MEMORANDUM

To	Juniper Nammi, AICP City of Shoreline	File no	5-917-17855-0
		cc	Paul Cohen City of Shoreline
From	Todd Wentworth, PE, LG Amec Foster Wheeler Environment & Infrastructure, Inc.		
Date	September 16, 2015		

Subject **Shoreline Geologic Hazards – Best Available Science – Revised**

This memo is a revised version of the previous memo dated July 6, 2015. It has been updated to addresses changes to the proposed code that were requested by the City of Shoreline Planning Commission. The updates mainly provide additional information regarding slope and buffer definitions. Two additional figures have been added that display how landslide hazard areas are delineated.

Attached to this memo are some suggested edits to the proposed Subchapter 2 Geologic Hazard Areas.

The City of Shoreline is in the process of reviewing and updating its Critical Areas Ordinance (CAO), which specifies standards for protection of critical areas, including areas of geologic hazards. Under Washington's Growth Management Act (GMA), and the Revised Code of Washington (RCW) 36.70A, protection of environmentally critical areas must take into account best available science (BAS). This memo provides a summary of the BAS relevant to Geologic Hazard Areas as regulated in the Shoreline Municipal Code (SMC) Sections 20.80.210 through 20.80.250. The intent is to summarize recent studies and to provide recommendations for updating the existing CAO where appropriate. This study focused on review of scientific articles, government agency guidance documents, and critical areas ordinances of other cities with similar geologic hazards.

The Shoreline CAO recognizes three types of geologic hazards:

- Landslide hazards,
- Seismic hazards (earthquakes), and
- Erosion hazards.

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These three hazards are discussed below.

LANDSLIDE HAZARDS

This section summarizes the review of available and relevant studies pertaining to landslide hazards for the Puget Sound region in general and for Shoreline specifically.

Puget Sound Wide Issues

Landslides within the Puget Sound region have been studied for decades. Our research revealed that studies of landslide hazards within the Puget Sound region have focused almost entirely on the City of Seattle. The majority of landsliding in the region has been attributed to geologic, climatic, and human factors (Tubbs, 1975). Landslides have been associated with concentrated winter precipitation, steep slopes, and glacial soils that are susceptible to instability (Laprade and Tubbs, 2008). Our review identified the two most significant recent advances pertaining to landslide hazards: (1) the improved ability to identify historic landslides using light distance and ranging (LIDAR) imagery, which provides more detail than aerial photographs in highly vegetated areas; and (2) forecasting the occurrence of landslides based on cumulative rainfall totals.

Identification of Landslide Hazard Areas

Recent studies (Baum et al., 2007) demonstrate the improvements in identification of landslide hazard areas using LIDAR. Researchers have found that LIDAR provided a much more thorough delineation of previous landslide areas than aerial photography and site reconnaissance and identified many heavily vegetated or undeveloped sloping areas within Seattle that have the potential for landsliding. The City of Shoreline utilized LIDAR, obtained in 2002, to map landslide hazard areas, so the maps represent BAS.

Development Issues in Landslide Hazard Areas

New development or redevelopment of property near landslide hazard areas has become a more contentious issue as more property owners attempt to maximize the developable portions of their land within the constraints of the CAO code. Many jurisdictions require site-specific studies to assess site conditions, identify the potential impacts of development proposals in geologic hazard areas, evaluate the risks, and recommend mitigation. The site-specific information required to review development proposals qualifies as the best available science, both for providing relevant and accurate information about site conditions, and identifying the mitigation measures necessary to reduce the risk and impacts of a specific proposal, based on the criteria in Washington Administrative Code (WAC) 365-195-905. Many jurisdictions do not have qualified geologists or geotechnical engineers on staff to determine the adequacy of site-specific CAO studies, and so they either require or have the option of a third-party independent geotechnical review. This peer-review process encourages BAS. Other cities in the region have detailed geotechnical report requirements in their CAO codes to improve the review process. If the reporting requirements encourage improvement of the standard of practice, BAS is maintained.

Conditions Unique to the City of Shoreline

Recent geologic mapping of King County (Booth and Wisher, 2006) identifies the City as being underlain primarily by glacially derived or glacially overridden soils. Steep slopes are found where the highlands descend to Puget Sound and within natural drainages, such as ravines. These steep slopes are typically composed of looser alluvial soils or recessional outwash overlying denser glacial soils, such as glacial till or advance outwash. Landslides occur most commonly where a veneer of looser soils overlies the denser soils on steeply inclined hillsides. The definition of landslide hazard areas in the City's CAO includes these types of areas, as well as, other areas that are potentially subject to risk of landslides due to geologic, topographic, and hydrologic conditions. Landslide hazard areas within the City of Shoreline occur predominantly along the western perimeter of the City, where the highlands descend to Puget Sound, or within steeply incised natural drainages, such as Boeing and McAleer Creeks.

Review of Existing Regulations in the City of Shoreline

Based on review of CAO codes of similar jurisdictions and our experience with other jurisdictions within Puget Sound, CAO codes, including the City of Shoreline's, generally protect landslide hazard areas by establishing buffers from landslide hazards and restricting activities within buffers. The codes tend to become complex in describing details, such as conditions for exemptions, alterations, or buffer reductions. In some cases, key terms are not defined specifically, and this lack of precision has led to disputes.

