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**THE CAPES LANDSLIDE,
TILLAMOOK COUNTY, OREGON**

**MEMORANDUM TO MYRA THOMPSON LEE, DIRECTOR
OREGON EMERGENCY MANAGEMENT (OEM)**

by

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NOTICE

The Oregon Department of Geology and Mineral Industries is publishing this paper because the information furthers the mission of the Department. To facilitate timely distribution of the information, this report is published as received and has not been edited to our usual standards.



Oregon

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February 3, 1998

MEMORANDUM

**TO: MYRA THOMPSON LEE
DIRECTOR, OREGON EMERGENCY MANAGEMENT (OEM)**

FROM: DR. GEORGE R. PRIEST

SUBJECT: THE CAPES LANDSLIDE, TILLAMOOK COUNTY, OREGON

SUMMARY AND CONCLUSIONS

The emergency nature of the landslide threat to The Capes development near Netarts, Oregon caused OEM to invite our agency to assess the situation and provide recommendations. Our findings thus far indicate that the slope failure is accelerating and is currently threatening a number of homes, the most critical being on lots 28 through 30, 34 through 38, and 47 through 50 (see attached map). Structures in these areas are in imminent danger of loss and should be evacuated, if not stabilized in the near future. Lots 71 through 77 are the next most at risk followed by lots 69, 70, and 51 through 59. Their stability should be monitored. Slope failure is proceeding at such speed that this report is probably not accurately reflecting the immediate threat to homes. Immediate mitigation should be undertaken, if viable options are, in fact available and the objective is to save homes and property. An array of possible measures are summarized below. Options range from doing nothing to complete stabilization of the landslide using extensive armoring of the slope with quarry rock. Positive and negative impacts of mitigation options are summarized in Appendix 1. The Capes Home Owner's Association, Inc. is monitoring the situation daily and informing residents. Warning tape has been installed around some of the most dangerous areas at the top of the bluff.

FIELD WORK AND MEETINGS

Mr. Richard Rinne of AGRA Earth & Environmental, Inc. (AEE) made a visual reconnaissance of the slide area at The Capes community on Tuesday, January 20, 1998 (AGRA has been retained by The Capes Home Owners Association to evaluate geotechnical mitigation options). Mr. Rinne and I visited the site on January 23, 1998, and did some field mapping on January 27 and 28. We also briefed Tillamook County Commissioners and answered questions from the public on January 28, 1998. We agreed to attend another such informational meeting on February 10, 1998. We also met with The Capes Home Owner's Association on Sunday, February 1, 1998 to answer questions and provide an overview of the landslide problem. The latter discussion focused entirely on the landslide itself. The discussion with the County Commissioners focused on the landslide and on wider technical issues such as regional sand supply and erosion.

BACKGROUND

In December, 1997 residents of The Capes noticed a minor slope failure about two-thirds of the way up the steep slope seaward of the development. The Capes Home Owners Association (CHOA) has been visually monitoring movement since. The original movement

appeared minor (inches) but fairly constant. The stairway down to the beach has been damaged and sections have been removed. In recent weeks (and days) the slide movement has been accelerating and ground cracks have opened up at the crest of the slope approximately 8-10 feet behind lots 34-35 area on the southeast margin of the headwall (see attached map). Vertical drop in the lawns of these units was on the order of 18 inches on January 27, 1998. By Sunday, February 1, 1998, the drop had reportedly grown to about 5 feet. Fresh slumping has also occurred just slightly down slope from the same units. In the three days between my field visits the overall slope had moved significantly (from three to five or more feet) and fresh cracking had occurred further up slope on the northeast side of the headwall below lots 71-77. Rapid propagation of slope failure is also occurring below lots 28-30. At this point, the total vertical drop for the central part of the landslide would appear to be in excess of 14 feet. Rapid wave erosion at the toe of the landslide is causing sloughing of the toe and contributing to extensive lateral movement of the low mound of material at the toe (see map and cross section).

