

# Horning Geosciences

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November 4, 2020

Terry Hendryx, PLS  
Assistant Director  
Clatsop County Public Works  
1100 Olney Avenue  
Astoria, Oregon 97103

RE: Geologic Hazard Investigation for roads, including Loukas Lane/Lewis & Clark Mainline and Fort Clatsop Road/Lewis & Clark Road, including the old Crown Zellerbach sorting yard, from the sorting yard south to the intersection of the Mainline with Wadsworth Road.

Dear Terry:

This report summarizes geologic hazards along the above-referenced roads for the purposes of predicting the degree of traffic disruption during a strong subduction zone earthquake. Approximately three hours have been spent on the roads examining landforms, soils, and vegetation, plus interviewing neighbors. Shaded-relief maps of the project area have been assembled and interpreted geomorphologically in order to delineate areas of landsliding and abrupt changes in slope inclination. Soils and bedrock geologic maps are shown in accompanying Figures 1 through 6.

## Background

Most of the subject area is underlain by elevated Pleistocene river terraces that lap onto siltstone bedrock of the Oligocene Smugglers Cove formation. Elevations range from about 70 to 140 ft NAVD, which suggests that multiple periods of terrace formation are present. Each terrace represents flood plain and channel sediment of the Lewis & Clark River that were laid down during brief warm-period high-stands of the ocean over the past 200,000 years, which rose to elevations of modern sea level. There have been a minimum of three to four periods of terrace formation during that period of time.

The terraces are composed mostly of clay-silt alluvium, but there can be sandy silt, as well. Channel gravels are not evident in the terraces, but they may be concealed, although in small amounts. Clay-silt flood plain sediment tends not to suffer significant liquefaction.

A concealed fault runs north-northwest beneath the valley. It offsets Smugglers Cove siltstone on the west from Miocene mudstone of the Astoria Formation on the east. Likely, the west side of the valley has risen differentially against the east side. Regional fault models suggest that this part of the county is actively involved in a clockwise rotation that involves both vertical uplift and horizontal strike-slope movement. The terrace sediments have been elevated above sea level at a rate of about 0.5 to 1.0 ft per 1000 years. This rate averages out the effects of slow chronic uplift interspersed with abrupt subsidence events of as much as 6 ft during regional earthquakes. It is possible that subsidence can be as little as 1 ft.

Modern rivers and creeks have incised small canyons and gullies into uplifted terraces. These steep-walled drainages are at risk of failure during seismic shaking. Cut banks may collapse onto roads, and filled road beds may

slide laterally and undermine the road. Based on past slumping of these gullies, future slope failure will likely extend back from the gully at a 2 Horizontal to 1 Vertical ratio, based on the local toe of slope.

Liquefaction hazard is greatest in modern flood plains and to a lesser degree where elevated terraces are prone to saturated conditions, especially if the sediments are sandy or gravelly. Liquefaction can cause loss of strength of saturated ground and lead to weakness of road fill, sinkhole formation, and lateral spreading of river banks and terrace edges. It is most likely to occur on dike roads in modern marsh. It is much less likely on elevated terrace.

### L&C Mainline

The Lewis & Clark Mainline/Loukas Lane is largely free of landslide hazards, except for possible failure of the filled causeway that crosses the Heckard Creek gully. The causeway is about 360 to 500 ft long and is about 50 ft high above the gully bottom at the greatest. That it has not failed in the past significantly is testimony to its good design and construction. Further work on its stability is required. Nearby steep gully slopes pose cut-bank failure hazard, particularly on the northwest side of the gully where slopes can be as steep as 100 percent.

Minor liquefaction hazard is present about midway between Heckard Creek and the sorting yard. Visual examination of saturation and LIDAR stream rill formation suggest that liquefaction is restricted to two isolated sites of about 100 ft each. The soils map suggests that saturation may be a hazard for as much as 1600 ft (Hebo silty clay loam- 23A). The absence of coarser clastic materials, such as sand and gravel, suggests that liquefaction is not very significant, as silt has a difficult time of expelling water and over-pressuring the ground, which weakens the soil, compared with sand and gravel. The presence of shallow groundwater is indicated, in part, by a private manufactured lake on the east side of the road.

Of possible interest is comment by Dennis Larson, a local resident, who describes considerable forest debris covered by road fill for the Mainline, including large hemlock stumps. A few anomalous circular puddles in the road bed suggest that the rotting stumps cause local weakness in the asphalt. This will likely become worse as the wood rots further.

### Lewis & Clark Road

Lewis & Clark/Fort Clatsop Road is exposed to landslide hazard and serious liquefaction/lateral spreading risk near rivers. The liquefaction hazard is confined to the dike road for 2000 ft in the northeast part of the study area, where the dike was placed to restrict the effects of tidal flooding. The road is experiencing lateral spreading and rifting asphalt where the dike road laps onto the steep embankment above the modern marsh. Future spreading is likely during shaking. The susceptible area on the edge of the terrace runs for about 300 ft.

