FINAL

Geotechnical Engineering Evaluation

Tillamook Bay Housing/Aufdermaur Property
920 3rd Street, Tillamook, Oregon 97141

EPA Cooperative Agreement Number: 02J20601

ACRES Number: 257722

Prepared for

Tillamook County
201 Laurel Avenue
Tillamook, Oregon 97141

and

CW Real Estate Partners

Prepared by

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Under Contract with CHA Consulting

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Acronyms and Abbreviations

ASCE	American Society of Civil Engineers
ASTM	ASTM International
bgs	below ground surface
Client	CHA Consulting, Inc.
CSZ	Cascadia Subduction Zone
F_{pga}	site-specific amplification factor
HazVu	Oregon HazVu: Statewide Geohazards Viewer
IBC 2021	*2021 International Building Code*
Ka	active lateral earth pressure
Ko	at-rest lateral earth pressure
MCE_R	risk-targeted maximum considered earthquake
pcf	pounds per cubic foot
PGA	peak ground acceleration
PGA_M	modified peak ground acceleration
psf	pounds per square foot
RAP	Rammed Aggregate Piers®
S_1	spectral response acceleration for a 1-second period
Site	920 3rd Street, Tillamook, Oregon
S_s	spectral response acceleration for short (0.2 seconds) period
Terraphase	Terraphase Engineering Inc.
TLUO	Tillamook County Land Use Ordinance
USDA	United States Department of Agriculture

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Signatures

All engineering information, conclusions, and recommendations in this document have been prepared under the responsible charge of an Oregon State licensed Professional Engineer.

105885PE
OREGON
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1 Introduction

This report presents the result of the geotechnical engineering evaluation conducted by Terraphase Engineering Inc. (Terraphase), on behalf of CHA Solutions (Client), in support of the planned multi-family residential development to be constructed at 920 3rd Street in an unincorporated area of Tillamook County, Oregon, just west of the city of Tillamook (Site; Figure 1). This project was funded by a community-wide Brownfield Assessment Grant.

1.1 Project Description

It is our understanding that CW Real Estate Partners intend to redevelop the Site with a new multi-family residential complex. Based on provided conceptual site plan drawings prepared by West of West, dated July 17, 2024, the planned redevelopment will include two 3-story, 18-unit, multi-family residential buildings, a leasing office building, a mail/support structure, new paved access drives, paved parking areas, a playground and outdoor gym, a community garden, a recreation field, and new support infrastructure. The design concept package prepared by West of West is attached to this report as Appendix A. The planned development will be on the eastern half of the Site; the western half will remain undeveloped. The Site currently supports an existing single-family residence with associated infrastructure, a gravel-surfaced parking area, and landscaping. The existing structure will be demolished as part of the planned development.

At the time of this report, Terraphase has not received any structural plans for the proposed complex, but we anticipate the planned buildings will be composed of wood framing and slab-on-grade floors. Based on the anticipated construction, we expect building loads to be light to moderate in scope. The Site is in an area designated as having a “high” susceptibility to liquefaction according to the online geohazard mapping application Oregon HazVu: Statewide Geohazards Viewer (HazVu).[1] Based on this rating, ground improvement methods will likely need to be employed to mitigate the liquefaction hazard. Alternatively, a deep foundation system, composed of driven H-piles or drilled shafts, could be utilized to mitigate this hazard, although they are not expected to be utilized for this project.

Terraphase recently completed three evaluations of the Site in support of the planned project, which are documented in the following reports: *Phase I Environmental Site Assessment, 910 West 3rd Street Property*, dated November 3, 2023; *Phase II Environmental Assessment Report, 910 West 3rd Street Property*, dated July 22, 2024; and *Hazardous Building Materials Survey Report, 3rd Street Property*, dated June 25, 2024. Please reference these reports regarding any environmental characterization of near surface soils and existing structure at the Site.

1.2 Scope

Our scope of services included:

- Reviewing available geologic maps and provided documents.

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[1] https://gis.dogami.oregon.gov/maps/hazvu/

- Performing an initial site visit to mark the Site with white paint for the public utility locating services and establish exploration locations with the Client.
- Completing a health and safety plan for field activities.
- Exploration of near surface soil and groundwater conditions by conducting 11 exploratory boreholes advanced by a subcontracted drill rig. Drilling services were provided by Holt Services, Inc.
- Performing grain size analysis and Atterberg limits tests on representative soil samples collected from our boring explorations. The laboratory testing was performed in our in-house laboratory.
- Preparing this geotechnical engineering report containing the results of our subsurface explorations and our conclusions and recommendations for geotechnical design elements of the project.

2 Site Conditions

This section provides a general site description along with geological and seismic settings of the Site and vicinity.

2.1 Site Description

The approximately 3.19-acre, irregularly shaped Site is identified as Tillamook County Assessor’s Taxlot Number 1S10250000403. The Site has maximum dimensions of approximately 315 feet in the north–south direction and 580 feet in the east–west direction.

Access to the Site is provided along the south side of the Site extending north from 3rd Street (Netarts Highway). The Site is bordered to the west by a health facility, to the south by 3rd Street followed by single- and multi-family housing, to the east by an agricultural structure, and to the north by undeveloped land, currently being utilized for agricultural purposes.

The Site is currently developed with a single-family residence on the southeast corner of the property. The area immediately surrounding the residence is a gravel-covered parking area, manicured lawn, and typical residential landscaping. The remaining area of the Site is surfaced primarily with field grass except for a gravel-covered parking/laydown area on the western margin of the Site. The Site is relatively level, with less than 5 feet of elevation variation across the property, except for the northern boundary of the Site which slopes down several feet to an existing drainage feature. A layout of the Site, including our exploration locations, is shown on Figure 2.

2.2 Geologic Setting

The Tillamook region is east of the Oregon Coastal Mountain Range and west of the Pacific Ocean. The low-lying area of the region is southeast of Tillamook Bay. The Tillamook, Trask, and Wilson Rivers form a broad alluvial plain that encompasses the majority of the low-lying area southeast of the bay. The geology of the plain is primarily composed of Holocene and Pleistocene alluvial clays, silts, sands, and gravels deposited by rivers and streams extending down to depths of 120 feet or more. Part of a typical geologic sequence within the area of the Site includes the following deposits from newest to oldest:

- **Artificial fill** is often locally placed by human activities, and the consistency will depend on the source of the fill. The thickness and expanse of this material is dependent on the extent of fill required to grade land to the exiting elevations. Density of the fill depends on earthwork activities and compaction efforts made during the placement of the material.
- **Fluvial and estuarine deposits** are comprised of unconsolidated alluvial clays, silts, sands, and gravels deposited along rivers and streams and may locally include poorly sorted, alluvial fan deposits along valley margins. This unit includes stabilized tidal flat muds, sands, and peat within Nehalem and Tillamook Bays.
- **Older fluvial and estuarine deposits** include alluvial clays, silts, sands, and gravels which form terraces above current flood plains. This unit may include bay mud and sand along the Tillamook and Nehalem Bays.
- **Cannon Beach Member of Niem and Niem** is a well-bedded, laminated to micaceous siltstone and mudstone with rhythmically bedded, graded feldspathic sandstone interbedded in the lower part. This unit commonly has low-angle cross lamination in coalescing channel deposits and can be up to 600 meters thick in the Tillamook quadrangle.

The geologic units for this area are mapped on the *Geologic Map of the Tillamook Highlands, Northwest Oregon Coast Range* (Wells et al. 1994). The Site is mapped as underlain by fluvial and estuarine deposits. Our site explorations encountered topsoil and fill soils underlain by a very soft, elastic silt followed by loose to dense poorly graded silty sands and gravels interpreted as fluvial deposits consistent with the mapped geology.

2.3 Seismic Setting

The Pacific Northwest is very seismically active. Off the coast, the Juan de Fuca Oceanic Plate collides into and descends (subducts) under the North American Continental Plate. The contact between these plates forms an approximately 600-mile-long fault known as the Cascadia Subduction Zone (CSZ). The resulting stresses generate three unique types of earthquakes that contribute to seismic risk in the region (Cascadia Region Earthquake Workgroup 2013):

- **Subduction (or megathrust) earthquakes.** Megathrust earthquakes are formed by a rupture of the contact between the plates along the CSZ. These events can generate a magnitude 9 or larger earthquake. The nearest mapped CSZ fault strand is approximately 30 miles west of the Site and poses great risk due to the extreme intensity and duration. Along the CSZ, megathrust earthquakes are understood to have a recurrence interval of roughly every 500 years. The last such event along the CSZ happened in 1700 AD, lowering the coastline several feet and generating a large tsunami across the Pacific Ocean.
- **Shallow (or crustal) earthquakes.** Stress from the subduction zone fractures and deforms the continental crust across the Pacific Northwest. When these near-surface crustal faults break, they generate earthquakes that affect smaller areas but can locally be more intense than the subduction

events off the coast. These faults pass under populous areas. Because of their proximity and local intensity, these fault zones are often the greatest contributing factor to seismic risk.

- **Deep (or intraslab) earthquakes.** These earthquakes are associated with fractures within the subducting Juan de Fuca plate. Because they occur more than 18 to 30 miles beneath the surface, the energy of these earthquakes is dissipated over large areas of ground surface, increasing the zone of influence but limiting the severity. However, these earthquakes are still capable of causing significant damage to structures and are the most frequent seismic events in the Puget Sound region but are rare in Oregon, based on historic record. A magnitude 6.5 or larger earthquake affecting the region can be expected, on average, every 30 years. The 2001 Nisqually earthquake was an intraslab earthquake with more than $4 billion in damages, 400 injuries, and 1 death. (Cascadia Region Earthquake Workgroup 2008).

According to the United States Geological Survey Quaternary Faults and Folds Database of the United States,[2] the Site is approximately 2.64 miles southwest of the Tillamook Bay Fault Zone. The fault zone is a series of major northwest-striking, left lateral, reverse faults. The fault zone parallels the mountain front along the northeastern margin of Tillamook Bay. This is a class A fault, meaning there is sufficient evidence of fault displacement during the Quaternary Period for the fault to be considered active.

2.4 Geologic Hazard Areas Designation

Terraphase reviewed TCLUO § 4.130 regarding the Site and planned redevelopment.[3] TCLUO § 4.130(2) lists nine separate criteria defining areas considered to be potentially geologically hazardous. The Site contains areas mapped as having a moderate to high susceptibility to shallow landslides per Oregon Department of Geology and Mineral Industries’ 2020*Open File Report O-20-13*, *Landslide Hazard and Risk Study of Tillamook County, Oregon,* and therefore is considered a geologic hazard area. Mapping of landslide susceptibility was referenced from the online interactive landslide mapping application *SLIDO: Statewide Landslide Information Layer for Oregon.*[4] Additionally, although not specified within the TCLUO, the Site is mapped as a tsunami and earthquake hazard area according to HazVu. Further details regarding areas considered as potential geologic hazards are described in subsequent sections of this report.

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[2] https://www.sciencebase.gov/catalog/quaternary-fault-and-fold-database-us

[3] Tillamook County, Oregon – Land Ordinance, Article IV – Development Standards, Section 4.130: Development Requirements for Geologic Hazard Areas (TCLUO § 4.130, May 27, 2015), https://www.tillamookcounty.gov/sites/community_development/27173/article_4_development_standards_2022.pdf.

[4] https://gis.dogami.oregon.gov/maps/slido/

3 Geotechnical Investigation

Terraphase explored subsurface conditions at the Site from November 12 to 14, 2024, by advancing 11 exploratory borings with a subcontracted drill rig. The borings were typically advanced to approximately 21.5 to 26.5 feet below ground surface (bgs), with two borings, B-8 and B-9, advanced to 61.5 and 46.5 feet bgs, respectively. The borings were located and advanced under the direction and observation of a Terraphase registered geologist, under the supervision of a licensed professional engineer. Our on-site representative examined the soils and geologic conditions encountered, maintained logs of the borings, and obtained representative soil samples. Boreholes 1 through 9 were located within the eastern half (area to be developed) of the Site. The remaining boreholes (10 and 11) were advanced within the central portion of the western half of the Site to provide limited data for the near surface soil and groundwater conditions. The approximate locations of the explorations are shown on Figure 2.

The borings were sampled at 2.5-foot intervals to 10 feet bgs and then at 5-foot intervals thereafter, except for borings B-8 and B-9 where sampling was performed at 2.5-foot intervals for the upper 20 feet before transitioning to 5-foot intervals. Samples were obtained using the standard penetration test method in ASTM International (ASTM) D1586,[5] which consists of driving a 2-inch-outside-diameter split-spoon sampler with a 140-pound hammer dropping 30 inches. The number of blows counted for penetration of three 6-inch intervals was recorded. To determine the standard penetration number at that depth, the number of blows required for the lower two intervals are summed. These numbers are then converted to a free-fall hammer energy transfer standard of 60 percent.

3.1 Sample Collection and Laboratory Testing

Samples collected during explorations were transported to our lab where the soil descriptions were reviewed in accordance with ASTM D2488 and amended as needed.[6] The soil classifications are presented on the boring logs in Appendix B.

Terraphase completed grain size analyses on seven representative soil samples obtained from our explorations in accordance with ASTM D6913.[7] In addition, Atterberg limits testing, in accordance with ASTM D4318,[8] was performed on two samples of the upper silty soils from our explorations. The results of these analyses are presented in Appendix A and have been used to classify the soil in general accordance with the Unified Soil Classification System (Figure 3).

3.2 Subsurface Conditions

The subsurface conditions at the Site are briefly described below based on conditions encountered during our field explorations, laboratory testing, and review of geologic maps available for the Site. For a

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[5] https://www.astm.org/d1586_d1586m-18e01.html

[6] https://www.astm.org/d2488-17e01.html

[7] https://www.astm.org/d6913-04r09e01.html

[8] https://www.astm.org/d4318-17e01.html

more detailed description of the encountered soil and groundwater conditions please reference the exploration logs provided in Appendix B.

3.2.1 Stratigraphy/Soil Conditions

Based on our exploratory borings, we interpret the Site's subsurface stratigraphy to be grouped into three soil units: variable fill soils ranging from medium stiff to stiff, sandy silts to very loose to dense sands and gravels; very soft to soft silts representative of estuarine deposits; and variable, interbedded silts, sands, and gravels interpreted as alluvial deposits (described below). The soils encountered within our geotechnical engineering explorations were found to be generally consistent with the subsurface conditions encountered during our explorations performed to support our previously prepared *Phase II Environmental Assessment* report (Terraphase 2024b).

- **Fill** soils were encountered extending from the surface at all borings advanced during our exploration. The depth of the fill soils ranged from 2.5 to 18.5 feet, with the shallowest fill located near the southeast corner of the Site with depths increasing to the north and west. The encountered fill soils were found to be variable across the Site with four separate fill units. Each unit is briefly described below.
  - The first fill unit is described as a medium dense to dense, dark brown, silty sand with trace angular gravel and some cobbles. This fill was found to extend from the surface at borings B1 through B6 and B8 but was not encountered within the remaining borings. This fill extended from 2 to 4 feet bgs and is underlain by other fill soils described below.
  - The second fill unit consisted of a stiff, dark gray to brown, sandy silt with trace subangular to subrounded gravel. This unit was found to underly the first fill unit (described above) at borings B1 and B2 but was not encountered at any of the remaining borings. This fill unit extended to approximately 4.5 and 3.0 feet bgs at B1 and B2, respectively. This fill was underlain by alluvial deposits (detailed below) at B1 and the third fill unit at B2.
  - The third fill unit is comprised of a loose to dense, black, poorly graded sand with angular gravel. This unit was encountered underlying fill unit 1 at borings B6 and B8, under fill unit 2 at B2, and extending from the surface at B7 and B9 through B11. This fill was not encountered at B1 or B3 through B5. The thickness of this unit at B2, B6, and B8 ranged from 1 to 9.5 feet and extended to 2 to 5 feet bgs at B7 and B9 through B11. The sandy fill soils overlie the fourth fill unit at B2 and B8 through B11, and the native alluvial soils at B6 and B7.
  - The final fill unit consisted of a very loose to medium dense dark gray to black, silty sand with angular gravel and abundant wood debris. The final fill unit was encountered under the first fill unit at borings B3 through B5 and third fill unit at B2 and B8 through B11. This fill unit was not observed in B1, B6, and B7. The thickness of the final fill unit ranged from 2.5 to 4.5 feet at B5, B8, and B9 and 10.5 to 14 feet in B2 through B4, B10, and B11. This fill unit was underlain by tidal flat deposits in B2 through B4 and B8 through B11, and alluvial soils at B5.
- **Tidal flat (estuarine) deposits** consisting of very soft to soft elastic silt with fine sand, abundant organics, and root fibers were encountered under the fill soils at borings B2 through B4 and B8 through B11. Tidal flat deposits were not encountered in the remaining boreholes (B1, B5, and B6).

Lenses of low plasticity silts were encountered in select borings. The tidal flat deposits extended to the terminal depth of 21.5 to 26.5 feet bgs in B2 through B4, B10, and B11.

- **Alluvial deposits** were encountered below the fill soils and tidal flat deposits at borings B1 and B5 through B9. The alluvial deposits consisted of loose to dense sands and gravels, and these conditions remained consistent to the terminal depth of 21.5 feet bgs at B1 and B5 to B-7. In B8 and B9, the sands and gravels extended to approximately 47 and 44 feet bgs, respectively. In B8, the alluvial sands and gravel graded to weathered mudstone and sandstone. B8 terminated within the weathered sandstone at 61.5 feet bgs. At B9, the alluvial sands and gravels graded to a soft to medium stiff lean clay followed by a clayey sand that continued to the terminal depth of 46.5 feet bgs.

3.2.2 Hydrogeologic Conditions

Groundwater seepage was encountered in all borehole explorations at depths ranging from 5 to 10 feet bgs. The groundwater elevations encountered during this scope of work were found to be generally consistent with the conditions observed in our explorations conducted in May 2024 in support of our *Phase II Environmental Assessment*. The groundwater encountered is interpreted to be representative of a local shallow groundwater table.

This report references groundwater conditions encountered at a specific time and location. Note that groundwater levels can be variable and that groundwater conditions referenced above may not be representative of other times and/or locations. Groundwater can be influenced by the nearby Tillamook Bay; Tillamook, Trask, and Wilson Rivers; precipitation; changes in on- and off-site use; and variability in subsurface conditions.

