212059 TS1
1970-3006
11, 12C

REQUEST FOR ALTERNATE PAVEMENT THICKNESS

July 10, 2012

City Engineer
City of Aurora, Public Works Department
15151 E. Alameda Parkway, Ste 3200
Aurora, CO 80012

Subject: 1470 S. Havana Street -- CCRC

Dear Sir:

1470 South Havana Street, LLC requests that the following pavement sections be approved for the above-referenced Assisted Living project: 1470 S. Havana Street.
Subdivision, lot, block: Buckingham Square (3rd Filing), Lot 1, Block 1.

All new asphalt paving to be 6.5" full depth asphalt in the drive isles, 5.5" full depth asphalt in the parking areas, and 5.5" full depth Portland cement concrete for the loading dock area, per Pickering, Cole & Hiver, LLC Geotechnical Report # 12.124.12 dated May 22, 2012.

As Owner of this property, 1470 South Havana Street, LLC is aware that this pavement design does not meet the criteria established by the City of Aurora for this application.

The attached soils report references the characteristics of the soil and recommends the above sections. In addition, 1470 South Havana Street, LLC shall hold the City of Aurora harmless for the performance and maintenance of this design.

Sincerely,

[signature] 7-10-12
(Authorized Signature) Date

Dennis Witte
(Type Authorized Signatory's Name) Date

1470 South Havana Street, LLC
(Company/Owner Name)

Mark L. Hahn 7-18-12
(Authorized Signature) Date

[signature] 7-19-12
(City Engineer) Date

Approved Pavement Sections:
Parking Areas: 5½" AC
Drive Isles: 6½" AC
Loading Dock Area: 5½" PCC
MLH
7-18-12

212059

Geotechnical Engineering Report

Proposed Office Building Renovations
1470 South Havana Street
Aurora, Colorado

Prepared for:

1470 S. Havana, LLC
770 West Hampden Avenue, Suite 175
Denver, Colorado 80110

Prepared by:

Pickering, Cole & Hivner, LLC
PCH Project No. 12.124.12

May 22, 2012

May 22, 2012

1470 S. Havana, LLC
770 West Hampden Avenue, Suite 175
Denver, Colorado 80110

Attn: Mr. Dennis Witte

Re: Geotechnical Engineering Report
Proposed Office Building Renovations
1470 South Havana Street
Aurora, Colorado
PCH Project No. 12.124.12

Pickering Cole & Hivner, LLC (PCH) has completed a geotechnical engineering investigation for the proposed building renovations and site improvements to the existing office development located at the above-referenced address. This study was performed in general accordance with the provided Consulting Agreement, executed by our firm on May 1, 2012.

EXECUTIVE SUMMARY

This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

- **Field Investigation:** In accordance with our proposed scope of services, geotechnical exploration of the site was performed by advancing nine test borings on the site. Of this total, four borings were advanced within the approximate footprint of the proposed carport, one boring was drilled within the approximate area of the proposed porte-cochere, and four borings were drilled in planned private pavement areas. At the request of the design team, six additional borings were advanced to shallow depths for percolation testing in support of stormwater detention pond design. Structural borings were advanced to depths ranging from about 15 to 25 feet, while pavement and percolation test borings were advanced to depths of about 5 feet below existing site grade.

- **Subsurface Conditions:** The soils encountered beneath about 1-½ to 3 inches of asphalt pavement at the site generally included up to 19 to 24 feet of loose to medium dense, silty and clayey sand. Stiff to very stiff lean clay soils were typically encountered beneath the sands and

were underlain by hard, sedimentary claystone bedrock at depths of about 22 to 24 feet below existing site grade. Groundwater was encountered in the deeper borings at depths ranging from about 11 to 13 feet below existing site grade. Other specific information regarding the lithology encountered is noted on the Boring Logs.

- **Structure Foundations:** We believe that shallow foundations will provide acceptable performance when bearing on approved undisturbed sand soils or properly compacted fill. Alternatively, shallow drilled piers may also be considered for support of the proposed carport. The bearing soils should be observed by the geotechnical engineer to confirm or modify these recommendations.

- **Surface Drainage:** The amount of movement associated with foundations, floor slabs, pavements, etc. will be related to the wetting of underlying supporting soils. Therefore, it is imperative the recommendations outlined in the "Grading and Drainage" section of this report be followed to reduce potential movement.

- **Pavement Design and Structural Sections:** Design of pavements for the project is based on the procedures outlined in the 1993 *Guideline for Design of Pavement Structures* by the American Association of State Highway and Transportation Officials (AASHTO) and City of Aurora Standards using assumed traffic volumes.

  Light duty pavements for automobile parking areas should include a minimum of 5-½ inches of asphalt concrete or, alternately, 5 inches of Portland cement concrete. Heavy-duty pavements such as for drive isles should include a minimum of 6-½ inches of asphalt concrete or, alternately, 5-½ inches of Portland cement concrete.

We appreciate being of service to you in the geotechnical engineering phase of this project, and are prepared to assist you during the construction phases as well. Please do not hesitate to contact us if you have any questions concerning this report or any of our testing, inspection, design and consulting services.

Sincerely,
Pickering Cole & Hivner, LLC

COLORADO REGISTERED PROFESSIONAL ENGINEER
ANDREW J. GARNER
34273
5/22/12

Andrew J. Garner, P.E.
Senior Project Manager

Thomas C. Cole, P.E.
Principal

Copies to: Addressee (3)

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GEOTECHNICAL ENGINEERING REPORT

PROPOSED RENOVATIONS
1470 SOUTH HAVANA STREET
AURORA, COLORADO

PCH Project No. 12.124.12
May 22, 2012

INTRODUCTION

This report contains the results of our geotechnical engineering exploration for proposed building renovations and site improvements for the office development located at the referenced address in Aurora, Colorado.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and bedrock conditions
- Groundwater conditions
- Foundation design and construction
- Below-grade construction
- Lateral earth pressures
- Floor slab design and construction
- Pavement structural sections
- Earthwork
- Drainage

The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, our experience with similar subsurface conditions and structures, and our understanding of the proposed project.

In addition, we have reviewed Soil and Foundation Investigations prepared for the original constriction (prepared by Kal Zeff and Associates, Ltd., dated September 27, 1972 and June 7, 1973). Information and recommendations presented in these reports were considered in preparing our recommendations for this current study.

PROJECT INFORMATION

We understand that the improvements to the subject property will include the construction of a new porte-cochere near the northwest building extents, a covered carport along the western site extents, and a new loading dock near the southeast building corner. As part of the redevelopment, site improvements will include removal of existing site pavements and construction of a reconfigured parking lot, including a circular drive at the building entrance and parking area at the southeast building corner.

We understand that plans have not been finalized at this time, however, we anticipate that future construction grades will be within 2 feet of the existing site grades in the areas of the planned improvements. For the purposes of developing our recommendations, we assume that structural loading will be relatively light with maximum point loads of less than 50 kips and continuous wall loads (if any) of about 2 to 4 kips per foot.

Storm water detention and is planned to be constructed within an island in the parking lot located west of the building and in a small pond to be constructed near the southwest corner of the site. We assume that appurtenant construction will include installation of new underground utilities, exterior flatwork, and landscaping.

SITE EXPLORATION PROCEDURES

The scope of the services performed for this project included site reconnaissance by a field engineer, a subsurface exploration program, laboratory testing and engineering analysis.

Field Exploration: Our original scope of services included geotechnical exploration of the subsurface materials at nine test borings on the site. Of this total, four borings were advanced within the approximate footprint of the proposed carport, one boring was drilled within the approximate area of the proposed porte-cochere, and four borings were drilled in planned private pavement areas. At the request of the design team, six additional borings were advanced to shallow depths for percolation testing in support of stormwater detention pond design. Structural borings were advanced to depths ranging from about 15 to 25 feet, while pavement and percolation test borings were advanced to depths of about 5 feet below existing site grade.

