CTL | THOMPSON
INCORPORATED

APPROVED

By: PLP Date: 5-20-14

City of Fort Collins
City of Fort Collins
Engineering Department

SUBGRADE INVESTIGATION
AND PAVEMENT RECOMMENDATIONS
OVERLAND TRAIL WIDENING
AT BELLA VIRA SUBDIVISION
FORT COLLINS, COLORADO

Prepared For:
RICHMOND AMERICAN HOMES
4350 South Monaco Street
Denver, Colorado 80237

Attention: Kelly Martinez

Project No. FC06224.002-135 (R1)

April 9, 2014
(Rev. May 5, 2014)

351 Linden Street | Suite 140 | Fort Collins, Colorado 80524
Telephone: 970-206-9455 Fax: 970-206-9441

TABLE OF CONTENTS

SCOPE

This report presents the results of our subgrade investigation and pavement recommendations for the planned roadway improvements to Overland Trail in Fort Collins, Colorado. The purpose of our subgrade investigation was to determine the subsurface conditions and to evaluate pavement support characteristics for our pavement recommendations. The report was conducted in general conformance with Chapter 10 of the *Larimer County Urban Areas Street Standards (LCUASS)* dated January 2, 2001 (repealed and reenacted April 1, 2007) as adopted by the City of Fort Collins (City).

This report was prepared from data developed during field exploration, laboratory testing, engineering analysis, and experience with similar conditions. The report includes a description of the subsurface conditions found in exploratory borings, laboratory test results, and pavement construction and material recommendations for the widening of part of Overland Trail. If plans change significantly, we should be contacted to review our investigation and determine if our recommendations still apply. A brief summary of our conclusions is presented below, with more detailed criteria and recommendations contained in the report.

SUMMARY OF CONCLUSIONS

1. Soils and rock encountered in our borings generally consisted of sandy clay fill, gravels and sand, and weathered claystone. Groundwater was not encountered in the borings. The soil from the stockpiles consisted of sandy clay.

2. The subgrade soils and stockpiles classified as A-7-6, which are considered to exhibit poor subgrade support.

3. Mitigation for swelling will not be required. However, we recommend chemical treatment of the existing and/or stockpile soils. Mitigation should consist of treating approximately one foot of the subgrade with fly ash.

4. Hot mix asphalt is appropriate surface pavements. Minimum pavement recommendations are presented in this report.

SITE LOCATION AND PROJECT DESCRIPTION

The project site is located in a partly developed area on the west side of Fort Collins, Colorado. The project includes widening to portions of the west side of the existing Overland Trail from West Elizabeth Street to approximately 500 feet south of West Elizabeth Street (Figure 1). The section to be widened is roughly one to 4 feet below the existing roadway, sloping generally to the south and west. Stockpiles of soil located at Bella Vira are planned to be used for fill under the roadway. The existing Overland Trail is paved with asphaltic concrete. Ground cover consists of grasses and weeds.

FIELD AND LABORATORY INVESTIGATION

Our field investigation consisted of drilling three borings to a depth of approximately 10 feet, logging the subsurface conditions, recording penetration-resistance tests, and acquiring samples of the subgrade materials. Borings were drilled at approximate 250-foot spacing, or less. The approximate locations of our borings are presented on Figure 1. The borings were drilled with 4-inch diameter solid-stem augers and a truck-mounted drill. Our field representative directed the field investigation as the borings were advanced. Bulk samples were obtained from the upper 4 feet of the borings and modified California samples were obtained from selected intervals within the borings. The number of blows from a 140-pound hammer falling 30 inches, required to drive the modified California sampler, were recorded. Bulk samples were also obtained from two stockpiles within the subdivision. Summary logs of the borings, including results of field penetration resistance tests, are presented on Figure 2.

After the samples were returned to our laboratory, our geotechnical engineer for this project examined the samples and assigned laboratory testing. Laboratory testing was performed in general accordance with AASHTO and ASTM methods to determine index properties, classification, and subgrade support values for those soil types influencing the pavement design. To evaluate potential heave, swell-consolidation testing was performed on samples of the subgrade soils under a pressure of 150 pounds per square foot (psf) as required under *LCUASS*. Other laboratory tests and analysis included moisture content, dry density, Atterberg limits, gradation analysis, Hveem Stabilometer (R-value) and water-soluble sulfate tests. Results of our laboratory tests are presented in Appendix A and summarized in Table A-I.

SUBSURFACE CONDITIONS

Soils and rock encountered in our borings generally consisted of sandy clay fill, gravels and sand, and weathered claystone. Groundwater was not encountered in the borings. The soil from the stockpiles consisted of sandy clay. Further descriptions of these materials are presented in the following sections. Summary logs of the borings are presented on Figure 2.

Clay Fill

Stiff to very stiff, sandy clay fill was encountered at the ground surface in all borings and extended to depths of approximately 2 to 6 feet. One sample of clay fill tested in the laboratory contained 76 percent clay and silt-sized particles (passing the No. 200 sieve). One of the samples had a liquid limit of 58 and a plasticity index of 36. Two samples of the fill tested for swell show low swell (0.8 and 1.0 percent). Samples from the stockpiles contained 63 and 89 percent clay and silt-sized particles (passing the No. 200 sieve), liquid limits of 54 and 50, and a plasticity indices of 33 and 31. The clay fill and stockpiles classified as A-7-6 in accordance with the AASHTO classification method with a group indices of 17 to

32. The clay is considered to exhibit poor to fair subgrade support. Compaction records for the existing fill were not available for our review. The fill material is considered unsuitable as suitable subgrade unless documentation can be provided that indicates otherwise.

Gravel and Sand

Medium dense, gravel with sand, silt and clay and clayey sand were encountered in two borings below the fill. One sample of clayey sand tested in the laboratory contained 37 percent clay and silt-sized particles (passing the No. 200 sieve), a liquid limit of 35 and a plasticity index of 20. We believe the gravels and sands to be non-expansive. The clayey sand classifies as A-6 soils with a group Index of 2 based on our laboratory tests and AASHTO classification. The gravels and sands are considered to be too deep to have a significant influence on the pavement structure.

Claystone

Weathered claystone was found in two borings from below the fill and/or gravels to the depths explored. We believe the claystone to have a low to high expansion potential. The claystone sandstone is considered to be too deep to have a significant influence on the pavement structure.

Groundwater

Groundwater was not encountered in the borings. Groundwater levels will vary seasonally. Groundwater levels are are not expected to affect roadway construction.

PAVEMENT DESIGN

Widening is planned for of a portion of Overland Trail. The City of Fort Collins requires the use of the AASHTO and CDOT pavement design methods for their roadways. These design methods require input parameters for traffic projections for a specified design life, roadway classification, characteristics of the subgrade materials, type and strength characteristics of pavement materials, groundwater conditions, drainage conditions, minimum pavement sections, and statistical data.

Traffic Projections

The traffic projections are based on vehicle loading, traffic volume, design period, and growth factor. Traffic projections are expressed as an 18-kip Equivalent Daily Load Application (EDLA) for a single day and as an 18-kip Equivalent Single Axle Load (ESAL) for the design period, which is typically 20 years. We interpolated an average annual daily traffic count (AADT) of 11,385 for 2014 using an AADT of 10,518 for 2008 from the City of Fort Collins for a 20-year design life for a 2-lane arterial roadway.

