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June 17, 2015

Clark County Department of Environmental Services
Attn: Mr. Mike Davis, Leichner Landfill Project Manager
1300 Franklin Street
Vancouver, Washington 98660-9810

Re: Geotechnical Data Review and Geologic Site Reconnaissance – Phase 1_Updated
Leichner Campus Development – Koski Property
8713 Northeast 94th Avenue, Vancouver, Washington
PBS Project No. 72971.006

INTRODUCTION AND BACKGROUND

PBS Engineering and Environmental Inc. (PBS) is pleased to provide this letter report for geotechnical engineering services in support of a feasibility/due diligence review for the approximately 25-acre Leichner Campus Development Koski Property (project site) located along Northeast 88th Street in Clark County, Washington (Figure 1, Vicinity Map). The geotechnical services are being performed in two phases and this report provides our Phase 1 Geotechnical Data Review.

PBS understands Clark County (County) is currently planning to develop the approximately 25-acre project site that may be split into six 3- to 6-acre lots for commercial and/or light industrial development (Figure 2, Site Plan). The project site is part of the larger and adjacent closed Leichner Landfill property located at 9411 94th Avenue. A majority of the Leichner Landfill property, including the project site, was purchased by the County in December 2012, and the County has begun the master planning process to guide decisions about the future use of the site. The Leichner Campus Development–Koski Property is planned to be sold or developed by the County separately from other portions of the overall Leichner Landfill property.

PREVIOUS WORK SUMMARY

Due to its historical uses, the Leichner Landfill area, of which the proposed Leichner Campus Development–Koski Property is part, has been thoroughly studied for potential environmental impacts since the 1980s. These studies have included environmental-related research, borings, and remediation for Environmental Site Assessment (ESA) Phases I, II, and III. Where appropriate, the previous environmental work was used to provide preliminary geotechnical information for the Leichner Campus Development–Koski Property.

The project site has had several uses, with the most recent activities connected with maintaining and closing the Leichner Landfill. Current and historical uses have included the following:

- The approximately 25-acre project site is currently undeveloped except for a residence (McPerhson residence) located in the northeast corner.
- Historical residential (former Koski residence), livestock grazing, and agricultural uses.
- Soil borrow source for clean fill soil used at the adjacent Leichner Landfill.
- Historical (1940s) refuse burning and landfilling along the project site's northern boundary.
- Historical (from at least 1981 to 1990) stormwater retention pond for the Leichner Landfill located in the north-central portion of the project site.

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The primary data sources used for this letter-report were prepared by other consultants working with the Leichner Landfill site, and included those shown below. Additional sources are referenced as footnotes.

- SCS Engineers, September 29, 2014, Phase I Environmental Site Assessment, Koski Property, 8713 NE 94th Avenue, Vancouver, Washington 98662.
- Shaw Environmental, Inc., July 22, 2010, Two-Foot Contour Topographic Map, Leichner Brothers landfill, Clark County, Washington, 1: 1 800.
- Berger, August 6, 2014, Leichner Property Conceptual Planning Option 2, Industrial Subdivision – 88th Street Access.
- Environmental Borings within the Leichner Campus Development – Koski Property:[1]

Boring No.	Consulting Firm	Date Drilled	Total Depth (ft bgs)
LB-5C	Sweet-Edwards/EMCON	August 1989	94.5
LB-5D	Sweet, Edwards & Associates, Inc.	May 1987	135.7
LB-5S	Sweet, Edwards & Associates, Inc.	April 1987	93.5
LB-6S	Sweet, Edwards & Associates, Inc.	July 1987	44.5
LB-13C	Sweet-Edwards/EMCON	August 1989	201.5
LC-13D	Sweet-Edwards/EMCON	August 1989	96.0
LB-13I	Sweet-Edwards/EMCON	August 1989	54.3
LB-17C	Sweet-Edwards/EMCON	August 1989	81.1
LC-17D	Sweet-Edwards/EMCON	August 1989	105.3
LB-17I	Sweet-Edwards/EMCON	August 1989	60.5
LB-17S	Sweet-Edwards/EMCON	August 1989	213.9
LC-26D	EMCON Northwest, Inc.	August 1992	102.5
LB-26I	EMCON Northwest, Inc.	August 1992	56.0
LC-27D	EMCON Northwest, Inc.	August 1992	116.0
LB-27I	EMCON Northwest, Inc.	August 1992	56.0

[1] – Presented on Figure 3, Previous Borings with Site Annotations

HISTORICAL AERIAL PHOTOGRAPH AND TOPOGRAPHIC REVIEW

Aerial photographs were reviewed from those included in the SCS Engineers 2014 report, Google Earth images between 1990 and 2014, and Clark County's MapsOnline viewer. Detailed site changes from the aerial images reviewed by SCS were described in their 2014 report.

In addition, U.S. Geological Survey (USGS) historical topographic maps between 1961 and 2011 were reviewed. However, the contours shown on these maps are all similar and the site was used as a borrow source for the adjacent landfill. Therefore, we have used the Light Detection and Ranging (LiDAR) imagery contours provided in 2010 by the U.S. Army Corp of Engineers (USACE) to make an assessment of grading modifications. These data appear to be sourced from Clark County (2001) though this could not be confirmed.

Only pertinent aerial and topographic modifications that could affect future geotechnical engineering recommendations are summarized in Table 1. In addition to PBS' observations, information from SCS Engineers (2014) was also used (see Figure 3).

Table 1: Summary of Aerial Photograph and Topography Review

Year	Property
Up to 1981	Primarily used for agricultural purposes, but was otherwise predominantly undeveloped, except for the the Koski residence (two or three structures) located in the southwest corner and the McPerhson residence on the northwest corner of the property. A small area at the north-central boundary (where the northern boundary has a dogleg bend) appeared to be graded adjacent to the landfill. This is the location of a former stormwater retention pond. There are two areas along the northern portion of the subject property that have distinctive, semi-circular grass patterns and correlate with the approximate locations of the two former trash burn areas
1980 to 1990	Conditions were generally the same in the 1981 photograph, except that the site did not appear to be used for agriculture. In the 1990 photograph, a small dirt road was present that extended into the property at the approximate location of the former burn areas.
1990 to 2000	Conditions were generally the same in the 1990 photograph, including the Koski residence and McPerhson residence structures. One exception is a small area with a different grass appearance than the surrounding area. This feature was semicircular in shape and seems to correspond with the western former burn area. The stormwater retention pond was absent, presumably removed at the time the adjacent former burn areas were excavated. There appeared to be a depression within the semicircular grass area where an existing depression is located. The 1994[a] aerial image clearly shows the excavation of the eastern portion of the property as a borrow source area for the clean fill.
2000 to 2014	Conditions on the Subject Property and adjacent properties were generally the same as currently exists. The Koski residence structures were absent in the 2009 photograph.

