THE DELINEATION OF LANDSLIDES IN THE LINCOLN COUNTY, OREGON COASTAL ZONE

by

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THE DELINEATION OF LANDSLIDES IN THE LINCOLN COUNTY, OREGON COASTAL ZONE

ABSTRACT: A study conducted along the Lincoln County, Oregon coast delineated the exact location of 153 landslides. The landslides were found through the interpretation of aerial photographs. Each landslide was verified in the field and its class (ancient, historic, recent), type (slump, debris slide or flow, planar slide), and status (stable, potential, active) was determined. Each slide was numbered and mapped at scales of 1:4800 and 1:62500.

The study area was divided into seven homogeneous reaches based on lithologic and morphologic differences. The number of slides occurring in the differing geologic units was then analyzed.

It was found that most landslides occur in conjunction with siltstone materials of Tertiary age. Areas with similar morphology but of sandstone materials are less likely to have landslides. Structurally, landslides occur in areas with steeply dipping Tertiary bedding planes or in areas with steep slopes such as river valleys.

A large portion of the landslides in the study area occur at contact zones between Tertiary and Quaternary materials. Most of these slides are ancient, stable slides and are larger than other slides in the study area. The only active ancient landslides in the coastal zone take place in the Nye mudstones near Beverly Beach State Park.

Those slides in the study area classed as historic and recent are predominantly active or likely to become active in the near future. Only 11 of these slides remain stable.

Landslides will continue to be a geologic hazard in Lincoln County, Oregon. However, knowledge of landslide location, lithology and morphology will reduce their impacts.

INTRODUCTION

Landslides are a frequently occurring geologic hazard. In the past, they have caused extensive damage to homes, highways, and other properties. Concern over geologic hazards is apparent at all levels of government. Federal, state and local authorities are attempting to identify potential hazards in an effort to anticipate and lessen damage to life and property.

The Coastal Zone Management Act (1972) mandates that each state initiate research toward the goal of providing local planning agencies with information necessary for the protection of future landowners in the coastal zone (Knuth, 1975).

In 1974, the Oregon Land Conservation and Development Commission (LCDC) set forth a comprehensive statewide plan issuing goals and guidelines for future development within the state. Areas subject to particular hazards such as flooding, erosion, landsliding, etc., were to be determined under comprehensive plans at the county level.

Toward this goal, Lincoln County, Oregon has initiated several research projects. This paper reports the findings of one research project undertaken during the summer of 1978.

The purpose of this study was to delineate the exact location of every landslide occurring along the Lincoln County coast. This would be accomplished by interpretation of aerial photographs and subsequent field verification. Landslides from ancient, historic, and recent times would be differentiated and mapped at a scale of 1:4800. Information concerning the status of the slide, stable, active, or potential, would also be determined from field evidence. For the purpose of this study, landslides were considered as those movements of earth materials occurring as deeply seated mass failures. This would exclude normal bluff erosion and most highway construction failures, as well as rock falls, soil creep, and other types of mass failures. An evaluation of the types of lithology and morphology most conducive to landslides would also be made.

The results of this study will provide land use planners with the information necessary to devise development plans which would restrict development to areas presenting the least threat to individuals and property. Although landslides are likely to be a continuing geologic hazard in Lincoln County, knowledge of their location and likelihood will help to reduce their impacts.

LITERATURE REVIEW

The study of landslides is of particular concern to geomorphologists, civil engineers, and land use planners. The general literature pertaining to landslides is found in a wide variety of sources. A review of this literature indicates that the study of landslides enables the geomorphologist to reconstruct past land forming sequences, and is an aid in the comprehension of present and future topographic processes. Whereas the civil engineer is concerned primarily with the safety factors of natural or artificial slopes, and with landslide prediction, prevention, and control, geomorphologists are concerned basically with their causes, courses of movement, and resulting surface formations. The information gained from geomorphologists and civil engineers is important to land use planners in their efforts to identify potential hazard areas.

The earth materials involved in landslides differ greatly, as do the rates of movement and amount of mass moved. As a result, a large variety of landslide types are produced under varying processes and causative factors. Numerous classification systems are found throughout the literature. These have been devised in an attempt to provide an orderly arrangement to the variety of landslide types. These systems are diverse in their characteristics and points of emphasis, including kinds of material, rate and type of movement, water content, as well as dimension of mass and initiating causes. Such systems have been developed by Ladd (1935), Sharpe (1938), Varnes (1958), and Zaruba and Mencl (1969).

In addition to differentiating between landslide types, the literature contains extensive information of landslide causes, mechanisms, and dynamics. Terazghi (1950) presents a detailed, comprehensive analysis of landslide mechanisms. Numerous authors (eg. Ladd [1935], Sharpe [1938], Terazghi [1950], Varnes [1958]) discuss the many causes of landslides, their dynamics, and identifiable features. Excellent summaries of landslides in general are presented by Schlicker (1956) and Morton and Streitz (1972).

Several studies concerning landslides along the Oregon coastline have been conducted. North (1964), in his masters thesis, developed a classification system for landslides occurring along the northern Oregon coast. His classification system is based principally upon the materials involved in a slide and its type of movement. Some of the major slides in Lincoln County were described in great detail and can be quite useful in understanding the dynamics of individual slides. The results of North's study indicate that the type of landslide is controlled by lithology.

Byrne (1963), in a study on coastal erosion, considered landsliding the primary type of bluff retreat. This study focused principally on the frequency and rates of erosion. Stratigraphy, structure, and lithology were determined as the factors controlling erosion rates. In this study, Byrne provides a general description of the Lincoln County shoreline, such as heights of cliffs, lengths of beaches, sizes of bays, and lithology of landforms.