Borings were advanced with a truck-mounted drilling rig utilizing 4-inch diameter, solid stem auger. Lithologic logs of each boring were recorded by our field personnel during the drilling operations. At selected intervals, samples of the subsurface materials were obtained by driving modified California and standard split-spoon barrel samplers. Penetration resistance measurements were obtained by driving the sample barrel into the subsurface materials with a 140-pound automatic hammer falling 30 inches. The penetration resistance value is a useful index to the consistency, relative density or hardness of the materials encountered.

Groundwater measurements were made in each boring at the time of site exploration and the borings loosely backfilled with the spoils following drilling. The pavement surface was swept and the borings patched with commercially available cold-patch material.

Laboratory Testing: Samples retrieved during the field exploration were returned to the laboratory for observation by the project geotechnical engineer, and were classified in general accordance with the Unified Soil Classification System described in Appendix C. At that time, an applicable laboratory-testing program was formulated to determine engineering properties of the subsurface materials. Following the completion of the laboratory testing, the field descriptions were confirmed or modified as necessary, and Boring Logs were prepared. These logs are presented in Appendix A.

Laboratory test results are presented in Appendix B. These results were used for the geotechnical engineering analyses and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable local or other accepted standards.

Selected soil and bedrock samples were tested for the following engineering properties:

- Water content
- Dry density
- Swell/Consolidation potential
- Grain size
- Plasticity Index

SITE CONDITIONS

The site is currently occupied by an existing eight-story office building. In general, existing site pavements direct surface water flows away from the building, with general site topography sloping down to the north. About 2 to 3 feet of vertical relief was estimated across the site. The site is bound on the north by East Idaho Place, on the east by South Joliet Street, on the south by East Florida Avenue, and on the west by a parking lot associated with a similar office development.

SUBSURFACE CONDITIONS

Geology: Surficial geologic conditions at the site, as mapped by the U.S. Geological Survey (USGS) ([1]Trimble and Machette, 1979), consist of windblown sand of Lower Holocene to Upper Pleistocene Age. These materials, as mapped in this area, are described as fine to medium sand derived from alluvium deposited to the east and southeast of source streams and waterways.

Bedrock underlying the surface units consists of the Denver Formation of Paleocene and Upper Cretaceous Age. These formations within this area have been reported to include sandstone, claystone and siltstone. The thickness of these units has been reported to be on the order of 900 feet.

[1]Trimble, Don E., and Machette, Michael N., 1979, ***Geologic Map of the Greater Denver Area, Front Range Urban Corridor, Colorado,*** United States Geological Survey, Map I-856-H.

Mapping completed by the Colorado Geological Survey ([2]Hart, 1972) indicates the site is located in an area of "High Swell Potential." Potentially expansive materials mapped in this area include bedrock, weathered bedrock and colluvium (surficial units).

Soil and Bedrock Conditions: The soils encountered beneath about 1-½ to 3 inches of asphalt pavement at the site generally included up to 19 to 24 feet of silty and clayey sand. Lean clay soils were typically encountered beneath the sands and were underlain by sedimentary claystone bedrock at depths of about 22 to 24 feet below existing site grade. The bedrock extended to the full depth of exploration. Other specific information regarding the lithology encountered is noted on the Boring Logs.

Field and Laboratory Test Results: Field test results indicate that the sand soils are generally loose to medium dense in relative density. The clay soils are stiff to very stiff in consistency and the bedrock is considered hard.

Testing indicated the sand soils on the site are non- to low plastic and have nil to low expansive potential. In our opinion, the clays and claystone bedrock should be considered at least low to moderately expansive at existing moisture contents. Other laboratory test results are presented in Appendix B.

Field Percolation Testing and Results: For the purposes of estimating storm water infiltration rates, field percolation testing was performed within the proposed storm water infiltration and detention pond areas. At the request of the project Civil engineer, three percolation test borings were advanced in each detention area as shown on the Boring Location Diagram in Appendix A. These borings were filled with water on May 8 and percolation testing was performed May 9, 2012.

Percolation test results are summarized as follows:

Percolation Test Results			
Test Number	**Depth (inches)**	**Avg. Ending Percolation Rate (min/in)***	**Recommended Design Percolation Rate (min/in)***
1	54	140	60
2	54	30	
3	54	17	
4	54	52	45
5	54	42	
6	54	11	

[2]Hart, Stephen S., 1972, ***Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado***, Colorado Geological Survey, Sheet 2 of 4.

* Each percolation test was run for approximately 4 hours in efforts to determine stabilized percolation rates; however, some fluctuation was still occurring at the conclusion of each test. As such, we have reported the average percolation rate based on the last four readings and provided a recommended rate considering these values and the soil conditions encountered.

The percolation rates in retention areas can be affected over time by factors including siltation and vegetative growth.

Groundwater Conditions: Groundwater was encountered in the deeper borings at depths ranging from about 11 to 13 feet below existing site grade. Groundwater conditions may fluctuate seasonally.

Based upon review of U.S. Geological Survey Maps ([3]Hillier, et al, 1983), regional groundwater beneath the project area is located in the Denver Aquifer, generally below a depth of 20 feet and commonly more than a depth of 100 feet below present ground surface. Locally, shallow groundwater can be found in alluvial and colluvial deposits along modern streambeds.

Zones of perched and/or trapped groundwater may occur at times in the subsurface soils overlying bedrock, on top of the bedrock surface or within zones of finer grained soils. The location and amount of perched water is dependent upon several factors including hydrologic conditions, type of site development, irrigation demands on or adjacent to the site, fluctuations in water features, seasonal and weather conditions. A detailed groundwater study was not included within the authorized scope of services for this site.

ENGINEERING RECOMMENDATIONS

Geotechnical Considerations: The site appears suitable for the proposed construction from a geotechnical standpoint. The native sand soils are considered suitable for support of shallow spread footings. Alternatively, the carport may be supported on drilled piers. Exposed soil bearing conditions should be observed by our firm prior to foundation construction to confirm that the recommendations in this report remain applicable.

Design and construction recommendations for the foundation systems and other earth-connected phases of the project are outlined below.

Foundation Design and Construction: Due to the presence of non- to low swelling sand soils on the site, spread footing foundations are suitable for support of the proposed structural elements. If desired, relatively shallow drilled pier foundations could be considered for support of the carport structure.

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[3]Hillier, Donald E.; Schneider, Paul A., Jr.; and Hutchinson, E. Carter, 1983, ***Depth to Water Table (1976-1977) in the Greater Denver Area, Front Range Urban Corridor, Colorado***, United States Geological Survey, Map I-856-K.

Spread footings or drilled shafts may be designed for a maximum net allowable bearing pressure of 3,000 pounds per square foot (psf). The design bearing pressure applies to dead loads plus design live load conditions. The design bearing pressures may be increased by 1/3 when considering total loads that include wind or seismic conditions.

Drilled foundation elements (as well as spread footings whose sides are cast against undisturbed earth) may also be designed using a maximum skin friction of 350 psf to resist axial compressive as well as uplift loads for that portion of the foundation deeper than 3 feet below finished grade.

Exterior footings should be placed a minimum of 36 inches below finished grade for frost protection and to provide confinement for the bearing soils. Finished grade is the lowest adjacent grade for perimeter footings.

Areas of low-density or soft soils may be encountered at foundation bearing depth. When such conditions exist beneath planned footing areas, the subgrade soils should be removed to a minimum depth of 18 inches and a minimum of 18 inches horizontally beyond the edge of footings. The soils should be replaced as engineered fill, conditioned to near optimum moisture content and compacted.

Footings should be proportioned to maintain a relatively consistent dead-load pressure in order to reduce differential settlement between adjacent footings. Total settlement resulting from the assumed structural loads is estimated to be on the order of 1 inch or less. Differential settlement should be on the order of 1/2 to 3/4 of the estimated total settlement. Additional foundation movements could occur if water from any source infiltrates the foundation soils; therefore, proper drainage should be provided in the final design and during construction. Failure to maintain the surface drainage recommendations outlined within this report may result in movements in excess of those outlined herein.

Foundation excavations and earthwork operations should be observed by the geotechnical engineer during construction. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations may be required.