[a] – 1994 Ortho, Clark County, Washington, http://gis.clark.wa.gov/mapsonline/?site=AerialPhotography&ext=1

LIDAR IMAGERY

LiDAR imagery was obtained from USACE covering the site. LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the earth. The elevation contours derived from the LiDAR data are presented on Figure 3 and a hillshade image on Figure 4. These light pulses, combined with other data recorded by an airborne system, generate precise three-dimensional information about the shape of the earth and its surface characteristics.

Figure 4 shows the borrow source area and the associated slopes on the eastern portion of the property as well as three other excavations along the southern boundary. Linear lines and structure-related grading are discernible along the western boundary. Other visible undulations in the site topography may be indications of past cut-and-fill areas and correlate with observations from the aerial photograph review.

SITE RECONNAISSANCE

A Licensed Engineering Geologist (LEG) from PBS completed a walking reconnaissance of the project site on April 10, 2015, which was performed by traversing the property to observe the current conditions and compare these with the data review findings. Observed features were marked on the 1994 ortho aerial obtained from Clark County's MapsOnline. The site was photo-documented and select pictures are presented in Attachment B.

The general topography of the site is flat with slopes along the eastern perimeter descending toward the property from the landfill on the north and residential developments on the east and south. These

slopes were graded and for the most part appear to be about 2H:1V (horizontal: vertical). Several depressions were also observed on the site. Three rectangular depressions are located along the south perimeter; these appear to be primarily for stormwater detention and are lined with large trees and shrubs. A north-south linear berm separates the eastern and western portions of the site. The former Koski and existing McPerhson residential structures are located in this portion. In the northern portion, the area is elevated about 3 to 6 feet above the rest of the property with a circular depression near the middle of its perimeter adjacent to the access road. The elevated area consists of two portions (see Figure 3): (1) a linear bench that extends from the east and adjacent to the access road to the circular depression, and (2) a roughly circular area that extends south and west away from the circular depression.

Vegetation consists primarily of small shrubs, grasses, and trees. In an effort to assist in determining areas of previous site grading, the types and condition of the vegetation growing on the property was closely observed. These included:

- Cut Areas – Sparse, dry vegetation could indicate areas of cuts since the soil would not have developed topsoil and primarily consist of sand and gravel that are exceedingly well drained based on the boring logs. These areas would also be flatter with vegetation growing in striations created by the grading equipment.
- Natural or Fill Areas – Well-established, green vegetation with thick grasses and small shrubs could indicate natural or fill areas since topsoil would not have been removed or would have been placed in piles. These areas would be more undulating or at a higher elevation than the surrounding area.

In general, the eastern half of the site has sparse vegetation and sandy/gravelly surface soils that extend to a berm near the west-center of the property; this likely indicates the area has been cut. A small area west of South Landfill Gas Plant south of the linear bench does have well-established grasses, which is due to water seepage from the storm drain system. The northern portion of the site is elevated above most of the property (with the exception of the circular depression discussed above), has established vegetative growth, and concrete debris was observed at the surface, suggesting this to be an area of fill. The western portion, with the exception of the former Koski residence pad, is lower in elevation but did have strong vegetative growth, indicating this is likely the natural, or at least the agricultural cultivated, surface. All of these observations generally coincide with the site disturbance and related dimensions observed in the 1994 aerial image (see Figure 3).

In general, the areas of the property with green grasses had dark brown, fine-grained soils exposed at the surface. Surface soils in areas of sparse and dry vegetation had sandier matrices and fine gravel. A few piles of fine to coarse, round gravel and round cobbles were observed in the eastern portion of the site.

No indications of slope instabilities along the perimeter or water ponding throughout the property were observed during the site visit.

GEOLOGIC SETTING

The site is located in the northeastern portion of the Willamette Lowland, a broad alluvial basin bordered on the west by Tertiary marine sedimentary and volcanic rocks of the Coast Ranges and on the east by Tertiary and Quaternary volcanic and volcaniclastic rocks of the Cascade Range. The northern boundary of the Willamette Lowland is generally recognized as the uplifted area north of the

Lewis River in southwestern Washington. The southern boundary is generally defined as the convergence of the Coast and Cascade Ranges just south of Eugene, Oregon.

Specifically, the project area is located in the Portland Basin, one of four separate basins within the Willamette Lowland. These basins include, from north to south: (1) the Portland Basin, (2) the Tualatin Basin northeast of the Chehalem Mountains and southwest of the Tualatin Mountains, (3) the central Willamette Valley between Salem and the Waldo Hills and the Chehalem Mountains, and (4) the southern Willamette Valley south of and including the Salem and Waldo Hills.[1] Basins within the Willamette Lowland and the tributary valleys are filled with over 1,600 feet of unconsolidated alluvial deposits derived from the surrounding uplands and the Columbia River Basin.[2] These deposits rest unconformably on a basement complex composed principally of the Columbia River Basalt Group. Fine-grained Miocene and Pliocene fluvial-lacustrine deposits occur near the bottom of the basin-fill deposits; coarse-grained fluvial deposits derived from the Cascade Range and the Missoula Floods generally comprise the upper 300 feet of the basin-fill deposits.

Widespread inundation of the lowland area occurred during the Missoula Floods, a series of more than 50 Pleistocene-age catastrophic floods believed to have originated at ancient Lake Missoula, Montana. These large-volume glacial outburst floods, originating approximately 12,000 to 15,000 years ago, deposited up to 250 feet of silt, sand, and gravel in the Portland Basin. Within the project area, these catastrophic flood deposits are mapped as Upper Pleistocene Outburst Deposits of Glacial Lake Missoula Flood Gravel (Qfg) coarse-grained unit of gravel with cobbles, boulders, and sand layers[3] (Figure 3, Geology Map).