North and Byrne (1965) described the general geology of the northern Oregon coast, and the dynamics and mechanisms of landslides. They also provide a simplified classification system. The general landslide topography along the northern coast of Oregon was mapped by lithology and type of landslide area.

Other studies of Oregon coast landslides are initiated as a result of a catastrophy. For example, Allen and Lowry (1944) describe the 1943 landslide at Jumpoff Joe in Newport, and Schlicker, et. al. (1961) describe the landslide at Ecola Park.

A report done by the State of Oregon Department of Geology and Mineral Industries on the Environmental Geology of Lincoln County, Oregon (Schlicker, et. al., 1973) provides a description of the geology of Lincoln County and environmental hazard areas. Hazards discussed include: flood prone areas, compressible soils, transient shorelines, earthquakes, high water tables, and landslide topography. This study provides the general background information needed by land use planners to begin delineating hazard areas. The section of the Bulletin dealing with landslides divides them into three categories; 1) ancient, 2) recent, and 3) active. These differences are not differentiated on the maps which accompany the Bulletin. Rather, landslides as a hazard in Lincoln County are mapped only as general landslide topography areas. Individual landslides are not mapped; however, photographs of the major slides in Lincoln County are included with the text.

FACTORS CONTRIBUTING TO LANDSLIDE PRODUCTION

Many times it appears that a landslide occurs as a surprise, without prior warning. However, it is often possible to predict the occurrence of a landslide by having sufficient knowledge of the conditions favorable to their production as well as observing visible evidence of movements which precede the final failure. The conditions favorable to a landslide may exist for long periods of time without any apparent movement. When given the proper impetus, a slide may be touched off within a relatively short period of time. The initiating factor is not usually simple however. Generally, several combined factors are responsible for landslide production. What may appear as a sole cause is in fact commonly only a contributory factor or trigger.

Slopes are generally stable when the shearing stress is less than the shearing resistance or strength (Diagram 1). When the shearing stresses acting upon a potential surface of sliding become equal to or greater than the shearing resistance a landslide develops. Likewise, a failure occurs if the shearing resistance decreases and becomes equal to the shearing stress. Therefore, landslides result from causes which either increase shearing stress or decrease shearing resistance (Terzaghi, 1950).

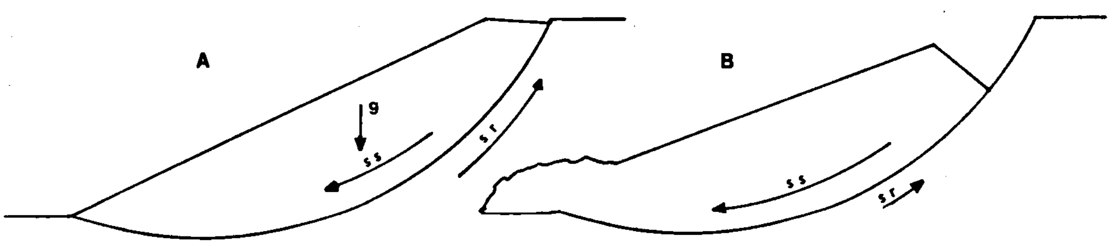

Diagram 1. ILLUSTRATION OF THE FORCES ACTING ON A SLOPE.
A) SHEAR STRESS & SHEAR RESISTANCE ARE EQUAL.
B) SHEAR STRESS EXCEEDS SHEAR RESISTANCE.
(g - normal stress)

. High Shear Stress

Increases in shearing stress result from several factors. One of the most common causes of landslides is the removal of underlying or lateral support. This is usually the result of undercutting by rivers or waves, or subaerial weathering. Man's activities, such as mining or highway construction, are also factors in removing support.

Other factors which contribute to high shear stress include overloading by rain, snow, talus, or buildings, etc.; and creation of a new slope by previous landslides, faulting, or subsidence. Tectonic stresses from earthquakes or blasting vibrations, and regional tilting which increases slope angle also increase shearing stress.

Low Shear Resistance

Internal Factors

The state of the material itself may be favorable to landslides. The material may have inherently low shearing resistance. These factors are part of the geologic setting and failures due to them may not occur for very long periods of time. The factors commonly involved are the stratigraphic, lithologic, and structural components of the material.

Stratigraphic causes consist of massive materials overlying weak or plastic materials, strata that is inclined toward a free face, and alternation of permeable beds with weak impermeable beds.

Lithologic conditions favoring landslides exist within inherently weak formations or those which may become weak from changes in external conditions. This is particularly common in clay, siltstone, and shale sediments, or decomposed rock.

Often the structural properties of materials are conducive to slope failures. These include such discontinuities as faults, bedding planes, joints, cleavage, and foliation.

External Factors

External factors which contribute to a reduction of shearing resistance and consequent slope failures include those which reduce cohesion and frictional resistance. Cohesion reduction results from the various forms of chemical and mechanical weathering, such as the breaking of soluble binders and expansion, contraction, and physical disintegration. A rise in water content, pressure, and ground water levels are factors which result in a reduction of frictional resistance. This occurs when air in voids is displaced by water, when slip surfaces are lubricated, when pressure is exerted on soil particles, or when subsurface erosion occurs.

METHODOLOGY

In order to determine the exact location of landslide occurrences along the Lincoln County coast, aerial photographs dated 1972 and 1977 were stereoscopically viewed and compared. The locating of landslides on aerial photographs was accomplished through the identification of characteristic features exhibited by landslides.