Exemptions

Exempt Activities on Slopes: SMC 20.80.030(F) currently allows an exemption for activities occurring on small steep slopes up to 20 feet high. Some other jurisdictions offer a similar exemption for slopes up to 10 feet or 20 feet high, but not all do. It should be noted that in the Seattle Landslide Study (Seattle Public Utilities, 2001) database, about 15% of the reported landslides had occurred on slopes with a height of 20 feet or less. We recommend that the City consider eliminating the exemption for activities occurring on "small steep slopes." As an alternative, the City may consider adjusting the definition of a very high landslide hazard, so that steep slopes less than 20 feet are not included.

Partial Exemption: SMC 20.80.040(A)(2) allows additions of up to 750 square feet (area large enough to construct a three-car garage) to existing structures within a buffer. In terms of BAS, the exemption allows a decrease in critical area protection without mitigation (more impervious surface, loss of vegetation, increased loading, etc.). We recommend the City consider revising this partial exemption so that structure modifications may be allowed based on recommendations from a site specific study of the potential for critical area impacts.

Critical Area Maps

According to SMC 20.80.020(A), critical area maps are adopted as part of the SMC. Critical areas are included as data layers in the City Geographic Information System (GIS). These maps identify general areas within the City that contain critical areas and alert the public and city officials of these general areas. They are not intended to define all critical areas precisely within the City. Site specific studies are necessary to determine if a particular parcel contains critical areas and to determine the extent of those areas. The maps currently used by the City serve this purpose sufficiently, in our opinion. Updating the maps based on more recent information could involve considerable effort and yield only minor changes. BAS may be more easily satisfied by the site-specific geologic mapping and reporting required for development near critical areas.

Landslide Hazard Area Buffers

SMC 20.80.230 requires a standard 50-foot buffer from all edges of a landslide hazard area. A standard buffer width of 50 feet has been adopted by many jurisdictions, although some jurisdictions require the buffer to be the vertical height of the slope or 50 feet, whichever is greater (Bainbridge Island, Edmonds). Based on review of available studies and our own experience, 50 feet from the top of the slope is a supportable standard buffer, because most landslides in the Puget Sound Area occur less than 50 feet from the top of the slope (Laprade and Tubbs, 2008), and most landslides are not affected by site development that occurs more than 50 feet away from the top of the slope. <u>Additionally, coastal bluff retreat rates estimate that a 50 foot buffer would last 80 years or more (Galster and Laprade, 1991).</u> Landslide impacts that extend more than 50 feet beyond the toe of the slope are more likely, but still not common within the Puget Sound area. An extreme example of this would be the Oso Landslide, in which the debris flow extended several hundred feet beyond the toe of the slope (Keaton, et al., 2014). If a landslide occurs, it is possible for the debris flow to accumulate a distance of more than 50 feet away from the toe of the slope, depending on site-specific conditions. This potential extension of a debris flow may be the reason that some jurisdictions call for a buffer of half the vertical height. For the landslide hazards that exist in Shoreline, either standard buffer would be sufficient for most situations, in our opinion.

Many jurisdictions, including the City, allow the standard buffer to be reduced based on findings from site-specific studies. This exception is recommended, since site-specific conditions are unique and site-specific studies represent BAS (Laprade and Tubbs, 2008). The City allows the site-specific critical area report to recommend a buffer reduction, but requires a minimum buffer of 15 feet from the slope. <u>Based on review of available studies and our own experience, 15 feet is a supportable minimum buffer, because most landslides in the Puget Sound Area are shallow colluvial landslides on</u>

steep slopes. Studies have found that the average thickness of these types of landslides is 8 feet (Harp, et al., 2008). Shoreline's minimum buffer should be greater than 10 feet for several reasons, such as:

- To prevent surcharges or surface water from destabilizing the slope;
- To allow some space between structures and a potential future landslide so that repairs can be made to protect the structure; and
- Protect structures from landslides thicker than 10 feet, which sometimes occur.

Many jurisdictions require a building setback in addition to a buffer (Sammamish, King County). Shoreline does not have a building setback requirement; however, site-specific studies could recommend a building setback in addition to a buffer. Although the buffer should remain undisturbed, non-native landscaping might be allowed in the building setback.

The Shoreline Municipal Code provides no definition as to what constitutes the "edge" of a landslide hazard area. Alternatively, we recommend establishing the buffer from the "top" and "toe" of landslide hazard areas related to steep topography and geology. The flanks or sides of landslide hazard areas are already defined in the following ways:

- If the classification is based on previous landslide activity, the flanks can be mapped by the boundary between disturbed and undisturbed ground.
- If the classification is based on the slope angle, then at any point on the ground, the steepest slope can be measured ascending and descending from that point to determine if that point is within a landslide hazard area. In other words, the elevation contours can be measured at various locations on a site map to fully define the landslide hazard area.

The top and toe definition is discussed below.

Code Definitions

1. Slope

Steep slopes are currently defined in SMC 20.20.046 S definitions. We recommend moving the definitions to be part of the landslide hazard definition in SMC 20.80.220 in order to be near the relevant part of the ordinance. The definition of slope should also be more specific. The "toe" and "top" of slope are currently defined as a "distinct topographic break in a slope." However, *distinct topographic break* is ambiguous and should be defined in a measureable way to minimize differing interpretations.