Subgrade Conditions

The subgrade soils will consist of new, compacted fill from the stockpiles and onsite soils, which classify as A-7-6 in accordance with AASHTO classification methods. Hveem stabilometer tests of soil acquired from the stockpiles subgrade soil resulted in R-value of 8 and 13. We converted the R-value of 8 to a resilient modulus of 3,311 psi based on CDOT criteria. Swell tests indicate the subgrade soils have a low expansion potential based on Table 10-3 of *LCUASS* criteria. LCUASS requires swell mitigation where swell is 2 percent or greater. Based on the results of laboratory testing and *CDOT- PDM* and *LCUASS*, we believe that mitigation for swell will not be required. However, due to the poor qualities of the anticipated fill, chemical treatment is recommended.

Pavement Thickness Calculations

We used DARWin™ software to develop our pavement thickness calculations for flexible pavements with input values provided by the City, *LCUASS*, and our laboratory tests and observations. For our design, we assumed the pavement will be constructed during a single stage. Input values including initial and terminal serviceability indices, reliability factor, layer strength coefficients, and minimum sections were provided by *LCUASS* for Overland Trail, which is classified as an arterial. Other input values not specified by *LCUASS* were estimated based on our experience with similar projects. Computer generated printouts of the DARWin™ calculations are presented in Appendix B. We have provided pavement design alternatives for new pavement including hot mix asphalt (HMA) on aggregate base course (ABC). Our pavement thickness alternatives are presented on Table A.

TABLE A
MINIMUM PAVEMENT THICKNESS RECOMMENDATIONS

Roadway	Hot Mix Asphalt (HMA) + Aggregate Base Course (ABC)+ Fly Ash Treated Subgrade (FATS)
Overland Trail ESAL = 2,804,000	7" HMA + 14" ABC+ 12" FATS or 8" HMA + 10" ABC+ 12" FATS

SUBGRADE AND PAVEMENT MATERIALS AND CONSTRUCTION

The construction materials are assumed to possess sufficient quality as reflected by the strength factors used in our design calculations. Materials and construction requirements of *LCUASS and CDOT Standard Specifications for Road and Bridge Construction* should be followed.

Based on the results of laboratory testing and *CDOT- PDM* and *LCUASS*, we believe that mitigation for swell will not be required. However, due to the poor qualities of the proposed fill, we recommend the subgrade soils be chemically treated. The City typically uses a prescribed amount of about 12% fly ash stabilizing agent for 12 inches of the subgrade when a mix design is not prepared. We understand the City allows credit for 10 inches of the FATS with one-half strength coefficient if 12 inches of the subgrade is treated and no mix design is conducted.

The method of applying the stabilizing agent to the soil will depend partly on the level of water-soluble sulfates in the subgrade soil. A reaction of water-soluble sulfates in the soil and available calcium in the stabilizing agent can occur creating the mineral ettringite, which can swell causing detrimental effects to the pavement surface. If unacceptable concentrations of water-soluble sulfates are present in the soil, the double-application method can reduce the risk of pavement heave due to ettringite formation to an acceptable level. Concentrations of water-soluble sulfates were below detectable limits in two samples. Our threshold limit of water-soluble sulfates in soils for single application of fly ash or lime for stabilization is 0.5 percent. Based on our test results, we believe single application is appropriate for the site. Recommendations for chemically stabilized subgrades are presented in Appendix C. Preparation of the subgrade should extend from back-of walk to back-of-walk where feasible.

These criteria were developed from analysis of the field and laboratory data, our experience and *LCUASS* requirements. If the materials cannot meet these requirements, our pavement recommendations should be re-evaluated based upon available materials. Materials planned for construction should be submitted and the applicable laboratory tests performed to verify compliance with the specifications.

MAINTENANCE

Routine maintenance, such as sealing and repair of cracks, is necessary to achieve the long-term life of a pavement system. We recommend a preventive maintenance program be developed and followed for all pavement systems to assure the design life can be realized. Choosing to defer maintenance usually results in accelerated deterioration leading to higher future maintenance costs, and/or repair. A recommended maintenance program is outlined in Appendix D.

Excavation of completed pavement for utility construction or repair can destroy the integrity of the pavement and result in a severe decrease in serviceability. To restore the pavement top original serviceability, careful backfill compaction before repaving is necessary.

SURFACE DRAINAGE

A primary cause of premature pavement deterioration is infiltration of water into the pavement system. This increase in moisture content usually results in the softening of base course and subgrade soil and eventual failure of the pavement. In addition, parts of Colorado experience many freeze-thaw cycles each season that can result in deterioration of the pavement. We recommend that subgrade, pavement, and surrounding ground surface be sloped to cause surface water to run off rapidly and away from pavements. Backs of curbs and gutters should be backfilled with compacted fill and sloped to prevent ponding adjacent to backs of curbs and to paving. The final grading of the subgrade should be carefully controlled so the pavement design cross-section can be maintained. Low spots in the subgrade that can trap water should be eliminated. Seals should be provided within the curb and pavement and in all joints to reduce the possibility of water infiltration.

LIMITATIONS

This report has been prepared for the exclusive use of Richmond American Homes for the purpose of providing geotechnical design and construction criteria for the proposed project. This report was prepared from data developed during our field exploration, laboratory testing, engineering analysis, and experience with similar conditions. The boring locations were spaced to obtain a reasonably accurate understanding of subsurface conditions. The borings are representative of conditions encountered only at the exact boring locations. Variations in subsurface conditions not indicated by our borings are always possible. The recommendations contained in this report were based upon our understanding of the planned construction. If plans change or differ from the assumptions presented herein, we should be contacted to review our recommendations.

A representative of our firm should observe subgrade preparation and pavement construction. Our representative should also conduct tests of construction materials for compliance with recommendations presented in this report and/or specifications of the controlling agency.

Due to the changing nature of site characterization, pavement design methods, standards, and practices, the information and recommendations provided in this report are only valid for one year following the date of issue. Following that time, our office should be contacted to provide, if necessary, any updated recommendations and design criteria as appropriate for the engineering methodologies used at that time.

We believe this investigation was conducted in a manner consistent with that level of skill and care ordinarily used by members of the profession currently practicing under similar conditions in the locality of this project. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the influence of subsurface conditions on design of the pavements, please contact the undersigned.

CTL | THOMPSON, INC. by:

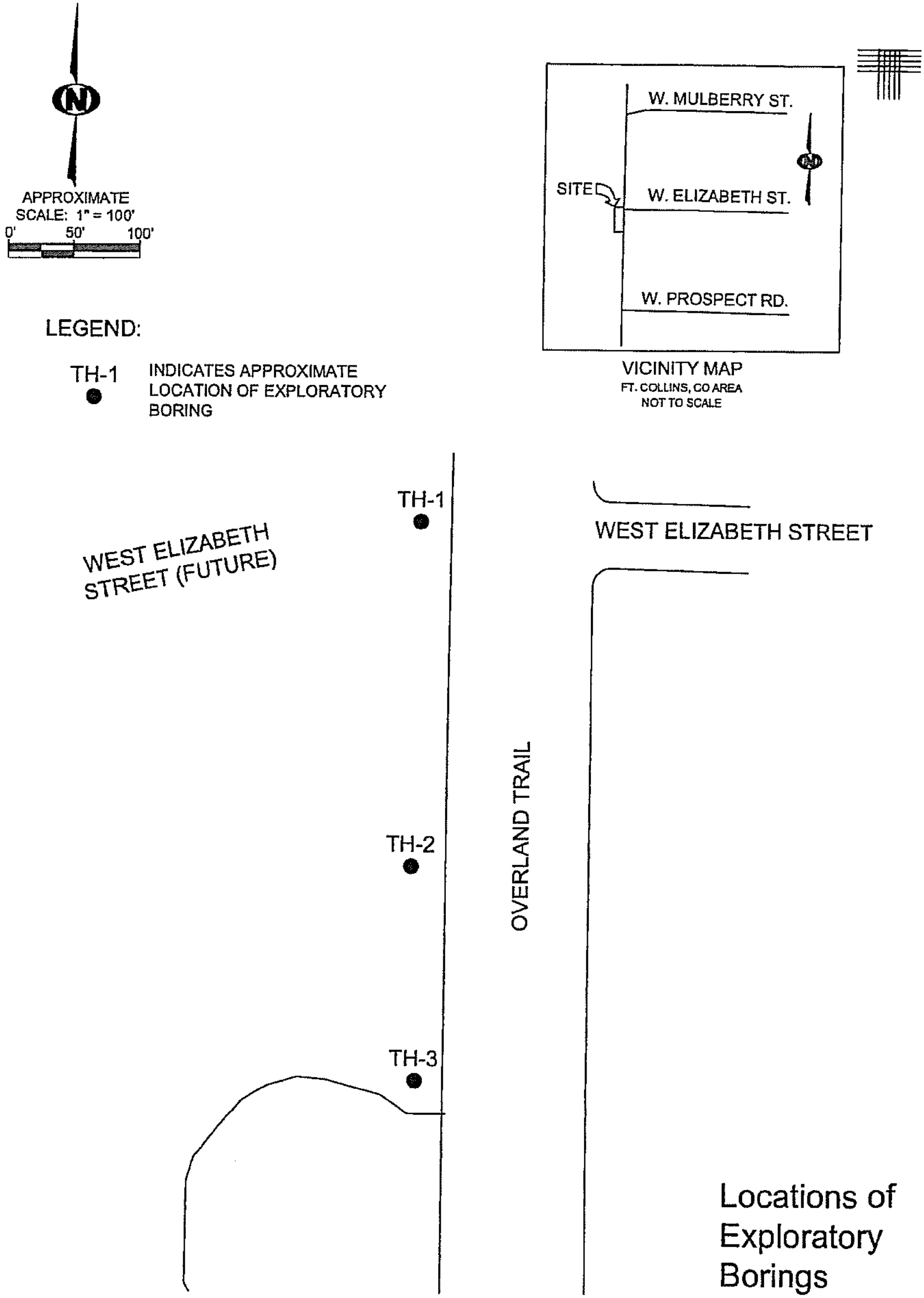
Thomas W. Finley, CPG
Senior Geologist

Spencer Schram, PE
Project Engineer

SAS:TWF

(3 Copies)

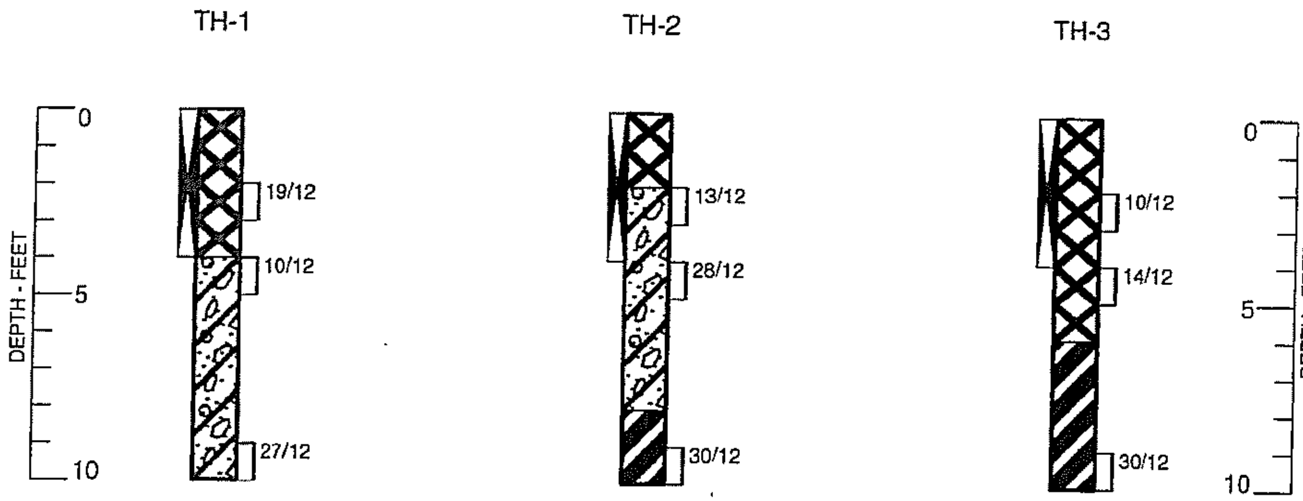
Via e-mail: Kelly.Martinez@mdch.com



Locations of Exploratory Borings

FIGURE 1

RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL I T PROJECT NO. FC05224.002-135



LEGEND:

FILL, CLAY, SANDY, WITH OCCASIONAL GRAVEL, MOIST, STIFF TO VERY STIFF, BROWN, DARK BROWN (CH)

GRAVEL, SLIGHTLY SILTY TO SANDY TO CLAYEY, WITH OCCASIONAL CLAYEY SAND, MOIST, MEDIUM DENSE, BROWN, DARK BROWN, TAN (GM, GP-GM, GP, SC)

WEATHERED CLAYSTONE, SANDY, MOIST, MEDIUM HARD, OLIVE, GRAY, BROWN

DRIVE SAMPLE. THE SYMBOL 19/12 INDICATES 19 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

BULK SAMPLE FROM AUGER CUTTINGS.

NOTES:

1. THE BORINGS WERE DRILLED ON MARCH 3, 2014 USING 4-INCH DIAMETER CONTINUOUS-FLIGHT AUGERS AND A TRUCK-MOUNTED DRILL RIG.

2. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS AND CONCLUSIONS IN THIS REPORT.

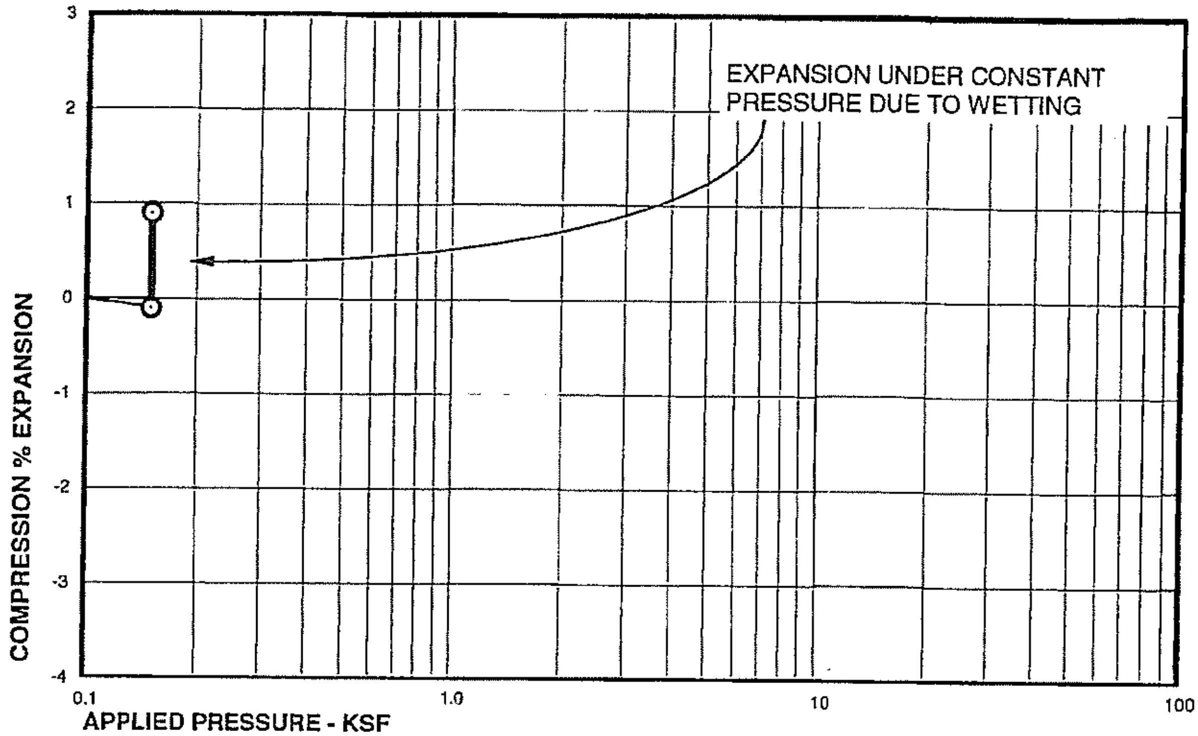
RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL | T PROJECT NO FC06224 002-135