The most readily identifiable landslides are those which have had recent or historic movement. These slides generally show distinct scars, usually in an arcuate pattern, and are often devoid of vegetative growth. The jackstraw arrangement of trees, sag ponds, and debris areas remain visible on aerial photos.

In contrast, time has obscured most of these features where ancient landslides are concerned. These failures are identifiable on aerial photographs by the remaining arcuate features and the hummocky nature of the deformed surface area.

Recent slides are sometimes visible on aerial photos through the displacement of cultural features such as buildings or highways. Recently repaired stretches of highway, debris remaining on beaches or roadsides, and leaning or fallen trees are also indicative of these slides.

Based on these factors, each slide within the study area was classified as either ancient (originating several hundred years ago), historic, or recent.

When a landslide was identified by photo evidence its exact location was plotted on contact photo maps according to its age classification. These maps, at a scale of 1:4800, correspond to a strip of the Lincoln County coastline approximately 1.3 miles in width. This area was delineated as the study area. These contact photo maps were numbered consecutively (1-25) from south to north.

Each slide was then field checked to insure accuracy of aerial interpretation. Field evidence used for verification of slides included cracked building foundations, tension cracks on surface areas, scarps devoid of vegetation, leaning trees, trees with curved trunks, seep lines, sag ponds, displaced stratification, debris accumulations, hummocky land surface, and arcuate patterns.

Utilizing this evidence, the slide's status was determined to be stable (showing no signs of recent movement), potential (currently not moving but likely to do so in the near future), or active.

After Schlicker (1956, 1973) landslides were determined to be of three types: 1) rotational slump - backward tilting blocks of earth material moving downslope on a curved slip plane; 2) debris slides or flows - highly deformed mass of earth material moving downslope on a straight slip plane (a debris slide is differentiated from a debris flow by the water content in the mass); 3) planar slide - a detached block of undeformed material moving downslope along a bedding plane.

For the purpose of this study, failures occurring in construction or highway cuts were not considered as landslides. Likewise, sloughing by erosion along the bluff edge was also excluded. These types of failures are not considered to be characteristic of deep-seated landslides.

Once a landslide was verified, its location was plotted on a topographic sheet at a scale of 1:62500. Information concerning the size of the slide was determined from aerial photographs and the 1:4800 contact maps. This included the slide's length and width in meters and areal hectares.

It was hypothesized that the number of landslides would correlate with the differing types of lithologies along the coastline. Therefore, the study area was divided into sections based on geologic materials. Each of these geologic units (reaches) was given a number (1-7) from north to south and mapped on the topographic sheet.

For the purpose of landslide reference, a five digit number was assigned to each landslide within the study area. This number was derived by combining the geologic reach number, the 1:4800 contact map number, and the number of the slide on the area covered by the contact map. For example, the number 5-13-05 corresponds to the landslide located in Reach 5, contact map number 13, slide number 5 in this area. The format of the number (reach-map-slide) affords quick recognition of the geologic unit as well as the location of the slide.

RESULTS

There are 153 landslides within the zone studied in Lincoln County. Each of the slides is delineated on a map which can be found in Appendix B. A table which accompanies this map (Appendix A) provides information on each slide's size (length/width, areal hectares), type (slump, debris slide, planar slide), class (ancient, historic, recent) and status (stable, potential, active). The table also gives a verbal description of each slide's location.

There are 73 ancient landslides within the study area (Table 1). Of these slides, 67 are stable at this time; however, seven of them show signs of potential movement. Only six of the slides classed as ancient are active. All six of these occur in Nye Mudstone materials in Reach 5 (Table 2).

Table 1. The evaluation of landslides by class and status.

STATUS	CLASS			
	Ancient	Historic	Recent	Total
ACTIVE	6	32	7	45
POTENTIAL	7	26	4	37
STABLE	60	11	0	71
Total	73	69	11	153

Table 2. Comparison of landslide status by class and reach.

REACH	ANCIENT			HISTORIC			RECENT		
	Act.	Pot.	Sta.	Act.	Pot.	Sta.	Act.	Pot.	Sta.
1	0	0	3	5	1	0	2	0	0
2	0	2	12	1	4	1	0	1	0
3	0	0	1	0	0	0	0	0	0
4	0	2	12	1	7	0	0	2	0
5	6	3	6	16	8	7	4	1	0
6	0	0	19	9	1	1	1	0	0
7	0	0	7	0	5	2	0	0	0

Of the 153 landslides, 69 are classed as historic. About one-half of these (32) remain active, while 26 show potential movement and 11 remain stable. Most of the historic slides (31) are found in Reach 5 where 16 of these are active (Table 3). The remaining slides (11) in the study area are recent. Four of these are potential and seven are active.

Table 3. Landslide numbers by class and reach.

REACH	CLASS				
	Linear (Km)	Ancient	Historic	Recent	Total
1	2.3	3	6	2	11
2	14.7	14	6	1	21
3	5.3	1	0	0	1
4	10.6	14	8	2	24
5	14.4	15	31	5	51
6	32.5	19	11	1	31
7	6.1	7	7	0	14
Total	85.90	73	69	11	153

Table 4 indicates the status of the Lincoln County landslides by reach. Notably, Reach 5 contains 58 percent of the active landslides and 34 percent of the potential slides in the study area. Forty-six percent of the landslides in the entire study area are stable.

Table 4. Landslide numbers by status and reach.