In the Puget Sound area, complex slopes that change in steepness and have mid-slope benches are common due to the surficial geology which includes several soil layers deposited through glacial processes, and due to landform processes, such as erosion, groundwater seepage and previous landslides (Godt et al., 2008, and Galster and Laprade, 1991). Landslides can occur on only a portion of these complex slopes, or through the entire length of the overall slope, both are common (Baum, et al, 2007). For that reason, it is important that critical area codes recognize the potential for a complex slope to be a higher hazard than individual segments of a slope. Only site specific studies by a qualified professional could determine whether the entire slope or a segment of the slope is the least stable.

The concern is that if there is no definition of distinct break, then a narrow mid-slope bench may divide a large slope into two smaller slopes, from a regulatory basis. But it is important for the engineer or geologist to assess the landslide hazards of the entire slope as well as smaller slope segments. For example, the following sentence could be added to clarify the definition: “A distinct topographic break is an area that extends at least 15 feet horizontally away from the slope and that slopes less than 15%.” The distance of 15 feet is suggested because it is the same distance as the minimum buffer. This definition is particularly useful when considering whether a mid-slope bench is present, which is common in Puget Sound (Godt et al., 2008), or if there are two independent slopes. Independent slopes are defined based on three conditions:

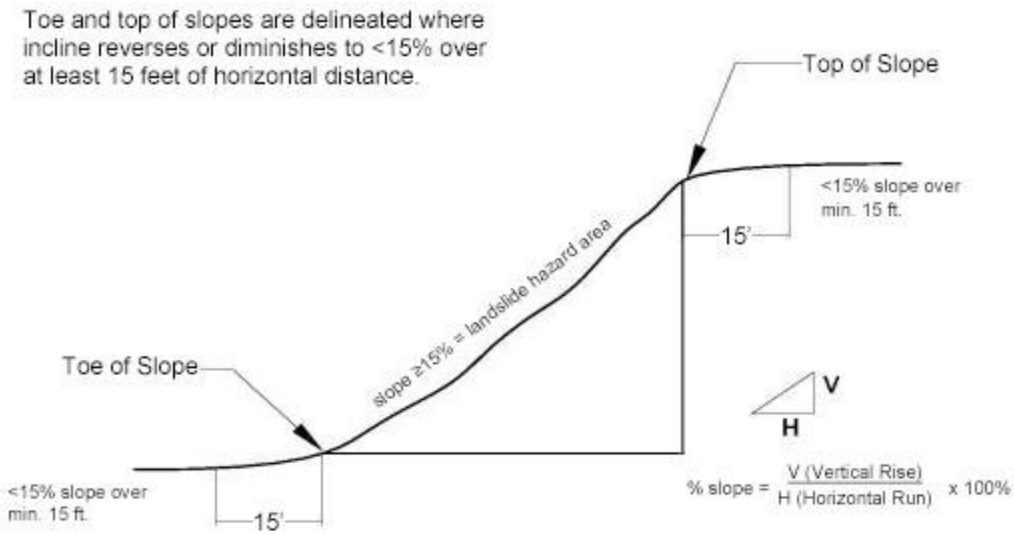
1. The bench must be wide enough and flat enough so that it is not classified as a landslide hazard.
2. The bench must not be part of an existing landslide.
3. The bench must be wide enough to accommodate the minimum buffer from the critical areas.

This definition encourages assessment of the entire landslide hazard area as well as smaller slope segments. The following figures display how to measure slopes and distinct breaks to determine the type of landslide hazard.