Active landslides expand by "regression" or landward propagating failure, if not stopped by nature or by mechanical means (i.e., buttressing, dewatering, etc). If the current rate of movement persists, structures on lots 28 through 30, 34 through 38, and 47 through 50 could be at risk within the next few days or weeks. All owners should be informed both by telephone and in writing of the hazards so that they may remove valuables, or in the case of permanent residents, temporarily move to another locality, if they so choose. The lots 71 through 77 above the northeast headwall that have slumps and ground cracks within a few feet of the top would be the next most at-risk. Lots 69, 70, and 51-59 could become at risk, if movement persists for weeks or months. Further movement has occurred since the last field investigation, so the level of threat may have changed.

OBSERVATIONS

The active ground movement is mainly confined to a 900-foot long (northwest-southeast) by 500-foot-wide (southwest-northeast) complex landslide that was in existence before the currently active movement (see attached map). The landslide cuts a thick (100 feet or more) mass of Holocene (<10,000 years old) Dune Sand overlying a thinner sequence of slightly consolidated Holocene mud interbedded with poorly sorted (many different sizes of particles) slightly to moderately consolidated debris flows, sands and silts with abundant logs and other dark-colored woody debris (see cross section). Some buried soils occur within this mud-debris flow unit, as evidenced by at least one upright tree stump. The mud is the apparent slip plane and overlies older (~15 million years) hard bedrock composed of Astoria Formation sandstones, minor mudstones, and interbedded submarine to subaerial Grand Ronde basalt.

The currently active landslide appears to be limited to the Holocene units where they fill a Pleistocene to Holocene (estimated between 18,000 and 4,000 years Before Present) paleovalley (former valley now filled with sediment or rock and not part of the present topographic setting). Ground water probably migrates into the sand filled paleovalley, which is lined with the impermeable mud. The mud inhibits the water from draining downward, so water builds up and, in effect, "lifts" the overlying sand, decreasing its strength and causing the slopes to fail. The paleovalley reaches sea level in the area of the landslide, so the underlying hard bedrock does not protect the Holocene sediments from wave erosion. Another contributing factor is recent removal by wave erosion of a 30 foot-high modern dune that mitigated erosion and helped to buttress the toe of the landslide. Dune removal may have been caused by gradual shifting of the Netarts estuary channel north to The Capes area.

While drilling and additional field work is needed to test this hypothesis, the field reconnaissance suggests that the active landslide may lie within a much larger tilted block or blocks. The Holocene/Astoria Formation contact (the paleovalley surface) appears to be dipping (inclined) landward in sea cliff exposures south of the active landslide. The expected dip would be seaward, both from the usual seaward inclination of coastal paleovalleys and from typical regional tilting of the Coast Range. The landward rotation implies but does not prove that block movements much larger than the active landslide and penetrate bedrock of the Astoria Formation. The rotation could be caused by either tectonic forces (e.g. active faulting and folding), or from large-scale slumping. If the latter, the failure plane possibly lies below sea level and the probable trigger could be large earthquakes or high rainfall events or cycles. Since these structures do not appear to be currently active, they probably do not pose as large a threat as the active landslide.

A detention pond (see map) that reportedly accepts all storm water from the development is located on a possible margin for one of these potential ancient slide blocks. Water from this pond reportedly drains quickly into the underlying sand and could contribute to instability of both the potential ancient slide block and active landslide.

POTENTIAL MITIGATION

A number of possible mitigation strategies are available for consideration, ranging from doing nothing to pursuing expensive engineering solutions. Five possible options and their consequences are summarized in the attached Appendix I and were presented informally in draft form to the Tillamook County Commissioners on January 28, 1998. Official representatives of The Capes Home Owner's Association were urged to seriously consider all options, taking into account the immediate hazard and the long term environmental consequences of any remediation actions

If some remediation is considered, reduction of water pressures within the slide is a logical first step. In virtually all landslides of this nature and especially in this part of the world, water is the primary driving force, and rates of movement are directly linked to the amount of water introduced into a slide mass. The shape of the paleovalley, and possibly the inclination of the rocks, may allow water to migrate from the detention pond toward the slide mass; additional surface and subsurface geological work will be necessary to test this hypothesis. If this is indeed the case, much of the storm water collected from the development may be entering the active slide mass. Rerouting of the storm water so it cannot enter the groundwater should be considered.

