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Report of
Geotechnical Investigation
Parkway Village Apartments – East Complex
3137-3167 7th Place NE
Salem, Oregon

CGT Project Number G1303961

Prepared for

Salem Housing Authority
Att: Mr. Andrew Wilch
360 Church Street SE
Salem, Oregon 97308-0808

January 2, 2014

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Dear Mr. Wilch:

Carlson Geotechnical (CGT), a division of Carlson Testing, Inc. (CTI), is pleased to submit this report summarizing our geotechnical investigation for the Parkway Village Apartments (East Complex). The site is located at 3137-3167 7th Place NE in Salem, Oregon. Our services were provided in general accordance with Salem Housing Authority's Professional Services Agreement number 134115, executed December 9, 2013. We appreciate the opportunity to work with you on this project. Please contact us at 503.601.8250 if you have any questions regarding this report.

Respectfully Submitted,
CARLSON GEOTECHNICAL

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BRAD MICHAEL WILCOX
Jan. 10, 2007
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TABLE OF CONTENTS

ATTACHMENTS

Doc ID: G:\GEOTECH\PROJECTS\2013 Projects\Parkway Village Apartments - Salem\East Complex - G1303961\G1303961 Report.doc

1.0 INTRODUCTION

Carlson Geotechnical (CGT), a division of Carlson Testing, Inc. (CTI), is pleased to submit this report summarizing our geotechnical investigation for the Parkway Village Apartments (East Complex). The site is located at 3137-3167 7th Place NE in Salem, Oregon, as shown on the attached Figure 1. CGT developed an understanding of project objectives based on our review of the "Request for Proposal: Geotechnical Engineering Services", dated September 4, 2013, from the Housing Development Center (HDC), subsequent phone and e-mail correspondence with HDC, and review of the site topographic plan entitled "Parkway Village Topography", dated June 2010 and prepared by Multitech Engineering Services, Inc. The following sections provide information related to the original construction of the site, a recent study of the site performed by others, geotechnical information requested in the referenced RFP, and the scope of services completed for this assignment.

1.1 Background

The eastern portion of the existing apartment complex, hereafter referred to as the "site", was developed in 1996, spans approximately 3.4 acres, and includes four, two- to three-story, wood-framed, apartment buildings. The site also includes three detached buildings, surface parking areas, play areas, and landscaping. Geotechnical Resources Incorporated (GRI) performed a geotechnical investigation of the site, the results of which were presented in their report titled "Foundation Investigation, Salem Parkway Apartments, Salem, Oregon" and dated October 3, 1994. A copy of this report was provided to us for review. The report was considered informational for this assignment.

1.2 Project Study in 2010

In a study performed in 2010, the project architect, Carleton-Hart Architecture, identified moisture-related problems within the existing buildings, with improper site grading, construction defects, and other factors attributed to the problems. We understand plans for site improvements include remodeling the existing buildings to alleviate moisture problems, adjusting site grades around the perimeter of the buildings to improve stormwater drainage, and construction of new vegetated swales. Distressed pavements at the site will also be repaired.

1.3 Geotechnical Evaluation Objectives

The RFP included specific objectives for the geotechnical evaluation of the project site, including (1) evaluate the depth to groundwater at the site, (2) perform one infiltration test, (3) evaluate possible causes of water infiltration into crawlspaces, (4) evaluate thickness of existing asphalt pavement, and (5) provide repair recommendations for distressed pavement areas. In addition, geotechnical recommendations for design and construction of proposed site improvements were requested in the "Evaluation and Recommendations" section of the RFP.

1.4 Scope of Services

Our scope of work included the following:

- Contact the Oregon Utilities Notification Center and subcontract a private utility locating service to mark the locations of public and private utilities within a 15-foot radius of our explorations at the site.

- Explore subsurface conditions near the existing apartment buildings by advancing a total of twelve hand auger borings and four dynamic cone penetrometer (DCP) tests to depths of about 3 to 8 feet below ground surface (bgs).
- Explore subsurface conditions within existing pavement areas at the site by advancing three pavement cores, three hand auger borings, and three DCP tests to depths up to about 5 feet bgs.
- Advance one additional hand auger boring in order to perform infiltration testing. The infiltration test was performed at a depth of about 10½ feet bgs.
- Perform laboratory tests on selected samples obtained from the explorations.
- Prepare this written report presenting the results of our geotechnical investigation, infiltration testing, and our conclusions and recommendations for the project.

2.0 SITE DESCRIPTION

2.1 Site Geology

Available geological mapping[1] of the area indicates the site is underlain by Holocene Lower terrace deposits of the Willamette River. These deposits are characterized as unconsolidated to semiconsolidated sediments on the flood plain and lowland terraces along the Willamette River, comprised of gravel, sand, silt, clay, muck, and organic matter of variable thickness (on the order of 30 to 50 feet).

2.2 Site Surface Conditions

A layout of the site is shown on the attached Site Plan, Figure 2. The site comprises the eastern 3.4 acres of the existing 7.1-acre Parkway Village apartment complex. At the time of our investigation, the site was occupied by four, two- to three-story, wood-framed, apartment buildings, three one-story garage buildings, asphalt-paved drive lanes and parking areas, play areas, and landscaped (grass- and barkdust-covered) areas. Topography at the site was generally flat, with less than about 5 feet of vertical relief across the site. Additional details regarding existing site grading and pavement conditions are presented in Section 3.5 below. Photographs of the site are presented in the attached Appendix A.

2.3 Building Designations

For the purposes of discussion in this report, the apartment buildings at the site were numbered 3 through 6 on the referenced Site Plan, Figure 2. This numbering scheme was used in identifying our borings and in the discussion and recommendations presented in this report. For reference, the building and corresponding street address numbers are presented in the following table.

Table 1: Referenced Building Numbers and Addresses

Building Number Shown on Site Plan	Corresponding Street Addresses
3	3143, 3147, 3149, 3151
4	3163, 3165, 3167
5	3153, 3155, 3157
6	3137, 3139

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[1] Bela, J.L., 1981. Geology of the Rickreall, Salem West, Monmouth, and Sidney 7.5' quadrangles. Oregon Department of Geology and Mineral Industries Geological Map Series 18.

3.0 FIELD EXPLORATION

3.1 Hand Auger Borings

CGT advanced a total of twelve hand auger borings (HA3-1 through HA6-3) adjacent to Buildings 3 through 6 on December 5th and 6th, 2013. Three hand auger borings (C-1 through C-3) were advanced within distressed pavement areas at the site on December 13, 2013. The approximate boring locations are shown on the attached Site Plan, Figure 2. The borings were located in the field relative to existing site features shown on the site plan and should be considered approximate. The borings were advanced to depths of about 3 to 8 feet bgs using a manual 3-inch diameter hand auger. The borings were loosely backfilled with the cuttings upon completion.

Prior to advancement of borings C-1 through C-3, the asphaltic concrete pavement was cored using an 8-inch diameter coring machine provided and operated by CTI personnel. The pavement surfaces were patched using cold patch asphalt upon completion of exploration in those locations.

3.2 Dynamic Cone Penetrometer Tests

In conjunction with selected hand auger borings, we performed dynamic cone penetrometer tests to depths ranging from about 5 to 8 feet bgs. These tests were performed using a Wildcat Dynamic Cone Penetrometer (WDCP) provided and operated by CGT. The WDCP test consists of driving 1.1-inch diameter, steel rods with a 1.4-inch diameter, cone tip into the ground using a 35-pound drop hammer with a 15-inch, free-fall height. The number of blows required to drive the steel rods is recorded for each 10 centimeters (3.94 inches) of penetration. The blow count for each interval is then converted to the corresponding Standard Penetration Test (SPT) “N_{60}” values, which are used to estimate the soil relative consistency for cohesive soils, or relative density for non-cohesive soils.

3.3 Soil Classification & Sampling

Members of CGT’s staff logged the soils observed within the borings in general accordance with the Unified Soil Classification System (USCS) and collected representative samples of the materials encountered. An explanation of the USCS is presented on the attached Soil Classification Criteria and Terminology, Figure 3. The soil samples were stored in sealable plastic bags and transported to our laboratory for further examination and testing. Our staff visually examined all samples returned to our laboratory in order to refine the field classifications. Logs of the borings are presented on the attached Boring Logs, Figures 4 through 19. Elevations indicated on the logs were based on the topographic contours shown on the attached Figure 2 and should be considered approximate. Results of the WDCP tests are shown on the logs.

3.4 Infiltration Testing

One infiltration test (IT-1) was performed at the site on December 12, 2013, in general accordance with the 1980 EPA Falling Head Test Method. The approximate location of the infiltration test is shown on the attached Site Plan, Figure 2. The infiltration test was performed within a 7-inch-diameter hand auger boring was advanced to a test depth of about 10½ feet bgs. This boring was prepared using a 7-inch diameter manual auger provided and operated by CGT. Following completion of the boring, a soil sample was collected from the test depth for laboratory testing. Following soil sampling, a 6-inch inner-diameter PVC pipe was lowered down the borehole and embedded approximately 3 inches into the soil horizon. The PVC pipe was placed within the borehole to eliminate the possibility of caving during testing. The test pipe was filled with about 12 inches of water and the soils were allowed to soak for about 4 hours. After the soaking period, we recorded the drop in water level at 15-minute intervals, for a total of 1 hour. Water was added between readings, as needed, to maintain an approximate 6-inch water depth within the pipe. The following table summarizes the results of our infiltration test.

Table 2: Results of Infiltration Test IT-1

<table>
<tr><th colspan="2">Test Depth (feet bgs)</th><th>10½</th><th>Soil Type</th><th>Sand with Silt (SP-SM)</th></tr>
<tr><th>Trial</th><th>Time Interval (minutes)</th><th colspan="2">Drop in Water Level (inches)</th><th>Raw Infiltration Rate (inches per hour)[a]</th></tr>
<tr><td>1</td><td>15</td><td colspan="2">2½</td><td>10</td></tr>
<tr><td>2</td><td>15</td><td colspan="2">$2^{7}/_{16}$</td><td>9¾</td></tr>
<tr><td>3</td><td>15</td><td colspan="2">2½</td><td>10</td></tr>
<tr><td>4</td><td>15</td><td colspan="2">2½</td><td>10</td></tr>
<tr><td colspan="5">[a] Does not include any safety or correction factors.</td></tr>
</table>

3.5 Site Reconnaissance

CGT Senior Geotechnical Engineer, Brad Wilcox, P.E., G.E., performed a reconnaissance of the site on December 30, 2013. The purpose of this reconnaissance was to characterize existing grading conditions around each of the apartment buildings and surface conditions of the existing pavement within the on-site drive lane and parking areas. The reconnaissance was performed based principally on visual methods during a time of relatively mild, dry weather. Site photographs taken during the reconnaissance are presented in the attached Appendix A. Grading conditions and pavement areas exhibiting distress (surface deficiencies) identified during the reconnaissance are shown in the attached Appendix B.

4.0 LABORATORY TESTING

Laboratory testing was performed on selected samples collected in the field to refine our initial field classifications and determine in-situ parameters. Laboratory testing included eighteen moisture content determinations (ASTM D2216) and three fines content (percentage passing the U.S. Standard No. 200 Sieve) tests (ASTM C117). Results of the laboratory tests are shown on the attached Boring Logs, Figures 4 through 19.

5.0 SUBSURFACE CONDITIONS

5.1 Soils

The following paragraphs provide a description of the subsurface materials encountered within our explorations at the site.

5.1.1 Building Areas - Buildings 3 through 6

The hand auger borings advanced near the existing buildings are designated by their respective building number. For instance, HA3-1 refers to a boring advanced adjacent to building number 3.

5.1.1.1 Silty Sand to Sandy Silt Fill (ML to SM Fill)

We encountered silty sand to sandy silt fill at the surface of borings HA4-1, HA4-2, HA4-3, and HA5-3 that, where fully penetrated, extended to depths of approximately 1 to 1½ feet bgs. Boring HA4-3 was terminated within the fill at a depth of about 3 feet bgs due to practical refusal of the manual hand auger. The existing fill was generally dark brown, moist, and contained varying amounts of gravel and organics. The silt component of the fill generally exhibited low plasticity. The sand component was generally fine-grained.