Lateral Earth Pressures: For soils above any free water surface, recommended equivalent fluid pressures for restrained elements, the following equivalent fluid pressures are:

- At rest:
  On-site sands or imported fill .... 60 psf/ft

Where the design includes unrestrained elements (free to move laterally), the following equivalent fluid pressures are recommended:

- Active:
  On-site sands or imported fill .... 40 psf/ft

- Passive:
  On-site soil backfill.. 350 psf/ft

The lateral earth pressures herein do not include any factor of safety and are not applicable for submerged soils/hydrostatic loading. As such, any walls that retain soil should be designed with adequate subsurface drainage systems. Additional recommendations may be necessary if submerged conditions are to be included in the design. A coefficient of friction of 0.35 may be utilized in the design of lateral resistance to sliding.

Fill against foundations should be processed, moisture conditioned and compacted according to the recommendations in the "Earthwork" section of this report. Compaction of each lift adjacent to walls should be accomplished with hand-operated tampers or other lightweight compactors. Over compaction may cause excessive lateral earth pressures that could result in wall movement.

Below-Grade Construction: As currently planned, below-grade, crawlspace or basement construction is not anticipated. Should basement construction be included in the final design, we should be contacted to provide additional recommendations for subsurface drainage systems.

Seismic Considerations: A site classification "D" should be used for the design of structures for the proposed project (2009 International Building Code, Table No. 1613.5.2).

Pavement Design and Construction: Design of pavements for the project is based on the procedures outlined in the 1993 *Guideline for Design of Pavement Structures* by the American Association of State Highway and Transportation Officials (AASHTO) and City of Aurora standards. In lieu of additional pavement-specific exploration and submittal of a separate pavement thickness design report meeting City of Aurora design standards, the pavement sections presented in this report will likely be approved by the City; however, the City will require that a waiver form be submitted (attached in Appendix D) prior to approval and issuance of a paving permit for the project.

The following traffic criteria were used for determining the recommended 20-year pavement thicknesses. If these estimated values are not accurate, please contact us to revise the applicable pavement thickness design recommendations.

Pavement Area	Daily Traffic			Total Design Equiv. Single-Axle Loads (ESAL's)
	Cars/Light Trucks	Delivery Trucks*	Tractor-trailer and Trash Trucks*	
Light Duty	1,000	0	0	25,000
Heavy Duty	1,000	10	2	70,000

* Single-unit delivery trucks maximum weight of 20,000 to 25,000 pounds. Typical tractor/trailer traffic to include large retail delivery vehicles.

Based upon AASHTO criteria, Colorado is located within Climatic Region VI of the United States. This region is characterized as being dry, with hard ground freeze and spring thaw. The spring thaw condition typically results in saturated or near-saturated subgrade soil moisture conditions. The AASHTO criteria suggest that these moisture conditions are prevalent for approximately 12-1/2 percent of the annual moisture variation cycle.

Local drainage characteristics of proposed pavement areas are considered to vary from fair to good depending upon location on the site. For purposes of this design analysis, fair drainage characteristics are considered to control the design. These characteristics, coupled with the approximate duration of saturated subgrade conditions, result in a design drainage coefficient of 1.0 when applying the AASHTO criteria for design.

For flexible pavement design associated with the proposed building, a terminal serviceability index of 2.0 was utilized along with an inherent reliability of 85 percent and a design life of 20 years.

Using a correlated design R-value of 15, the appropriate ESAL values, environmental criteria and other factors, the structural numbers (SN) of the pavement sections were determined on the basis of the 1993 AASHTO design equation.

In addition to the flexible pavement design analyses, a rigid pavement design analysis was completed based upon AASHTO design procedures. Rigid pavement design is based on an evaluation of the Modulus of Subgrade Reaction of the soils (K-value), the Modulus of Rupture of the concrete, and other factors previously outlined. The design K-value for the subgrade soil was determined by correlation to the laboratory test results using City of Aurora reductions. A modulus of rupture of 600 psi (working stress 450 psi) was used for pavement concrete. The rigid pavement thickness for each traffic category was determined on the basis of the AASHTO design equation.

Recommended alternatives for flexible and rigid pavements are summarized for each traffic area as follows:

Traffic Area	Alternative	Recommended Pavement Thickness (Inches)			
		Asphalt Concrete Surface	Aggregate Base Course	Portland Cement Concrete	Total
Light Duty Automobile Parking	A	5-½			5-½
	B	4	6		10
	C			5	5
Heavy Duty Driveways, Drive-thru, Truck access, heavy vehicles	A	6-½			6-½
	B	4	8		12
	C			5-½	5-½

Each alternative should be investigated with respect to current material availability and economic conditions. A minimum 6-inch thickness of rigid concrete pavement is recommended at the location of dumpsters where trash trucks park and load.

Subgrade Preparation and Pavement Materials: We recommend the pavement areas be rough graded and then thoroughly proof rolled with a loaded tandem axle dump truck, water truck, or other heavy equipment prior to final grading and paving. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted engineered fills. All pavement areas should then be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving.

Aggregate base course (if used) should consist of a blend of sand and gravel that meets strict specifications for quality and gradation. Use of materials meeting Colorado Department of Transportation (CDOT) Class 5 or 6 specifications is recommended. In addition, the base course material should be moisture stable. Aggregate base course material should be tested to determine compliance with these specifications prior to importation to the site. Aggregate base course should be placed in lifts not exceeding 6 inches and compacted to a minimum of 95 percent of modified Proctor density (ASTM D1557), within a moisture content range of 2 percent below to 2 percent above optimum. Where base course thickness exceeds 6 inches, the material should be placed and compacted in 2 or more lifts of equal thickness.

Asphalt concrete should be obtained from an approved mix design stating the Hveem properties, optimum asphalt content, job mix formula (JMF), and recommended mixing and placing temperatures. Aggregate used in asphalt concrete should meet a particular gradation. Use of materials meeting CDOT Grading S and SX specifications is recommended. The mix design should be performed using the Superpave procedures as outlined in the Standards for Traffic Level I. The mix design should be submitted prior to construction to verify its adequacy. The asphalt concrete should be placed in maximum 3-inch lifts and compacted to between 92 and 96 percent of Rice value (AASHTO T-209).

Where rigid pavements are used, the concrete should be obtained from an approved mix design conforming to CDOT Class P specifications. Concrete should be deposited by truck mixers or agitators and placed a maximum of 90 minutes from the time the water is added to the mix. Longitudinal and transverse joints should be provided as needed in concrete pavements for expansion/contraction and isolation. The location and extent of joints should be based upon the final pavement geometry. Sawed joints should be cut within 24 hours of concrete placement and should be a minimum depth of 25 percent of slab thickness plus 1/4 inch. All joints should be sealed to prevent entry of foreign material and doweled where necessary for load transfer. Where dowels cannot be used at joints accessible to wheel loads, pavement thickness should be increased by 25 percent at the joints and tapered to regular thickness in 5 feet.

Compliance: Recommendations for pavement design and construction presented depend upon compliance with recommended material specifications. To assess compliance, observation and testing should be performed under the observation of the geotechnical engineer.

Pavement Performance: Future performance of pavements constructed on the subgrade at this site will be dependent upon several factors, including:

- Maintaining stable moisture content of the subgrade soils.
- Providing for a planned program of preventative maintenance.

The performance of all pavements can be enhanced by minimizing excess moisture, which can reach the subgrade soils. The following recommendations should be considered at minimum:

- Site grading at a minimum 2 percent grade onto or away from pavements.
- Water should not be allowed to pond behind curbs.
- Compaction of any utility trenches for landscaped areas to the same criteria as the pavement subgrade.
- Sealing all landscaped areas in or adjacent to pavements to minimize or prevent moisture migration to subgrade soils.
- Placing compacted backfill against the exterior side of curb and gutter.
- Placing curb, gutter and/or sidewalk directly on subgrade soils without the use of base course materials.

Preventative maintenance should be planned and provided for an ongoing pavement management program in order to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment.

Preventative maintenance consists of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). Preventative maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements.