Farther to the south, bank failure below Lewis & Clark Road is a hazard near the Heckard Creek causeway. It affects about 1200 ft of roadway.

### Zellerbach Sorting Yard

The sorting yard is built on ground that presently slopes to the northwest at 4 to 6 percent. It appears that the yard rests on ground that slopes much like the field to its east, on the opposite side of the road, which is free of landslide landforms. Examination of the asphalt and concrete sorting bins finds no evidence of damage from recent or ongoing slope instability and landslide movement. However, a review of aerial photos going back to 1994 shows that the west and north sides of the yard have been progressively filled to construct ponds that presumably have been used to wash logs. It constitutes ground that is saturated and filled with assumed weak materials. The calculated slope for the west side, which drops down into the Johnson Creek drainage, averages about 20 percent over a horizontal distance of about 145 ft. Until it can be verified how it was built, it should be regarded as at risk of lateral spreading and should be avoided. A rough setback line is shown in Figure 8.

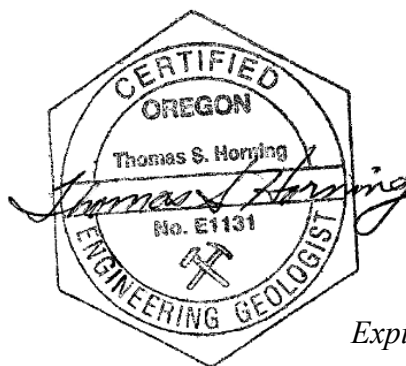
It is my opinion that the absence of significant landslide landforms near the sorting yard in terraces that have experienced subduction zone earthquakes for many thousands of years is a powerful indicator of slope stability during the next subduction zone event. The landslide susceptibility maps by DOGAMI are based on slope inclinations and materials properties of the soils and bedrock. The maps do not include runout estimates. These maps are useful for planning purposes, but their interpretation should be enhanced with landform analysis and field checking to determine past history of slope failure. Field inspections and LIDAR landform review are more reliable than simple susceptibility maps.

### Comparison of Roads

The Mainline is superior to the Lewis & Clark county road with respect to damage susceptibility from a regional seismic event, due primarily because the Mainline is built on the gentle slopes of an elevated terrace and the county road is built along its edge. The main challenge for the Mainline is possible collapse of 500 ft of the Heckard Creek causeway. In contrast, the county road is susceptible to 2000 ft of liquefaction and lateral spreading, plus 1200 ft of damage due to slumping of the Heckard Creek gully walls. Further, if regional subsidence is on the order of 4 to 6 ft, the dike road is likely to be flooded by monthly high tides, even in summer, until the dike is repaired.

Please feel free to call or write if you have questions.

Thomas S. Horning, CEG E1131  
Horning Geosciences



*Expires: 7/1/21*

### References Cited or Examined

Niem, A. R., and Niem, W. A., 1985, Oil and Gas Investigation of the Astoria Basin, Clatsop and Northernmost Tillamook Counties, Northwest Oregon: OGI-14, State of Oregon, Department of Geology and Mineral Industries.

Schlicker, H. G., Deacon, R. J., Beaulieu, J. D., and Olcott, G. W., 1972, Environmental Geology of the Coastal Region of Tillamook and Clatsop Counties, Oregon: Bulletin 74, State of Oregon, Department of Geology and Mineral Industries; 164 p. with plates.

