BULLETIN 90 TEXT

LAND-USE GEOLOGY

OF

WESTERN CURRY COUNTY, OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

STATE OF OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES 1069 State Office Building, Portland, Oregon 97201

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WESTERN CURRY COUNTY, OREGON

John D. Beaulieu
Oregon Department of Geology and Mineral Industries
and
Paul W. Hughes, Consulting Geologist

Research was sponsored in part by the U. S. Geological Survey, Dept. of the Interior, under USGS Grant 14-08-0001-G-135

The preparation of this report was financed in part through a project development grant under the Coastal Zone Management Act of 1972 administered by the Office of Coastal Zone Management of the National Oceanic and Atmospheric Administration



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1976

CONTENTS

INTRODUCTION	_	-	-	-	-	1
Purpose	_	_	-	_	_	1
Acknowledgments	_	-	-	-		1
Previous Work and Sources of Data	_	-	_	_	_	2
How to Use the Report	_	_	_	_	_	2
General	_	_	_	_	_	2
Site evaluations	_	_	_			2
Land use capability analysis	_	_	_	_	_	4
Projection of data	_	_	_	_	_	4
Policy formulation	_	_	_	_	_	4
			,			•
GEOGRAPHY	_	_	_	_	_	5
Location and Extent	_	_	_	_	_	5
Climate	_	_	_	_	_	6
Topography	_	_	_	_	_	6
Population and Economic Trends	_	_	_	_	_	9
Land Use	_	_	_		_	10
Land Ose	_	_	_	_	_	10
ENGINEERING GEOLOGY	_	_	_	_		11
General	_	_	_	_		ii
	-	-	-	_	-	
Bedrock Geologic Units	-	_	-	-	-	11
Sedimentary rocks of late Tertiary age -	_	-	_	-	-	11
Sedimentary rocks of early Tertiary age –	-	-	-	-	-	13
Sedimentary rocks of Late Cretaceous age			-	-	-	14
Sedimentary rocks of Early Cretaceous age		-	-	-	-	15
Sedimentary and volcanic rocks of Jurassic	age	•	-	-	-	16
Otter Point Formation	-	-	-	-	-	16
Dothan Formation	-	-	-	-	-	18
Galice Formation	_	-	-	-	-	19
Igneous and metamorphic rocks of various a	ges	-	_	-	-	20
Mount Emily Dacite	_	_	_	_	_	20
Colebrooke Schist	_	_	_	_	_	21
Pearse Peak Diorite	_	_	_	_	_	22
Serpentine (serpentinite) and peridoti	te	_	_	_	_	23
Surficial Geologic Units	_	_	_	_	_	24
General	_	_	_	_		24
	_	_	_	_	_	24
Beach sand	_	-	-	-	-	25
Unstable dune sand	-	-	-	-	-	
Stable dune sand	-		-	-	-	25
Marsh deposits	-	-	-	-	-	26
Quaternary alluvium	-	-	-	-	-	26
Quaternary fluvial terrace deposits	-	-	- "	-	-	27
Quaternary lower marine terrace deposits	-	-	-	-	-	28
Quaternary middle marine terrace deposits	-	-	-	-	-	29
Quaternary upper marine terrace deposits	-	-	-	-	-	29
Quaternary higher marine terrace deposits	- ·	_	-	-	-	31
Soils	-	_	_	_	-	31
General	_	_	_	_	_	31
Systems of soils classification	_	_	_	_	_	31
Distribution	_	_ :	_	_	_	32

TECTO	DINC	SETTING				-	-		-	-	35	
	Gener	al				-	-		-	-	35	
		nal Onshore Stru	cture -			_	_		_	_	35	
	•	Rogue-Galice su				_	_		_	_	35	
		Otter Point and			ion -	_	_		_		35	
		Rogue–Galice th				_	_		· _ ·	_	35	
		-				_			_	_	37	
		Colebrooke Schi				_			_	_	38	
		Block faulting of				-	-		-	_		
		Shear zones of lo		oic ag	e -	-	_		-	_	38	
		nal Offshore Stru	cture –	- ' -		-	-		-	-	38	
1		ηuakes − − −					- 1		-	-	40	
		General		- ' -		-	-		-	-	40	
•	-	Earthquake poter	ntial –			- '	-	- ' -	-	-	42	
		Possible lo	cations ar	nd mag	nitud	es –	-		-	-	42	
		Effect of d	istance			-	-		-	_	42	
		Ground res				_	_		_		45	
**		Type of co		.		_	_		: _ :	_	45	
		Impact				_	_		_	_	46	
		Recommendation							_	_	47	
		Recommendation							5.4		7/	
AAINIT	-DALD	CCOLIDCEC .							in in the second		4 8	
MIINE		ESOURCES				_	_		_	-		
	Gene		- -			-	_		_	-	48	
	Const	ruction Materials	;			-	-		_	-	48	
	J .	General				-	-		· -	-	48	
	-	Consumption -			-, -	-	-	- '	-	-	49	
٠.		Sources				· - ·	- '		-	-	49	
		Planning conside	rations			-			-	-	49	
	Meta	llic Mineral Reso	urces -	- -		-	-		-	-	51	
		General				-	<u> -</u>	- 11	_	-	51	
		Lode deposits ar	d laterite	depos	its -	٠	_ '		-	_	55	
		Gold and					_			_	55	
		Chromite -		_ ' _		_	_		_	_	55	
		Platinum -				_	-			_	55	
		Copper -			201		4		_	_	55	
		Nickel -				_	4 <u>2</u> .	_			55	
		Other -		<u> </u>			_		_	_	56	
				 		-	-			_		
		Placer deposits -		- -		_	_		-	-	56	
		Fluvial pla				_	-		-	-	56	
` -		Coastal pl							-	_	56	
	Nonm	netallic Mineral	Resources			_	-		-	-	57	
		General				-	-		-	-	57	
		Priceite	·	"		-	-			-	57	
4.5		Ultramafic mine	rals –			· –	-		-	-	57	
		Coal	- -	- - "		· ·		- ' -	-	_	57	
		Oil and gas -	- -			-	_			_	58	
	Grou	nd Water 🕒 –				_			_	_	58	
		General		<u> </u>			-			-	58	
	~	Distribution -	. <u>-</u> - '				_			_	59	
		Uplands -					_			_	59	
		Terraces -			_ =	_	_			_	59	
		Low lands -				· -	_			_	62	
**						_	_		_		62	
		Water quality -				-	-		-	-		
		Planning conside	erations			·	-		-	-	64	
		\		-								
	r		h.									
			, ,	١V							• .	

viass	Mover	ARDS nent -	- -	-	-	-	-	-	-	_	-	-		-	-	65 65
	Gene	ral			_	-	-	_	_	-	-	-	-	-	-	65
	Cause	s		_	-		_	-	_	- ,	-	-	-	-	_	65
r	4-	Downs	lope g	grav	ity	com	pon	ent	-	-	- ,	_	_	_	-	67
		Shear				-	·_	_	_	_	-	-	-	_	_	67
	Distri	bution	_	_	-	-	_	_	_	_	-	-	-	-	_	67
	Impac	ts -		_	-	-	_	-	_	_	_	-	-	-	-	70
		nmendo	itions	-	-	-	_	_	-	_	-	-	-	_	-	70
Осеа	n Floo	ding .		_	_	_	_	_	_		_	_	_	_	_	73
	Gene	_		_	_	_		_	-	_	_	_	_	_	_	73
	Tidal	floodi	na -	_	_	_	_	_	_	_	-	-	-	-	_	73
		Causes		_	_	_	_	_	_	_	_	_		_	_	73
		Tidal		tion	· –	_	_	_	_	_	_	_		_	_	74
		Impact				end	atio	ns	_	_	_	_	_			74
	Storm	surge ·		-	_		_	-	_	_	_		_	_	_	74
	5101111	Gener		_	_	_	_	_	_	_	_	_	_	_	_	74 74
		Magni		_	_	_	_	_	_	_	_		_	_	_	74 76
				_	_	_	_	_	_	_	_	_	_	_		
	T	Impact	_	-	-	-	-	-	_	-	-		_	-	-	76
	Tsuna			-	-	_	-	-	-	-	-	· - .	-	-	-	76
		Gener		<u>.</u>	<u>-</u>	_	-	-	-	-	-	-			. 7	76
		Magni			ıstuı	bar	nce	-	-	-	-	-	_	_	-	76
	-	Attenu			-	-	-	-	-	-	-		-	-	-	77
	,	Bathyn	•	-	-	-	-	-	-		-	-	-	-	-	77
		Run-u		= .	-	-	-	-	-		-		-	. · -	-	78
		Impact		_	-	-	-	-	-	-	-	-	-	-	-	7 8
		Recom				-	-	-	-	-	-	-	· —	-	-	78
Vave		on and	Depo	sitio	on	-	-	-	-	-	-	-	-	-	-	79
	Gene			-	-	-		-	-	-	-	-	-	-	- 1	79
	Head	land ar	nd sec	-cli	ff e	rosi	on	-	-	. – .	. -	-	· -	-	-	79
		Hard p	re-Te	ertia	ry k	edr	ock	-		-	-		-	-	-	79
		Tertia				-	-		-	-	-	-	-	-	-	79
		Sheare				ry b	edro	ock	-	-	-		· - ,	-	-	8 2
		Terrac								-	-	_	-	-	_	82
		Impact								_	_				_	82
	Beach	•		_	_	_	-	-	_	_	_	_	_	_	_	83
		Drift k	each	es	_	_	_	_	_	_	_	_	_		_	83
			Effect		lone	sho	re d	drift	_	_	_	_	_	_	_	83
			Effect		_				_	_	_	_	_	_	_	84
			Effect					`_	_	_	_	_	_	_	_	84
			Gold			_	_	_	_	_	_	_	_	_	_	86
			Port (ea-	h	_	_	_	_	_	_	_	_	86
			Beach					اسب	Čt	<u>-</u>	,- ne ^E	 } ~-	-	_	_	86
							iu \$0	חוטכ	ΟĪ	Ca	pe [un	CO	-	-	
			Chetc				-	-	_	-	-	-	-	_	-	87
			Other		ache	es	-	-	-	-	-	-	-	_	-	88
		Swash			-	-	-	-	-	-	-	-	-	_	-	88
	_	Recom	mend	atio	ns	-	-	-	-	_	-	-	-	-	-	88
olope	Erosi			-	-	-	-	-	-	-	-	-	-	-	-	88
		ition a		ıuse:	s -	-	-	-	-	-	-	-	-	-	-	88
	Distri	bution	-	-	-	-	-	-	-	-	-	-	-	-	-	91
	Impa	cts -		-	-	-	-	-	-	_	-	-	-	-		91
	•	nmendo	ations	-	_	-	-	_	_	-	-	-	_	-	-	91
	Recor															
trea	m Floo			-	-	-	-	-	-	-	-	-	-	-	-	92