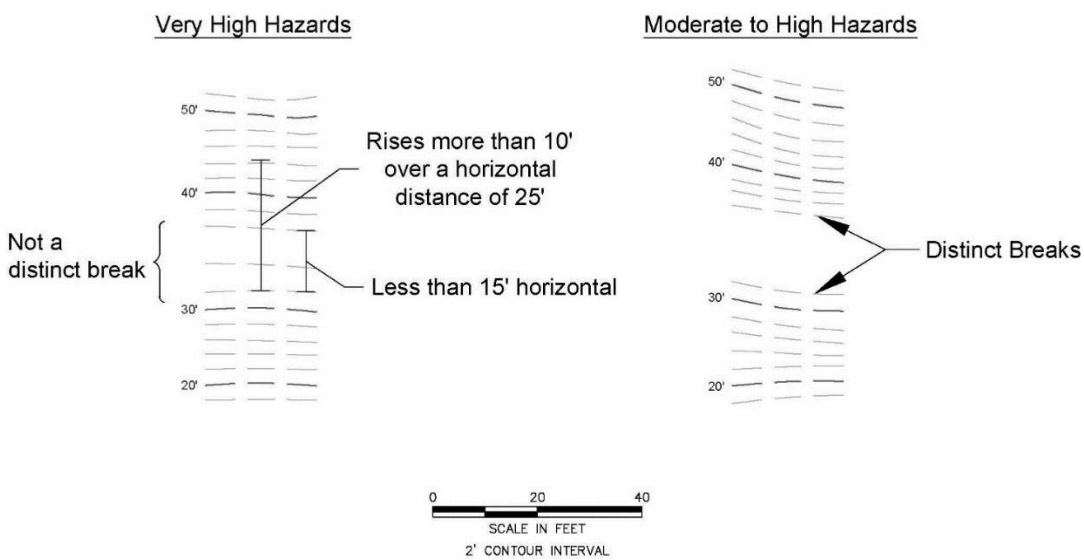
2. Geologist

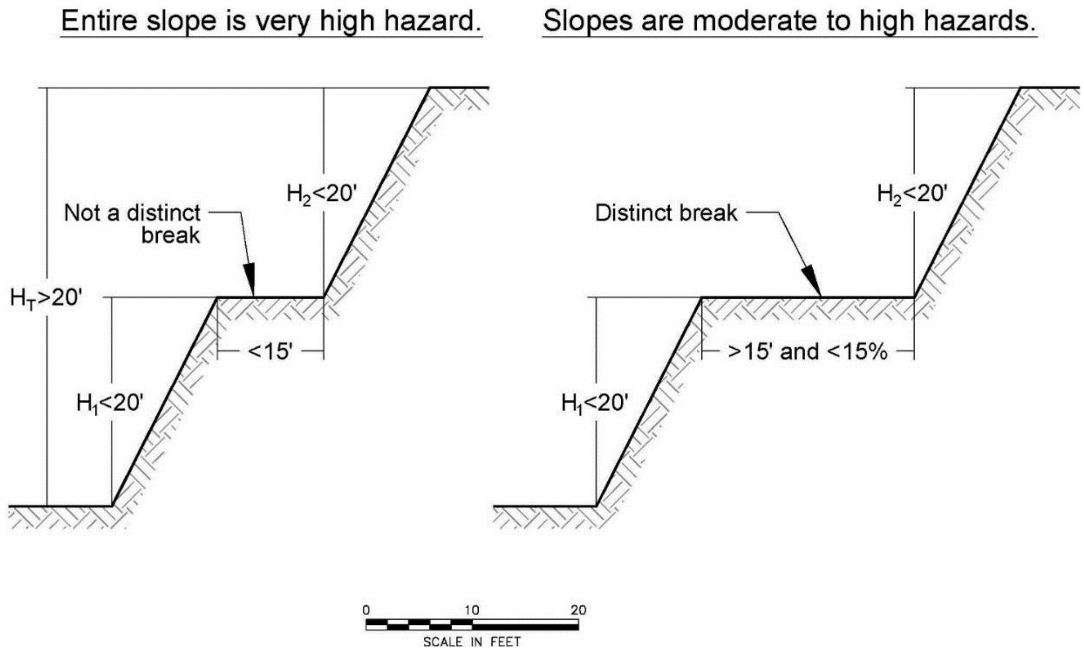
SMC 20.20.022(G) defines “Geologist” as a person who has earned at least a Bachelor of Science degree in the geological sciences from an accredited college or university or who has equivalent educational training and at least four years of professional experience. We recommend updating the definition to “A professional geologist licensed in the State of Washington.” The licensing of geologists became a requirement in the State of Washington in 2000 (WAC 308-15) and is not currently reflected in the definition.

Slope Delineation



Plan Views Displaying Topographic Contours of Landslide Hazards





Site-Specific Studies by Qualified Professionals

Shoreline requires site-specific critical areas studies to be performed by qualified professionals, and the City created an approved list of qualified professionals based on consultants submitting their credentials, experience, and sample reports for review. This is a suitable method to identify experts and request a sufficient scope of study, even though it is not a common practice among other cities.

SMC 20.80.240(C) states that alterations to moderate and high landslide hazards should be evaluated by a qualified professional through preparation of a geotechnical report. The SMC then goes on, however, to state that the City may waive the requirement for a geotechnical report at its sole discretion. In our opinion, this statement could lead to the appearance of inconsistent decisions by the City regarding alterations of critical areas. We recommend that alterations always be evaluated by a qualified professional with the City's understanding that the type of alteration and site conditions will determine the scope of the evaluation. In other words, some studies might be submitted as a short letter, while others might need detailed engineering analysis and data to evaluate the proposed alteration. For cases where the City may have granted a waiver in the past, they should expect to see a relatively brief geotechnical report, such as a site reconnaissance letter.

Although the City has published detailed Geotechnical Report Guidelines, the guidelines are for general site development and do not specifically discuss critical areas. We understand that the City would like to add report guidelines to the critical area ordinance. In the critical areas codes for other jurisdictions, there are general critical area report requirements, and then additional requirements specifically for geologic hazards. Provided below are recommended report requirements for geologic hazards.

- Site Plan. This should be a map of the site, drawn at an engineering scale, with topographic contours, that displays the existing conditions and proposed development. The critical areas and buffers should be shown on the map.
- A general description of the site vicinity and critical areas within at least 200 feet of the project site.
- A general description of the proposed development.
- Description of the site-specific field investigations; exploration logs and laboratory testing results should be included in the report.
- A summary of the existing site conditions, including:
  - The surface topography, existing features, and vegetation;
  - Soil types to a sufficient depth; and
  - Groundwater conditions.
- Analysis of surface and subsurface drainage and the potential for erosion.
- Assessment of the seismic conditions, including design ground motions and the susceptibility for liquefaction.
- For very high landslide hazard areas:
  - A geologic cross-section displaying the critical design slope conditions;
  - <u>Slope stability analysis for existing conditions, during construction, and the final proposed development conditions. The stability criteria described in the City's Geotechnical Report Guidelines are appropriate and consistent with the standard of practice (WSDOT, 2015);</u>
  - If the area is a coastal bluff, an estimate of the bluff retreat rate that recognizes and reflects potential episodic and catastrophic events; and
  - An estimate of the impacts of landslide debris flow run-out and accumulation.
- Analysis of impacts due to the development near the critical area, and potential impacts to the development from the critical area.
- Recommended critical area buffers. There could be more than one recommended buffer, such as a no disturbance buffer and an additional buffer for structures.