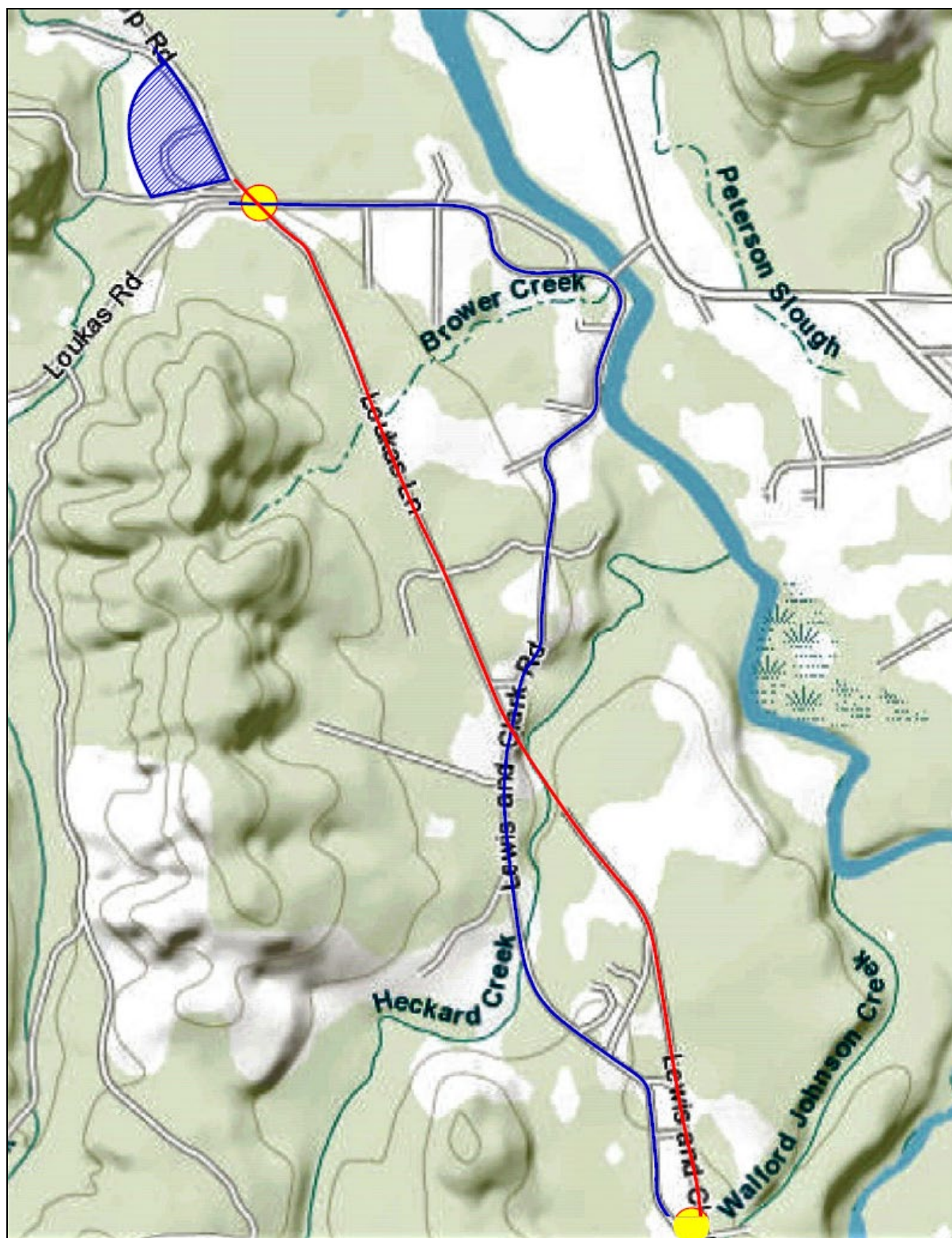


Figure 1: Project location map; courtesy Clatsop WebMaps. Blue and Red Lines delineate the study area between the two yellow dots.