Earthwork:

General Considerations: The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project.

All earthwork on the project should be observed and evaluated by PCH. The evaluation of earthwork should include observation and testing of engineered fills, subgrade preparation, foundation bearing soils and other geotechnical conditions exposed during the construction of the project.

Site Preparation: Strip and remove existing pavements, landscaping vegetation, and other deleterious materials from proposed building and pavement areas. Stripped materials consisting of vegetation and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations. Re-use of existing asphalt and concrete materials may be considered if processed to a maximum size of 3 to 4 inches and blended with the on-site soils under the observation of the geotechnical engineer.

Although not encountered in our borings, debris, rubble, or trash may be present will likely be present following demolition and removal of existing improvements. Demolition should include complete removal of all foundation systems and underground utilities within the proposed construction area. This should include removal of any loose backfill found adjacent to or above any existing elements. All materials derived from the demolition of existing facilities should be removed from the site and should not be allowed for use in any on-site fills without approval of the engineer.

The site should be initially graded to create a relatively level surface to receive fill and to provide for a relatively uniform thickness of fill beneath proposed building structures. All exposed areas that will receive fill, once properly cleared and benched, should be scarified to a minimum depth of 8 inches, conditioned to near optimum moisture content and compacted.

Although evidence of low-density fills or unknown underground facilities such as septic tanks, cesspools, old foundations, etc. was not observed during the site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed and the excavation thoroughly cleaned prior to backfill placement and/or construction.

Due to the anticipated disturbance associated with demolition activities, the subsoil beneath all proposed foundations should be observed and approved by the geotechnical engineer. If any loose or disturbed soils are encountered, the exposed subgrade should be scarified to a depth of at least 8-inches, moisture conditioned and compacted to not less than 98 percent of the maximum dry density as determined in accordance with ASTM D698. The resulting excavation should be brought to final construction grades with engineered fills. Clean on-site soils may be used in this zone.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively stable. However, the stability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unstable conditions are encountered or develop during construction, workability may be improved by scarifying and drying. Overexcavation of wet zones and replacement with granular materials may be necessary. Use of lime, fly ash, kiln dust, cement or geotextiles could also be considered as a stabilization technique. Laboratory evaluation is recommended to determine the effect of chemical stabilization on subgrade soils prior to construction. Lightweight excavation equipment may be required to reduce subgrade pumping.

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Depending on the depth of excavations, groundwater and caving soils may be encountered. The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

Subgrade Preparation: All exposed subgrade soils below exterior flatwork and pavements should be scarified to a minimum depth of 12 inches, moisture conditioned and compacted as discussed below. The stability of the subgrade may be affected by precipitation, repetitive construction traffic, or other factors. If unstable conditions are encountered or develop during construction, workability may be improved by scarifying and drying. A proofroll should be performed in all pavement areas to confirm that the subgrade soils are stable prior to paving.

Fill Materials and Placement: Clean on-site soils or approved imported materials may be used as fill material. Imported soils (if required) should conform to the following:

Gradation	**Percent finer by weight (ASTM C136)**
6"	100
3"	70-100
No. 4 Sieve	50-100
No. 200 Sieve	35 (max)

- Liquid Limit .... 35 (max)

- Plasticity Index .... 15 (max)
- Maximum expansive potential (%)* 0.5

  *Measured on a sample compacted to approximately 95 percent of the ASTM D1557 maximum dry density at about optimum water content. The sample is confined under a 200 psf surcharge and submerged.

Engineered fill should be placed and compacted in relatively thin horizontal lifts (typically 8 to 12 inches), using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. On-site or imported sand soils should be moisture conditioned within 2 percent below to 3 percent above optimum moisture content.

Fill comprised of the on-site or imported sands should be compacted to 95 percent of the standard Proctor dry density (ASTM D698) in general areas including beneath pavements and exterior flatwork. Fill placed and compacted beneath structures should be compacted to minimum of 98 percent of standard Proctor dry density.

Excavation and Trench Construction: It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Excavations into the on-site soils will encounter a variety of conditions. Excavations into the on-site sands may be subjected to localized caving and/or sloughing. In addition, groundwater may be encountered. The individual contractor(s) should be made responsible for designing and constructing stable, dry, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

As a safety measure, it is recommended that all vehicles and soil piles be kept to a minimum lateral distance from the crest of the slope equal to no less than the slope height. The exposed slope face should be protected against the elements.

Additional Design and Construction Considerations:

Exterior Slab Design and Construction: Compacted subgrade or existing clayey soils will provide variable support; therefore, exterior concrete grade slabs will be subject to soil or frost-related movement resulting in cracking or vertical offsets. The potential for damage would be greatest where exterior slabs are constructed adjacent to the building or other structural elements. To reduce the potential for damage, we recommend:

- exterior slabs be supported on fill with no, or very low, expansion potential.
- strict moisture-density control during placement of subgrade fills.
- placement of effective control joints on relatively close centers and isolation joints between slabs and other structural elements.
- provision for adequate drainage in areas adjoining the slabs.
- use of designs which allow vertical movement between the exterior slabs and adjoining structural elements.

Underground Utility Systems: All underground piping within or near the proposed structure should be designed with flexible couplings, so minor deviations in alignment do not result in breakage or distress. Utility knockouts in foundation walls should be oversized to accommodate differential movements. Coarse-grained backfill materials should not be utilized within the building or at building penetrations to minimize the potential for infiltration.

It is strongly recommended that a representative of the geotechnical engineer provide full-time observation and compaction testing of trench backfill within building and pavement areas.

Corrosion Protection: Testing to determine corrosion potential of the existing soils was not included in the scope of services for this study. Local concrete suppliers should be contacted to discuss the potential for concrete corrosion on the site. At a minimum, the use of ASTM Type II Portland cement is recommended to provide moderate sulfate resistance for all concrete elements constructed at or below grade. Foundation concrete should be designed in accordance with the provisions of Section 318, Chapter 4, of the *ACI Design Manual.*

The City of Aurora will require corrosivity testing (typically limited to resistivity and pH) of subsurface soils present along alignments of any *new* water lines. We are not aware of any new water lines to be installed in conjunction with the planned improvements, but are available to discuss these additional services with you, upon request.

Surface Drainage: All grades must be adjusted to provide positive drainage away from structures during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. Landscaped irrigation adjacent to the foundation system should be minimized or eliminated.

Water permitted to pond near or adjacent to the perimeter of the structures (either during or post-construction) can result in significantly higher soil movements than those discussed in this report. As a result, any estimations of potential movement described in this report cannot be relied upon if positive drainage is not obtained and maintained, and water is allowed to infiltrate the fill and/or subgrade.

Exposed ground should be sloped at a minimum of 5 percent grade for at least 5 feet beyond the perimeter of buildings/structures, where possible. Swales sidewalk chases, area drains may be required to facilitate drainage. Backfill against footings, exterior walls and in utility and sprinkler line trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration. After building construction and prior to project completion, we recommend that verification of final grading be performed to document that positive drainage, as described above, has been achieved.

Flatwork will be subject to post construction movement. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond. In addition, allowances in final grades should take into consideration post-construction movement of flatwork, particularly if such movement would be critical. Where paving or flatwork abuts the structure, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Sprinkler mains and spray heads should be located a minimum of 5 feet away from the building line. Roof drains should discharge on pavements or be extended away from the structure a minimum of 5 feet through the use of splash blocks or downspout extensions. A preferred alternative is to have the roof drains discharge to storm sewers by solid pipe or daylighted to a detention pond or other appropriate outfall.

GENERAL COMMENTS

PCH should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. PCH should also be retained to provide testing and observation during the excavation, grading, foundation and construction phases of the project.