REACH	STATUS			
	Active	Potential	Stable	Total
1	7	1	3	11
2	1	7	13	21
3	0	0	1	1
4	1	11	12	24
5	26	12	13	51
6	10	1	20	31
7	0	5	9	14
Total	45	37	71	153

The Lincoln County shoreline was divided into seven homogeneous reaches. A reach was considered to be a continuous, uninterrupted extent of the shoreline area based upon similar lithologic and morphologic characteristics. The length of each reach can be found in Table 3. Five of these reaches are north of Yaquina Bay and two are to the south. The reaches are differentiated on the map in Appendix B.

Reach 1 is from the mouth of the Salmon River (Lincoln - Tillamook County line) south to the north end of the village of Roads End. This reach is characterized by high cliffs protected in places by resistant igneous dikes of late Eocene age. Elevations in Reach 1 are such that high, near vertical cliffs (122 m) are formed at the ocean interface. Where this occurs, the siltstones of the Nestucca Formation are subject to mass failure. The ancient landslides within this area moved as rotational slumps and are currently stable. These slides occured on the upper portion of the bluff and are found approximately 300 meters inland of the bluff edge. The remainder of the slides in this reach are debris slides which remain active. The recent activity is indicated by the lack of vegetation on the bluff and the debris cones formed on the beach.

Reach 2 extends from the north end of Roads End to the southern end of Siletz Bay, near Gleneden Beach. This reach consists primarily of Quaternary marine terrace deposits overlying seaward dipping Tertiary siltstones of the Yamhill and Nestucca Formation. The majority of the slides in Reach 2 are ancient, stable slides. Most of these are found along the contact zone between the Quaternary and Tertiary materials. The slides which are active are rotational in nature and occur primarily along the coast.

Reach 3 extends from Gleneden Beach south to Fishing Rock. Reach 3 is distinquished from Reach 2 by a difference in underlying Tertiary material. In Reach 3 the material underlying the marine terrace deposits is sandstone of the Yaquina Formation rather than a siltstone. There is only one landslide in Reach 3. However, this occurs in an area where the marine terrace deposits have contact with a siltstone. Therefore, no deepseated slides in this reach have taken place in the marine terrace deposits underlain by sandstone.

Reach 4 stretches from Fishing Rock south to and including Otter Crest State Park. Lithologically, Reach 4 is composed of Cape Foulweather and Depoe Bay basalts of middle Miocene age, Tertiary sandstones, and pockets of Quaternary marine terrace deposits. In this region, most of the slides occur in the sandstone where it comes in contact with the basalt. Several slides also occur in the weathered basalt regolith along Otter Crest Loop. These are evidenced by the tension cracks and repairs along this road.

The basalt in this region is exposed as outcrops along the coast. The resistance of this basalt protects the overlying marine terrace deposits from undermining. However, in Boiler Bay and Whale Cove the Quaternary deposits are unprotected and slides have occured as a result. Whale Cove contains a large ancient slide which is currently stable. Boiler Bay has experienced three slides, now stabilized by riprap, but the potential for further movement still exists.

Reach 5 includes the area between Otter Crest State Park and Yaquina Bay. This reach has experienced the most intensive landsliding activity along the Lincoln County coastline. Although the reach comprises only 16 percent of the study area, it contains 33 percent of the landslides. Generally, Reach 5 is composed of Quaternary marine terrace deposits underlain by Nye Mudstone, a siltstone of the early Miocene epoch. The continuity of this area is interrupted by a basalt headland, Yaquina Head. There are also sandstone outcrops along the coast, north of Yaquina Head.

Within the study area, excluding Reach 5, all the ancient landslides are stable, although a few show signs of potential future movement. In Reach 5, several large ancient slides occur in the Beverly Beach area. These slides are in the Nye Mudstone and remain active. The movements of these landslides toward the ocean contribute to a large number of mass failures in the marine terrace deposits along the bluff edge. The ancient slides which do remain stable within this reach are located in Yaquina sandstones.

Highway 101 is often damaged as a consequence of the seaward movement of the active ancient landslides. An interesting landslide (5-14-06) occurs along Highway 101, between Beverly Beach State Park and Coal Creek. This slide originated as an ancient rotational slump. The horizontal strata, through backward tilting, has been displaced to nearly vertical. Highway 101 is built atop this tilted detached block and lateral splitting of this block in both directions causes continual damage to the highway.

The city of Newport has been subjected to extensive landsliding. Eleven landslides have been delineated within the city's coastal region, ten of which remain active or show signs of potential movement. The best known of these slides occurs at Jumpoff Joe. This slide involves 1.9 areal hectares to the north of the point (5-12-04) and 2.8 hectares to the south (5-12-05). This failure has been attributed to ground-water lubrication and slippage along bedding planes of the Astoria and Nye complex (Allen and Lowry, 1944).

Reach 6 stretches from Yaquina Bay south to Starr Creek, just north of Yachats and is the largest reach in the study area. This area is 32.5 kilometers long and has 31 individual landslides. The entire length of the reach is composed of marine terrace deposits. The underlying materials are similar to those in Reaches 2 and 3, sandstone and siltstone. However, the lower relative relief and the more horizontal dip of the underlying materials are reason for distinction.

A few small landslides along the coast occur in marine terrace deposits underlain by sandstone, but the majority (28) are in siltstones and occur in the river valleys where the relief is higher. In this reach the slides are primarily located along the contacts between the terrace deposits and the siltstones. An exception to this is a unique slide in the vicinity of Hidden Lake (6-06-01). This slide is a large detached block of Alsea siltstone which is migrating along a slip surface toward the ocean. The block remains relatively intact but is subject to wave attack at its toe during high tides. Drainage in the area has been diverted around the block since the siltstone is comparatively impermeable. There is also evidence of seepage through the weathered material on top of the block.

