Research Report
KTC-03-22/FR-122-03-1F

KENTUCKY TRANSPORTATION CENTER

College of Engineering

PAVEMENT EVALUATION
I-265 JEFFERSON COUNTY
MP 15.0-19.0

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Research Report
KTC-03-22/FR-122-03-1f

Pavement Evaluation, I-265 Jefferson County MP 15.0 - 19.0

by

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Commonwealth of Kentucky

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I. Introduction

The Transportation Center conducted a field survey of the pavement conditions located on I-265 in Jefferson County from MP 15.17 to 18.34, in both the eastbound and westbound directions. The existing pavement structure consists of 10" of PCC pavement and 6" of DGA. The field survey involved testing the 3.17 mile segment with a Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR), and taking core samples of the pavement structure.

The existing pavement exhibits numerous areas of differential settlement of the right lane in relation to the left lane of up to 2.5 inches. In some areas, differential settlement is also present between the right lane and the outside shoulder. Mid slab transverse cracking was also observed in many areas along the project. These distresses will be summarized later in this report. Faulting of the transverse joints and some of the transverse cracks was also observed. An example of the distress which was observed is shown in Figure 1.

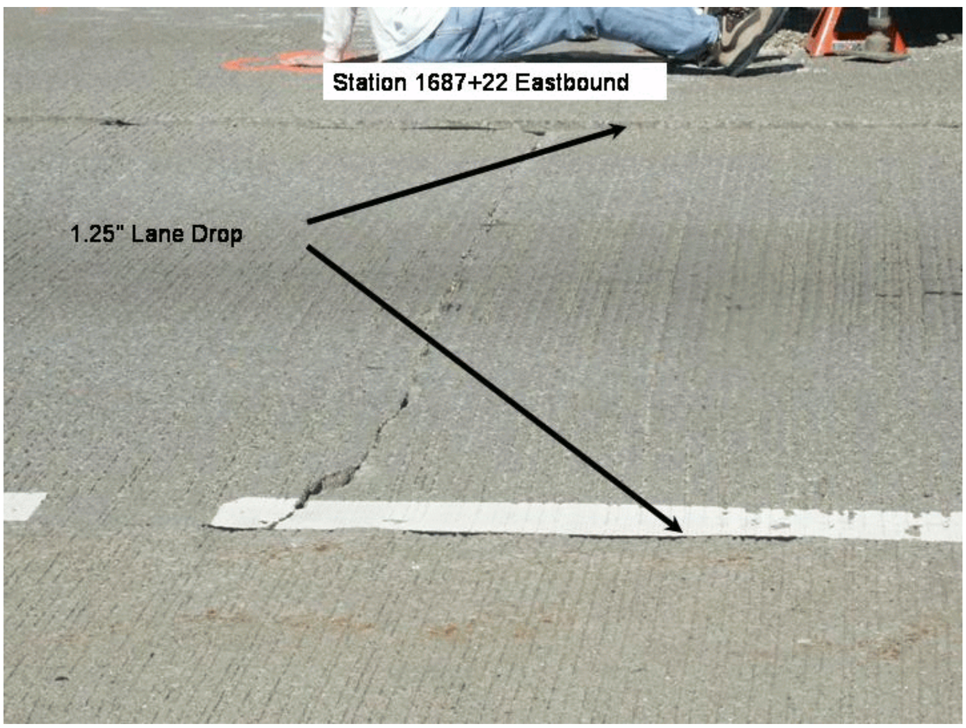

Figure1: Differential Settlement and Transverse Cracking, Station 1687+22, Right Lane Eastbound

Field Evaluations (core information)

Pavement cores were taken in a number of areas to verify the condition of the subgrade materials, and to evaluate the condition of the transverse joints and the longitudinal shoulder joint. Traffic control constraints did not permit any cores to be taken from the centerline pavement joint. The results of these pavement cores are summarized as follows:

Eastbound

Station 1562+00
No apparent between-lane faulting, joint faulting of less than 0.25”
PCC – 10.75” - 10.25”
DGA -- 4.75” - 5.0”
10” – Clay soil, above rock road bed

Station 1582+43
Approximately 2” between-lane faulting
PCC -- 10.25” – 9.75”
DGA – 6.25” – 5.75”
8 – 10” Clay soil above rock road bed

Station 1687+22
1” between-lane faulting
PCC -- 10”
DGA – 4.75”
Apparent rock subgrade intermixed with soil, water standing on top of Subgrade

Station 1699+73
No between-lane faulting
PCC -- 10” – 10.25”
DGA – 4.75” – 5.25”
Apparent rock subgrade

Westbound

Station 1681+66
Less than ½” lane faulting
PCC – 10”
DGA – 6”
Weathered rock subgrade to depth of 22” below surface

Station 1672+15
No apparent faulting
PCC 9.75”
DGA – 7”
Rock Roadbed Below DGA

Station 1566+00 Left Lane Only
1” between-lane faulting
PCC 10”
DGA – 6”
Clay Subgrade to a depth of 23” below surface
Water disappeared during coring operation
Possible void under pavement

Station 1540+00 Left Lane Only
2” between-lane faulting, right lane injected with URETEK.
PCC – 10”
DGA – 4.5”
Clay sugbrade to a depth of 28.5” below surface, no rock roadbed encountered.
Water Disappeared during coring operation.

Cores were also taken to evaluate the condition of the transverse pavement joints and the longitudinal outside shoulder joint. Figures 2 through 4 illustrate the condition of the shoulder tie assembly at station 1687+22 eastbound. It may be seen from these photographs that the assembly has corroded and is not providing the necessary load transfer. Figure 5 illustrates the condition of the shoulder joint at station 1681+66, westbound. Deterioration of the tie assembly may also be observed in this location. Figures 6 and 7 illustrate the condition of the transverse joints where low load transfer efficiency was observed with the FWD. It may be seen from these figures that deterioration of the dowel bar has begun and thus the load transfer efficiency is diminished. In addition, the Neoprene joint seal material has appears to have lost some of its elasticity and is permitting water to infiltrate the transverse joints.

Figure 2. Shoulder Joint, Eastbound Station 1687+22

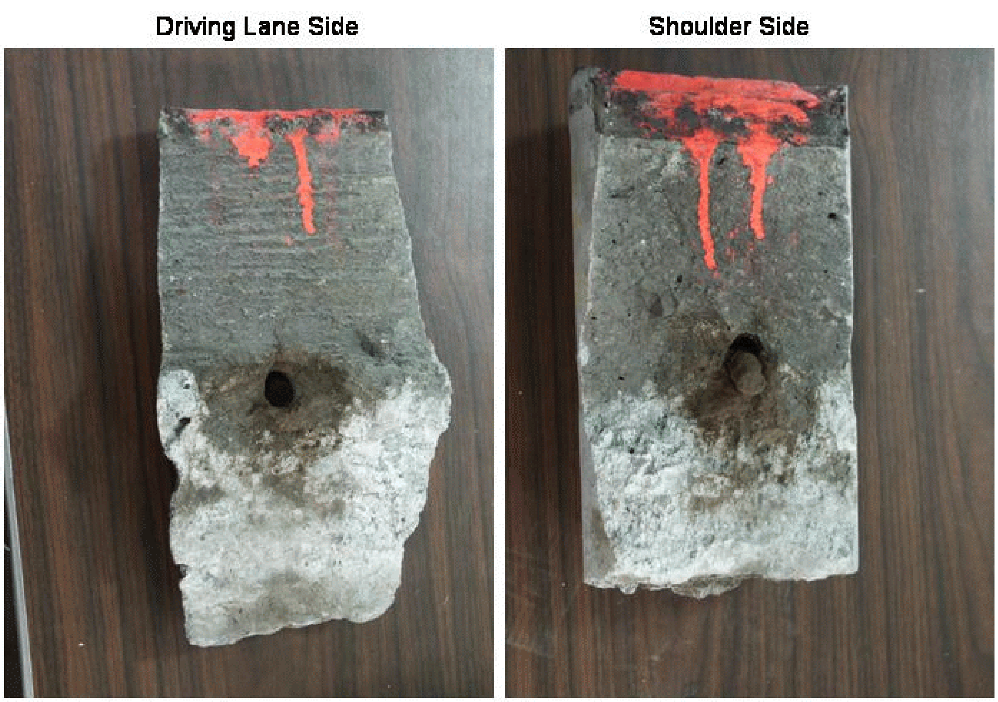

Figure 3. Shoulder Joint, Eastbound Station 1687+22

Figure 4. Tie Bolt, Shoulder Joint, Eastbound Station 1687+22

Figure 5. Shoulder Tie Assembly, Westbound Station 1681+66

Figure 6. Transverse Joint Dowel Bar, Right Lane Westbound Station 1681+66

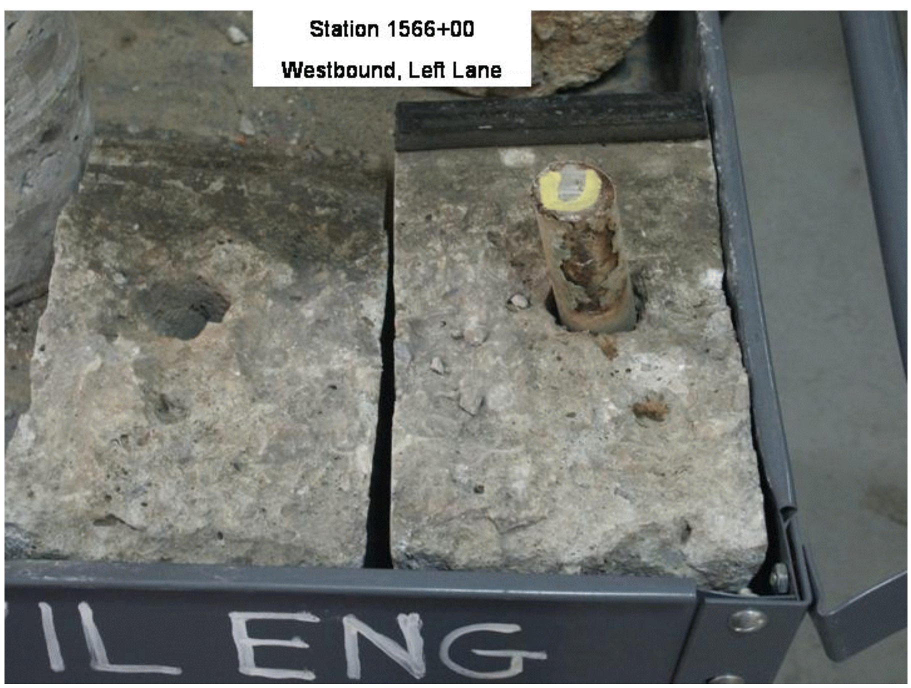

Figure 7. Transverse Joint Dowel Bar, Left Lane Westbound Station 1681+66

III. Pavement Deflection Testing

Pavement surface deflections were obtained with the FWD at 200 foot intervals along both lanes of the project. At each location, tests were conducted at the mid-slab location, across the transverse joint, to measure load transfer. The test locations were referenced to the station numbers which are stamped in the roadway edge. This project contained a station equation near the western end of the project. For the purpose of displaying the test results this equation was removed and the stationing on the eastern end of the project was continued throughout. The station equation is as follows: 978+05.72 BK = 1562+81.29 AH. Based on this equation, the test data included in this report was collected from Station 1535+00 to 1702+00.