Summary Logs of Exploratory Borings

FIGURE 2

APPENDIX A

RESULTS OF LABORATORY TESTING

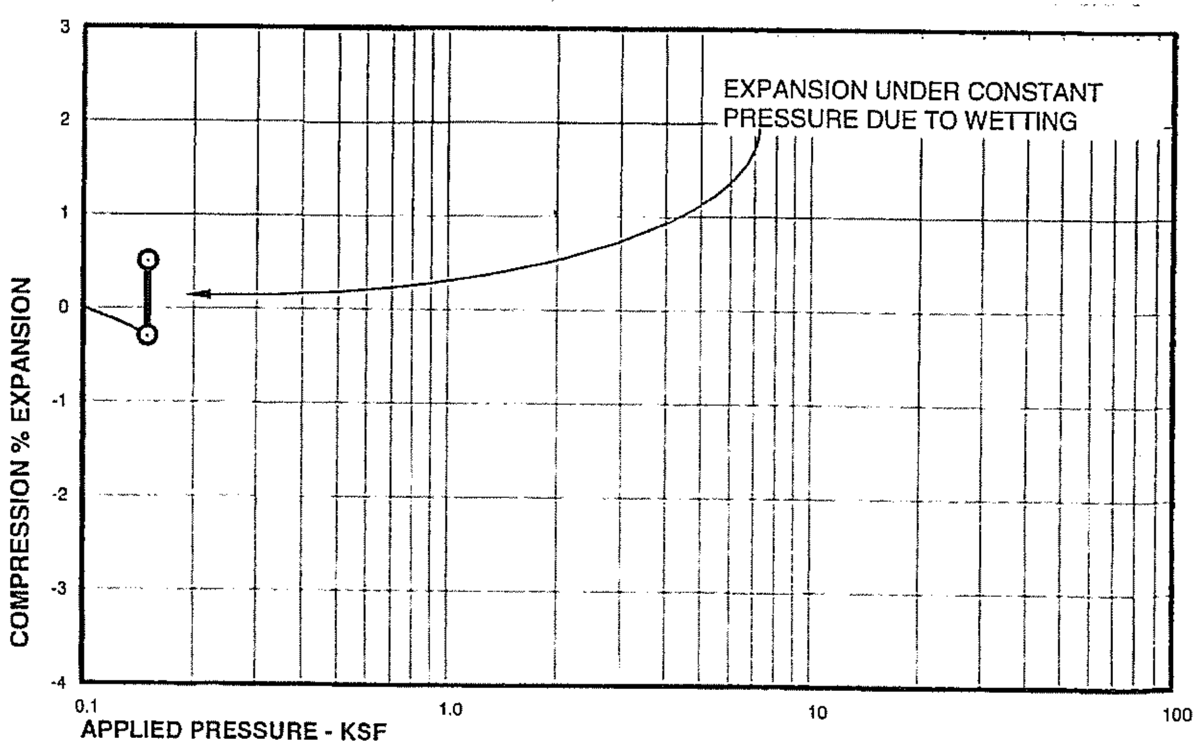


Sample of FILL, CLAY, SANDY (CH)

From TH - 1 AT 2 FEET

DRY UNIT WEIGHT= 110 PCF

MOISTURE CONTENT= 16.1 %



Sample of FILL, CLAY, SANDY (CH)

From TH - 3 AT 2 FEET

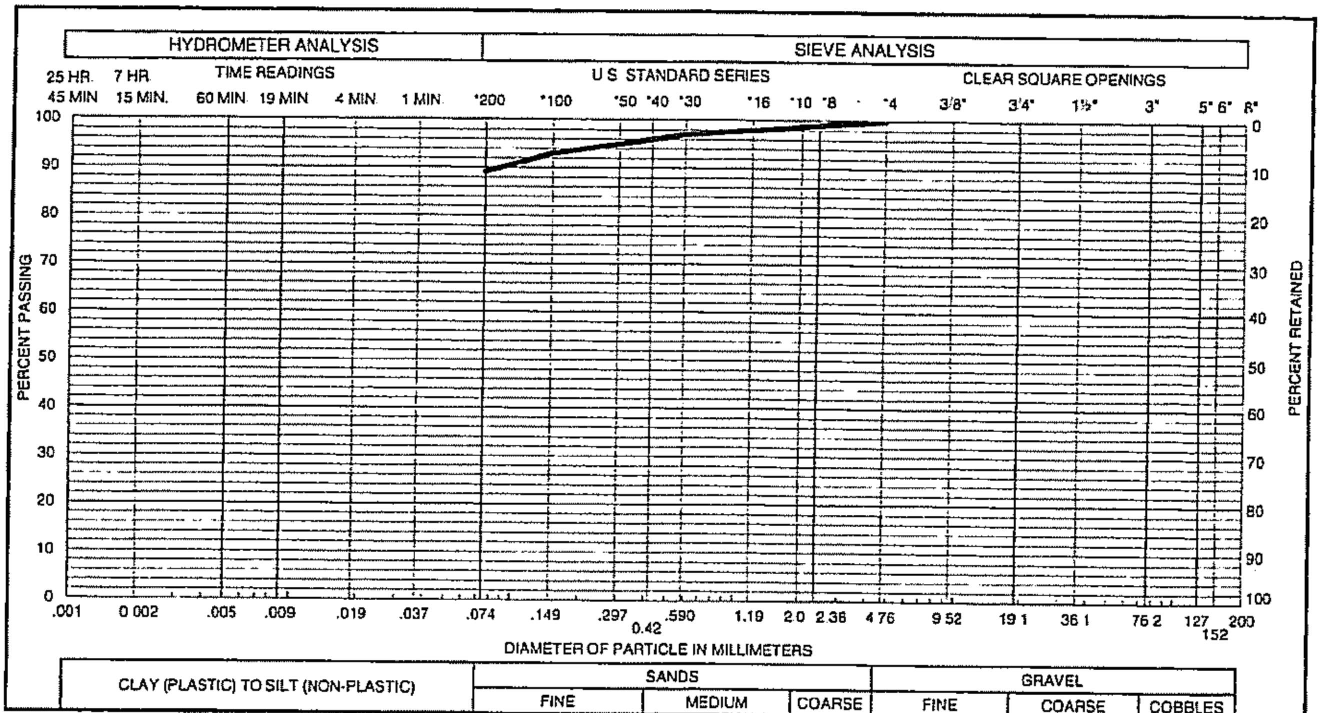
DRY UNIT WEIGHT= 114 PCF

MOISTURE CONTENT= 20.6 %

RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL | T PROJECT NO. FC05224.002-135