The final reach, Reach 7, includes the area between Starr Creek and the Lincoln-Lane County line. This reach is in the basalt of Yachats found in the Cape Perpetua area. Much of this late Eocene material has developed into a thick regolith. Landslides in this reach are found in areas with steep slopes. Here the regolith is subject to saturation during heavy rains and movements occur mainly as debris flows or torrents. Two such slides are worth noting.

Landslide 7-01-04 developed in an area that had been harvested of timber several years before. Residents in this area indicate that several debris jams developed in the drainage system and caused increased ground-water saturation. During a period of heavy rains, soils and other debris cascaded down this valley causing damage to Highway 101 and moving a house eight inches off its foundation. Debris from the slide is still pushed up against the back of the house. There are no deep scars in recent air photos of this area; however, barren patches of land indicate that this slide began as a sheet wash accumulating debris as it moved and developed into a rapid flow. The path of this slide is obvious on recent air photos since the channel is cleared of debris and vegetation. Debris jams are still forming in this area and residents fear a recurrence is likely.

Slide 7-01-05 occurred in the Cape Perpetua campgrounds. This slide also developed during heavy rains and moved as a debris flow; however, there is evidence of a deep rotation at the source of the slide.

The remaining active and potential slides in Reach 7 are either debris slides or debris flows depending on water content.

CONCLUSIONS

The results of this study indicate that Lincoln County, Oregon has experienced extensive landslide activity in its coastal region. Many of these slides occurred in the distant past, many are currently active, and others are likely to become active in the near future.

It is apparent that the combined influence of lithology, stratigraphy, and structure determine the location and number of landslides in the study area. Reach 5 is by far the most sensitive to landslides with one-third of the slides in the entire study area. In fact, the only active ancient landslides occur in this reach. In Reach 5, as in most of the study area, the materials involved in the slides are marine terrace deposits overlying inclined siltstones. Siltstones, particularly the Nye mudstone seem most conducive to landslide activity. In areas where the marine terrace deposits overlay sandstones, landslides are less likely to occur even if the dip of the Tertiary beds is similar. This is obvious in Reaches 2 and 3. Reach 2, underlain by siltstone, has numerous landslides, while Reach 3, similar to Reach 2 except for the sandstone lithology, has only one landslide and this slide occurs in an outcrop of siltstone material.

The structure of Reach 6 causes considerable variance in the number of slides. This reach is similar to Reaches 2 and 3 in lithology but the dip of the Tertiary materials is less than in the other reaches as is the total relief. Slides which do occur in Reach 6 are smaller by comparison or occur in river valleys where the slopes are steeper.

Most of the landslides in the study area occur either along the coast or at contact zones where two materials come together. Landslides occuring at the contact zones are usually larger than the other slides in the study area. Ground water seepage and the differing porosities of the materials may be a factor in this case.

It is difficult to differentiate landslides from erosion along the coast. The primary difference is in the contributing causes. Whereas sloughing or erosion is primarily due to undercutting, landslides are usually in conjunction with steeply dipping strata toward an open face.

Reaches 1, 4, and 7 are principally composed of basalt. In Reaches 1 and 4 the basalt acts to protect the coastline from wave attack. However, in places where this material has been breached, wave energy is concentrated and damage is intense. This is also the case in Reach 7. However, most of the slides occur further inland in this reach. These slides are involved in deeply weathered basalt regolith. Slides in this reach are probably the most devastating when they occur since they are usually triggered in periods of high rainfall and take the form of rapid debris flows or torrents.

The ancient landslides are the largest in the study area. Most of these slides are located inland from the coast. It is probable that smaller slides also occured in ancient periods; however, evidence of these slides has long since disappeared. Most of the ancient landslides in the study area are stable, however, some show signs of potential movement. Any movements in these slides are likely to be smaller than the original slides. This is not the case with those active ancient slides in Reach 5. The size of these slides approximates the original slide. These slides are moving as soil creep and are impetus for extensive landslide activity in the Beverly Beach area.

It is likely that landslides will always be a hazard in Lincoln County, Oregon. By knowing where landslides have occurred in the past and what materials are most conducive to landslides, it is possible to anticipate where slides are most likely to occur in the future. This information will enable land use planners to implement programs which will lessen the impact of landslides in the future.

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APPENDIX A

Location, size, and nomenclature of landslides in the Lincoln County study area.