In addition to re-routing the storm water, the active slide could also be de-watered by a series of wells that reach the base of the dune sand landward of the slide. The size and spacing of the wells can be determined by the engineering firm, but some degree of immediate mitigation could be accomplished by drilling a number of wells as soon as possible. The wells should be constructed with the assumption that they will be permanent structures, operating year-around on a demand basis. A series of borings with piezometers and inclinometers should also be constructed in an appropriate configuration to monitor the effect of the dewatering program on water table height and ground deformation.

Additional remediation could be considered, if it is judged that dewatering provides insufficient mitigation. For example, undercutting by waves is contributing to the instability regardless of

ground water pore pressures. Adding buttresses of quarry rock from the toe of the steep upper slope of the slide to the slide top and/or at the open coastal toe would probably stop further movement, especially if combined with dewatering. In both cases the buttresses should probably have at their toe a trench ("key") excavated below the slip plane and filled with quarry rock. Drilling and/or trenching across the slip plane of the slide at the toe of the steep slope and at the open coastal toe of the slide would probably be necessary to evaluate the feasibility of buttressing.

NEGATIVE IMPACTS FROM BUTTRESSING

Whenever dunes or rocky bluffs are armored with quarry rock or cement to stop shoreline erosion, potential sand resources are generally lost as a future source for the beaches. The Capes is underlain by the most valuable type of sand resource – youthful (<10,000 years old) beach sand. If a permanent buttress of rip rap covers all or most of this resource, future sand resources will be locked up. Global sea level gradually rises from melting of glaciers. Sea level can also rise a few feet very suddenly, when the area experiences earthquakes. The sudden increase in sea level will cause beach retreat, eroding sand from dunes and bluffs landward of the present shoreline. These sand sources can maintain a sandy beach throughout the littoral cell (segment of the shoreline between bounding headlands). If such sand supplies are mostly locked up by armoring with quarry rock and sea walls, then the beach could be lost over wide areas when sea level rises. In addition, armoring can lead to increased wave attack to adjacent properties, and, if quarry rock or sea walls are exposed at the shoreline, scenic values can be impacted. These well known phenomena are the reason that shoreline protection structures are often discouraged. In fact a stringent permitting process is required by State Parks and the Department of State Lands to construct shoreline protection structures.

The policy implications of buttressing (Options 3-5, Appendix 1) with regard to littoral cell resources and management practices are beyond the scope of this report but should be given serious consideration. Consultation with Tillamook County, Department of State Lands, Oregon State Parks, Department of Land Conservation and Development, and other stake holders should be sought. Detailed oceanographic analysis of the impacts of Options 3-5 on littoral cell sand supplies and erosion processes would facilitate these discussions.

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Richard Rinne, AGRA Earth & Environmental, Inc.
Chuck Holliman, representative, The Capes Home Owners Association, Inc. (for distribution to the home owners)
Abby Kershaw, Joseph Murray, Mark Darienzo & Ken Keim, Oregon Emergency Mgmt.
Steve Williams, Oregon State Parks
Steve Purchase, Division of State Lands
Eldon Hout and Emily Toby, Department of Land Conservation and Development
Vic Affolter, Tom Ascher, and Wesley P. Greenwood, Tillamook County Community Development
Mike Pickett, Tillamook County Sheriff's Department
Onno Husing, Oregon Coastal Zone Management Association
Fran Recht, Oregon Shores Conservation Coalition

APPENDIX I: POSSIBLE OPTIONS FOR MITIGATION OF LANDSLIDE HAZARDS AT THE CAPES (Note that there are many other possible options; these are just representative of the range of possibilities).

Option 1: Do nothing.

Negative consequences: Current accelerating slope failure will probably continue as long as high ground water and wave attack continue. The landslide will probably propagate under the first row of houses at the headwall of the active landslide causing partial to complete loss of these structures, unless they are moved. Future erosion and slope movement will probably affect additional houses in the second row and beyond in the future. Costs will be incurred from loss or removal of houses. Property values could be affected, owing to uncertainty of the safety of the property.

Positive consequences: There will be no cost for engineering solutions, sand will be added to the littoral cell, future sand supply will not be locked up and scenic/environmental values will be preserved.