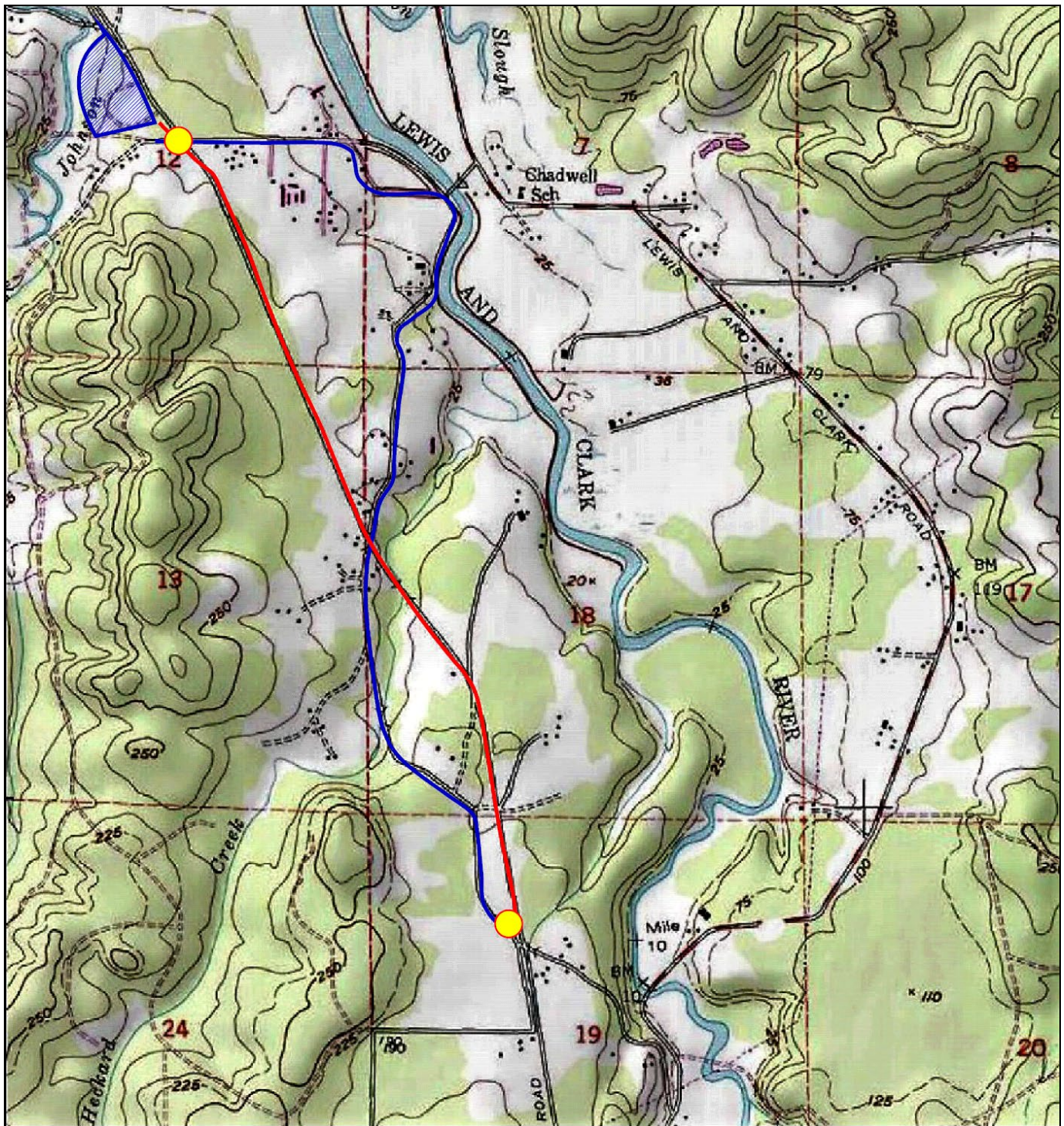
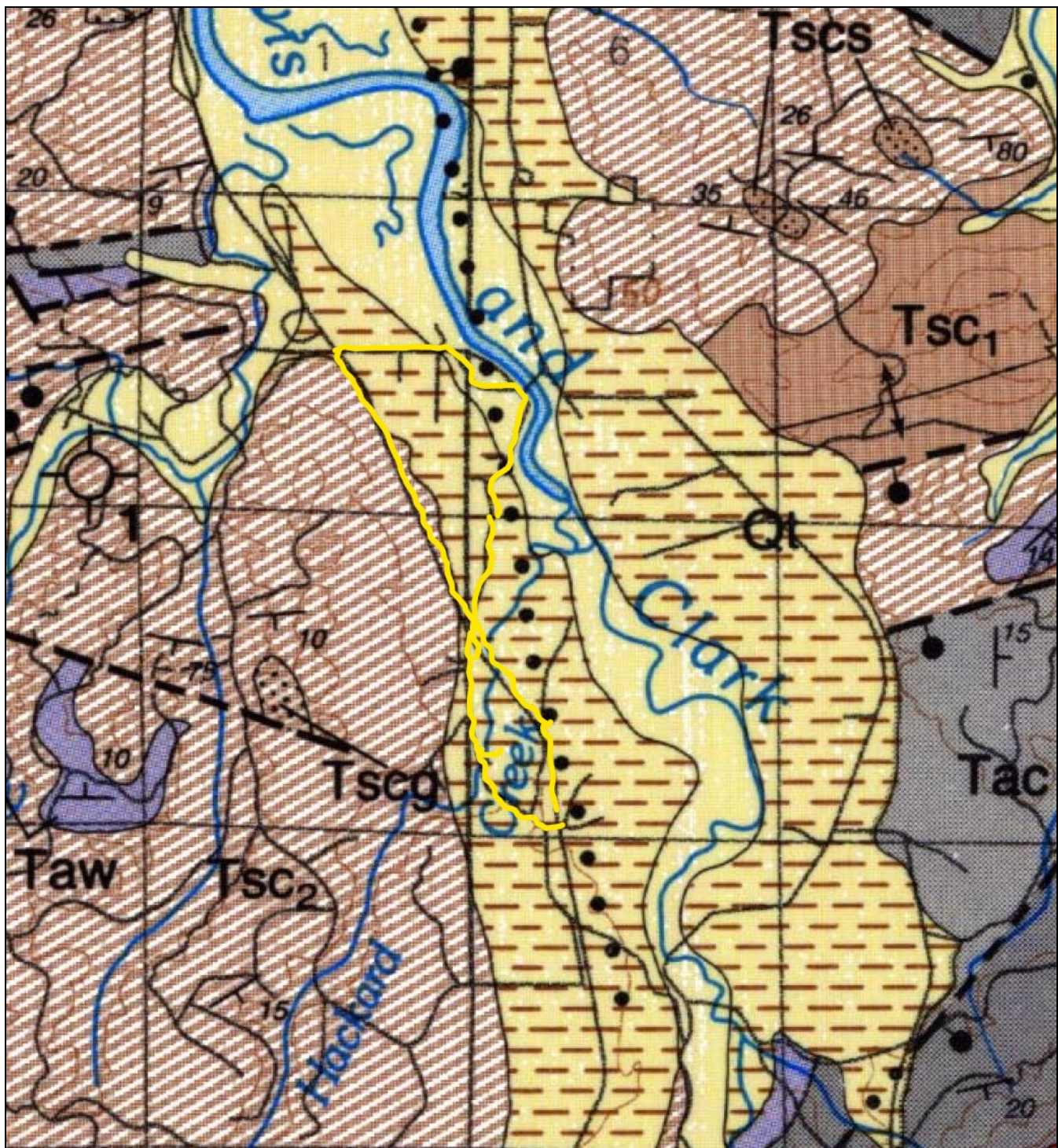