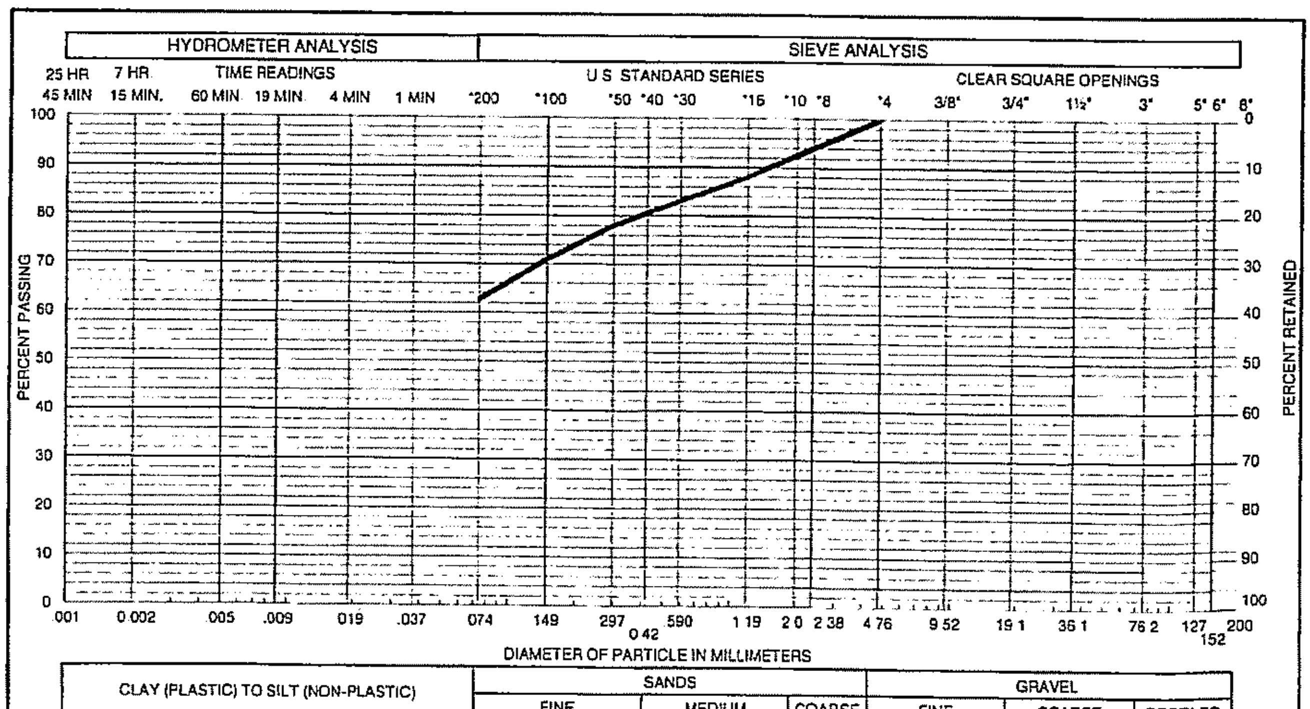
Swell Consolidation Test Results

FIGURE A -1



Sample of CLAY, SANDY (CH)
From S - 1 AT 0-4 FEET

GRAVEL	0 %	SAND	11 %
SILT & CLAY	89 %	LIQUID LIMIT	54 %
PLASTICITY INDEX			33 %



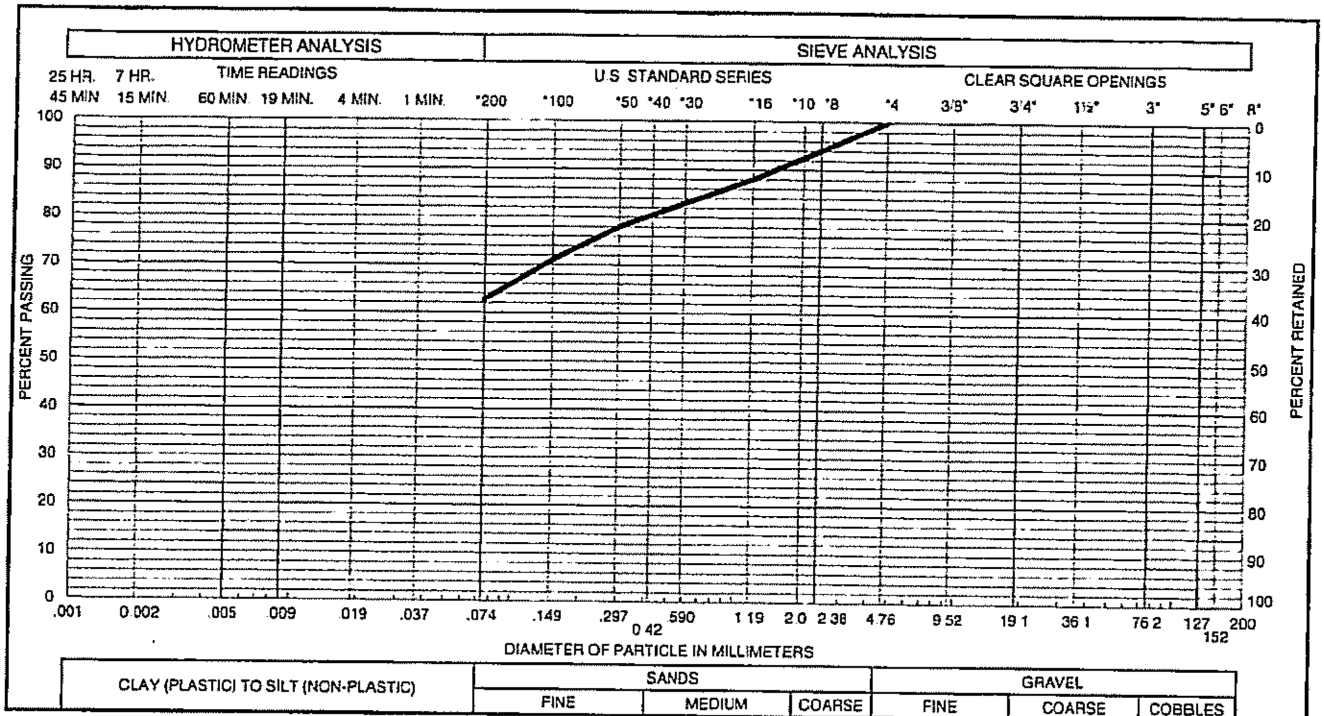
Sample of CLAY, SANDY (CH)
From S - 2 AT 0-4 FEET

GRAVEL	0 %	SAND	37 %
SILT & CLAY	63 %	LIQUID LIMIT	50 %
PLASTICITY INDEX			31 %

RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL | T PROJECT NO. FC06224.002-135