4 Conclusions and Recommendations

The Site is underlain by variable fill soils which extend to depths ranging from 2 to 18 feet bgs and are underlain by soft to very soft silts followed by saturated silty sands extending to approximately 45 feet bgs. The existing fill soils are not considered suitable for building support and the underlying soils are susceptible to liquefaction during a design level seismic event. Therefore, ground improvement methods such as Rammed Aggregate Piers® (RAP) or similar method should be implemented to improve the existing Site soils to provide suitable support and mitigate against liquefaction induced settlements. Shallow conventional foundations can be used for building support over existing Site soils improved though the installation of RAP or similar improvement methods. Alternatively, a deep foundation system composed of driven H-piles or drilled shafts could be used to mitigate settlements due to liquefaction, and provide building support, but are not expected to be used for the project.

The project includes planned paved access drive and parking areas north of the planned buildings. We do not anticipate that RAP will be installed in this area and that full removal of the existing fill soils will not be favorable from a financial and/or environmental aspect. To provide suitable support to the new pavement sections, we recommend they be placed on a compacted fill prism (minimum thickness of 18 inches) overlying remedially compacted existing fill soils. We also recommend that all organic material and surficial topsoil be removed prior to placing the fill prism and that a woven geotextile, such as Mirafi Tencate RS280i (or performance equivalent), be placed at the interface of structural fill and the remedially compacted existing fill soils.

4.1 Seismic Engineering

Seismic design in the *2021 International Building Code* (IBC 2021 [International Code Council, Inc. 2021]) is based on the mapped values for the risk-targeted maximum considered earthquake (MCE_R). Ground motion values in these maps include a probability of exceedance equal to 2 percent in 50 years, which corresponds to a 2,475-year return period. These mapped values have been prepared by the United States Geological Survey in collaboration with the FEMA-funded Building Seismic Safety Council and the American Society of Civil Engineers (ASCE).

The mapped MCE_R spectral response accelerations are referred to as S_s for short periods (0.2 seconds) and S1 for a 1-second period. IBC 2021 directs that correction factors be applied to these response spectra based on an evaluation of site-specific subsurface conditions, referred to as the soil site class (defined in ASCE Standard 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, Section 20.3). The seismic design category shall be determined by the design in accordance with ASCE Standard 7-16 and IBC 2021.

Seismic design for geologic hazards including slope stability, liquefaction, seismic settlement, lateral spreading, and other seismic risks follow ASCE Standard 7-16. The seismic design procedures in this standard are based on MCE_R peak ground acceleration (PGA) multiplied by a correction factor for site-specific amplification (F_{PGA}). This results in a site-modified PGA (PGA_M). Seismic design parameters for this Site were obtained from the ASCE 7 Hazard Tool.[9] Input values based on our understanding of the proposed project and our interpretations of subsurface conditions (described in Section 3.2) are shown in Table 1. The seismic design parameters are shown in Table 2. The output summary report from the ASCE 7 Hazard Tool is included in this report as Appendix C.

Table 1 ASCE 7 Hazard Tool Inputs

Site Inputs	Value
Latitude	45.45636
Longitude	-123.857057
Class	E*

**If the fundamental period of vibration of the structures (as determined by the Structural Engineer) is greater than 0.5 seconds, then a Site Class F will need to be used for design per ASCE 7-16, Section 20.3.1.*

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[9] https://ascehazardtool.org/

Table 2 Seismic Design Parameters

IBC 2021 Design Parameter	Recommended Value
Seismic Design Category	D
PGA_M (2% in 50 years – 2,475-year event)	0.668
Design K_h (1/2 * PGA_M)	0.334

4.1.1 Seismic Hazards

Aside from the direct impact of ground shaking on structures, additional seismic hazards to be considered in a seismic event include ground surface displacement from fault rupture, liquefaction and amplification of ground motion, and landslides, as described below:

- **Surface displacement.** Due to the distance from the Site to the nearest known strand (discussed in Section 2.3), and the lack of evidence of past fault displacement on Site, we expect the Site to have a low risk for surface displacement.
- **Liquefaction.** The liquefaction potential is highest for loose sand with a high groundwater table. The Site is mapped as having a high susceptibility to liquefaction according to HazVu. The Site is underlain by variable fill soils, very soft to soft elastic silts, and loose to medium dense alluvial sands and gravels, with groundwater present at 5 to 10 feet bgs based on our field explorations. The observed conditions support the mapped susceptibility rating. Due to the mapped rating and support subsurface conditions, Terraphase conducted a liquefaction analysis using the collected subsurface data. The results of our analysis are summarized in Section 4.1.2.
- **Landslides.** The Site is generally level, specifically the area of the planned buildings, except for the northern boundary of the Site which gradually slopes down approximately 10 to 12 feet to the lot located to the north. The planned structures will be offset a minimum 15 horizontal feet from the slope along the northern property boundary. Considering the planned offset and low gradient of the slope, it is our opinion that that seismically induced landslide presents a very low risk to the planned development.
- **Tsunami.** The Site is located within a modeled Cascadia Event Tsunami inundation zone per HazVu. According to HazVu, inundation at the Site could be up to 6 to 8 feet with an arrival time of approximately 44 minutes from the event. Based on this classification, we consider the Site to be at risk following a design level Cascadia event. We recommend that the criteria listed in TCLUO § 3.580 and other appropriate design criteria be incorporated into the project design.[10]

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[10] Tillamook County, Oregon – Land Ordinance, Article III – Zone Regulations, Overlay Zones, *TCLUO Section 3.580 Tsunami Hazard Overlay Zone (TH)*, https://www.tillamookcounty.gov/sites/community_development/27173/section_3.580_th_tsunami_hazard_overlay.pdf.

4.1.2 Liquefaction Analysis

Terraphase used pertinent geotechnical characteristics of the soils encountered in boring B8 to evaluate the liquefaction potential. The subsurface conditions within this boring consisted of approximately 14.5 feet of variable fill soils overlying a 4-foot lens of elastic silt followed by alluvial soils with groundwater at approximately 10 feet bgs. At other locations, the groundwater was observed as shallow as 5 feet bgs. Therefore, a shallower groundwater condition was also considered for our analysis. The computer program LiquefyPro Version 5.9c was used to evaluate potential liquefaction and the amount of potential settlement during an earthquake. The liquefaction resistance of the soil (expressed as cyclic resistance ratio) is compared to the earthquake-induced loading (expressed as cyclic stress ratio); we used a magnitude of Mw = 7.2.

The following input parameters were used to evaluate:

- PGA = 0.607 (estimate from the IBC 2021 and ASCE 7-16)
- Site coefficient F_{PGA} = 1.1 for Site Class D soils and PGA greater than or equal to 0.6
- PGA adjusted for Site class effects; $PGA_M = PGA^* F_{PGA}$ = 0.668 (per Equation 11.8-1, ASCE 7-16)
- Groundwater elevation of 5–10 feet bgs
- Ishihara/Yoshimine – Settlement Analyses
- Stark/Olsen et al.– Fine Correction
- Factor of safety = 1.0
- Hammer energy ratio of C_o = 1.25
- Borehole diameter of C_b = 1.15
- Sample method (liner) C_s = 1.0

The detailed graph of the analysis is shown in Appendix D as Plate A-1. The results of the analysis indicate up to approximately 8.5 to 10 inches of settlement due to liquefaction during an MCE shaking event; we expect that differential[11] settlements will be approximately half of the total settlement. This liquefaction appears to occur to a depth of approximately 47 feet bgs.

The amount of predicted settlement due to liquefaction during a design level seismic event exceeds typical allowances for structural design. Consequently, ground improvement methods, such as RAP, will need to be performed at the Site to provide adequate support to shallow conventional foundation systems for the planned residential and office structures. In lieu of ground improvement methods, a deep foundation system could be utilized to mitigate the liquefaction hazard and provide support for the planned structures. However, we do not anticipate this type of support system to be used for the project. We have provided recommendations to be used in the design of the ground improvement system below.

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[11] Differential settlement between footings or across approximately 30 feet.

4.2 Slope Stability

The stability of slopes on or near the project area was assessed to evaluate for potential hazards. For landslide hazards, this included a Site evaluation, review of jurisdictional codes and available topographic contour maps, and the potential impacts of the project on slope stability. Erosion hazard, the risk of the surficial transport of soil from a site, is a function of soil type and slope angle. Erosion hazard was reviewed through applicable United States Department of Agriculture (USDA) soil survey publications and its Natural Resources Conservation Service Web Soil Survey information system.[12]

4.2.1 Erosion Hazard

The erosion hazard criteria used for determination of affected areas includes soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to vegetative cover and the specific surface soil types (group classification), which are related to the underlying geologic soil units. We reviewed the Web Soil Survey by the USDA Natural Resources Conservation Service to determine the erosion hazard of the on-site soils. The Site surface soils were classified using the USDA Soil Conservation Service Soil Classification System as Urban land-Quillamook complex, 0 to 7 percent slopes (Unit 95B), and Coquille silt loam, 0 to 1 percent slopes, diked (Unit 103A). The Urban land-Quillamook complex is mapped in the southeast corner of the Site with the Coquille silt loam mapped elsewhere. The parent materials of the Quillamook and Coquille silt loams are silty alluvium and estuarine deposits, respectively, which is in general agreement with the soils encountered below the fill soils in our explorations. The Site is generally level with gradual to moderate slopes present along the northern boundary of the lot away from the planned development areas. Due to the generally level nature of the lot, it is our opinion that the Site has a low erosion hazard.

4.2.2 Landslide Hazard

The Site is relatively level with no significant slopes and only gradual to moderate sloping terrain along the northern property boundary. The slope along the northern boundary contains approximately 10 to 12 feet of vertical relief and is offset over 15 horizontal feet from any planned structure. The near surface soils at the Site consist of fill soils overlying very soft to soft estuarine deposits, followed by loose to medium dense alluvial soils which are interpreted to have very low to moderate shear strength. As the Site only contains gradual to moderate gradients with a vertical relief of 10 to 12 feet that are offset from any planned structures by a horizontal distance greater than the slope height, it is our opinion that there is a low risk of landslides occurring at the Site and a very low risk to the proposed development.

4.3 Foundation Design

The near surface soils encountered below the anticipated building footprints consist of 2 to 9 feet of variable fill soils (as described in Section 3.2.1 above) overlying soft to very soft sandy silts, followed by

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[12] https://websoilsurvey.nrcs.usda.gov/app/.

saturated loose to medium dense sands, with groundwater at depths ranging from 5 to 10 feet bgs. The fill soils are not considered suitable for building support and the underlying soils were found to be susceptible to substantial settlement due to liquefaction in a design level seismic event. As such, ground improvements and/or a deep foundation system will need to be employed to provide adequate support and mitigate liquefaction for the planned buildings. We anticipate that RAP (or similar ground improvement method) will be utilized for the project and have provided commentary and recommendations below. If the project team elects to utilize a deep foundation system consisting of driven H-piles or drilled shafts, Terraphase can provide additional recommendations upon request.

RAP consists of mechanically stabilized stone piers that are installed using “bottom-up” dynamic compaction to install thin layers of aggregate into a shaft created by displacing existing soil and densifying the surrounding strata. The aggregate is generally placed and compacted in 12-inch lifts for the entire length of the shaft. Pier lengths typically do not extend beyond 35 to 40 feet below grade. The piers are generally constructed at regularly spaced intervals within the foundation and/or building footprint and typically occupy 30 to 50 percent of the footprint area.

We recommend that the RAP system be designed by the ground improvement contractor selected for the project. Ground improvement contractors typically have in-house design professionals that can provide the most economical and efficient designs for their product. The ground improvement calculations, drawings, specifications, and load testing program should be signed and sealed by a professional engineer licensed in the State of Oregon. Terraphase can provide requested design parameters and work in conjunction with the RAP designer throughout the design process. The RAP contractor/designer would be responsible for establishing a pier testing program. Table 3 below provides recommended soil parameters for the encountered soils that can be used in the RAP design. If additional parameters are needed to complete the design, Terraphase can provide the specific parameters upon request. Terraphase should be allowed to review the RAP design to ensure the design aligns with the findings and recommendations presented within this report.

We recommend that the RAP (or similar) system be designed such that no more than 1-inch of total settlement occurs under static conditions over the life of the structures. In addition, the RAP system should be designed in accordance with ASCE 7-16, specifically Table 12.13-3, with regards to liquefaction/seismic induced settlements. In our experience, RAP systems, in similar subsurface conditions, have provided allowable bearing capacities of at least 3,000 psf. Please note that the final allowable bearing capacity to be used in the structural design will be provided by the RAP designer (ground improvement contractor) and that the above value is based on our experience on similar projects.

Table 3 Recommended Soil Parameters to be Used for RAP Design

Soil Unit*	Dry Density (pcf)	Friction Angle (Degrees)	Cohesion (psf)
Existing Fill	100 -110	26	0
Estuarine Deposits	80 - 90	22	0
Alluvial Deposits	105 - 115	30	0

**See Section 3.2 for description of soil units and depths encountered.*

After the RAP are installed conventional shallow spread foundations placed over the RAP will be used to provide building support. The allowable bearing capacity for the shallow foundations will be determined after the design of the RAP system has been completed by the RAP designer. More detailed foundation recommendations will be determined/provided after the RAP design is complete.

Foundation footings should extend at least 18 inches below the lowest adjacent finished ground surface for frost protection. Minimum foundation widths should conform to IBC 2021 requirements. IBC 2021 guidelines should also be followed when considering short-term transitory wind or seismic loads. Standing water should not be allowed to accumulate in footing trenches. All loose or disturbed soil should be removed from the foundation excavation prior to placing concrete.

4.4 Lateral Loads

The lateral earth pressure acting on retaining and/or foundation walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement, which can occur as backfill is placed, and the inclination of the backfill. Walls that are free to yield at least one-thousandth of the height of the wall are in an “active” condition. Walls restrained from movement by stiffness or bracing are in an “at-rest” condition.

Terraphase recommends the design earth pressure values as given in Table 4; “H” represents a potential wall height. These values assume that the on-site soils or imported granular fill are used for backfill, and that the wall backfill is drained and has a level backslope. The given values do not include the effects of surcharges (e.g., due to foundation loads, other surface loads, or a backslope). Surcharge effects should be considered where appropriate. Additionally, this assumes that buried structures extend more than 5 feet below grade. If surcharges or backslopes are expected to be present at planned retaining and/or foundation walls or if structures will be founded more than 5 feet below grades, Terraphase should be contacted to provide updated recommendations. Seismic lateral loads are a function of the Site location, soil strength parameters, and the peak horizontal ground acceleration for a given return period. We used the seismic design parameters discussed in Section 4.1 to compute the additional seismic lateral loads for the Site.

Table 4 Lateral Earth Pressure Parameters

Soil Unit	Earth Pressure Condition	Backslope Angle	Equivalent Fluid Density (pcf)	Seismic Earth Pressure Kicker* (psf)
Structural Fill	Active (Ka)	Level	35	10H
Structural Fill	At-Rest (Ko)	Level	55	14H

**Kicker is to be applied at 60 percent of the wall height (H).*

The above lateral pressures may be resisted by friction at the base of the structure and passive resistance against the foundation. We recommend resistance values as given in Table 5. To achieve these values of passive resistance pressure, the foundations should be poured “neat” against the site soils improved by RAP or compacted fill should be used as backfill against the front of the footing, and the soil in front of the wall should extend a horizontal distance at least equal to three times the foundation depth. A resistance factor of 0.67 has been applied to the passive pressure to account for required movements to generate these pressures. If passive pressures below 5 feet bgs are to be incorporated into the design, Terraphase should be contacted to provide parameters for the soils at the project site.

Table 5 Passive Resistance to Lateral Earth Pressure Parameters

Soil Type	Coefficient of Friction	Equivalent Fluid Density (pcf)
Structural Fill/Improved Site Soils	0.54	296

All wall backfill should be well compacted. Care should be taken to prevent the buildup of excess lateral soil pressures due to over compaction of the wall backfill.

4.5 Slabs on Grade

Slabs should be supported on Site soils improved through the installation of RAP (as described above). Where moisture control is a concern, we recommend that slabs be underlain by 6 inches of pea gravel or clean crushed rock as a capillary break. A suitable vapor barrier, such as heavy plastic sheeting, should be placed over the capillary break. An additional 2-inch-thick damp sand blanket can be used to cover the vapor barrier to protect the membrane and to aid in curing the concrete. This will also help prevent cement paste bleeding down into the capillary break through joints or tears in the vapor barrier. The capillary break material should be connected to the footing drains to provide positive drainage.

4.6 Surface Drainage

Terraphase recommends that runoff from impervious surfaces, such as roofs, driveways, access roadways, parking areas, and sidewalks be collected and routed to an appropriate storm water discharge system. The finished ground surface should be sloped at a minimum gradient of 5 percent for a distance of at least 10 feet away from the buildings or to an approved method of diverting water from the foundation per IBC 2021, Section 1804.4.[13] Surface water should be collected by permanent catch basins and drain lines and discharged into a storm drain system.

We recommend that footing drains be used around all structures where moisture control is important. The underlying native soils may pond water that could accumulate in crawlspaces. It is good practice to use footing drains installed at least 1 foot below the planned finished floor slab or crawlspace elevation to provide drainage for the crawlspace. At a minimum, crawlspaces should be sloped to drain to an outlet tied to the drainage system. If drains are omitted around slab-on-grade floors where moisture control is important, the slab should be a minimum of 1 foot above surrounding grades.

Where used, footing drains should consist of a 4-inch-diameter perforated PVC pipe that is surrounded by free-draining material, such as pea gravel. Footing drains should discharge into tightlines leading to

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[13] https://codes.iccsafe.org/content/IBC2021P2/chapter-18-soils-and-foundations#IBC2021P2_Ch18_Sec1804.

an appropriate collection and discharge point. Crawlspaces should be sloped to drain, and a positive connection should be made into the foundation drainage system. For slabs-on-grade, a drainage path should be provided from the capillary break material to the footing drain system. Roof drains should not be connected to wall or footing drains.

4.7 Infiltration Feasibility

The Site is underlain by up to 18 feet of uncontrolled fill soils, with groundwater as shallow as 5 feet bgs during our explorations conducted in mid-November. As our explorations were conducted in the early part of the winter wet season, we anticipate that seasonal high groundwater elevations may be higher than those encountered during our explorations. Based on the depth of the uncontrolled fill soils and shallow groundwater, it is our opinion that the Site is not suitable for on-site infiltration. Alternate means of managing stormwater will need to be considered for the project.