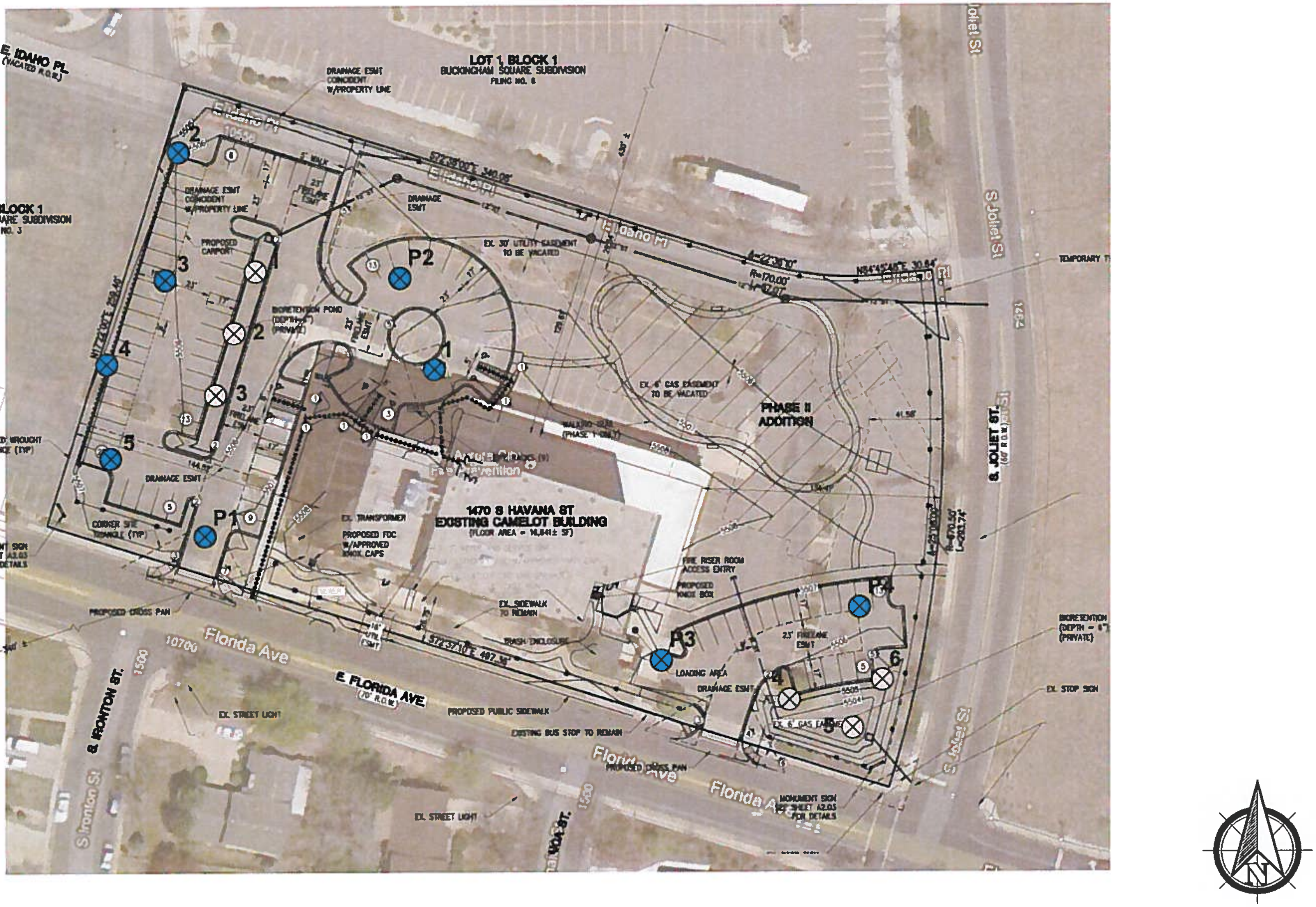
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include, either specifically or by implication, any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes are planned in the nature, design, or location of the project as outlined in this report, the conclusions and recommendations contained in this report shall not be considered valid unless PCH reviews the changes, and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

BORING LOCATION MAP
BORING LOGS



1 APPROXIMATE BORING LOCATION

1 APPROXIMATE PERCOLATION TEST LOCATION

BORING LOCATION DIAGRAM
STANDLEY SHORES SHOPPING CENTER
WESTMINSTER, COLORADO
PCH PROJECT NO. 12.251.11

Pickering, Cole, & Hivner, LLC
1070 W. 124th Ave., Suite 300
Westminster, CO 80234
(303) 996-2999

PCH

LOG OF BORING NO. 1

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ 13 ft. WD ▽		

Depth	Soil Graphic	Description	No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
		Approximately 3" asphalt pavement at ground surface									
0–5		**SILTY SAND**, fine to medium grained, dark brown to dark grey, moist to wet, medium dense	1	SM	CB	24	12	13.4	119	-0.6	0.35
5–10		varies to reddish-brown	2	SM	CB	32	12	9.7	120		
10–15 (▼ 13)		varies to light brown, beige	3	SM	CB	22	12	14.0	117		
15–20		19 ft **LEAN CLAY**, brown, moist, stiff	4	CL	CB	18	12	23.5	100		
20–25		22 ft **CLAYEY SANDSTONE BEDROCK**, brown, grey, iron stained, moist, hard	5		CB	66/11"	11	22.6	104		
25		Boring Terminated at 25 feet									

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).
Transitions between layers is shown for information only, actual transitions may be gradual.
This information pertains only to this boring and should not be interpreted as being indicative of the site.
** Disturbed sample

PCH

LOG OF BORING NO. 2

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ 11 ft. WD ▽		

Depth	Description	No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
	Approximately 2" asphalt pavement at ground surface									
0	**SILTY SAND**, fine to medium grained, dark brown to dark grey, moist to wet, medium dense									
5		1	SM	CB	65	12	8.7	119		
10		2	SM	CB	10	0				
11 ▼										
15	varies to light brown, beige	3	SM	CB	11	12	15.8	109		
19	19 ft									
20	**LEAN CLAY**, brown, moist, very stiff	4	CL	CB	20	12	21.6	105		
22	22 ft									
22	**SANDY CLAYSTONE BEDROCK**, brown, olive, iron stained, moist, hard									
25		5		CB	70	12	27.4	97	0.6	3.0
25	Boring Terminated at 25 feet									

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).

Transitions between layers is shown for information only, actual transitions may be gradual.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

** Disturbed sample

PCH

LOG OF BORING NO. 3

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ 11 ft. WD ▽		

Depth	Soil Graphic	Description	Samples No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
		Approximately 2" asphalt pavement at ground surface									
0–15		**SILTY SAND**, fine to medium grained, dark grey to brown, moist to wet, loose to medium dense									
5			1	SM	CB	36	12	7.3	116		
10			2	SM	CB	6	0				
11 ▼											
15			3	SM	CB	22	12	15.7	113		
		Boring Terminated at 15 feet									

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).
Transitions between layers is shown for information only, actual transitions may be gradual.
This information pertains only to this boring and should not be interpreted as being indicative of the site.
** Disturbed sample

PCH

LOG OF BORING NO. 4

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ 11 ft. WD ▽		

Depth	Soil Graphic	Description	Samples								
			No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
		Approximately 3" asphalt pavement at ground surface									
0–15		**SILTY SAND**, fine to medium grained, brown to dark brown, moist to wet, loose to medium dense									
5			1	SM	CB	36	12	7.3	116		
10			2	SM	CB	14	12				
11 ▼											
15			3	SM	CB	31	12	15.7	113		
		Boring Terminated at 15 feet									

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).
Transitions between layers is shown for information only, actual transitions may be gradual.
This information pertains only to this boring and should not be interpreted as being indicative of the site.
** Disturbed sample

PCH

LOG OF BORING NO. 5

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ 11 ft. WD ▽		

Depth	Soil Graphic	Description	Samples No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
0		Approximately 2" asphalt pavement at ground surface									
		SILTY SAND, fine to medium grained, dark grey to brown, moist to wet, loose to medium dense									
5			1	SM	CB	22	12	7.0	114		
10			2	SM	CB	17	12	14.1	113		
11 ▼											
15			3	SM	CB	13	12	17.6	111		
20		with lean clay lenses at depth									
24		24 ft									
25		**SANDY CLAYSTONE BEDROCK**, brown, olive, iron stained, moist, hard	4		CB	64	12	24.5	99		
		Boring Terminated at 25 feet									
30											
35											
40											

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).
Transitions between layers is shown for information only, actual transitions may be gradual.
This information pertains only to this boring and should not be interpreted as being indicative of the site.
** Disturbed sample

PCH

LOG OF BORING NO. P1

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ None WD ▽		

Depth	Soil Graphic	Description	Samples No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
		Approximately 2" asphalt pavement at ground surface									
0–5		**SILTY SAND**, fine to medium grained, dark brown, moist, medium dense	1	SM	CB	37	12	7.4	121		
5		Boring terminated at 5 feet									

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).

