NORTHWEST GEOLOGICAL SERVICES, INC.
***Consulting Geologists and Hydrogeologists***
2505 N.E. 42nd Avenue, Portland, Oregon 97213-1201
503-249-1093 ngs@spiritone.com

**Matthew & Crystal Perry** **27 September 2022**
**P. O. Box 5654**
**Salem, Or 97304**

Attention: Mr. & Ms. Perry

**Geologic Hazard Assessment**
**2828 Doaks Ferry Rd**
**7S/3W-8DA TL 7000**
**Salem, Oregon**

Dear Perrys:

The purpose of this letter is to present Northwest Geological Services, Inc. (NGS) Geologic Hazard Assessment for the above referenced property (Figure 1) as per your authorization of 9 September 2022. We understand that our services are in support of your effort to partition TL 7000 into 3 parcels (Figure 2).

## 1. Purpose and Scope of Study

City of Salem Planning rules indicate that partitioning and/or development of the site requires a geologic hazard assessment. The purpose of this letter is to meet that requirement.

For the study we conducted the following tasks:

- Reviewed USGS and DOGAMI hazard studies and geologic maps of the area;
- Obtained LIDAR data from Salem and NOAA;
- Reviewed historic aerial photographs and imagery;
- Conducted a site and area engineering geologic reconnaissance on 20 September 2022; and
- Prepared this letter-report.

## 2. Site Setting

The subject property (Figures 1, 2 and 3) consists of a 1.6-acre lot located on the southeast flank of Wallace Hill. It is on the east side of Doaks Ferry Rd NW, about 1200 ft north of the intersection with Brush College Rd NW. The site slopes southeast from Doaks Ferry Rd towards Gibson Creek (Figure 1). Site elevation ranges from ~256 msl at the NW corner down to ~215 at the SE corner (Figures 2 and 3). Natural slopes average 15%, while man-made slopes range from ~2% up to 56% (Figure 2).

## 3. Government Geologic Hazards Estimates

Salem relies on studies by DOGAMI and its own GIS to estimate potential geologic hazards. None of the available geologic mapping studies (Price, 1967; Bela, 1981; Beeson & Tolan, 2001) identified any nearby slope failures. Three other DOGAMI studies (Table 1) relied on these geologic maps to estimate hazards: GMS-105 by Wang and Leonard (1996); IMS-5 by Harvey and Peterson (1998); and IMS-18 by Hofmeister and Wong, 2000. DOGAMI and Salem compile and interpret these geologic and hazards into the DOGAMI online statewide hazard site SLIDO (Figure 4) and Salem compiles hazard information on its GIS (Figure 3).

Table 1 Summary of Government Hazard Estimates

| Source | Author | Hazards in Source | Hazards Estimated for Site |
|---|---|---|---|
| GMS-105 | Wang & Leonard (1996) | EQ liquefaction susceptibility | none |
| | | EQ amplification susceptibility | low (<1.4), but moderate on steeper slopes |
| | | EQ landslide susceptibility | low, but moderate along steeper slopes |
| | | EQ Relative Hazard Risk | lowest, intermediate along steeper slopes |
| IMS-5 | Harvey & Peterson (1998) | Water induced landslide risk | Low on slopes < 15% |
| | | | Moderate on slopes ≥15% |
| IMS-18 | Hofmeister & Wang (2000) | Earthquake induced landslides | low to moderate on steeper slopes |
| SLIDO | DOGAMI | Historic & active landslides | none |
| | | Landslide susceptibility | moderate to high on steep slopes (Figure 4) |
| GIS | City of Salem | Landslide Score (Points) | 2-3 points, 5 on steep slopes (Figure 3) |

## 3.1 GMS-105 Relative Earthquake Hazards Estimate

Wang and Leonard (1996) estimated the relative earthquake hazards from: soil amplification of ground shaking; liquefaction; and slope failure, from the available geologic mapping (in ~1995) and the USGS digital elevation model. The model estimated risk level on a 30 m grid. They estimated that liquefaction was unlikely. They also estimated that the NE part of the site has low (>1.2) amplification factor and the west part has Category 2 (>1.2 – 1.4). Wang and Leonard (1996) also estimated that the site low to intermediate risk of earthquake-induced landslide on slopes > 6 - 14°. They summarized the total relative earthquake hazard to range from “lowest” to “low to intermediate hazard”. The hazards estimated by GMS-105 do not appear to be included in the City Hazard map for the site.

## 3.2 IMS-5 Water Induced Landslide Hazard Estimate

IMS-5 (Harvey and Peterson, 1998) is the authoritative source for water induced landslide hazards in West Salem. Their study estimates a “low” risk on site slopes of 15% or less. They estimated a “Moderate” risk for slopes >15% and recommend subdivision scale engineering geologic and geotechnical studies for developing those slopes

## 3.3 IMS-18 Earthquake Induced Slope Instability Estimate

IMS-18 authors (Hofmeister and Wong, 2000) estimated a “Low - Moderate” relative risk rating for the most of the site on a scale of very low, low, moderate, and high risk. The hazards evaluated were failure of “…steep rock slope, soil slide and lateral spread…”. IMS-18 used slightly different methodology than GMS-105 to estimate relative risk. The method employed is, in our opinion, generally more realistic than that used by GMS-105.