4.8 Earthwork and Construction Considerations

Soil and groundwater conditions often impact the safety, cost, and anticipated schedule of Site development. Our recommendations in this section are based on our knowledge of the Site, region, construction practices, and industry standards.

4.8.1 Site Preparation and Grading

Site preparation and grading within the proposed building footprint and nearby area will be dictated by the requirements of the ground improvement design. To facilitate the installation of the RAP, ground improvement contractors typically require an 18- to 24-inch-thick working pad composed of compacted imported structural fill. The working pad will be placed over existing Site soils after the surficial topsoil and organic material is removed. The exposed subgrade should be compacted to a firm, non-yielding condition. We recommend that the exposed subgrade within structural areas be verified prior to placing structural fill.

We do not expect that RAP will be installed within the paved access drive and parking areas north of the planned buildings. Additionally, the variable fill soils extend to depths of up to 18 feet within these areas. We do not anticipate that full removal of the fill soils within the paved areas is financially favorable for the project site, and additional environmental impacts may result in the removal of the existing fill. We recommend that the planned pavement sections be supported by a reinforced structural fill prism. The fill prism should be composed of a minimum of 18 inches of gravel borrow placed over existing fill soils that have been stripped of organic material and remedially compacted to a firm and unyielding condition. We recommend that a woven geotextile, such as Mirafi Tencate RS280i, be placed at the interface of the structural fill and remedially compacted existing fill soils.

Verification may be accomplished through proof rolling with a loaded dump truck, large self-propelled vibrating roller, or similar piece of construction equipment applicable to the size of the excavation. Terraphase recommends that proof rolling be observed by a geotechnical professional. Areas observed to pump or yield should be repaired prior to continued construction. During periods of wet weather site conditions, proof rolling may damage the exposed subgrade. Therefore, a geotechnical professional should be consulted prior to proof rolling the subgrade during wet conditions.

If it is considered unfeasible to proof roll the exposed subgrade due to weather conditions, space, elevation, or other Site constraints, Terraphase recommends alternative methods of verification, such as soil probe or similar means.

Note that the near-surface existing fill, native estuarine deposits, and alluvial soils are considered moisture sensitive. Therefore, we recommend that earthwork be performed during extended periods of dry weather, such as summer and early fall, when feasible. Earthwork performed during wet site conditions will likely incur significant, unavoidable expense compared to dry weather construction.

4.8.2 Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, such as the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open, and the presence of surface or groundwater. It is exceedingly difficult under these variable conditions to estimate the geometry of a stable, temporary cut slope. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations, since the contractor is continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered.

We recommend protecting cut slopes from erosion. Measures taken may include covering cut slopes with plastic sheeting and diverting surface water runoff away from the top of the cut slopes. We do not recommend vertical slopes for cuts deeper than 4 feet if worker access is necessary. Cut slope heights and inclinations should conform to local and United States Department of Labor Occupational Safety and Health Administration standards.

According to Occupational Safety and Health Administration's *Appendix A to Subpart B of Part 1926-Soil Classification,*[14] the fill soils, estuarine, and alluvial deposits are classified as a Type C soil. For temporary, unsupported excavations exceeding 4 feet in height, Terraphase recommends that temporary cuts in the near surface topsoils and existing fill be no steeper than 1.5 Horizontal to 1 Vertical (1.5H:1V). Flatter inclinations will likely be necessary if groundwater seepage is encountered.

Final slope inclinations for granular structural fill and the native soils should be no steeper than 2H:1V. Lightly compacted fills, common fills, or structural fill predominately consisting of fine-grained soils should be no steeper than 3H:1V. Common fills are defined as fill material with some organics that are "trackrolled" into place, which would not meet the compaction specification of structural fill. Final slopes should be vegetated and covered with straw or jute netting. The vegetation should be maintained until it is established.

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[14] https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926SubpartPAppA

4.8.3 Structural Fill

All fill placed beneath buildings, pavements, or other settlement sensitive features should be placed as structural fill in accordance with prescribed methods and standards with oversight provided by an experienced geotechnical professional or soils technician. Field observation procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction.

Imported structural fill should consist of a good quality, free-draining granular soil free of organics and other deleterious material, and well graded to a maximum size of about 3 inches. Imported, all-weather structural fill should contain no more than 5 percent fines (soil finer than a Standard U.S. No. 200 sieve), based on that fraction passing the U.S. 3/4-inch sieve.

The near surface Site soils are composed of variable uncontrolled fill soils and elastic (high plasticity) silt. Due to the difficulties associated with reuse of these soils, we do not recommend that planning incorporate the reuse of on-site soils as structural fill. In addition, we understand the project team is looking to minimize the amount of soil to be excavated as part of the development and construction may not produce a significant amount of excavation spoils. Terraphase can provide further consultation regarding the reuse of on-site soils as structural fill, as requested, if sufficient quantities are generated. All topsoil, soils containing deleterious material, or not properly moisture conditioned should be placed in non-structural areas or disposed off Site.

Following subgrade preparation, as outlined elsewhere in this report, placement of the structural fill may proceed. Fill should be placed in 8- to 10-inch-thick uniform lifts, and each lift should be spread evenly and thoroughly compacted prior to placement of subsequent lifts. All structural fill underlying building areas, and within 2 feet below the pavement and sidewalk subgrade, should be compacted to at least 95 percent of its maximum dry density (as determined by the ASTM D1557[15] compaction test procedure). Fill placed more than 2 feet beneath sidewalks and pavement subgrades should be compacted to at least 90 percent of the maximum dry density. The moisture content of the soil to be compacted should be within approximately 2 percent of optimum so that a readily compactable condition exists. It may be necessary to over excavate and remove wet surficial soils when drying to a compactable condition is not feasible. All compaction should be accomplished by equipment of a type and size sufficient to attain the desired degree of compaction.

4.8.4 Utilities

Groundwater was observed at approximately 5 to 10 feet bgs within our boring explorations performed in mid-November. Our explorations were performed in the early part of the winter wet season, and groundwater levels may rise throughout the winter. Therefore, we recommend that excavations for utilities be performed outside of the winter wet season. If the project schedule allows, we recommend utility trenching be performed in the late summer or early fall when groundwater levels are generally at their lowest. Assuming utility trench excavation work is performed outside of the winter wet season we

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[15] https://www.astm.org/d1557-12r21.html

anticipate that deep dewatering will not be needed to install standard-depth utilities. Anticipated groundwater is expected to be handled with pumps in the trenches, provided this work is performed during the dryer times of the year.

If utility trenching is performed during the winter wet season, we expect that significant groundwater seepage will be encountered within the trench excavation. If utility trenching is to occur within the winter wet season, a more robust dewatering system will likely be required.

The soils likely to be exposed in utility trenches after Site stripping are considered highly moisture sensitive. We recommend considering the exposed soils for trench backfill during the drier portions of the year. Provided these soils are within 2 percent of the optimum moisture content, they should be suitable to meet compaction specifications. During the wet season, it may be difficult to achieve compaction specifications; therefore, soil amendment with kiln dust or cement may be needed to achieve proper compaction with the on-site materials.

4.8.5 Dewatering

Groundwater was encountered between 5 and 10 feet bgs in our explorations performed in mid-November of 2024. We expect that groundwater levels may rise throughout the winter wet season and may impact excavations performed in the winter wet season. Provided excavations are performed outside of the winter wet season we expect that only minor seepage will be observed within the excavation and dewatering through standard construction pumps should be adequate means to remove groundwater. If excavations are performed during the winter wet season a significant amount of water may be encountered during earthwork and a more robust dewatering program may be required. Groundwater seepage behind retaining and/or foundation walls should be collected in a drainage system, as discussed in Section 4.6.

4.8.6 Wet Weather Construction Considerations

The on-site fill, estuarine, and alluvial deposits contain fines content exceeding 15 percent by mass, according to our laboratory testing, and are considered to be moisture sensitive. These soils, when exposed to wet weather during construction, can be particularly susceptible to degradation. We expect these soils would be difficult, if not impossible, to compact to structural fill specifications in wet weather. We recommend that earthwork be conducted during the drier months. Additional expenses of wet weather or winter construction could include extra excavation and use of imported fill or rock spalls. During wet weather, alternative site preparation methods may be necessary. These methods may include using a smooth bucket trackhoe to complete Site stripping and diverting construction traffic around prepared subgrades. Disturbance to the prepared subgrade may be minimized by placing a blanket of rock spalls or imported sand and gravel in traffic and roadway areas. Cutoff drains or ditches can also be helpful in reducing grading costs during the wet season. These methods can be evaluated at the time of construction and additional recommendations can be provided upon a review of the final site plan.

5 Additional Services

The intent of this *Geotechnical Report* is to provide the Client with a professional evaluation of existing subsurface and slope conditions at the Site and recommendations for geotechnical design elements of the proposed project. This section describes additional services Terraphase may provide for the proposed project (e.g., engineering, design, and project management specific to the chosen design).

5.1 Construction Observation

Terraphase should be retained for observation and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, and to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated. As part of our services, we would also evaluate whether installation activities comply with contract plans and specifications.

We recommend that Terraphase perform the following tasks:

- Review ground improvement design submittals
- Review contractor submittals
- Observe ground improvement installation & load testing
- Observe subgrade conditions in structural areas
- Observe foundation installation
- Observe foundation and wall drainage installation
- Perform compaction tests on soil and asphalt
- Perform laboratory tests as needed
- Attend project meetings as needed
- Provide ongoing geotechnical consultation

6 Limitations

This document was prepared solely for CHA Consulting and Tillamook County in accordance with professional standards at the time the services were performed and in accordance with the contract between the Client and Terraphase dated September 11, 2024. Additionally, the commentary and recommendations contained within this report may be relied upon by CW Real Estate Partners for their planned site redevelopment. We have relied on information or instructions provided by the Client and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

We have prepared this report for the Client and its agents for use in planning and design of the 3rd Street housing project in Tillamook, Oregon. The data and report should be provided to prospective contractors for bidding and estimating purposes; however, our report, conclusions and interpretations should not be construed as a warranty of subsurface conditions.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractors' methods, techniques, sequences, or procedures, except as specifically described in our report, for consideration in design. There are possible variations in subsurface conditions. We recommend that project planning include contingencies in budget and schedule, should areas be found with conditions that vary from those described in this report.

Our services were completed within the limitations of the approved scope, schedule, and budget, in accordance with generally accepted practices, at the time this report was prepared. No other conditions, expressed or implied, should be understood.

7 References

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Figures

0 2,500 5,000 Feet

1 inch = 2,500 feet

N

Legend

▢ Site Location

Base Map: ESRI World Topographic Map
(data providers include HERE, Garmin, USGS, et al.)

SAFETY FIRST

terraphase engineering

CLIENT: CHA Solutions

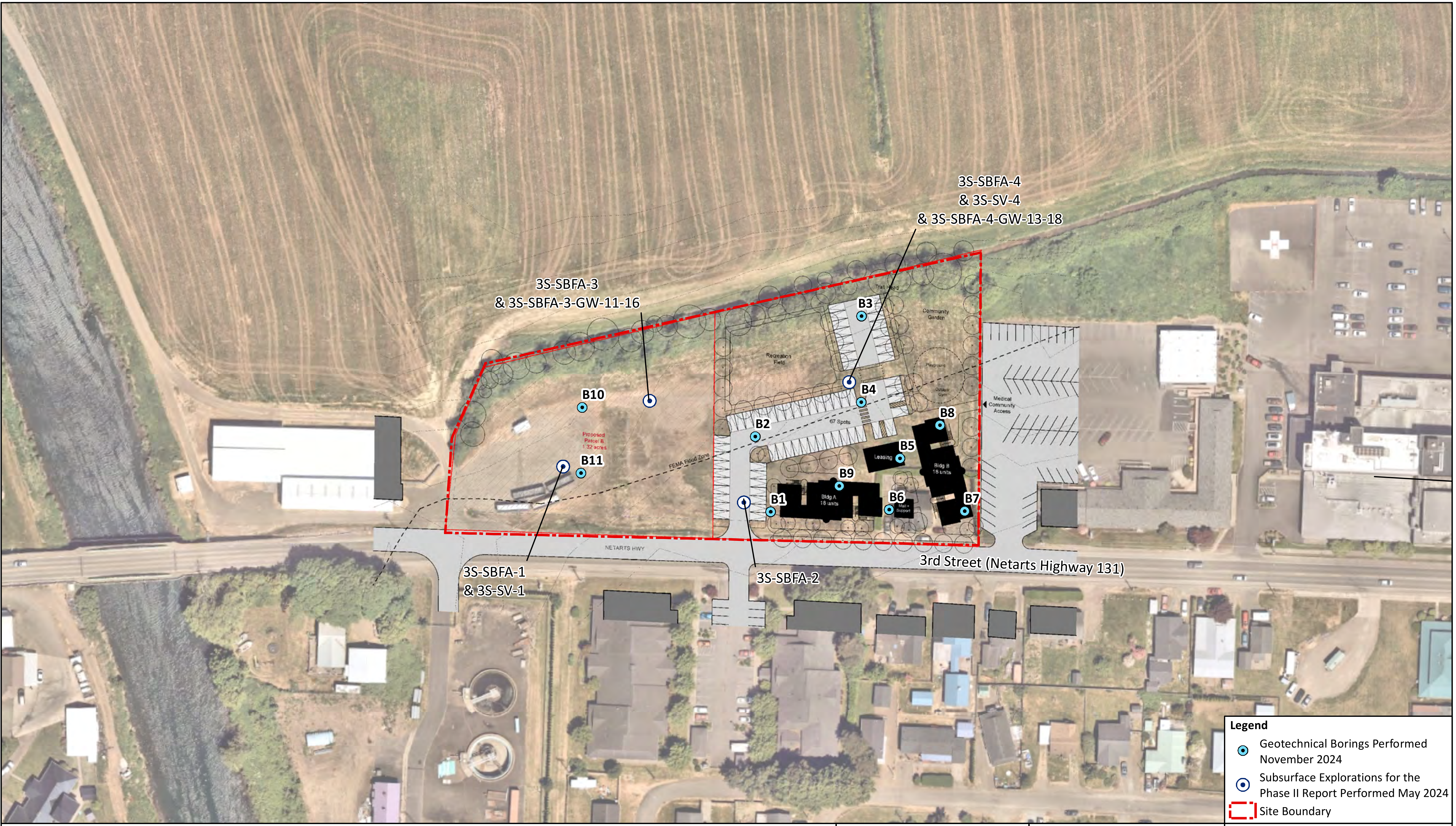
PROJECT: Tillamook Housing - 3rd Street
920 3rd Street, Tillamook, OR

PROJECT NUMBER: O053.011.001

Site Location

FIGURE 1

File: N:\GIS\Prj\O053.011_Tillamook Housing\MXDs\Figure 1 - Site Location.mxd 12/13/2024 Created by: ALV Coordinate System: NAD 1983 StatePlane Oregon North FIPS 3601 Feet



Aerial Imagery Source: Nearmap (June 3, 2023)

0 50 100 200 Feet
1 inch = 100 feet

N

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CLIENT: CHA Solutions

PROJECT: Tillamook Housing - 3rd Street
920 3rd Street, Tillamook, OR

PROJECT NUMBER: O053.011.001

Site Map

FIGURE 2

File: T:\Projects\O053.011_Tillamook Housing\MXDs\(20241213) Figure 2 - Site Map.mxd 12/19/2024 Created by: ALV Coordinate System: NAD 1983 StatePlane Oregon North FIPS 3601 Feet

Unified Soil Classification System

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50% RETAINED ON number 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50%	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50% OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488

2) Soil classification using laboratory tests is based on ASTM D 2487

3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS

Dry- Absence of moisture, dusty, dry to the touch

Moist- Damp, but no visible water

Wet- Visible free water or saturated, usually soil is obtained from below water table

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CLIENT: CHA Solutions

PROJECT: Tillamook Housing - 3rd Street
920 3rd Street, Tillamook, OR

PROJECT NUMBER: O053.011.001

Unified Soil Classification System

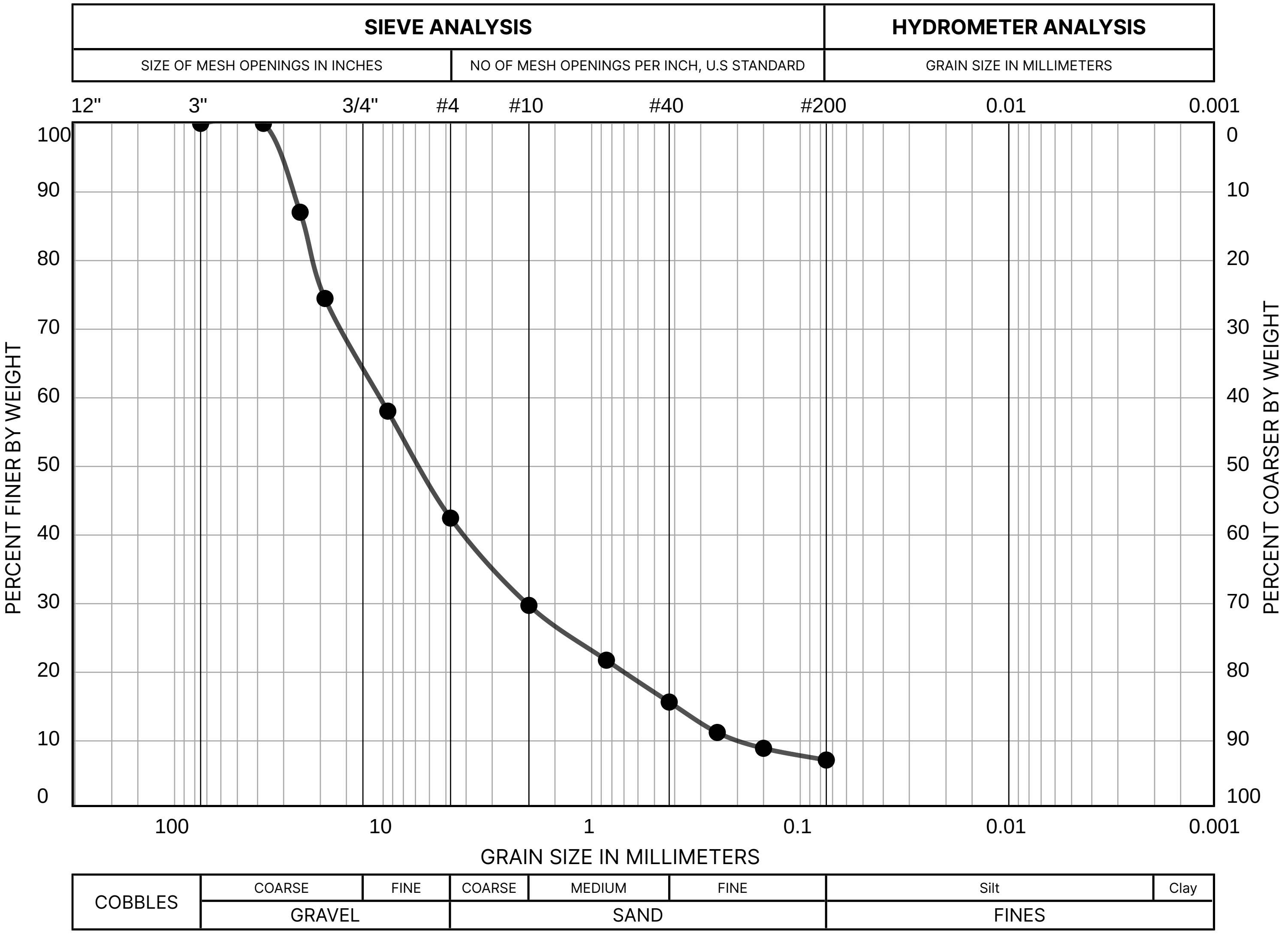
FIGURE 3

Appendix A

Laboratory Testing

GRAIN SIZE DISTRIBUTION TEST RESULTS

B-1, 7.5'