- A stormwater pollution prevention plan (also known as an erosion control plan) should be described, or should be referenced if it is being prepared separately.
- Geotechnical engineering recommendations for proposed grading and structures according to the City's Geotechnical Report Guidelines.

These report requirements for site specific studies will encourage BAS and represent the standard of practice (Bainbridge Island, Edmonds, Sammamish).

Many jurisdictions require independent third-party review of geotechnical reports to assure that the study meets the code and achieves the current standard of practice as a minimum, which is a way of achieving BAS (WAC 365-195-905). In our experience, such review is warranted when the jurisdiction employs no qualified engineers or geologists on staff to determine completeness and adequacy of the reports. This review is needed because in many cases developers may try to minimize the cost of the study, and thus the scope of work is reduced and may not be sufficient. The cost of third-party review is usually administered by the City and borne by the applicant.

SEISMIC HAZARDS

"Seismic hazard areas are lands that, due to a combination of soil and groundwater conditions, are subject to severe risk of ground shaking, subsidence or liquefaction of soils during earthquakes" (SMC 20.80.220(B)). The two components that cause earthquake damage are strong ground motions and loose saturated soils that lose strength during ground motion.

Puget Sound-Wide Issues

All of western Washington is generally at risk of strong ground motions resulting from movement of tectonic plates in the Cascadia Subduction Zone. Geologic studies have documented large earthquakes in the past, such as the estimated magnitude 9.0 earthquake that occurred approximately 300 years ago. This earthquake was located near the Washington coast and relatively deep below the surface (Washington DNR, Earthquakes in Washington). Shallow crustal movement along the Seattle Fault represents another potential source of strong ground motion. The Seattle Fault crosses Seattle in an east-west direction from near Alki Beach along I-90 toward Bellevue (Johnson et al., 2004). Geologic studies indicate that surface movement along the Seattle Fault caused an earthquake with an estimated magnitude of 7.5 approximately 1,000 years ago (Washington DNR, Earthquakes in Washington). An earthquake from the Seattle Fault could cause ground motions that are just as strong as that caused by a subduction zone earthquake, because the Seattle Fault is closer to the City of Shoreline and closer to the ground surface. Ground motions could also derive from other crustal faults, such as the magnitude 6.0 Nisqually Earthquake in 2001.

Some land areas are more susceptible to earthquake damage due to local ground conditions. Loose, saturated, cohesionless soils tend to experience the most severe ground shaking during an earthquake. When shaken, these soils lose strength and can settle, crack and deform. Some soils will lose strength to the point of behaving like a liquid, in a process called liquefaction. The loss of soil strength damages structures that had been supported by these soils (Washington DNR, Earthquakes in Washington).

These ground conditions are usually located in low-lying areas with recent deposits of unconsolidated soils (alluvial or fluvial soils, or artificial fills) combined with shallow groundwater. Areas with peat deposits are also a hazard, because ground motions can cause large permanent deformations of peat deposits (Palmer et al., 2004)

Conditions Unique to the City of Shoreline

The most significant BAS document for seismic hazard areas for Shoreline is the *Liquefaction Susceptibility and Site Class Maps of Washington State, By County* (Palmer et al., 2004). These maps and report were prepared by the Washington State Department of Natural Resources (DNR) primarily to describe the location and extent of earthquake hazards in Washington State. One of the stated purposes of the maps was to provide an information source for local officials:

> Local jurisdictions can use these maps to delineate earthquake hazard areas and enforce critical areas ordinances as required by the State Growth Management Act. Also, local building officials will be able to use these maps to help delineate areas requiring thorough geotechnical investigation in their enforcement of state and local building codes. (Palmer et al., 2004)

Shoreline is located within the area of detailed study on the *Liquefaction Susceptibility Map of King County, Washington*. The detailed map area is based on 1:24,000-scale geologic mapping. Quantitative engineering analysis was utilized to characterize the risk of liquefaction. The analytical methods have been validated by reports of liquefaction during previous earthquakes in the Puget Sound region. More recent and improved engineering analytical methods were used for the detailed map area, as compared to previously published maps.

Another important document is the 2008 U.S. Geological Survey (USGS) *National Seismic Hazard Maps* (Peterson et. al., 2008). These maps provide several different probabilities of earthquake ground motions, which are used in seismic provisions of building codes, insurance rate structures, risk assessments, and other public policy. The abstract and web site states that “national seismic maps represent our assessment of the ‘best available science’ in earthquake hazards estimation for the United States” (Peterson et al., 2008).

The following engineering manuals are routinely updated to address potential seismic ground motions for the design of buildings and other structures. They provide engineering design values based on the 2008 USGS National Seismic Hazard Maps probabilistic and deterministic ground motion parameters for designing structures.