5.1.1.2 Native Sandy Silt to Silty Sand (ML to SM)

Beneath the fill in borings HA4-1, HA4-2, and HA5-3, and at the surface of the remaining borings, we encountered native, sandy silt to silty sand that extended to the full depths explored, approximately 5 to 8 feet bgs. These soils were generally soft to medium stiff (loose to medium dense), dark brown to orange-brown, and moist. The silt component generally exhibited low to moderate plasticity and generally decreased with depth. The sand component was generally fine-grained. Trace rootlets were observed within the upper ½-foot of this material.

5.1.2 Pavement Areas

The hand auger borings advanced within core holes in the existing asphalt pavements are designated by the letter "C", such as HA-C4.

5.1.2.1 Pavement Materials

In these borings, the existing pavement (asphaltic concrete) ranged from about 3 and 5½ inches thick underlain by gravel fill (GP Fill). The gravel fill was approximately 6 to 8 inches thick in borings HA-C4 and HA-C5, extending to depths of about ¾ to 1 foot bgs. In boring HA-C6, the gravel fill extended the full depth explored, approximately 2 feet bgs. This deeper gravel fill is anticipated to consist of backfill placed alongside a nearby manhole structure. The gravel fill was generally loose to medium dense, gray, moist, angular, and contained particles up to about ¾-inch in diameter. Based on visual observation, the material resembled commercially produced, ¾-inch minus crushed rock.

5.1.2.2 Native Sandy Silt to Silty Sand (ML to SM)

Beneath the gravel fill in borings HA-C4 and HA-C5, we encountered native, sandy silt to silty sand that extended to the full depths explored, approximately 5 feet bgs. These materials were generally soft to medium stiff (medium dense to dense), brown to dark brown, and moist. The silt component generally exhibited low to moderate plasticity and generally decreased with depth. The sand component was generally fine-grained

5.2 Groundwater

We did not encounter groundwater within the depths explored in the borings conducted at the site in December 2013. Groundwater was not reportedly encountered within the tests pits excavated as part of GRI's previous geotechnical investigation of the site, which extended to depths of about 8 to 10 feet below pre-development ground surface. To determine approximate regional groundwater levels in the area, we researched well logs available at the Oregon Water Resources Department (OWRD)[2] website. We identified numerous wells located within approximately 1,000 feet of the site. Our review indicated that groundwater levels in the area ranged from about 10 to 29 feet bgs. It should be noted that groundwater levels vary with local topography and water levels reported on the OWRD logs often reflect the purpose of the well, so water well logs may only report deeper, confined groundwater, while geotechnical or environmental borings will often report any groundwater encountered, including shallow, unconfined groundwater. Therefore, the levels reported on the OWRD well logs referenced above are considered generally indicative of local water levels and may not reflect actual groundwater levels at the project site.

We anticipate that groundwater levels will fluctuate due to seasonal and annual variations in precipitation, changes in site utilization, or other factors. In addition, the on-site, sandy silt (ML) and silty sand (SM) are conducive to formation of perched groundwater.

6.0 SEISMIC CONSIDERATIONS

6.1 Seismic Design

Based on the results of the explorations and review of geologic mapping, we have assigned the site as Site Class D for the subsurface conditions encountered in accordance with Table 1613.5.2 of the 2010 Oregon Structural Specialty Code (2010 OSSC). Earthquake ground motion parameters for the site were obtained based on the United States Geological Survey (USGS) Seismic Design Values for Buildings - Ground Motion Parameter Calculator[3]. The site Latitude 44.9729° North and 123.02435° West were input as the site location. The following table shows the seismic design parameters recommended for structural design at this site.

Table 3: Seismic Ground Motion Values (Section 1613.5 of 2010 OSSC)

Parameter		Value
Mapped Acceleration Parameters	Spectral Acceleration, 0.2 second (S_s)	0.801g
	Spectral Acceleration, 1.0 second (S_1)	0.339g
Coefficients (Site Class D)	Site Coefficient, 0.2 sec. (F_A)	1.179
	Site Coefficient, 1.0 sec. (F_V)	1.721
Adjusted MCE Spectral Response Parameters	MCE Spectral Acceleration, 0.2 sec. (S_{MS})	0.945g
	MCE Spectral Acceleration, 1.0 sec. (S_{M1})	0.584g
Design Spectral Response Accelerations	Design Spectral Acceleration, 0.2 seconds (S_{DS})	0.630g
	Design Spectral Acceleration, 1.0 second (S_{D1})	0.389g

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[2] Oregon Water Resources Department, 2013. Water well logs obtained from OWRD website http://www.wrd.state.or.us/

[3] United States Geological Survey, 2013. Seismic Design Parameters determined using:, "U.S. Seismic Design Maps Web Application - Version 3.0.1," from the USGS website *http://earthquake.usgs.gov*.

6.2 Seismic Hazards

6.2.1 Liquefaction

In general, liquefaction occurs when deposits of loose/soft, saturated, cohesionless soils, generally sands and silts, are subjected to strong earthquake shaking. If these deposits cannot drain quickly enough, pore water pressures can increase, approaching the value of the overburden pressure. The shear strength of a cohesionless soil is directly proportional to the effective stress, which is equal to the difference between the overburden pressure and the pore water pressure. When the pore water pressure increases to the value of the overburden pressure, the shear strength of the soil approaches zero, and the soil can liquefy. The liquefied soils can undergo rapid consolidation or, if unconfined, can flow as a liquid. Structures supported by the liquefied soils can experience rapid, excessive settlement, shearing, or even catastrophic failure.

For fine-grained soils, susceptibility to liquefaction is evaluated based on penetration resistance and plasticity, among other characteristics. Criteria for identifying non-liquefiable, fine-grained soils are constantly evolving. Current practice[4] to identify non-liquefiable, fine-grained soils is based on plasticity characteristics of the soils, as follows: (1) liquid limit greater than 47 percent, (2) plasticity index greater than 20 percent, and (3) moisture content less than 85 percent of the liquid limit. Soils identified as susceptible to liquefaction are analyzed using the industry standard “simplified procedure”, originally published by Seed and Idriss[5] in 1971 and updated continually since that time. The susceptibility of sands, gravels, and sand-gravel mixtures to liquefaction is typically assessed based on penetration resistance, as measured using SPTs, CPTs, or Becker Hammer Penetration tests (BPTs).

Based on the lack of saturated conditions, the soils encountered within the depths explored at the site are considered non-liquefiable.

6.2.2 Slope Instability

Due to the relatively level topography at and in the immediate vicinity of the site, the risk of seismically-induced slope instability at the site is considered negligible.

6.2.3 Surface Rupture

6.2.3.1 Faulting

Although the site is situated in a region of the country with known active faults and historic seismic activity, no known faults exist on or immediately adjacent to the site. Therefore, the risk of surface rupture at the site due to faulting is considered low.

6.2.3.2 Lateral Spread

Surface rupture due to lateral spread can occur on sites underlain by liquefiable soils that are located on or immediately adjacent to slopes steeper than about 3 degrees (20H:1V), and/or adjacent to a free face,

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[4] Seed, R.B. et al., 2003. Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework. Earthquake Engineering Research Center Report No. EERC 2003-06.

[5] Seed, H.B., and Idriss, I.M., 1971, Simplified Procedure for Evaluating Soil Liquefaction Potential, Journal of Geotechnical Engineering Division, ASCE, 97(9), 1249-1273.

such as a stream bank or the shore of an open body of water. During lateral spread, the materials overlying the liquefied soils are subject to lateral movement downslope or toward the free face. Given the lack of liquefiable soils within the depths explored at the site, the risk of surface rupture due to lateral spread is considered low.

7.0 GEOTECHNICAL REVIEW & DISCUSSION

7.1 Building Drainage Conditions

As indicated above, we did not encounter groundwater within the depths explored (up to 8 feet bgs) in our borings completed along the perimeter of the existing buildings. In addition, we did not observe any indications of a fluctuating groundwater level (such as soil mottling) within the depths explored in the borings. During our site reconnaissance, we observed numerous locations where positive drainage away from the buildings had not been established or maintained. Areas of positive and negative drainage that were identified around the buildings are shown on Figure B1 of the attached Appendix B. Several area drains were observed within landscaped areas around the buildings; some of which were located in areas exhibiting negative drainage. However, the functionality of the area drains observed at the site was not known.

Recognizing the fine-grained nature of the subsurface materials, and less than favorable grading conditions near the apartment buildings, we interpret the reported water problems within the crawlspace areas are principally attributed to water ponding from stormwater runoff. Recommendations for drainage improvements along the perimeter of the existing apartment buildings are presented in Section 8.0 below.

7.2 Existing Pavements

As indicated in Section 5.1.2.1 above, our explorations showed the existing pavement structure (where investigated) contained about 3 to 5½ inches of asphaltic concrete underlain by at least 6 inches of gravel fill (crushed rock). At the explored locations, the respective thickness of the asphaltic concrete pavement and underlying base rock was in conformance with that recommended as minimums in the referenced GRI geotechnical report. GRI indicated that "…*some maintenance of the pavements will be required over the design life of the pavement (15 to 20 years)*". We are not aware of any records detailing maintenance of on-site pavements. Such records could be sought to provide more information on this matter.

As shown on Figure B1 of the attached Appendix B, we observed some pavement areas that exhibited distress (surface deficiencies) in the form of cracking, localized disintegration (raveling), and upheaval. Photographs showing examples of surface deficiencies in existing pavement are shown in the attached Appendix A. The localized areas exhibiting upheaval were located adjacent to planter strips containing a moderately-sized, deciduous tree. In each of those cases, we attribute the upheaval in the pavement to root growth from the nearby tree. We interpret the other surface deficiencies (cracks and raveling) observed within the existing pavement are the result of the pavement structure being near the end of its intended service life. Further deterioration of the existing pavement is expected to occur over time in its current condition and with future use.

To help maintain serviceability of the existing drive lanes and pavements at the site for intended use, two options are presented for the owner's consideration:

- **Option 1 – Complete Removal & Replacement:** This option would include complete removal of the existing pavement structure and replacement with a new pavement section. Geotechnical recommendations for pavement removal, preparation, placement, and compaction of new pavement sections at the site in Section 9.8 of this report.
- **Option 2 – Surface Treatment:** This option would include treating surface deficiencies identified at the site with the intent to extend the service life of the existing pavement. Surface treatments, in the form of sealants, can be performed to repair most of the cracks identifed within existing pavements. Sawcutting and patching could be performed in other areas exhibiting increased deterioration. Limitations of surface treatments would need to be recognized and accepted by the owner. If this option is considered, CGT can provide recommendations for treatment of existing pavement on a case-by-case basis for an additional fee.

8.0 RECOMMENDATIONS – DRAINAGE IMPROVEMENTS

The following measures are recommended to help mitigate ponding of water within/near the crawlspaces of the existing buildings and to limit further saturation of areas surrounding the apartment buildings. The recommendations presented as “primary” represent measures we believe can be implemented without significant modifications to the existing apartment complex and at a relatively low cost for the owner. The recommendations presented as “secondary” may be considered in addition to those presented as primary. All recommendations presented herein are considered conceptual in nature. We recommend a licensed, experienced civil engineer and/or landscape architect be consulted to help facilitate final planning and design of drainage improvements at this site.

8.1 Primary Measures

8.1.1 Inspect Existing Roof Drains

The existing roof drainage system for each building should be inspected to confirm they are in proper working order. If damage or improper function is observed, the drains should be repaired to their original condition.

8.1.2 Inspect Existing Area Drains

Existing area drains near existing buildings should be inspected to confirm they are in proper working order. If damage or improper function is observed, the drains should be repaired to their original condition.