TEST RESULTS

SIEVE SIZE	% PASSING
3”	100
1.5”	100
1”	87
3/4”	74
3/8”	58
#4	42
#10	30
#20	22
#40	16
#60	11
#100	9
#200	7

SPECIMEN DESCRIPTION

DESCRIPTION	**Well-Graded Gravel with Silt**
USCS CLASS.	**GW-GM**
AASHTO CLASS.	**A-1-a**
ATTERBERG LIMITS	

LL	PL	PI

COEFFICIENTS

D10	D15	D30	D50	D60	D85	D90
0.2	0.4	2.06	7.23	10.75	24.08	28

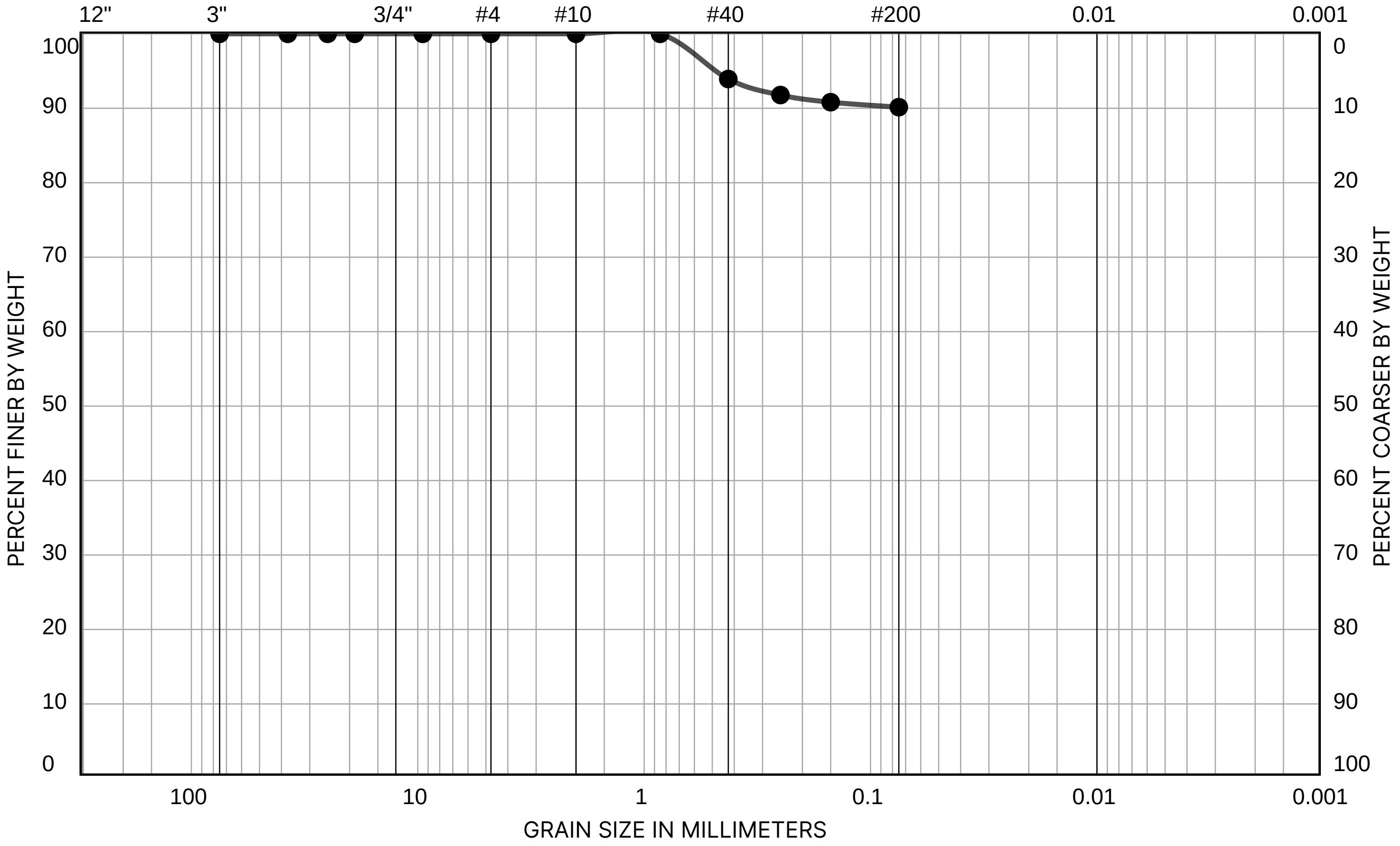
D100	C_u	C_c
56.25	53.75	1.97

PROJECT	Tillamook Housing	**PROJECT NO.**	O053.011
CLIENT	CHA Consulting, Inc.	**FIGURE NO.**	A-1
LOCATION	920 West 3rd Street, Tillamook, Oregon		

GRAIN SIZE DISTRIBUTION TEST RESULTS

B-3, 15'

SIEVE ANALYSIS		HYDROMETER ANALYSIS
SIZE OF MESH OPENINGS IN INCHES	NO OF MESH OPENINGS PER INCH, U.S STANDARD	GRAIN SIZE IN MILLIMETERS



COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	Silt	Clay
	GRAVEL		SAND			FINES	

TEST RESULTS

SIEVE SIZE	% PASSING
3”	100
1.5”	100
1”	100
3/4”	100
3/8”	100
#4	100
#10	100
#20	100
#40	94
#60	92
#100	91
#200	90

SPECIMEN DESCRIPTION

DESCRIPTION	**Elastic Silt with Fine Sand**
USCS CLASS.	**MH**
AASHTO CLASS.	
ATTERBERG LIMITS	

LL	PL	PI

COEFFICIENTS

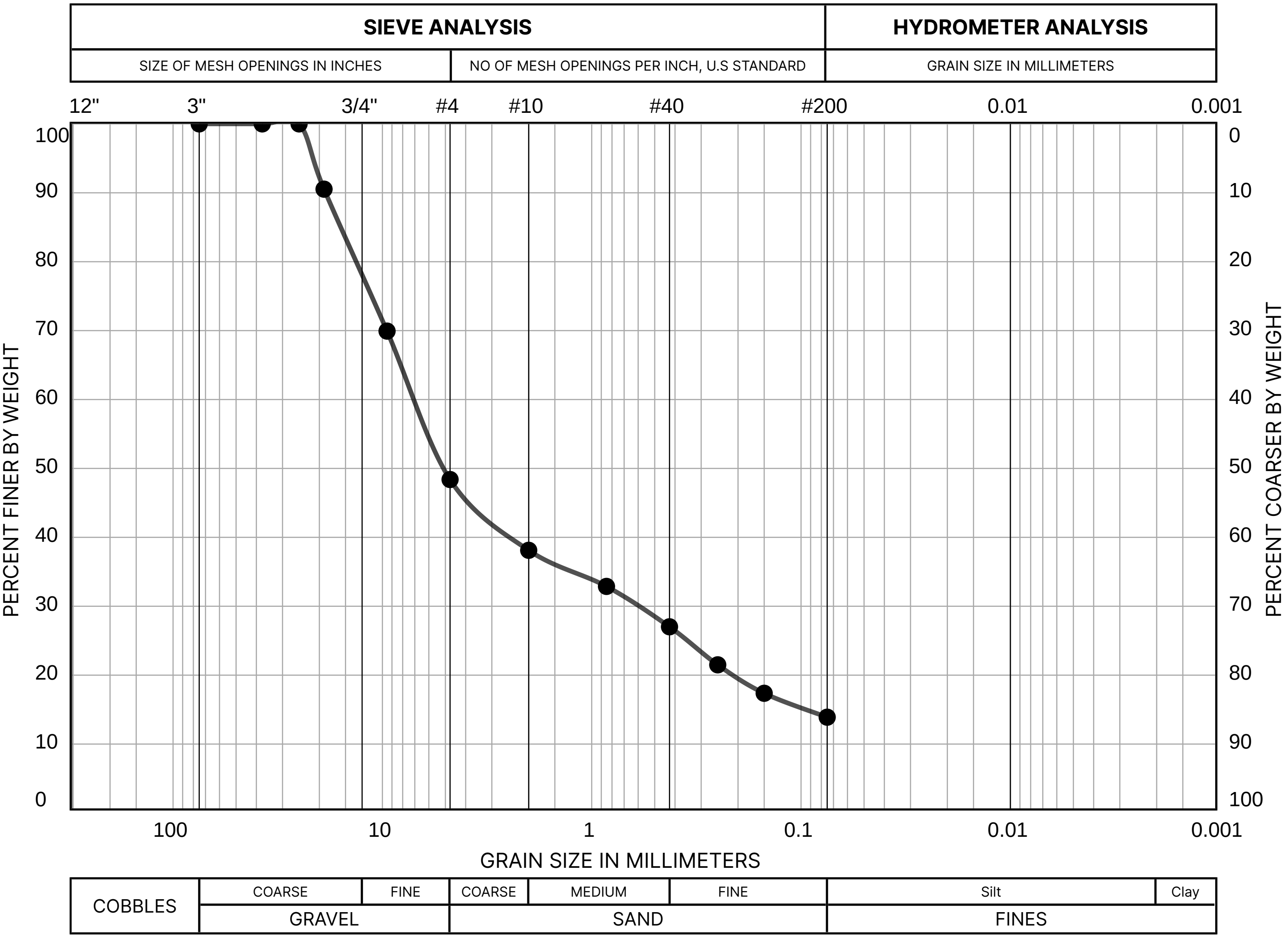
D10	D15	D30	D50	D60	D85	D90

D100	C_u	C_c
56.25		

PROJECT	Tillamook Housing	**PROJECT NO.**	O053.011
CLIENT	CHA Consulting, Inc.	**FIGURE NO.**	A-2
LOCATION	920 West 3rd Street, Tillamook, Oregon		

GRAIN SIZE DISTRIBUTION TEST RESULTS

B-7, 5'



TEST RESULTS

SIEVE SIZE	% PASSING
3”	100
1.5”	100
1”	100
3/4”	91
3/8”	70
#4	48
#10	38
#20	33
#40	27
#60	22
#100	17
#200	14

SPECIMEN DESCRIPTION

DESCRIPTION **Silty Gravel with Coarse to Fine Sand**

USCS CLASS. **GM**

AASHTO CLASS. **A-1-a**

ATTERBERG LIMITS

LL	PL	PI

COEFFICIENTS

D10	D15	D30	D50	D60	D85	D90
	0.1	0.65	5.17	7.52	16.68	18.78

D100	C_u	C_c
56.25		

PROJECT Tillamook Housing

CLIENT CHA Consulting, Inc.

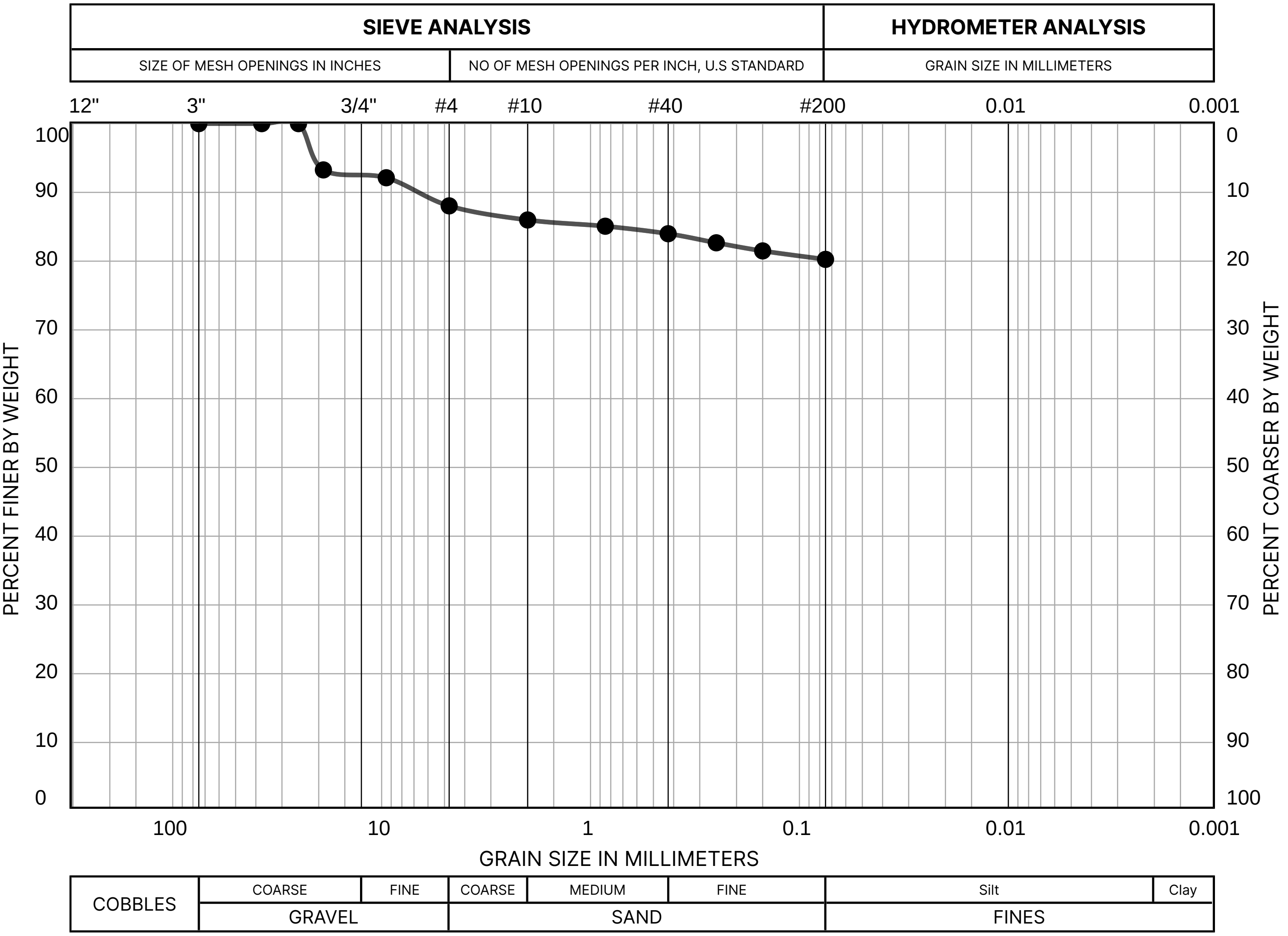
LOCATION 920 West 3rd Street, Tillamook,
Oregon

PROJECT NO. O053.011

FIGURE NO. A-3

GRAIN SIZE DISTRIBUTION TEST RESULTS

B-8, 15'



TEST RESULTS

SIEVE SIZE	% PASSING
3”	100
1.5”	100
1”	100
3/4”	93
3/8”	92
#4	88
#10	86
#20	85
#40	84
#60	83
#100	81
#200	80

SPECIMEN DESCRIPTION

DESCRIPTION	**Elastic Silt with Gravel and Sand**
USCS CLASS.	**MH**
AASHTO CLASS.	
ATTERBERG LIMITS	