### 3.4 SLIDO Landslide Hazard Estimate

Figure 4 shows the Statewide Landslide Information Database for Oregon (SLIDO) compilation for the site area. According to SLIDO there are no nearby historic slope failures and no previous studies showing prehistoric failures nearby. Neither the topography nor LIDAR (Figures 2 and 3) show anomalies that indicate slope failures at or near the site. However, SLIDO estimates an overall moderate to high landslide potential for slope near the center of Figure 4, center).

### 3.5 City of Salem GIS Estimate

Salem's GIS assigns hazard points based on available DOGAMI studies, slope and intended use of development. Figure 3 shows LIDAR contours and landslide hazard points plotted on a mid-2010s aerial photo base. The flattest site areas are assigned 2 points, midslopes 3 points and moderate to moderately steep slopes 4 points. The GIS points largely correspond with the recommendations of the State studies IMS-5 and IMS-18.

## 4. Site Setting and Engineering Geology

### 4.1 Site Setting and History

The 1917 USGS Salem Quadrangle shows Doaks Ferry Rd built, but nothing at the site. Subsequent maps and historic aerial photos indicate the site was farmed together with adjacent properties through the 1950s. The USGS 1967 air photo shows the house and gardens on site. Air photos indicate the parcels were farmed for grass, hay or grains as were those to the north. Parcels to the south were orchards until developed in the early 1990s. Parcels downhill to east were developed between 1967 and 1970. Homes on the west side of Doaks Ferry Rd were built between 1970 and 1984.

The 1944, 1954 and 1967 air photos show the result of grading to level the west ends of lots on the east side of Doaks Ferry Rd. The lots were leveled to established house sites and yards east of the house sites. On TL 7000 the yards were underlain by fill graded from the house sites. The fill consisted of the red-brown saprolite developed on the weathered basalt. The steeper slope across the south-center of TL7000 (Figure 2) is the east edge of that fill.

### 4.2 Site Engineering Geology

Published and unpublished geologic mapping by State and Federal agencies show that most of the site is underlain by lava flows of the Columbia River Basalt (Tcr, Figure 5). Mapping by USGS identified the basalt flows as part of the Winter Water basalt (Figure 6). Based on nearby exposures, depth to bedrock is probably no more than 5 to 10 ft in the west end of the site. The available geologic mapping suggests it could be 30 to 40 ft deep below the east end of the site where basalt is covered by Missoula Flood Deposits. The top several feet of the basalt are usually weathered to a hard to very hard clayey silt (laterite).

Bella (1981) mapped sediments overlying the TCR as Quaternary terrace deposits (Qth). However, he noted that some terrace deposits are similar to the Willamette Silt[1] and contain glacial erratics. Beeson and Tolan (2001) mapped site sediments as "Older alluvial deposits (Qoal)… poorly indurated glaciofluvial clays and silts deposited by the catastrophic (Missoula) Floods" (Figure 6). Our reconnaissance and work at nearby sites indicate the Qoal

[1] Willamette Silt is a local name for fine grained Missoula Flood deposits.

is comprised of fine-grained Missoula Flood deposits. At the site they are grey brown to tan, medium to stiff, very fine to fine sandy SILT thin laminae of silty very fine to fine SAND, both with a trace to some clay. The Qoal is laminated and contains fragments of wood. The stiff silt behaves like soft (RH-1) rock.

Test pits in the fine-grained Missoula Flood deposits at nearby sites (NGS, 2003; 2016; 2020) found the deposit becomes tan at 1.5 to 2ft depth and stiff to 4 ft (PP>4; Qv=2.5 to 6.5).

### 4.3 Site and Area Slopes

The natural slopes at the site are gentle (Figure 7) having been sculpted by the Missoula floods. They average 12% to 15%, except in the west area along Doakes Ferry Rd NW where house sites were graded. Site elevations range from a high of ~275 ft near the SW corner down to 215 at the SE corner. The steepest slopes are up to 56% along the east edge of the fill for 2828's back yard.

Our reconnaissance and review of maps and aerial photos indicate that the current and man-made site slopes have been in their present configuration since the mid-1950s, over 60 years. We found no evidence of slope failure on the site. Tall straight mature fir trees indicate very slow – if any -soil creep (Figure 7, top).

## 5. Geologic Hazards

The available geologic mapping suggests that there are no known slope failures at or near the site under natural conditions. The site slopes are gentle to moderate (Figure 7) and underlain by weathered basalt or up to 30+ ft of relatively indurated Missoula Flood deposits. Those deposits overlay the weathered to fresh basalt.

### 5.1 Potential for Earthquake Induced Geologic Hazards

The bedrock at the site is not susceptible to lateral spreading. In our experience the bedrock under the low to moderate slopes at the site has only a slight potential to fail during an earthquake. However, the Missoula Flood silts mantling the bedrock show a low susceptibility to soil creep that could indicate some slight potential for seismically-induced failures at the soil/bedrock interface and/or lateral spreading. The Missoula Flood deposits are >10,000 years old. There have been five very large and thirteen large Cascadia earthquakes during that span (Witter & others, 2011). No indicators of lateral spreading[2] have been reported by geologic mapping in the area nor have we found any at this, or nearby, sites.