To obtain a measure of the structural condition of the pavement, pavement stiffness was determined along the length of the project. Pavement stiffness is defined as the applied load from the FWD in kilo pounds (kips) divided by the measured deflection under the load in mils (thousandths of an inch) under the load. The result is a overall measure of the stiffness of the pavement structure. These results are given in Figures 8a, 9a, 10a, and 11a. It may be seen from these figures that there is considerable variability along the project, with stiffness values ranging from 4.5 to 1.5 kips/mil. In general, the areas which exhibited the lower stiffness values have exhibited more distress in terms of mid-panel cracking and slab settlement.

Load transfer efficiency was determined for each joint based on the ratio between the deflection on the loaded slab divided by the deflection of the unloaded slab. For pavements in good condition, this value would typically be greater than 0.90, or 90% load transfer efficiency. The load transfer results are given in Figures 8b, 9b, 10b and 11b. It may be seen from these figures that in many instances, the load transfer efficiency is actually less than 50%, which is typically considered to be in need of repair. Many locations have efficiencies which are less than 30%.

IV. Pavement Lane Settlement

The settlement between the lanes which has been reported by WMB Consulting Engineers in a report dated February 11, 2003, is given in Figures 8c, 9c, 10c, and 11c. These graphs represent the reported settlement between the two driving lanes. A summary of this data is given in tabular form on page 68 of the previously mentioned report. Based on the WMB report, 4,421 feet of settlement was observed in the eastbound direction, and 9,404 feet of settlement was observed in the westbound direction.

V. Mid-Panel Cracking

An attempt was made to identify the number of mid-panel cracks for each 200-foot section. This was preformed by doing a visual survey of each lane and counting the cracks. No attempt was made to determine the severity of the cracks. Figures 8d, 9d, 10d, 11d, show the number of cracks observed for each 200-foot section for the eastbound left lane, eastbound right lane, westbound left lane, westbound right lane, respectfully.

Figure 8. 1-265 Eastbound Left Lane

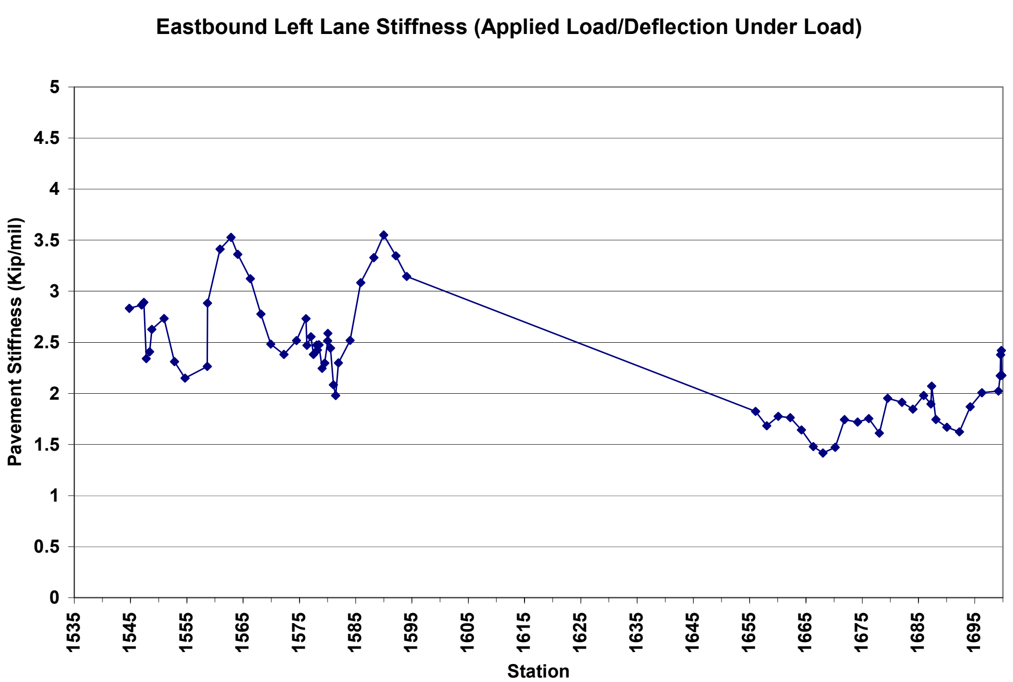

Figure 8a. Pavement Stiffness

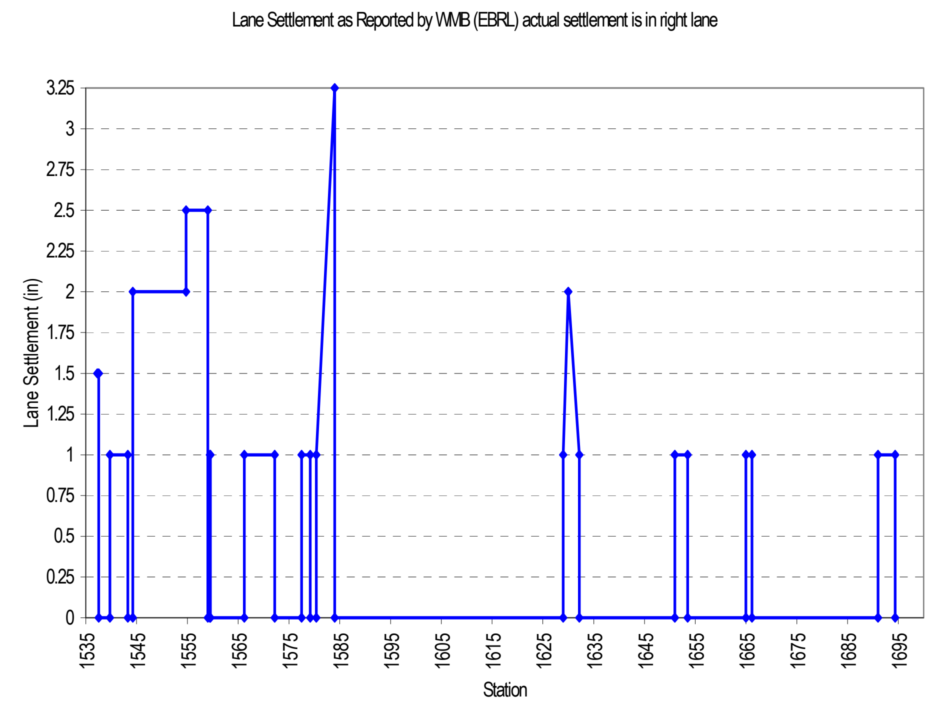

Figure 8c. Lane Settlement

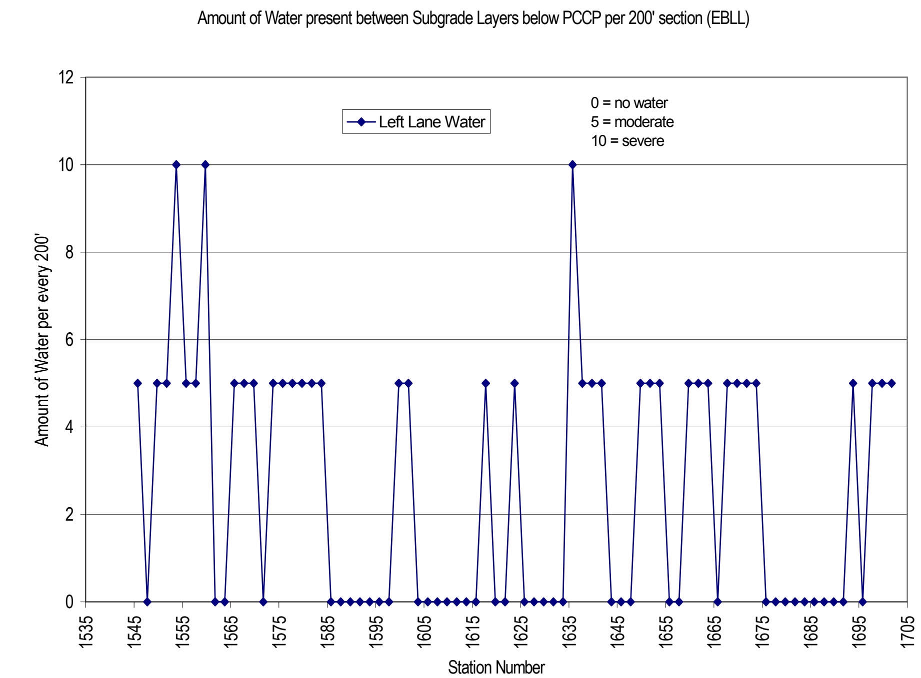

Figure 8e. Subgrade Water

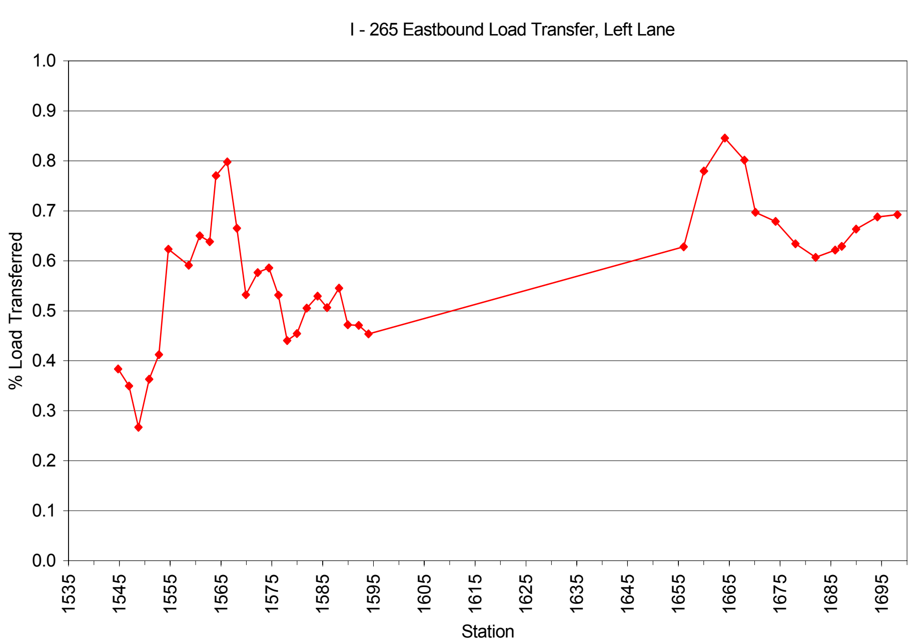

Figure 8b. Pavement Load Transfer

Figure 9.

