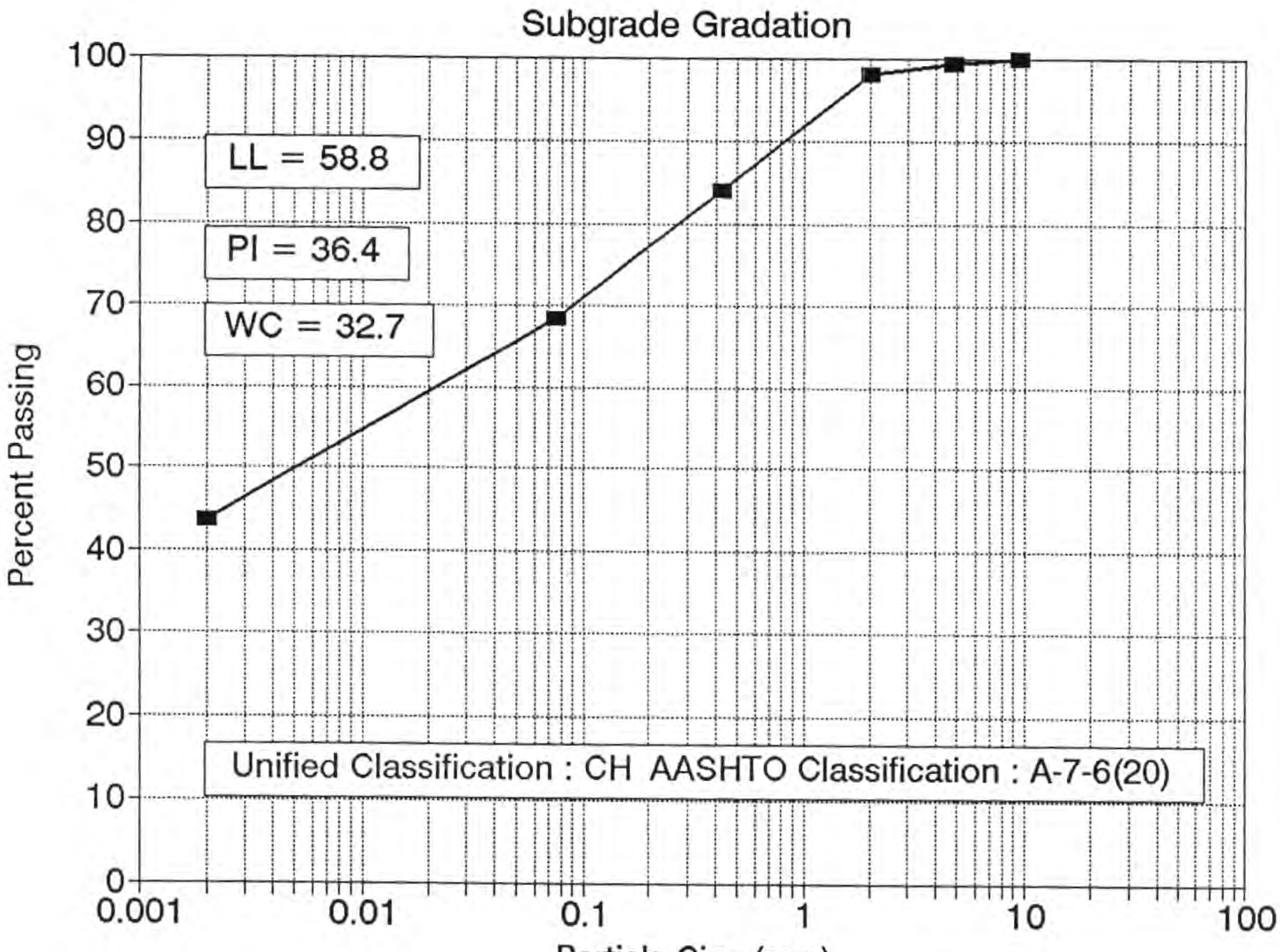



Figure B24  Minnehaha  County 131 North Of Sioux Falls (Timber)