The moderately-steep edges of the fills appear stable under current conditions. Experience along the Willamette and Columbia Rivers has shown the steep slopes cut into fine grained Missoula Flood deposits may fail during drawdown from saturation.

## 6. Conclusions and Recommendations

The site has a low susceptibility to landsliding under any natural geologic circumstance, in our opinion. In our experience, stiff to hard sandy clayey SILTs and silty fine SAND such as at the site are not unusually susceptible to slope spreading or liquefaction during strong ground motions from earthquakes unless fully saturated or under excess pore pressures. The basalt bed-

[2] E.g., vertical or high-angle fissures or microfaults, clastic dikes or contorted bedding.

rock is at shallow depth and is certainly not susceptible to failure of any sort during earthquakes. Thus, the site does not appear to be at significant risk from the other forms of slope instability evaluated by IMS-18.

The remaining earthquake related risk is the GMS-105 assignment of the site to an area of 4 (out of 5) for relative amplification hazard. In our experience and our reading of the literature, indurated SILT acts like weathered bedrock or very stiff soil during ground shaking. Yet, soils that typically cause amplification are more apt to be unconsolidated silty and/or clayey soils and are usually of a significant thickness. Neither the soil thickness nor nature required for significant amplification appears present at the site.[3]

Finally, in our opinion, the development proposed for this site (Figure 2) should not create new or exacerbate existing geologic hazards. However, we caution that site drainage should be professionally designed to maintain low heads in the Missoula Flood deposits.

Cuts, fills and pavements should be designed by a qualified professional and reviewed by a geotechnical engineer. Foundations and retaining walls should also be designed by a qualified engineer to withstand forces from soil creep and lateral loads from earthquakes. Given the thin soils and shallow depth to the stiff SILT and/or weathered basalt, this requirement should not be onerous.

In our opinion, footing drains for new structures could be routed to infiltration trenches, to diffusers downhill from structures or to the area storm sewer, if available. Neither option should have a measurable impact on the ground water or drainage ways at the site because the volume of water will be small. However, we recommend against infiltration of large volumes of storm water into small volumes of the ground (i.e., disposal to drywells), particularly during intense rainfall events. The soils do not have the capacity to take large volumes of storm water in a short time. Infiltration trenches that diffuse the water and storm water retention facilities have both been successfully employed in the Missoula Flood deposits. Any such facilities should be designed and constructed in consultation with the project geotechnical engineer.

In our opinion, development of the new parcels as proposed should not increase the potential for slope hazards on the site or adjacent properties, given the above caveats. We repeat that it would be prudent to conduct geotechnical investigations of any infrastructure or structures that require deep fills (>2 ft), or high cuts (>4 ft).

## 7. LIMITATIONS AND LIABILITY

The area is changing through development, evolution of the terrain by weathering and erosion and by global warming. Such factors may change the balance between ground water, evapotranspiration, vegetation and soil and rock properties. Consequently, the interpretation and recommendations presented herein are limited to the near future and are limited to this specific project. For this report near future is defined as the next 5 years and this project as the improvements shown on Figure 2, herein.

We call your attention to the paragraphs on Warranty and Liability in the General Conditions dated 1/2022 and approved previously. Interpretations and recommendations presented herein are based on limited data and observations. Actual subsurface conditions may vary from

[3] We do not question that such conditions were present at DOGAMI's test boring ½ mile north of the site. However, it seems better to us to rely on well known, nearby geologic conditions rather than projection from a distance.

those inferred from the limited information available to us. If site excavations for development find conditions to differ significantly from those inferred herein, you should contact us and provide an opportunity for us to review our recommendations for the site.

We thank you for the opportunity to assist you with your project. Please contact me if you have questions about the report.

Yours very truly,
Northwest Geological Services, Inc.