LL	PL	PI

COEFFICIENTS

D10	D15	D30	D50	D60	D85	D90
					0.82	7.05

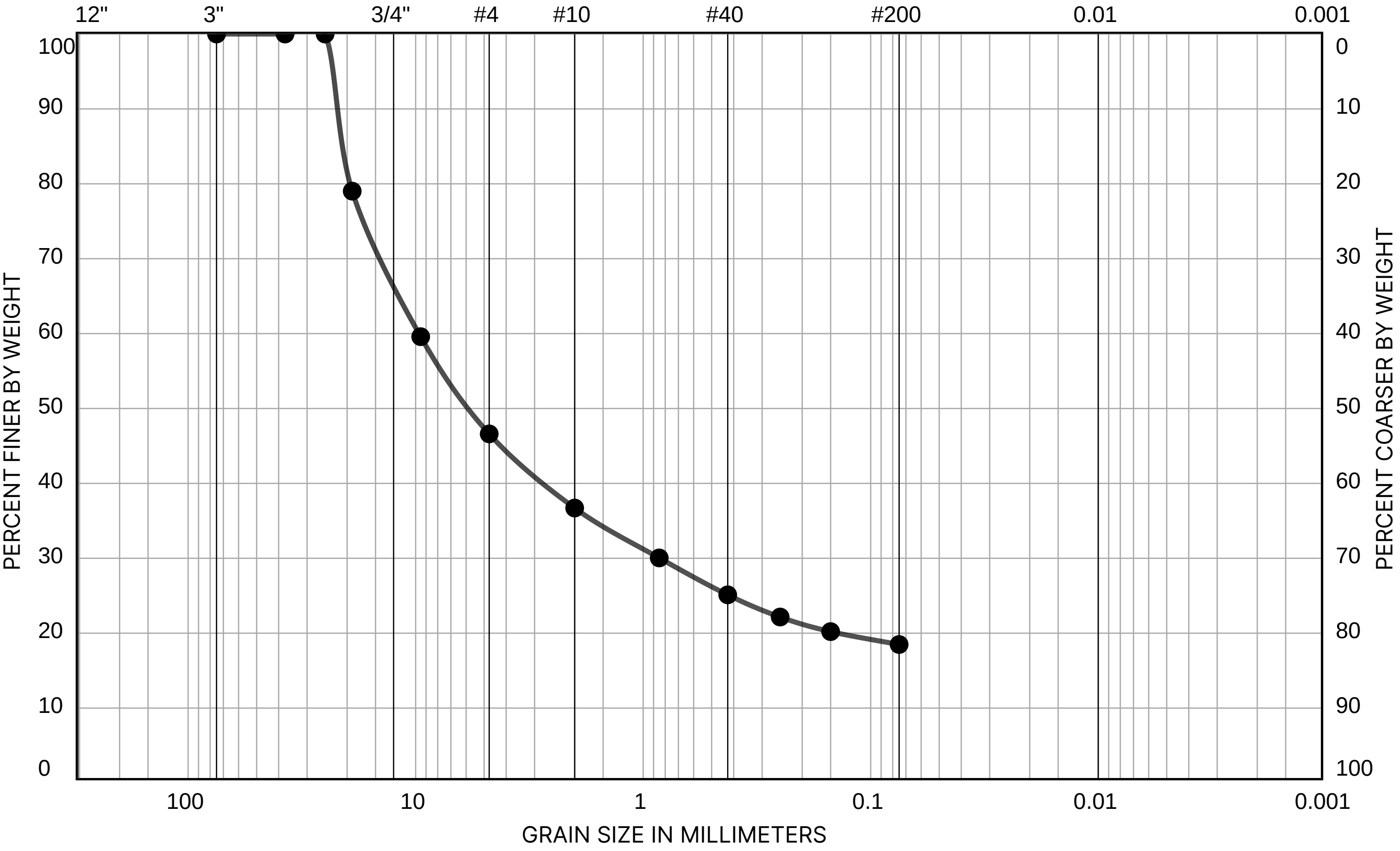
D100	C_u	C_c
56.25		

PROJECT	Tillamook Housing	**PROJECT NO.**	O053.011
CLIENT	CHA Consulting, Inc.	**FIGURE NO.**	A-4
LOCATION	920 West 3rd Street, Tillamook, Oregon		

GRAIN SIZE DISTRIBUTION TEST RESULTS

B-8, 25'

SIEVE ANALYSIS		HYDROMETER ANALYSIS
SIZE OF MESH OPENINGS IN INCHES	NO OF MESH OPENINGS PER INCH, U.S STANDARD	GRAIN SIZE IN MILLIMETERS



COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	Silt	Clay
	GRAVEL		SAND			FINES	

TEST RESULTS

SIEVE SIZE	% PASSING
3”	100
1.5”	100
1”	100
3/4”	79
3/8”	60
#4	47
#10	37
#20	30
#40	25
#60	22
#100	20
#200	18

SPECIMEN DESCRIPTION

DESCRIPTION **Silty Gravel with Sand**

USCS CLASS. **GM**

AASHTO CLASS. **A-1-b**

ATTERBERG LIMITS

LL	PL	PI

COEFFICIENTS

D10	D15	D30	D50	D60	D85	D90
		0.85	6.11	9.73	20.86	22.32

D100	C_u	C_c
56.25		

PROJECT Tillamook Housing

CLIENT CHA Consulting, Inc.

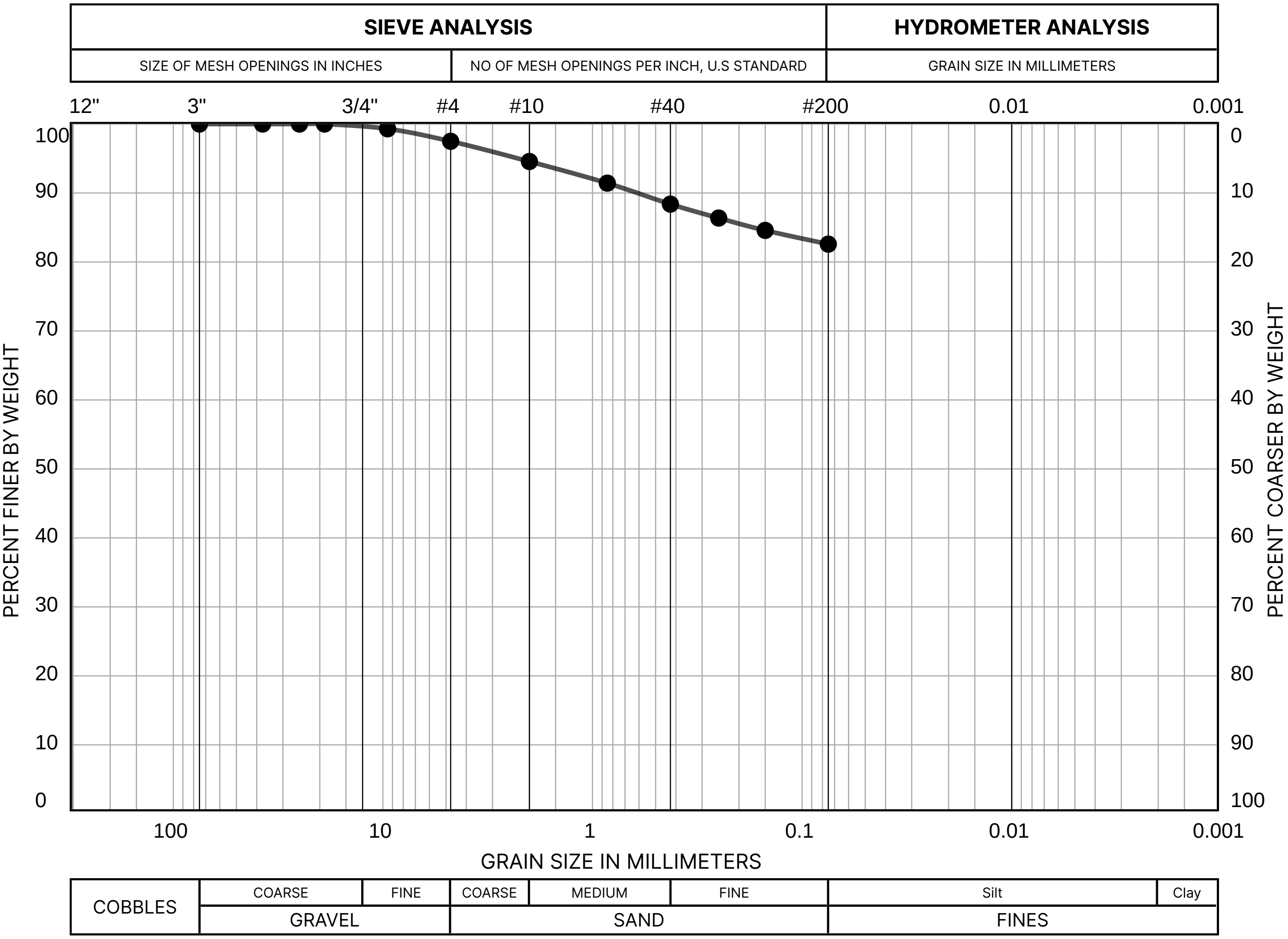
LOCATION 920 West 3rd Street, Tillamook,
Oregon

PROJECT NO. O053.011

FIGURE NO. A-5

GRAIN SIZE DISTRIBUTION TEST RESULTS

B-8, 50'



TEST RESULTS

SIEVE SIZE	% PASSING
3”	100
1.5”	100
1”	100
3/4”	100
3/8”	99
#4	98
#10	95
#20	91
#40	88
#60	86
#100	85
#200	83

SPECIMEN DESCRIPTION

DESCRIPTION	**Sandy Silt**
USCS CLASS.	**ML**
AASHTO CLASS.	
ATTERBERG LIMITS	

LL	PL	PI

COEFFICIENTS

D10	D15	D30	D50	D60	D85	D90
					0.17	0.65

D100	C_u	C_c
56.25		

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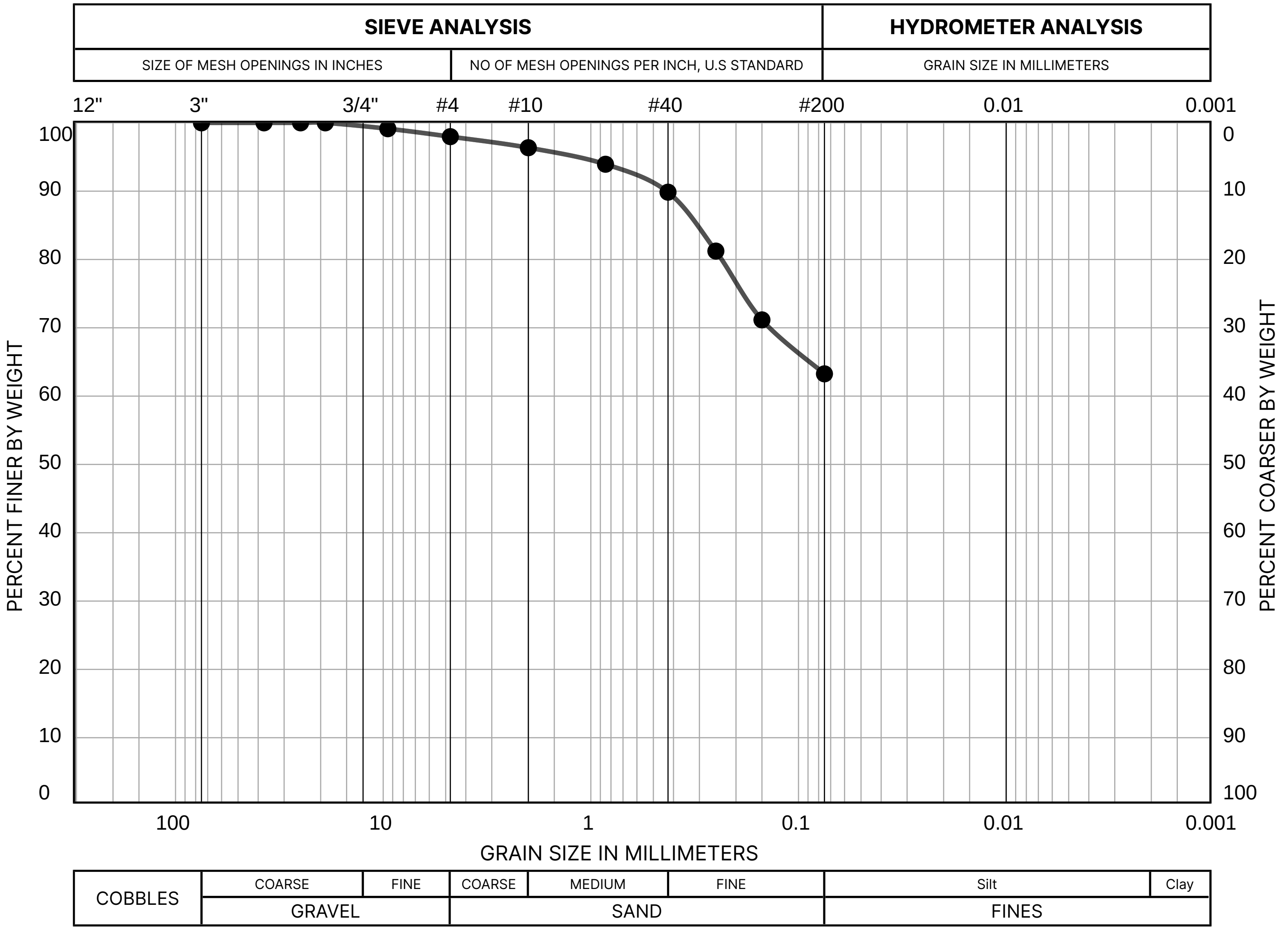
PROJECT	Tillamook Housing	**PROJECT NO.**	O053.011
CLIENT	CHA Consulting, Inc.	**FIGURE NO.**	A-6
LOCATION	920 West 3rd Street, Tillamook, Oregon		

GRAIN SIZE DISTRIBUTION TEST RESULTS

B-8, 55'



TEST RESULTS

SIEVE SIZE	% PASSING
3”	100
1.5”	100
1”	100
3/4”	100
3/8”	99
#4	98
#10	96
#20	94
#40	90
#60	81
#100	71
#200	63

SPECIMEN DESCRIPTION

DESCRIPTION	**Sandy SIlt**
USCS CLASS.	**ML**
AASHTO CLASS.	
ATTERBERG LIMITS	

LL	PL	PI

COEFFICIENTS

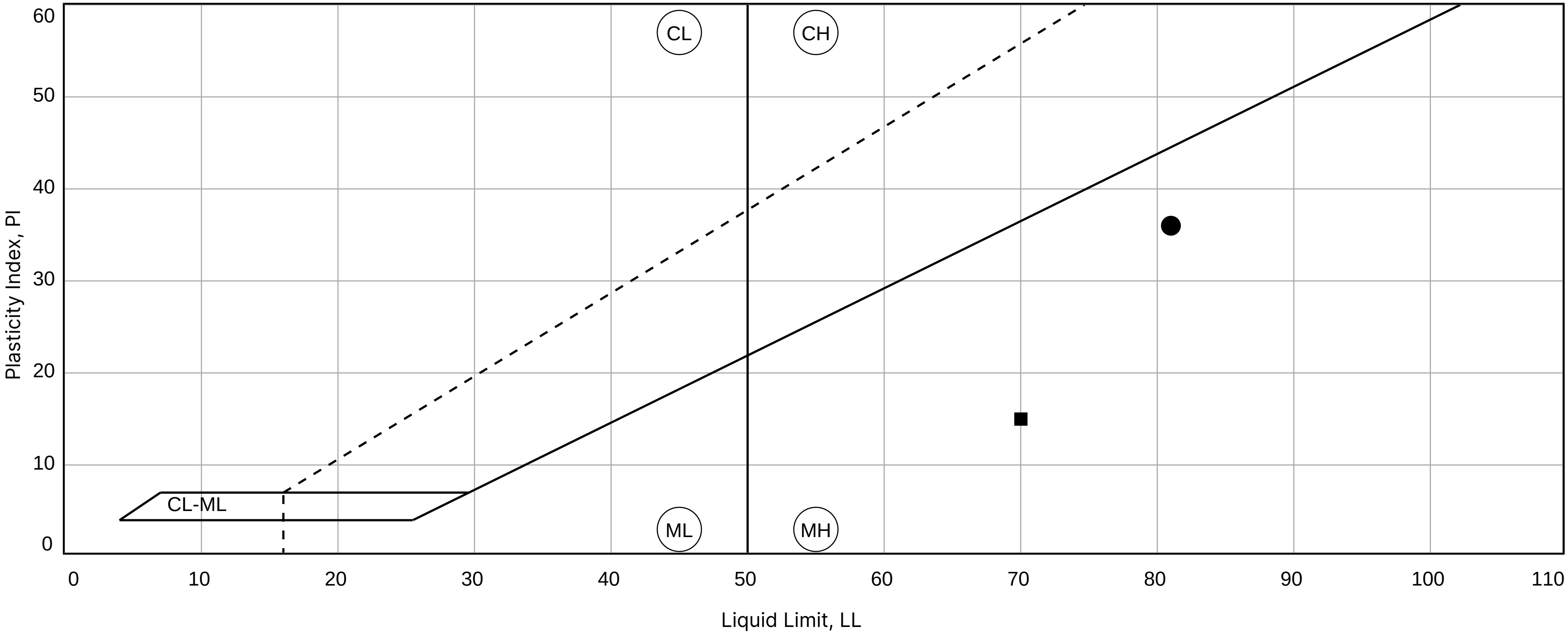
D10	D15	D30	D50	D60	D85	D90
					0.33	0.44

D100	C_u	C_c
56.25		

PROJECT	Tillamook Housing	**PROJECT NO.**	O053.011
CLIENT	CHA Consulting, Inc.	**FIGURE NO.**	A-7
LOCATION	920 West 3rd Street, Tillamook, Oregon		

ATTERBERG LIMITS TEST RESULTS

PROJECT Tillamook Housing
CLIENT CHA Consulting, Inc.
PROJECT NO. O053.011
LOCATION 920 West 3rd Street, Tillamook, Oregon



EXPLORATION	SAMPLE NUMBER	DEPTH	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC (%)	TEST BY/RVW	TEST STD	TEST NOTE
B-2	B-2-8	20			70	55	15				D4318	
B-3	B-3-6	20			81	45	36				D4318	