Option 2: Lower ground water pore pressures in the slide by pumping from water wells and rerouting storm water runoff.

Negative consequences: There will a significant cost for drilling wells and rerouting surface water. Current accelerating slope failure may or may not continue, depending on the amount of pore pressure reduction. Wave erosion will continue at the toe of the slide, which may cause additional movement, regardless of pore water pressure. Wave erosion will continue, even if slide movement is halted and will eventually undercut the houses. Provides little remediation on the scale of a few days, so the slide could propagate under the first row of houses, causing partial to complete loss of these structures, unless they are moved. Costs will be incurred from loss or removal of houses. Property values could be affected, owing to uncertainty of the safety of the property.

Positive consequences: The cost is modest relative to Options 3- 5. Sand will be added to the littoral cell, albeit at a slower rate than Option 1. Future sand supply will not be locked up and scenic/environmental values will be preserved. There is a much reduced chance that houses in the second row and beyond will be in jeopardy in the near term. Provides remediation on the scale of a few weeks and may provide long term mitigation on the scale of decades or longer, depending on the shoreline recession rate. In any case, the erosion processes might be slowed enough to allow time for moving houses.

Option 3: Lower ground water pore pressures in the slide and buttress only the open coastal toe of the slide, digging a "key" below the slide plane and filling it with quarry rock.

Negative consequences: The cost will be higher than Option 3. Sand supply in the young dunes will be locked up and unavailable to nourish beaches in the littoral cell (unless the buttress is only temporary). Houses could still be lost owing to potential continued failure of the upper, steep slope of the slide, but the probability is less than in Options 1 and 2. Scenic/environmental values may be compromised. Provides little remediation on the scale of

a few days. The permitting process will be more difficult than for Options 1 and 2.

Positive consequences: Costs are less than for Options 4 and 5. Long term slope failure will eventually be halted, once the upper part of the slide reaches a stable slope inclination. The upper part of the slope will be free of quarry rock, possibly improving scenic values over options 4 and 5. Even a temporary buttress at the toe of the slide would be beneficial in slowing down wave erosion-induced slope failure long enough to allow time for dewatering to have its full effect. Such a temporary buttress would also facilitate evaluation of Option 4, since it would make geotechnical exploration of the slide much safer.

Option 4: Lower ground water pore pressures in the slide and buttress only the upper, steep portion of the slide, placing an excavated "key" of quarry rock below the slide plane at the toe of this slope (this option would probably require a temporary buttress of the slide toe, which would be removed as the "key" was excavated)

Negative consequences: The cost will be high, approaching or exceeding the value of the first row of houses above the active landslide. The slip plane may be so deep that it is impractical to excavate a "key" below it. Sand supply in the young dunes above the "key" will be locked up and unavailable to nourish beaches in the littoral cell. Scenic/environmental values may be compromised. The permitting process will be more difficult than for Options 1 and 2.

Positive consequences: Slope failure might be halted quickly enough to preserve the first row of houses, since, in addition to dewatering, a rock blanket could be conveyor belted onto the upper part of the slide, increasing the shearing strength fairly quickly. Long term stabilization would prevent losing houses behind the first row. The large block of the slide at the toe but seaward of the "key" would still be available to add sand to the littoral cell and provide scenic values, until it is eroded away; hence, the permitting process may be somewhat easier than for either Options 3 or 5.