Figure 2: Project location map showing south and north ends of the area, between the yellow dots, plus the sorting yard in blue hatching, overlain on the USGS quadrangle map to show section lines.





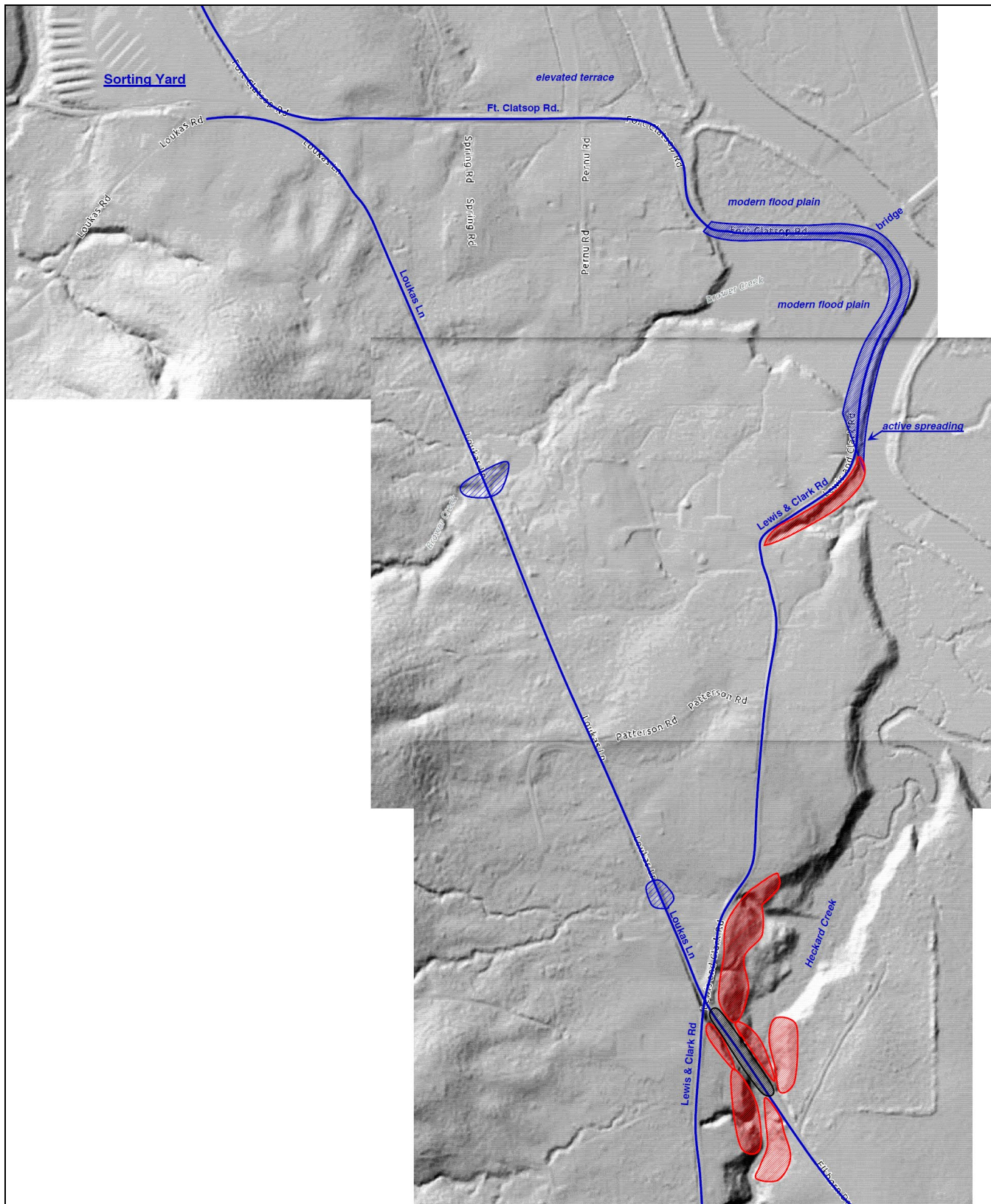
**Figure 3:** Geologic map for the project area; after Niem and Niem (1985). Most the roadways lie on uplifted Pleistocene river terraces (Qt; buff with dashed pattern) or younger modern flood plain (buff without dash pattern). A concealed, but inferred, fault runs NNW beneath the valley, as indicated by heavy dark dots. The terrace sediments lap onto and partly bury Oligocene Smugglers Cove tuffaceous siltstone (Tsc2). Roads inspected are highlighted in Yellow.