8.1.3 Install Cut-Off Trenches (French Drains)

We recommend cut-off trenches (french drains) be constructed along the buildings where the ground surface is level or descending towards the buildings. The purpose of the cut-off trenches is to the intercept the surface runoff and direct it away from the buildings. A conceptual detail of a typical cut-off trench is presented in Figure B2 of the attached Appendix B. We recommend the cut-off trench extend a minimum of 3 feet below the existing ground surface and be a minimum of 12 inches wide. The walls and base of the trench should be lined with a non-woven, geotextile fabric (filter fabric) in conformance with Table 02320-1 of the most recent Oregon Standard Specifications for Construction for “Type 1, Drainage

Geotextile". A minimum 4-inch diameter, perforated PVC drainpipe should be placed in the bottom of the trench, graded to maintain positive drainage toward a suitable discharge point away from the buildings. The trench should be backfilled with open-graded drain rock, wrapped in geotextile fabric, to about 6 inches below the adjacent, permanent grade. The upper 6 inches of the cut-off trench should be backfilled with drain rock to match the existing grades. CGT would be pleased to assist the project civil engineer or landscape architect in selecting locations for cut-off trenches.

8.1.4 Install Sumps in Crawlspaces of Buildings

We recommend sump pumps be installed within the crawlspaces of the existing buildings. The sumps should be installed at the low point within each crawlspace with discharge line(s) routed to a suitable discharge point away from the buildings. The sump discharge line should be equipped with a backflow preventer device (check valve) to prevent water from flowing back into the crawlspaces.

8.2 Secondary Measures

8.2.1 Improve Grading Around Buildings

If desired, the areas exhibiting less than favorable drainage around the buildings could be re-graded to improve drainage. Paved surfaces (hardscaping) and ground near or adjacent to the buildings should be re-graded to achieve a minimum 2 percent declivity away from the buildings to promote proper drainage away from the buildings. Surface water from paved surfaces and open spaces should be collected and routed to a suitable discharge point.

8.2.2 Interior Foundation Drains

Foundation drains along the interior of building perimeter foundations could be installed to enhance drainage within the crawlspace areas. If considered, we recommend foundation drains consist of a minimum 4-inch diameter, perforated, PVC drainpipe wrapped with a non-woven geotextile filter fabric. Foundation drains should be positively sloped and outlet to a sump (if installed) or another suitable discharge point.

8.2.3 Install Crawlspace Moisture Barrier

A visual condition survey of the crawlspace areas of the existing apartment buildings was not performed as part of this assignment. Accordingly, it was not possible to ascertain the existence and condition of a moisture (vapor) barrier in the crawlspace areas. If a vapor barrier is not in place, and access allows, we recommend installing a ground cover moisture barrier within the crawlspace area of each building. As a guideline, we recommend placing minimum 6-mil polyethylene sheeting or approved equivalent that is placed directly on the ground surface. Seams should be overlapped a minimum of 12 inches and taped. The sheeting should extend a minimum of 12 inches up the foundation walls.

9.0 PRELIMINARY RECOMMENDATIONS – NEW CONSTRUCTION

At the time this report was prepared, the full scope of improvements to the site was not known. The recommendations presented below are preliminary in nature and intended to assist in the planning and design of new structural features at the site (where applicable). As project plans are being finalized, the geotechnical engineer should be consulted to review the proposed construction in order to “finalize” the recommendations presented below.

9.1 Site Preparation

9.1.1 Site Stripping

Existing vegetation, topsoil, pavement materials, undocumented fill (where encountered) should be removed from, and for a minimum 5-foot margin around, proposed structural fill areas, building pad areas, and pavement locations. Stripping depths at the site are anticipated to be approximately ½ to 3 feet bgs based on the results of our field explorations. These materials may be deeper or shallower at locations away from our explorations. The geotechnical engineer or his representative should provide recommendations for actual stripping depths based on observations during site preparation. Stripped materials should be transported off-site for disposal, or stockpiled for later use in landscaped areas.

9.1.2 Grubbing

Grubbing of trees slated for removal should include the removal of the root mass, and roots greater than ½-inch in diameter. Grubbed materials should be transported off-site for disposal. Where root masses are removed, the resulting excavation should be properly backfilled with imported granular structural fill in conformance with Section 9.4.2 of this report.

9.1.3 Existing Utilities & Below-Grade Structures

All existing utilities at the site should be identified prior to excavation. Abandoned utility lines beneath new structures, pavements, and exterior hardscaping should be completely removed or grouted full. Soft, loose, or otherwise unsuitable soils encountered in utility trench excavations should be removed and replaced with structural fill as described in Section 9.4 of this report. No below-grade structures were encountered in our explorations. If encountered during site preparation, buried structures (i.e. footings, foundation walls, slabs-on-grade, tanks, etc.) should be completely removed and disposed of off-site and replaced with structural fill in conformance with Section 9.4 of this report.

9.1.4 Subgrade Preparation – New Building Pads & Pavements

9.1.4.1 Dry Weather Construction

After site preparation as recommended above, but prior to placement of structural fill and/or base rock, the geotechnical engineer or his representative should observe a proof roll test of exposed building pad and pavement subgrade soils in order to identify areas of excessive yielding. Proof rolling of subgrade soils is typically conducted during dry weather conditions using a fully-loaded, 10- to 12-cubic-yard, tire-mounted, dump truck or equivalent weighted water truck. Areas that appear too soft and wet to support proof rolling equipment should be prepared in general accordance with the recommendations for wet weather construction presented in Section 9.3 of this report. If areas of soft soil or excessive yielding are identified, the affected material should be over-excavated to firm, stable subgrade, and replaced with imported granular structural fill in conformance with Section 9.4.2 of this report.

9.1.4.2 Wet Weather Construction

Preparation of building pad and pavement subgrade soils during wet weather[6] should be in conformance with Section 9.3 of this report. As indicated therein, increased base rock sections and a geotextile separation fabric may be required in wet conditions in order to support construction traffic and protect the subgrade. Cement amendment may also be considered to help stabilize subgrade soils during wet weather.

9.1.5 Erosion Control

Erosion and sedimentation control measures should be employed in accordance with applicable City, County, and State regulations regarding erosion control.

9.2 Temporary Excavations

9.2.1 Overview

All excavations should be in accordance with applicable OSHA and state regulations. It is the contractor's responsibility to select the excavation methods, to monitor site excavations for safety, and to provide any shoring required to protect personnel and adjacent improvements. A “competent person”, as defined by OR-OSHA, should be on-site during construction in accordance with regulations presented by OR-OSHA. CGT’s current role on the project does not include review or oversight of excavation safety.

9.2.2 Utility Trenches

Temporary trench cuts should stand near vertical to depths of approximately 4 feet in the sandy silt (ML) to silty sand (SM) soils encountered near the surface of the site. Some instability may occur in these soils if groundwater seepage is encountered. If seepage undermines the stability of the trench, or if caving of the sidewalls is observed during excavation, the sidewalls should be flattened or shored. Depending on the time of year trench excavations occur, trench dewatering may be required in order to maintain dry working conditions, particularly if the invert elevations of the proposed utilities are below the groundwater level. Pumping from sumps located within the trench will likely be effective in removing water resulting from seepage. If groundwater is present at the base of utility excavations, we recommend placing trench stabilization material at the base of the excavations. Trench stabilization material should be in conformance with Section 9.4.4 of this report.

9.2.3 OSHA Soil Type

Conventional earthmoving equipment in proper working condition should be capable of making necessary excavations for the anticipated cuts at the site as described earlier in this report. For use in the planning

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[6] Refer to Section 9.3 for a discussion of the wet weather season typical for this region.

and construction of temporary excavations up to 8 feet in depth, an OSHA soil type "C" should be used for the sandy silt (ML) and silty sand (SM) soils encountered near the surface of the site.

9.2.4 Excavations Near Foundations

Excavations near footings should not extend within a 1H:1V (horizontal:vertical) plane projected out and down from the outside, bottom edge of the footings. In the event that excavation needs to extend below the referenced plane, temporary shoring of the excavation and/or underpinning of the subject footing may be required. The geotechnical engineer should be consulted to review proposed excavation plans for this design case to provide specific recommendations.

9.3 Wet Weather Considerations

For planning purposes, the wet season should be considered to extend from late September to late June. It is our experience that dry weather working conditions should prevail between early July and the middle of September. Notwithstanding the above, soil conditions should be evaluated in the field by the geotechnical engineer or his representative at the initial stage of site preparation to determine whether the recommendations within this section should be incorporated into construction.

9.3.1 General

The near-surface sandy silt (ML) and silty sand (SM) soils are susceptible to disturbance during wet weather. Trafficability of these soils may be difficult, and significant damage to subgrade soils could occur, if earthwork is undertaken without proper precautions at times when the exposed soils are more than a few percentage points above optimum moisture content. For construction that occurs during wet weather, site preparation activities may need to be accomplished using track-mounted equipment, loading removed material onto trucks supported on granular haul roads, or other methods to limit soil disturbance. A geotechnical representative from CGT should evaluate the subgrade during excavation by probing rather than proof rolling. Soils that have been disturbed during site preparation activities, or soft or loose areas identified during probing, should be over-excavated to firm, stable subgrade, and replaced with imported granular structural fill.

9.3.2 Geotextile Separation Fabric

CGT recommends a geotextile separation fabric be placed as a barrier between the prepared fine-grained subgrade and granular fill/base rock in areas of repeated or heavy construction traffic. The geotextile fabric should meet the requirements presented in the current Oregon Department of Transportation (ODOT) Standard Specification for Construction, Section 02320. In accordance with Table 02320-1 of ODOT specifications, the separation fabric should have minimum puncture strength (ASTM D4833) of 80 pounds and an apparent opening size (ASTM D4751) no larger than the U.S. Standard No. 30 sieve. Examples of products that currently meet these requirements include Propex Geotex 200ST and US Fabrics US200. Other products meeting the requirements presented by ODOT may be considered for separation geotextile fabric.

9.3.3 Granular Working Surfaces (Haul Roads & Staging Areas)

Haul roads subjected to repeated heavy, tire-mounted, construction traffic (e.g. dump trucks, concrete trucks, etc.) will require a minimum of 18 inches of imported granular material. For light staging areas, 12 inches of imported granular material should be sufficient. Additional granular material, geo-grid reinforcement, or cement amendment may be recommended based on site conditions and/or loading at the time of construction. The imported granular material should be in conformance with Section 9.4.2 of this report and have less than 5 percent material passing the U.S. Standard No. 200 Sieve. The prepared subgrade should be covered with geotextile fabric prior to placement of the imported granular material. The imported granular material should be placed in a single lift (up to 24-inches deep) and compacted using a smooth-drum, non-vibratory roller until well-keyed.

9.3.4 Subgrade Protection for New Foundations

A minimum of 3 inches of imported granular material is recommended to protect fine-grained foundation subgrades from foot traffic during inclement weather. The imported granular material should be in conformance with Section 9.4.2 of this report, have less than 5 percent material passing the U.S. Standard No. 200 Sieve, and have a maximum particle size limited to 1-inch. The imported granular material should be placed in one lift over the prepared, undisturbed subgrade, and compacted using non-vibratory equipment until well keyed.

9.4 Structural Fill

The geotechnical engineer should be provided the opportunity to review all materials considered for use as structural fill (prior to placement). The geotechnical engineer or his representative should be contacted to evaluate compaction of structural fill as the material is being placed. Evaluation of compaction may take the form of in-place density tests and/or proof roll tests with suitable equipment. Structural fill should be evaluated at intervals not exceeding every 2 vertical feet as the fill is being placed.

9.4.1 On-Site Soils – General Use

9.4.1.1 Sandy Silt (ML) and Silty Sand (SM)

Re-use of the on-site sandy silt (ML) and silty sand (SM) as structural fill may be difficult because these soils are sensitive to small changes in moisture content and are difficult, if not impossible, to adequately compact during wet weather. We anticipate that the moisture content of these soils will be higher than the optimum moisture content for satisfactory compaction. Therefore, moisture conditioning (drying) should be expected in order to achieve adequate compaction. If used as structural fill, these soils should be free of organic matter, debris, and particles larger than 1½ inches. When used as structural fill, these soils should be placed in lifts with a maximum thickness of about 8 inches at moisture contents within –1 and +3 percent of optimum, and compacted to not less than 92 percent of the material's maximum dry density, as determined in general accordance with ASTM D1557 (Modified Proctor).