- Recommended Seismic Provisions for New Buildings and Other Structures, FEMA P-750 ("2009 NEHRP Provisions") (NEHRP, 2009);
- 2010 Minimum Design Loads for Buildings and Other Structures, ASCE 7-10 ("2010 ASCE-7 Standard") (ASCE, 2010); and
- 2012 International Building Code (International Code Council, 2012).

These three similar manuals represent the best available engineering for seismic design of structures.

The 2006 Geologic Map of King County is another BAS document (Booth & Wisher, 2006). It shows detailed soil types and the zone of the Seattle Fault. The purpose of the map is for more general geology uses, but it appears to be consistent with the 2004 Liquefaction Susceptibility Map in terms of the location of soil types susceptible to liquefaction and the location of peat deposits.

Review of Existing Regulations in the City of Shoreline

Definition

The current CAO definition of seismic hazard areas provides a general description of the type of ground conditions mapped as seismic hazard areas. However, the terminology is not consistent with geologic maps of these hazards. For example, the use of the word "severe" could cause some interpretive arguments since that word is not used on the maps. It would be more specific and legally defendable to use a definition that correlates directly with the BAS geologic map, such as "Those areas mapped as moderate to high and high liquefaction susceptibility and peat deposits on the *Liquefaction Susceptibility Map of King County, Washington*, Washington Division of Geology and Earth Sciences, OFR 2004-20, Palmer, Stephen, et al., September, 2004."

Map

Currently the City's Generalized Liquefaction Susceptibility Map uses preliminary data from the Washington State DNR from 1993. Amec Foster Wheeler recommends using Palmer et al.'s (2004) liquefaction susceptibility map. It is based on more detailed geologic mapping and improved engineering analysis (BAS) as compared to previous maps, including the King County Environmentally Sensitive Areas Map. The geospatial data for the map are available from the DNR web site, so this information could be incorporated into the City's GIS.

Standards

The City of Shoreline CAO states that development proposals in seismic hazard areas must follow the International Building Code (IBC). By linking the CAO to the current building codes, the City has maintained BAS in the CAO for seismic hazard areas. This is because building permits in seismic hazard areas require detailed, site-specific investigation (BAS) and project-specific mitigation measures (best available engineering) to reduce the risk of damage to structures.

EROSION HAZARDS

Soil erosion is the removal of soil from its original location by wind, water, ice, or gravity (Ecology, 2011). Four principal factors of soil erosion are soil characteristics, climate, topography, and ground cover (Goldman et al., 1986). Erosion is typically associated with sedimentation, which is the settling of soil particles in water by gravity (Ecology, 2011). Because of impacts associated with erosion and sedimentation, erosion and sedimentation control (ESC) plans are typical requirements for ground-disturbing construction throughout Western Washington. Additionally, many jurisdictions limit activities that can contribute to erosion and sedimentation.

Impacts of Erosion and Sedimentation

The impacts of erosion and sedimentation are understood to include (Ecology, 2011):

- Nutrient loading from phosphorus and nitrogen, which are attached to soil particles and transported to lakes and streams, produce eutrophication and changes in water pH, which can lead to algal blooms and oxygen depletion that cause fish kills.
- Eroded soil particles decrease the viability of macroinvertebrates and food-chain organisms and impair the feeding ability of aquatic animals; they also clog gill passages of fish and reduce photosynthesis.
- Sediment-clogged gravel diminishes fish spawning and can smother eggs or young fry.
- Natural, nutrient-rich topsoils erode, making re-establishment of vegetation difficult without applying soil amendments and fertilizers.
- Silt fills culverts and storm drains, decreasing capacities and increasing flooding and maintenance requirements.
- Detention facilities fill rapidly with sediment, decreasing storage capacity and increasing flooding.
- Sediment clogs infiltration devices, causing failure.
- Shallow areas in lakes form rapidly, resulting in growth of aquatic plants and reduced usability.

- Water treatment for domestic uses becomes more difficult and costly.
- Turbid water replaces aesthetically pleasing, clear, clean water in streams and lakes.

Erosion Hazard Map

Erosion hazard areas are included as a data layer in the City Geographic Information System (GIS). The data appears to be from King County, which is probably from the 1952 Soil Survey of King County (US Dept. of Agriculture, 1952). We were unable to find any updated soil survey for the City of Shoreline. As stated above, the map should be used as a general indicator of erosion hazard areas. By using the definition of erosion hazard areas, site specific studies can determine if erosion hazard areas are present.

Erosion and Sedimentation Control

Based on review of neighboring jurisdictions' CAOs and Amec Foster Wheeler's experience with other jurisdictions across Puget Sound, we have found the following typical main regulatory protections for erosion hazard areas:

- Requirements to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) for land-disturbing activities;
- Restrictions on developable land;
- Seasonal restrictions on clearing and grading;
- Requirements to control stormwater discharges; and
- Vegetation management requirements.

To address erosion and sedimentation impacts, grading and stormwater codes of agencies and municipalities require preparation of a SWPPP before grading permits are issued. Such plans are prepared based upon the requirements of the adopted Surface Water Design Manual. If the area of ground disturbance exceeds one acre, then a National Pollutant Discharge Elimination System (NPDES) permit is also required. Projects seeking NPDES permit coverage typically conform to the conditions of the Department of Ecology's (Ecology) Construction Stormwater General Permit (CSWGP), which include implementation of a SWPPP and protocols for monitoring site discharges for compliance with water quality standards.