The site lies within a tectonically active area that has undergone multiple structural deformation events. Several potentially active Quaternary faults are located in the vicinity of the site that includes the Lacamas Lake, Portland Hills, and East Bank faults.[4] The estimated age of the most recent events?faults? suggest possible offset on the Lacamas Lake fault probably occurred at least 15,000 years ago, while the Portland Hills and East Bank faults occurred within the last 15,000 years. In addition to the local crustal faults, the Cascadia Subduction Zone (CSZ), a major zone of plate convergence located offshore, is located approximately 100 miles west of the site. The CSZ extends from offshore northern California to southern British Columbia and may have generated at least seven great earthquakes (those of magnitude M8 or greater) in the last 3,500 years, suggesting a recurrence interval of approximately 300 to 600 years. Detailed tsunami records from Japan indicated the last significant CSZ earthquake occurred on January 26, 1700.[5] Atwater and others (2005) estimated the earthquake had a magnitude of between M8.7 to 9.2

[1] Gannett, M. W. and Caldwell, R.R., 1998, Geologic Framework of the Willamette Lowlands and Aquifer System, Oregon and Washington: U.S. Geologic Survey Professional Paper 1424-BG, 82 p.
[2] O'Connor, J.E., Sarna-Wojcicki, A., Wozniak, K.C., Polette, D.J., and Fleck, R.J., 2001, Origin, Extent, and Thickness of Quaternary Geologic Units in the Willamette Valley, Oregon: U.S. Geological Survey Professional Paper 1620, 52 p.
[3] Walsh, Timothy J., Korosec, Michael A., Phillips, William M., Logan, Robert L., Schasse, Henry W., Digital database by Meagher, Karen L., Haugerud, Ralph A., 1999, Geologic map of Washington - southwest quadrant (digital edition): U. S. Geological Survey Open-File Report 99-382, http://pubs.usgs.gov/of/1999/0382/.
[4] Beeson, M. H., Tolan, T. L., and Madin, I. P., 1991, Geologic map of the Portland quadrangle, Multnomah and Washington counties, Oregon: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-75.
[5] Atwater, B.F., Musumi-Rokkaku Satoko, M-R., Kenji, S., Yoshinobu, T., Kazue, U., Yamaguchi, D.K., 2005, The Orphan Tsunami of 1700—Japanese Clues to a Parent Earthquake in North America, U.S. Geological Survey, Professional Paper 1707.

NRCS SOIL DESCRIPTIONS

The Natural Resources Conservation Service (NRCS) provides information from local soil surveys through the U.S. Department of Agriculture (USDA) Web Soil Survey portal.[6] The soil surveys provide the mapped shallow soil unit that includes soil type, soil profiles, soil quality, and soil engineering characteristics. In addition, the soil survey also has suitabilities and limitations for various land use purposes based on the mapped soil units. Please note the NRCS soil descriptions are generalizations of the soil characteristics and do not always provide site-specific information for features, such as the depth to groundwater, since the soil units may cover a larger area than that being studied.

Table 2 provides the soil units mapped at the site and other applicable information to assist in determining the suitability and limitations of development. In general, soils with **more than** 5 percent of the total area are included.

The NRCS uses a rating system that combines soil characteristics (soil type and slope) to determine the suitability or limitations of a soil unit. Definitions of the ratings and criteria for the soil characteristics, or suitability/limitations, are provided in Attachment A.

Table 2: Summary of Applicable Soil Information

Soil Unit	**SvA - Sifton gravelly loam, 0 to 3 percent slopes**
Parent Material	Gravelly alluvium
Typical Profile (inches)	0 to 5 inches: gravelly loam 5 to 16 inches: gravelly loam 16 to 60 inches: very gravelly coarse sand
Unified Soil Classification (Surface)	GM
AASHTO Group Classification (Surface)	A-4
Slope (percentage)	0 to 3
Depth to Restrictive Layer	Depth to restrictive feature: 8 to 20 inches to strongly contrasting textural stratification
Natural Drainage Class	Somewhat excessively drained
Capacity of Most Limiting Layer to transmit Water	Moderately high to high (0.57 to 1.98 in/hr)
Depth to Water Table	More than 80 inches
Frequency of Flooding	None
Frequency of Ponding	None
Linear Extensibility (Shrink-Swell)	1.5 percent
Hydrologic Soil Group	B
Corrosion to Steel	High
Corrosion to Concrete	High
Mechanical Site Preparation (Surface)	Well Suited
Mechanical Site Preparation (Deep)	Well Suited
Local Roads and Streets	Not limited

[6] http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

SUBSURFACE CONDITIONS

Environmental Soil Boring Logs

Based on the available information, 15 environmental borings grouped into six clusters have been drilled at the project site between 1987 and 1992. Subsurface conditions encountered in the environmental borings were summarized in a remedial investigation (RI) amendment report dated October 7, 1991,[7] that showed the site is underlain by two distinct geologic units:

1. *Pleistocene alluvium consisting of sand and sand with gravel that is locally silty or clayey from the ground surface to a depth of about 70 to 100 feet below ground surface (bgs).*

   Where blow counts were recorded with 2- or 3-inch split spoon samplers (Standard Penetration Test N-values), the relative densities of the soil layers were variable. In general, the soil layers in the upper 30 to 35 feet contained gravel (gravelly sand, sand with gravel, sand with trace gravel, etc.) and were medium dense to very dense. Soil layers below these depths and above the underlying Troutdale Formation were generally loose to medium dense and did not contain gravel (silty sand, sand, etc.). The types of hammers and its efficiencies on the various drill rigs used to drill the borings were not provided on the available logs.

   Based on our data review and site reconnaissance, fill containing rubble, debris, organics, and other deleterious materials may be present in the upper 10 feet in the northern portion of the project site. PBS understands burn materials were previously removed from the site[8,9,10,11].

   The borings on the eastern portion (LB-5C, LB-5D, and LB-5S) were drilled prior to the area's use as a clean fill source for the adjacent landfill. Therefore, the upper 10 to 20 feet shown in the boring logs has been removed and the depth to groundwater will be shallower than those indicated.

2. *Pliocene Troutdale Formation predominantly consisting of gravel with a fine sand and silt matrix that is weakly to moderately cemented.*

   Where the borings extended into the Troutdale Formation, relative densities were very dense with blow counts per foot typically being greater than 50 blows per 6 inches.

[7] Sweet-Edwards/EMCON, Inc., 1991, Leichner Landfill, Remedial Investigation Amendment, Volume 1, Administrative Order DE 89-S119, prepared for the Leichner Brothers Land Reclamation Corporation, Vancouver, Washington, October 7.

[8] EMCON Northwest, Inc., 1992a, Letter (Re: Burn Area Study, Leichner Landfill), prepared for Washington State Department of Ecology, Olympia, Washington, and Southwest Washington Health District, Vancouver, Washington, April 21, 1992.

[9] EMCON Northwest, Inc., 1992b, Memorandum (Re: Leichner Landfill, Burn Area Excavation/Remediation), prepared Leichner Brothers Landfill Reclamation Corporation, Vancouver, Washington, June 8.

[10] EMCON Northwest, Inc., 1992c, Letter (Re: June 1992 Progress Report for the Leichner Landfill Project), prepared for Washington State Department of Ecology, Olympia Washington, July 8.