If the on-site soils cannot be properly moisture-conditioned and/or processed, we recommend using imported granular material for structural fill.

9.4.2 Imported Granular Structural Fill – General Use

Imported granular structural fill should consist of angular pit or quarry run rock, crushed rock, or crushed gravel that is fairly well graded between coarse and fine particle sizes. The granular fill should contain no organic matter, debris, or particles larger than 4 inches, and have less than 5 percent material passing the U.S. Standard No. 200 Sieve. For fine-grading purposes, the maximum particle size should be limited to 1½ inches. The percentage of fines can be increased to 12 percent of the material passing the U.S. Standard No. 200 Sieve if placed during dry weather, and provided the fill material is moisture-conditioned, as necessary, for proper compaction. Granular fill material should be placed in lifts with a maximum thickness of about 12 inches, and compacted to not less than 95 percent of the material's maximum dry density, as determined in general accordance with ASTM D1557 (Modified Proctor). Proper moisture conditioning and the use of vibratory equipment will facilitate compaction of these materials.

Compaction of granular fill materials with high percentages of particle sizes in excess of 1½-inches should be evaluated by periodic proof-roll observation or continuous observation by the CGT geotechnical representative during fill placement, since it cannot be tested conventionally using a nuclear densometer. Such materials should be "capped" with a minimum of 12 inches of 1½-inch-minus (or finer) granular fill under all structural elements (footings, concrete slabs, etc.).

9.4.3 Floor Slab Base Rock

Floor slab base rock should consist of well-graded granular material (crushed rock) containing no organic matter or debris, have a maximum particle size of ¾-inch, and have less than 5 percent material passing the U.S. Standard No. 200 Sieve. Floor slab base rock should be placed in one lift and compacted to not less than 90 percent of the material's maximum dry density as determined in general accordance with ASTM D1557 (Modified Proctor).

9.4.4 Trench Base Stabilization Material

If groundwater is present at the base of utility excavations, trench base stabilization material should be placed. Trench base stabilization material should consist of a minimum of 1-foot of well-graded granular material with a maximum particle size of 4 inches and less than 5 percent material passing the U.S. Standard No. 4 Sieve. The material should be free of organic matter and other deleterious material, placed in one lift, and compacted until well-keyed.

9.4.5 Trench Backfill Material

Trench backfill for the utility pipe base and pipe zone should consist of granular material as recommended by the utility pipe manufacturer. Trench backfill above the pipe zone should consist of well-graded granular material containing no organic matter or debris, have a maximum particle size of ¾-inch, and have less than 8 percent material passing the U.S. Standard No. 200 Sieve. As a guideline, trench backfill should be placed in maximum 12-inch-thick lifts. The earthwork contractor may elect to use alternative lift thicknesses based on their experience with specific equipment and fill material conditions during construction in order to achieve the required compaction. The following table presents recommended relative compaction percentages for utility trench backfill.

Table 4: Utility Trench Backfill Compaction Recommendations

Backfill Zone	Recommended Minimum Relative Compaction	
	Structural Areas[1]	Landscaping Areas
Pipe Base and Within Pipe Zone	90% ASTM D1557 or pipe manufacturer's recommendation	88% ASTM D1557 or pipe manufacturer's recommendation
Above Pipe Zone	92% ASTM D1557	90% ASTM D1557
Within 3 Feet of Design Subgrade	95% ASTM D1557	90% ASTM D1557
[1] Includes new or existing buildings, pavements, hardscaping, etc.		

9.5 New Shallow Spread Foundations

The recommendations presented below are preliminary in nature and based on the assumption that maximum column and continuous wall loads will be less than 30 kips and 3 kips per lineal foot (klf) respectively. If increased loads are anticipated, the geotechnical engineer should be consulted.

9.5.1 Subgrade Preparation

Satisfactory subgrade support for new shallow foundations can be obtained from the native, medium stiff or better, sandy silt (ML), the native, medium dense or better, silty sand (SM), or new structural fill that is properly placed and compacted on these materials during construction. These soils were first encountered at depths of about ½ to 3 feet bgs within our explorations. The geotechnical engineer or his representative should be contacted to observe subgrade conditions prior to placement of forms, reinforcement steel, or granular backfill (if required). If soft, loose, or otherwise unsuitable soils are encountered, they should be over-excavated as recommended by the geotechnical representative at the time of construction. The resulting over-excavation should be brought back to grade with imported granular structural fill in conformance with Section 9.4.2 of this report. The maximum particle size of over-excavation backfill should be limited to 1½ inches. All granular pads for footings should be constructed a minimum of 6 inches wider on each side of the footing for every vertical foot of over-excavation.

9.5.2 Minimum Footing Width & Embedment

Minimum footing widths should be in conformance with the most recent, Oregon Residential Specialty Code (ORSC). As a guideline, CGT recommends individual spread footings have a minimum width of 24 inches. Similarly, one-story, light-framed structures, we recommend continuous wall footings have a minimum width of 12 inches. For two- and three-story, light-framed structures, we recommend continuous wall footings have a minimum width of 15 and 18 inches, respectively. All footings should be founded at least 18 inches below the lowest, permanent adjacent grade.

9.5.3 Bearing Pressure & Settlement

Footings founded as recommended above should be proportioned for a maximum allowable soil bearing pressure of 2,000 pounds per square foot (psf) for footings founded as recommended above. This bearing pressure is a net bearing pressure, applies to the total of dead and long-term live loads, and may be increased by one-third when considering seismic or wind loads. For footings founded as recommended, total settlement of foundations is anticipated to be less than 1 inch. Differential settlements between adjacent columns and/or bearing walls should not exceed ½-inch.

9.5.4 Lateral Capacity

A maximum passive (equivalent fluid) earth pressure of 150 pounds per cubic foot (pcf) is recommended for design of footings confined by the native soils described above, or imported granular structural fill that is properly placed and compacted during construction. The recommended earth pressure was computed using a factor of safety of 1½, which is appropriate due to the amount of movement required to develop full passive resistance. In order to develop the above capacity, the following should be understood:

1. Concrete must be poured neat in excavations or the foundations must be backfilled with imported granular structural fill,
2. The adjacent grade must be level,
3. The static ground water level must remain below the base of the footings throughout the year.
4. Adjacent floor slabs, pavements, or the upper 12-inch-depth of adjacent, unpaved areas should not be considered when calculating passive resistance.

An ultimate coefficient of friction equal to 0.35 may be used when calculating resistance to sliding for footings founded on the native soils described above. An ultimate coefficient of friction equal to 0.45 may be used when calculating resistance to sliding for footings founded on a minimum of 6 inches of imported granular structural fill (crushed rock) that is properly placed and compacted during construction.

9.5.5 Subsurface Drainage

Recognizing the fine-grained nature of the native soils, we recommend perimeter foundation drains be placed at the exterior base elevations of the footings. This recommendation is presented for new buildings to be constructed at the site. Foundation drains should consist of a minimum 4-inch-diameter, perforated, HDPE (High Density Polyethylene) drainpipe wrapped with a non-woven geotextile filter fabric. The drains should be backfilled with a minimum of 2 cubic feet of open graded drain rock per lineal foot of pipe. The drain rock should be encased in a geotextile filter fabric in order to provide separation from the surrounding soils. Foundation drains should be positively sloped and should outlet to a suitable discharge point. A representative from CGT should be contacted to observe the drains prior to backfilling. Roof drains should not be tied into foundation drains.

9.6 Floor Slabs

9.6.1 Subgrade Preparation

Satisfactory subgrade support for floor slabs constructed on grade, supporting up to 150 psf area loading, can be obtained from the native, medium stiff or better, sandy silt (ML), the native, medium dense or better, silty sand (SM), or new structural fill that is properly placed and compacted on these materials during construction. These soils were first encountered at depths of about ½ to 3 feet bgs within our explorations. Subgrade preparation of floor slabs should be in conformance with Section 9.1.4 of this report.

9.6.2 Crushed Rock Base

Concrete floor slabs should be supported on a minimum 6-inch-thick layer of crushed rock (base rock). The crushed rock base should conform to the recommendations presented in Section 9.4.3 of this report. For design cases where a vapor barrier or retarder is not placed below the slab, the surface of the base rock should be choked with sand just prior to concrete placement. Choking means the voids between the largest aggregate particles are filled with sand, but does not provide a layer of sand above the base rock. Choking the base rock surface reduces the lateral restraint on the bottom of the concrete during curing.

9.6.3 Design Considerations

For floor slabs constructed as recommended, a modulus of subgrade reaction of 100 pounds per cubic inch (pci) is recommended for the design of the floor slab. Floor slabs constructed as recommended will likely settle less than ½-inch. For general floor slab construction, slabs should be jointed around columns and walls to permit slabs and foundations to settle differentially.

9.6.4 Subgrade Moisture Considerations

Liquid moisture and moisture vapor should be expected at the subgrade surface. The recommended crushed rock base is anticipated to provide protection against liquid moisture. Where moisture vapor emission through the slab must be minimized, e.g. impervious floor coverings, storage of moisture sensitive materials directly on the slab surface, etc., a vapor retarding membrane or vapor barrier below the slab should be considered. Factors such as cost, special considerations for construction, floor coverings, and end use suggest that the decision regarding a vapor retarding membrane or vapor barrier be made by the architect and owner.

If a vapor retarder or vapor barrier is placed below the slab, its location should be based on current American Concrete Institute (ACI) guidelines, ACI 302 Guide for Concrete Floor and Slab Construction. In some cases, this indicates placement of concrete directly on the vapor retarder or barrier. Please note that the placement of concrete directly on impervious membranes increases the risk of plastic shrinkage cracking and slab curling in the concrete. Construction practices to reduce or eliminate such risk, as described in ACI 302, should be employed during concrete placement.

9.7 Rigid Retaining Walls

9.7.1 Footings

Retaining wall footings should be designed and constructed in conformance with the recommendations presented in Section 9.5 of this report, as applicable.

9.7.2 Wall Drains

Subject to review of the wall designer, we recommend placing a retaining wall drain at the base elevation of the heel of the retaining wall footing. Retaining wall drains should consist of a minimum 4-inch-diameter, perforated, HDPE (High Density Polyethylene) drainpipe wrapped with a non-woven geotextile filter fabric. The drains should be backfilled with a minimum of 2 cubic feet of open graded drain rock per lineal foot of pipe. The drain rock should be encased in a geotextile fabric in order to provide separation from the surrounding soils. Retaining wall drains should be positively sloped and should outlet to a suitable discharge point. The geotechnical engineer or his representative should be contacted to observe the drains prior to backfilling. Roof or area drains should not be tied into retaining wall drains.

9.7.3 Wall Backfill

Retaining walls should be backfilled with imported granular structural fill in conformance with Section 9.4.2 and contain less than 5 percent passing the U.S. Standard No. 200 Sieve. The backfill should be compacted to a minimum of 90 percent of the material's maximum dry density as determined in general accordance with ASTM D1557 (Modified Proctor). When placing fill behind walls, care must be taken to minimize undue lateral loads on the walls. Heavy compaction equipment should be kept at least "H" feet from the back of the walls, where "H" is the height of the wall. Light mechanical or hand tamping equipment should be used for compaction of backfill materials within "H" feet of the back of the walls.

9.7.4 Design Parameters & Limitations

For retaining walls founded, backfilled, and drained as recommended above, the following table presents soil parameters recommended for design.

Table 5: Recommended Retaining Wall Design Parameters

Retaining Wall Condition	Backfill Condition	Static Equivalent Fluid Pressure (S_A)	Additional Seismic Equivalent Fluid Pressure (S_{AE})
Not Restrained from Rotation	Level (i = 0)	32 pcf	10 pcf
Restrained from Rotation	Level (i = 0)	54 pcf	2 pcf

Note 1. Refer to the attached Figure 20 for a graphical representation of static and seismic loading conditions. Seismic component of active thrust acts at 0.6H above the base of the wall.
Note 2. Seismic / dynamic lateral loads were computed using the Mononobe-Okabe Equation as presented in the 1997 Federal Highway Administration (FHWA) design manual.