Minimum requirements and best management practices (BMPs) for SWPPP s are established by the Washington State Department of Ecology in the *Stormwater Management Manual for Western Washington* (Stormwater Manual; Ecology, 2012); municipalities typically adopt these minimum requirements and BMP design standards, or their equivalents, as part of their stormwater management requirements for site development. The City of Shoreline has adopted the Stormwater Manual and the *Low Impact Technical Guidance Manual for Puget Sound* (LID Manual; Washington State University and Puget Sound Partnership, 2012). The City also encourages the use of emerging technologies that are part of the Washington Department of Ecology's Technology Assessment Protocol (TAPE). These BMPs, together with the erosion and sedimentation control BMPs of the Stormwater Manual, constitute the BAS for prevention of erosion and the treatment of sediment-laden runoff.

Wet Season Restrictions

It is not unusual to have seasonal requirements for clearing and grading stated in critical areas codes, or in stormwater codes that are referenced by critical area codes. Ecology (2011) states that for Western Washington, soils must not remain exposed and unworked for more than 7 days during the dry season (May 1 – September 30), and for no more than 2 days during the wet season (October 1 – April 30). The City of Shoreline CAO states that the City may restrict major earthwork between October 15 and April 15 (SMC 20.80.240 E. 5). These dates are reasonable and similar to other jurisdictions; for example, the City of Seattle restricts activities between October 31 and April 1(Seattle Municipal Code, Bellevue Municipal Code).

RECOMMENDED CHANGES TO THE CURRENT CODE

Table 1 presents a list of recommended changes to the existing Shoreline Municipal Code.

Table 1 Recommended Changes to the Critical Areas Code, Geologic Hazards

Code	Recommended Changes	Reasons
20.20.022(G) Definitions	Revise the definition of Geologist to: Professional geologist licensed in the State of Washington	Geologists are now licensed by the State for the purposes of providing the services described in this CAO. Requiring studies by licensed geologists and engineers utilizes BAS.
20.20.046(S) Definitions	Delete the definition of Steep Slope Hazard Areas in this section.	Term not used anywhere else in the Code; top and toe of slope defined in Critical Area chapter.
20.80.030 Exemptions	Delete the exemption for small steep slopes up to 20 feet high.	Landslides have been documented on slopes less than 20 feet high.
20.80.040(A)(2) Partial Exemptions	Revise this to say structural modifications may be allowed based on recommendations from a site specific study of the potential for critical area impacts.	The current exemption increases the impact to the critical area buffer without mitigation.

Table 1 Recommended Changes to the Critical Areas Code, Geologic Hazards

Code	Recommended Changes	Reasons
20.80.220	Insert the slope definition here where Landslide Hazard Areas are classified. Revise to define "distinct topographic break."	The current definition of steep slopes does not provide a measurable way to determine a "distinct topographic break" in the slope. A precise definition is needed in order to determine the critical area and buffer locations.
20.80.220 (B) Seismic Hazard Areas	Update the definition and data source for the map to be consistent with Palmer et al., 2004.	Using the updated map will represent BAS and provide a clear definition of a seismic hazard area.
20.80.240(C) Alterations	Delete the sentence that allows the City to waive the requirement for a geotechnical report.	To avoid the appearance of arbitrary waivers, require a critical area study, but understand that the necessary scope of the study will depend on the proposed alteration and the site conditions.

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20.80.220 GEOLOGIC HAZARDS - Classification.

Geologic hazard areas shall be classified according to the criteria in this section as follows:

A. **Landslide Hazard Areas.** Landslide Hazard Areas are those areas potentially subject to landslide activity based on a combination of geologic, topographic and hydrogeologic factors as classified in SMC 20.80.220(B) with slopes 15 percent or steeper within a vertical elevation change of at least 10 feet or all areas of prior landslide activity regardless of slope. A slope is delineated by establishing its toe and top, and measuring the inclination over 10 feet of vertical relief (see Figure 20.80.220(B)). The edges of the geologic hazard are identified where the characteristics of the slope cross section change from one landslide hazard classification to another or no longer meet any classification. Additionally:

1. The toe of a slope is a distinct topographic break which separates slopes inclined at less than 15 percent from slopes above that are 15 percent or steeper. A distinct topographic break is an area that extends at least 15 feet horizontally away from the slope and that slopes less than 15 percent; and

2. The top of a slope is a distinct topographic break which separates slopes inclined at less than 15 percent from slopes below that are 15 percent or steeper. A distinct topographic break is an area that is at least 15 feet horizontally away from the slope and that slopes less than 15 percent.

B. **Landslide Hazard Area Classification.** Landslide hazard areas are classified as follows:

1. Moderate to High Risk:

a. Areas with slopes between 15 percent and 40 percent and that are underlain by soils that consist largely of sand, gravel or glacial till that do not meet the criteria for Very High Risk areas in (3) below.

b. Areas with slopes between 15 percent and 40 percent that are underlain by soils consisting largely of silt and clay and do not meet the criteria for Very High Risk areas in (3) below; and

c. All slopes of 10 to 20 feet in height that are 40 percent slope or steeper and do not meet the criteria for Very High Risk in (3)(a) or (3)(b) below.