*Expires 30 October 2023*

Clive F. (Rick) Kienle, Jr.
Vice President

NGS Reference 337.1-1

## 8. References Cited

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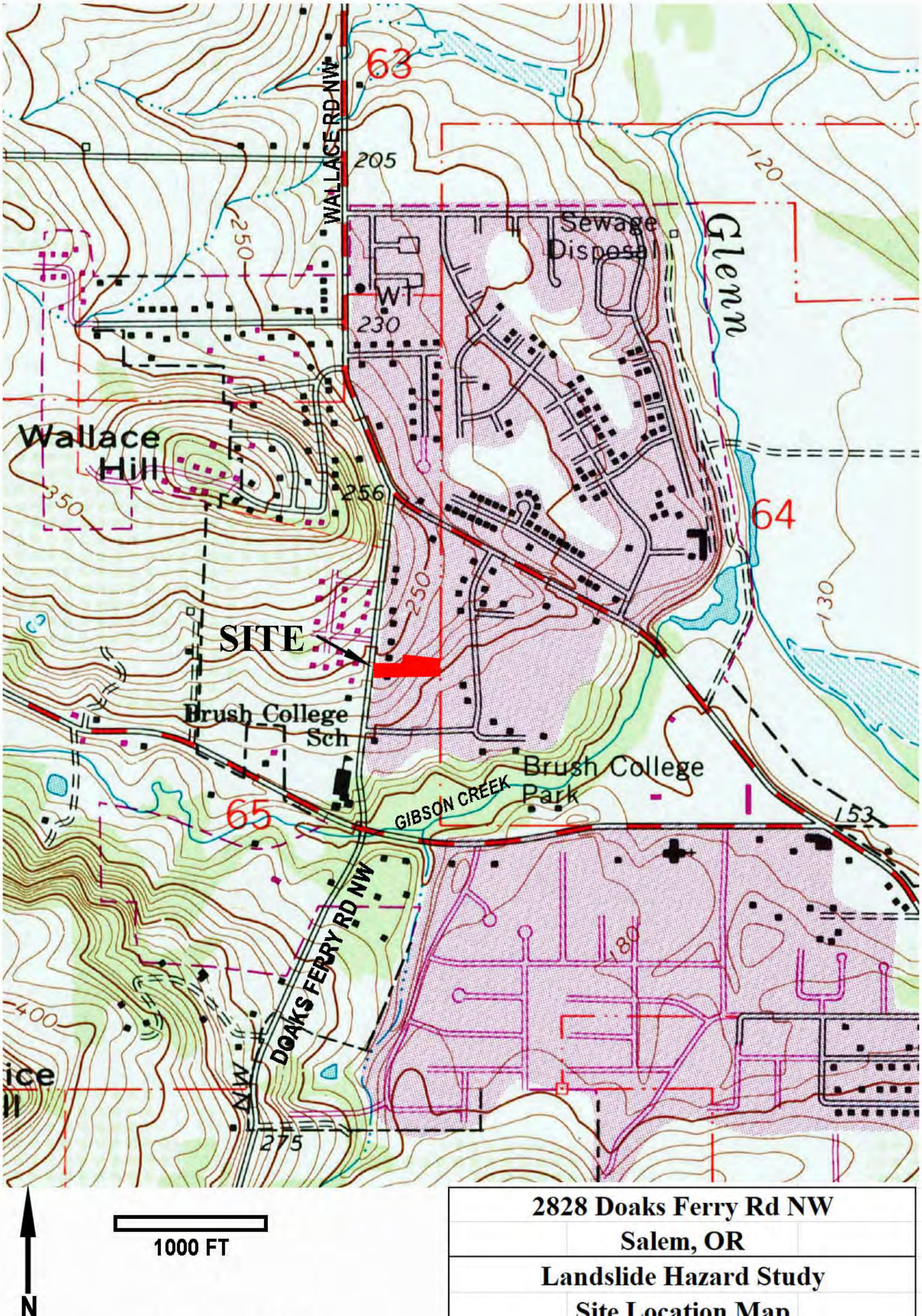



Base from USGS 1970
Salem W OR Quadrangle

| | | |
|---|---|---|
| **2828 Doaks Ferry Rd NW** | | |
| **Salem, OR** | | |
| **Landslide Hazard Study** | | |
| **Site Location Map** | | |
| NGS, Inc. | September 2020 | **Figure 1** |