[11] EMCON Northwest, Inc., 1992d, Letter (Re: August 1992 Progress Report for the Leichner Landfill Project), prepared for Washington State Department of Ecology, Olympia Washington, September 14.

Table 3. Depth to Troutdale Formation in the Borings Located on the Leichner Campus Development – Koski Property

Boring Number	Depth to Troutdale Formation (ft bgs)
LB-5C	94
LB-5D	87
LB-5S	87
LB-13D	70
LB-17C	80
LB-17D	80
LB-26D	68
LB-27D	82

Groundwater
The hydrostratigraphy at the site consists of an approximately 35-foot-thick unsaturated zone of sand and gravel, an unconfined to semi-confined zone about 35 to 55 feet thick, and a semi-confined to confined aquifer in the Troutdale Formation. However, historical groundwater data collected as part of the Leichner Landfill post-closure monitoring program indicate groundwater occurs beneath the property between depths ranging from 12 to 19 feet bgs in the eastern portion and 17 to 37 feet bgs in the western portion with flow generally toward the west-southwest (SCS, 2014).

GEOLOGIC AND SEISMIC HAZARDS

Geologic and seismic hazards are defined as those conditions associated with the geologic and seismic environment that could influence existing and/or proposed improvements. In general, the geologic and seismic hazards most commonly associated with the physical and chemical characteristics of near-surface soil, rock, and groundwater include:

Geologic Hazards:

- Slope stability
- Subsurface voids
- Erosion and sedimentation
- **Hazardous minerals and gases**
- Adverse soils
- **Hydrology and drainage**
- Permafrost and freeze-thaw
- Land subsidence
- Volcanic hazards
- Hydrogeology and groundwater

Seismic Hazards:

- **Liquefaction**
- Fault ground rupture
- **Earthquake-induced landslides**
- **Lateral spreading**
- Tsunami and Seiches
- **Ground shaking**
- Seismically-Induced Settlement

Those shown in **bold** above are geologic and seismic hazards that could affect the study areas' development and should be considered in the planning process. Specific hazards are presented below in Table 4. The "Level of Concern" is a qualitative assessment based on our engineering geology and engineering judgment. Where noted with footnotes, the terminology is taken from a specific source (i.e. HazVu).

Table 4: Summary of Potential Geologic and Seismic Hazards

Geologic and Seismic Hazard	Examples	Level of Concern
Adverse Soils	Artificial Fill Expansive Soil Compressible Soil Organic-Rich Soil Sensitive Clay	High Low Low to Moderate Low to Moderate None
Hydrology and Drainage	Flooding[a] Seiches or Standing Water Dam Inundation	Not mapped within a flood zone, unknown impacts in the eastern portion None Unknown
Hazardous Minerals and Gases	Methane gases	To be Considered
Seismic Hazards	Earthquake Hazard - NEHRP[b] Local Fault Rupture Liquefaction and Lateral Spread[b] Seismically-Induced Settlement Seismically-Induced Slope Instability Tsunami	Site Class C Very Low Very Low Low None None

[a] – FEMA Map Number 53011C0387D, effective on09/05/2012.
[b] – Clark County MapsOnline, http://gis.clark.wa.gov/mapsonline/?site=GeoHazards&ext=1

The primary geologic hazard to consider in the site's planning and development, in our current opinion, is the presence of variable and undocumented fill. These materials may consist of backfill and general undocumented fill throughout the area.

The primary seismic hazards are most likely ground shaking and susceptibility to liquefaction (mapped as "very low"). The soils and soft sedimentary rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density.

The IBC-2012 methodology defines six soil categories that are based on average shear-wave velocity in the upper 100 feet (30 meters) of the soil column. The shear-wave velocity is the speed with which a particular type of ground vibration travels through a material, and can be measured directly by several techniques. The six soil categories are Hard Rock (A), Rock (B), Very Dense Soil and Soft Rock (C), Stiff Soil (D), Soft Soil (E), and Special Soils (F). Based on Clark County MapsOnline, the site is shown as a Site Class C. Additional seismic considerations are presented in the Preliminary Conclusions and Recommendations Section below.

Liquefaction is a phenomenon in which shaking of a saturated soil causes its material properties to change so that it behaves as a liquid. Soils that liquefy tend to be young, loose, granular soils that are saturated with water.[12] Unsaturated soils will not liquefy, but they may settle. Typical displacements can range from inches to feet. Thus, if the soil at a site liquefies, the damage resulting from an earthquake can be dramatically increased over what shaking alone might have caused. Although the area is

[12] National Research Council (U.S.), 1985, Liquefaction of soils during earthquakes, Committee on Earthquake Engineering Research, National Science Foundation (U.S.), Washington, D.C. : National Academy Press

mapped as “very low” liquefaction susceptibility, a more detailed analysis will be performed during Phase 2 per State of Washington code.

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Based on our research and reference information and documents, the site conditions, in our current opinion, are suitable for the proposed Leichner Campus Development–Koski Property but will require further specific geotechnical explorations and analyses during design and construction. The geotechnical-related considerations include:

- The site uses of the property throughout its history have resulted in variable, deleterious fill materials that will impact excavations and foundation performance. Potential areas of fill should be investigated and over-excavation and replacement may be required prior to or during construction (see Figure 3).
- Subsurface conditions on the eastern portion of the property will be 10 to 20 feet shallower than those represented on the boring logs because of apparent site cuts.
- The site is mapped as “very low” liquefaction susceptibility. However, liquefaction will need to be further evaluated based on the conditions encountered in additional geotechnical borings.
- Ground shaking will occur at the site during an earthquake and the site is mapped by Clark County as Site Class C. Actual site class will need to be further evaluated based on the actual conditions encountered in the geotechnical borings.

Seismic Considerations: New buildings will be designed in accordance with the requirements of the 2012 International Building Code (IBC) with Washington-specific amendments, or subsequent editions. The 2012 IBC requires buildings be designed to consider ground motions from the risk-targeted maximum considered earthquake (MCE_R), defined by the IBC as an earthquake with a 2,500-year return interval (probability of exceedance of 2 percent in 50 years). The IBC recommends that the effects of site conditions on building response be determined using site factors, Fa, and Fv, based on site classification defined as follows:

SITE CLASS A, HARD ROCK – a profile with rock characterized by a shear-wave velocity greater than 5,000 feet per second (ft/s).

SITE CLASS B, ROCK – a profile with rock characterized by a shear-wave velocity of 2,500 to 5,000 ft/s.

SITE CLASS C, VERY DENSE SOIL AND SOFT ROCK – a profile characterized by: average soil shear-wave velocity from 1,200 to 2,500 ft/s; average Standard Penetration Resistance, N, greater than 50 blows/ft; and average soil undrained shear strength, Su, greater than 2,000 pounds per square foot (psf).