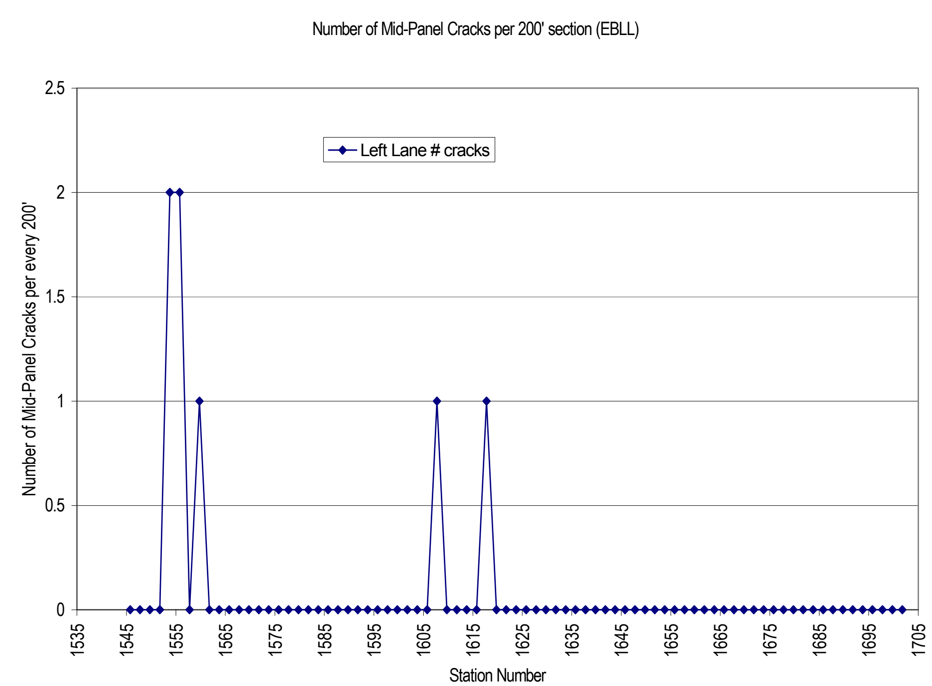

Figure 8d. Mid-Panel Cracking

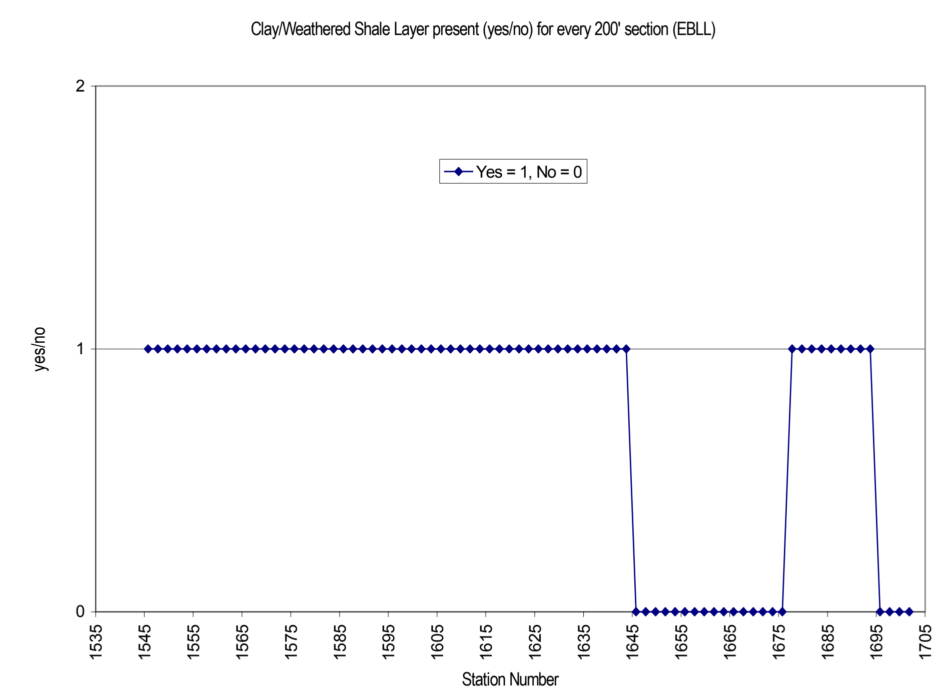

Figure 8f. Weathered Shale/Clay Layer

I -

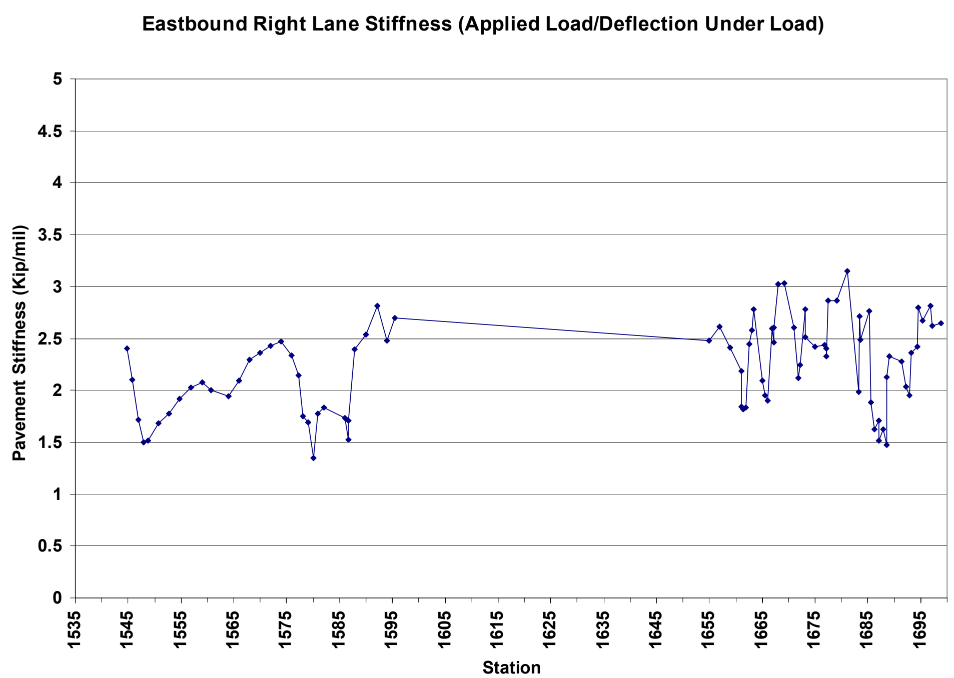

Figure 9a. Pavement Stiffness

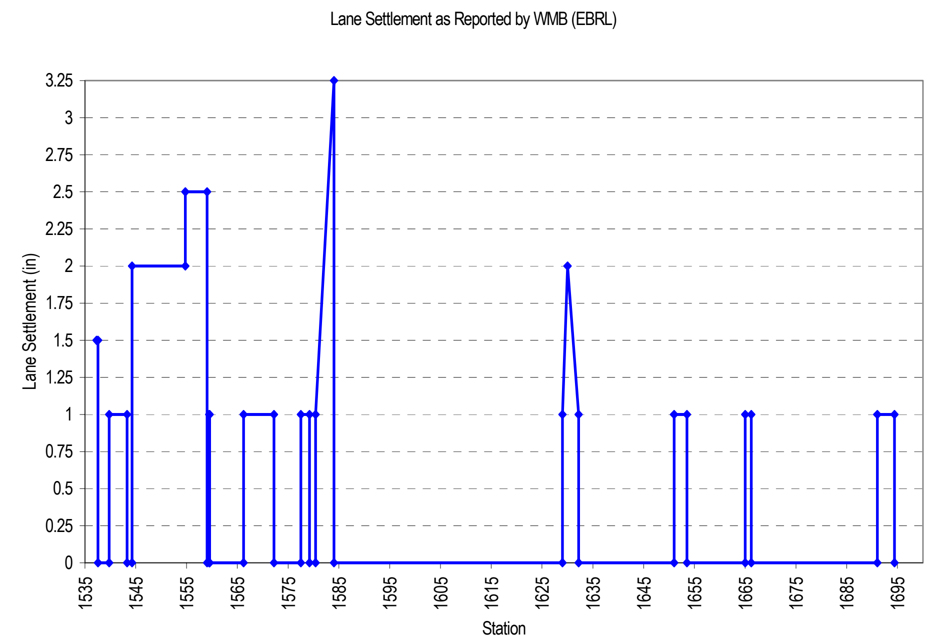

Figure 9c. Lane Settlement

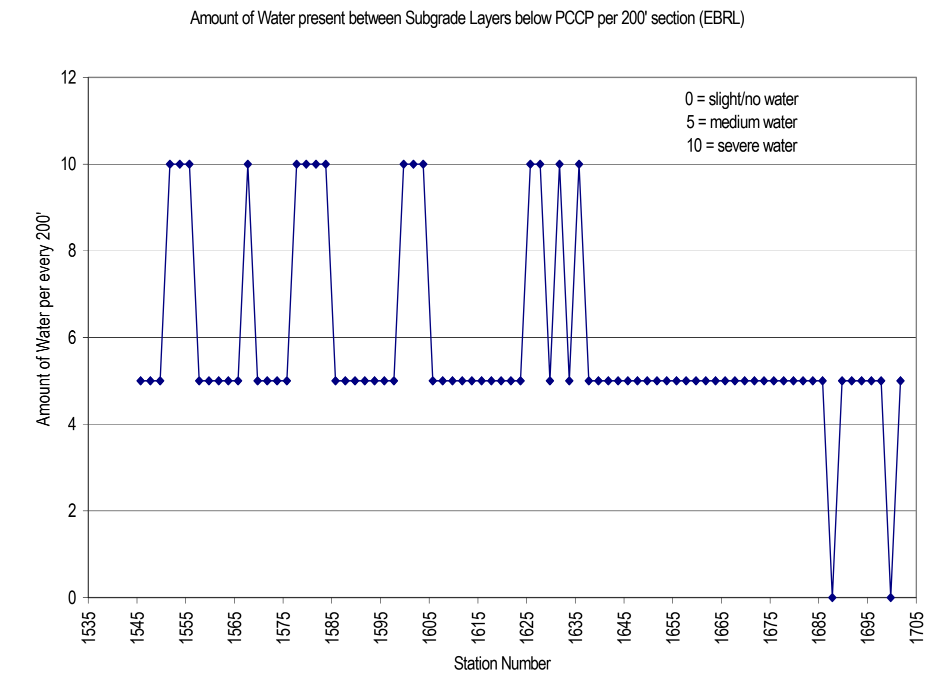

Figure 9e. Subgrade Water

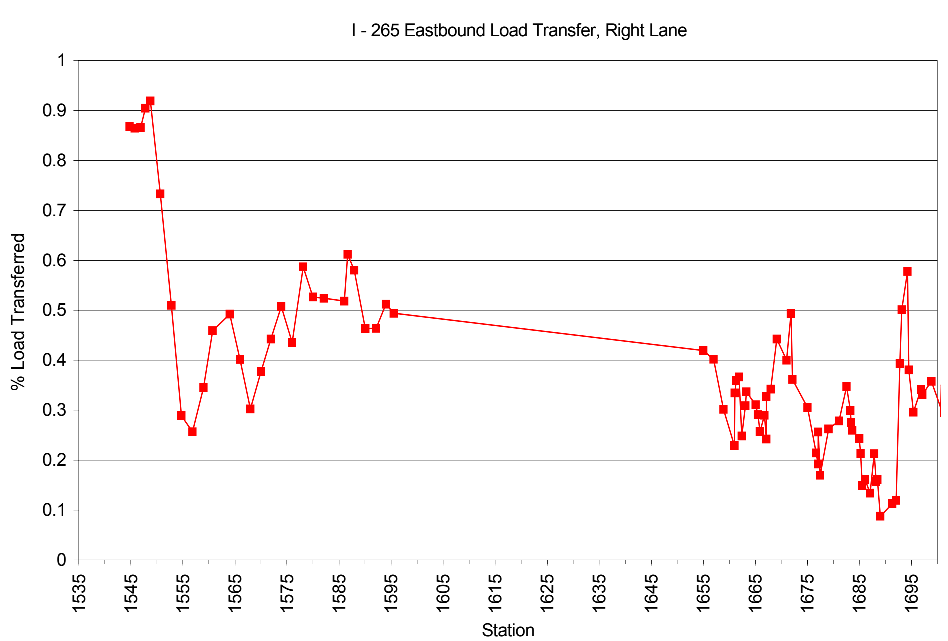

Figure 9b. Pavement Load Transfer

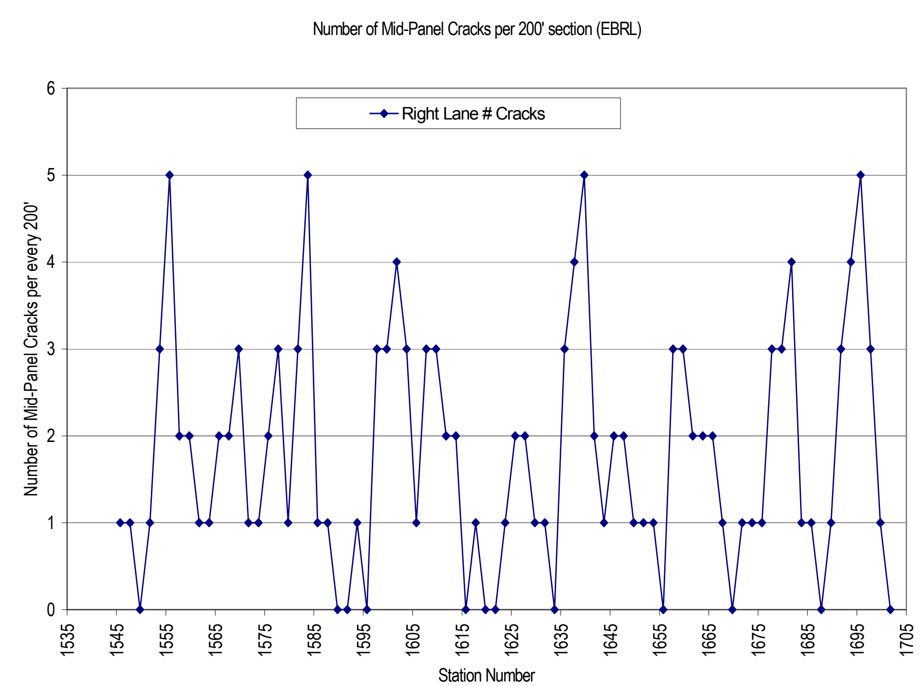

Figure 9d. Mid-Panel Cracking

Figure 10.