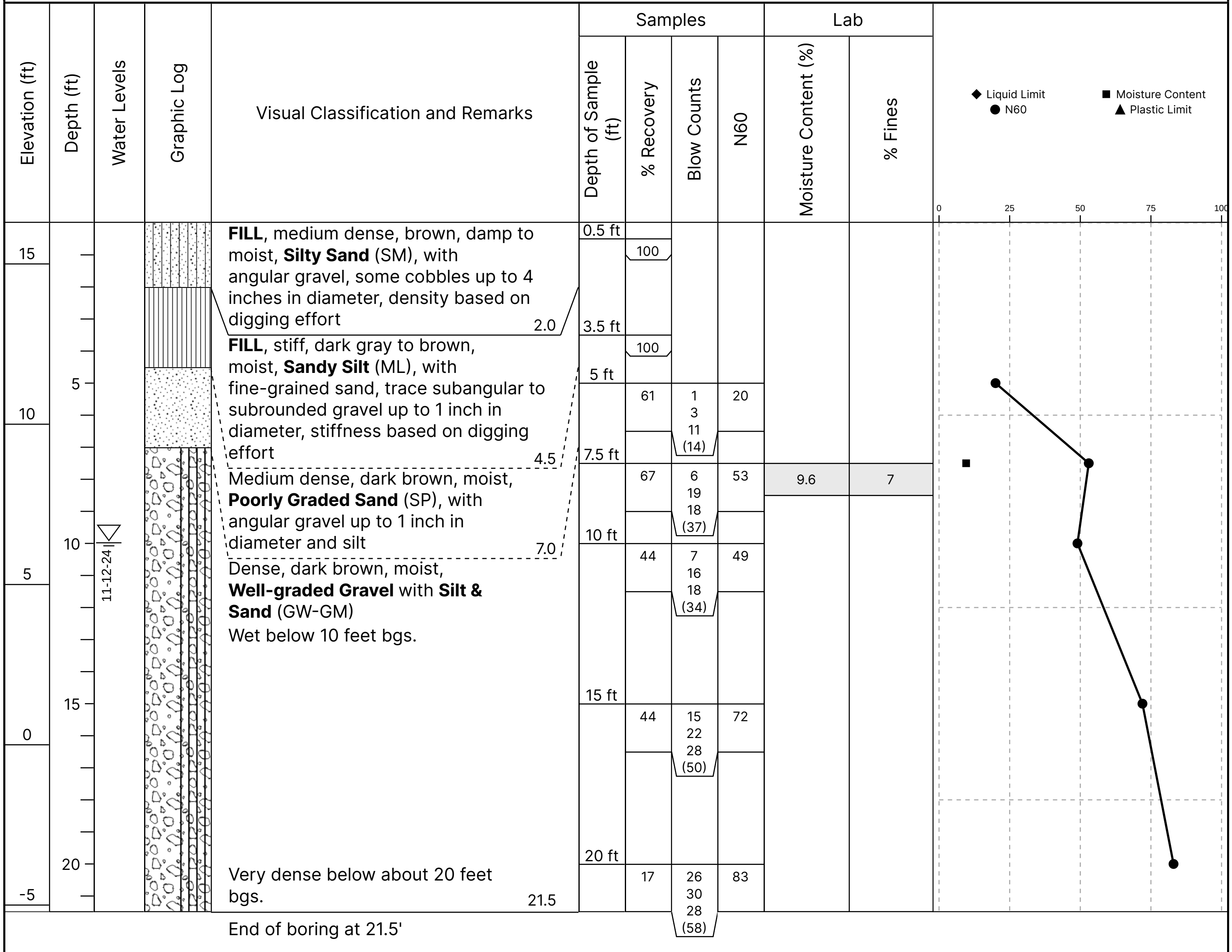
Appendix B

Boring Logs

Tillamook Housing

Soil Boring: B-1

Date Started:	11/12/2024	Date Completed:	11/12/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~16.3'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	21.5'	Boring Diameter:	8 in	Lat Lng:	45.456396, -123.857091



Visual Classification and Remarks	
FILL, medium dense, brown, damp to moist, **Silty Sand** (SM), with angular gravel, some cobbles up to 4 inches in diameter, density based on digging effort	2.0
FILL, stiff, dark gray to brown, moist, **Sandy Silt** (ML), with fine-grained sand, trace subangular to subrounded gravel up to 1 inch in diameter, stiffness based on digging effort	4.5
Medium dense, dark brown, moist, **Poorly Graded Sand** (SP), with angular gravel up to 1 inch in diameter and silt	7.0
Dense, dark brown, moist, **Well-graded Gravel** with **Silt & Sand** (GW-GM) Wet below 10 feet bgs. Very dense below about 20 feet bgs.	21.5

End of boring at 21.5'

Depth of Sample (ft)	% Recovery	Blow Counts	N60	Moisture Content (%)	% Fines
0.5 ft	100				
3.5 ft	100				
5 ft	61	1 3 11 (14)	20		
7.5 ft	67	6 19 18 (37)	53	9.6	7
10 ft	44	7 16 18 (34)	49		
15 ft	44	15 22 28 (50)	72		
20 ft	17	26 30 28 (58)	83		

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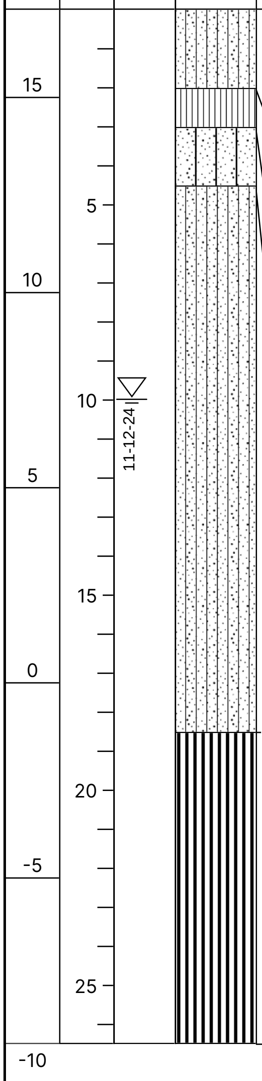
Tillamook Housing

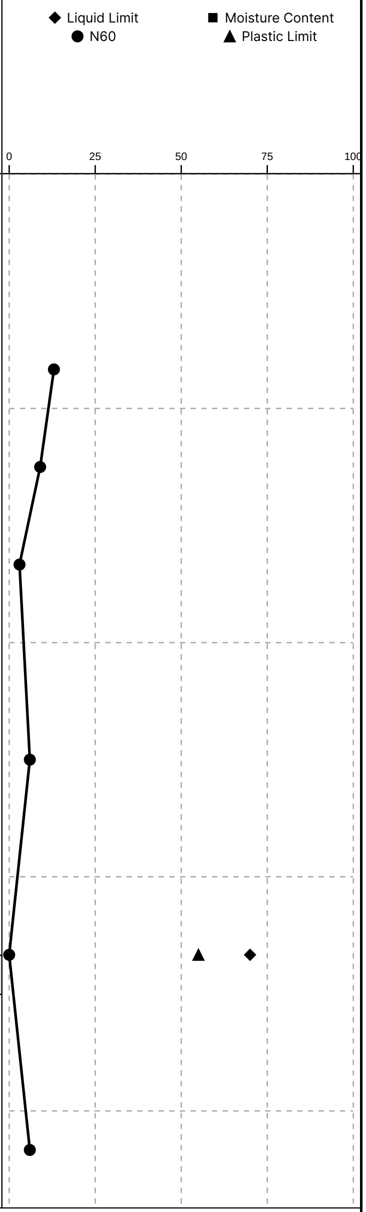
Soil Boring: B-2

Date Started:	11/12/2024	Date Completed:	11/12/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.2'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	26.5'	Boring Diameter:	8 in	Lat Lng:	45.456628, -123.857169



Visual Classification and Remarks	Depth (ft)
FILL, medium dense, dark brown, moist, **Silty Sand** (SM), with trace angular gravel up to 2 inches in diameter, density based on digging effort	2.0
FILL, medium stiff, brown, wet, **Sandy Silt** (ML), with trace angular gravel and cobbles up to 4 inches in diameter, stiffness based on digging effort	3.0
FILL, loose, black, moist, **Poorly Graded Sand** (SP), with angular gravel up to 1 inch in diameter and silt	4.5
FILL, loose, dark gray to black, moist, **Silty Sand** (SM), with angular gravel up to 1 inch in diameter, abundant wood debris (interbedded) Very loose below ~7.5 feet bgs. Wet below 10 feet bgs	18.5
Very soft, dark gray to black, wet, **Elastic Silt** (MH), low to medium plasticity, with fine-grained sand, some organics abundant rootlets, increase in plasticity below ~25 feet bgs.	26.5
End of boring at 26.5'	

Samples				Lab
Depth of Sample (ft)	% Recovery	Blow Counts	N60	Atterberg Limits (LL-PL-PI)
0.5 ft	100			
2.5 ft	100			
3 ft	100			
5 ft	33	1 3 6 (9)	13	
7.5 ft	67	2 2 4 (6)	9	
10 ft	61	1 1 1 (2)	3	
15 ft	6	2 2 2 (4)	6	
20 ft	89	0 0 0 (0)	0	70-55-15
25 ft	50	0 0 4 (4)	6	



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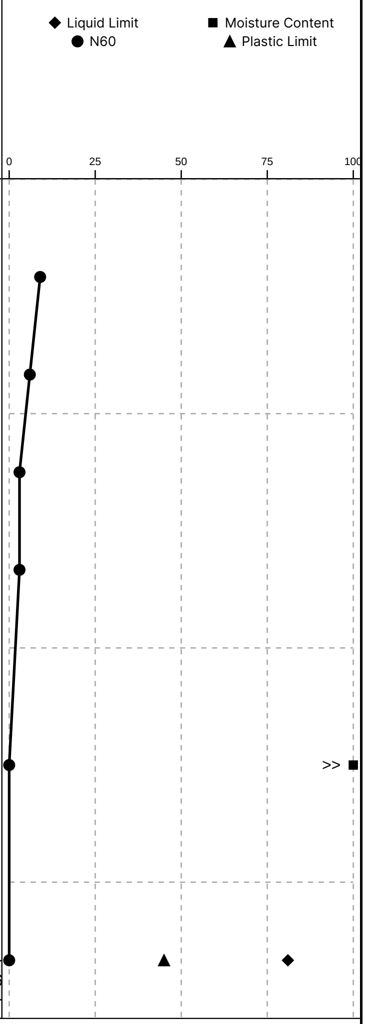
Tillamook Housing

Soil Boring: B-3

Date Started:	11/12/2024	Date Completed:	11/12/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.2'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	21.5'	Boring Diameter:	8 in	Lat Lng:	45.457051, -123.856732

Elevation (ft)	Depth (ft)	Water Levels	Graphic Log	Visual Classification and Remarks	Samples				Lab		
					Depth of Sample (ft)	% Recovery	Blow Counts	N60	Moisture Content (%)	% Fines	Atterberg Limits (LL-PL-PI)
15				**FILL**, dense, brown, damp, **Silty Sand** (SM), fine- to coarse-grained, low plasticity fines, with angular gravel up to 3 inches in diameter and cobbles up to 6 inches in diameter (15%) 2.0	2.5 ft	50	1 6 (6)	9			
	5			**FILL**, loose, dark gray to black, moist, **Silty Sand** (SM), fine- to coarse-grained, low plasticity fines, with angular gravel up to 1 inch in diameter (5%), abundant wood debris	5 ft	50	1 2 2 (4)	6			
10		▽ 11-12-24		Very loose, wet, increase in gravel content below ~7.5 feet bgs	7.5 ft	11	0 1 1 (2)	3			
5	10			12.5	10 ft	11	1 1 1 (2)	3			
	15			Very soft, brown to grayish brown, moist, **Elastic Silt** with **Fine Sand** (MH), medium plasticity, abundant organics, and root fibers 17.5	15 ft	89	0 0 0 (0)	0	233.2	90	
0	20			Very soft, gray, moist to wet, **Elastic Silt** with **Fine Sand** (MH), medium plasticity and abundant organic debris (root fibers) 21.5	20 ft	100	0 0 0 (0)	0			81-45-36
-5				End of boring at 21.5'							



Tillamook Housing

Soil Boring: B-4

Date Started: 11/12/2024
Date Completed: 11/12/2024
Project No: O053.011
Client Name: CHA Consulting, Inc.
Project Address: 920 West 3rd Street, Tillamook, Oregon
Surface Elevation: ~18.2'
Drilling Firm: Holt
Logged By: Adrienne Venegas
Checked By: Joseph Schmidt
Method: Auger
Hammer Type: Auto
Hammer Efficiency: 86%
Depth: 26.5'
Boring Diameter: 8 in
Lat Lng: 45.456795, -123.856651

Elevation (ft): 15, 10, 5, 0, -5

Depth (ft): 5, 10, 15, 20, 25

Water Levels: ▽ 11-12-24 (at 5 ft)

Graphic Log

Visual Classification and Remarks

FILL, dense, brown, damp, **Silty Sand** (SM), with angular gravel up to 3 inches in diameter, density based on digging effort — 3.0

FILL, medium dense, dark gray to black, damp, **Silty Sand** (SM), abundant wood debris, some angular gravel up to 2 inches in diameter, density based on digging effort

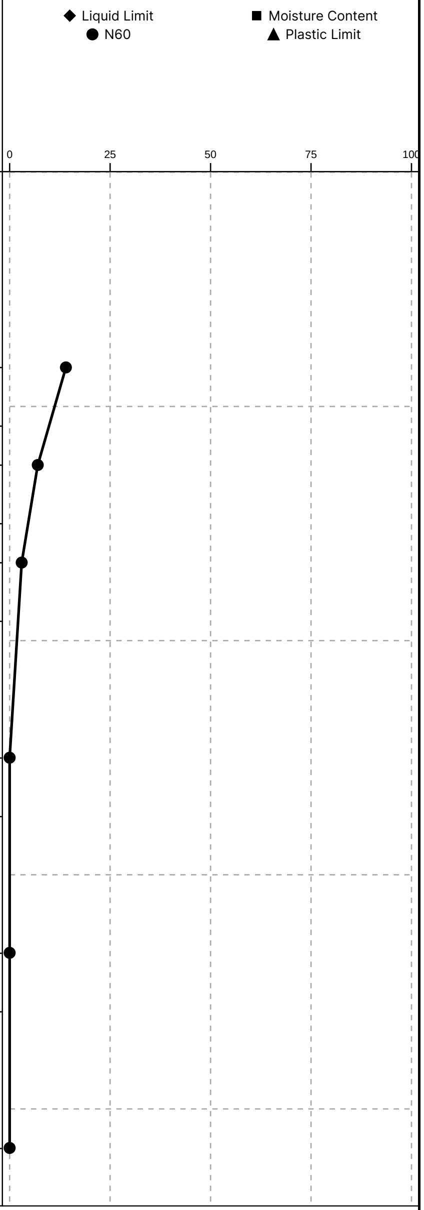
Loose, wet below 5 feet bgs — 13.5

Very soft, brown to grayish brown, moist, **Silt** (ML), low to medium plasticity, some fine-grained sand, abundant organics and root fibers

Gray, wet, decrease in organic content below ~25 feet bgs. — 26.5

End of boring at 26.5'

Samples			
Depth of Sample (ft)	% Recovery	Blow Counts (N/Refusal)	N60
0.5 ft	100		
3 ft			
3.5 ft	100 100		
5 ft	6	1 4 6 (10)	14
7.5 ft	6	3 3 2 (5)	7
10 ft	6	2 1 1 (2)	3
15 ft	100	0 0 0 (0)	0
20 ft	6	0 0 0 (0)	0
25 ft	100	0 0 0 (0)	0



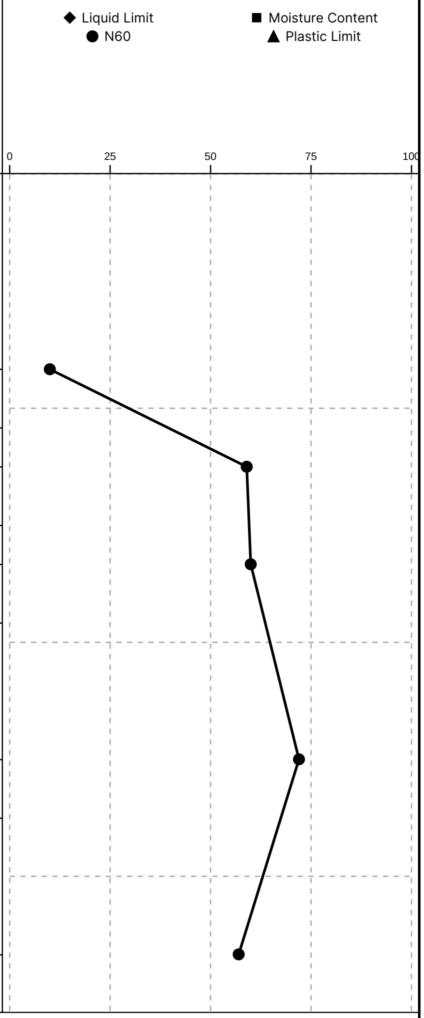
Tillamook Housing

Soil Boring: B-5

Date Started:	11/13/2024	Date Completed:	11/13/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~20.1'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	21.5'	Boring Diameter:	8 in	Lat Lng:	45.456635, -123.856524

Elevation (ft)	Depth (ft)	Water Levels	Visual Classification and Remarks
	0		**FILL**, medium dense, dark brown, moist, **Silty Sand** (SM), some angular gravel up to 2 inches in diameter, trace terra cotta debris Black, angular to subrounded gravel, significant wood and organic debris below 2 feet bgs Increase in moisture below 3 feet bgs
15	5		
	6.5	▽ 11-13-24	Dense, orange to brown, wet, **Poorly Graded Gravel** (GP-GM), angular to subrounded, up to 3 inches in diameter, fine- to coarse-grained, subrounded to rounded sand, with low to medium plasticity clayey silt
10	10		
5	15		Medium- to coarse-grained sand interbeds below ~15 feet bgs.
0	20		Predominantly rounded gravel below ~20 feet bgs.
	21.5		End of boring at 21.5'

Depth of Sample (ft)	% Recovery	Blow Counts (N/Refusal)	N60
0.5 ft	100		
2 ft	100		
5 ft	56	1 0 7 (7)	10
7.5 ft	67	3 20 21 (41)	59
10 ft	67	22 21 21 (42)	60
15 ft	67	25 24 26 (50)	72
20 ft	67	10 16 24 (40)	57



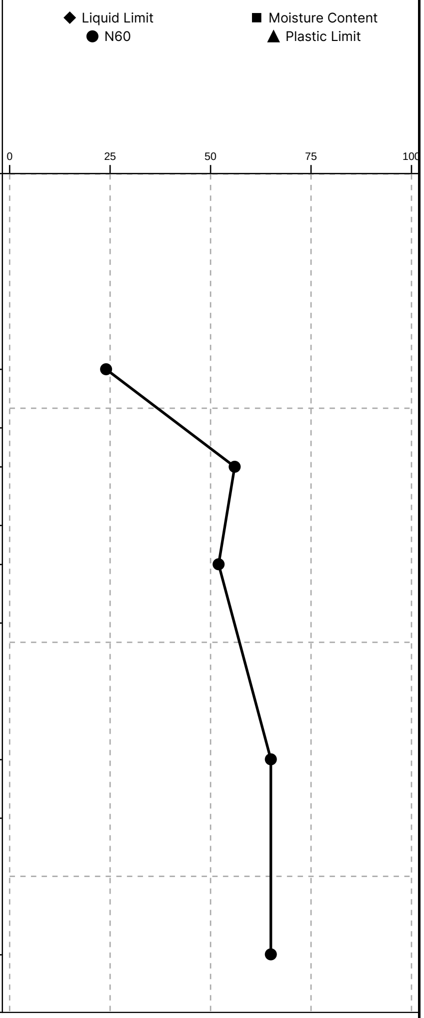
Tillamook Housing

Soil Boring: B-6

Date Started:	11/13/2024	Date Completed:	11/13/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.9'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	21.5'	Boring Diameter:	8 in	Lat Lng:	45.456469, -123.856696