PARTITION TENTATIVE PLAN
Matthew & Crystal Perry
PO Box 5654 Salem, OR 97304

Forty Five North Surveying, LLC
7230 3rd St. SE, Turner, OR 97392

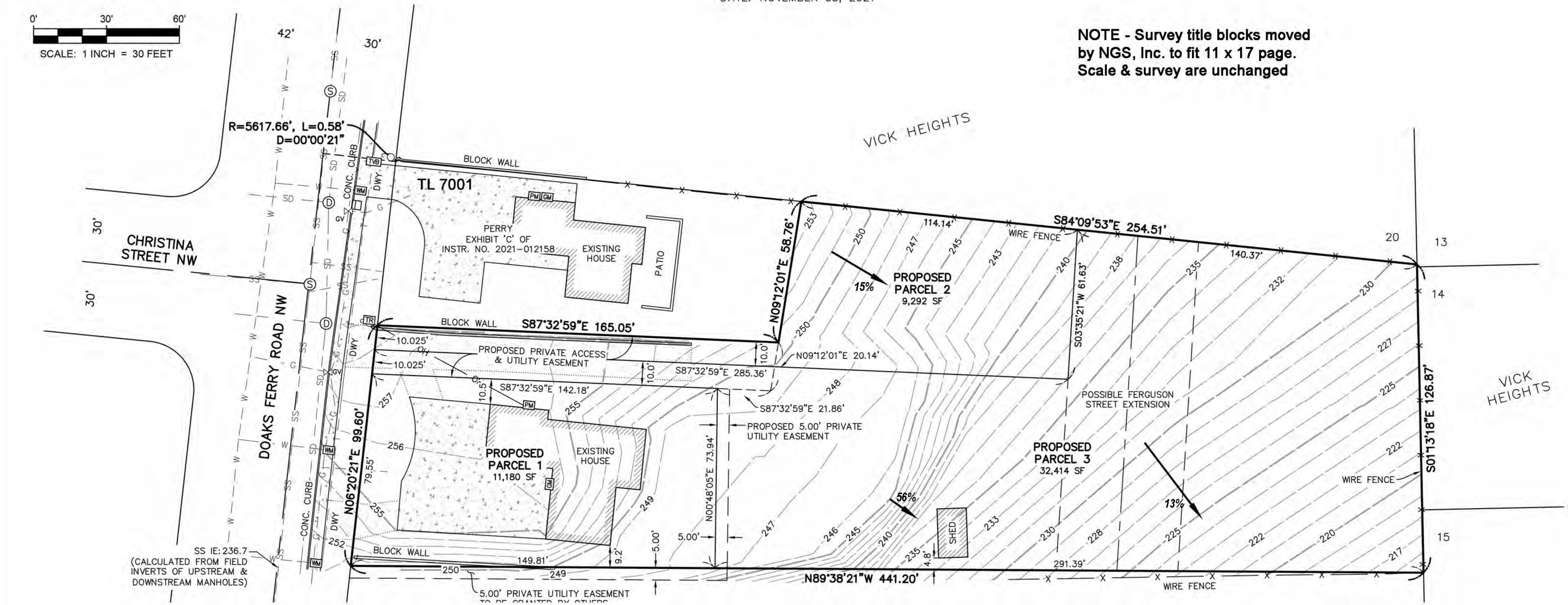
# EXISTING & PROPOSED CONDITIONS

IN THE SE 1/4 OF SECTION 8, T.7S., R.3W., W.M.
CITY OF SALEM, POLK COUNTY, OREGON

DATE: NOVEMBER 03, 2021

0' 30' 60'
SCALE: 1 INCH = 30 FEET

**NOTE - Survey title blocks moved by NGS, Inc. to fit 11 x 17 page. Scale & survey are unchanged**




## LEGEND

| | |
|---|---|
| (D) | STORM DRAIN MANHOLE |
| ⊟ | CURB INLET |
| (S) | SANITARY SEWER MANHOLE |
| WM | WATER METER |
| PM | POWER METER |
| | UTILITY POLE |
| TR | COMMUNICATION RISER |
| TVB | COMMUNICATION BOX |
| GV | GAS VALVE |
| GM | GAS METER |
| | CONCRETE |
| | GRAVEL |
| — — SS — — | SEWER LINE UNDERGROUND |
| — — SD — — | STORM LINE UNDERGROUND |
| — — W — — | WATERLINE UNDERGROUND |
| — — G — — | GAS LINE UNDERGROUND |
| — — T — — | COMMUNICATION LINE UNDERGROUND |
| —— OH —— | OVERHEAD POWER LINE |
| —— X —— | FENCE LINE |
| CONC | CONCRETE |
| DWY | DRIVEWAY |
| INSTR. NO. | DEED INSTRUMENT NUMBER |
| SF | SQUARE FEET |

56% *Slope estimated by NGS from contours on map*

## NOTES

1) BASIS OF BEARINGS IS THE OREGON COORDINATE REFERENCE SYSTEM "SALEM ZONE".

2) ELEVATIONS SHOWN ARE NAVD88 DATUM DERIVED FROM GPS OBSERVATIONS.

SURVEYED FOR: MATTHEW PERRY

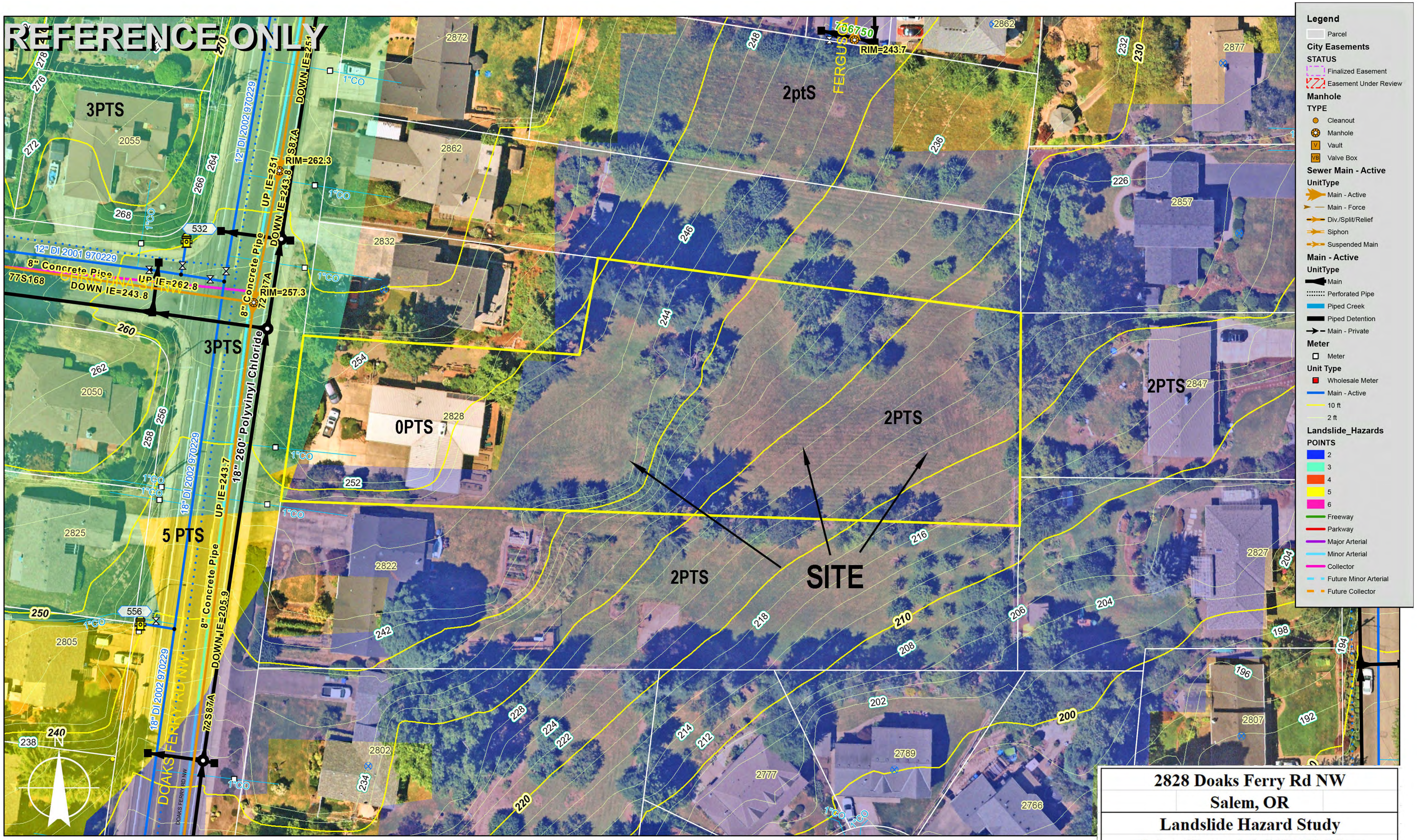
FORTY FIVE NORTH SURVEYING, LLC
7230 3rd Street SE #145, Turner, OR 97392
P: (503) 558-3330 E: info@ffnsurveying.com