Causes 9	3
	4
	6
Recommendations 10	0
Stream Erosion and Deposition 10	0
General 10	0
Uplands 10	1
Flood plains 10	2
Esturaries 10	2
Rogue River 10	
Chetco River 10)7
GEOLOGY OF CITIES 10	8
General 10	
Port Orford 10	
Gold Beach 11	1
Brookings 11	4
SUMMARY 11	7
Use of This Bulletin 11	7
Geographic Setting 11	7
Engineering Geology 11	7
Mineral Resources 11	
Geologic Hazards 11	
Geology of Cities 12	
BIBLIOGRAPHY 12	21
*	•
APPENDIX 13	33
A. Guide for the textural classification of soils 13	
B. Unified soil classification system 13	
	37
D. Comparison of three systems of particle-size classification - 13	
E. Ground-water well-numbering system 13	
F. Longshore drift 14	
G. Constants for calculating sheet and rill erosion,	Ю
	12
Curry County, Oregon 14	12
CLOSSARV	12
GLOSSARY 14	13

ILLUSTRATIONS

Figures		1.
	Suggested use of this bulletin in site evaluations	3
	Index map of study area showing quadrangle map coverage	. 5
	Cape Blanco, the westernmost point in Oregon, consists of middle marine terrace	
	deposits overlying Tertiary and Pre-Tertiary bedrock	7
4.	Time distribution of stratigraphic and surficial geologic units	12
	High shear cliff faces in Cape Sebastian Sandstone	17
	Otter Point, the type locality of the Otter Point Formation, is a barren headland	
٠.	two miles north of Wedderburn	17
7	Well developed schistosity in phyllites and schists of the Colebrooke Schist	21
	Gravel and sand of a fluvial terrace deposit exposed in a roadcut on Floras Creek	27
	The middle marine terrace rises from near sea level on the Port Orford area to	2/
7.		30
10	200 feet in the Cape Blanco area	36
	Major structures of Curry County and southwestern Oregon	30
11.	Regional shearing of Jurassic and Cretaceous rocks in the Port Orford Shear Zone	39
10	has resulted in extensive landsliding	
	Pliocene rocks are truncated by a fault at Cape Blanco	39
	Tectonism of the Gorda Basin	41
14.	McVay Rock, on the Harbor Bench, consisted of blueschists and was excavated for	
	use in jetty construction	51
15.	Planar deposits of gravel in the Rogue River flood plain are indicative of rapid	
	bedload transport and high current velocities	54
16.	Bedload deposits of gravel along the Rogue River are characterized by high	
,	proportions of gravel and low proportions of sand or silt	54
17 <i>.</i>	Extremely irregular topography in the Lookout Rock area south of Humbug Mountain	
	indicates deep earthflow and slump resulting from coastal undercutting of	
5.	sheared bedrock	69
18.	Coastal undercutting promotes rock fall and other steep slope failures in unsheared	
	bedrock at Humbug Mountain	69
19.	Continual movement of massive coastal slides in western Curry County is the under-	
	lying reason for the dips and swales in the coastal highway	71
20.	Slumps of road material are commonly caused by stream undercutting, saturation of	
	fill material, or simple failure of improperly placed fill material	71
21.	Extremely high rockfall danger on parts of the Rogue River highway necessitates	
	screening to protect motorists	72
22.	Wave heights of the 1964 tsunami above mean high water	77
	Coastal retreat at Rocky Point has almost totally removed the old highway	81
	Coastal retreat of Tertiary bedrock cliffs south of Cape Blanco results from massive	
	slumps, slides, and slope erosion	81
25.	Erosion and deposition plotted as a function of particle size and current velocity	84
26.	The sand spit and shoals between the jetties at the mouth of the Rogue River	
	present severe hazards to navigation	85
27.	The mouth of Floras and Willow Creeks is blocked by beach material swept in	
_, .	from the south by longshore drift	85
28.	Jetty construction at the mouth of the Chetco River stabilized the spit and has	
	prompted construction of diverse water-dependent facilities	87
29	Severe gullying of an area originally exposed by sliding has removed topsoil making	٠,
2/.	this slope unsuitable for reforestation	92
30	A small group of trees was all that prevented this house from floating out the mouth	, _
.	of the Chetco River to the Pacific Ocean during the flood of 1964	97
	5. The shored kirter to the ractife decail dorling the mode of 1704	,,

31.	Rogue mail service boats were anchored in the driveway of Lex Fromm's boat
	house during the 1964 flood 97
32.	Boats in the Del Rogue parking lot at Wedderburn during the 1964 flood were
	later washed to sea when the water rose several more feet 98
33.	Water rose to window sill heights at Angler's Resort and other establishments
	along the Rogue River at Wedderburn during the 1964 flood 98
34.	Damage caused by the 1964 flood at the Port of Brookings exceeded several
	hundred thousand dollars — — — — — — — — — — — 99
35.	Where torrential floods spill onto flatter terrain debris scoured from upland areas
	is commonly deposited as debris fans 101
	The flood waters of 1964 destroyed the swinging bridge at Agness 103
37.	Riprap is used to protect the county road on the outer bend of a meander along
	the Pistol River 103
38.	On the south side of Humbug Mountain an overflow channel has been carved out of the
	slope to direct excess runoff out of Brush Creek over a 200-foot cliff to the ocean
	to protect downstream areas (Figure 39) – – – – – – – – – – 104
39.	The lower reaches of Brush Creek (behind Humbug Mountain) are cemented to
	prevent undercutting of the highway in highly critical areas – – – – – 104
	This boat was left hanging from the trees by the flood of 1964 on the lower Rogue River – 105
41.	This two-bedroom home was moved one-fourth of a mile downstream from its Kimble
	Kourt 'mooring' before being 'deposited' during the flood of 1964 on the
	Rogue River 105
42.	A Warrenton Sea Food executive kneels in four inches of mud and silt to
	dramatize the problems of deposition associated with flooding 106
43.	Aerial view of Port Orford, Curry County 109
44.	Aerial view of Gold Beach, Curry County 112
45.	Aerial view of Brookings, Curry County 113

Maps in folder

Geologic maps of the following quadrangles:

Agness (in part)

Cape Blanco and part of Langlois

Cape Ferrelo

Gold Beach

Mt. Emily (in part)

Port Orford

Geologic hazards maps of the following quadrangles:

Agness (in part)

Cape Blanco and part of Langlois

Cape Ferrelo

Gold Beach

Mt. Emily (in part)

Port Orford

Τa	b	lе	s
----	---	----	---

Tables	
<u>Tables</u>	
1. Climatic data, Curry County, Oregon	- 6
· 2. Landforms of western Curry County, Oregon	- 8
3. Population of Curry County, Oregon	- 9
4. Population of communities, Curry County, Oregon	- 9
5. Generalized engineering properties of soils in Curry County, Oregon	- 33
6. Scale of earthquake intensities and magnitudes	- 43
7. Historic seismicity - major earthquakes affecting Curry County, Oregon	- 44
8. Repair ratios for earthquakes of varying intensity	- 46
9. Impacts of an earthquake of Intensity VIII in Curry County, Oregon	- 46
10. Production of construction materials, western Curry County, Oregon	- 50
11. Active construction material operations in western Curry County, Oregon	- 50
12. Potential sources of construction materials, western Curry County, Oregon	- 52-53
13. Representative water wells, western Curry County, Oregon	-60-61
14. Water quality of selected municipal wells, western Curry County, Oregon	- 63
15. Drinking water standards defined by U. S. Public Health Service, 1962	- 63
16. Classification of mass movement, Curry County, Oregon	- 66
17. Distribution of mass movement, Curry County, Oregon	- 68
18. Representative tidal elevations of the Oregon Coast	- 75
19. Summary of coastal erosion, Curry County, Oregon	- 80
20. Engineering treatment of coastal erosion	- 89
21. Calculated slope erosion, western Curry County, Oregon	- 90
22. Basic streamflow and tidal data for major streams, Curry County, Oregon	- 95
23. Discharge and recurrence frequency of major floods of the Rogue River	- 96
24. Land-use geology of geologic units, western Curry County, Oregon	- 116

LAND USE GEOLOGY OF WESTERN CURRY COUNTY, OREGON

INTRODUCTION

Purpose

Responsible land use planning and land management require an adequate data base with regard to the use potentials and use limitations of the land. Providing the maximum amount of practical information to the greatest number and variety of users in western Curry County is the purpose of this study.

The need for systematic and reliable information about geologic hazards, engineering properties, and resources is gaining wider recognition by State officials, County officials, planners, developers, engineers, and private citizens. Senate Bill 100, passed by the Oregon Legislature in 1973, created a Land Conservation and Development Commission for the purpose of implementing statewide planning goals and coordinating comprehensive plans. Technical information of the sort provided in this bulletin is essential to the success of that and similar efforts on the State and local level in Oregon.

Legal trends in recent years have been toward placing increasing responsibilities on permit-granting agencies. In California, recently, a county road project perpetrated a landslide, and runoff from a county-approved subdivision adversely affected neighboring property. In both cases, liability was placed upon the county (Schlicker and others, 1973). The information provided in this bulletin will enable the personnel of Curry County to evaluate and plan future development more effectively.

Acknowledgments

The authors greatly appreciate the cooperation and help given by many individuals and organizations in the preparation of this report. The investigation of Curry County was funded in part by a grant of \$20,000 from the Western Environmental Geology Branch of the U. S. Geological Survey, and in part by a grant of \$10,000 from the Land Conservation and Development Commission of the State of Oregon. Special thanks are extended to Dr. M. Clark Blake, Jr. of the U. S. Geological Survey and Grant J. Ross of the Oregon Department of Land Conservation and Development for their efforts in securing these funds. Additional funds included \$3,500 provided by Curry County and \$12,000 provided as in-kind services by the State of Oregon Department of Geology and Mineral Industries.

The enthusiastic assistance of Burton Weast (Planning Director, Curry County) and Curtis Brown (Assistant Planner, Curry County) was invaluable. Agencies supplying major assistance included the U.S. Geological Survey (Portland Office), the U.S. Soil Conservation Service, and the State Water Resources Department. Photographs were provided by the Brookings Harbor Pilot, the Curry County Reporter, and the Oregon State Highway Department.

The authors also wish to thank the staff members of the State of Oregon Department of Geology and Mineral Industries who helped in the project: Steven Renoud and Charles Schumacher for cartographic preparation of the maps for printing and Ruth E. Pavlat, Carol Brookhyser, Ainslie Bricker, Cynthia Drayer, Len Ramp, and Margaret Steere for their contributions in editing, camera-copy typing, proof reading, and preparation of the layout for final publication.

Previous Work and Sources of Data

This report is a comprehensive and systematic treatment of the geology and geologic hazards of western Curry County. It is broader in scope than any previous investigation in the area and treats topics never before studied on a regional basis in the area. It is part of an ongoing program of basic geologic hazards research in Oregon being conducted by the Oregon Department of Geology and Mineral Industries.

Major recent investigations in the study area include small-scale geologic mapping by Dott (1971) and Wells and Peck (1961), and more detailed geologic mapping in the west central part of the County by Koch (1966). Phillips (1968) and Brownfield (1972) mapped parts of northern Curry County. Coleman (1972) investigated the structure and rock composition of the Colebrooke Schist. More local studies include those at Cape Blanco (Dott, 1962), Cape Sebastian (Howard and Dott, 1961), and Humbug Mountain (Koch and others, 1961), on the various sea stacks (Hunter and others, 1970), at scenic points along the coast (Lund, 1975), and in the Agness area (Baldwin, 1968). Offshore structures and tectonics are presently being investigated by personnel of the U. S. Geological Survey and Oregon State University and others. Depositional environments, marine terraces, and possible Pleistocene faults are being investigated by the U. S. Geological Survey on a long-term basis. Soil properties and use limitations are the subject of continuing investigations by the U. S. Soil Conservation Service.