Elevation (ft)	Depth (ft)	Water Levels	Graphic Log	Visual Classification and Remarks	Samples Depth of Sample (ft)	% Recovery	Blow Counts (N/Refusal)	N60
				FILL, medium dense, brown, damp, **Silty Sand** (SM), with angular to subangular gravel and cobbles up to 6 inches in diameter Decrease in gravel content below 2 feet bgs POORLY GRADED **GRAVEL** (GP-GM), Grayish brown below 4 feet bgs	0.5 ft	100		
15					2 ft	100		
	5			5.0 Medium dense, orange to brown, moist, subangular to rounded, **Poorly Graded Gravel** with **Silt** (GP-GM), up to 3 inches in diameter Wet below ~7.5 feet bgs	5 ft	83	3 7 10 (17)	24
10		▽			7.5 ft	67	3 20 19 (39)	56
5	10				10 ft	56	15 17 19 (36)	52
0	15			Dense to very dense, medium- to coarse-grained sand interbeds below ~15 feet bgs	15 ft	83	16 23 22 (45)	65
	20			21.5	20 ft	67	8 25 20 (45)	65

End of boring at 21.5'

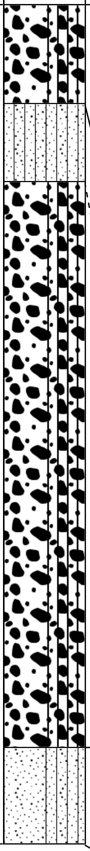


Tillamook Housing

Soil Boring: B-7

Date Started: 11/13/2024
Date Completed: 11/13/2024
Project No: O053.011
Client Name: CHA Consulting, Inc.
Project Address: 920 West 3rd Street, Tillamook, Oregon
Surface Elevation: ~17.2'
Drilling Firm: Holt
Logged By: Adrienne Venegas
Checked By: Joseph Schmidt
Method: Auger
Hammer Type: Auto
Hammer Efficiency: 86%
Depth: 21.5'
Boring Diameter: 8 in
Lat Lng: 45.456530, -123.856271

Elevation (ft)	Depth (ft)	Water Levels	Graphic Log	Visual Classification and Remarks
15 10 5 0 -5	5 10 15 20	11-13-24		



FILL, brown, damp, **Poorly Graded Gravel** (GP-GM), sandy, angular to subangular, up to 3 inches in diameter

Grayish brown below 1.5 feet bgs, with subrounded cobbles up to 4 inches in diameter 2.5

Very loose, grayish brown, moist, **Silty Sand** (SM), some subangular to subrounded gravel up to 1 inch in diameter 4.5

Medium dense, orangish brown to dark brown, moist, **Silty Gravel** with **Sand** (GM), angular to subrounded, up to 2 inches in diameter, with clayey silt

Subrounded to rounded gravel below ~7.5 feet bgs.

Dense, wet below ~10 feet bgs.

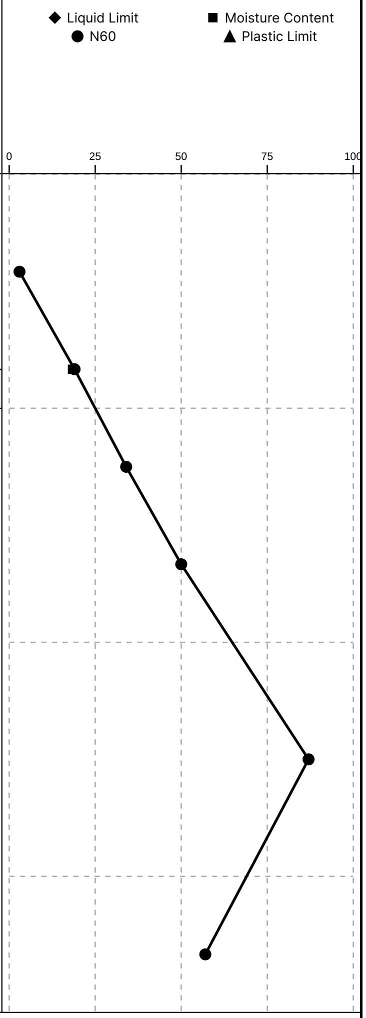
Very dense below ~15 feet bgs.

19.0

Dense, dark brown, wet, **Poorly Graded Sand** (SP-SM), medium- to coarse-grained, with low plasticity silt. 21.5

End of boring at 21.5'

Samples				Lab	
Depth of Sample (ft)	% Recovery	Blow Counts	N60	Moisture Content (%)	% Fines
2.5 ft	50	0 1 1 (2)	3		
5 ft	33	1 2 11 (13)	19	18.4	14
7.5 ft	50	1 8 16 (24)	34		
10 ft	67	5 14 21 (35)	50		
15 ft	67	11 28 33 (61)	87		
20 ft	17	17 27 13 (40)	57		



Tillamook Housing

Soil Boring: B-8

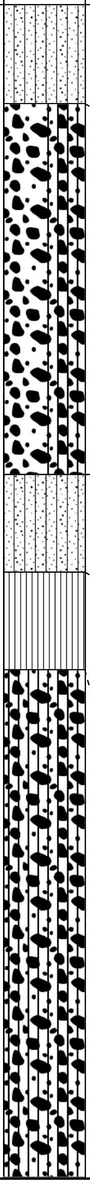
Date Started:	11/13/2024	Date Completed:	11/14/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.8'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	61.5'	Boring Diameter:	8 in	Lat Lng:	45.456740, -123.856359

Elevation (ft): 15, 10, 5, 0, -5, -10

Depth (ft): 5, 10, 15, 20, 25

Water Levels: ▽ 11-13-24

Graphic Log



Visual Classification and Remarks

FILL, medium dense, orange, moist, **Silty Sand** (SM), with angular gravel and cobbles up to 6 inches in diameter

2.5

FILL, loose, brown to gray, moist, **Poorly Graded Gravel** (GP-GM), angular to subrounded, up to 1 inch in diameter

Black, wet, increase in sand content below ~10 feet bgs

12.0

FILL, very loose, dark gray to black, wet, **Silty Sand** (SM), trace angular to subrounded gravel up to 0.25-inch in diameter

14.5

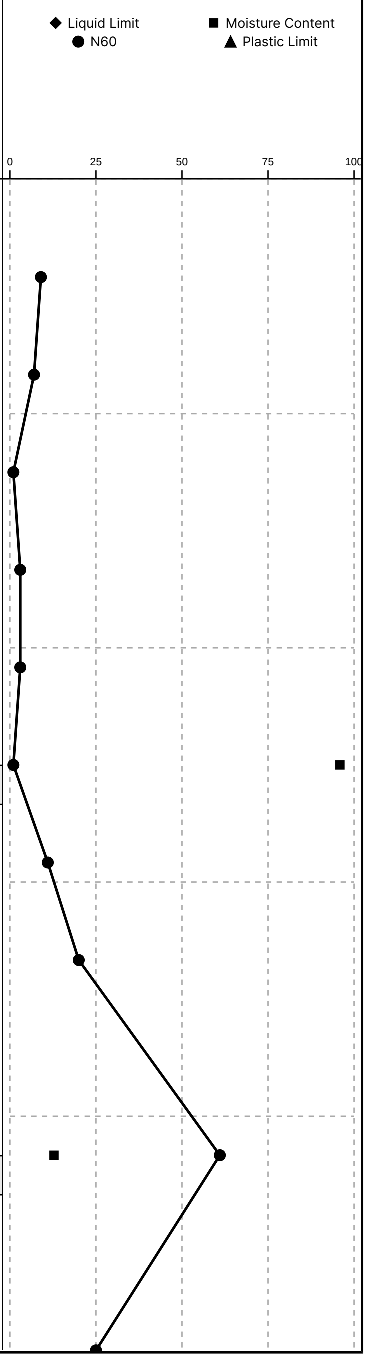
Soft, dark gray to black, **Elastic Silt** with **Gravel and Sand** (MH), medium plasticity, clayey, fine-grained sand, trace subrounded to rounded gravel up to 0.25-inch in diameter

17.0

Loose, orangish brown, wet, subangular to subrounded, **Silty Gravel** (GM), up to 2 inches in diameter, medium plasticity silt, with fine- to coarse-grained sand

Medium dense to dense below ~20 feet bgs.

Samples				Lab	
Depth of Sample (ft)	% Recovery	Blow Counts	N60	Moisture Content (%)	% Fines
0.5 ft	100				
1.5 ft	100				
2.5 ft		3 4 3 (7)	9		
5 ft	6	4 4 1 (5)	7		
7.5 ft	6	1 1 0 (1)	1		
10 ft	33	1 1 1 (2)	3		
12.5 ft	67	1 1 1 (2)	3		
15 ft	67	0 0 1 (1)	1	95.9	80
17.5 ft	33	2 4 4 (8)	11		
20 ft	22	5 6 9 (15)	20		
25 ft	67	18 18 28 (46)	61	12.8	18

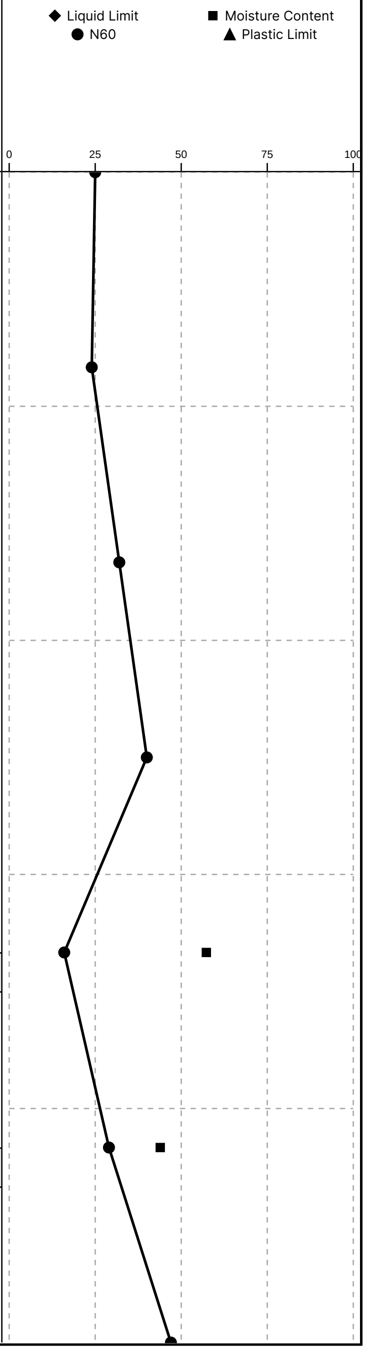


Tillamook Housing

Soil Boring: B-8

Date Started:	11/13/2024	Date Completed:	11/14/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.8'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	61.5'	Boring Diameter:	8 in	Lat Lng:	45.456740, -123.856359

					Samples				Lab	
Elevation (ft)	Depth (ft)	Water Levels	Graphic Log	Visual Classification and Remarks	Depth of Sample (ft)	% Recovery	Blow Counts	N60	Moisture Content (%)	% Fines
-15				Loose, orangish brown, wet, subangular to subrounded, **Silty Gravel** (GM), up to 2 inches in diameter, medium plasticity silt, with fine- to coarse-grained sand	30 ft	6	10 11 8 (19)	25		
-20	35			Weathered gravel below ~35 feet bgs.	35 ft	22	5 5 13 (18)	24		
-25	40				40 ft	67	10 10 14 (24)	32		
	45				45 ft	17	12 17 13 (30)	40		
-30				47.0 Stiff, orange to orangish brown, moist, **Sandy Silt** (ML), medium plasticity, with fine- to coarse-grained sand (interbedded) [Weathered Siltstone]						
-35	50				50 ft	83	1 3 9 (12)	16	57.3	83
				53.5 Hard, orange to orangish brown, moist, **Sandy Silt** (ML), fine- to medium grained, medium plasticity silt [Weathered Sandstone]						
-40	55				55 ft	83	5 8 14 (22)	29	43.9	63



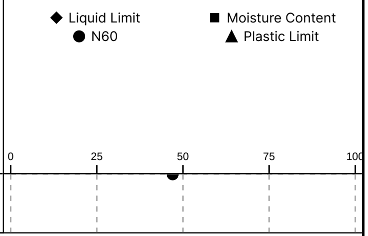
Tillamook Housing

Soil Boring: B-8

Date Started:	11/13/2024	Date Completed:	11/14/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.8'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	61.5'	Boring Diameter:	8 in	Lat Lng:	45.456740, -123.856359

Elevation (ft)	Depth (ft)	Water Levels	Graphic Log	Visual Classification and Remarks	Samples				Lab	
					Depth of Sample (ft)	% Recovery	Blow Counts	N60	Moisture Content (%)	% Fines
			▨	Hard, orange to orangish brown, moist, **Sandy Silt** (ML), fine- to medium grained, medium plasticity silt [Weathered Sandstone] 61.5	60 ft	89	8 15 20 (35)	47		

End of boring at 61.5'



Tillamook Housing

Soil Boring: B-9

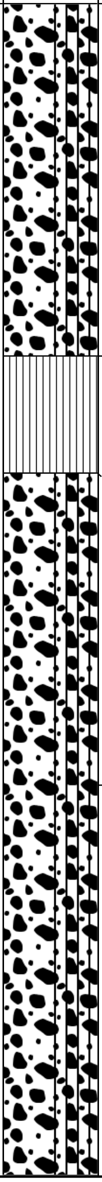
Date Started:	11/14/2024	Date Completed:	11/14/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.5'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	46.5'	Boring Diameter:	8 in	Lat Lng:	45.456543, -123.856879

Elevation (ft): 15, 10, 5, 0, -5, -10

Depth (ft): 5, 10, 15, 20, 25

Water Levels

Graphic Log



Visual Classification and Remarks

FILL, dense, brown, wet, subangular to subrounded, **Poorly Graded Gravel** with **Sand** (GP-GM), up to 4 inches in diameter

dark grayish brown, angular to rounded, up to 2 inches in diameter, abundant wood debris below ~5 feet bgs.

9.0

Soft to medium stiff, dark gray, wet, **Sandy Silt** (ML), medium plasticity, fine- to medium-grained sand, with subrounded to angular gravel up to 1 inch in diameter

12.0

Medium dense to dense, orange-brown to gray-brown, wet, subangular to subrounded, **Poorly Graded Gravel** with **Sand** (GP-GM), fine- to coarse-grained, subrounded to subangular sand, with low plasticity fines

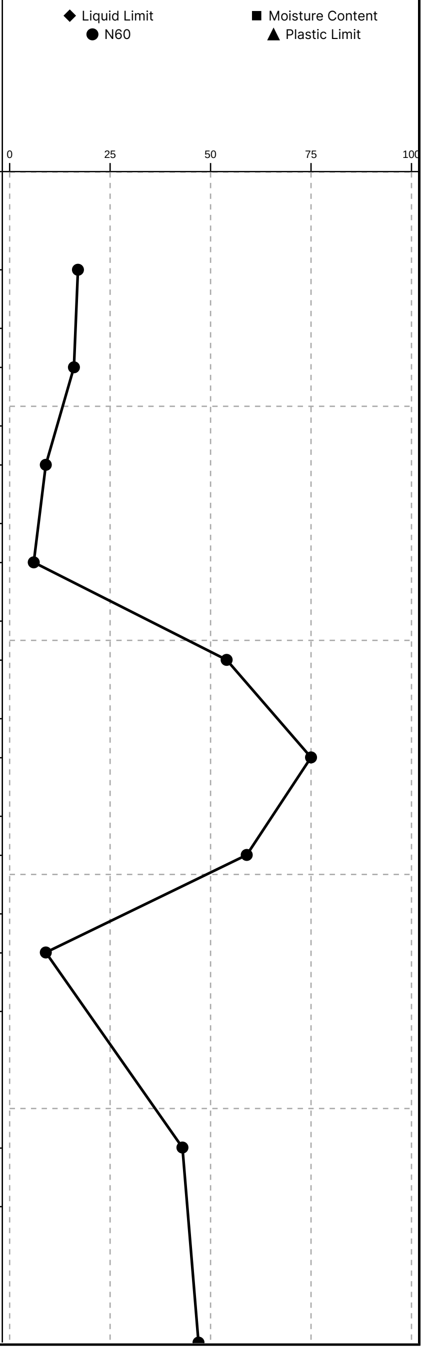
Weathered sand and gravel below ~17.5 feet bgs

20.0

Loose to medium dense, orangish brown to brown, wet, **Poorly Graded Gravel** (GP-GM), silty and sandy (increase in silt content)

Clayey silt below ~25 feet bgs

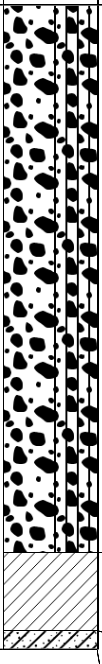
Samples			
Depth of Sample (ft)	% Recovery	Blow Counts (N/Refusal)	N60
0.25 ft	100		
2.5 ft	11	6 5 7 (12)	17
5 ft	67	6 4 7 (11)	16
7.5 ft	33	2 3 3 (6)	9
10 ft	33	1 2 2 (4)	6
12.5 ft	50	13 19 19 (38)	54
15 ft	50	17 27 25 (52)	75
17.5 ft	67	19 20 21 (41)	59
20 ft	50	7 5 1 (6)	9
25 ft	67	4 14 16 (30)	43