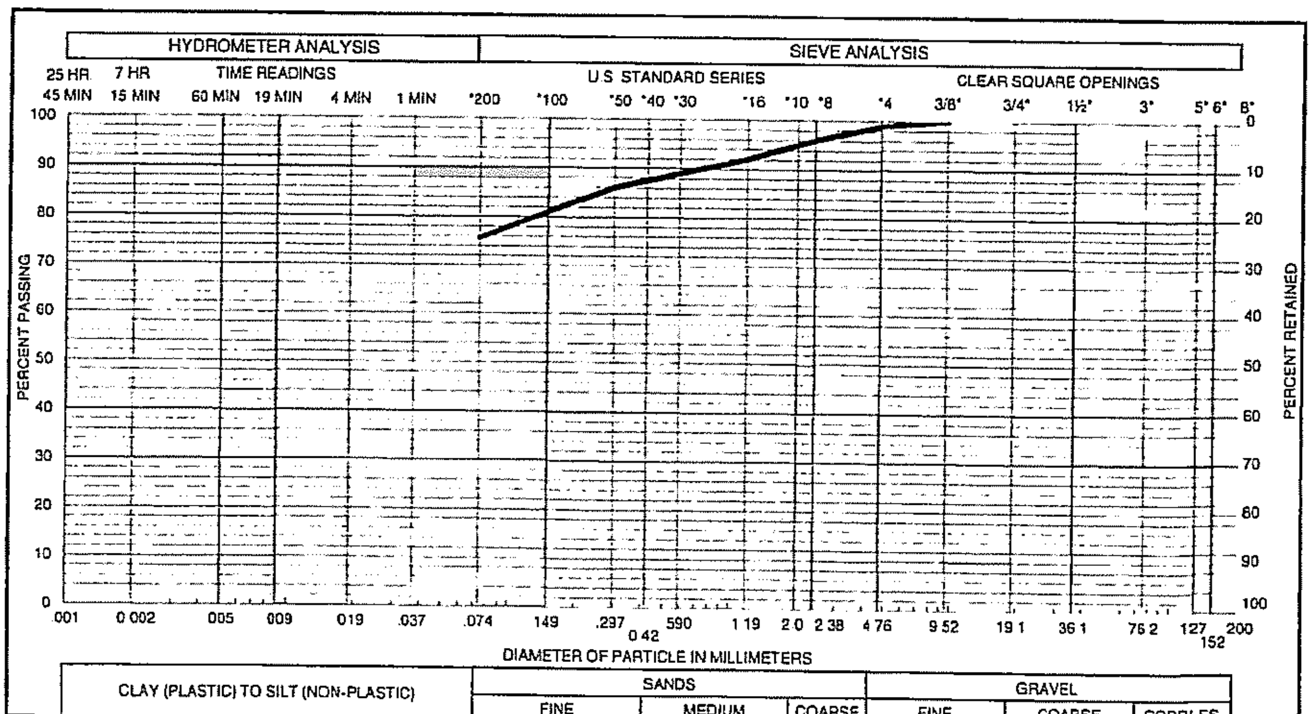
Gradation Test Results

FIGURE A -2



Sample of CLAY, SANDY (CH)
From TH - 2 AT 0-4 FEET

GRAVEL	0 %	SAND	37 %
SILT & CLAY	63 %	LIQUID LIMIT	50 %
PLASTICITY INDEX			31 %



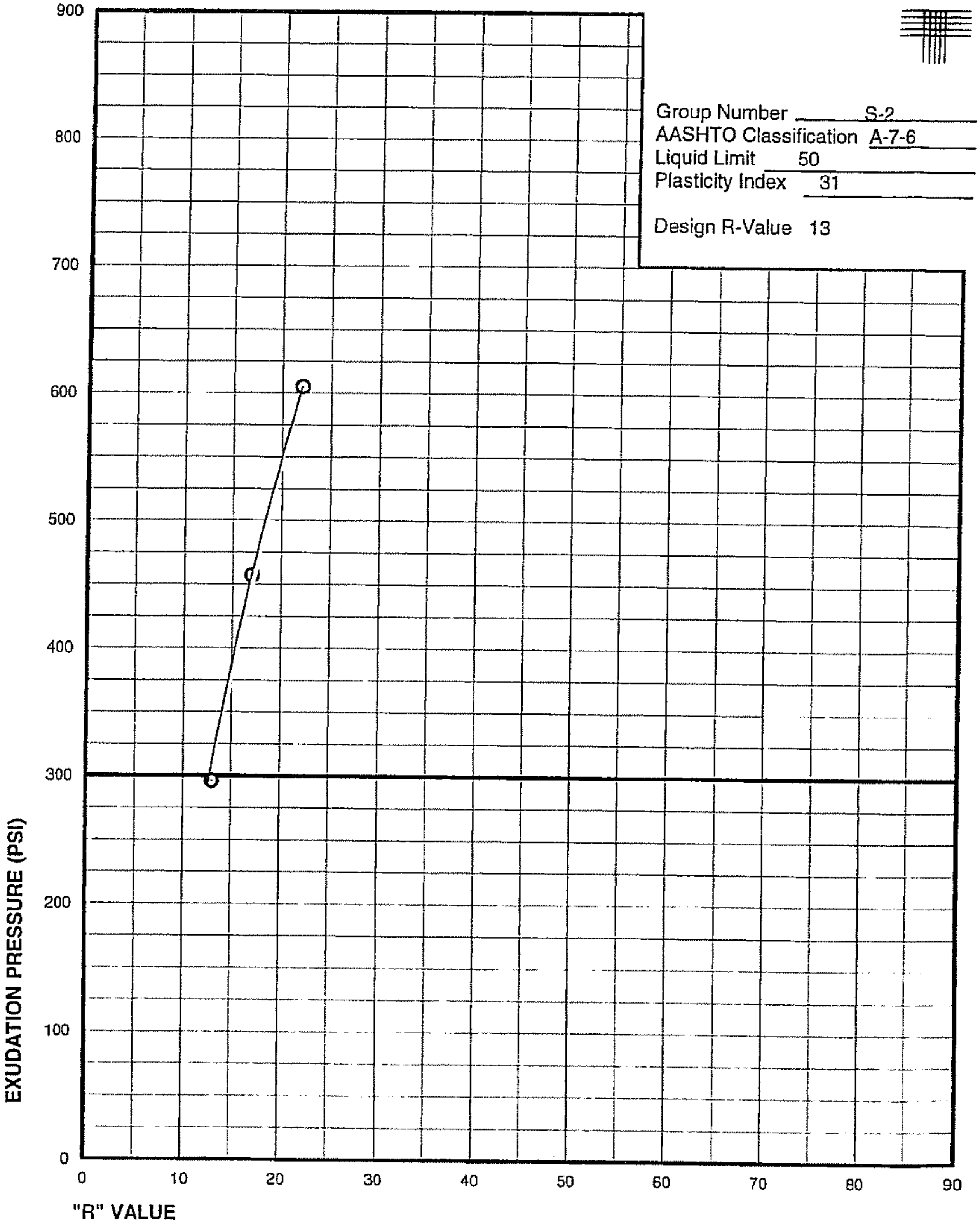
Sample of FILL, CLAY, SANDY (CH)
From TH - 3 AT 4 FEET

GRAVEL	1 %	SAND	23 %
SILT & CLAY	76 %	LIQUID LIMIT	58 %
PLASTICITY INDEX			36 %

RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL | T PROJECT NO. FC06224.002-135