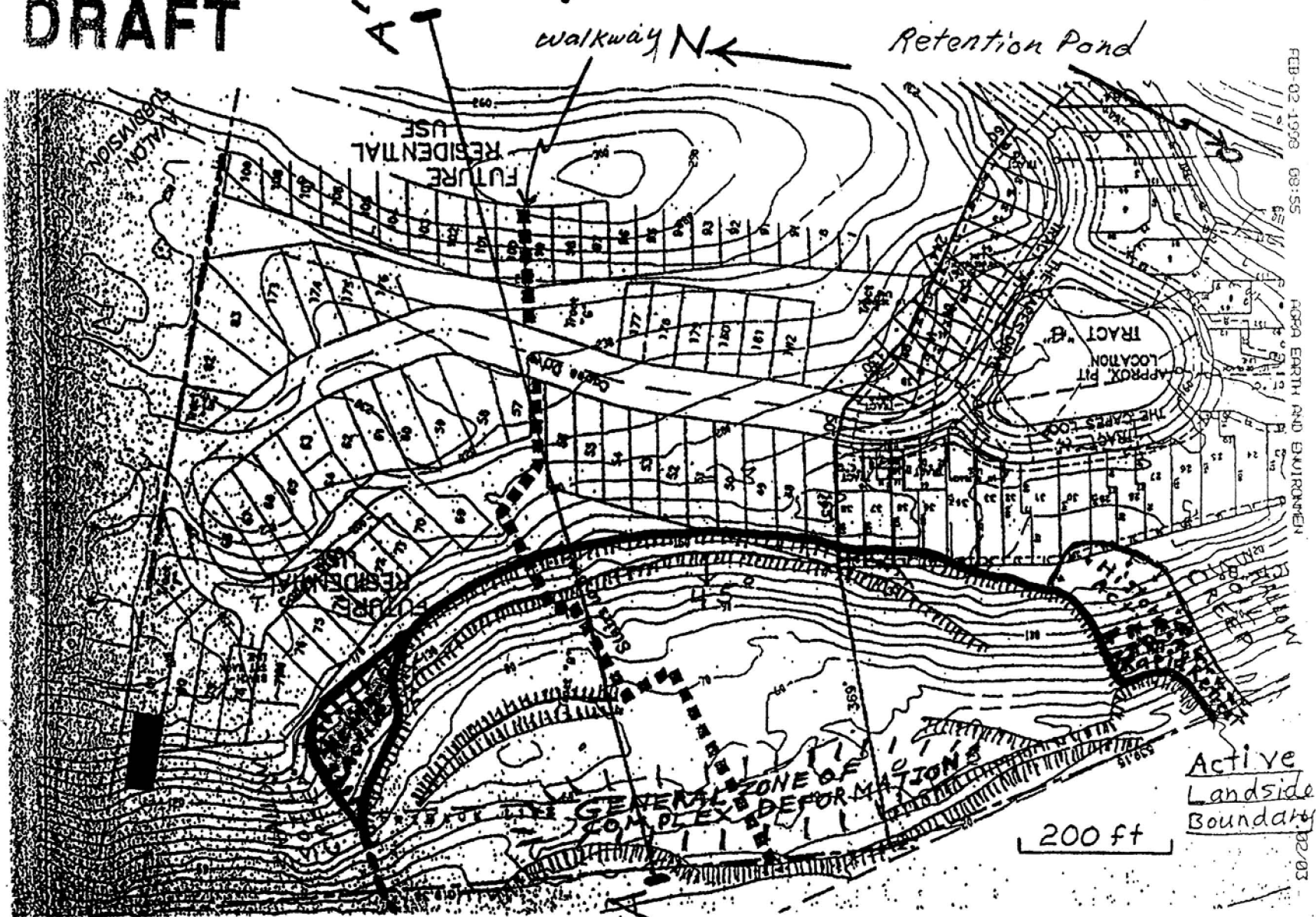
Option 5: Lower ground water pore pressures in the slide and buttress the entire slide (the toe and the upper, steep slope).

Negative consequences: The cost will be high, approaching or exceeding the value of the first row of houses above the active landslide. All sand supply in the young dunes will be locked up and unavailable to nourish beaches in the littoral cell. Scenic/environmental values may be compromised. The permitting process will be more difficult than for Options 1 and 2, and possibly more difficult than for Option 4.

Positive consequences: Since, like Option 4, this option could allow placement of a rock blanket by conveyor belt to the upper, steep slope of the slide, the first row of houses might be preserved. Long term stabilization will probably prevent losing houses behind the first row. Since a "key" of rip rap will be left at the base of the steep active slope and the open coastal toe of the landslide, it is highly unlikely that future erosion would threaten the houses. Even if it is impractical to excavate deep enough to place a key at the base of the steep slope of the slide, the key at the toe would probably still be enough to provide long term stabilization.

The Capes Landslide Map

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