SITE CLASS D, STIFF SOIL – a profile characterized by: average soil shear-wave velocity less than 600 ft/s; average Standard Penetration Resistance, N, less than 15 blows/ft; average soil undrained shear strength, Su, from 1,000 to 2,000 psf.

SITE CLASS E, SOIL – a profile characterized by: average soil shear-wave velocity from 600 to 1,200 ft/s; average Standard Penetration Resistance, N, of 15 to 50 blows/ft; and average soil undrained shear strength, Su, less than 1,000 psf, or any profile with more than 10 feet of soft

clay defined as soil with plasticity index, PI, greater than 20, water content greater than 40 percent and undrained shear strength, Su, less than 500 psf.

SITE CLASS F – a profile for any soils requiring site-specific evaluation, such as: more than 10 feet of peat or highly organic clays; more than 25 feet of very high plasticity clay with plasticity index, PI, greater than 75; or more than 120 feet of soft/ medium stiff clay.

Foundations Considerations: Our current understanding of the planned site development is that it will be for light industrial and commercial use. Depending on the building height and anticipated subsurface soils, we anticipate the foundation type most likely will be spread footings. Typical column loads and the estimated allowable soil bearing pressures for these conditions is provided in Table 5.

Table 5: Potential Foundation Type

Foundation Type	Column Load (kips)	Estimated Allowable Soil Bearing Pressure (psf)
Shallow Foundation – Spread Footing	Less than 200	2000 to 3000

Construction Considerations: In general, all vegetation, topsoil and existing structural elements (slabs, footings, etc.) should be removed from new building and pavement areas. Construction of the proposed new buildings may require areas of over-excavation.

Due to the presence of fine-grained silt and clay in the near-surface materials in some areas of the site, construction equipment may have difficulty operating on the near-surface soils when above the optimum moisture required for compaction. Construction of granular haul roads placed over geo-textile stabilization fabric may help reduce disturbance of site soils. The thickness of the granular material for haul roads and staging areas will depend on the amount and type of construction traffic.

All excavations should be made in accordance with applicable Occupational Safety and Health Administration (OSHA) and state regulations. The contractor is responsible for adherence to the OSHA requirements. Trench cuts may stand relatively vertical to a depth of approximately 4 feet, provided no groundwater seepage is present in the trench walls. Open excavation techniques may be used provided the excavation is configured in accordance with the OSHA requirements, groundwater seepage is not present, and with the understanding that some sloughing may occur. The trench walls should be flattened if sloughing (i.e., the raveling or breaking off of material from any sloped or vertical face) occurs or seepage is present. The use of a trench shield or other similar temporary shoring is not recommended for cuts that extend below the groundwater table or if vertical walls are desired for cuts deeper than 4 feet bgs without appropriate groundwater control.

A wide range of material may be used as structural fill; however, all material used should be free of organic matter or other unsuitable materials, and should meet the specifications provided in the 2014 Standard Specifications for Road, Bridge, and Municipal Construction, Washington State Department of Transportation (WSDOT), SS 2014, depending on the application

The silt/clay fraction of site soils is moisture sensitive and during wet weather, may become unworkable due to excess moisture content. In order to reduce moisture content, some aerating and drying of native or imported silty soils may be required. If moisture content of silty/clayey soils cannot be reduced by air drying, it may be necessary to grade the site with granular soils that do not contain more than five

percent passing the No. 200 Sieve (wet sieve analysis). We recommend that fills intended to support structures or pavement sections be placed in horizontal lifts not exceeding about eight inches in loose thickness and be compacted to at least 92 percent of the maximum dry density as determined by the standard proctor test method (ASTM D 1557).

Fill placed on slopes steeper than 5H:1V must be keyed/benched into the existing slopes and installed in horizontal lifts. Vertical steps between benches should be approximately 2 feet.

PHASE 2 SCOPE OF SERVICES

A typical Phase 2 scope that should be performed in order to provide geotechnical engineering recommendations for site development follows:

1. **Subsurface Exploration:** The proposed explorations should consist of test pits and/or borings in the area of the proposed new development. In addition, test pits should be performed to locate a potential High Density Polyethylene (HDPE) liner under rubble area. A member of the PBS engineering staff should log the test pits and borings and collect samples for laboratory testing.
2. **Soils Testing:** All samples should be returned to our PBS laboratory and classified in general accordance with the Unified Soil Classification, Visual-Manual Procedure. Laboratory tests should include natural moisture contents, grain-size analysis, and Atterberg limits, as appropriate.
3. **Geotechnical Engineering Analysis:** All data collected during the subsurface exploration, literature research, and testing should be evaluated and used to develop geotechnical design and construction recommendations.
4. **Deliverable:** A Phase 2 Geotechnical Engineering Report should be prepared summarizing the results of our explorations and analyses, including information relating to the following:

    - Exploration logs and site plan with exploration locations
    - Laboratory test results
    - Earthwork and grading, cut, and fill recommendations:
        - building pad preparation
        - utility trench backfill
        - structural fill materials and preparation
        - wet and cold weather conditions considerations
    - Shallow foundation design recommendations:
        - minimum embedment
        - allowable bearing pressure
        - estimated settlement
        - sliding coefficient
    - Groundwater consideration

- Seismic design criteria in accordance with the 2012 International Building Code (IBC) with State of Washington amendments
- Slab and pavement subgrade preparation
- Pavement section recommendations

LIMITATIONS

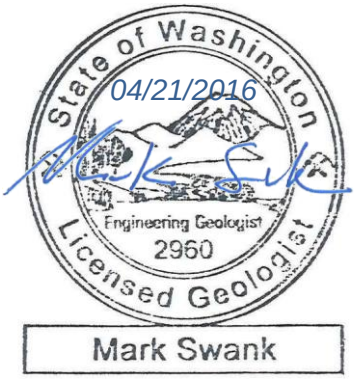
Our evaluations and recommendations are based upon limited review of the referenced documents. No subsurface explorations were completed during this work to verify the type and depth of fill, soil, bedrock, or depth of groundwater at the site. We should be contacted to review the proposed site development plan to evaluate their possible affect on the site property. A geotechnical engineering report that includes site-specific explorations and infiltration testing will be required prior to design.

The information provided in this letter report is only for your information, for use in feasibility planning associated with the site and that you will not hold PBS liable in any regard for decisions related to due diligence, purchase, or design and construction estimating. Site-specific exploration and engineering is required in order to refine the very general discussion of subsurface conditions (based on previous work by others) provided in this letter-report.