Gradation Test Results

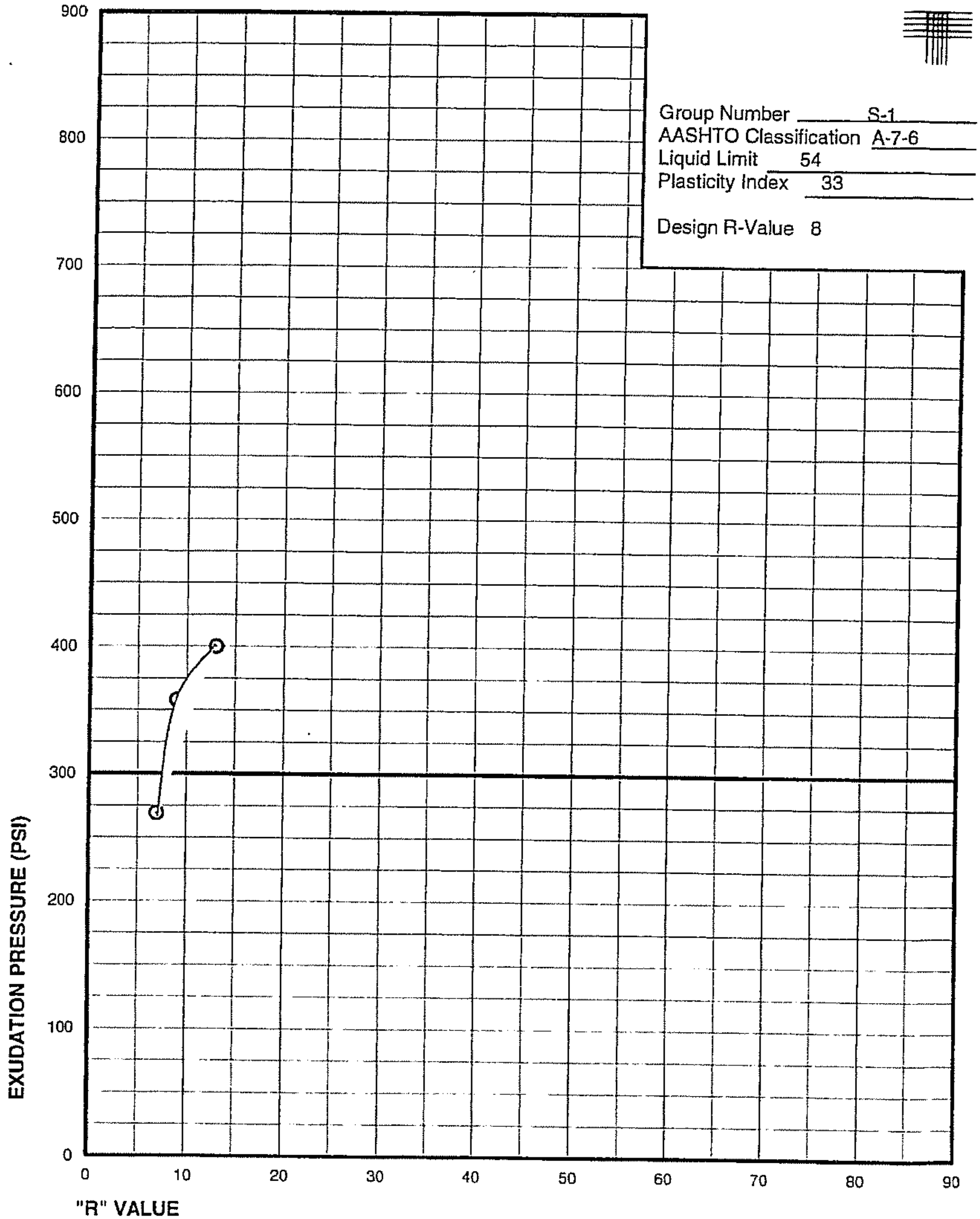
FIGURE A -3



RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL | T PROJECT NO. FC06224.002-135

Hveem Stabilometer Test Results

FIGURE A-4



RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL | T PROJECT NO. FC06224.002-135

Hveem Stabilometer Test Results

FIGURE A-5

TABLE A -I

SUMMARY OF LABORATORY TESTING

BORING	DEPTH (FEET)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS		SWELL TEST RESULTS*			PASSING NO. 200 SIEVE (%)	WATER-SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (GROUP INDEX)	DESCRIPTION
				LIQUID LIMIT	PLASTICITY INDEX	SWELL* (%)	APPLIED PRESSURE (PSF)	SWELL PRESSURE (PSF)				
S-1	0-4			54	33				89		A-7-6 (32)	CLAY, SANDY (CH)
S-2	0-4			50	31				63		A-7-6 (17)	CLAY, SANDY (CH)
TH-1	2	16.1	110			1.0	150			<0.01		FILL, CLAY, SANDY (CH)
TH-2	2	8.5	118	35	20				37		A-6 (2)	SAND, CLAYEY (SC)
TH-3	2	20.6	114			0.8	150			<0.01		FILL, CLAY, SANDY (CH)
TH-3	4	21.7	97	58	36				76		A-7-6 (28)	FILL, CLAY, SANDY (CH)

* NEGATIVE VALUE INDICATES COMPRESSION.

RICHMOND AMERICAN HOMES
OVERLAND TRAIL WIDENING AT BELLA VIRA
CTL|T PROJECT NO. FC06224 002-135

APPENDIX B

PAVEMENT DESIGN CALCULATIONS

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

CTL Thompson, Inc.

Flexible Structural Design Module

Overland Trail Widening - Bella Vira Subd.
South of Elizabeth St., Fort Collins, CO
Project No. FC06224.002-135

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	2,804,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,311 psi
Stage Construction	1
Calculated Design Structural Number	5.15 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	7	24	3.08
2	ABC	0.11	1.05	14	24	1.62
3	FATS	0.05	1	10	24	0.50
Total	-	-	-	31.00	-	5.20

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

CTL Thompson, Inc.

Flexible Structural Design Module

Overland Trail Widening - Bella Vira Subd.
South of Elizabeth St., Fort Collins, CO
Project No. FC06224.002-135

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	2,804,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,311 psi
Stage Construction	1
Calculated Design Structural Number	5.15 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	8	24	3.52
2	ABC	0.11	1.05	10	24	1.16
3	FATS	0.05	1	10	24	0.50
Total	-	-	-	28.00	-	5.18

APPENDIX C

PAVEMENT CONSTRUCTION RECOMMENDATIONS

SUBGRADE PREPARATION

Chemically Stabilized Subgrade (CSS)

1. Utility trenches and all subsequently placed fill should be properly compacted and tested prior to subgrade preparation. As a minimum, fill should be compacted to 95 percent of standard Proctor maximum dry density.

2. The subgrade should be stripped of organic matter and should be shaped to final line and grade.

3. The contractor or owner's representative should have a mix design performed in general accordance with ASTM D 558 using the actual site soils and the approved stabilizing agent (lime, fly ash or a combination of lime and fly ash). Scheduling should allow at least two weeks for the mix design to be completed prior to construction.

4. High calcium quicklime should conform to the requirements of ASTM C 977 and ASTM C 110. Dolomitic quicklime, magnesia quicklime with magnesium oxide contents in excess of 4 percent, or carbonated quicklime should not be used.

5. Fly ash should consist of Class C in accordance with ASTM C 593 and C 618.

6. All stabilizing agents should come from the same source as used in the mix design. If the source is changed, a new mix design should be performed.

7. Stabilizing agents should be spread with a mechanical spreader from back of curb to back of curb for detached sidewalks or back of walk to back of walk for attached sidewalks, where applicable.

8. The subgrade should be mixed to the specified depth and at the specified concentration until a uniform blend of soil, stabilizing agent and water is obtained and the moisture content is at least 2 percent (for fly ash) and 3 percent (for lime) above the optimum moisture content of the design mixture (ASTM D 558).