Geologic mapping conducted during this investigation included reconnaissance field work to all accessible areas, examination of satellite and U-2 imagery, and detailed study of aerial photographs with stereoscopic coverage. Numerous other investigations of more limited scope have been completed in recent years. A complete listing of all data sources used in this study is given in the bibliography. Much data and many concepts used in this report were developed outside the study area and are being applied to Curry County for the first time. These references are also listed. References of special significance to particular topics are cited in the appropriate parts of the text.

How to Use the Report

General

A land use planner is any person or body of persons who uses or manages the land with foresight regarding the characteristics of the land. In addition to county and city planners, land use planners should include developers, policy formulators on the national, state, and local level, land holders, architects, engineers, natural resource specialists, and others.

This bulletin provides planners in Curry County with information necessary to make valid decisions. It is a synthesis of present thought regarding the geologic conditions and hazards of the region. The material is reconnaissance in nature, however, and is subject to refinement based upon additional investigations. The maps, like all maps, represent average conditions as they actually occur on the ground, and on-site examination is required for specific site evaluation.

The bulletin is organized to facilitate easy reference. It includes maps and tables which interrelate the various hazards and systematically present information about them. The text is divided into sections dealing with each specific hazard and is an elaboration of the material presented on the tables and maps. It is thoroughly cross referenced. A summary and glossary are also included. It has a potential for a wide variety of uses as discussed below.

Site evaluations

Proper use of this document in preliminary site evaluations is shown diagrammatically on the flow chart in Figure 1. In general, the maps, tables, and text are used to assess the use potentials and use limitations of the land. These are matched by the planner with the specific site requirements of the proposed development and the surrounding area to determine if the development and site characteristics are compatible. An appreciation of scale is a key prerequisite to the proper use of this bulletin. For precise decisions it is essential that the text and probably other sources of information be consulted.

1. DEFINE TASKS	Examples include evaluating proposed developments, advising residents, implementing or revising zoning codes, evaluating zoning variances, developing goals and guidelines.						
2. LOCATE SITE	Locate the site visually on the appropriate geologic units map and geologic hazards map.						
3. IDENTIFY GEOLOGIC HAZARDS AND NATURAL RESOURCES	Use the geologic units map and text to determine bedrock and natural resources and to approximate soil type. Use geologic hazards map and text to determine geologic hazards. Specific reference may be made to the site in various parts of the text.						
4. ASSESS THE SITE	Define the physical capabilities and resources of the land. Define the physical liabilities of the land. The text is organized and cross-referenced to facilitate this type of use. Consult cited references or appropriate agencies where necessary.						
5. EVALUATE THE PROJECT	Compare the physical capobilities and liabil- ities of the land with the physical requirements of proposed use. Consider possible engineering and land management solutions. Consider im- pact on surrounding properties and land uses.						
6. PlAN	Consideration must be given to information from other sources including local and regional goals, guidelines and policies, in addition to economic, social, and political conditions.						

Figure 1. Suggested use of this bulletin in site evaluations: The bulletin is of use not only to planners on the city, county, and state level, but also to policy formulators on the notional, state, and local level, resource specialists, landholders, developers, architects, engineers, and the general public.

Land use capability analysis

Data provided in this bulletin and on the accompanying maps can be used to develop sets of generalized overlay maps to aid in land-use capability analyses. For particular types of land use, overlays of relevant hazards and bedrock conditions can be abstracted from the text and maps. Composite maps can then be made for terrain evaluations. To be valid, however, such maps should meet three specifications:

- The maps should be prepared for one type of development or for sets of closely related types of development. Because the physical requirements for unrelated types of land use differ considerably; single maps depicting land use capability for numerous types of use are commonly too generalized to be practical.
- (2) Capability categories described in the map legends must be realistic. This requires thorough knowledge of a) the information presented in the text, b) the specific requirements of the land use under consideration, and c) the types of engineering solutions available. Assignment of purely arbitrary values to the various hazards is unrealistic.
- (3) Scale must be properly appreciated. On the map scale used in this publication statements must be viewed as generalized first approximations of actual on-site conditions for specific parcels of land. Provisions must be made for more detailed study.

Projection of data

On the county and city level, specialists commonly possess a wealth of detailed information on specific sites in their respective fields of expertise, but do not have readily at their disposal a mechanism for projecting their observations into other areas. Thus, an individual may have detailed information of a specific septic-tank failure or a man-induced landslide but may not have adequate means of anticipating similar problems elsewhere. This bulletin, by interrelating geologic units, soils, slopes, landforms, hazards, and mineral resources and by mapping these features on a regional basis, provides the specialist with the tools he needs to extrapolate his observations into new areas and to make preliminary assessments on sites for which no detailed information is available. The distribution and causes of the various hazards discussed in the text are emphasized partly to insure maximum utility of the bulletin for this purpose. An additional benefit of the bulletin is that it informs the specialist of additional land characteristics related to his field of expertise about which he might otherwise be unaware.

Policy formulation

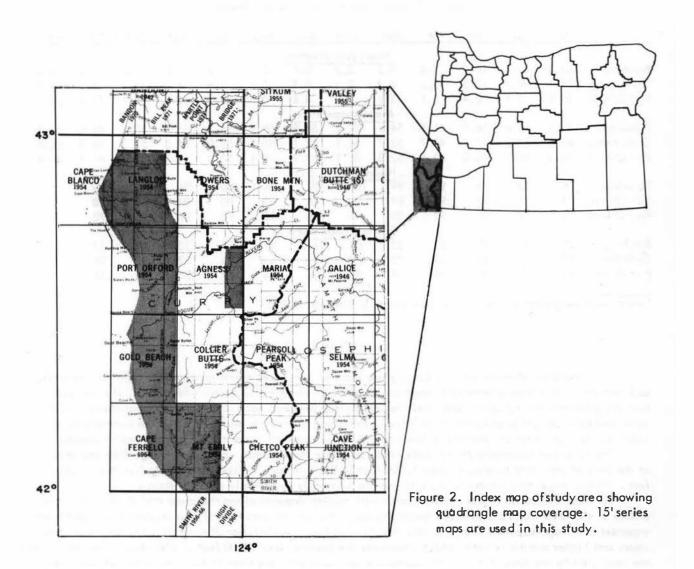
Used in conjunction with a set of realistic goals, this publication can be invaluable in formulating land-use policies on the local and regional level. Such policies should represent a coordinated effort on the part of government agencies of various levels, should consider all significant geologic hazards, and should make provisions for local conditions as revealed by on-site evaluations. Although policies are designed to protect the public, they should not be based on over-reactions arising from inadequate information regarding the magnitude of given hazards of other geologic conditions.

GEOGRAPHY

Location and Extent

The study area encompasses the western third of Curry County and the area surrounding the community of Agness on the Rogue River (Figure 2). It is bounded on the west by the Pacific Ocean, on the north by Coos County, and on the south by California. The eastern boundary follows the edges of topographic maps or section lines selected to include part of the Chetco drainage.

Parts of all seven topographic quadrangle maps are included. Total areal extent is approximately 750 square miles. Access is provided by Highway 101 along the Caast and county roads along the Rogue River, Chetco River, and other major drainages. Private roads provide access to the more remote upland areas.



Climate

The climate of the study area is moist and temperate owing to the prevailing westerlies and the proximity of the Pacific Ocean. Winters are wet and mild to cool, and summers are warm and dry with intermittent rain. Temperature data are summarized on Table 1. Rainfall varies from approximately 80 inches along most of the coast to as much as 120 inches on the slopes of the more rugged interior uplands in the eastern parts of the study area. Annual rainfall is 81 inches at Brookings and Gold Beach and 70 inches at Port Orford, and is summarized on Table 1. Measureable precipitation in coastal areas falls about 125 days out of the year.

Summer winds are characterized by steady moderate breezes from the north and northwest. Winter winds consist of steady offshore breezes from the south and southeast and occasional strong onshore gales from the southwest. Wind velocities during the Columbus Day storm (October 18, 1962) were clocked at 145 miles per hour at Cape Blanco after one cup had been blown off the anemometer. Winds with gusts up to 140 miles per hour were clocked during a brief storm in December 1975. Autumn and spring winds are transitional between those of summer and winter and are a mix of both.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
		-,				an preci	pitation						
Brooking s	13.2	11.1	10.2	5.4	4.3	2.5	0.6	0.6	1.8	7.3	10.8	13.8	81.4
Gold Beach	14.1	10.7	10.5	5.5	4.2	2.1	0.5	0.6	1.8	7.0	10.7	14.0	81.4
Port Orford	11.9	9.1	8.4	5 <i>.</i> 1	3.6	2.0	0.6	0.6	2.5	5.8	9.1	11.4	70.1
					Med	an tempe	rature						
Brookings	47.1	48.0	48.9	51.1	54.6	57.7	58.9	58.9	59.5	56.0	51.7	48.8	53.4
Gold Beach	46.3	47.2	47.7	49.7	52.7	56.1	58.1	58.5	58.0	54.5	51.2	48.3	52.4
Port Orford	46.3	46.9	48.0	50.1	52.8	56.1	58.9	59.4	58.0	54.7	50.2	47.9	52.4
					High	nest temp	erature						
Brookings	<i>7</i> 8	80	88	92	99	100	99	98	100	96	88	79	
Gold Beach	73	77	81	92	89	96	88	93	90	98	76	70	
Port Orford	78	79	82	90	90	89	86	85	95	95	78	78	
					Low	est temp	erature						.*
Brookings	21	26	29	30	33	34	41	37	34	32	28	17	
Gold Beach	20	25	25	27	23	34	37	36	36	32	25	20	
Port Orford	20	22	27	28	32	36	36	35	37	30	24	15	

Table 1. Climatic data - Curry County, Oregon*

Topography

The landforms of western Curry County are grouped into three major categories: uplands, terraces, and lowlands. The characteristics of each are products of the materials which form them, the processes that are presently acting upon them, and the interaction between each of these. Each landform is characterized by a unique association of rock type, soils, and process or geologic hazard as summarized on Table 2. A knowledge of landform is fundamental to the regional understanding of geologic hazards.

The hills and mountains of the study area constitute the uplands. Elevations range from sea level at the base of sea cliffs to greater than 4,000 feet in the interior. Relief is generally less than 2,000 feet. Slopes range from gentle to vertical but are commonly moderately steep to steep.

Terraces consist of 1) wave-cut surfaces with marine deposits along the coast and 2) dissected remanents of elevated flood plains along major streams. Marine terraces form flat to regionally warped coastal expanses and ridge caps and are generally less than 200 feet in elevation (Figure 3). Exceptions are the upper and higher marine terraces which commonly are greater than 1,000 feet in elevation. Stream terraces are restricted to the lower walls of drainages and are generally less than 50 feet above the adjacent present-day flood plains and streamways.

^{*}Based upon approximately 50 years of observation to the year 1960



Figure 3. Cape Blanco, the westernmost point in Oregon, consists of thin marine terrace deposits overlying Tertiary and pre-Tertiary bedrock. Moderate slopes at the "neck" and on the sea cliffs to the north and south are undergoing mass movement.