CLOSING

We trust this feasibility report meets your current needs. If you have any questions or wish to further discuss our observations, conclusions, and recommendations, please contact Mark Swank at 503.417.7738 or Ryan White at 503.417.7608.

Sincerely,
PBS Engineering and Environmental Inc.



Mark Swank, LG, LEG
Senior Engineering Geologist

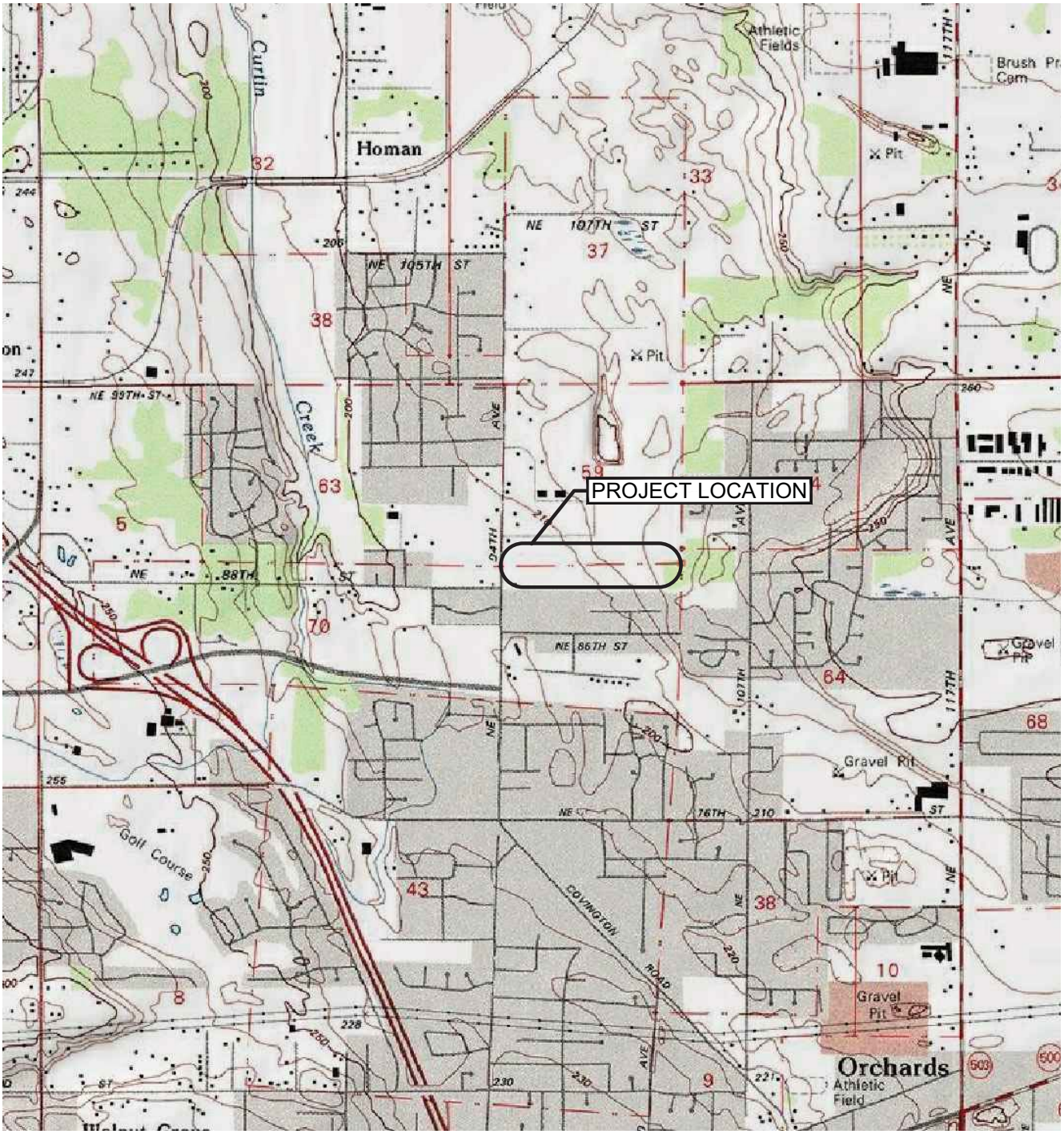
Ryan White, PE, GE
Geotechnical Discipline Lead

MQ/AR/ln

Figures: Figure 1 – Vicinity Map
Figure 2 – Site Plan
Figure 3 – Environmental Borings with Site Annotations
Figure 4 – LiDAR Hillshade Image

Attachment: A – Soil Classification Descriptions
B – Site Photographs

FIGURES



SOURCE: USGS ORCHARDS WA QUADRANGLE 1990.

WASHINGTON

0' 1,000' 2,000' 4,000'