9. If lime is used, a mellowing period of up to seven days may be required following initial mixing. Once the pH of the mixture is 12.3 or higher and the plasticity index is less than 10, the soils shall again

be mixed and moisture conditioned to at least 3 percent over optimum moisture content and compacted to at least 95 percent of the mixture's maximum dry density (ASTM D 558). Up to seven additional days may be required for curing prior to paving. The treated surface shall be kept moist or sealed with emulsified asphalt. Traffic should not be allowed on the surface during the mellowing and curing periods.

10. If fly ash is used, the mixture should be moisture conditioned to at least 2 percent over optimum moisture content and compacted to at least 95 percent of the mixture's maximum dry density (ASTM D 558) within 2 hours from the time of initial fly ash mixing.

11. If a lime/fly ash combination is used, the lime should be mixed first and allowed to mellow as indicated for lime treatment in item 9. Following the mellowing period, the fly ash should be added, moisture conditioned and compacted as indicated above within 2 hours of initial fly ash mixing.

12. Samples of loose, blended stabilizing agent/soil mixture should be sampled by a representative of CTL Thompson, Inc. for compressive strength testing (ASTM D 1663) to determine compliance (optional) when full credit for the FASS layer is used in the pavement thickness design.

13. Batch tickets should be supplied to the owner or owner's representative with the application area for that batch to determine compliance with the recommended proportions of fly ash to soil.

14. The subgrade should be re-shaped to final line and grade.

15. The subgrade should be sealed with a pneumatic-tire roller that is sufficiently light in weight so as to not cause hairline cracking of the subgrade.

16. Where sulfate concentrations are over 0.5 percent, a double treatment method should be performed. When a double treatment is required, the first half of the stabilizing agent should be placed, moisture treated and allowed to mellow or cure for at least two weeks. The remaining half of the stabilizing agent plus an additional 0.5 (for lime) to 2 (for fly ash) percent shall then be applied.

17. Mixing of the fly ash, lime, or lime/fly ash treated subgrade should not occur if the temperature of the soil mixture is below 40°F.

18. We recommend a minimum of 2 days curing prior to paving. The surface of the stabilized area should be kept moist during the cure period by periodic, light sprinkling if needed. Strength gains will be slower during cooler weather. Traffic should not be permitted on the treated subgrade during the curing period. The subgrade should be protected from freezing or drying at all times until paving.

19. The treated areas will gain greater strength if they are allowed to cure for 1 to 3 days prior to paving. Construction traffic on the treated subgrade prior to pavement section construction should be limited and the subgrade should be protected from freezing or drying at all times until paving.

20. Placement, mixing and compaction of stabilized subgrade should be observed and tested by a representative of our firm.

PAVEMENT MATERIALS AND CONSTRUCTION

Aggregate Base Course (ABC)

1. A Class 5 or 6 Colorado Department of Transportation (CDOT) specified ABC should be used.

2. Bases should have a minimum Hveem stabilometer value of 72, or greater. ABC must be moisture stable. The change in R-value from 300-psi to 100-psi exudation pressure should be 12 points or less.

3. ABC, RAP or RCP bases should be placed in thin lifts not to exceed 6 inches and moisture treated to near optimum moisture content. Bases should be moisture treated to near optimum moisture content, and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698, AASHTO T 99).

4. Placement and compaction of ABC, RAP, or RCP should be observed and tested by a representative of our firm. Placement should not commence until the underlying subgrade is properly prepared and tested.

Hot Mix Asphalt (HMA)

1. HMA should be composed of a mixture of aggregate, filler, hydrated lime and asphalt cement. Some mixes may require polymer modified asphalt cement, or make use of up to 20 percent reclaimed asphalt pavement (RAP). A job mix design is recommended and periodic checks on the job site should be made to verify compliance with specifications.

2. HMA should be relatively impermeable to moisture and should be designed with crushed aggregates that have a minimum of 80 percent of the aggregate retained on the No. 4 sieve with two mechanically fractured faces.

3. Gradations that approach the maximum density line (within 5 percent between the No. 4 and 50 sieves) should be avoided. A gradation with a nominal maximum size of 1 or 2 inches developed on the fine side of the maximum density line should be used.

4. Total void content, voids in the mineral aggregate (VMA) and voids filled should be considered in the selection of the optimum asphalt cement content. The optimum asphalt content should be selected at a total air void content of approximately 4 percent. The mixture should have a minimum VMA of 14 percent and between 65 percent and 80 percent of voids filled.

5. Asphalt cement should meet the requirements of the Superpave Performance Graded (PG) Binders. The minimum performing asphalt cement should conform to the requirements of the governing agency.

6. Hydrated lime should be added at the rate of 1 percent by dry weight of the aggregate and should be included in the amount passing the No. 200 sieve. Hydrated lime for aggregate pretreatment should conform to the requirements of ASTM C 207, Type N.

7. Paving should be performed on properly prepared, unfrozen surfaces that are free of water, snow and ice. Paving should only be performed when both air and surface temperatures equal, or exceed, the temperatures specified in Table 401-3 of the 2006 Colorado Department of Transportation Standard Specifications for Road and Bridge Construction.

8. HMA should not be placed at a temperature lower than 245°F for mixes containing PG 64-22 asphalt, and 290°F for mixes containing polymer-modified asphalt. The breakdown compaction should be completed before the HMA temperature drops 20°F.

9. Wearing surface course shall be Grading S or SX for residential roadway classifications and Grading S for collector, arterial, industrial, and commercial roadway classifications.

10. The minimum/maximum lift thicknesses for Grade SX shall be 1½ inches/2½ inches. The minimum/maximum lift thicknesses for Grade S shall be 2 inches/3½ inches. The minimum/maximum lift thicknesses for Grade SG shall be 3 inches/5 inches.

11. Joints should be staggered. No joints should be placed within wheel paths.

12. HMA should be compacted to between 92 and 96 percent of Maximum Theoretical Density. The surface shall be sealed with a finish roller prior to the mix cooling to 185°F.

13. Placement and compaction of HMA should be observed and tested by a representative of our firm. Placement should not commence until approval of the proof rolling as discussed in the Subgrade Preparation section of this report. Sub base, base course or initial pavement course shall be placed within 48 hours of approval of the proof rolling. If the Contractor fails to place the sub base, base course or initial pavement course within 48 hours or the condition of the subgrade changes due to weather or other conditions, proof rolling and correction shall be performed again.

APPENDIX D

MAINTENANCE PROGRAM

MAINTENANCE RECOMMENDATIONS FOR FLEXIBLE PAVEMENTS

A primary cause for deterioration of pavements is oxidative aging resulting in brittle pavements. Tire loads from traffic are necessary to "work" or knead the asphalt concrete to keep it flexible and rejuvenated. Preventive maintenance treatments will typically preserve the original or existing pavement by providing a protective seal or rejuvenating the asphalt binder to extend pavement life.

1. Annual Preventive Maintenance

   a. Visual pavement evaluations should be performed each spring or fall.
   b. Reports documenting the progress of distress should be kept current to provide information on effective times to apply preventive maintenance treatments.
   c. Crack sealing should be performed annually as new cracks appear.

2. 3 to 5 Year Preventive Maintenance

   a. The owner should budget for a preventive treatment at approximate intervals of 3 to 5 years to reduce oxidative embrittlement problems.
   b. Typical preventive maintenance treatments include chip seals, fog seals, slurry seals and crack sealing.

3. 5 to 10 Year Corrective Maintenance

   a. Corrective maintenance may be necessary, as dictated by the pavement condition, to correct rutting, cracking and structurally failed areas.
   b. Corrective maintenance may include full depth patching, milling and overlays.
   c. In order for the pavement to provide a 20-year service life, at least one major corrective overlay should be expected.