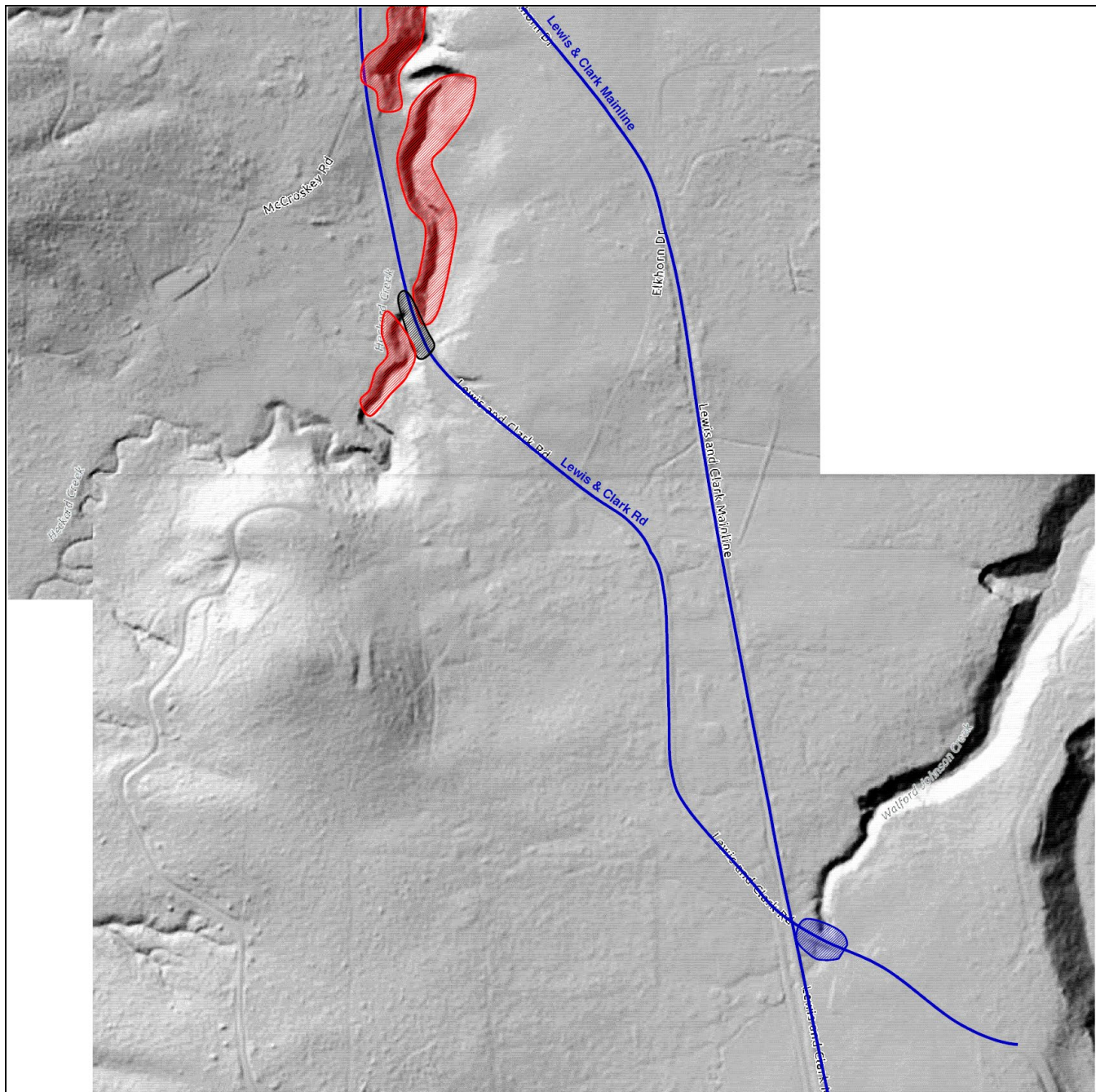
**Figure 4:** Soil map for the study area. Primary soils for this study consist of silty clay soils of the Walluski (71B), Grindbrook (21B), and Hebo (23A) soils. All form on terraces. Hebo soils tend to be saturated during winter and pose a small liquefaction risk. Coquille-Clatsop complex (12A) is modern swamp that is tidally influenced and composed of peat and clay.