2. Very High Risk:

a. Areas with slopes steeper than 15 percent with zones of emergent water (e.g., springs or ground water seepage);

b. Areas of landslide activity (scarps, movement, or accumulated debris) regardless of slope; and

c. All slopes that are 40 percent or steeper and more than 20 feet in height. Very high risk areas shall include any mid-slope benches that do not meet the distinct topographic break criteria in 20.80.220(A).

3. A 40% slope can be delineated on a topographic survey as areas where there is 10 feet of vertical rise (five 2-foot contour lines) over a distance of 25 feet or less.

D. **Minimum Report Contents for Geologic Hazard Areas.** A critical area report for geologic hazard areas shall include a field investigation and contain an assessment of whether or not each type of geologic hazard identified in SMC 20.80.210 is present or not present and if the proposed development of the site will increase the risk of the hazard on or off site. The written critical area report(s) and accompanying plan sheet(s) shall contain the

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topographic change that extends at least 15 feet horizontally away from the slope and that slopes less than
40 percent, as determined by two (2) foot contour intervals, not averaging over the full landslide hazard
area.

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areas greater than 40 percent slope that are not separated by breaks greater than 15 feet wide
(horizontal run) less than 40 percent slope, as illustrated in Figure 20.80.220(B).

following information at a minimum:

1. The minimum report contents required per SMC 20.80.080(E);

2. Documentation of any fieldwork performed on the site, including field data sheets for soils, test pit locations, baseline hydrologic data, site photos, etc.;

3. A description of the methodologies used to conduct the geologic hazard areas delineations, classifications, hazards assessments and/or analyses of the proposal impacts including references;

4. **Site and Construction Plans.** The report shall include a copy of the site plans for the proposal, drawn at an engineering scale, showing:

a. The type and extent of geologic hazard areas, any other critical areas, and buffers on, adjacent to, within 200 feet of, or that are likely to impact or be affected by the proposal;

b. Proposed development, including the location of existing and proposed structures, fill, significant trees to be removed, vegetation to be removed, storage of materials, and drainage facilities;

c. The topography, in two-foot contours, of the project area and all hazard areas addressed in the report;

d. Height of slope, slope gradient, and cross-section of the project area;

e. The location of springs, seeps, or other surface expressions of ground water on or within 200 feet of

the project area or that have the potential to affect or be affected by the proposal;

f. The location and description of surface water on or within 200 feet of the project area or that have the potential to be affected by the proposal; and

g. Clearing limits, including required tree protection consistent with SMC 20.50.370.

5. **Stormwater Pollution Prevention Plan (SWPPP)**. For any development proposed with land disturbing activities on a site containing a geologic hazard area, a stormwater pollution prevention plan (also known as an erosion and sediment control plan) shall be required. The SWPPP, in compliance with the requirements of SMC Chapter 13.10, shall be included in the critical area report or be referenced if it is prepared separately.

6. **Assessment of Geological Characteristics.** The report shall include an assessment of the geologic characteristics of the soils, sediments, and/or rock of the project area and potentially affected adjacent properties, and a review of the site history regarding landslides, erosion, and prior grading. Soils analysis shall be accomplished in accordance with accepted classification systems in use in the region. The assessment shall include, but not be limited to:

a. A detailed overview of the field investigations, published data, and references; data and conclusions from past assessments of the site; and site-specific measurements, tests, investigations, or studies that support the identification of geologically hazardous areas; and

b. A summary of the existing site conditions, including:

i. the surface topography, existing features, and vegetation found in the project area and in all hazard areas addressed in the report;

ii. surface and subsurface geology and soils to sufficient depth based on data from site-specific explorations;

iii. geologic cross-section(s) displaying the critical design conditions;

iv. surface and ground water conditions; and

c. A description of the vulnerability of the site to seismic and other geologic events.

7. **Analysis of Proposal.** The report shall contain a hazards analysis including a detailed description of the project, its relationship to the geologic hazard(s), and its potential impact upon the identified hazard area(s), the subject property, and affected adjacent properties. The hazards analysis component of the critical areas report shall include the following based on the type(s) of geologic hazard areas identified:

a. An estimate of the present stability of the subject property, the stability of the subject property during construction, the stability of the subject property after all development activities are completed and a discussion of the relative risks and slide potential relating to adjacent properties during each stage of development including the effect construction and placement of structures, clearing, grading, and removal of vegetation will have on the slope over the estimated life of the structure;

b. An estimate of the bluff retreat rate that recognizes and reflects potential catastrophic events such as seismic activity or a one hundred-year storm event;

c. Consideration of the run-out hazard of landslide debris and/or the impacts of landslide run-out on down slope properties.

d. A study of slope stability including an analysis of proposed cuts, fills, and other site grading;

e. Recommendations for the minimum buffer consistent with 20.80.230, or as recommended, and recommended minimum drainage and building setbacks from any geologic hazard based upon the geotechnical analysis. Buffers must be maintained consistent with SMC 20.80.090, however the qualified professional may recommend additional setbacks for drainage facilities or structures which do not have to be maintained as undisturbed native vegetation;

f. An analysis of proposed surface and subsurface drainage, and the vulnerability of the site to erosion; and

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Commented [t2]: These requirements only apply to landslide hazards and so these should be moved to the following section that is specific to landslide hazards.