SLIDE NUMBER	LOCATION	SIZE Length (m)	Width (m)	Hectares	NOMENCLATURE Type	Class	Status
1-25-01	Along coast, 1159 m south of Salmon River	242	73	1.8	debris slide	historic	active
1-25-02	256 m inland from slide 1-25-01 azimuth 130°	293	85	1.6	slump	ancient	stable
1-25-03	Along coast, 1464 m south of Salmon River	317	98	2.1	debris slide	historic	active
1-25-04	Inland 252 m from slide 1-25-03 azimuth 160°	207	98	1.6	slump	recent	active
1-25-05	Inland 366 m from slide 1-25-03 azimuth 153°	366	268	9.1	slump	ancient	stable
1-25-06	Along coast, 2074 m south of Salmon River	220	171	3.8	debris slide	historic	active
1-25-07	244 m south of slide 1-25-06	195	31	.6	debris slide	historic	active
1-25-08	244 m inland from slide 1-25-07 azimuth 80°	159	61	.7	slump	ancient	stable
1-25-09	122 m inland from slide 1-25-10 azimuth 35°	244	98	1.8	slump	recent	active
1-25-10	Along coast, 295 m south of slide 1-25-07	427	85	2.6	debris slide	historic	active
1-24-01	Along coast, at north end of Roads End	146	67	.7	slump	historic	potential
2-24-02	At end of Neptune Drive, Roads End, south of slide 1-24-01	122	73	.8	slump	historic	potential
2-24-03	Northern section of Roads End, inland of slide 1-24-01	647	220	10.9	slump	historic	stable
2-24-04	Between Neptune Dr. and Port Rd. 183 m inland from 69th St. Roads End	85	61	.4	slump	historic	potential
2-24-05	244 m inland of slide 2-24-04	390	305	10.1	-	ancient	stable
2-24-06	From the end of Port Lane north to Sal-La-Sea Dr., Roads End	683	98	4.4	-	ancient	stable
2-24-07	From 59th and Neptune Ave. north to Port Lane, Roads End	525	122	4.3	-	ancient	stable
2-24-08	From 39th St. north to 50th St. and Logan Rd., Roads End	756	378	20.6	-	ancient	potential
2-24-09	Along coast, within slide 2-24-08	317	24	.8	slump	recent	potential
2-23-01	From West Devils and Holms Rd. to Surf Dr., near 35th St. Lincoln City	549	280	9.7	-	ancient	stable
2-23-02	From Keel Ave. and 22nd St. to N. Oar and 30th, Lincoln City	671	146	6.3	-	ancient	stable
2-23-03	From Lake View Dr. and Alder Way across Devils Lake Rd. to Alice St. Lincoln City	488	281	10.5	-	ancient	stable
2-23-04	From N. 8th and N. Harbor Ave. north to 21st and Harbor Ave., Lincoln City	720	415	20.5	-	ancient	stable
2-23-05	Harbor Ave. and N. 15th St., Lincoln City	37	12	.1	slump	historic	active
2-23-06	Vicinity of Inlet Ave. and S. 3rd St., Lincoln City	183	49	.6	slump	historic	potential
2-22-01	North of S.14th St. near S. Oar Ave., Lincoln City	476	122	3.9	-	ancient	stable

2-22-02	244 m north of Thorpe Road, Lincoln City	415	134	3.6	-	ancient	stable
2-22-03	488 m south of S. 23rd St., Lincoln City	732	159	3.8	-	ancient	stable
2-22-04	From S. 31st St. to S. 37th St., Lincoln City	622	122	5.2	-	ancient	stable
2-22-05	Along S. Beach Ave., from S.40th St. to S. 51st St., Lincoln City	732	85	4.3	slump	ancient	potential
2-21-01	800 m off Hgwy 101 on Oregon 229 north side of Siletz Bay	73	37	.1	slump	historic	potential
2-21-02	Adjacent to slide 1-21-01	183	37	.4	slump	ancient	stable
3-19-01	Along Fogarty Creek, 1300 m east of Hgwy 101	439	244	7.6	-	ancient	stable
4-19-02	North face of Fishing Rock	122	24	.4	slump	historic	potential
4-19-03	South face of Fishing Rock	244	49	.7	slump	historic	potential
4-19-04	Along coast, 333 m south of Fishing Rock	146	31	.4	slump	ancient	potential
4-18-01	Along coast, azimuth 33°,1165m from Boiler Bay Park rest room	85	24	.3	debris slide	historic	potnetial
4-18-02	Along coast, north side of Boiler Bay	134	24	.4	debris slide	historic	potential
4-18-03	Where Boiler Bay undercuts Hgwy 101	98	37	.8	slump	historic	potential
4-18-04	From Boiler Bay rest room, azimuth 83°, 1037 m	305	183	5.2	-	ancient	stable
4-18-05	Adjacent to slide 4-18-04	403	171	6.5	-	ancient	stable
4-18-06	Near the fork in North Depoe Bay Creek	732	427	24.9	-	ancient	stable
4-17-01	Between Hgwy 101 and South Depoe Bay Creek	561	220	7.5	-	ancient	stable
4-17-02	North of Whale Cove, Between Hgwy 101 and coast	378	329	10.4	-	ancient	stable
4-17-03	Along Rocky Creek, off Hgwy 101	342	55	1.3	-	ancient	stable
4-16-01	Along Otter Crest Loop, 1.16 km north of Cape Foulweather	134	61	.8	slump	recent	potential
4-16-02	Along Otter Crest Loop, 1 km north of Cape Foulweather	73	37	.2	slump	historic	potential
4-16-03	Along Otter Crest Loop, .8km north of Cape Foulweather	244	122	1.2	slump	historic	active
4-16-04	East of Hgwy 101 .37km, azimuth 30° from Cape Foulweather	647	586	31.9	-	ancient	stable
4-16-05	Along coast, .3km north of Cape Foulweather	195	134	.7	debris slide	historic	potential
4-16-06	Along Otter Crest Loop, .3km north of Cape Foulweather	427	61	3.6	-	ancient	potential
4-16-07	Due east of Cape Foulweather, .8km	1439	244	27.9	-	ancient	stable
4-16-08	Along Otter Crest Loop, .5km south of Cape Foulweather	366	146	3.0	-	ancient	stable
4-16-09	Along Otter Crest Loop, .9km south of Cape Foulweather	427	49	1.5	-	ancient	stable
4-16-10	1km northeast of the junction of Hgwy 101 and Otter Rock Rd.	549	207	7.4	-	ancient	stable
4-16-11	.7km north of the junction of Hgwy 101 and Otter Rock Rd.	622	49	2.4	-	ancient	stable
4-16-12	.5km north of Otter Rock Rd., along east side of Hgwy 101	268	49	1.0	slump	recent	potential
5-16-13	Along coast, north of Devils	403	55	1.1	debris	historic	potential