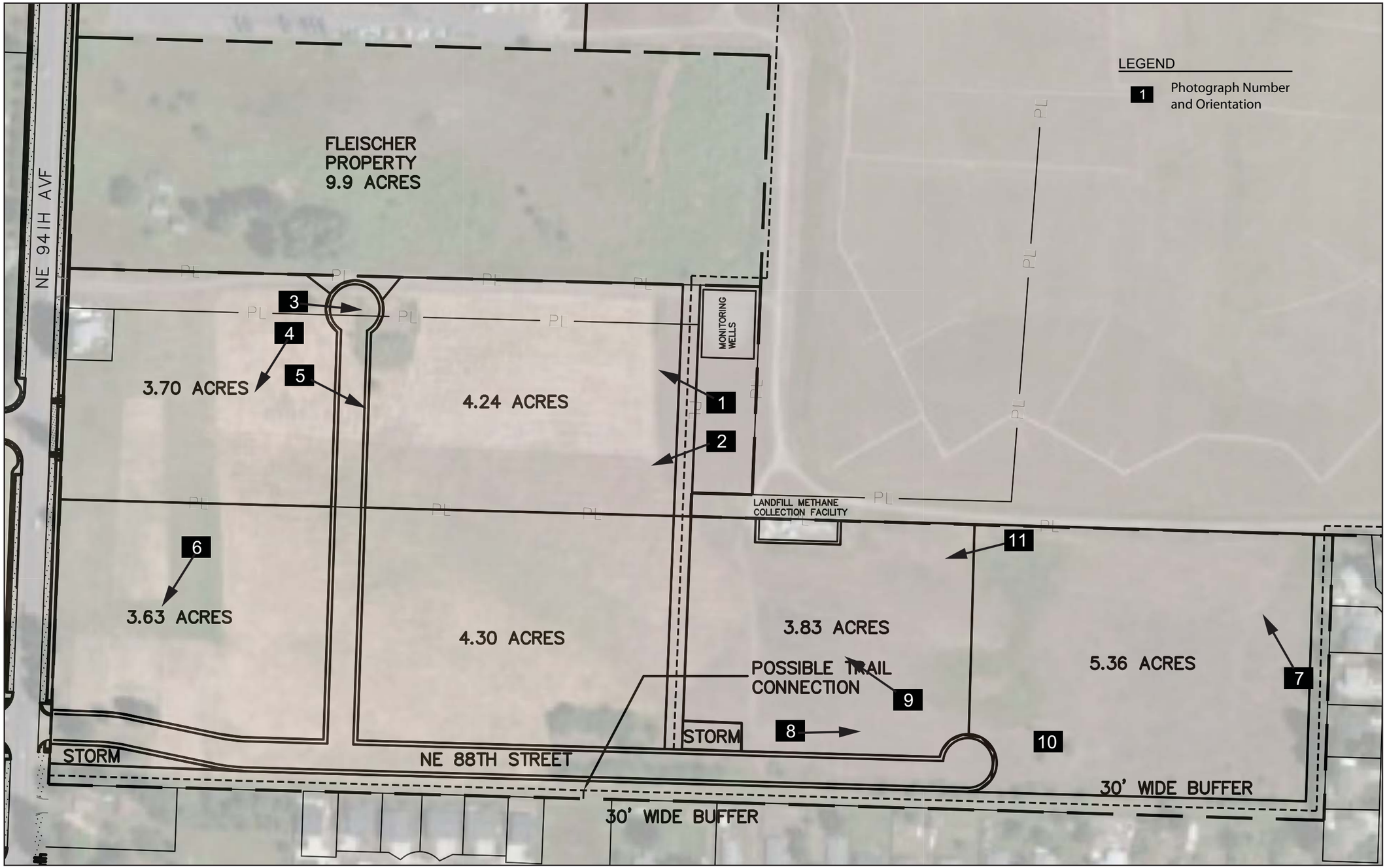
SCALE: 1" = 2,000'

PREPARED FOR: CLARK COUNTY

PBS

PROJECT #	VICINITY MAP	FIGURE
72971.006	LEICHNER CAMPUS DEVELOPMENT - KOSKI PROPERTY VANCOUVER, WASHINGTON	1
DATE APRIL 2015		

L:\Projects\72000\72900-72999\72971_Clark County\72971.006_LeichnerProp\DWG\72971.006_FIGURES 1-2.dwg Apr 09, 2015 10:19am Jimb



SOURCES: Berger (August 6, 2014)

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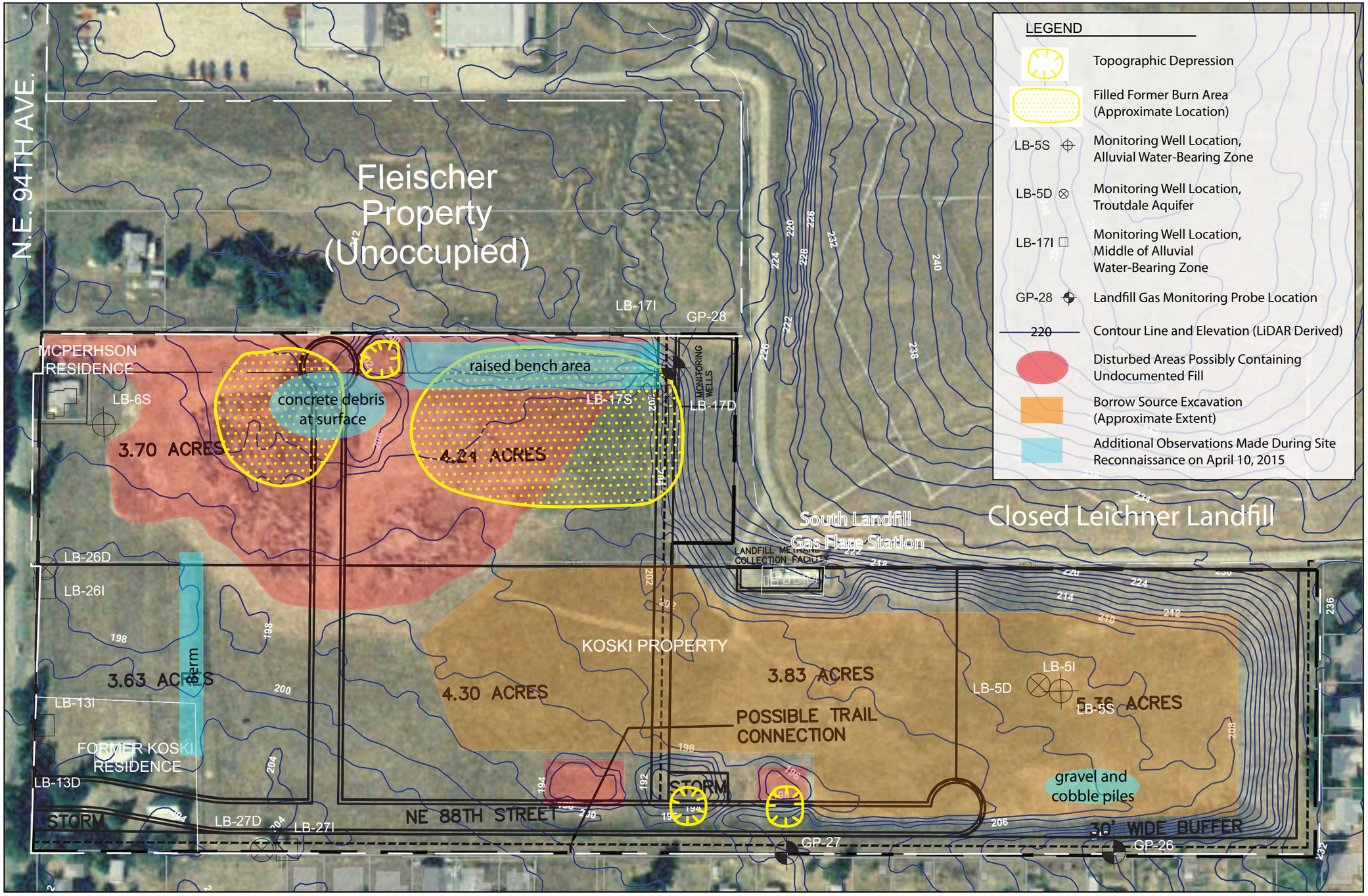
SITE PLAN

160 80 0 160
Feet
1 inch = 160 feet

PBS
Engineering + Environmental
4412 SW Corbett Ave
Portland, OR 97239
503.248.1939 Main
866.727.0140 Fax
www.pbsenv.com