Table 2. Landforms of western Curry County, Oregon

	Landform	Features	Rock types	Soils	Processes and hazards
	Very steep	Hill and mountain slopes	Hard intrusive rock (Tod, Jpp),	Gravelly loam	Severe erosion
		with regional slopes (see	hard sandstone (Kr, Kh, Kim),	Silty loam	Torrential flooding
S		hazards maps) greater	unsheared sandstone, basalt, and	Silty clay loam	Debris avalanche and flow,
Uplands		than 50%	conglomerate of other units	Sandy loam	debris slide
吕	Gently to	Hill and mountain slopes	Sandstone and siltstone (Jd, Jg,	Silty loam	Rapid to severe erosion
	moderately	with regional slopes less	other units) and sheared bedrock	Clay loam	Torrential flooding
	steep	than 50% and greater	(Jop, Kuh, Kh, others)		Slump and earthflow, local rapid
		than 5%			mass movement
	High er	Flat to gently sloping	Weathered sand and silt with	Clay loam	Moderate to severe erosion
	marine	deeply dissected terraces;	basal gravel in places	Silty loam	Local mass movement
	terrace	often ridge crests			Variable depths to bedrock
	Upper	Flat to gently sloping dis-	Semi-consolidated sand, silt,	Clay loam	Local mass movement
	marine	sected terraces above	and basal gravel	Silty loam	Variable depth to bedrock
	terrace	younger terraces		Silty clay	
es	Middle	Flat, gently dissected sur-	Sand, silt, and clay with basal	Silty loam	Iron pan and poor drainage in
B	marine	faces over marine and	gravel; wind-blown sand on sur-	Clay loam	places, variable thickness to
Terrace	terrace	eolian deposits	face locally	Silty clay, iron pan	bedrock, wave erosion
-	Lower	Low-lying flat surfaces	Sand, silt, clay, and basal	Sandy Ioam	Flooding
	marine	over marine deposits; the	gravel	Silty loam	High water table, poor drainage,
	terrace	lowest terrace level		Clay loam	compressible soils
	Fluvial	Dissected flat remnants	Semi-consolidated sand, silt,	Silty loam	Stream –bank erosion
	terrace	of former flood plains	and gravel deposited by major	Silty clay loam	Flooding even at high elevations
		along major streams	streams	Silty clay	along the Rogue River
	Flood	Flat river deposits near	Sand and gravel along major	Silty loam, silty clay	Flooding, high ground water,
	plain	level of present-day	streams; includes silt and clay	loam, silty clay,	poor drainage, stream-bank
ခြ		streams	along lesser streams	gravel	erosion
Low lands	Marsh	Poorly drained, vegetated	Sand, silt, clay, and organic	Silty loam, silty clay	Ocean and stream flooding
<u> </u>		flat wetlands of estuaries	material	loam, organic soil	Compressible soils
۲	Dunes	Mounds of wind-blown	Stable sand, unstable sand,	Sand, fine sand,	Wind erosion and deposition
		sand with varying amounts	beach sand	active dunes and	Wave erosion and deposition
		of prot e ctive cover		beaches	Local stream and ocean flooding

GEO GRAPHY 9

Lowland landforms include flood plains, channel deposits, marsh, dunes, and beaches. Major low-land geographic areas are parts of the north coastal plains, the areas near the mouths of major streams, and the dunes at the mouth of the Pistol River. Elevations are generally 40 feet or less above sea level and slopes are generally very low with the exception of those in sand-dune areas.

Population and Economic Trends

The population of Curry County increased dramatically in the 1950's as a result of better transportation facilities and has stabilized in recent years (Table 3). In the last few years population has begun to grow again, and a 15 percent increase is projected for the period between 1970 and 1975 (Coos-Curry Council of Governments, 1974). The 8 percent increase between 1970 and 1975 indicates that this projection may be too low.

Brookings is the fastest growing major community in the County (Table 4). Projections for the period between 1970 and 1990 indicate population increases averaging 15 percent for all the major communities (Coos-Curry Council of Governments, 1974). Significant new developments in the Floras Lake, Illinois River, and Harbor Bench areas are anticipated.

Table 3. F	Population	of Curry	County,	Oregon
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Year	Population	Percent change
<u> 1910</u>	2,044	
1920	3,025	+48
1930	3,257	+ 8
1940	4,031	+24
1950	6,048	+50
1960	13,983	+131
1965	13,000	- 7
1970	13,006	0
1975	14,100	+ 8

Table 4. Population of communities, Curry County, Oregon

Community	1960	1965	1970	1975
Brookings	2,58 0	2,74 0	2,72 0	3,15 0
Gold Beach	1 <i>,7</i> 69	1,677	1,554	. 1,600
Port Orford	1,172	1,164	1,037	1,040

Gold Beach was incorporated in 1845, and its economic base has shifted over the years from gold to lumber and finally to tourism, fisheries, and lumber. Shoaling of the mouth of the Rogue is a continuing hazard to navigation in the summer months. Port Orford was settled in 1851 and has had an economy centered around gold, fish, wood products, and small trade over the years. Hazards to the fishing industry were dominated by storms prior to jetty construction and now are dominated by a continuing siltation problem in the boat basin area. Brookings was named in 1913 and has an economy centered on fishing, tourism, and retirement living.

With the trend towards urbanization it is expected that the services, trade, and government sectors of the economy will increase in future years to slightly offset projected declines in the wood products

industry, agriculture, and manufacturing. Tourism presently is the fastest growing sector of the local economy and will continue to grow in the future especially if improvements of Highway 101 are completed and a more adequate road from Agness east to the Grants Pass area is constructed.

Land Use

Historically, land use in western Curry County has been closely related to landform. Terraces at the mouths of the major rivers (Rogue and Chetco Rivers) and near protected coves (Port Orford area) have been the sites of industrial, commercial, residential, and agricultural development. On the flood plains, development has been largely restricted to pastureland and other agricultural uses.

Industrial development has included logging at each of the major communities. Agricultural development has included cranberry farming on poorly drained terraces and lily bulb cultivation on well-drained fertile soils near Harbor. Residential development has spread into upland areas around Port Orford, Gold Beach, and Brookings in recent years and is spreading onto the Harbor Bench. Future more intensive development of the terraces is favored by the relative lack of physical constraints, but will require increasing management with regard to ground-water contamination and development, waste disposal, erosion, and sliding.

Dominant land uses in the uplands are forestry, recreation, and scattered residential development. Potential for a rejuvenated mining industry is recognized for some upland areas. In the future, scattered homes and support facilities for logging and possibly mining will place increasing burdens on the delicate upland terrain and will require careful management in critical areas.

Future urbanization and associated economic diversification into trade, education, government, and services will lead to increased development pressures on the land surrounding present major communities and in areas of new growth. Proper management of the land resource will be needed to derive maximum benefit from the potential uses of the land and to minimize existing and future potential problems inherent in the three categories of landform: erosion and mass movement in the uplands; ponding ground-water contamination, and waste disposal on the terraces; and a variety of hazards on the scattered lowlands including flooding, compressible soils, and wind erosion in places. The greatest problems will be experienced in regions of noncompatible land use in areas of diverse potential such as the Harbor Bench where groundwater production and subsurface waste disposal are being promoted in close proximity to one another.

ENGINEERING GEOLOGY

General

Geologic units are distinguished primarily on the basis of rock type and to a lesser extent on the basis of other physical properties, distribution, or age. The geologic units fall into two main categories: consolidated (firmly cemented when fresh) and surficial (can be crushed in the hand) materials. Engineering properties of the units are summarized on Table 24 (see Summary).

Consolidated bedrock geologic units underlie the sea cliffs and uplands of Curry County and consists chiefly of sandstone, siltstone, basalt, intrusive rock, and schist. A total of 19 bedrock units are recognized, but in the discussion that follows, the 19 units are grouped together into 11 associations having similar engineering properties and potential geologic hazards. As shown in Figure 4, the bedrock geologic units range in age from 150 million years to less than 10 million.

Surficial geologic units consist of semiconsolidated to unconsolidated terrace and lowland deposits resting upon bedrock. Individual units are recognized on the basis of type of material, environment of deposition, and age. The surficial geologic units are less than 2 million years old, with the bulk of them less than 100,000 years old.

Soils are developed on the various bedrock and surficial geologic units. They are relatively young and their properties are dependent to varying degrees on the nature of the underlying geologic units.

Bedrock Geologic Units

Sedimentary rocks of late Tertiary age (Tmp)

Geology: This group of rocks is exposed in sea cliffs and headlands between Floras Lake and Port Orford and in the valleys of the lower Elk and Sixes Rivers (Cape Blanco and Langlois quadrangles). It includes three distinct units of similar lithology but different ages. The oldest are massive marine semiconsolidated sandstone exposed southeast of Cape Blanco and semiconsolidated gravel and sandstone exposed north of Blacklock Point to Floras Lake.

Poorly consolidated massive marine sandstones of the Empire Formation of early to middle Pliocene age unconformably overlie the Miocene beds in the Cape Blanco area. In addition, lower Pliocene fossils have been recovered from small outcrops near the mouth of Hubbard Creek 1.5 miles southeast of Port Orford.

Eastward-dipping middle Pliocene sedimentary rock unconformably overlies the Empire Formation in the Cape Blanco area. Baldwin (1945) named these beds the Port Orford Formation. They consist of up to 200 feet of basal buff sandstone overlain successively by conglomerate, rusty sand, and argillaceous sandstone containing concretions. Where the conglomerate is directly overlain by basal terrace deposits of Pleistocene age the contact is difficult to locate. Diller (1902) included the Port Orford Formation and the Pleistocene terrace deposits in his Elk River beds, and the Empire Formation and Miocene sedimentary rocks in his Empire beds.

The Miocene sedimentary rock contains numerous invertebrate and scattered vertebrate fossils including sea lions and whales. The middle Pliocene sedimentary rocks (Port Orford Formation) contain a rich vertebrate fauna which includes sea lions, sea otters, and birds. An unconformity separates the Port Orford Formation from the overlying terrace deposits. The Miocene beds, Empire Formation, and Port Orford Formation represent local shallow-marine deposition and to some extent may also represent lagoonal and estuarine deposition, as indicated by gravel deposits and leaf horizons in places.

Engineering characteristics: The sedimentary rocks of late Tertiary age form steep sea cliffs and moderately steep canyon walls. They are overlain by Pleistocene terrace material over large areas. On

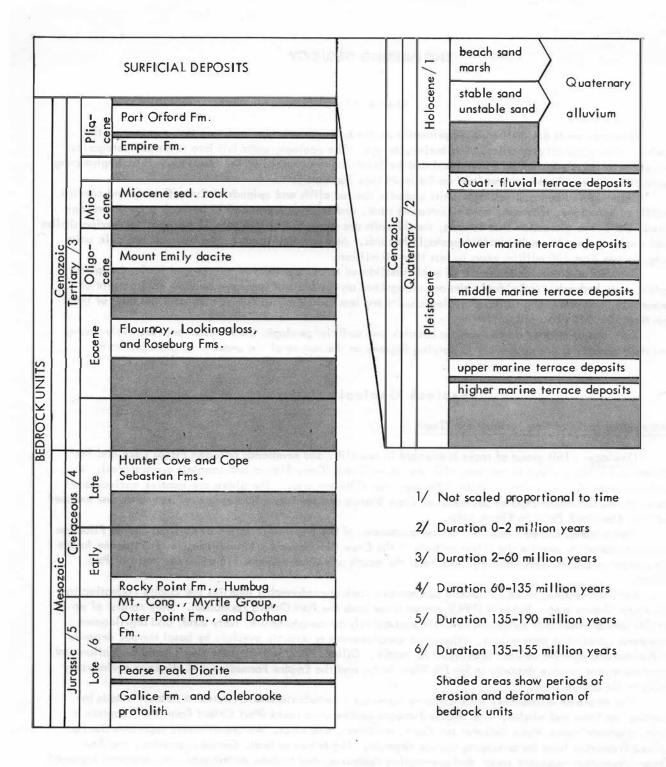


Figure 4. Time distribution of stratigraphic and surficial geologic units.

side slopes the unit is excavated with moderate difficulty, but it requires no blasting in small cuts. Foundation characteristics are good in areas having no slope limitations.