JOB NO. 21-246

SHEET 1/1

REGISTERED PROFESSIONAL LAND SURVEYOR
DRAFT
OREGON
SEPTEMBER 12, 2017
STEVEN LEE HOWELL
91569
RENEWS: 6-30-2023

| | | |
|---|---|---|
| **2828 Doaks Ferry Rd NW** | | |
| **Salem, OR** | | |
| **Landslide Hazard Study** | | |
| **SITE SURVEY** | | |
| NGS, Inc. | September 2022 | **Figure 2** |




50 25 0 50 100 150 200 Feet

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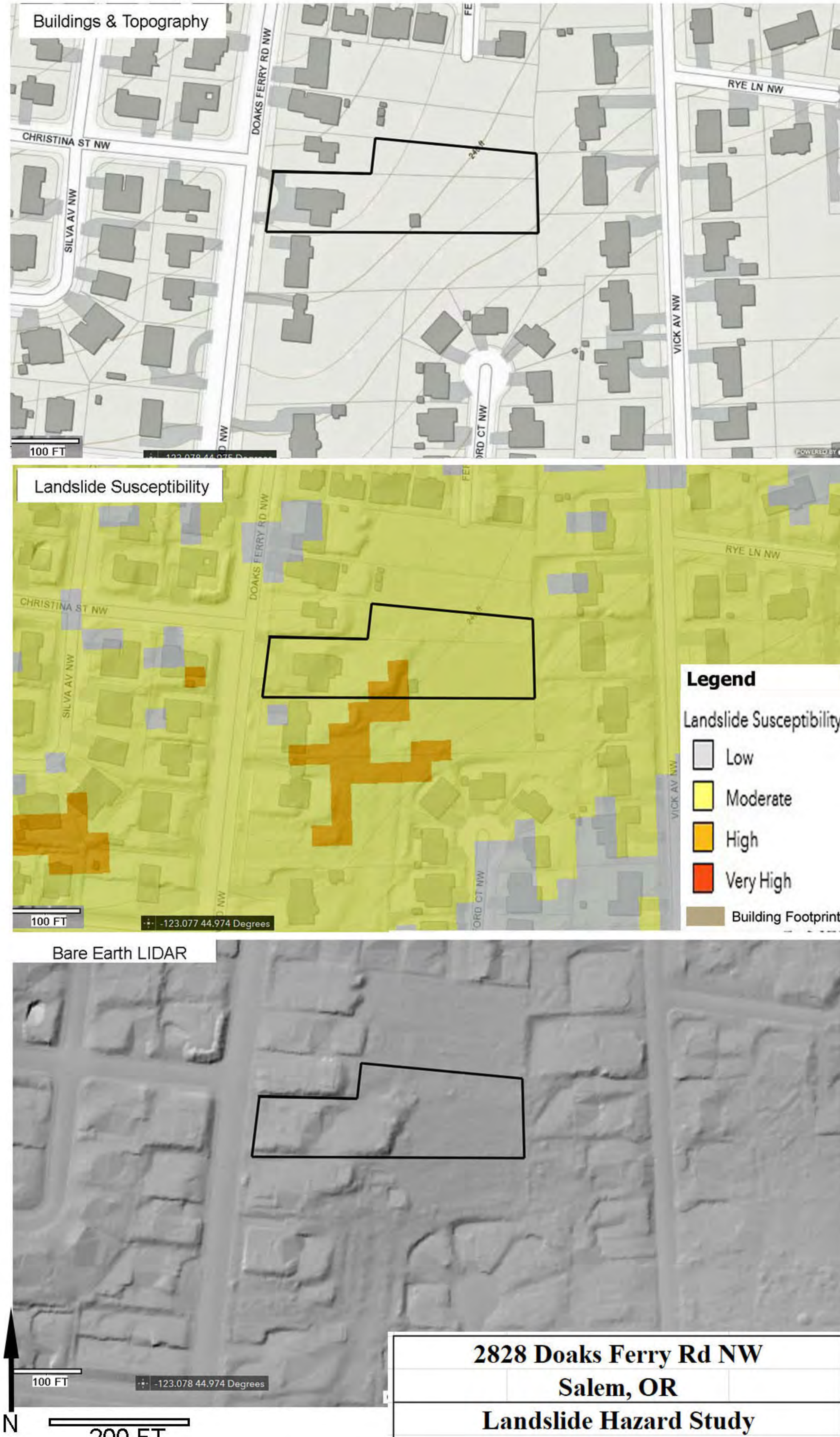
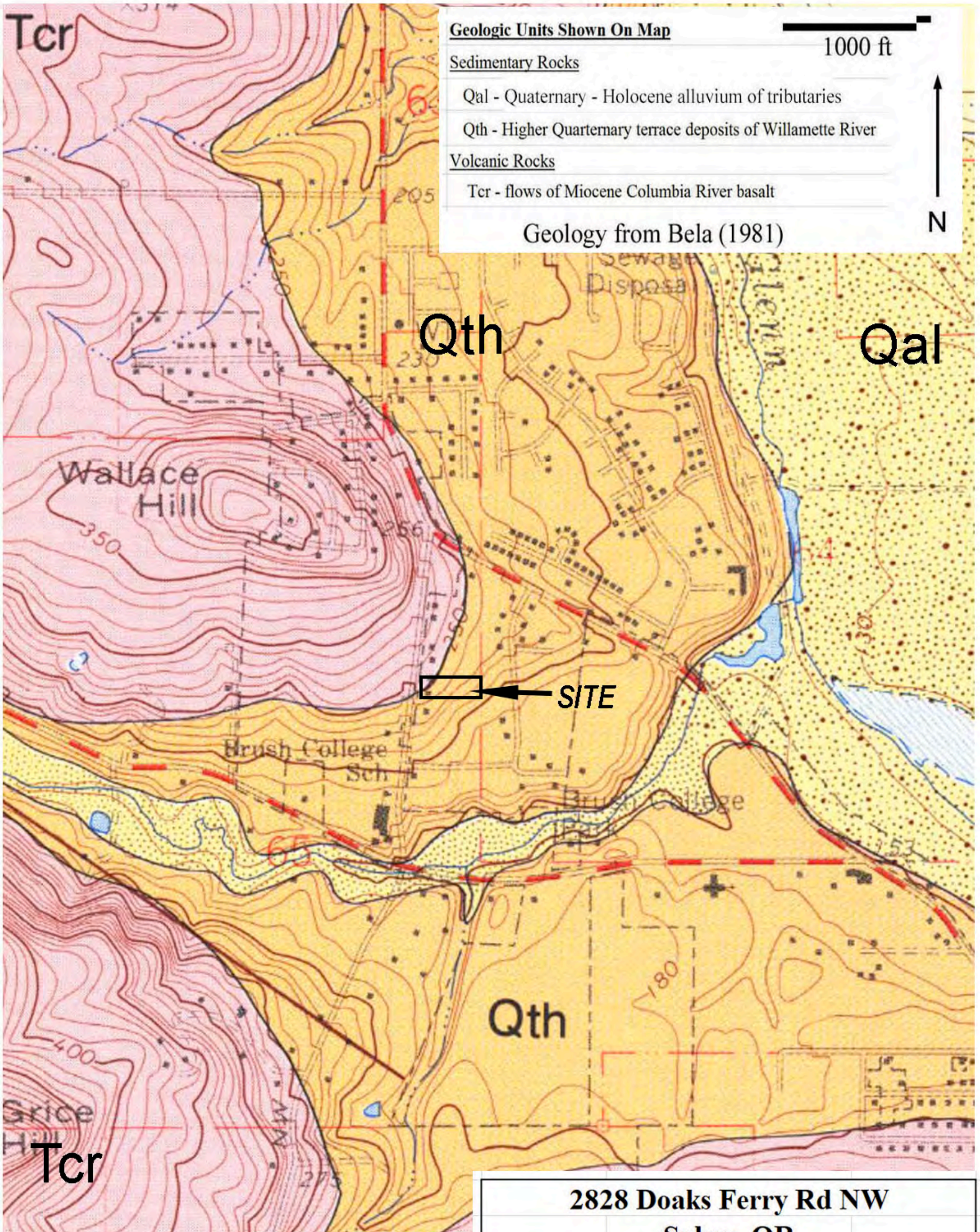
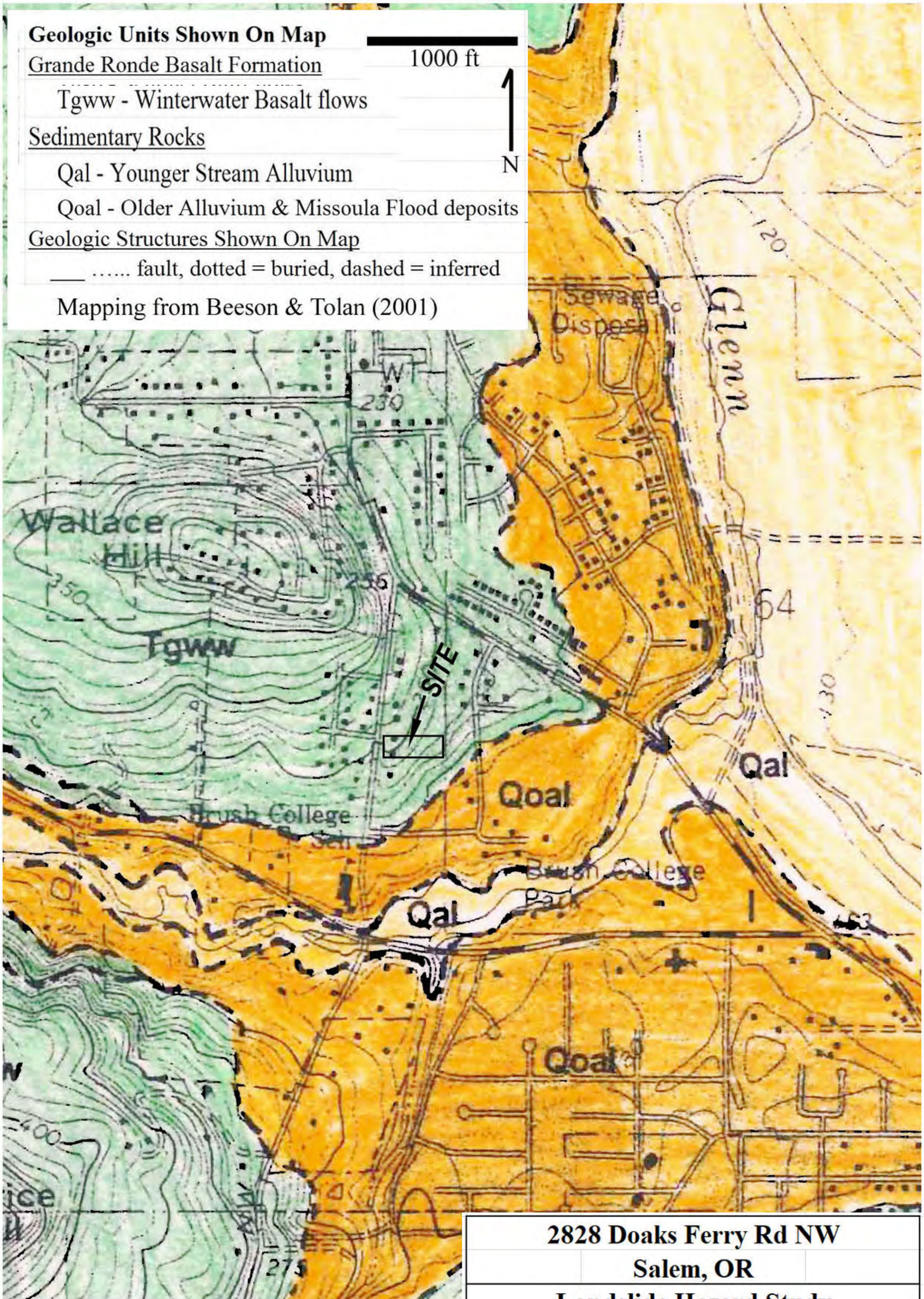
| 2828 Doaks Ferry Rd NW | | |
|---|---|---|
| Salem, OR | | |
| Landslide Hazard Study | | |
| Salem Hazard & LIDAR Map | | |
| NGS, Inc. | September 2022 | Figure 3 |