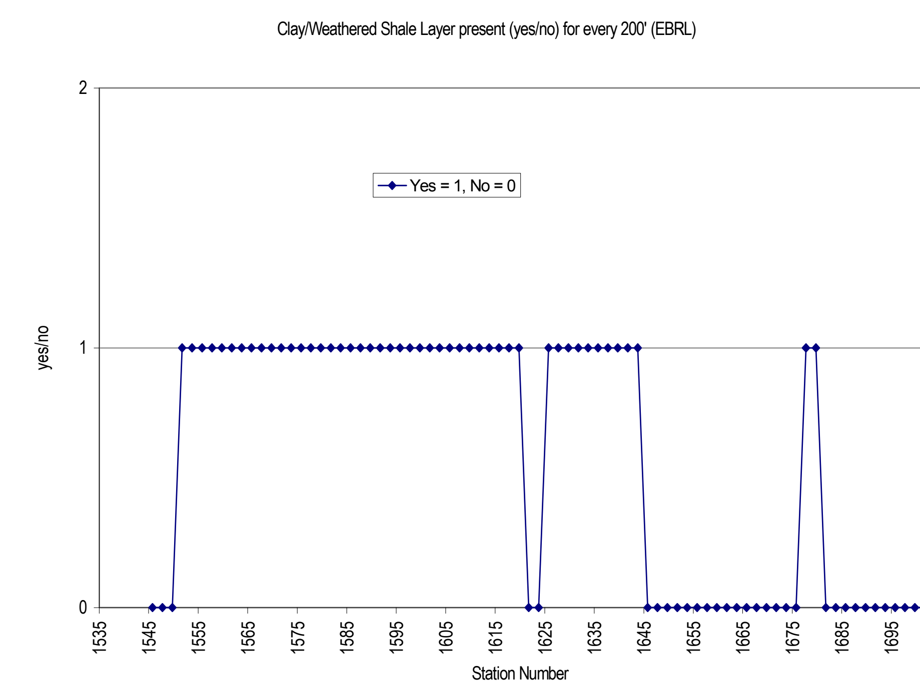

Figure 9f. Weathered Clay/Shale Layer

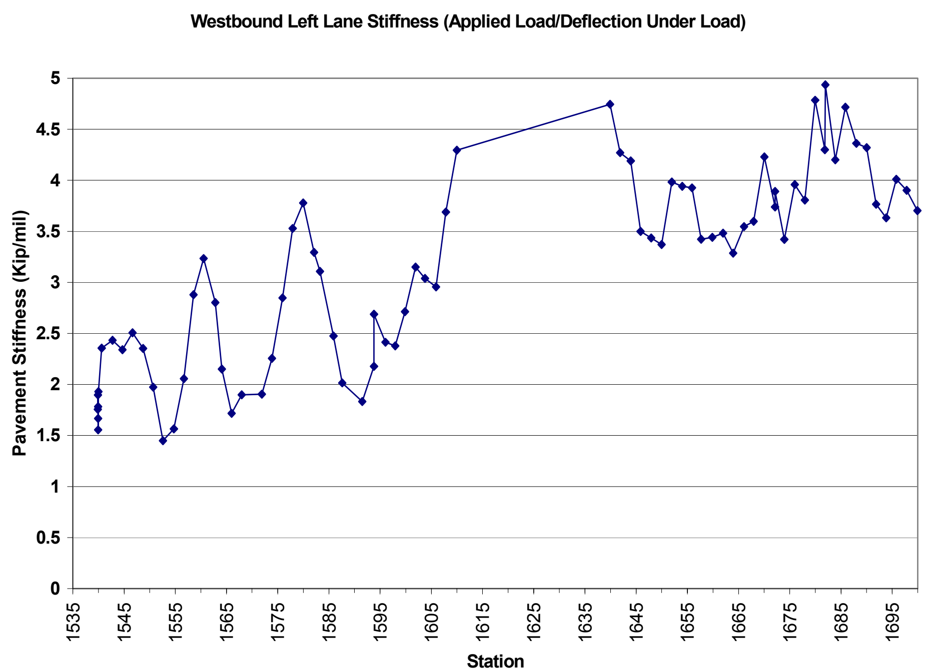

Figure 10a. Pavement Stiffness

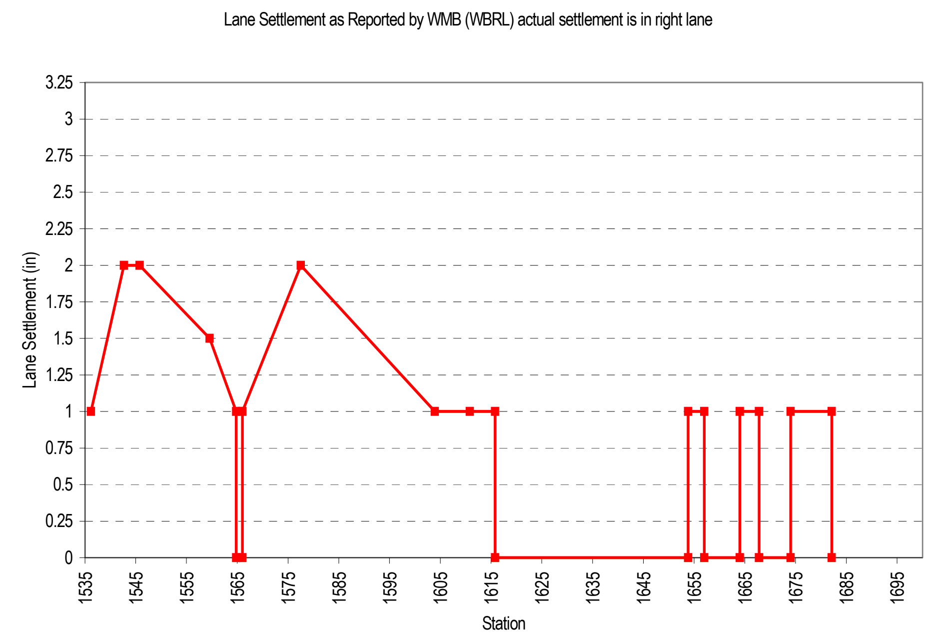

Figure 10c Lane Settlement

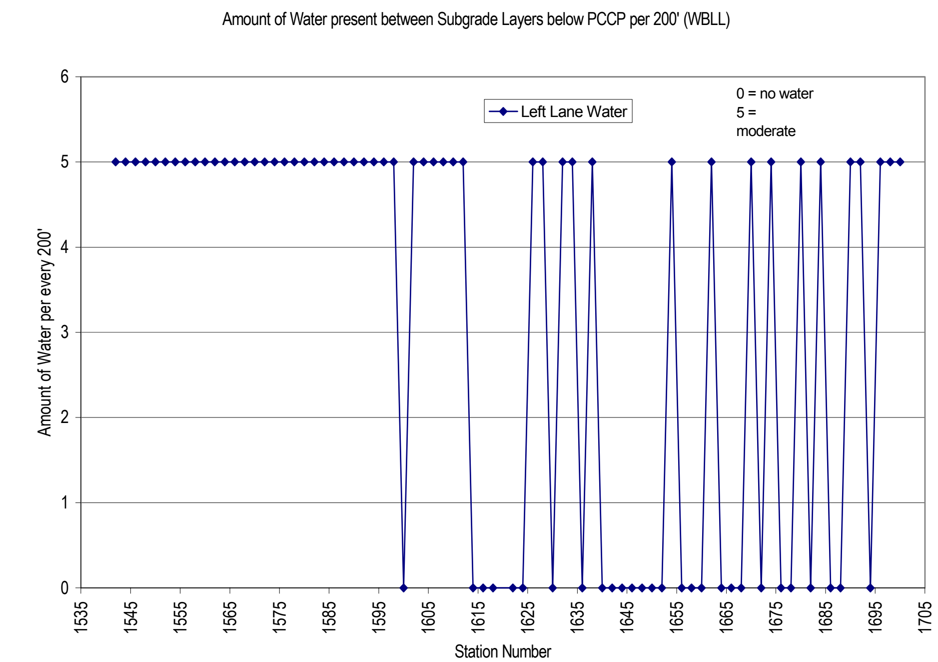

Figure 10e. Subgrade Water

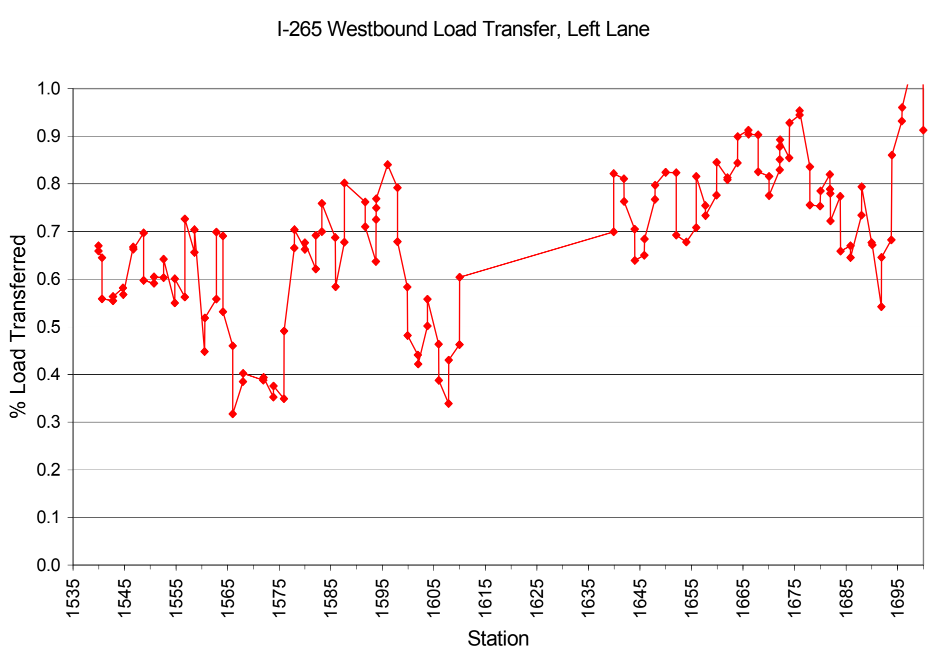

Figure 10b. Pavement Load Transfer

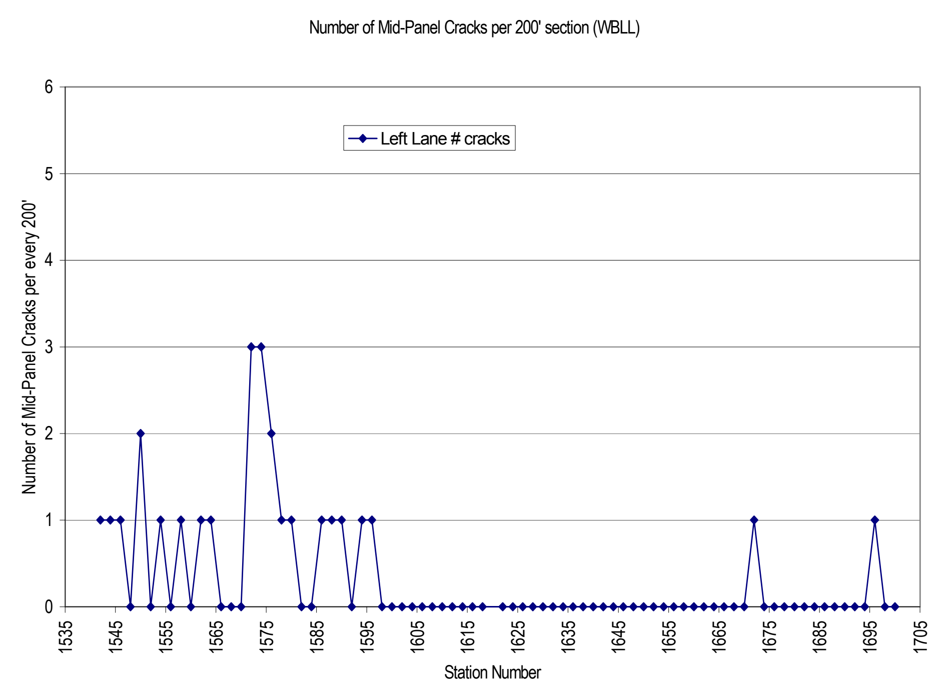

Figure10d. Mid-Panel Cracking

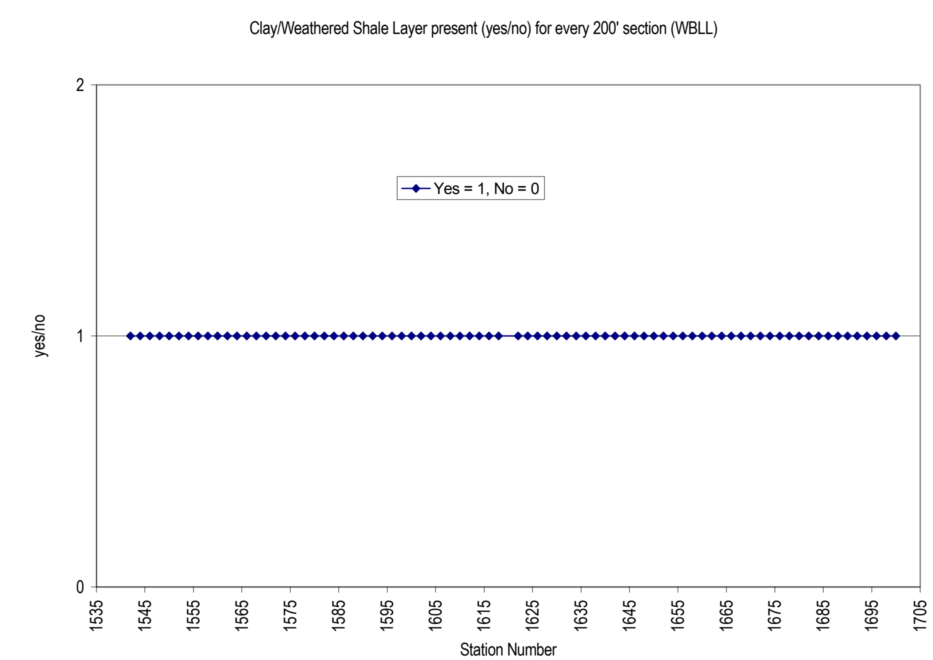

Figure 10f. Weathered Shale/Clay Layer

I-265 Westbound Left Lane

Figure 11. 1-265 West Bound Right Lane

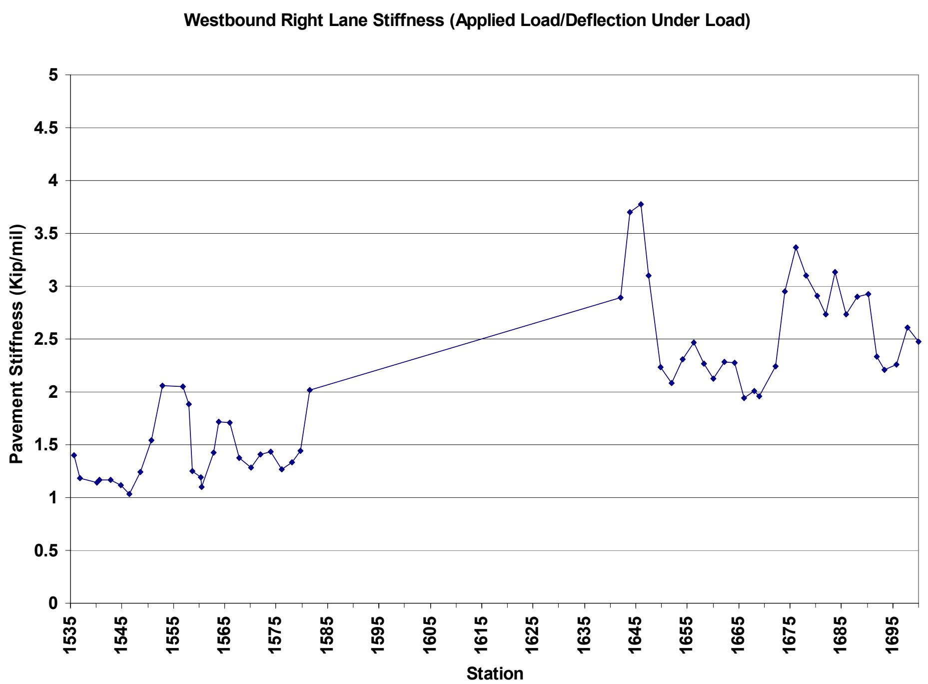

Figure 11a. Pavement Stiffness

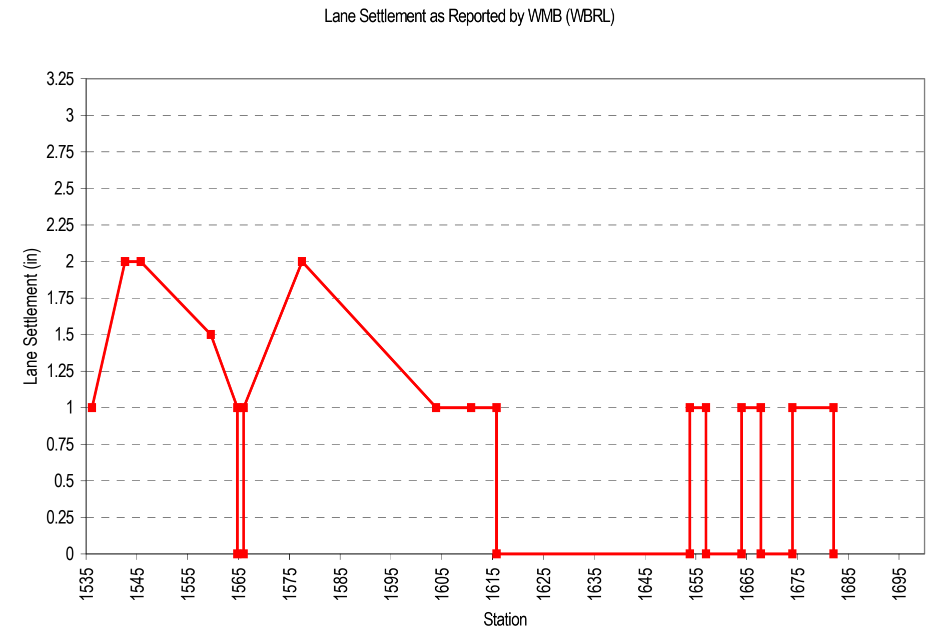

Figure 11c. Lane Settlement

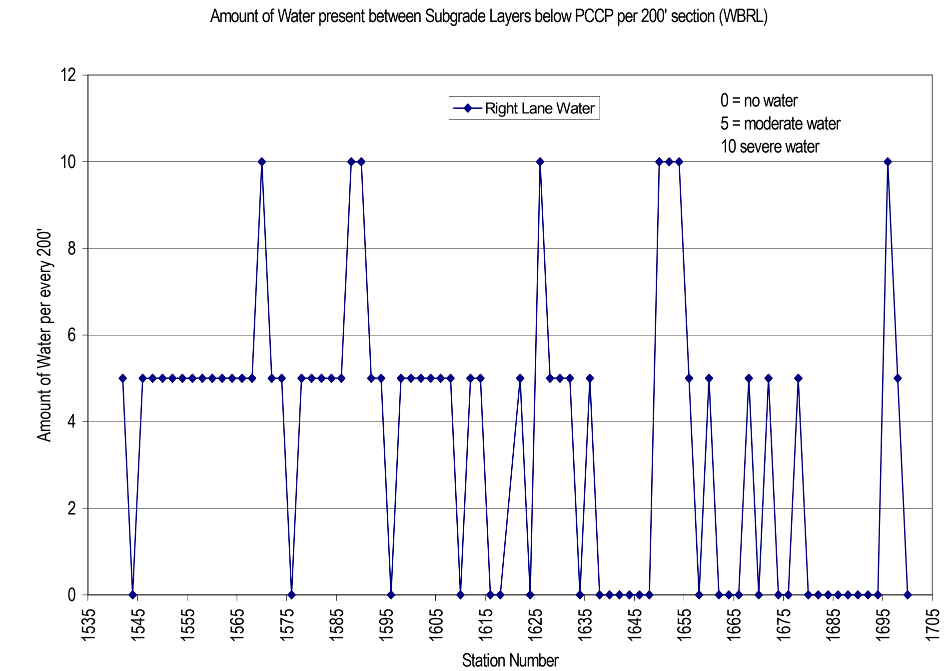