Major hazards include slumping and debris slides in sea cliff exposures (see Wave erosion and deposition). Earthflow topography is common along the canyons of major drainages. Caving is possible in deep roadcuts and in other excavations.

Permeability of the unit is probably moderate to high especially in gravelly to sandy interbeds and lenses. Cementation is incomplete and water storage capacity is probably moderate to low. The ground-water potential of the unit is probably relatively good. However, a meaningful assessment is difficult to make owing to the limited exposures over large areas and the paucity of water wells penetrating into the unit. A well at Cape Blanco State Park produces 20 gallons per minute.

The sedimentary rocks of late Tertiary age are suitable for use in fill or embankments. Suitability for use as load-bearing aggregate in roads is questionable owing to possible weathering and probable low proportions of gravel and sand to clay and silt in many areas. Overburden is an additional limiting factor for high-volume use as construction or embankment material. More detailed mapping of this unit into subunits would probably reveal specific areas with high potential for use as construction material.

Sedimentary rocks of early Tertiary age (Tef, Telg, Ter, Teu)

Geology: This group of rocks forms isolated exposures in the uplands of northern Curry County (Langlois quadrangle) and also is exposed in the Agness area and in sea cliffs at Cape Blanco. It includes three distinct units of similar rock type. but slightly different ages and vastly different structure. Originally referred to as the Umpqua Formation, these and similar exposures in southwestern Oregon are now subdivided into the Roseburg Formation (Ter), the Lookingglass Formation (Telg), and the Flournoy Formation (Tef). The exposure at Cape Blanco (Teu) is undifferentiated (Dott, 1962).

The Flournoy Formation (the youngest unit) consists of up to 1,000 feet of rhythmically bedded sandstone and siltstone with a prominent basal conglomerate in places. The sandstone interbeds are 5 to 15 feet thick. Regionally the Flournoy Formation overlies faults in the Lookingglass and older formations, but it is not cut by major faulting. An upper age limit of middle Eocene is indicated for some of the faults of the study area.

The Lookingglass Formation is similar in rock type to the Flournoy. In the Langlois quadrangle it is identified on the basis of similarities with known Lookingglass Formation in surrounding areas (Brownfield, 1972). In the Agness area the unit consists of thick-bedded, silty sandstone and siltstone with a very prominent, hard basal conglomerate. Of considerable structural significance is the discovery of pebbles of Colebrooke Schist in the Lookingglass Formation outside the study area (Coleman, 1972; Baldwin, 1975). The depositional contact of the Lookingglass Formation with the Otter Point Formation is exposed in the Langlois quadrangle (Brownfield, 1972).

The Roseburg Formation consists of hard sandstone and siltstone and contains scattered coalified plant remains in places signaling deposition along the margin of the Roseburg basin. In the Floras Creek drainage the beds dip steeply beneath the northern edge of the Colebrooke Schist thrust plate (Brownfield, 1972) suggesting possible thrust faulting as late as the Eocene (see Tectonic Setting).

The ages of rocks assigned to the Flournoy, Lookingglass, and Roseburg Formations in the study area are based largely on inferences from surrounding areas. Local evidence also includes the extreme deformation of the Roseburg Formation compared to younger units, lower Tertiary palynologic evidence in rocks mapped as Roseburg by Brownfield (1972) and middle Eocene microfossils in rocks mapped as Lookingglass by Lent (1969). Elsewhere, Baldwin (1965) suggests that parts of the Roseburg Formation may be as old as Paleocene or even latest Cretaceous. The specific ages of the exposures is critical to structural interpretations, especially of the exposures of Roseburg in the Floras Creek drainage (see Tectonic Setting).

The three formations were deposited under shallow to deep marine conditions around the edges of the ancestral Klamath Mountains. Scattered coalified interbeds indicate lagoonal conditions locally. The environments of deposition were similar, resulting in similar rock types. However, the extreme deformation of the Roseburg Formation distinguishes it from the two younger units.

Engineering characteristics: The sedimentary rocks of early Tertiary age form steep to moderately steep slopes with uniform V-shaped canyons. Soils are generally thin and consist of silty loams and silty

clay loams. The rocks are moderately hard, are excavated with considerable difficulty, and may require blasting, especially in the thicker interbeds of sandstone. Foundation strengths are moderate to moderately high. Jointing is blocky and fine to coarse depending on the thickness of the beds. Caving is a potential hazard in deep excavations, especially where bedding dips at steep angles into the excavation or where jointing is coarse and well developed.

Major hazards include debris slides on steep slopes, ravelling of siltstone interbeds (which commonly clogs side drainages of roads), and severe erosion potential. Depths to bedrock vary considerably and are commonly shallow on steep slopes, necessitating special consideration for all excavations.

Permeabilities are generally very low except along major fractures and bedding planes. Water-holding capacity is low. Potential for ground water is limited to scattered supplies for stock or single-family dwellings.

The unit is suitable for use as fill or embankments if properly sized and properly compacted. Use of oversized pieces in fill can lead to prolonged settling over a period of many years. The stone is not suitable for load-bearing aggregate owing to the low abrasion resistance and the potential for rapid weathering to clay. Larger blocks of sandstone are suitable for use as riprap along streams, but not ocean riprap or jetty stone.

Sedimentary rocks of Late Cretaceous age (Kuh, Kuc)

Geology: This group of rocks consists of two distinct stratigraphic formations, the Cape Sebastian Sandstone and the overlying Hunters Cove Formation (Gold Beach quadrangle), and also includes two additional Late Cretaceous exposures, one north of Blacklock Point (Cape Blanco quadrangle) and the other in the Sixes River drainage (Langlois quadrangle).

The Cape Sebastian Sandstone consists of 800 to 900 feet of massive to cross-bedded, medium—hard sandstone and basal conglomerate. In general the rocks and their depositional structures are similar to those of the Pleistocene terrace deposits (see Surficial Geologic Units). A similar origin is interpreted although the unit is somewhat thicker than any of the terrace deposits. The unit passes upsection gradationally into 700 to 800 feet of thinner bedded siltstones and sandstones assigned to the Hunters Cove Formation. Sandstone interbeds typically are a few inches thick in this unit and display cross laminations rather than graded bedding. Deposition by bottom tractive currents rather than turbidity currents is interpreted by Dott (1971).

Abundant Late Cretaceous invertebrate fossils recovered from the Cape Sebastian Sandstone and Hunters Cove Formation are listed by Dott (1971). The most diagnostic fossils indicate a Campanian to Maestrichtian age. Approximately half a mile north of Blacklock Point, 1,500 to 2,000 feet of graded sandstone and sandstone and siltstone are correlated with the Hunters Cove Formation by Dott (1971). The rocks are similar lithologically and contain medial Late Cretaceous fossils of probable Coniacian age (slightly older than the Cape Sebastian Sandstone). A short distance inland, rhythmically bedded sandstones and siltstones are tentatively assigned to the Late Cretaceous (Lent, 1969) in the Edson Creek area of the Sixes River drainage. Regionally, isolated exposures of Late Cretaceous strata are scattered around the Klamaths and possibly were derived from a land mass off the coast of present-day Curry County (Hunter and others, 1970).

The exposures of Cape Sebastian Sandstone and Hunters Cove Formation at Cape Sebastian and to the south are folded into gentle northwest trending folds and occupy northwest trending fault slivers of probable Cenozoic age. North of Blacklock Point the Late Cretaceous strata are faulted against serpentine on the south and are overlain by Cenozoic strata on the north. In the Sixes River drainage the Late Cretaceous strata rest upon Otter Point rocks between remnants of the Colebrooke Schist thrust plate on the north and south indicating deposition prior to final thrusting in that area.

Engineering characteristics: The rocks of Late Cretaceous age form bold headlands and moderately steep slopes. Soils are generally thin and consist of silty loam and silty clay loam. The lower parts of the section are coarsely to very coarsely jointed. Excavation is difficult and requires blasting. In deep cuts the coarse jointing can release large blocks presenting a severe hazard. Excavation of the softer sandstone and siltstone is moderately difficult; deep cuts are generally stable and present only a minimal caving hazard. Foundation strengths for the unit vary from very high in the hard lower sandstone to moderately high for the siltstone.

Major hazards include massive blockfall and rockfall along the coast and in deep cuts in jointed sandstone. At Cape Sebastian several large blockfalls covering several acres were generated by coastal erosion and coarse jointing (Figure 5). Depth to bedrock is shallow and must be considered in assessing all development involving excavations or subsurface disposal of effluents.

Ground-water percolation is restricted to joints and shear zones, and storage capacity is low. Ground-water potential is very low and probably is restricted to use for stock or single-family dwellings. The material is suited to use for fill or embankments; it is not suited to use as load-bearing aggregate owing to the potential for alteration to clay and to the low abrasion resistance.

Sedimentary rocks of Early Cretaceous age (Kr, Kh, KJm)

Geology: This group of rocks consists of three distinct stratigraphic units: the Humbug Mountain Conglomerate (Kh) and overlying Rocky Point Formation (Kr), both in the Pearse Peak area (Langlois and Port Orford quadrangles) and the Myrtle Group (KJm) near Agness.

The Humbug Mountain consists of massive to thick-bedded fine-grained conglomerate, pebbly sand-stone and coarse-grained sandstone. In places the conglomerate is very hard and contains boulders over one foot in diameter. Clasts consist of chert, diorite, quartz diorite, and volcanic and metamorphic rock. Sandstone and siltstone are progressively more abundant near the top of the unit. The Rocky Point Formation overlies the Humbug Mountain Conglomerate along a gradational contact and consists of sharply alternating beds of hard sandstone and moderately hard siltstone.

The Myrtle Group in the Agness area consists of rhythmically bedded sandstone and siltstone and minor conglomerate and is similar to the exposures of Humbug Mountain Conglomerate and Rocky Point Formation farther west. Pebbles consist of chert and diorite and include no serpentine. Conglomeratic exposures mapped as Myrtle Group by Baldwin (1968) east of the Rogue River are here included in the Lookingglass Formation.

The Humbug Mountain Conglomerate overlies the Late Jurassic Pearse Peak Diorite with a depositional contact. Fossil evidence for an Early Cretaceous age is cited by Koch (1966) and Dott (1971). More recently Jones (written communication, 1975) states that <u>Buchia pacifica</u> of Early Cretaceous age (Valanginian) occurs in the Rocky Point-Humbug Mountain sequence as well as in the Agness sequence. In addition, other exposures of the Myrtle Group outside the study area have yielded <u>Buchia uncitoides</u> and <u>Buchia piochii</u> of lowermost Early Cretaceous (Berriassian) and uppermost Jurassic (Tithonian) age respectively.