The above design recommendations are based on the assumptions that:
(1) the walls consist of conventional cantilevered retaining walls ($\beta = 0$ and $\delta = 24$ degrees).

(2) the walls are 6 feet in height or less in height.
(3) the backfill is drained and consists of imported granular structural fill (ϕ = 38 degrees).
(4) no line load or point load surcharges are imposed behind the walls.
(5) the grade behind the wall is level, or sloping down and away from the wall, for a distance of 6 feet or more.
(6) the grade in front of the walls is level or sloping up for a distance of at least 5 feet.

Re-evaluation of our recommendations will be required if the retaining wall design criteria for the project vary from these assumptions.

9.8 Flexible Pavements

9.8.1 Subgrade Preparation

Subgrade preparation of pavements should be in conformance with Section 9.1.4 of this report. Pavement subgrade surfaces should be crowned (or sloped) for proper drainage in accordance with specifications provided by the project civil engineer.

9.8.2 Input Parameters

Our pavement section designs were based on the American Association of State Highway and Transportation Officials (AASHTO) 1993 "Design of Pavement Structures" manual. A number of design assumptions and variables were required in order to develop design sections for pavements proposed at the site. The following table presents the input parameters assumed for the design:

Table 6: Input Parameters Assigned for Pavement Design

Input Parameter		Design Value[1]
Pavement Design Life		20 years
Annual Percent Growth		0 percent
Serviceability		4.2 initial, 2.2 terminal
Reliability		75 percent
Standard Deviation		0.49
Drainage Factor[2]		1.0
Resilient Modulus	Subgrade[3]	4,500 psi
	Crushed Aggregate Base	22,500 psi
Structural Coefficients	Crushed Aggregate Base	0.10
	Asphalt	0.42
Vehicle Traffic[4] (range)	APAO Level I (Very Light)	Less than 10,000 ESAL
	APAO Level II (Light)	Less than 50,000 ESAL

[1] If any of the above parameters need revision, please contact us so that we may revise our recommendations, if warranted.

[2] Assumes good drainage away from pavement, base, and subgrade is achieved by proper crowning of subgrades.

[3] Value presented is based on experience with similar soils in the area of the site.

[4] ESAL = Total 18-Kip equivalent single axle load. Refer to Section 9.8.3 below for discussion of pavement traffic levels considered for this project.

9.8.3 Design Traffic Loading

Recognizing that traffic data has not been provided, CGT has considered two levels of traffic demand for review and design of the pavement sections for this project. The levels of traffic loading presented in the following table reflect those considered by the APAO Asphalt Pavement Design Guide for Level I (very light traffic) and Level II (light traffic). The following table presents the design ESALs and assumed average daily truck traffic for each APAO traffic level and project pavement area designated for this project.

Table 7: Traffic Levels Considered for Design

Project Pavement Area	Assigned APAO Traffic Level[1]	Design ESALs[2]	Average Daily Truck Traffic (ADTT)[3]
Private Passenger Car Parking	Level I (Very Light Traffic)	10,000 to 50,000	1 over 20 years
Private Entrance/Service Drive Lanes	Level II (Light Traffic)	50,000 to 100,000	2 to 7 over 20 years

[1] Traffic loading levels shown above are per Table 3.1 of the APAO Asphalt Pavement Design Guide.
[2] ESAL = Total 18-kip equivalent single axle load over design period.
[3] ADTT assumes EAL (per truck) = 2.0

9.8.4 Recommended Minimum Sections

The following table presents the minimum asphalt pavement sections for various traffic loads indicated in the preceding table, based on the referenced AASHTO procedures.

Table 8: Recommended Minimum Asphalt Pavement Sections

Material	APAO Traffic Loading	
	Level I (Passenger Car Parking)	Level II (Entrance & Service Lanes)
Asphalt Pavement (inches)	3	3½
Crushed Aggregate Base[1] (inches)	7	9
Subgrade Soils	Prepared in conformance with Section 9.1.4 of this report.	

[1] Thickness shown assumes dry weather construction. A granular sub-base section and/or a geotextile separation fabric may be required in wet conditions in order to support construction traffic and protect the subgrade. Refer to Section 9.1.4.2 of this report for recommendations for wet weather construction.

Asphalt pavement and base course material should conform to the most current State of Oregon, Standard Specifications for Highway Construction. Place aggregate base in one lift, and compact to not less than 95 percent of the material's maximum dry density as determined in general accordance with ASTM D1557 (Modified Proctor). Asphalt pavement should be compacted to at least 91 percent of the material's theoretical maximum density as determined in general accordance with ASTM D2041 (Rice Specific Gravity).

9.9 Additional Considerations

9.9.1 Drainage

Subsurface drains should be connected to the nearest storm drain, onsite storm water system (if incorporated into the project, designed by others), or other suitable discharge point. Paved surfaces and ground near or adjacent to new buildings should be sloped to drain away from the building. Surface water from paved surfaces and open spaces should be collected and routed to a suitable discharge point. Surface water should not be directed into foundation or retaining wall drains.

9.9.2 Expansive Potential

The near surface soils consist of low plasticity, sandy silt (ML) and silty sand (SM). These soils are not considered to be susceptible to appreciable movements from changes in moisture content. Accordingly, no special considerations are required to mitigate expansive potential of the near surface soils at the site.

10.0 RECOMMENDED ADDITIONAL SERVICES

10.1 Design Review

Geotechnical design review is of paramount importance. CGT recommends that the geotechnical design review take place prior to releasing bid packets to contractors.

10.2 Observation of Construction

Satisfactory earthwork, foundation, and pavement performance depends to a large degree on the quality of construction. Sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. Subsurface conditions observed during construction should be compared with those encountered during subsurface explorations, and recognition of changed conditions often requires experience. We recommend that qualified personnel visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those observed to date and anticipated in this report.

We recommend that the geotechnical engineer or their representative attend a pre-construction meeting coordinated by the contractor and/or developer. The project geotechnical engineer or their representative should provide observations and/or testing of at least the following earthwork elements during construction (as applicable for the finalized project):

- Stripping and Grubbing.
- Subgrade Preparation for Structural Fills, Shallow Foundations, Floor Slabs, and Pavements.
- Compaction of Structural Fill.
- Compaction of Utility Trench Backfill.
- Placement of Foundation Drains and Other Drains.
- Placement and Compaction of Utility Trench Backfill.
- Compaction of Base Rock for Floor Slabs and Pavements.
- Placement and Compaction of Asphaltic Concrete for Pavements.

It is imperative that the owner and/or contractor request earthwork observations and testing at a frequency sufficient to allow the geotechnical engineer to provide a final letter of compliance for the earthwork activities.

11.0 LIMITATIONS

We have prepared this report for use by the owner/developer and other members of the design and construction team for the proposed development. The opinions and recommendations contained within this report are not intended to be, nor should they be construed as a warranty of subsurface conditions, but are forwarded to assist in the planning and design process.

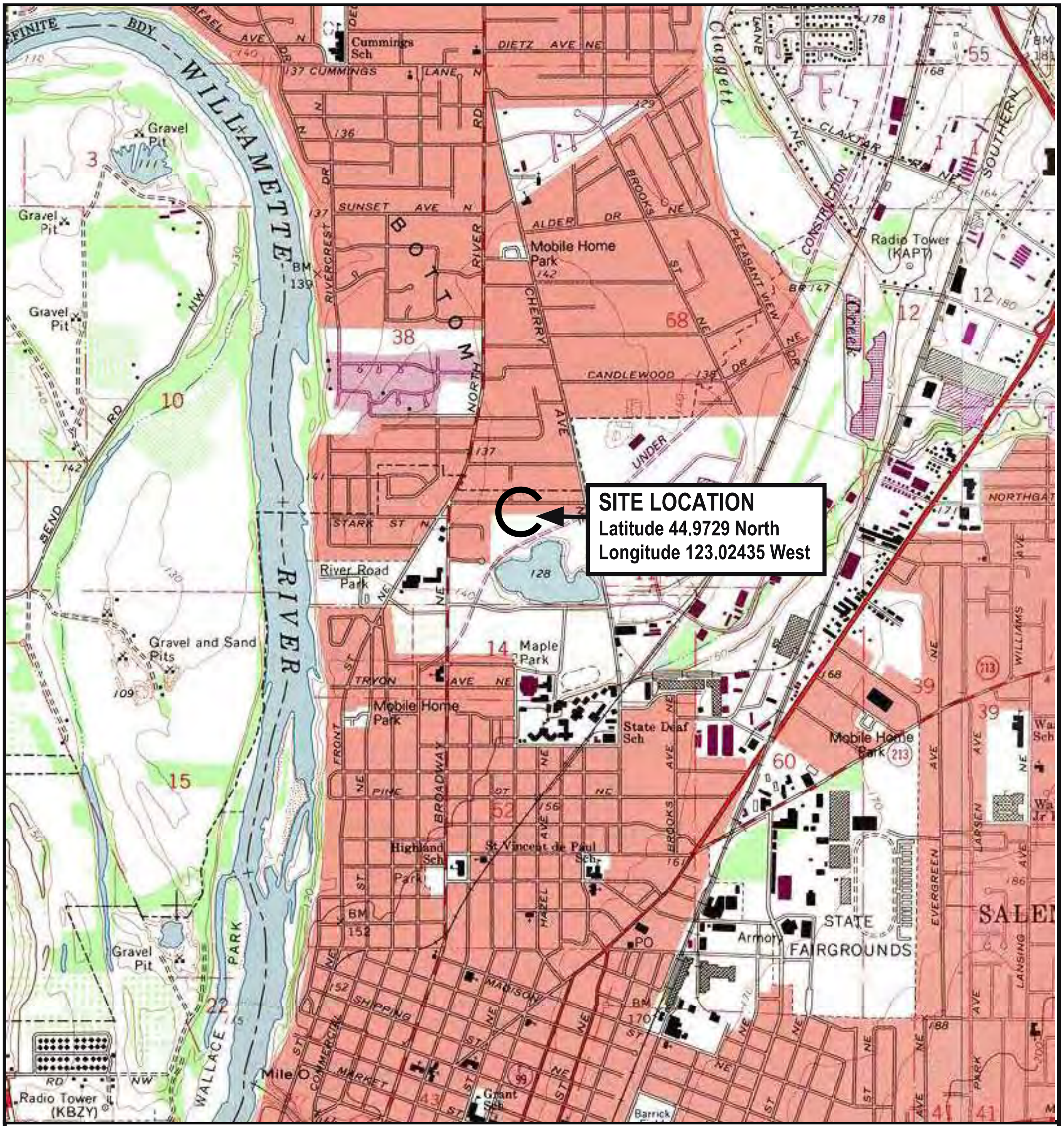
We have made observations based on our explorations that indicate the soil conditions at only those specific locations and only to the depths penetrated. These observations do not necessarily reflect soil types, strata thickness, or water level variations that may exist between or away from our explorations. If subsurface conditions vary from those encountered in our site explorations, CGT should be alerted to the change in conditions so that we may provide additional geotechnical recommendations, if necessary. Observation by experienced geotechnical personnel should be considered an integral part of the construction process.

The owner/developer is responsible for ensuring that the project designers and contractors implement our recommendations. When the design has been finalized, prior to releasing bid packets to contractors, we recommend that the design drawings and specifications be reviewed by our firm to see that our recommendations have been interpreted and implemented as intended. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification. Design review and construction phase testing and observation services are beyond the scope of our current assignment, but will be provided for an additional fee.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor’s methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design.

Geotechnical engineering and the geologic sciences are characterized by a degree of uncertainty. Professional judgments presented in this report are based on our understanding of the proposed construction, familiarity with similar projects in the area, and on general experience. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared; no warranty, expressed or implied, is made. This report is subject to review and should not be relied upon after a period of three years.