5-15-01	Azimuth 55°, .67km from the south junction of Hgwy 101 & Otter Crest Loop	793	159	7.0	-	ancient	stable
5-15-02	.37km from the south junction of Hgwy 101 and Otter Crest Loop, on west side of Hgwy 101	207	31	.3	slump	recent	active
5-15-03	Azimuth 97°, .37km from the south junction of Hgwy 101 & Otter Crest Loop	915	183	11.2	-	ancient	active
5-15-04	Azimuth 125°, .24km from the south junction of Hgwy 101 and Otter Crest Loop	366	134	3.2	-	ancient	active
5-15-05	Along coast, 305m south of Devils Punch Bowl	134	31	.2	debris slide	historic	stable
5-15-06	Along coast, 488m south of Devils Punch Bowl	98	24	.2	debris slide	historic	stable
5-15-07	Along Hgwy 101, 183m south of south junction of Hgwy 101 & Otter Crest Loop	244	232	3.5	slump	historic	active
5-15-08	366m south of south junction of Hgwy 101 & Otter Crest Loop	195	98	1.3	slump	historic	active
5-15-09	.73km nw of Beverly Beach State Park ranger station	732	146	7.2	-	ancient	active
5-15-10	Along Hgwy 101, 1km south of south junction of Hgwy 101 & Otter Crest Loop	122	24	.2	slump	historic	active
5-15-11	Azimuth 140°, .9km from the entrance of Beverly Beach State Park	1159	171	10.7	-	ancient	active
5-15-12	Along Hgwy 101, 366m south of Beverly Beach State Park entrance	134	31	.3	slump	recent	active
5-15-13	Along Hgwy 101, .73km south of Beverly Beach State Park entrance	110	24	.2	slump	historic	active
5-15-14	Along Hgwy 101, .87km south of Beverly Beach State Park entrance	146	31	.3	slump	historic	active
5-15-15	Along Hgwy 101, 1.1km south of Beverly Beach State Park entrance	244	73	1.1	slump	historic	active
5-14-01	17.6m south of Wade Creek mouth	98	85	.7	slump	recent	active
5-14-02	.85 km east of Hgwy 101, between Wade and Coal Creeks	610	110	4.3	-	ancient	active
5-14-03	Adjacent to slide 5-14-02 (south)	500	232	6.8	-	ancient	active
5-14-04	Along Coal Creek, 1.8km east of Hgwy 101	403	500	17.6	-	ancient	stable
5-14-05	244m NE of Coal Creek & Hgwy 101	268	37	.7	-	ancient	stable
5-14-06	Along Hgwy 101, 220m N of Coal Creek	293	49	1.3	slump	historic	active
5-14-07	Along Hgwy 101, 122m S of Coal Creek	183	37	.4	slump	historic	potential
5-14-08	Along coast, 122m S of Coal Creek	85	12	.1	debris slide	recent	active
5-14-09	Just N of Moolack Creek mouth	85	24	.2	slump	historic	stable
5-14-10	366m S of Moolack Creek, along Hgwy 101	744	232	9.5	slump	ancient	potential
5-14-11	Directly E of landfill, N of Moolack Beach	793	177	9.0	-	ancient	stable
5-14-12	Along coast, .73km S of Moolack Creek	244	49	.7	slump	ancient	potential
5-14-13	Along coast, 1.1km S of Moolack Creek	49	24	.1	debris slide	historic	stable
5-14-14	Along coast, 1.3km S of Moolack Creek	183	49	.5	debris slide	historic	stable
5-14-15	Along coast, 305m S of Schooner Creek mouth	122	37	.3	debris slide	historic	potential
5-13-01	Along coast, 1.2km N of Yaquina	98	24	.3	debris	historic	potential