The Humbug Mountain Conglomerate and Rocky Point Formation form part of a large structural block between the latitudes of the Sixes River and Euchre Creek that was thrust into the area from far to the east in medial Cretaceous times (see Tectonic Setting). The Myrtle Group in the Agness area also is believed to be part of a large thrust sheet on the basis of fossil and environmental evidence (see Tectonic Setting). The exposures near Agness contain no pebbles derived from underlying strata and are structurally discordant with the underlying serpentine.

Engineering characteristics: The rocks of Early Cretaceous age form prominent headlands and steep hills and canyons. In areas of regional shearing, slopes are moderately steep and hummocky. Soils are generally thin and consist of silty loam, silty clay loam, and gravelly loam. Pockets of colluvium are developed on steep slopes. The rocks are generally very hard and require blasting in excavations except where siltstone interbeds are numerous and sandstone interbeds are thin (parts of the Rocky Point Formation and Myrtle Group). Foundation strengths are high, and depths to bedrock are shallow and should be considered in evaluating all developments involving excavations. Bedding is generally thick to moderately thick and jointing is coarse (in sandstone) to irregular (in conglomerate).

Infiltration is restricted to joints, and permeability is very low. Water-storage capacity is very low and ground-water potential is very low. Potential ground-water production is probably suited to supplying stock or single-family dwellings.

Hazards include debris avalanches on steep slopes, severe erosion potential, continued sporadic earthflow in areas of shearing and coastal retreat (south Humbug Mountain), and extremely hazardous bedding plane slides north of Agness. Future logging and road construction in areas of this unit will require careful management and engineering. The rock is suited for use as fill, embankments, and river riprap. The

conglomerate is moderately well-suited to use as load-bearing aggregate, but the sandstone and siltstone are not suited to such use owing to low abrasion resistance and high potential for alteration to clay. Minor quarries are located in the conglomerate in the Elk River area.

Sedimentary and volcanic rocks of Jurassic age

Otter Point Formation (Jop)

Geology: The Otter Point Formation is a complex structural association of highly varied rocks of diverse origin and is commonly referred to as a "mélange" in recognition of its pervasive shearing and apparent lack of structural continuity. It is also referred to as an "ophiolite" in reference to its deep-sea-floor composition. Rock types include poorly sorted sandstone and siltstone, submarine basalts, chert, conglomerate, and pods of medium- to high-grade metamorphic rock called blueschists. The Otter Point Formation is widespread in the foothills of northern Curry County north of the Sixes River and in the western parts of the County southward to Whalehead Cove a few miles north of Brookings. The unit is bounded by prominent faults of regional significance. It is interpreted as a deep-sea island-arc assemblage (Coleman, 1972) and is equated with the Franciscan Assemblage of California on the basis of age, rock types, and structure.

Sedimentary rocks of the Otter Point Formation include hard to sheared, graded sandstone and silt-stone in the northern parts of the County and massive to thick-bedded, hard conglomerate in the Thomas Creek area. Bedding, hardness, shearing, and other physical features are highly variable (Figure 6). Lent (1969) includes isolated exposures of hard, massive, quartz-rich sandstone in the Otter Point Formation in the Langlois quadrangle. Because of the extremely different depositional environment of rocks of this type (continental shelf), they are here regarded as younger in age, probably Cretaceous. In addition, the exposures at Sugarloaf Mountain have blueschist granules (Lent, 1969), indicating a post-Otter Point or post-Colebrooke Schist age.

Volcanic rocks include flows, tuffs, and breccias of basaltic composition. Volcanic rock is generally altered to greenstone and displays fine, irregular jointing. Associated with the volcanic rocks are small multicolored, thin-bedded chert deposits. The deposition of the chert is believed to be indirectly related to submarine volcanism, and the two rock types commonly occur together. The Otter Point Formation also includes exposures of peridotite and serpentine; these are discussed in a separate section (see Serpentine and Peridotite).

The blueschist pods consist of metamorphic minerals of high-pressure origin such as phengite mica, glaucophane, and garnet. A small percentage of the pods consist of gneiss. The pods vary from a few feet to a few hundred yards in diameter, are subequant in shape, and represent only a very small portion of the rock unit from which they were originally derived. Consequently an interpretation of their origin is difficult. The pods are associated with serpentine and occur in sheared or otherwise tectonically disturbed zones. They are restricted to the Otter Point Formation and possibly were sheared into the unit while it was being thrust beneath the western edge of the North American continent in Late Jurassic times (see Tectonic Setting - Regional Onshore Structure). The pods may be related to the higher grade amphibolites of the Big Craggies, which rest on the Dothan Formation north of the Chetco River.

The volcanic and sedimentary rocks of the Otter Point Formation are Late Jurassic in age (Dott, 1971; Koch, 1966). Jones (1975, written communication) states that the Late Jurassic fossils include <u>Buchia piochii</u> and <u>Buchia occidentalis</u>, and also states that no fossils of Cretaceous age are known from the unit.

Radiometric age dates for phengite mica in the blueschist range between 142 and 149 million years in the Langlois quadrangle and 147 million years at Tupper Rock (Coleman and Lanphere, 1971). This compares with an age of approximately 150 million years for hornblendes at Big Craggies (Coleman, 1972). Age dates for glaucophane in the same localities (Langlois quadrangle and Tupper Rock) are 132, 132, and 145 million years respectively. Coleman and Lanphere suggest that the older age represents the metamorphic event which formed the high-grade blueschists. The younger age in the glaucophane represents a later period of less extreme metamorphism during which argon was released from the glaucophane (giving a younger age indication), but was retained by the phengite. The second period of metamorphism coincides in a general way with the deposition of the Otter Point Formation on the sea floor and the deposition of the Early Cretaceous sedimentary rocks on the continental crust far to the east.



Figure 5. High shear cliffs of Cape Sebastian Sandstone immediately north of the Cape are the result of joint-controlled rockfall. (Oregon Highway Division Photo)



Figure 6. Otter Point, the type locality of the Otter Point Formation, is a barren headland 2 miles north of Wedderburn. Note irregular pattern of coastalerosion prompted by heterogeneous lithology. (Oregon Highway Division Photo)

The Otter Point Formation is pervasively sheared in the northern part of Curry County and is intensly sheared along broad shear zones of probable Cenozoic age along the coast. In the southern part of the County the contact with the Dothan Formation is intensively sheared. Thick conglomerates and sandstones south of Crook Point are hard and are not sheared. The regional shearing probably occurred during underthrusting of the Otter Point and Dothan Formations in Late Jurassic times (see Tectonic Setting – Regional Onshore Structure). The linear shear zones affect younger units and are not related to the origin of the Otter Point Formation.

Engineering characteristics: The Otter Point Formation forms moderately sloping irregular terrain in the northern and central parts of the County and steep canyons in the southern part of the County. The irregularity of much of the terrain is a product of the heterogeneous lithology and mass movement. Soils include gravelly loam on steep slopes and near exposures of very hard bedrock, organic silty clay, and silty clay loam in poorly drained areas, and silty clay loam and silty clay on slopes of volcanic or sedimentary bedrock. Soils are thin on steep, unsheared, bedrock slopes and are of variable thickness on irregular slopes.

Engineering properties vary considerably with the nature of the bedrock. Unsheared conglomerates and greenstones in the southern part of the County are very hard and require blasting for excavation. Foundation strengths are very high. Sheared sedimentary rocks are more easily excavated but may still require blasting in deep cuts. Foundation strengths for them are moderately high except in regions of mass movement. Cherts and blueschist are very hard and require blasting. On-site examination is required to identify specific rock types and to determine their properties. Shallow depths to bedrock in places and the extreme heterogeneity of rock types and soil properties must be adequately considered for developments involving excavations or subsurface waste disposal.

Hazards include rockfall in very steep terrain, mass movement on irregular or moderately steep slopes, and severe earthflow along shear zones being undercut by coastal erosion (see Mass Movement).

Infiltration rates and permeabilities range from very low in unsheared bedrock to low or moderate in sheared bedrock. Storage capacity is low, and ground-water potential is generally low. In areas of favorable conditions, ground water is sufficient for stock or single-family dwellings. Many slide areas discharge near-surface ground water or soil water and are hazardous in terms of soil conditions and subsurface waste disposal. The large coastal slide areas are relatively permeable and may constitute significant sources of local ground water, although actual production would pose technical problems.

Blueschist pods are suitable for use as load-bearing aggregate and have been used for ocean riprap where jointing permitted. The chert is thin-bedded and finely jointed and is well-suited for use as road-surface material. The greenstone is generally finely and irregularly jointed and is not suited for use as riprap except along rivers and streams. Alteration is generally pervasive and much of the stone is only moderately well-suited for use as road metal. It probably is not well-suited for use in asphalt owing to the presence of clay minerals and the potential for poor bonding with bitumen. The sedimentary rock is poorly suited for use in road construction in the north but is adequate for use as base material in the south. Rocks of the Otter Point Formation are suitable for use as fill and small embankments except in areas of shearing. Evaluation of specific bodies of rock for construction purposes require individual inspection and testing.

Dothan Formation (Jd)

Geology: The Dothan Formation consists of hard, thin- to thick-bedded sandstone and mudstone with minor amounts of volcanic rock, chert, and conglomerate along the southern Curry County coast. The Dothan Formation is not pervasively sheared like the Otter Point Formation, nor is it as varied in rock type in most areas. Also, it does not contain exotic pods of metamorphic rock (blueschist) of uncertain origin. The unit was laid down on the continental slope and the deep sea floor shoreward of the island arc that is represented by the Otter Point Formation. The Dothan and the Otter Point Formations are contemporaneous and are analogous to parts of the Franciscan Formation of California.

In the Cape Ferrelo quadrangle the Dothan Formation consists of massive poorly sorted sandstone, submarine basalt, and chert. At Rainbow Rock the chert is multicolored and is in distinct beds one inch to one foot thick. The rocks (Macklyn member of Dott, 1971) are similar to those of the Otter Point Formation to the north but are separated from that unit by a prominent shear zone. In the Chetco drainage

the Dothan Formation consists of mudstone and sandstone with sandstone interbeds increasing in thickness and in number towards the east. Between the mouths of the Winchuck and Chetco Rivers, rocks mapped as the Dothan Formation are highly varied in lithology and contain scattered pods of blueschist such as the one at McVay Rock. Possibly these exposures are part of the Otter Point Formation.

A Late Jurassic age is interpreted for the Dothan Formation. The general geology of the unit suggests deposition contemporaneous with that of the Otter Point Formation and regional structures indicate a premedial Cretaceous age (see Tectonic Setting). In addition, Ramp (1969) discovered <u>Buchia piochii</u> in rocks believed to be Dothan in the Boulder Creek area in the upper reaches of the Chetco drainage. Dott (1965) reports a radiometric age date of 149 million years, but Coleman (1972) questions the true identity of the sample dated.

Schistose rocks occupy shear zones in the Dothan Formation at Long Ridge, on the Pistol River, at Whalehead Creek, near Ram Creek, and near Carpenterville (Dott, 1971). The rocks are mapped as Colebrooke Schist by Dott (1971) but here are considered part of the Dothan. Structurally they are part of the Dothan, and petrographically they reportedly grade into the Dothan. The Colebrooke Schist, in contrast, is a later thrust sheet which truncates structures of the Dothan as well as other units. Schistose mudstones are also present within the Dothan Formation at Quail Prairie Mountain. Origin of the schistose mudstones is discussed in a later section (see Tectonic Setting).