Figure 11e. Subgrade Water

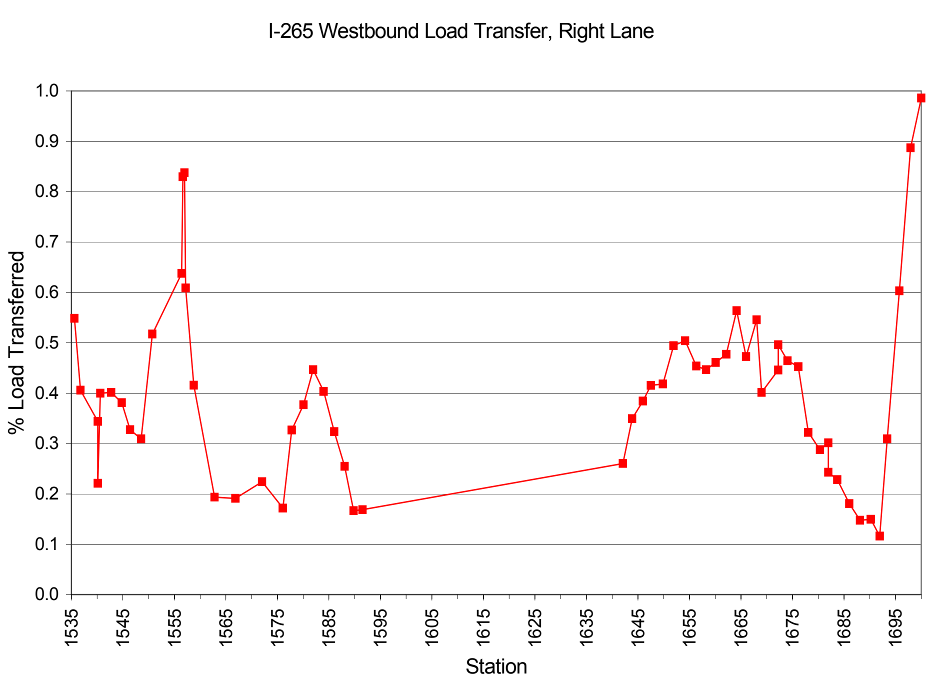

Figure 11b. Pavement Load Transfer

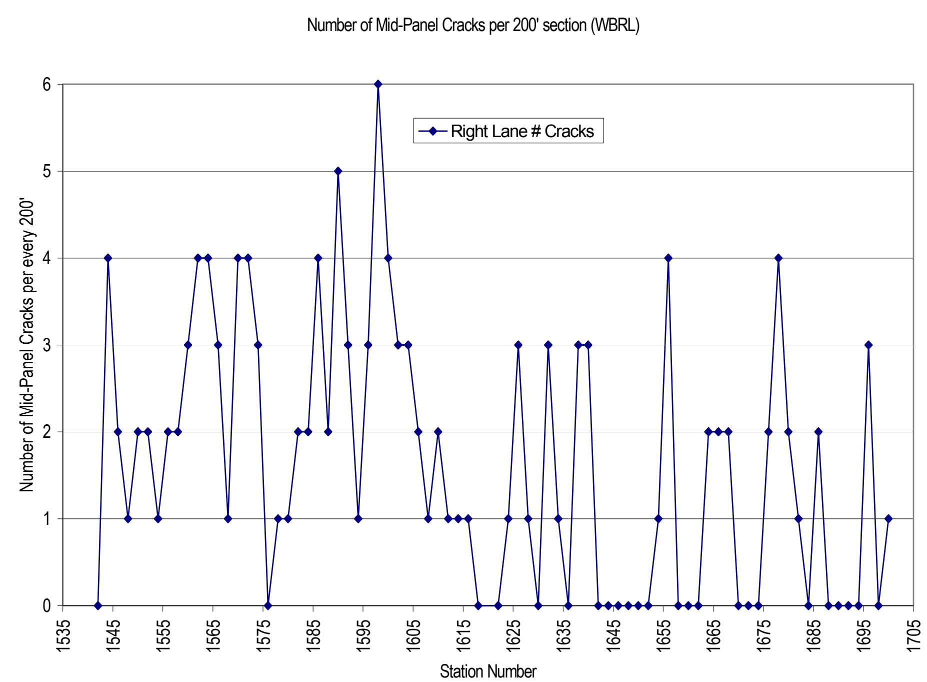

Figure 11d. Mid-Panel Cracking

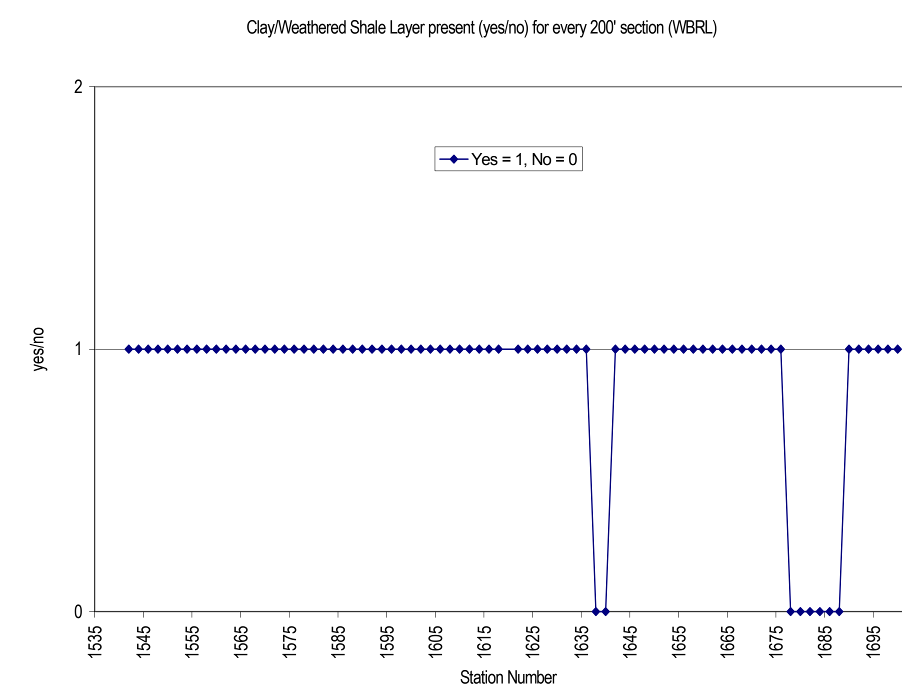

Figure 11f. Weathered Shale/Clay Layer

VI. Ground Penetrating Radar (GPR) Evaluation:

Ground Penetrating Radar (GPR) was initially used along the I-265 corridor to determine the presence of voids beneath the pavement and to detect areas that maybe saturated with water. After reviewing the radar output, it was determined that using GPR to determine voids beneath the pavement proved to be inconclusive. However, the GPR was able to determine areas that were retaining water between the bottom of PCCP and the top of the DGA layer. In addition a layer of clay/weathered shale was located between the rock sub-grade and the DGA layer.

Figures 8e, 9e, 10e, and 11e indicate GPR's interpretation of water beneath the PCCP or in the DGA layer. However, GPR does not have a way to quantify the amount of water being displayed in the said figures. Therefore engineering judgement has been used to quantify the amount of water that GPR graphically displays. Figure 12a has been determined to be an area that represents severe water (where the DGA layer appears red in color), figure 12b has been determined to be an area that represents moderate water (where the DGA layer appears more green in color), and figure 12c represents an area that is determined to have little or no water beneath the PCCP (where the DGA layer appears more yellow in color).