PARKWAY VILLAGE APARTMENTS EAST COMPLEX - SALEM, OREGON
SITE LOCATION



Map created with TOPO!™, © 2006 National Geographic Holdings
USGS 7.5 Minute Topographic Map Series, Salem West, Oregon Quadrangle.

Approximate Scale: 1 inch = 2,000 feet

0 2000 4000

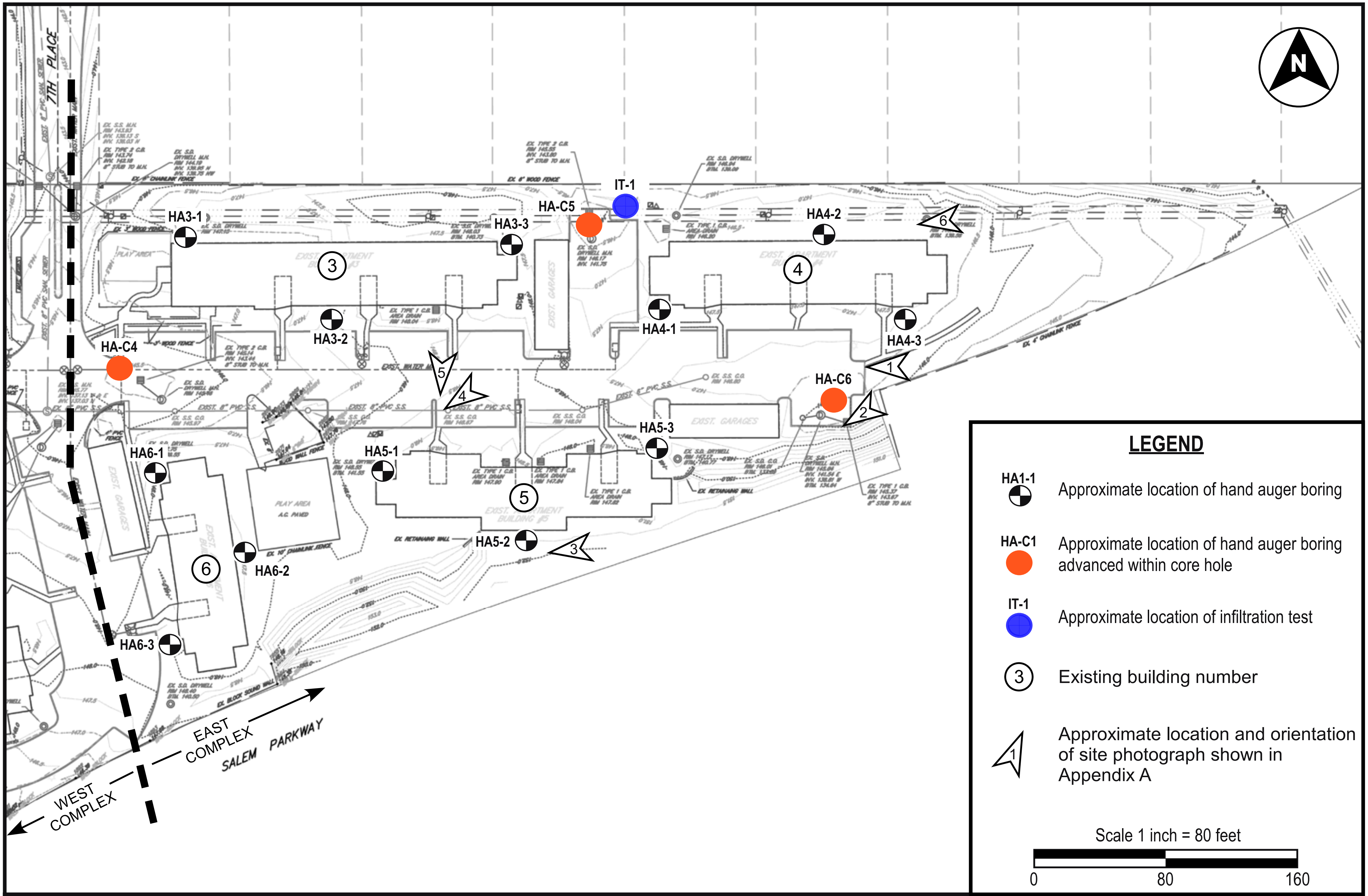
Township 7 South, Range 3 West, Section 11 Willamette Meridian

CARLSON CGT GEOTECHNICAL 503-601-8250

Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303961

FIGURE 1



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PARKWAY VILLAGE APARTMENTS EAST COMPLEX SALEM, OREGON

SITE PLAN

CGT Job No. G1303961

Figure 2

PARKWAY VILLAGE APARTMENTS EAST COMPLEX - SALEM, OREGON

SOIL CLASSIFICATION CRITERIA AND TERMINOLOGY

Classification of Terms and Content

NAME : MINOR Constituents (12-50%); MAJOR Constituents (>50%); Slightly (5-12%)
Relative Density or Consistency
Color
Moisture Content
Plasticity
Trace Constituents (0-5%)
Other: Grain Shape, Approximate gradation, Organics, Cement, Structure, Odor...
Geologic Name or Formation: Fill, Willamette Silt, Till, Alluvium...

USCS Grain Size

Fines		<#200 (.075 mm)
Sand	Fine	#200 - #40 (.425 mm)
	Medium	#40 - #10 (2 mm)
	Coarse	#10 - #4 (4.75)
Gravel	Fine	#4 - 0.75 inch
	Coarse	0.75 inch - 3 inches
Cobbles		3 to 12 inches; scattered <15% est., numerous >15% est.
Boulders		> 12 inches

Relative Density or Consistency

Granular Material		Fine-Grained (cohesive) Materials				
SPT N-Value	**Density**	**SPT N-Value**	**Torvane tsf Shear Strength**	**Pocket Pen tsf Unconfined**	**Consistency**	**Manual Penetration Test**
		<2	**<0.13**	**>0.25**	**Very Soft**	**Thumb penetrates more than 1 inch**
0 - 4	**Very Loose**	**2 - 4**	**0.13 - 0.25**	**0.25 - 0.50**	**Soft**	**Thumb penetrates about 1 inch**
4 - 10	**Loose**	**4 - 8**	**0.25 - 0.50**	**0.50 - 1.00**	**Medium Stiff**	**Thumb penetrates about 1/4 inch**
10 - 30	**Medium Dense**	**8 - 15**	**0.50 - 1.00**	**1.00 - 2.00**	**Stiff**	**Thumb penetrates less than 1/4 inch**
30 - 50	**Dense**	**15 - 30**	**1.00 - 2.00**	**2.00 - 4.00**	**Very Stiff**	**Readily indented by thumbnail**
>50	**Very Dense**	**>30**	**>2.00**	**>4.00**	**Hard**	**Difficult to indent by thumbnail**

Moisture Content

Dry: Absence of moisture, dusty, dry to the touch
Damp: Some moisture but leaves no moisture on hand
Moist: Leaves moisture on hand
Wet: Visible free water, likely from below water table

	Plasticity	Dry Strength	Dilatancy	Toughness
ML	Non to Low	Non to Low	Slow to Rapid	Low, can't roll
CL	Low to Med.	Medium to High	None to Slow	Medium
MH	Med to High	Low to Medium	None to Slow	Low to Medium
CH	Med to High	High to V. High	None	High

Structure

Stratified: Alternating layers of material or color >6 mm thick
Laminated: Alternating layers < 6 mm thick
Fissured: Breaks along definate fracture planes
Slickensided: Striated, polished, or glossy fracture planes
Blocky: Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lenses: Has small pockets of different soils, note thickness
Homogeneous: Same color and appearance throughout

Unified Soil Classification Chart (Visual-Manual Procedure) (Similar to ASTM Designation D-2488)

Major Divisions			Group Symbols	Typical Names
Coarse Grained Soils: More than 50% retained on No. 200 sieve	Gravels: 50% or more *retained* on the No. 4 sieve	Clean Gravels	GW	Well graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands: more than 50% *passing* the No. 4 Sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly-graded sands and gravelly sands, little or no fines
		Sands with Fines	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils: 50% or more Passes No. 200 Sieve	Silt and Clays Low Plasticity Fines		ML	Inorganic silts, rock flour, clayey silts
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
			OL	Organic silt and organic silty clays of low plasticity
	Silt and Clays High Plasticity Fines		MH	Inorganic silts, clayey silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils

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CGT Job No. G1303961

FIGURE 3

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FIGURE 4

Boring HA3-1

PAGE 1 OF 1

CLIENT Salem Housing Authority

PROJECT NAME Parkway Village Apartments - East Complex

PROJECT NUMBER G1303961

PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303

DATE STARTED 12/12/13

ELEVATION DATUM See Figure 2

DRILLING CONTRACTOR CGT

GROUND ELEVATION 146.5 ft

DRILLING METHOD Hand Auger

GROUND WATER LEVELS:

LOGGED BY BN/TT **CHECKED BY** JAJ

AT TIME OF DRILLING ---

NOTES Manual 3-inch diameter hand auger

AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
					0.0						
145		ML	**SANDY SILT:** Medium stiff, dark brown, moist, and exhibited moderate plasticity.								
					2.5						
		SM	**SILTY SAND:** Loose to medium dense, brown, moist, and fine grained.								
					5.0						
140			-Boring terminated at about 5½ feet bgs. -Caving and groundwater not observed within the depth explored. -Boring loosely backfilled with cuttings upon completion.								
135											

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FIGURE 5

Boring HA3-2

CLIENT Salem Housing Authority

PROJECT NAME Parkway Village Apartments - East Complex

PROJECT NUMBER G1303961

PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303

DATE STARTED 12/12/13

ELEVATION DATUM See Figure 2

DRILLING CONTRACTOR CGT

GROUND ELEVATION 148 ft

DRILLING METHOD Hand Auger & WDCP

GROUND WATER LEVELS:

LOGGED BY BN/TT **CHECKED BY** JAJ

AT TIME OF DRILLING ---

NOTES WDCP and manual 3-inch diameter hand auger

AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
145		SM	**SILTY SAND:** Loose, dark brown, moist, and fine grained. Tree root encountered at about 2½ feet bgs. Medium dense below about 6 feet bgs.		0.0 2.5 5.0			3 5 5 5 5 5 3 5 5 5 4 2 3 5 5 7 7 9 11 11 13			
140			-Boring terminated at about 7 feet bgs. -Caving and groundwater not observed within the depth explored. -Boring loosely backfilled with cuttings upon completion.		7.5	GRAB 1		16 11 12			

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FIGURE 6

Boring HA3-3

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/12/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 147.5 ft
DRILLING METHOD Hand Auger
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		ML	**SANDY SILT:** Medium stiff, dark brown, moist, and exhibited low to moderate plasticity.		0.0						
145					2.5						
		SM	**SILTY SAND:** Medium dense, dark brown, moist, silt exhibited low plasticity.								
					5.0						
140					7.5	✋ GRAB 1					

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

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FIGURE 7

Boring HA4-1

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 147 ft
DRILLING METHOD Hand Auger & WDCP
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES WDCP and manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
	▨	SM FILL	**SILTY SAND FILL:** Medium dense, dark brown, moist, low plasticity, with gravel (angular) and trace rootlets.		0.0			2 5			
	░		**SILTY SAND:** Loose to medium dense, brown, and moist.					6 6 8			
145	░		Medium dense below about 2 feet bgs.		2.5			17 12 15 25 24 15			
	░	SM	Trace of roots (about ½-inch in diameter) at about 4 feet bgs.		5.0			16 25 25			
140	░				7.5	GRAB 1					● 14
135											

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

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FIGURE 8

Boring HA4-2

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 147 ft
DRILLING METHOD Hand Auger
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SM FILL	**SILTY SAND FILL:** Dense, dark brown, moist, with gravel (angular).		0.0						
145		SM	**SILTY SAND:** Medium dense, dark brown, moist, silt exhibited low plasticity, and with trace roots.								
					2.5	GRAB 1					MC 29
					5.0						
140					7.5						