Engineering characteristics: The Dothan Formation forms uniform, moderately steep slopes with thick, silty clay loam and silty loam soils as well as steep, rugged slopes with exposed bedrock and patchy colluvium. The sandstone is very hard, has high foundation strength and, where thickly bedded, requires blasting in excavations. The siltstone is moderately hard and does not require blasting in shallow cuts. Interbeds of basalt west of the Chetco River are very hard and are characterized by thin, bouldery soils. Foundation strength for the basalt is very high and the rocks require blasting in excavations. Depths to bedrock in the Dothan Formation are variable and often are shallow; they require careful consideration in evaluating developments involving excavations and subsurface waste disposal.

Hazards include rock fall and debris slides on steep slopes, caving and gully formation on moderately steep slopes with thick weathering zones, and highly variable mass-movement and foundation conditions locally (mass movement topography north of the Winchuck River). Road construction and surface runoff require careful management even in areas of thick soil.

Infiltration rates are very low on steep slopes but are fair on gentle to moderately steep slopes where thick soil cover retards runoff. Permeability of the bedrock is restricted to joints and bedding planes, and water storage capacity is low. Well production is restricted to use for watering stock and supplying domestic water for single-family dwellings.

Sandstone of the Dothan Formation is thin- to thick-bedded and finely to coarsely jointed. The more blocky material is well-suited to use as river riprap but is not suited to use for ocean riprap owing to the low abrasion resistance. When properly sized the sandstone is suitable for use as fill. The siltstone is less suitable but is adequate for small fills. The basalt is suited to use for riprap, fill, embankment material, and load-bearing aggregate. Alteration of some of the basalt minerals in places may preclude use for asphalt, owing to possible poor binding properties with bitumen.

Chert of the Dothan Formation is thinly bedded and is well-suited to use as road metal owing to high abrasion resistance and lack of alteration. The blueschist pods south of Harbor are well-suited to use as road rock, riprap, and asphalt. McVay Rock has been totally removed and used for these purposes. Other blueschist pods are of much more limited extent.

Galice Formation (Jg)

Geology: The Galice Formation is a deep-sea association of oceanic rocks consisting primarily of slates and slaty mudstones and minor greenstone, thin-bedded graded sandstone, and chert. Out of the study area it is interbedded with and overlies the Rogue Formation. The rocks have undergone low-grade metamorphism and are hard where fresh. Contact metamorphism is of local extent near dioritic intrusions in the Pearse Peak area. The Galice Formation underlies much of northeastern Curry County, but in the study area it is restricted to isolated exposures northwest of Agness and near Pearse Peak.

The Galice Formation is Late Jurassic in age but is significantly older than the Dothan and Otter Point Formations, for which a Late Jurassic age is also interpreted. <u>Buchia concentrica</u> recovered from the unit is indicative of an Oxfordian-Kimmeridgian age (middle Late Jurassic). The unit is clearly older than the Pearse Peak diorite which intrudes it. A radiometric age of 145 million years has been assigned to the Pearse Peak Diorite.

The Galice Formation forms part of a large structural block between the latitudes of the Sixes River and Euchre Creek which was thrust into western Curry County from far to the east in medial Cretaceous times (see Tectonic Setting – Regional Onshore Structure).

Engineering characteristics: The Galice Formation forms rugged, moderately steep to steep, uniform slopes. Soils are predominately silty clay loams and gravelly loams and are generally thin. Bedrock is very hard and requires blasting in deep cuts. The thin bedding and close jointing of the siltstone promote a relative ease of excavation, and blasting is generally not required for shallow cuts in this material. Basalt interbeds are coarsely jointed and massive. In general, foundation strengths for the Galice Formation are moderately high, but construction is restricted by topography.

Hazards include scattered debris slides on steep slopes and severe erosion potential. Earthflow and slump failures are possible along mapped shear zones in the inaccessible parts of the interior.

The bedrock is impermeable, and infiltration is restricted to bedding planes and joints. Water storage capacity is very low, and ground-water potential is generally low. Locally in areas of gentle topography, ground-water supplies may be adequate for watering livestock and for supplying single-family dwellings.

The siltstones are generally not suited for use as construction material owing to low abrasion resistance, small size of individual fragments, and the potential for alteration to clay under exposure and heavy use. Interbedded greenstones are suited for use as load-bearing aggregate but not for use in asphalt.

Igneous and metamorphic rocks of various ages

Mount Emily Dacite (Tod)

Geology: This unit consists of bodies of light-colored igneous intrusive rock which include dacite, diorite, and syenite. The dacite consists of relatively large crystals of quartz and feldspar set in a finer-grained to glassy matrix. The Mount Emily Dacite forms two large intrusions and sets of radiating dikes in the Mount Emily area (Mount Emily quadrangle) and a series of smaller elongate bodies scattered along the prominent shear zone between Brookings and Carpenterville (Cape Ferrelo quadrangle). Jointing is variable and the rock is very hard where fresh.

The Mount Emily Dacite is middle Oligocene in age. A radiometric age date of 30 million years has been obtained from excellent exposures at Harris Beach State Park (Dott, 1971). The unit correlates with other Oligocene intrusions throughout much of the Oregon Coast Range. In addition, basaltic dikes cutting the Otter Point Formation between Thomas Creek and Horse Prairie Creek have been dated at 28 million years (Dott, 1971). Their origin is probably closely related to the origin of the Mount Emily Dacite.

Engineering characteristics: The Mount Emily Dacite forms a prominent mountain and numerous radiating dike ridges in the lower Chetco drainage and several other scattered dikes north of Brookings. The rock is generally very hard and forms bedrock exposures covered locally by colluvial material. On gentler slopes on Mount Emily weathering has produced pockets of residual silty loam and crumbly regolith to depths of 30 feet or more. Excavation requires blasting except in weathered areas, which are difficult to identify beforehand. Jointing is blocky and is medium to coarse. Foundation strengths are high.

Hazards include rockfall, severe erosion potential, and the possibility of caving in deep cuts in weathered material. Road construction requires consideration of highly variable conditions presented by the steep rocky slopes, pockets of weathered regolith, and hard dikes cutting through the weathered regolith. Side-hill fills are not recommended for steep, bedrock slopes.

Infiltration rates and permeabilities are generally very low on fresh bedrock, and percolation of water is restricted to joints. Weathered bedrock is moderately permeable and may represent significant local sources of ground water for small-scale use. Ground-water potential and water storage capacity of the fresh bedrock are very low.

The Mount Emily Dacite is ideal for load-bearing aggregate owing to high abrasion resistance, close jointing, and freshness. Where coarsely jointed it is suited for use as riprap. The rock is probably unsuitable for use as concrete aggregate owing to its angularity, high gloss content, and intermediate composition. Unfavorable reactions with the concrete mortar are indicated.

Colebrooke Schist (Jc)

Geology: The Colebrooke Schist forms large exposures in Curry County, but in the study areo it is exposed only in the central Langlois and central Port Orford quadrangles. The original rocks from which the Colebrooke Schist was derived were an oceanic suite which included thin-bedded siltstone, thin sandstone interbeds, minor pillow lavas and tuffs, and chert. The rocks ore metamorphosed to the greenschist and blueschist facies of metamorphism to give quartz-mica phyllites, quartz-mica schists, and greenstones.

Although the unit is metamorphic in origin, it is probably not directly related to the pods of highgrade blueschist in the Otter Point Formation, or the amphibolites at the Big Croggies, or the schists in the Briggs Creek area to the east.

The phyllites and schists of the Colebrooke Schist ore characterized by a pronounced parallel orientation of individual mineral groins (Figure 7), especially mica. This is of considerable significance from on engineering standpoint (see below). Not all schistose rocks in the study area belong to the Colebrooke Schist. Foliate rocks described from shear zones in the Dothan Formation (Dott, 1971) are of a different structural setting and were derived from that unit. Also, foliate rocks in the Pearse Peak area may not belong to the Colebrooke Schist although they are mopped as such. These exposures seem to occur in low structural positions which appear to be inconsistent with the presently interpreted overthrusting of the Colebrooke Schist.

Rocks of the Colebrooke Schist were metamorphosed in latest Jurassic or earliest Cretaceous times. Potassium-argon dotes for the metamorphism reported by Dott (1971) include ages of 138 million years in the Collier Butte quadrangle and approximately 125 million years in the Port Orford quadrangle. Strontium-rubidium ages of about 128 million years in the Port Orford quadrangle. Strontium-rubidium ages of about



Figure 7. Well-developed schistosity in phyllites and schists of the Colebrooke Schist.

128 million years are reported by Coleman (1972). These age dates correlate roughly with the age of retrograde metamorphism of the blueschist pods of the Otter Point Formation, the age of the South Fork Mountain Schist of California (Suppe, 1969), and the age of deposition of part of the Myrtle Group.

Metamorphic grade is consistent with metamorphism along a zone of active subduction. On the basis of geochemical evidence, Coleman (1972) concludes that the Galice Formation is a more likely protolith than either the Dothan or Otter Point Formations.

The Colebrooke Schist rests on a subhorizontal contact which truncates underlying structures and geologic units. Current thought is that the unitwas thrust faulted into the area probably in mid Cretaceous times (see Tectonic Setting –Regional Onshore Structure). The unit is characterized by a planar arrangement of mineral grains (schistosity) which was formed during metamorphism and by small–scale, northerly trending folds which formed when the unit was thrust into the area. There are no internal structures associated with the northward thrusting of the unit postulated in the northern part of the County.

Engineering characteristics: The Colebrooke Schist forms steep to moderately steep uniform slopes with local hummocky areas in regions underlain by serpentine (see Serpentine and peridotite) and scattered knobs and hills in regions of relatively hard bedrock. Soils overlying schistose rocks are generally a few feet thick and consist of silty clay loam and silty clay with scattered rock fragments near the base. Soils on steep slopes are colluvial. The rock is generally ripped with only moderate difficulty, owing to the fine jointing and the schistosity. Blasting is required in deep cuts and in greenstone or other nonfoliate rocks in the unit. Foundation strengths are moderately high. However, large construction projects and road fills must proceed only after adequate consideration of the potential for failure along foliation planes.

Infiltration rates probably vary from moderately low to moderately high depending upon the development of fractures along the schistosity. Water storage probably shows similar variations and ground-water potential is moderately low to moderate. Streams draining areas of Colebrooke Schist appear to have more uniform summer flows than streams draining other bedrock units for which low and very low ground-water potentials are interpreted.

The schistose rocks are not suited for use as fill or embankment material owing to the planar shape of the particles and consequent high potential for settling under load. Similarly the rock is not suited to use as load-bearing aggregates owing to its potential for settling, low abrasion resistance, and high mica content (and consequent high potential for weathering to clay). In areas of non-schistose rock, such as greenstone or chert, potential for use as embankment material or road metal is fair to moderate. Deep cuts formed by the Rogue River have exposed extensive unweathered exposures that are suitable for use as fill.