**Figure 5:** Northern part of the study area. Roads are highlighted in blue and overlain onto LIDAR-based shaded relief maps. Areas prone to slumping during a regional earthquake or from heavy saturation are highlighted by Red hatching. Areas subject to liquefaction and lateral spreading are highlighted by Blue hatching. Areas of structural fill at risk of failure are highlighted in Black hatching. Base maps are courtesy of the DOGAMI LIDAR viewer website. North is up. The elevated terrace is free of landslide landforms, except where incised by creek gullies or river banks. The absence of hummocky landslide landforms is strong evidence that future landslides will not occur.

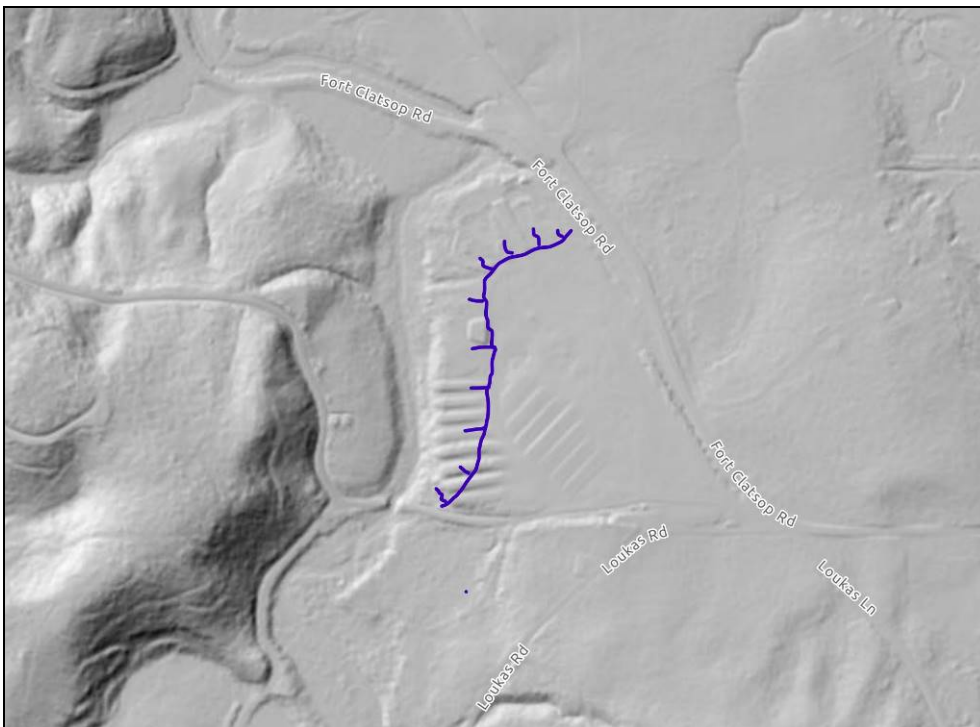




**Figure 6:** Southern part of the study area. Roads are highlighted in blue and overlain onto LIDAR-based shaded relief maps. Areas prone to slumping during a regional earthquake or from heavy saturation are highlighted by Red hatching. Areas subject to liquefaction and lateral spreading are highlighted by Blue hatching. Areas of structural fill at risk of failure are highlighted in Black hatching. Base maps are courtesy of the DOGAMI LIDAR viewer website. North is up. The elevated terrace is free of landslide landforms, except where incised by creek gullies or river banks. The absence of hummocky landslide landforms is strong evidence that future landslides will not occur.



**Figure 7:** Sorting yard aerial photo showing ponds that presumably were for washing logs. Most likely they are filled with loose sediment and organic wastes. The edge of the sorting yard drops about 28 ft over a horizontal distance of 145 ft for an average slope of 19 percent.



**Figure 8:** The blue toothed line delineates the edge of the settling ponds and weak fill that could spread during an earthquake. Compare with Figure 7.



## Monica Steele

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**From:** Terry Hendryx  
**Sent:** Monday, November 9, 2020 10:48 AM  
**To:** Monica Steele  
**Subject:** FW: Contract Deadline

Monica,

See Tom's comments on my previous email.

TLH

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**From:** Tom Horning <[horning@pacifier.com](mailto:horning@pacifier.com)>  
**Sent:** Friday, November 6, 2020 9:56 AM  
**To:** Terry Hendryx <[THendryx@co.clatsop.or.us](mailto:THendryx@co.clatsop.or.us)>  
**Subject:** RE: Contract Deadline

I went through the same thinking, Terry; now that you mention it. I let the map you sent me overrule things. However, your comments are consistent with what I would have found. The terrace is superior and has no slopes of any kind from Wadsworth to L&C Rd, unlike L&C Road. You can probably guess at the outcome. The Mainline will win. I have created the LIDAR images showing the terrace and valleys, but the instability of the eroding valley walls has not been drafted yet.