Transitions between layers is shown for information only, actual transitions may be gradual.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

PCH

LOG OF BORING NO. P2

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ None WD ▽		

Depth	Soil Graphic	Description	Samples								
		Approximately 2" asphalt pavement at ground surface	No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
5		**SILTY SAND**, fine to medium grained, dark brown, moist, medium dense	1	SM	CB	22	12	9.4	120		
		Boring terminated at 5 feet									
10											
15											
20											
25											
30											
35											
40											

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).
Transitions between layers is shown for information only, actual transitions may be gradual.
This information pertains only to this boring and should not be interpreted as being indicative of the site.

PCH

LOG OF BORING NO. P3

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ None WD ▽		

Depth	Soil Graphic	Description	No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
		Approximately 1.5" to 2" asphalt pavement at ground surface									
0–5		**CLAYEY SAND**, fine to medium grained, dark brown, moist, medium dense	1	SC	CB	18	12	14.4	117		
5		Boring terminated at 5 feet									
10											
15											
20											
25											
30											
35											
40											

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).
Transitions between layers is shown for information only, actual transitions may be gradual.
This information pertains only to this boring and should not be interpreted as being indicative of the site.

PCH

Pickering, Cole, and Hivner
Geotechnical and Environmental Engineers
Westminster, Colorado – 303.996.2999

LOG OF BORING NO. P4

PROJECT:	1470 South Havana Street	PROJECT NO.:	12.124.12
CLIENT:	1470 S. Havana, LLC	DATE:	4-May-12
LOCATION:	Aurora, CO	ELEVATION:	Not Recorded
DRILLER - RIG:	Dakota Drilling - CME 55	LOGGED BY:	G. Ohlsen
DEPTH TO WATER:	▼ None WD ▽		

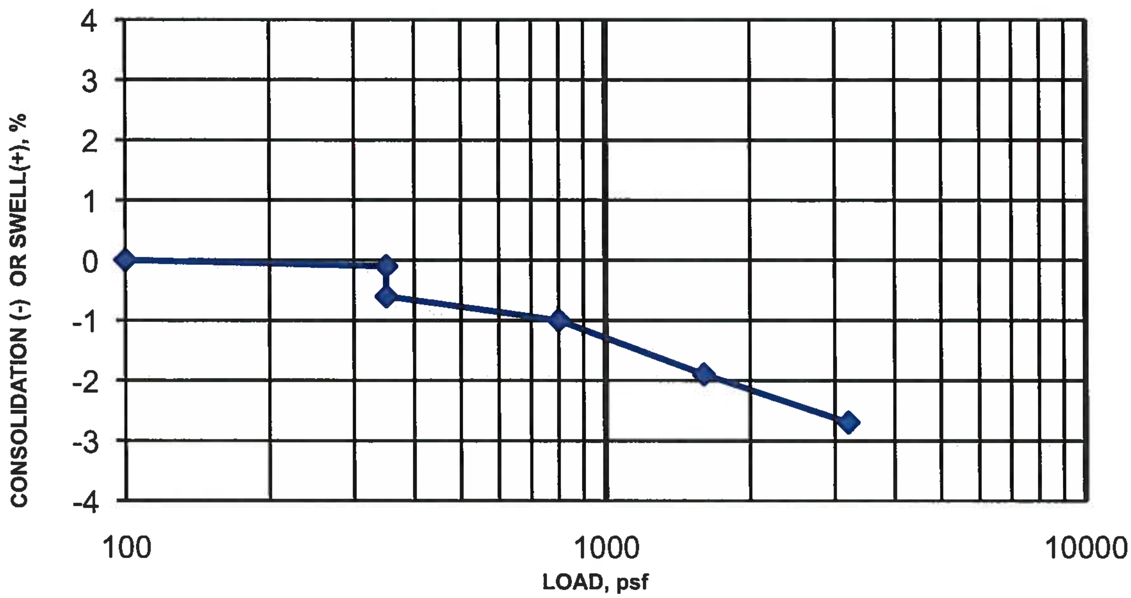
Depth	Soil Graphic	Description	No.	USCS	Type	Blows per foot*	Recovery, in	Moisture Content, %	Dry Density, pcf	Swell or Consol. (-), %	Surcharge, ksf
		Approximately 1.5" to 2" asphalt pavement at ground surface									
0–5		**CLAYEY SAND**, fine to medium grained, dark brown, moist, medium dense	1	SC	CB	17	12	13.2	117		
5		Boring terminated at 5 feet									
10											
15											
20											
25											
30											
35											
40											

* Values represent blows/ft (unless otherwise noted) using sampler indicated. This value may not be indicative of Standard Penetration Test (N-values).
Transitions between layers is shown for information only, actual transitions may be gradual.
This information pertains only to this boring and should not be interpreted as being indicative of the site.

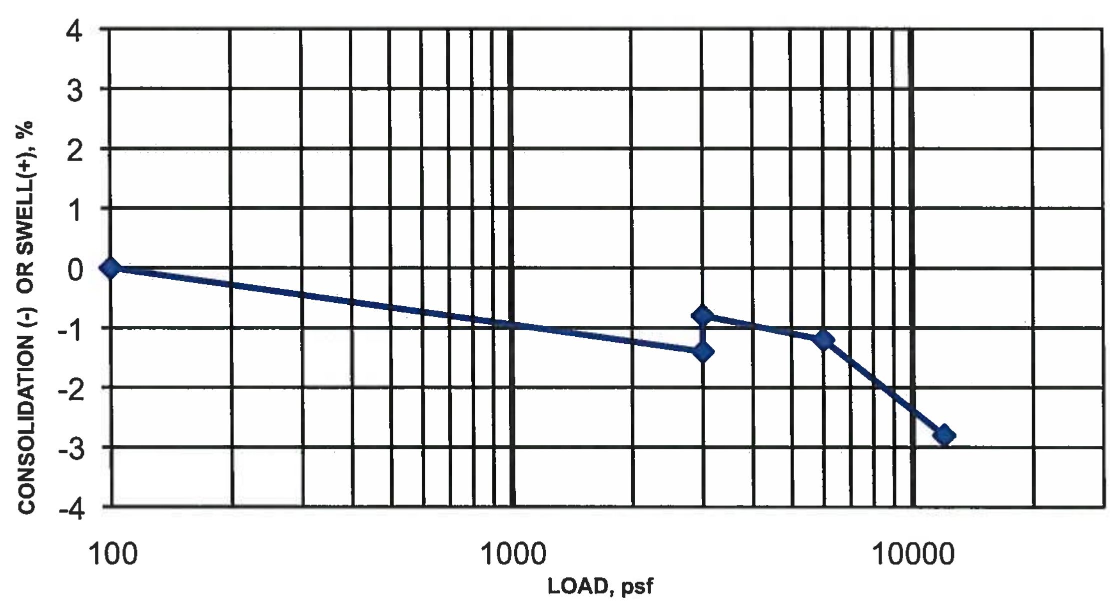
APPENDIX B

LABORATORY TEST RESULTS

SWELL/CONSOLIDATION TESTING



PROJECT	1470 South Havana St.	**PROJECT NO.**	12.124.12
SAMPLE ID	Boring 1 at 4 ft	**START DATE**	5/16/12
SAMPLE DESCRIPTION	Silty Sand		
PRE-TEST MOISTURE CONTENT	13.4%	**DRY DENSITY**	119 pcf