LEICHNER CAMPUS DEVELOPMENT
KOSKI PROPERTY
8713 NORTHEAST 94TH AVENUE
VANCOUVER, WASHINGTON

PROJECT	72971.006
DATE	APR 2015
FIGURE	2



SOURCES: WGS_1984_Web_Mercator_Auxiliary_Sphere
Clark County, WA. GIS - http://gis.clark.wa.gov
This map was generated by Clark County's "MapsOnline" website using the 1994 Ortho
SCS Engineers (2014)
Berger (August 6, 2014)
Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
USACE (2010)

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ENVIRONMENTAL BORINGS WITH SITE ANNOTATIONS

160 80 0 160
Feet
1 inch = 160 feet

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FIGURE	3

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LEGEND
taxlots

HILLSHADE DERIVED FROM USACE LIDAR

160 80 0 160
Feet
1 inch = 160 feet

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PROJECT	72971.006
DATE	APR 2015
FIGURE	4

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ATTACHMENT A

Soil Classification Descriptions

ATTACHMENT A – SOIL CLASSIFICATION DESCRIPTIONS

AASHTO Group Classification

AASHTO group classification is a system that classifies soils specifically for geotechnical engineering purposes that are related to highway and airfield construction. It is based on particle-size distribution and Atterberg limits, such as liquid limit and plasticity index. This classification system is covered in AASHTO Standard No. M 145-82. The classification is based on that portion of the soil that is smaller than 3 inches in diameter.

The AASHTO classification system has two general classifications: (i) granular materials having 35 percent or less, by weight, particles smaller than 0.074 mm in diameter and (ii) silt-clay materials having more than 35 percent, by weight, particles smaller than 0.074 mm in diameter. These two divisions are further subdivided into seven main group classifications, plus eight subgroups, for a total of fifteen for mineral soils. Another class for organic soils is used.

For each soil horizon in the database one or more AASHTO Group Classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil.

Depth to Restrictive Layer

A "restrictive layer" is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers.

This theme presents the depth to any type of restrictive layer that is described for each map unit. If more than one type of restrictive layer is described for an individual soil type, the depth to the shallowest one is presented. If no restrictive layer is described in a map unit, it is represented by the "> 200" depth class.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Natural Drainage Class

"Drainage class (natural)" refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized-excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the "Soil Survey Manual."

Capacity of Most Limiting Layer to transmit Water

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity is considered in the design of soil drainage systems and septic tank absorption fields.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

The numeric Ksat values have been grouped according to standard Ksat class limits.

Depth to Water Table
"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Frequency of Flooding
Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent.

"None" means that flooding is not probable. The chance of flooding is nearly 0 percent in any year. Flooding occurs less than once in 500 years.

"Very rare" means that flooding is very unlikely but possible under extremely unusual weather conditions. The chance of flooding is less than 1 percent in any year.

"Rare" means that flooding is unlikely but possible under unusual weather conditions. The chance of flooding is 1 to 5 percent in any year.

"Occasional" means that flooding occurs infrequently under normal weather conditions. The chance of flooding is 5 to 50 percent in any year.

"Frequent" means that flooding is likely to occur often under normal weather conditions. The chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year.

"Very frequent" means that flooding is likely to occur very often under normal weather conditions. The chance of flooding is more than 50 percent in all months of any year.

Frequency of Ponding
Ponding is standing water in a closed depression. The water is removed only by deep percolation, transpiration, or evaporation or by a combination of these processes. Ponding

frequency classes are based on the number of times that ponding occurs over a given period. Frequency is expressed as none, rare, occasional, and frequent.

"None" means that ponding is not probable. The chance of ponding is nearly 0 percent in any year.

"Rare" means that ponding is unlikely but possible under unusual weather conditions. The chance of ponding is nearly 0 percent to 5 percent in any year.

"Occasional" means that ponding occurs, on the average, once or less in 2 years. The chance of ponding is 5 to 50 percent in any year.

"Frequent" means that ponding occurs, on the average, more than once in 2 years. The chance of ponding is more than 50 percent in any year.

Linear Extensibility (Shrink/Swell) (Figure 12)
Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Corrosion of Steel
"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Corrosion of Concrete
"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens concrete. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The concrete in installations that intersect soil boundaries or soil layers is more susceptible to

corrosion than the concrete in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Mechanical Site Preparation (Surface)
The ratings in this interpretation indicate the suitability for use of surface-altering soil tillage equipment during site preparation in forested areas. The ratings are based on slope, depth to a restrictive layer, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The part of the soil from the surface to a depth of about 1 foot is considered in the ratings.

The ratings are both verbal and numerical. Rating class terms indicate the degree to which the soils are suited to this aspect of forestland management. The soils are described as "well suited," "poorly suited," or "unsuited" to this management activity. "Well suited" indicates that the soil has features that are favorable for the specified kind of site preparation and has no limitations. Good performance can be expected, and little or no maintenance is needed. "Poorly suited" indicates that the soil has one or more properties that are unfavorable for the specified kind of site preparation. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. "Unsuited" indicates that the expected performance of the soil is unacceptable for the specified kind of site preparation or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Mechanical Site Preparation (Deep)
The ratings in this interpretation indicate the suitability for the use of deep soil tillage equipment during site preparation in forested areas. The ratings are based on slope, depth to a restrictive layer, rock fragments on or below the surface, depth to a water table, and ponding. The part of the soil from the surface to a depth of about 3 feet is considered in the ratings.

The ratings are both verbal and numerical. Rating class terms indicate the degree to which the soils are suited to this aspect of forestland management. The soils are described as "well suited," "poorly suited," or "unsuited" to this management activity. "Well suited" indicates that

the soil has features that are favorable for the specified kind of site preparation and has no limitations. Good performance can be expected, and little or no maintenance is needed. "Poorly suited" indicates that the soil has one or more properties that are unfavorable for the specified kind of site preparation. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. "Unsuited" indicates that the expected performance of the soil is unacceptable for the specified kind of site preparation or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Local Roads and Streets

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

ATTACHMENT B

Site Photographs

Photo 1. Looking west from upper slope

Photo 2. Looking southwest showing vegetation transition

Photo 3. Circular depression along northern perimeter

Photo 4. Elevated area in northern portion

Photo 5. Panoramic view looking east

Photo 6. Looking southwest at Koski building pad

Photo 7. General slope grade on eastern perimeter

Photo 8. Depression in eastern portion looking east

Photo 9. Sparse vegetation looking west

Photo 10. Gravel and cobble pile in eastern portion

Photo 11. Looking southwest showing vegetation transition