| 2828 Doaks Ferry Rd NW | | |
|---|---|---|
| Salem, OR | | |
| Landslide Hazard Study | | |
| SLIDO Hazard Maps | | |
| NGS, Inc. | September 2022 | **Figure 4** |




| 2828 Doaks Ferry Rd NW | | |
|---|---|---|
| Salem, OR | | |
| Landslide Hazard Study | | |
| USGS Geologic Map | | |
| NGS, Inc. | September 2022 | Figure 5 |




| 2828 Doaks Ferry Rd NW | | |
|---|---|---|
| Salem, OR | | |
| Landslide Hazard Study | | |
| DOGAMI Geologic Map | | |
| NGS, Inc. | September 2022 | Figure 6 |

ABOVE - Panorama looking S to SW across east end of site. Note the smooth 15% slope of the Missoula Flood deposits and that the mature conifers are straight and erect.


LEFT - Close up of the grey clayey, silty, fine sandy Missoula Flood deposits exposed at at ground surface. Where undisturbed, they are in thin graded beds. However, the hillside on & around the site was plowed repeatedy up to the the mid 1950s, destroying the original soil structure.

RIGHT - Red-brown residual soil developed on the weathered basalt exposed at west (uphill) end of the site. Note exrratic pebbles left by the Missoula Floods


LOWER LEFT - View west across NW part of site towards house on TL 7001. Note straight fir & redwood trees (left & center) at base of fill for house pad. Ponderosa at right is slightly tilted away from it's too-close neighbor, but straight & erect at the top. The transition from grey (foreground) to red soils marks where basalt emerges fom beneath the Missoula Flood deposits.

| | | |
|---|---|---|
| **2828 Doaks Ferry Rd NW** | | |
| **Salem, OR** | | |
| **Landslide Hazard Study** | | |
| **Site Photographs** | | |
| NGS, Inc. | September 2022 | **Figure 7** |