PROJECT	1470 South Havana St.	**PROJECT NO.**	12.124.12
SAMPLE ID	Boring 2 at 24 ft	**START DATE**	5/15/12
SAMPLE DESCRIPTION	Sandy Claystone Bedrock		
PRE-TEST MOISTURE CONTENT	27.4%	**DRY DENSITY**	97 pcf

Pickering, Cole and Hivner, LLC

1070 W. 124th Ave., Suite 300 • Westminster, Colorado 80234

SUMMARY OF LABORATORY TEST RESULTS

Test Boring	Depth (ft)	Soil Description	Moisture Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-) (%)	Surchagre Pressure (psf)	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Atterberg Limits		
									LL	PL	PI
1	4	Silty Sand	13.4%	119	-0.6	350					
1	9	Silty Sand	9.7%	120			100	13	NV	NP	NP
1	14	Silty Sand	14.0%	117							
1	19	Lean Clay	23.5%	100							
1	24	Clayey Sandstone Bedrock	22.6%	104							
2	4	Silty Sand	8.7%	125							
2	14	Silty Sand	15.8%	109							
2	19	Lean Clay	21.6%	105							
2	24	Sandy Claystone Bedrock	27.4%	97	+0.6	3,000					
3	4	Silty Sand	7.3%	116			100	16	NV	NP	NP
3	14	Silty Sand	15.7%	113							
4	4	Silty Sand	7.9%	120							
4	9	Silty Sand	11.2%	105							
4	14	Silty Sand	15.3%	115							
5	4	Silty Sand	7.0%	114							
5	9	Silty Sand	14.1%	113							
5	14	Silty Sand	17.6%	111							
5	24	Sandy Claystone Bedrock	24.5%	99							
P1	2	Silty Sand	7.4%	121			100	24	NV	NP	NP
P2	2	Silty Sand	9.4%	120			92	17	NV	NP	NP
P3	2	Clayey Sand	14.4%	117			100	35	34	18	16
P4	2	Clayey Sand	13.2%	117			100	39	32	19	13

APPENDIX C

GENERAL NOTES

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1⅜" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube – 2.5" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
CB:	California Barrel - 1.92" I.D., 2.5" O.D., unless otherwise noted	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". For 2.5" O.D. California Barrel samplers (CB) the penetration value is reported as the number of blows required to advance the sampler 12 inches using a 140-pound hammer falling 30 inches, reported as "blows per inch," and is not considered equivalent to the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling
WCI:	Wet Cave in	WD:	While Drilling
DCI:	Dry Cave in	BCR:	Before Casing Removal
AB:	After Boring	ACR:	After Casing Removal

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

FINE-GRAINED SOILS

(CB) Blows/Ft.	(SS) Blows/Ft.	Consistency
< 3	0-2	Very Soft
3-5	3-4	Soft
6-10	5-8	Medium Stiff
11-18	9-15	Stiff
19-36	16-30	Very Stiff
> 36	> 30	Hard

COARSE-GRAINED SOILS

(CB) Blows/Ft.	(SS) Blows/Ft.	Relative Density
0-5	< 3	Very Loose
6-14	4-9	Loose
15-46	10-29	Medium Dense
47-79	30-50	Dense
> 79	> 50	Very Dense

BEDROCK

(CB) Blows/Ft.	(SS) Blows/Ft.	Consistency
< 24	< 20	Weathered
24-35	20-29	Firm
36-60	30-49	Medium Hard
61-96	50-79	Hard
> 96	> 79	Very Hard

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Terms of Other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Terms of Other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

ROCK CLASSIFICATION
(Based on ASTM C-294)

Sedimentary Rocks

Sedimentary rocks are stratified materials laid down by water or wind. The sediments may be composed of particles or pre-existing rocks derived by mechanical weathering, evaporation or by chemical or organic origin. The sediments are usually indurated by cementation or compaction.

Chert Very fine-grained siliceous rock composed of micro-crystalline or cyrptocrystalline quartz, chalcedony or opal. Chert is various colored, porous to dense, hard and has a conchoidal to splintery fracture.

Claystone Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Soft massive and may contain carbonate minerals.

Conglomerate Rock consisting of a considerable amount of rounded gravel, sand and cobbles with or without interstitial or cementing material. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other materials.

Dolomite A fine-grained carbonate rock consisting of the mineral dolomite [$CaMg(CO_3)_2$]. May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

Limestone A fine-grained carbonate rock consisting of the mineral calcite ($CaCO_3$). May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

Sandstone Rock consisting of particles of sand with or without interstitial and cementing materials. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other material.

Shale Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Shale is hard, platy, of fissile may be gray, black, reddish or green and may contain some carbonate minerals (calcareous shale).

Siltstone Fine grained rock composed of or derived by erosion of silts or rock containing silt. Siltstones consist predominantly of silt sized particles (0.0625 to 0.002 mm in diameter) and are intermediate rocks between claystones and sandstones and may contain carbonate minerals.

LABORATORY TEST
SIGNIFICANCE AND PURPOSE

TEST	SIGNIFICANCE	PURPOSE
California Bearing Ratio	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Consolidation	Used to develop an estimate of both the rate and amount of both differential and total settlement of a structure.	***Foundation Design***
Direct Shear	Used to determine the consolidated drained shear strength of soil or rock.	***Bearing Capacity, Foundation Design, and Slope Stability***
Dry Density	Used to determine the in-place density of natural, inorganic, fine-grained soils.	***Index Property Soil Behavior***
Expansion	Used to measure the expansive potential of fine-grained soil and to provide a basis for swell potential classification.	***Foundation and Slab Design***
Gradation	Used for the quantitative determination of the distribution of particle sizes in soil.	***Soil Classification***
Liquid & Plastic Limit, Plasticity Index	Used as an integral part of engineering classification systems to characterize the fine-grained fraction of soils, and to specify the fine-grained fraction of construction materials.	***Soil Classification***
Permeability	Used to determine the capacity of soil or rock to conduct a liquid or gas.	***Groundwater Flow Analysis***
pH	Used to determine the degree of acidity or alkalinity of a soil.	***Corrosion Potential***
Resistivity	Used to indicate the relative ability of a soil medium to carry electrical currents.	***Corrosion Potential***
R-Value	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Soluble Sulfate	Used to determine the quantitative amount of soluble sulfates within a soil mass.	***Corrosion Potential***
Unconfined Compression	To obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.	***Bearing Capacity Analysis for Foundations***
Water Content	Used to determine the quantitative amount of water in a soil mass.	***Index Property Soil Behavior***

REPORT TERMINOLOGY
(Based on ASTM D653)

Allowable Soil Bearing Capacity	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
Alluvium	Soil, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.
Aggregate Base Course	A layer of specified material placed on a subgrade or subbase usually beneath slabs or pavements.
Backfill	A specified material placed and compacted in a confined area.
Bedrock	A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.
Bench	A horizontal surface in a sloped deposit.
Caisson (Drilled Pier or Shaft)	A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier or drilled shaft.
Coefficient of Friction	A constant proportionality factor relating normal stress and the corresponding shear stress at which sliding starts between the two surfaces.
Colluvium	Soil, the constituents of which have been deposited chiefly by gravity such as at the foot of a slope or cliff.
Compaction	The densification of a soil by means of mechanical manipulation
Concrete Slab-on-Grade	A concrete surface layer cast directly upon a base, subbase or subgrade, and typically used as a floor system.
Differential Movement	Unequal settlement or heave between, or within foundation elements of structure.
Earth Pressure	The pressure exerted by soil on any boundary such as a foundation wall.
ESAL	Equivalent Single Axle Load, a criteria used to convert traffic to a uniform standard, (18,000 pound axle loads).
Engineered Fill	Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a geotechnical engineer.
Equivalent Fluid	A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil. This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.
Existing Fill (or Man-Made Fill)	Materials deposited throughout the action of man prior to exploration of the site.
Existing Grade	The ground surface at the time of field exploration.