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

135

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FIGURE 9

Boring HA4-3

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 147 ft
DRILLING METHOD Hand Auger
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL ● MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
146	▨	SM FILL	**SILTY SAND FILL:** Medium dense, brown, moist, with trace rootlets.		0.0						
144	▨	ML FILL	**GRAVELLY SILT FILL:** Stiff, dark brown, moist, and exhibited moderate to low plasticity.		2.5	GRAB 1					● 20
142			-Boring terminated at about 3 feet bgs due to practical refusal on gravel fill. -Caving and groundwater not observed within the depth explored. -Boring loosely backfilled with cuttings upon completion.								
140											
138											
136											

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FIGURE 10

Boring HA5-1

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 149 ft
DRILLING METHOD Hand Auger
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
					0.0						
		ML	**SILT:** Stiff, dark brown, moist, and exhibited moderate plasticity.								
		ML	**SANDY SILT:** Stiff, orange-brown, moist, and exhibited low plasticity.			GRAB 1					18
					2.5						
145		SM	**SILTY SAND:** Medium dense, orange-brown, moist, and fine grained.			GRAB 2					25
					5.0						
					7.5						

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

140

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FIGURE 11

Boring HA5-2

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 151.5 ft
DRILLING METHOD Hand Auger
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft) 0.0	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
150		ML	**SILT:** Stiff, dark brown, moist, medium plasticity, with trace of organics and roots.		2.5	GRAB 1					● 19
		ML	**SANDY SILT:** Stiff, orange-brown, moist, medium plasticity and with isolated roots (about ½-inch in diameter).								
		SM	**SILTY SAND:** Medium dense, orange-brown, moist, and fine grained.			GRAB 2					● 24 ☐
					5.0	GRAB 3					● 26
145						GRAB 4					● 14
					7.5						

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

140

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FIGURE 12

Boring HA5-3

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 148 ft
DRILLING METHOD Hand Auger & WDCP
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES WDCP and manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		ML FILL	**SANDY SILT FILL:** Medium stiff, dark brown, moist, medium plasticity, with gravel (subangular to angular), and trace rootlets.		0.0			3 8 8 7			
		SM	**SILTY SAND:** Loose, dark brown, moist, silt exhibited low plasticity.		2.5			5 5 3 3			
145						GRAB 1		6 7 8 7 9 8			● 25
			Medium dense below about 5 feet bgs.		5.0			14 13 12 11 12 9 9			
140					7.5	GRAB 2		8 9 10			● 29

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

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FIGURE 13

Boring HA6-1

PAGE 1 OF 1

CLIENT Salem Housing Authority

PROJECT NAME Parkway Village Apartments - East Complex

PROJECT NUMBER G1303961

PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303

DATE STARTED 12/6/13

ELEVATION DATUM See Figure 2

DRILLING CONTRACTOR CGT

GROUND ELEVATION 148 ft

DRILLING METHOD Hand Auger

GROUND WATER LEVELS:

LOGGED BY BN/TT **CHECKED BY** JAJ

AT TIME OF DRILLING ---

NOTES Manual 3-inch diameter hand auger

AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
			SANDY SILT: Medium stiff, dark brown, moist, and exhibited medium plasticity.		0.0						
					2.5	GRAB 1					● 23
145											
		ML									
					5.0						
					7.5						
140											

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

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FIGURE 14

Boring HA6-2

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 147.5 ft
DRILLING METHOD Hand Auger
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft) 0.0	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		ML	**SILT:** Stiff, dark brown, moist, and exhibited moderate plasticity.								
145		ML	**SANDY SILT:** Stiff, orange-brown, moist, and exhibited moderate plasticity.		2.5	GRAB 1					● 24
		SM	**SILTY SAND:** Medium dense, orange-brown, moist, and fine grained.			GRAB 2					☐● 27
		ML	**SANDY SILT:** Medium stiff, orange-brown, very moist, and exhibited moderate plasticity.		5.0						
140		SM	**SILTY SAND:** Medium dense, orange-brown, moist, and fine grained.		7.5						

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

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FIGURE 15

Boring HA6-3

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CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/6/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 148 ft
DRILLING METHOD Hand Auger & WDCP
GROUND WATER LEVELS:
LOGGED BY BN/TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES WDCP and manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL ● MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
145		ML	**SANDY SILT:** Soft to medium stiff, dark brown, moist, exhibited moderate plasticity and with rootletes.		0.0 2.5			2 3 8 11 8 7 7 5 5 10 9 6 4 5 5			
140		SM	**SILTY SAND:** Loose, brown, moist, and fine grained.		5.0 7.5	GRAB 1 GRAB 2		4 4 4 5 5 4 7 6 3			● 27 ● 27

-Boring terminated at about 8 feet bgs.
-Caving and groundwater not observed within the depth explored.
-Boring loosely backfilled with cuttings upon completion.

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FIGURE 16

Boring HA-C4

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/13/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 145.5 ft
DRILLING METHOD Coring Machine, Hand Auger & DCP
GROUND WATER LEVELS:
LOGGED BY TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES WDCP and manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
			ASPHALT PAVEMENT: About 3 inches thick.		0.0						
145		GP FILL	**GRAVEL FILL:** Medium dense to dense, gray, angular, moist, and resembled ¾"-inch minus.					24 25			
		ML	**SANDY SILT:** Stiff to very stiff, brown, moist, exhibited medium plasticity.					25 13			
		SM	**SILTY SAND:** Medium dense, brown, moist, and fine grained.		2.5 5.0			15 10 10 10 11 11 11 12 11 9 11			
140 135			-Boring terminated at about 5 feet bgs. -Caving and groundwater not observed within the depth explored. -Boring loosely backfilled with cuttings upon completion.					11			

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FIGURE 17

Boring HA-C5

PAGE 1 OF 1

CLIENT Salem Housing Authority

PROJECT NAME Parkway Village Apartments - East Complex

PROJECT NUMBER G1303961

PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303

DATE STARTED 12/13/13

ELEVATION DATUM See Figure 2

DRILLING CONTRACTOR CGT

GROUND ELEVATION 146 ft

DRILLING METHOD Coring Machine, Hand Auger & DCP

GROUND WATER LEVELS:

LOGGED BY TT **CHECKED BY** JAJ

AT TIME OF DRILLING ---

NOTES WDCP and manual 3-inch diameter hand auger

AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
	■		**ASPHALT PAVEMENT:** About 4 inches thick.		0.0						
	▨	GP FILL	**GRAVEL FILL:** Medium dense to dense, gray, angular, moist, and resembled ¾"-inch minus.					10 10			
145		ML	**SANDY SILT:** Soft to medium stiff, dark brown, moist, and exhibited moderate plasticity.		2.5			8 7 6 5 3 2 3 3 2			
		SM	**SILTY SAND :** Loose, orange brown, moist, fine grained, silt exhibited low to moderate plasticity.		5.0			3 3 3 3 3			
140			-Boring terminated at about 5 feet bgs. -Caving and groundwater not observed within the depth explored. -Boring loosely backfilled with cuttings upon completion.								
135											

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FIGURE 18

Boring HA-C6

PAGE 1 OF 1

CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/13/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 146 ft
DRILLING METHOD Coring Machine, Hand Auger & DCP
GROUND WATER LEVELS:
LOGGED BY TT **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES WDCP and manual 3-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft) 0.0	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL ● LL MC ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
	■		**ASPHALT PAVEMENT:** About 5½ inches thick.					3			
145	▨	GP FILL	**GRAVEL FILL:** Loose, gray, angular, moist, and resembled ¾"-inch minus.					6 6 7 8 6			
			-Boring terminated at about 2 feet bgs due to practical refusal on gravel fill. -Groundwater not observed within the depth explored. -Boring loosely backfilled with cuttings upon completion.		2.5 5.0			8 8 8 7 3 2 3 2 3 2			
140											
135											

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FIGURE 19

Boring IT-1

PAGE 1 OF 1

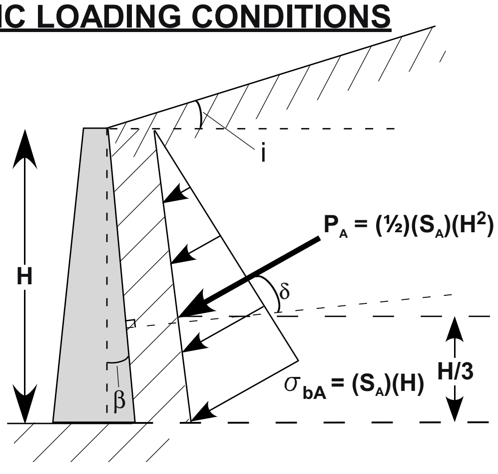
CLIENT Salem Housing Authority
PROJECT NAME Parkway Village Apartments - East Complex
PROJECT NUMBER G1303961
PROJECT LOCATION 3137-3167 7th Place NE, Salem, OR 97303
DATE STARTED 12/12/13
ELEVATION DATUM See Figure 2
DRILLING CONTRACTOR CGT
GROUND ELEVATION 146 ft
DRILLING METHOD Hand Auger
GROUND WATER LEVELS:
LOGGED BY BN/BMW **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Manual 7-inch diameter hand auger
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
145		ML FILL	**SILT FILL:** Medium stiff, dark brown, moist, with gravel (round), exhibited low plasticity.		0.0						
		ML	**SANDY SILT:** Medium stiff, brown, moist, well graded, and exhibited low plasticity.		2.5 5.0						
140		SM	**SILTY SAND:** Medium dense, brown, moist, and fine grained. Sand content increased with depth. Grab Sample 1 obtained prior to initiation of infiltration test.		7.5 10.0	GRAB 1					☐● 17
135			-Boring terminated at about 10½ feet bgs. -IT-2 performed at about 10½ feet bgs. See text for results. -Caving and groundwater not observed within the depth explored. -Boring loosely backfilled with cuttings upon completion.								

PARKWAY VILLAGE APARTMENTS EAST COMPLEX - SALEM, OREGON

ACTIVE LATERAL PRESSURE DISTRIBUTION

STATIC LOADING CONDITIONS



LEGEND:

S_A = STATIC EQUIVALENT FLUID PRESSURE (LB/FT^3)*

P_A = STATIC ACTIVE THRUST FORCE ACTING AT A TRIANGULAR DISTRIBUTION ON WALL (LB/FT)*

δ = ANGLE FROM NORMAL OF BACK OF WALL (DEGREES). BASED ON FRICTION DEVELOPING BETWEEN WALL AND BACKFILL.**

ϕ = INTERNAL ANGLE OF FRICTION FOR BACKFILL (DEGREES).**

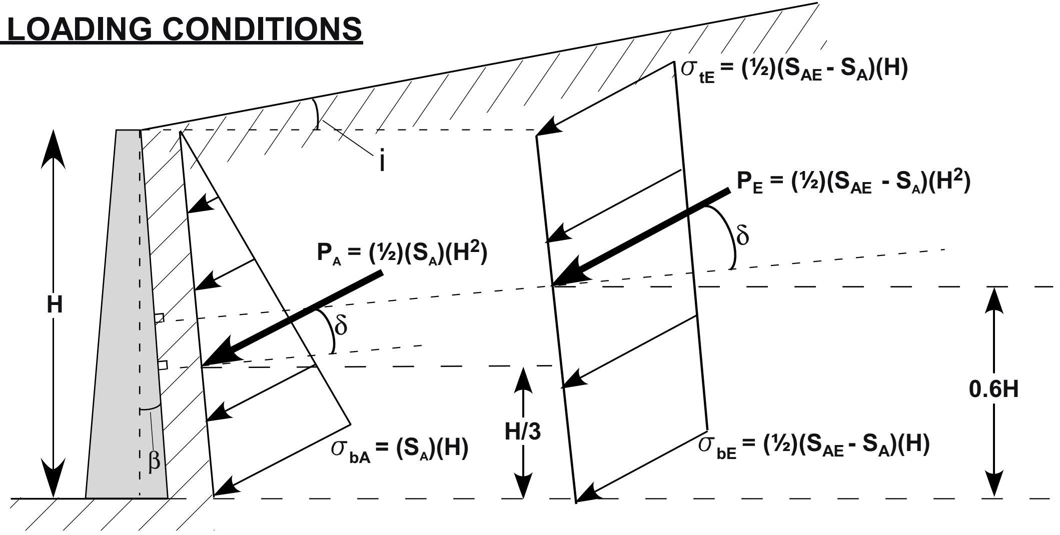
i = SLOPE OF BACKFILL (DEGREES).**

β = SLOPE OF BACK OF THE WALL (DEGREES).**

σ_{bA} = ACTIVE EARTH PRESSURE (STATIC) AT THE BOTTOM OF THE WALL.