5-13-02	366m N of South St. and Schooner Ave., Agate Beach	305	49	1.3	-	ancient	stable
5-13-03	Along Rhododendron Ave. and Fossil St., Agate Beach	586	220	8.5	-	ancient	stable
5-13-04	Along coast, 183m N of Fossil St., Agate Beach	159	24	.3	debris slide	historic	potential
5-13-05	Along coast, at end of Fossil St., Agate Beach	159	67	.7	slump	historic	active
5-13-06	SW of slide 5-13-05	159	37	.5	slump	historic	active
5-13-07	At end of Agate St., Agate Beach	220	73	.9	planar	historic	active
5-13-08	Along Ocean View Dr. 220 m N of Big Creek	122	37	.7	slump	historic	potential
5-13-09	Along coast, 488m N of Big Creek	220	49	.8	slump	historic	active
5-13-10	Along coast, 732m N of Big Creek	207	98	1.4	slump	historic	active
5-12-01	Along coast, at Pacific St. and N. 23rd St., Newport	342	85	1.6	planar	historic	active
5-12-02	Along coast, at Pacific St. and N. 18th St., Newport	232	55	.9	slump	historic	active
5-12-03	W side of Park Dr., vicinity of N 14th St., Newport	390	122	3.8	slump	ancient	potential
5-12-04	North side, Jumpoff Joe, 12th and Spring St., Newport	281	98	1.9	slump	historic	active
5-12-05	South side, Jumpoff Joe, N 10th and Coast St., Newport	415	85	2.8	slump	historic	active
5-12-06	Along coast, vicinity of Evans and Elizabeth St., Newport	281	37	.6	slump	historic	potential
5-12-07	Along coast, at Shannon and Elizabeth St., Newport	232	43	.6	slump	recent	potential
5-12-08	Along coast, at Eulio and Mark St., Newport	122	43	.4	slump	historic	potential
5-12-09	Along coast, at Mark and Minnie St., Newport	159	61	.3	debris slide	historic	stable
5-12-10	.2km E of McLean Pt. on Yaquina Bay Rd.	110	49	.5	debris slide	historic	stable
6-11-01	2.3km S of the junction of Ferry Slip Rd. and Hgwy 101	610	98	4.1	-	ancient	stable
6-11-02	Inland 793m from slide 6-11-01	525	92	4.5	-	ancient	stable
6-11-03	N side of King Slough, Yaquina Bay	317	110	2.3	-	ancient	stable
6-10-01	Along coast, 305m S of Henderson Creek	281	37	.8	planar	historic	active
6-10-02	Along coast, 305m N of Grant Creek	342	37	1.0	planar	historic	active
6-10-03	Along coast, 152m S of Thiel Creek	122	24	.2	debris slide	historic	active
6-09-01	Along coast, 1.5km N of Lost Creek	159	24	.4	planar	historic	active
6-09-02	Along coast, 1.3km N of Lost Creek	219	43	.8	planar	historic	active
6-09-03	Along coast, 1km S of Lost Creek	122	43	.4	debris slide	historic	active
6-08-01	Azimuth 55° 300m from the junction of Hgwy 101 and Beaver Creek Rd.	366	85	1.6	-	ancient	stable
6-08-02	.4km from Hgwy 101, 300m NE of Beaver Creek Rd.	317	110	2.4	-	ancient	stable
6-08-03	1km from Hgwy 101 on Beaver Creek Rd., Azimuth 40° 1.28km	512	537	28.8	-	ancient	stable
6-08-04	1km from Hgwy 101 on Beaver Creek Rd., Azimuth 206° 610m	403	134	3.6	-	ancient	stable
6-08-05	Azimuth 200° 1.3km from the	427	415	15.8	-	ancient	stable

6-08-06	.6km S of Beaver Creek Rd. on Hgwy 101, Azimuth 150° 512m	366	281	7.6	-	ancient	stable
6-08-07	Along coast, .5km N of Seal Rock State Park	179	31	.5	debris slide	historic	active
6-08-08	N of Hill Creek, at Seal Rock State Park	195	37	.5	debris slide	recent	active
6-07-01	Along coast, .6km S of Seal Rock Rd.	220	55	.7	debris slide	historic	stable
6-07-02	Along coast, .8km S of Seal Rock Rd.	171	55	.6	debris slide	historic	potential
6-06-01	Along coast, N end of Sandpiper Vg.	512	98	3.6	planar	historic	active
6-06-02	.2km off Hgwy 101 on Sandpiper Dr.	159	24	.3	-	ancient	stable
6-06-03	Along N side of Bay View Dr. 2.7km from Hgwy 101, Alsea Bay	610	73	2.8	-	ancient	stable
6-06-04	inland of slide 6-06-03	610	500	27.5	-	ancient	stable
6-05-01	East side of Lint Slough, Waldport	403	158	4.5	-	ancient	stable
6-05-02	East side of Lint Slough, Waldport	500	427	17.9	-	ancient	stable
6-03-01	Between Big Creek and Blodgett Rd. 1km east of Hgwy 101	488	281	10.4	-	ancient	stable
6-03-02	Between the S fork of Big Creek & Vingie Creek, 1.2km E of Hgwy 101	500	281	10.7	-	ancient	stable
6-03-03	Between the S fork of Big Creek & Vingie Creek, 1.5km E of Hgwy 101	610	244	8.6	-	ancient	stable
6-02-01	South of Vingie Creek, 1.4km inland of Hgwy 101	488	500	21.0	-	ancient	stable
6-02-02	South of Vingie Creek, .9km inland of Hgwy 101	366	207	5.5	-	ancient	stable
6-02-03	Along coast, S of Starr Creek 244m	49	19	.1	debris slide	historic	active
7-02-04	Along N side of Yachats River Rd., 1km off Hgwy 101	708	207	11.0	-	ancient	stable
7-02-05	Along N side of Yachats River Rd., .6km off Hgwy 101	244	342	7.9	-	ancient	stable
7-02-06	Along the Yachats River, 427m from Hgwy 101	244	61	.7	slump	historic	potential
7-02-07	Along coast, 427m N of Yachats R.	183	49	.6	debris slide	historic	potential
7-02-08	Along coast, 183m N of Yachats R.	85	12	.3	debris slide	historic	potential
7-02-09	Along N side of Yachats River Rd., 1.6km from Hgwy 101	610	439	23.4	-	ancient	stable
7-02-10	Along N side of Yachats River Rd. 2.2km from Hgwy 101	915	366	26.5	-	ancient	stable
7-01-01	.8km S of Yachats River along Hgwy 101, east side	512	195	6.8	-	ancient	stable
7-01-02	488m W of slide 7-01-01	525	214	8.3	-	ancient	stable
7-01-03	460m W of slide 7-01-02	268	220	4.5	-	ancient	stable
7-01-04	122m S of slide 7-01-03	256	122	1.7	debris flow	historic	potential
7-01-05	East end of Cape Perpetua Campgrounds	171	61	9.1	debris flow	historic	potential
7-01-06	Above Devils Churn, N of Hgwy 101	329	110	3.0	debris flow	historic	stable
7-01-07	Above Devils Churn, N of Hgwy 101	281	37	1.1	debris slide	historic	stable

APPENDIX B

Map of landslide locations in
the Lincoln County study area.