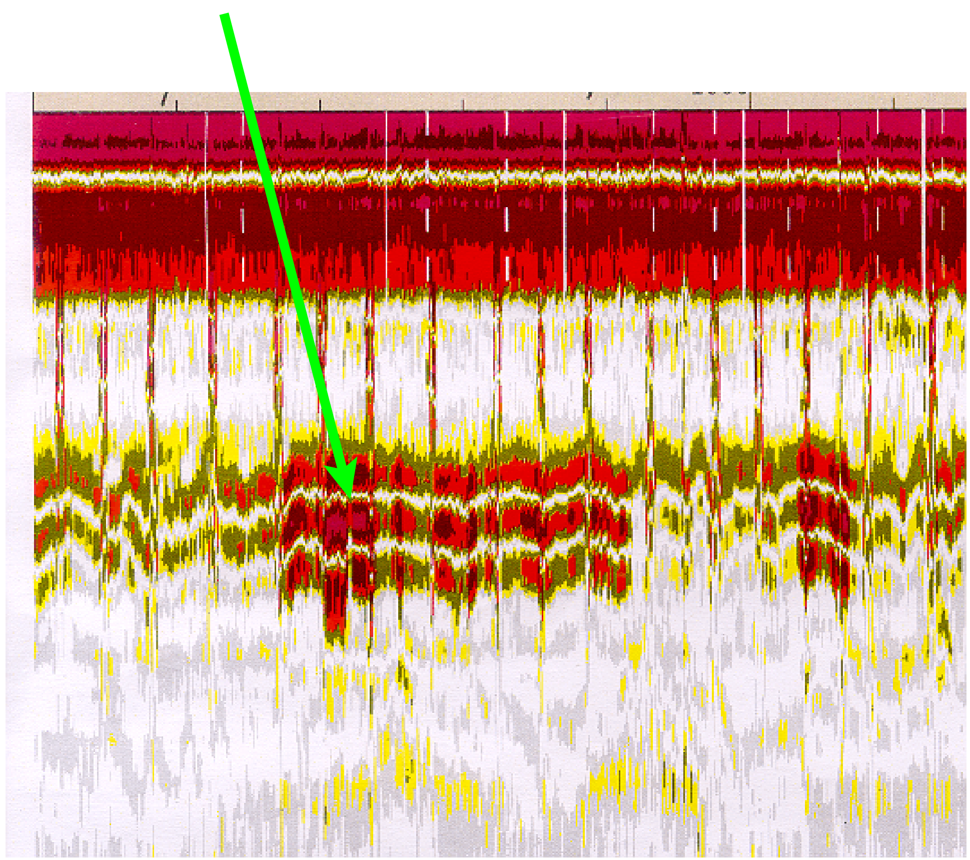

Figure 12a: Example of Severe Water in DGA Layer

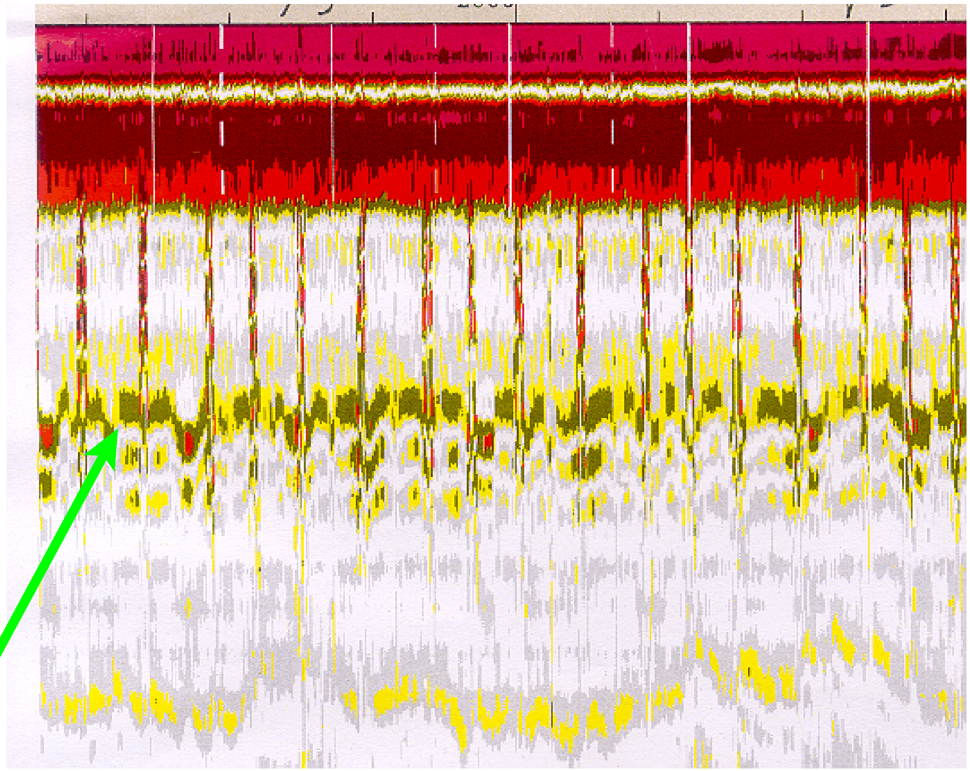

Figure 12b: Example of Moderate Water in DGA Layer

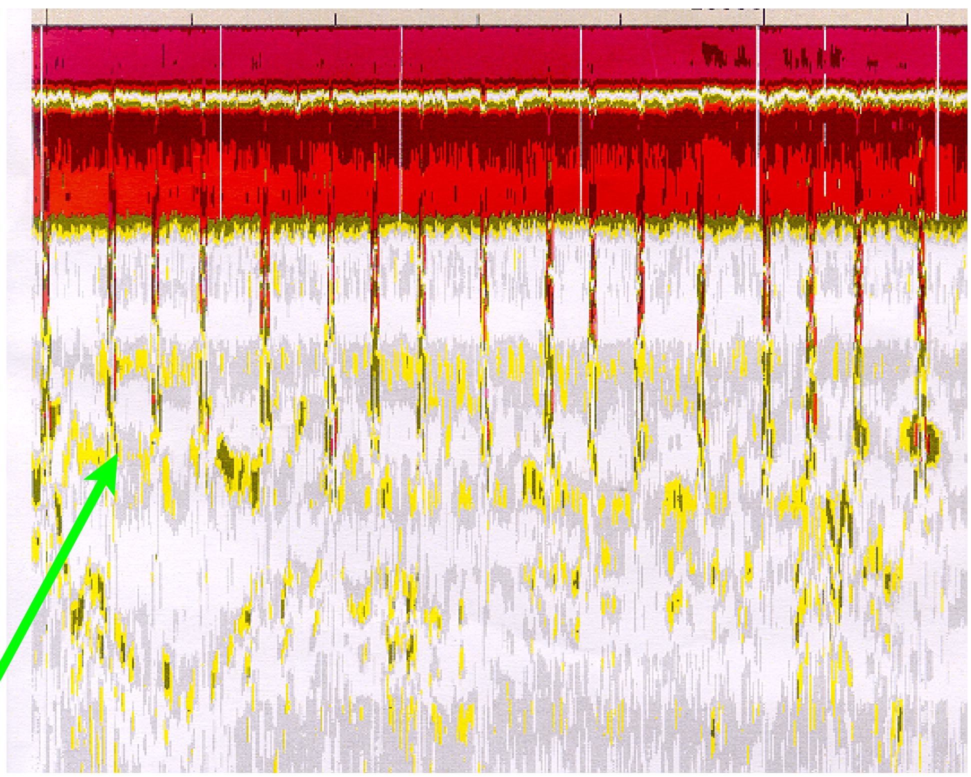

Figure 12c: Example of Little to No Water in DGA Layer

Once a visual threshold was established for the amount of water present in the DGA layer, a rating was given to every 200 feet in both the right and left lanes of both the east and west bound directions. Ten points were given to the sections with severe water, five points were given to the sections with moderate water, and zero points were given to the sections with little or no water. In order to determine how each 200-foot section varied along the route all water ratings were graphed. Figures 8e and 9e show the left and right lanes of the eastbound direction, and figures 10e and 11e show the left and right lanes of the westbound direction, respectfully. It appears that edge drains should be installed along this section of I-265 to help drain the subgrade/DGA layer. However, if providing edge drains throughout the entire project is not possible, it is suggested that subgrade drainage be provided to those areas that have a rating of ten.

Although it was an unexpected find, GPR was able to determine an additional layer of material that was located between the rock subgrade and the DGA layer. Core analysis indicates that this material is a clayey type material and/or weathered shale. It is believe that this material maybe compressive in nature, and do to heavier traffic loads in the right lane, this may be the cause of the differential settlement between right and left lanes.

Figure 13a indicates an area where the additional layer was observed. Figure 13b indicates an area where the additional layer was not observed. The entire project was scanned using GPR, attempting to define the limits of this material along the tested section. A simple yes/no ranking was given to every 200-foot section that identifies whether the extra layer was present or not. Graphs that identify the location of the additional layer along the entire project for each lane can be found in Figures 8f, 9f, 10f, and 11f. It should be noted a ranking of 1 means, yes, the layer was present, and 0 means, no, the layer was not present in Figures 8f, 9f, 10f, and 11f.

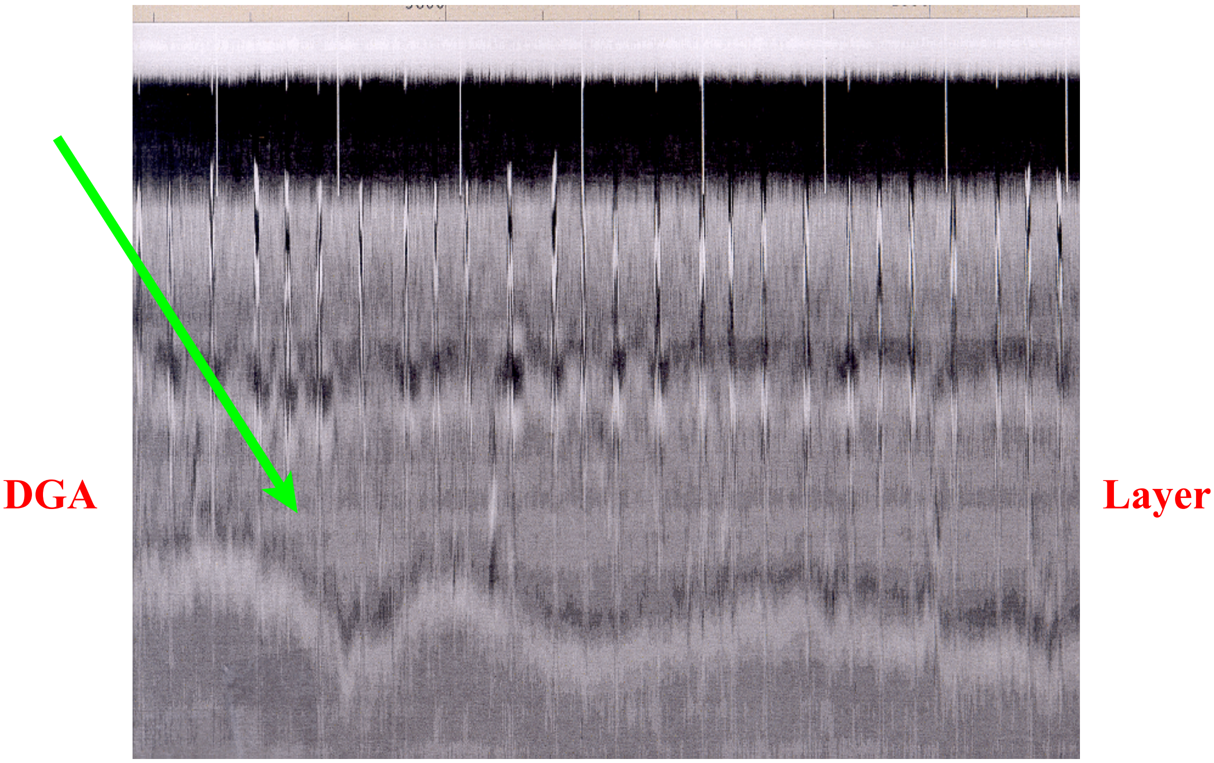

Figure 13a. G.P.R., Additional Weathered Shale/Clay Layer Found

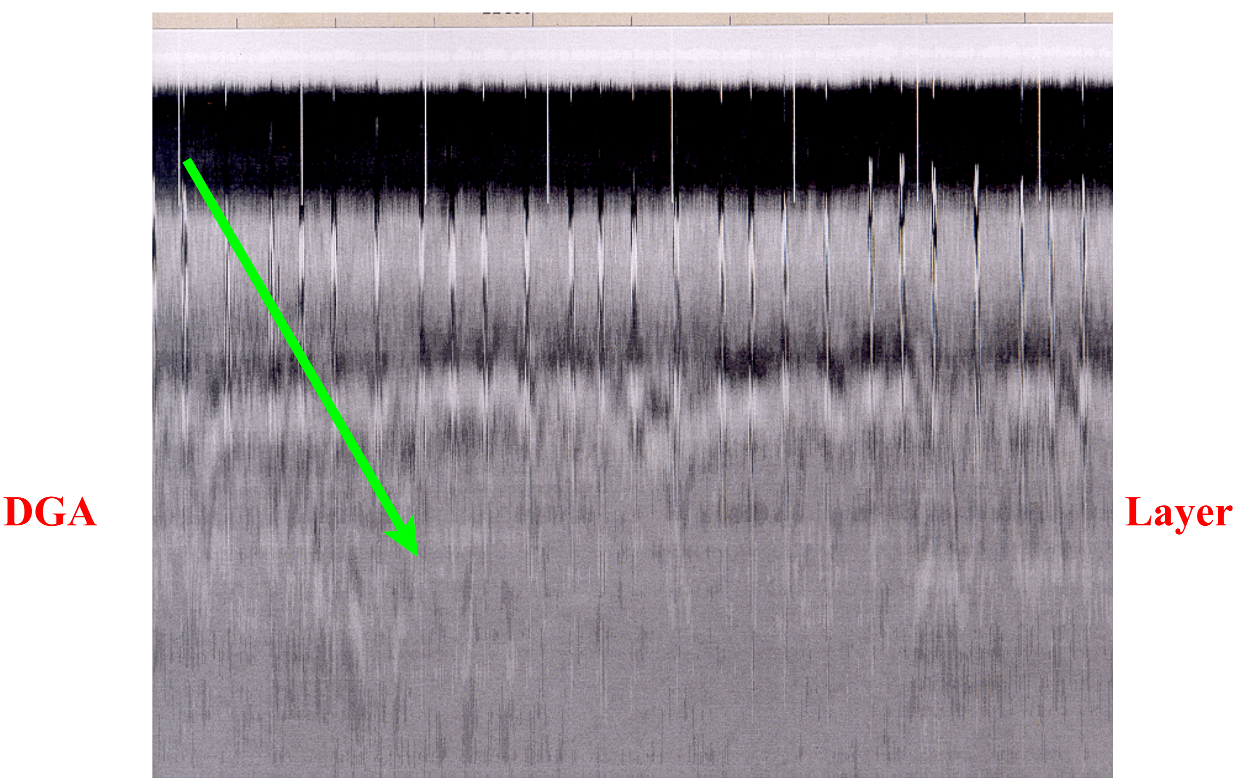

Figure 13b. G.P.R. No Additional Layers Found

VII. Combining all methods of distress investigation

Although it is recommended that both the driving lanes be reconstructed in both directions for this project, Figures 14 and 15 identify areas that are considered to be more distressed than others. As can be seen in Figures 14 and 15, different areas with different levels of distress have been identified. The areas shaded in red indicate areas that have settled more than one inch, have less than 50% load transfer over the transverse joints, and have moderate to severe water located under the pavement slab. Areas that are shaded in blue indicate areas that are experiencing approximately one inch of settlement and have a severe amount of water located under the concrete pavement. Areas that have been shaded in yellow indicate areas that are experiencing approximately one inch of settlement only. The least moderately distressed areas have been shaded in green. These areas are exhibiting less than 50% load transfer, and have some settlement and/or water beneath the concrete pavement. All other areas displayed with a white background are experiencing moderate to no distress at this time. However, as noted in figures 8f, 9f, 10f, and 11f the majority of the tested sections display the presence of a clay layer between the D.G.A. layer and the rock roadbed.