Tillamook Housing

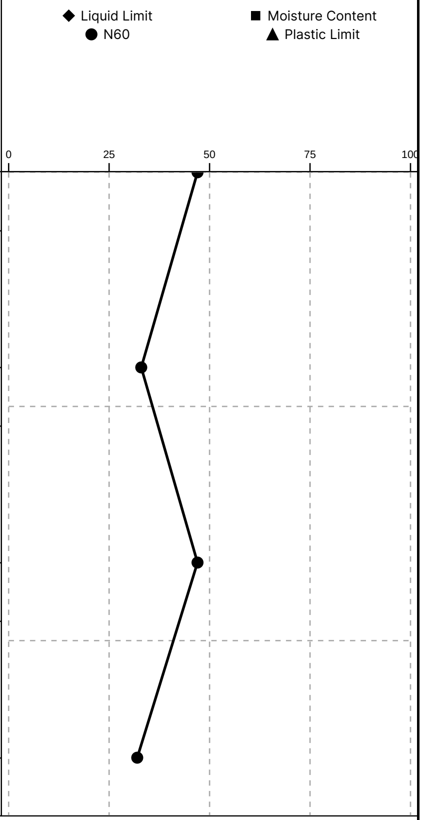
Soil Boring: B-9

Date Started:	11/14/2024	Date Completed:	11/14/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~17.5'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	46.5'	Boring Diameter:	8 in	Lat Lng:	45.456543, -123.856879



Elevation (ft)	Depth (ft)	Water Levels	Graphic Log	Visual Classification and Remarks	Samples Depth of Sample (ft)	% Recovery	Blow Counts (N/Refusal)	N60
-15				Loose to medium dense, orangish brown to brown, wet, **Poorly Graded Gravel** (GP-GM), silty and sandy (increase in silt content)	30 ft	50	11 16 17 (33)	47
-20	35			Increase in sand and silt content below ~35.5 feet bgs.	35 ft	67	11 11 12 (23)	33
-25	40			44.0	40 ft	50	8 16 17 (33)	47
	45			Soft to medium stiff, brown with mottling, wet, **Lean Clay** (CL), low to medium plasticity, trace fine-grained sand 46.0	45 ft	89	1 4 18 (22)	32
				Medium dense, orange-brown, wet, angular to subangular, **Clayey Sand** (SC), medium- to coarse-grained, low plasticity fines, trace subrounded to subangular gravel up to 0.5-inches in diameter 46.5				

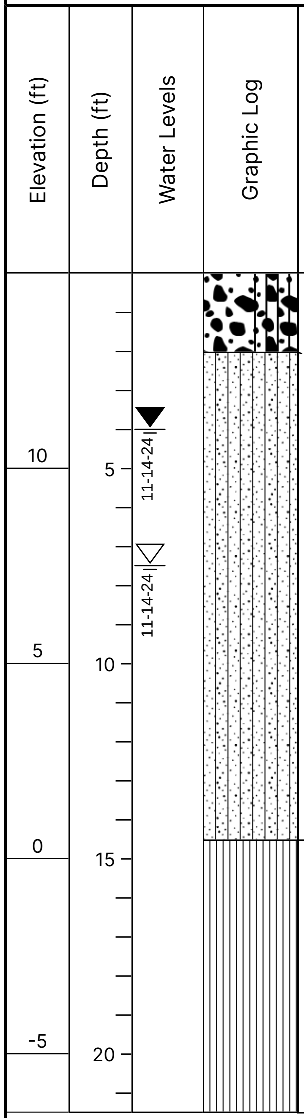
End of boring at 46.5'



Tillamook Housing

Soil Boring: B-10

Date Started:	11/14/2024	Date Completed:	11/14/2024	Project No:	O053.011
Client Name:	CHA Consulting, Inc.	Project Address:	920 West 3rd Street, Tillamook, Oregon	Surface Elevation:	~15.0'
Drilling Firm:	Holt	Logged By:	Adrienne Venegas	Checked By:	Joseph Schmidt
Method:	Auger	Hammer Type:	Auto	Hammer Efficiency:	86%
Depth:	21.5'	Boring Diameter:	8 in	Lat Lng:	45.456653, -123.857850



Visual Classification and Remarks

FILL, dense to very dense, dark brown, wet, angular, **Poorly Graded Gravel** with **Sand & Silt** (GP-GM), up to 4 inches in diameter 2.0

FILL, very loose, black, wet, **Silty Sand** (SM), fine- to coarse-grained, low plasticity fines, abundant organics

Abundant wood debris below ~5 feet bgs.

Wet, trace angular gravel up to 1 inch in diameter below ~7.5 feet bgs.

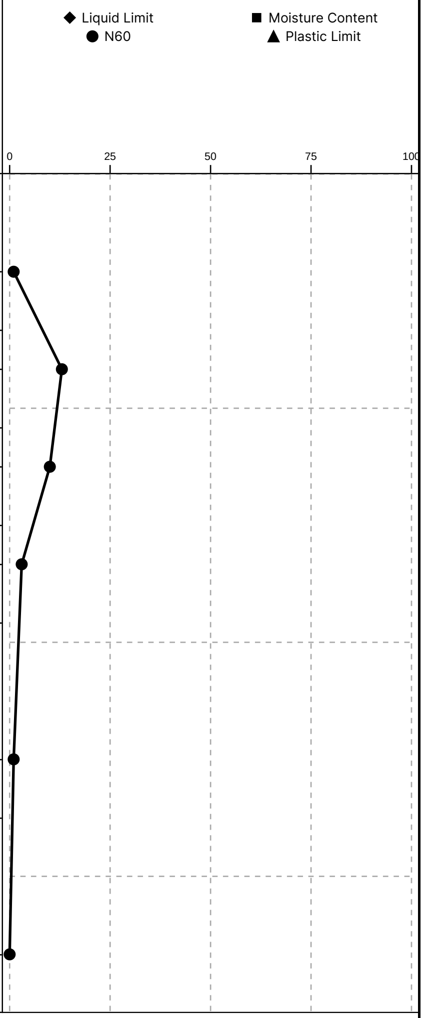
14.5

Very soft, dark gray to brown, moist, **Sandy Silt** (ML), low plasticity, fine-grained sand, abundant organics

21.5

End of boring at 21.5'

Samples			
Depth of Sample (ft)	% Recovery	Blow Counts (N/Refusal)	N60
0.5 ft	100		
2.5 ft	89	1 0 1 (1)	1
5 ft	78	0 5 4 (9)	13
7.5 ft	33	2 3 4 (7)	10
10 ft	11	2 1 1 (2)	3
15 ft	100	0 0 1 (1)	1
20 ft		0 0 0 (0)	0

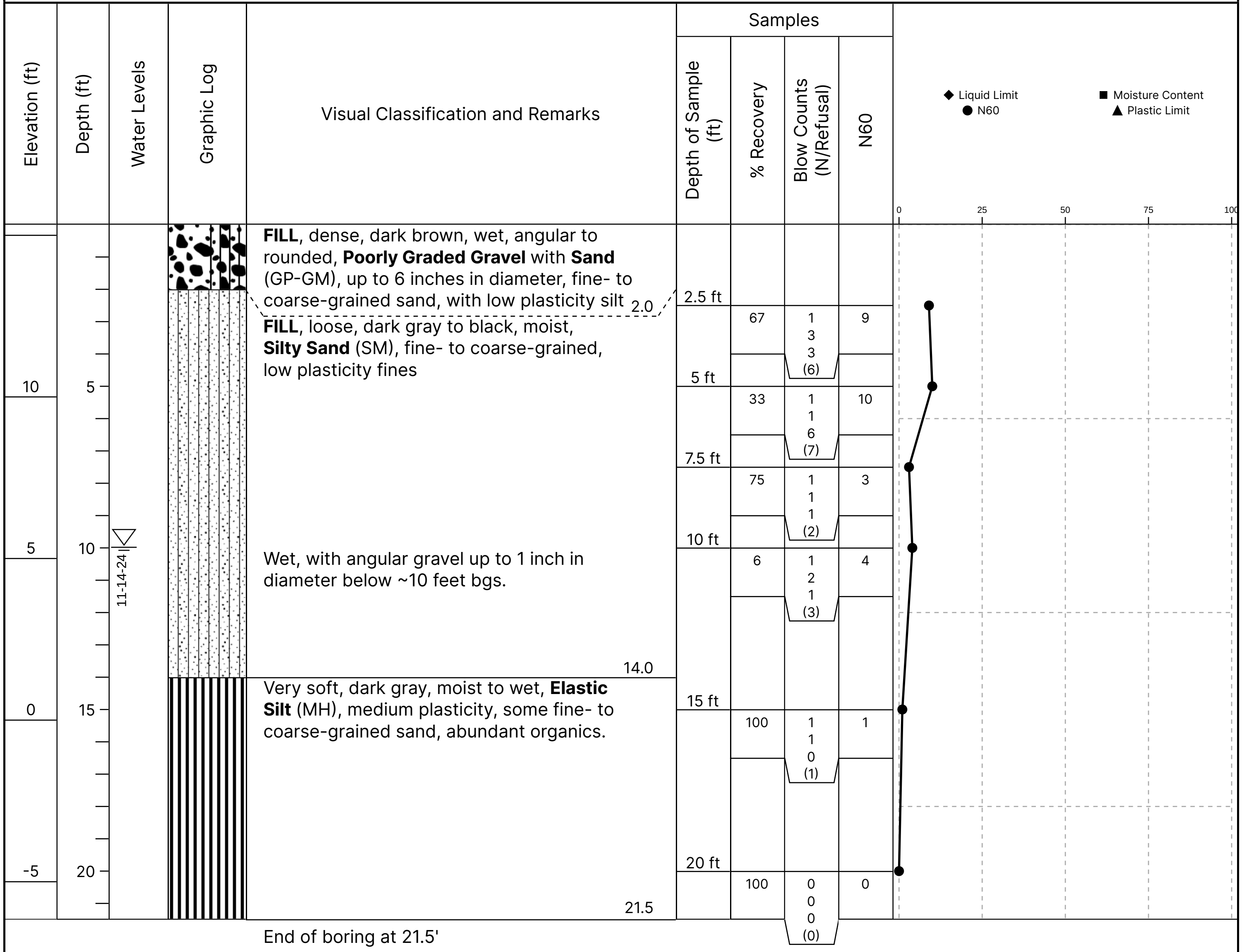


terraphase engineering

Tillamook Housing

Soil Boring: B-11

Date Started: 11/14/2024
Date Completed: 11/14/2024
Project No: O053.011
Client Name: CHA Consulting, Inc.
Project Address: 920 West 3rd Street, Tillamook, Oregon
Surface Elevation: ~15.3'
Drilling Firm: Holt
Logged By: Adrienne Venegas
Checked By: Joseph Schmidt
Method: Auger
Hammer Type: Auto
Hammer Efficiency: 86%
Depth: 21.5'
Boring Diameter: 8 in
Lat Lng: 45.456554, -123.857871



Depth (ft)	Visual Classification and Remarks
0–2.0	**FILL**, dense, dark brown, wet, angular to rounded, **Poorly Graded Gravel** with **Sand** (GP-GM), up to 6 inches in diameter, fine- to coarse-grained sand, with low plasticity silt
2.0–14.0	**FILL**, loose, dark gray to black, moist, **Silty Sand** (SM), fine- to coarse-grained, low plasticity fines Wet, with angular gravel up to 1 inch in diameter below ~10 feet bgs.
14.0–21.5	Very soft, dark gray, moist to wet, **Elastic Silt** (MH), medium plasticity, some fine- to coarse-grained sand, abundant organics.

End of boring at 21.5'

Depth of Sample (ft)	% Recovery	Blow Counts (N/Refusal)	N60
2.5 ft	67	1 3 3 (6)	9
5 ft	33	1 1 6 (7)	10
7.5 ft	75	1 1 1 (2)	3
10 ft	6	1 2 1 (3)	4
15 ft	100	1 1 0 (1)	1
20 ft	100	0 0 0 (0)	0

Appendix C

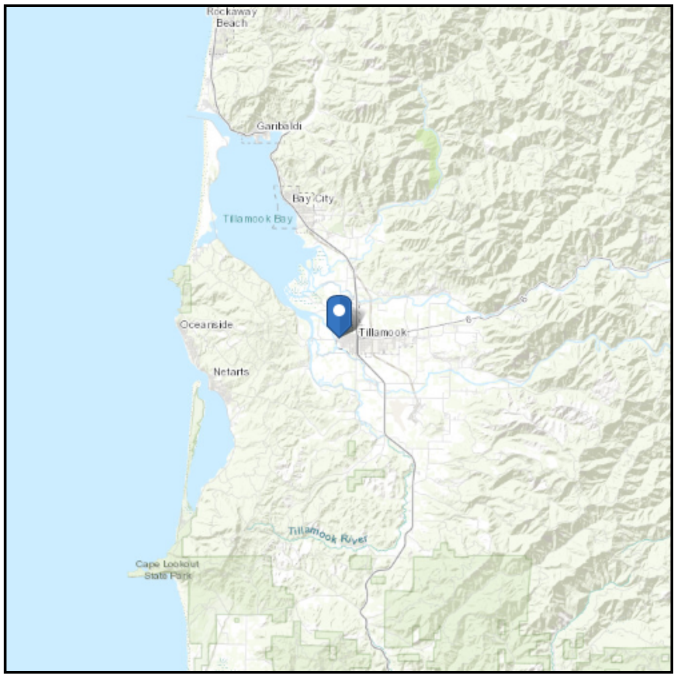
ASCE Hazards Report

ASCE Hazards Report

Address:
920 3rd St
Tillamook, Oregon
97141

Standard: ASCE/SEI 7-16
Risk Category: II
Soil Class: E - Soft Clay Soil

Latitude: 45.45636
Longitude: -123.857057
Elevation: 17.73847895673892 ft (NAVD 88)



Seismic

Site Soil Class: E - Soft Clay Soil

Results:

S_S :	1.231	S_{D1} :	N/A
S_1 :	0.64	T_L :	16
F_a :	N/A	PGA :	0.607
F_v :	N/A	PGA_M :	0.668
S_{MS} :	N/A	F_{PGA} :	1.1
S_{M1} :	N/A	I_e :	1
S_{DS} :	N/A	C_v :	N/A

Ground motion hazard analysis may be required. See ASCE/SEI 7-16 Section 11.4.8.

Data Accessed: Wed Dec 11 2024

Date Source: [USGS Seismic Design Maps]

The ASCE Hazard Tool is provided for your convenience, for informational purposes only, and is provided “as is” and without warranties of any kind. The location data included herein has been obtained from information developed, produced, and maintained by third party providers; or has been extrapolated from maps incorporated in the ASCE standard. While ASCE has made every effort to use data obtained from reliable sources or methodologies, ASCE does not make any representations or warranties as to the accuracy, completeness, reliability, currency, or quality of any data provided herein. Any third-party links provided by this Tool should not be construed as an endorsement, affiliation, relationship, or sponsorship of such third-party content by or from ASCE.

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Appendix D

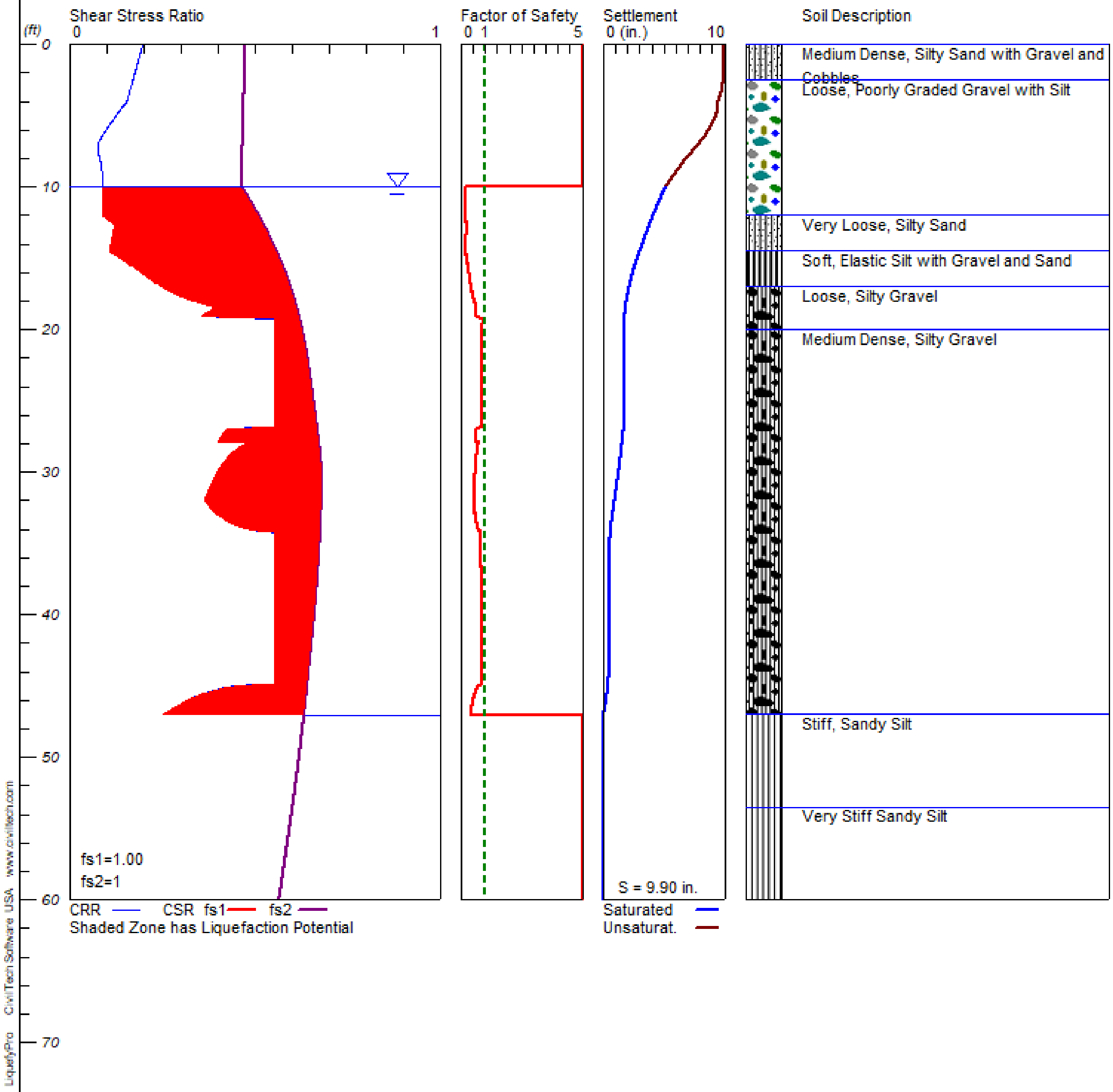
Liquefaction Analysis

LIQUEFACTION ANALYSIS

Tillamook Housing

Hole No.=B-8   Water Depth=10 ft

Magnitude=7.2
Acceleration=0.73g



920 W. 3rd St.2.

Plate A-1