REPORT TERMINOLOGY
(Based on ASTM D653)

Expansive Potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
Finished Grade	The final grade created as a part of the project.
Footing	A portion of the foundation of a structure that transmits loads directly to the soil.
Foundation	The lower part of a structure that transmits the loads to the soil or bedrock.
Frost Depth	The depth at which the ground becomes frozen during the winter season.
Grade Beam	A foundation element or wall, typically constructed of reinforced concrete, used to span between other foundation elements such as drilled piers.
Groundwater	Subsurface water found in the zone of saturation of soils or within fractures in bedrock.
Heave	Upward movement.
Lithologic	The characteristics which describe the composition and texture of soil and rock by observation.
Native Grade	The naturally occurring ground surface.
Native Soil	Naturally occurring on-site soil, sometimes referred to as natural soil.
Optimum Moisture Content	The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.
Perched Water	Groundwater, usually of limited area maintained above a normal water elevation by the presence of an intervening relatively impervious continuous stratum.
Scarify	To mechanically loosen soil or break down existing soil structure.
Settlement	Downward movement.
Skin Friction (Side Shear)	The frictional resistance developed between soil and an element of the structure such as a drilled pier.
Soil (Earth)	Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.
Strain	The change in length per unit of length in a given direction.
Stress	The force per unit area acting within a soil mass.
Strip	To remove from present location.
Subbase	A layer of specified material in a pavement system between the subgrade and base course.
Subgrade	The soil prepared and compacted to support a structure, slab or pavement system.

APPENDIX D

PAVEMENT THICKNESS DESIGN CALCULATIONS
CITY OF AURORA WAIVER FORM

AASHTO FLEXIBLE PAVEMENT DESIGN

1470 SOUTH HAVANA STREET
AURORA, COLORADO
LIGHT-DUTY FLEXIBLE PAVEMENTS

SN Determination

Design Inputs

W18 =	25,000		*ESALs Applications Over Design Period*
R =	80	%	*Reliability*
So =	0.44		*Standard Deviation*
MR =	4,195	psi	*Subgrade Resilient Modulus*
Pi =	4.5		*Initial Serviceability*
Pt =	2		*Terminal Serviceability*

DESIGN SN = 2.13

Full Depth Section

SN req. 2.13
AC Coeff. 0.4
Calc. Thick. 5.32

Rounded up to nearest 1/2 inch
5.5 inches of Asphalt Concrete

Composite Section

Layer No.	Description	Layer Coefficient, ai	Drainage Coefficient, mi	Layer Thickness, in	SN
Layer 1	AC	0.40	1.00	4.00	1.60
Layer 2	ABC	0.12	1.00	6.00	0.72
Layer 3					0.00
Subgrade	Subgrade	N/A	N/A	N/A	N/A

Trial SN 2.32

Design SN to Match or Exceed 2.13

AASHTO FLEXIBLE PAVEMENT DESIGN

1470 SOUTH HAVANA STREET
AURORA, COLORADO
HEAVY-DUTY FLEXIBLE PAVEMENTS

SN Determination

Design Inputs

W18 =	70,000		*ESALs Applications Over Design Period*
R =	80	%	*Reliability*
So =	0.44		*Standard Deviation*
MR =	4,195	psi	*Subgrade Resilient Modulus*
Pi =	4.5		*Initial Serviceability*
Pt =	2		*Terminal Serviceability*

DESIGN SN = 2.50

Full Depth Section

SN req.	2.50
AC Coeff.	0.4
Calc. Thick.	6.25

Rounded up to nearest 1/2 inch
6.5 inches of Asphalt Concrete

Composite Section

Layer No.	Description	Layer Coefficient, ai	Drainage Coefficient, mi	Layer Thickness, in	SN
Layer 1	AC	0.40	1.00	4.00	1.60
Layer 2	ABC	0.12	1.00	8.00	0.96
Layer 3					0.00
Subgrade	Subgrade	N/A	N/A	N/A	N/A

Trial SN 2.56

Design SN to Match or Exceed 2.50

AASHTO RIGID PAVEMENT DESIGN

1470 SOUTH HAVANA STREET
AURORA, COLORADO
HEAVY-DUTY RIGID PAVEMENTS

PCH

Design Inputs

W18 =	70,000		*ESALs Applications Over Design Period*
PCC MR =	600	psi	*Concrete Modulus of Rupture*
E =	3,400,000	psi	*Concrete Elastic Modulus*
k-value =	25	psi/in	*Modulus of Subgrade Reaction*
R =	80	%	*Reliability*
So =	0.34		*Standard Deviation*
J =	3.6		*Load Transfer Coefficient*
Cd =	1		*Drainage Coefficient*
Pi =	4.5		*Initial Serviceability*
Pt =	2		*Terminal Serviceability*

DESIGN D, inches, =	5.01

REQUEST FOR ALTERNATE PAVEMENT THICKNESS

____
(Date)

City Engineer
City of Aurora, Public Works Department
15151 E. Alameda Parkway, Ste. 3200
Aurora, CO 80012

Subject: ____
(Project or Subdivision Name)

Dear Sir:

_________________________ requests that the following pavement sections be approved for the
(Company/Property Owner)

above-referenced ______________ project: _________________________.
(Zoning/Use) (Name)

Subdivision, lot, block: ____

All new asphalt paving to be __________ full depth asphalt (or __________ asphalt and
(thickness) (thickness)

______________ base course), per ______________________________
(thickness) (Geotechnical Firm)

Report #______ dated __________.

As Owner of this Property, ______________________________ is aware that
(Company/Property Owner)

this pavement design does not meet the criteria established by the City of Aurora for this application.

The attached soils report references the characteristics of the soil and recommends the above section.

In addition, ______________________ shall hold the City of Aurora harmless for the
(Company/Property Owner)

performance and maintenance of this design.

Sincerely,

______________________________	______________________________
(Authorized Signature) Date	(Reviewing Engineer) Date
______________________________	______________________________
(Type Authorized Signator's Name)	(City Engineer) Date
______________________________	
(Company/Owner)	

CITY OF AURORA PAVING AND GEOTECHNICAL FOLDER REVIEW
ROUTING SLIP - CHECKLIST

FOLDER RSN: 667703 - PA Subdivision #: 1970-3006 Reviewer: MLH

Title: BUCKINGHAM SQUARE FLG #03
L1 B1, 1470 S HAVANA ASSISTED LIVING

Applicant: VISION LAND CONSULTANTS Grid Location: 11C,12C

Contact Name: FRANK FEERO Phone: 303-674-7355

Geotech Consultant: ______ Fax: 303-674-3263

EDN: 212059 (PARENT RSN:659869) Sheet 8

Final Design Report X **P.O. LETTER** X **DEFAULT LETTER** ______

Date Received: Jul 11 2012 Returned: 08.01.12 **# Text Documents:** 1

Dave Received: ______ Returned ______ Recommend Approval: MLH OK 7-18-12

Dwg. signed 7-31-12 MLH

Request for Alt. Pave. Tkness Letter:
Parking Areas: 5½"AC
Drive Isles: 6½"AC
Loading Dock Area: 5½"PCC
MLH 7-18-12

	YES	NO	COMMENTS
1. Map with location of test holes	X		
2. Drill logs: Depths 4' and 9' (Sec. 5.02)	X		
3. Grading analysis curves: A-1 to A-4 soils		X	
4. Moisture/density curves		X	
5. Atterberg limits: AASHTO T89 and T90	X		
6. Soil classifications and groupings	X		USED USCS classifications
7. Swell tests: except A-1 and A-4	X		
8. Addresses Swell, if needed			
9. Sulfate tests: A-6 and A-7 soils		X	N/A
10. Addresses Sulfates, if needed			
11. ESAL Calc's: Study or Equation (Sec. 5.04) >Minimums in Table 5.1	X		
12. M_R Conversion - Flexible (Sec. 5.03.2)			
13. K Conversion - Rigid (Sec. 5.03.2)			
14. Structural Number or Concrete thickness Design nomograph or acceptable printout	X		
15. Correct coefficient: asphalt, base course, etc. (Table 5.4)	X		
16. Calculations for Recommended Alternates	X		
17. Min. pavement sections met (Table 5.2a)	X		
18. Limits of different soils / pavement sections			