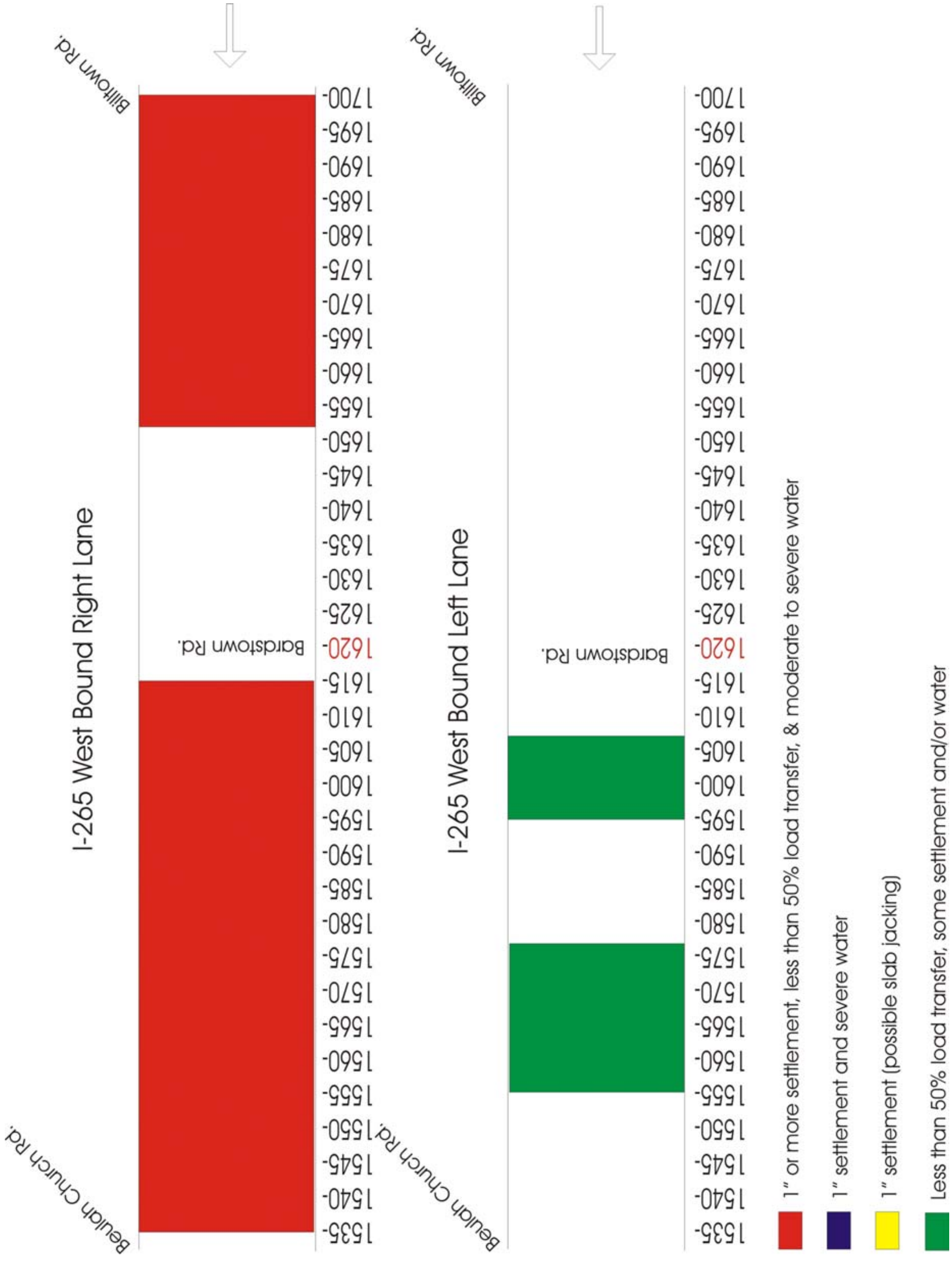

Figure 14. Westbound Strip Map

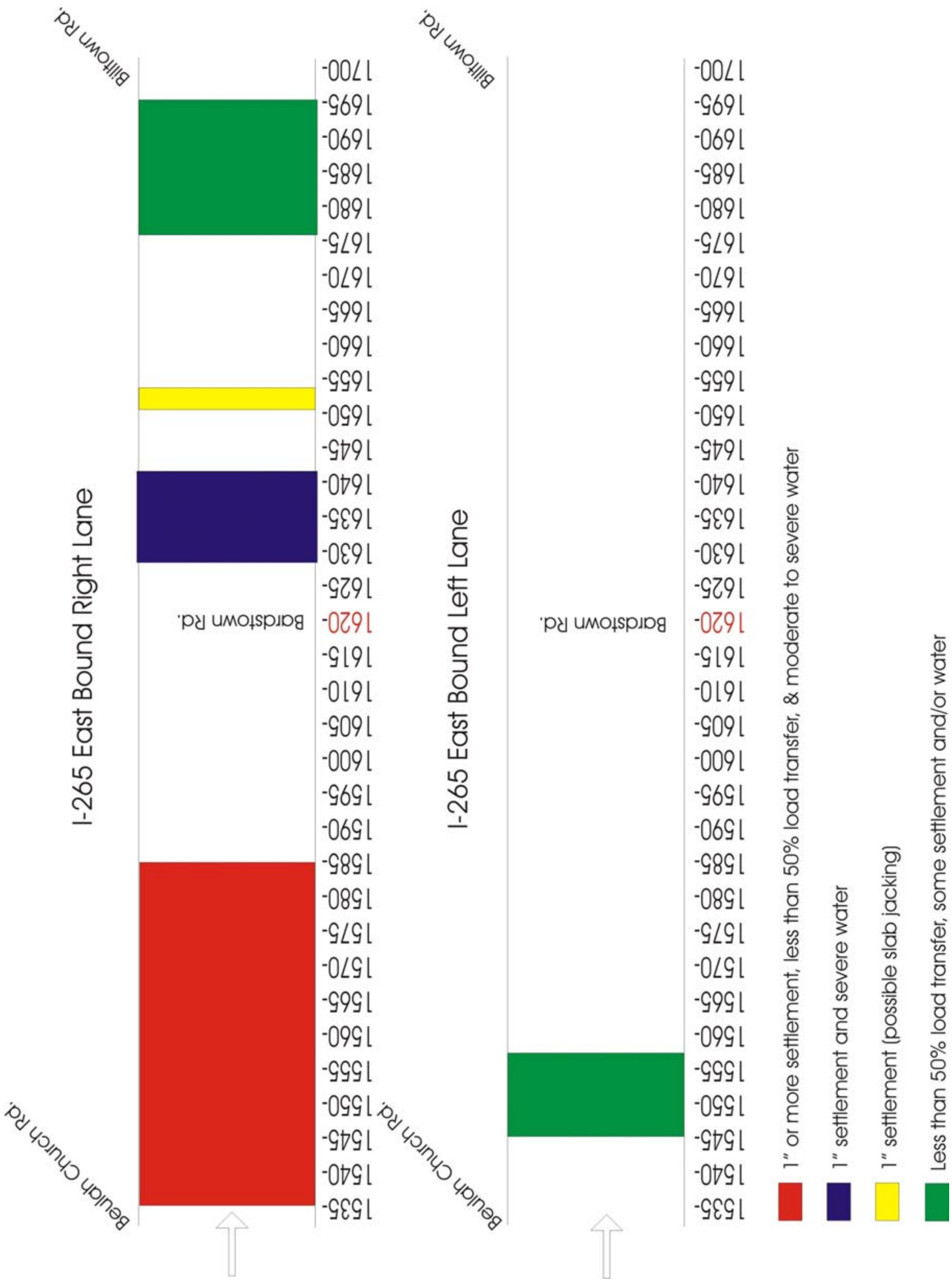

Figure 15. Eastbound Strip Map

VIII. Summary and Conclusions

A complete survey of the pavement and subgrade conditions was performed on I-265 in Jefferson County between mile-points 15.17 to 18.34, in both the eastbound and westbound directions. The investigation was prompted by several areas along the 3.17 mile section experiencing differential settlement of one to two inches between the right and the left driving lane. In efforts to determine why the right driving lane has been settling and to test the existing integrity of the pavement structure, several different destructive and non-destructive tests were performed.

Preliminary results provided by the falling weight deflectometer (FWD) indicate that both the load transfer across the majority of the transverse joints are below an acceptable 90%. In addition the FWD was used to determine the sub-grade stiffness. Subgrade stiffness values ranged from 4.5 to 1.5 kips/mil along the 3.17 mile section. A quantitative pavement lane settlement analysis was performed by WMB Consulting Engineers. Results from their survey indicate that approximately 4,421 feet of settlement has been observed in the eastbound direction, and 9,404 feet of settlement has been observed in the westbound direction.

Ground penetrating radar (GPR) was used to identify areas beneath the pavement structure that has been retaining water. Initial results from the GPR indicate that a majority of the 3.17 mile section is currently retaining a moderate to severe amount of water underneath the concrete pavement. In addition to finding water trapped beneath the concrete pavement structure, the GPR equipment was able to identify a additional layer of weathered shale/clay between the D.G.A. and rock roadbed. This additional layer was found throughout to the majority of the 3.17 mile section. It is suspected that this compressible weathered shale/clay layer maybe one of the larger contributors to the right lane settlement. This assumption is based on the fact that the right lane is traveled more that the left lane, and therefore is experiencing more loading then the left lane.

GPR technology was also used to locate both the longitudinal tie bars and the transverse dowel bars. After extracting cores from both the tie bar and dowel bar locations a visual inspection was performed on each of the bars. Preliminary results indicate that both bars are being subjected to a wet environment because of the amount of corrosion each bar is experiencing. The amount of corrosion the longitudinal tie bars are experiencing maybe an indication that the Neoprene water seals maybe failing. In addition, the longitudinal tie bars are bending downward. This may indicate that the tie bars are structurally failing, and thus allowing the right driving lane to settle. The corrosion around the transverse dowel bars may be attributing to the low load transfer across the transverse joints.

IX. Recommendations

After compiling the results from the previously mentioned tests contained in this report, it is recommended that this 3.17 mile section along the I-265 east and west bound corridor be considered for a full reconstruction. However, if there are constraints to performing a full reconstruction at this time, it is recommended that the areas that are experiencing the most severe distress be reconditioned/replaced (Figures 14 and 15). It is also recommended that some type of drainage structure be installed along this 3.17 mile long section to extract water away from the pavement structure.

In light of both the longitudinal ties bars and the transverse dowel bars experiencing a severe amount of corrosion, it may indicate that the Neoprene water seals are not performing properly. It is suggested that other highway routes with similar Neoprene water seals be evaluated to determine the integrity of the Neoprene seals.