Tom

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**From:** Terry Hendryx [<mailto:THendryx@co.clatsop.or.us>]  
**Sent:** Friday, November 6, 2020 9:32 AM  
**To:** 'Tom Horning' <[horning@pacifier.com](mailto:horning@pacifier.com)>  
**Subject:** RE: Contract Deadline

Tom,

After I reviewed your report I thought there was an area I had requested reviewed as well. Going back through my emails, I see where I had asked for the 5 mile stretch of mainline between Wadsworth and the 4-way where the mainline runs to the old CZ Camp. Unfortunately, the map I provided to you did not include that piece of mainline. Based on your report, I believe in this area the liquefaction and subsidence potential is low since it sits on a terraced plain with virtually no side slopes.

I will start the process of extending the contract and moving forward with your payment today.

Thanks again,  
TLH

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**From:** Tom Horning <[horning@pacifier.com](mailto:horning@pacifier.com)>  
**Sent:** Friday, November 6, 2020 9:17 AM  
**To:** Terry Hendryx <[THendryx@co.clatsop.or.us](mailto:THendryx@co.clatsop.or.us)>  
**Subject:** RE: Contract Deadline

Got it. Filled out, attached. Thanks for your help.

Tom H.

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**From:** Terry Hendryx [<mailto:THendryx@co.clatsop.or.us>]  
**Sent:** Friday, November 6, 2020 8:51 AM  
**To:** 'Tom Horning' <[horning@pacifier.com](mailto:horning@pacifier.com)>  
**Subject:** RE: Contract Deadline

Tom,

Unfortunately I needed to put the invoice you sent into our payment system yesterday to make the deadline. Please sign the attached Reinstatement and send it back to me and I'll get the payment process started.

I reviewed your report and it reaffirmed what we believed all along. Thank you working us in between your other work, Covid and running for City Council. Congratulations on your win.

TLH

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**From:** Tom Horning <[horning@pacifier.com](mailto:horning@pacifier.com)>  
**Sent:** Friday, November 6, 2020 7:31 AM  
**To:** Terry Hendryx <[THendryx@co.clatsop.or.us](mailto:THendryx@co.clatsop.or.us)>  
**Subject:** RE: Contract Deadline

Well, blew the deadline, but unintentionally for what it is worth. Got my days mixed up. Thought it was Wednesday. Sorry about that. See what you think, attached.

Tom Horning, CEG  
Horning Geosciences

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**From:** Terry Hendryx [<mailto:THendryx@co.clatsop.or.us>]  
**Sent:** Tuesday, November 3, 2020 11:22 AM  
**To:** 'Tom Horning' <[horning@pacifier.com](mailto:horning@pacifier.com)>  
**Subject:** RE: Contract Deadline

Great, look forward to the final product.

TLH

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**From:** Tom Horning <[horning@pacifier.com](mailto:horning@pacifier.com)>  
**Sent:** Tuesday, November 3, 2020 11:09 AM  
**To:** Terry Hendryx <[THendryx@co.clatsop.or.us](mailto:THendryx@co.clatsop.or.us)>  
**Subject:** RE: Contract Deadline

I think I can make it. Turned out to be as suspected from LIDAR imagery.

Tom

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**From:** Terry Hendryx [<mailto:THendryx@co.clatsop.or.us>]  
**Sent:** Tuesday, November 3, 2020 9:45 AM



**To:** 'Tom Horning' <[horning@pacifier.com](mailto:horning@pacifier.com)>

**Subject:** RE: Contract Deadline

Morning Tom,

Just checking in to see how your weekend went? If we're to make the Thursday's completion deadline, I will need the report and an invoice for work performed prior to noon on Thursday. If it looks like you'll need an extension, I will need to get it out today.

Thanks,

TLH

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**From:** Tom Horning <[horning@pacifier.com](mailto:horning@pacifier.com)>

**Sent:** Friday, October 30, 2020 3:06 PM

**To:** Terry Hendryx <[THendryx@co.clatsop.or.us](mailto:THendryx@co.clatsop.or.us)>

**Subject:** RE: Contract Deadline

I think we will be okay. Depends on this weekend and the weather. Still have some field work to complete. Will advise Monday. Thanks for checking in

Tom

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**From:** Terry Hendryx [<mailto:THendryx@co.clatsop.or.us>]

**Sent:** Friday, October 30, 2020 2:47 PM

**To:** 'Tom Horning' <[horning@pacifier.com](mailto:horning@pacifier.com)>

**Subject:** Contract Deadline

Good Afternoon Tom,

Just checking on the progress of our report and to see if we needed to extend the upcoming contract termination date of November 5th?

Thanks,

TLH

Terry Hendryx, PLS

Assistant Director

Clatsop County Public Works

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