*REFER TO REPORT TEXT FOR CALCULATED VALUES.
**REFER TO REPORT TEXT FOR MODELED / ASSUMED VALUES.

SEISMIC LOADING CONDITIONS



LEGEND:

S_A = STATIC EQUIVALENT FLUID PRESSURE (LB/FT^3)*

S_{AE} = TOTAL (STATIC+DYNAMIC) EQUIVALENT FLUID PRESSURE (LB/FT^3)*

P_A = STATIC COMPONENT OF ACTIVE THRUST FORCE ACTING AT A TRIANGULAR DISTRIBUTION ON WALL (LB/FT)

P_E = DYNAMIC COMPONENT OF ACTIVE THRUST FORCE ACTING AT A UNIFORM DISTRIBUTION ON WALL (LB/FT)

δ = ANGLE FROM NORMAL OF BACK OF WALL (DEGREES)**

ϕ = INTERNAL ANGLE OF FRICTION FOR BACKFILL, REFER TO REPORT TEXT FOR VALUE (DEGREES)**

i = SLOPE OF BACKFILL (DEGREES)**

β = SLOPE OF BACK OF WALL (DEGREES)**

σ_{bA} = ACTIVE EARTH PRESSURE (STATIC) AT THE BOTTOM OF THE WALL.

σ_{bE} = ACTIVE EARTH PRESSURE (DYNAMIC) AT THE BOTTOM OF THE WALL.

σ_{tE} = ACTIVE EARTH PRESSURE (DYNAMIC) AT THE TOP OF THE WALL.

*REFER TO REPORT TEXT FOR CALCULATED VALUES.
**REFER TO REPORT TEXT FOR MODELED / ASSUMED VALUES.

Note:
1. Uniform pressure distribution of seismic loading is based on emperical evaluations [Sherif et al, 1982 and Whitman, 1990].
2. Placement of seismic resultant force at 0.6H is based on wall behavior and model test results [Whitman, 1990].

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FIGURE 20

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Salem Office	**(503) 589-1252**
Tigard Office	**(503) 684-3460**

Appendix A: Site Photographs

Parkway Village Apartments – East Complex
3137-3167 7th Place NE
Salem, Oregon

CGT Project No. G1303961

January 2, 2014

Prepared For:

Salem Housing Authority
Att: Mr. Andrew Wilch
360 Church Street SE
Salem, Oregon 97308-0808

Prepared By:

Carlson Geotechnical

PARKWAY VILLAGE APARTMENTS EAST COMPLEX
SALEM, OREGON
SITE PHOTOGRAPHS

Photograph 1

Photograph 2

Photograph 3

Photograph 4

Photograph 5

Photograph 6

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Appendix B: Results of Site Reconnaissance

Parkway Village Apartments – East Complex
3137-3167 7th Place NE
Salem, Oregon

CGT Project No. G1303961

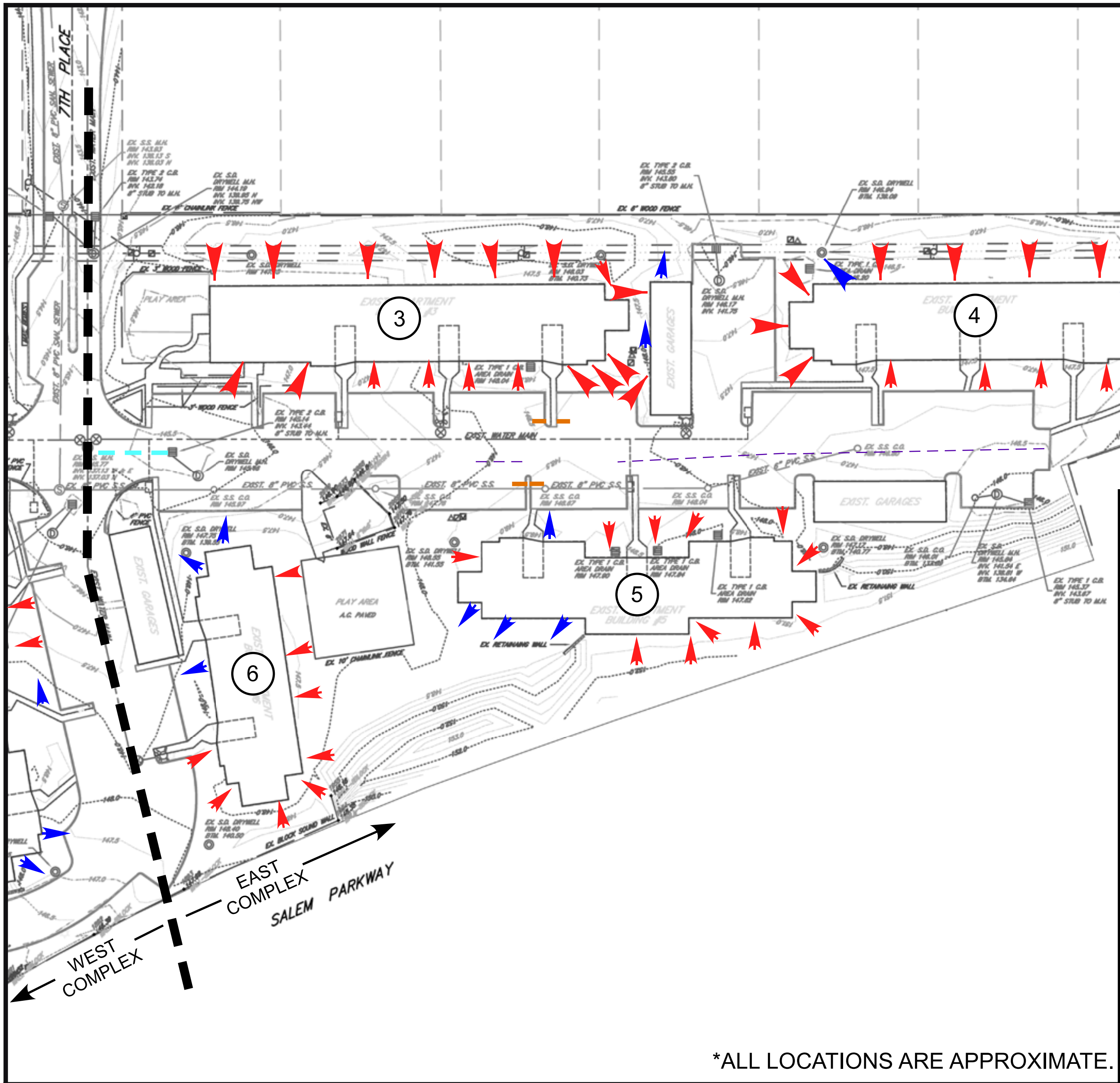
January 2, 2014

Prepared For:

Salem Housing Authority
Att: Mr. Andrew Wilch
360 Church Street SE
Salem, Oregon 97308-0808

Prepared By:

Carlson Geotechnical



*ALL LOCATIONS ARE APPROXIMATE.

LEGEND

➤	Observed positively sloped ground surface (graded to drain <u>away</u> from the building)
➤	Observed negatively sloped ground surface (graded to drain <u>towards</u> from the building)
- - -	Observed crack in pavement, less than 1/4-inch thick. Appeared to be at seam of pavement panel. See Photograph 1 in Appendix B.
- -	Observed crack and raveling in pavement, up to about 6 inches wide. Appeared to be at seam of pavement panel.
—	Observed crack and upheaval in pavement. Located near existing tree. See Photographs 4 and 5 in Appendix B.
③	Designated building number

Scale 1 inch = 80 feet

0 80 160

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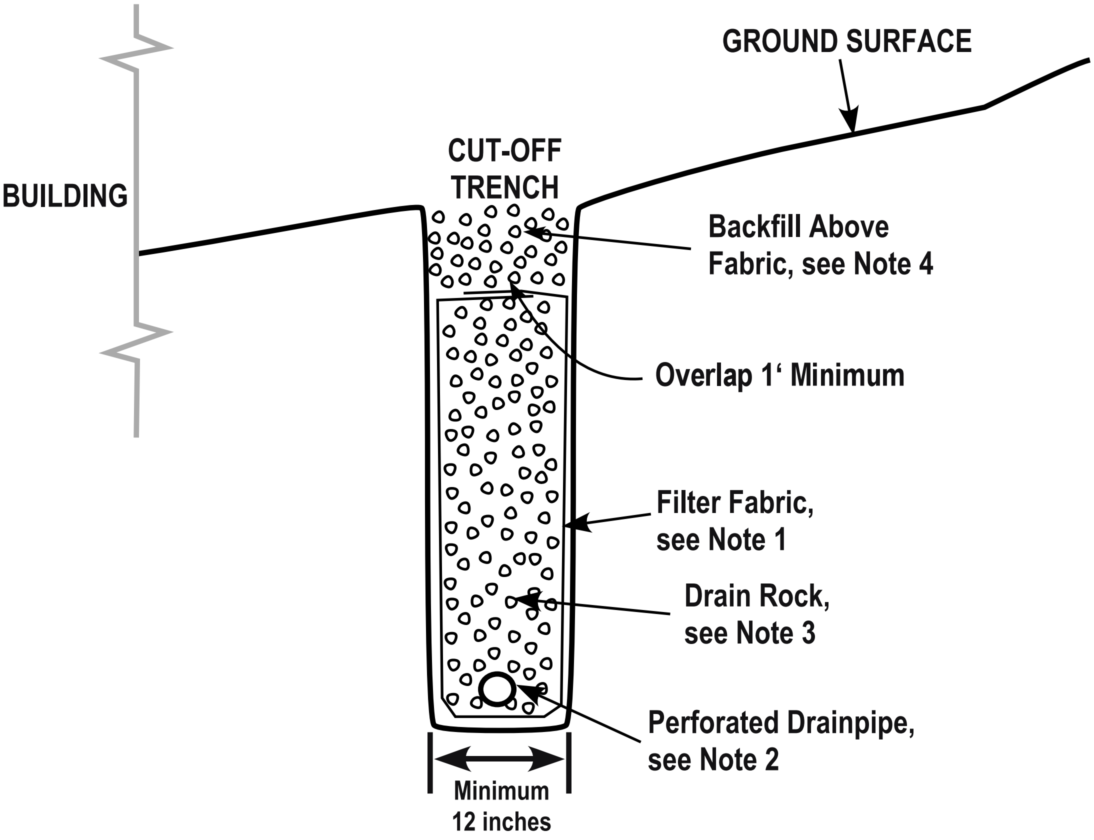
PARKWAY VILLAGE APARTMENTS EAST COMPLEX
SALEM, OREGON

SITE DRAINAGE & PAVEMENT CONDITIONS

CGT Job No. G1303961

Figure B1

PARKWAY VILLAGE APARTMENTS EAST COMPLEX - SALEM, OREGON
CONCEPTUAL CUT-OFF TRENCH DETAIL



NOTES:
1. Wrap drain rock completely in non-woven filter fabric, overlap fabric a minimum of 12 inches at joining point.
2. Minimum 4-Inch diameter, perforated PVC drainpipe, graded to maintain positive drainage (minimum of 1 percent) and tight-lined to approved discharge point
3. Drain rock to consist of open-graded drain rock with a maximum particle size of 1½ inches.
4. Cover drain rock and fabric with a minimum of 6 inches of drain rock.

- NO SCALE -

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FIGURE B2