Pearse Peak Diorite (Jpp)

Geology: The Pearse Peak Diorite is a body of intrusive rock of intermediate composition which intrudes the Galice Formation in the Pearse Peak area (Port Orford quadrangle). It consists of hornblende-biotite-quartz diorite near its core and of pyroxene-hornblende diorite in its northwesterly exposures. On the southwest side it is sheared and altered. Jointing is generally fine and produces blocks a foot or less in their greatest dimensions. Small dikes penetrate the neighboring Galice Formation. Zones of contact metamorphism are narrow. The petrology of the unit is discussed briefly by Dott (1971), Lund and Baldwin (1969), and Koch (1966).

Radiometric age dates for the Pearse Peak Diorite range between 141 and 146 million years (Dott, 1965; Koch, 1966). The unit postdates the Galice Formation and predates the Otter Point and Dothan Formations. An age date of 275 million years (Dott, 1965) is regarded as spurious by Dott (1971). The unit forms part of a large structural block between the latitudes of the Sixes River and Euchre Creek that was thrust into the area from far to the east in medial Cretaceous times (see Tectonic Setting - Regional Onshore Structure).

Dott (1971) reports ages of 285 million years and 215 million years for dioritic bodies surrounded by serpentine at Saddle Mountain (east of study area) and near Carpenterville (Cape Ferrelo quadrangle) respectively. These dioritic bodies (too small to show on maps) are not part of the Pearse Peak Diorite but instead represent pieces of continental crust sheared into the area along with the serpentine.

Engineering characteristics: The Pearse Peak Diorite forms steep uplands and underlies some of the highest terrain of the study area. Soils consist generally of silty to sandy loam and are dominated by patches of gravelly colluvium on very steep slopes. Fresh rock is hard and jointed, yielding mediumsized angular blocks. Excavations require blasting, and foundation strengths are very high.

Hazards include severe erosion potential, high debris-slide potential in areas of colluvium on steep slopes, and thin soils. Construction of logging roads generally requires bedrock cuts on steep slopes, adequate drainage facilities, and careful assessment of depths to bedrock.

Percolation of ground water is restricted to joints, and water storage capacities are low. Ground-water potential is very low, except possibly in areas of deep weathering on gentle slopes where it may be sufficient for stock or single-family dwellings.

The suitability of the rock for construction uses varies with weathering and jointing characteristics. Generally, the rock is well-suited to use for fill or load-bearing aggregate. Because of its intermediate composition and relatively high potential for adverse reactions with cement mortar, the rock is not suited for use as aggregate for concrete. Abrasion resistance is high. Coarse jointing is rare and suitability for use as riprap is apparently limited.

Serpentine (serpentinite) and peridotite (spp)

Geology: Serpentine is the name of a mineral group which includes several platy minerals rich in magnesium and iron and analogous to certain clay minerals in terms of structure. Peridotite is hard, massive rock composed of iron- and magnesium-rich minerals such as olivine and pyroxene. Geologists commonly refer to rocks composed of serpentine as "serpentinite" and to serpentinite and peridotite as "ultramafic rocks."

In the study area serpentine occurs in many different structural settings. It occurs as horizontal slabs beneath thrust plates, as subhorizontal lenses within the Otter Point Formation, and as vertical slabs along vertical faults of varying ages. It is generally highly sheared and is commonly associated with tectonic blocks of foreign material such as peridotite.

North of Wedderburn, the Vondergreen Hill peridotite lies within Otter Point terrain. Its borders are sheared and are grossly concordant with the surrounding rock (Koch, 1966). It is interpreted as a piece of Late Jurassic ocean-floor crust that was sheared into the Otter Point Formation as that unit was being thrust beneath the North American continent (see Tectonic Setting-Regional Onshore Structure). Exposures of smaller bodies of serpentine in the Gold Beach area show gently dipping serpentine separated above and below by thrust faults from rocks of the Otter Point Formation.

In general terms, all the serpentine and peridotite of the study area probably represents slabs of oceanic crust that have been introduced into the area by regional thrusting. The specific mineralogy of the rocks is consistent with such an origin (Ghent and Coleman, 1973), and serpentines similar to those of the study area have been recovered from dredge hauls along ocean ridges (Medaris and Dott, 1970).

Because several periods of thrusting and faulting have affected the area (see Tectonic Setting - Regional Onshore Structure), the origins of specific ultramafic bodies may vary considerably. Thus, some serpentine represents a sole for the Colebrooke thrust sheet while other serpentine bodies represent more local slabs of crustal material along smaller thrusts within the Otter Point Formation. In still other areas the serpentine was remobilized along vertical faults in Cenozoic times to form vertical slabs. Although the actual age of formation for the ultramafic rocks is Late Jurassic, the times of its final emplacement into present settings is highly variable.

Engineering characteristics: Large exposures of serpentine form flat, gentle ridge crests at Red Flats, irregular, moderately steep slopes in major drainages, and large landslides in places. Smaller exposures of serpentine are commonly resistant to erosion, relative to the enclosing bedrock, and form prominent knobs. Soils are generally iron-rich, clay-rich loams, and silty clays. They commonly are only a few feet thick, even in areas of prolonged weathering. The soils are bouldery in the subsurface and pass into jointed and sheared bedrock with depth.

Serpentine is moderately hard but crumbles into progressively finer slabs and sheets upon impact. Excavations are troublesome owing to the numerous residual boulders of greatly varying size, and blasting is required in deep cuts. In the extensive uplands areas underlain by serpentine, blasting is generally not

economical. There, roads bladed to bedrock are generally very rough, owing to the concentration of weathering and clay alteration along shears and joints. The result is sharply alternating hard and soft material in the road base. With time the clay is eroded by overland flow to produce very rough surfaces.

Foundation strengths are moderately high and the unit is capable of supporting structures of moderate size in areas free of mass movement or extreme weathering.

Geologic hazards include shallow depths to bedrock and the consequent limitations on excavations and subsurface disposal of waste effluent. Mass movement potential varies considerably and includes active mass movement in some areas (e.g. parts of the Floras Creek drainage) and stable ground in others (small exposures in the Gold Beach area). On-site inspection is required to assess the slide potential of serpentine exposures.

Infiltration rates are generally very low. Water storage capacity and ground-water potential are also very low. Owing to the impermeability of the underlying bedrock at Red Flats and other flat-lying serpentine areas, small quantities of water are stored in the soil or at shallow depths. Potential for contamination of this supply of ground water is very high, both because of the shallow depth of the reservoir and the rangeland use of much of the terrain.

Serpentine and peridotite are poorly suited for fill or embankments owing to the generally high clay content and the wide size distribution of the boulders. Achieving acceptable compaction is extremely difficult. In addition, the boulders are generally round rather than angular, a factor which contributes to the instability of fill. Abrasion resistance and resistance to weathering are also very low and the material is not suited to use as load-bearing aggregate.

Surficial Geologic Units

General

Ten surficial geologic units are recognized. They are 1) beach sand, 2) unstable dune sand, 3) stable dune sand, 4) marsh, 5) Quaternary alluvium, 6) Quaternary fluvial (river) terrace deposits, 7) Quaternary lower marine terrace deposits, 8) Quaternary middle marine terrace deposits, 9) Quaternary upper marine terrace deposits, and 10) Quaternary higher marine terrace deposits. Surficial geologic units are semiconsolidated to unconsolidated deposits formed by relatively recent processes; they form thin layers over older bedrock units and structures. Surficial geologic units differ from soils in the strict sense in that they are products of deposition rather than weathering.

The relative ages of the surficial deposits are summarized schematically in Figure 4. The marine terraces are the remnants of past sea floor elevated by recent uplift, and the river terraces are the dissected remnants of prior flood plains. The various sand deposits were laid down relatively recently as rising sea level moved the shoreline inland (see Geologic Hazards – Wave Erosion and Deposition). Identification of individual terraces involves a balanced consideration of elevation, surrounding terraces, degree of dissection, and other local factors; long-range correlations are not possible.

Beach sand (sb)

Geology: Beaches are gently sloping zones of unconsolidated sand that extend landward from the low-water line to a point where there is a definite change in rock type or landform. Major beaches of Curry County are located north and south of Cape Blanco and in the Rogue River area. Lesser beaches are present in the many coves which characterize much of the coastline. Beach material is generally thin and consists primarily of sand with coarser material near headlands and sea stacks. Beach material is derived from local sources (Laudon, 1967 quoted in Dott, 1971) and from major drainages (see Geologic Hazards – Wave Erosion and Deposition – Beaches). Beaches are adjusted to the present sea level and are not more than a few thousand years old.

Engineering characteristics: Beach sands are easily excavated, are generally not compressible, and exhibit no cohesion. Excavation or use for foundations is generally not advised owing to the dynamic setting (see Geologic Hazards - Wave Erosion and Deposition). Possible resource potential may include black sand deposits short distances offshore, especially in the vicinity of the Sixes River (see Mineral Resources).

Unstable dune sand (su)

Geology: This unit includes dunes that are unprotected or poorly protected from the wind by vegetation. Major areas of unstable dune sand include the active foredunes and related dunes of the New River area and the exposed hummocks south of the Pistol River. Stabilized foredunes are also included because they represent areas of active sand deposition by the wind.

Unstable dunes are composed of fine- to medium-grained sand and have direct connections to continuing sources of sand supply such as beaches. The unstable dune sand of the study area is generally thin except in the Pistol River area where thicknesses of up to 100 feet are possible. Because the sand is not stationary, pan horizons and other soil developments are generally absent or poorly developed. The unstable dune sand is adjusted to present-day beach activity and generally the dunes are a few thousand years or less in age.

Engineering characteristics: Unstable dune sand is easily excavated, noncohesive, and noncompressible. Layers of compressible organic or clay-rich soil may be present in the subsurface and should be adequately researched prior to large construction (see Marsh deposits). Soils are not developed and infiltration is rapid. Major hazards include wave erosion (see Geologic Hazards - Wave Erosion and Deposition) and ocean flooding (see Geologic Hazards - Ocean Flooding).

Active dunes represent a balanced response of the terrain to present wind patterns, vegetative cover, and sand supply. Changes in any one of these can initiate changes in patterns of wind erosion or wind deposition. Sand deposition is promoted where natural or man-made obstructions divert or slow the wind, causing it to lose its carrying capacity. The result can be burial or partial burial of roads, lawns, or parking lots. In urban areas where excavations expose old dune deposits, sand blown into streets can clog storm sewers during heavy rains. In coastal areas where houses or condominiums are constructed in regions of wind-blown sand, local adjustments of wind patterns can result in partial burial of structures. Blowing sand also abrades surfaces of cars, houses, and other man-made objects. The irritation factor of blowing sand should be considered in the location of camping facilities and similar land uses. Where vegetation is removed by fire, logging, or overgrazing, wind erosion may remove soil horizons necessary for revegetation.

Owing to their rapid infiltration and high storage capacity, the thicker dune deposits south of the Pistol River may constitute a significant local source of ground water. Contamination by septic tanks should be avoided. An additional resource value of the unstable dune sand is its suitability for use as fill material. Well-sorted sand should not be used for fill in submerged areas, however, because of the potential for lique-faction during earthquakes (see Tectonic Setting - Earthquakes) or other vibrations.

Stable dune sand (ss)

Geology: Stable dune sand consists of fine- to medium-grained unconsolidated sand blown off the present-day beaches into dunes and stabilized by vegetation. Owing their origin to the most recent rise of sea level, the stable dune sand deposits are less than 5,000 years in age. Not included in the unit are vegetated dune deposits, situated on terraces, which were formed during prior high stands of sea level (see Quaternary middle marine terrace deposits). The unit consists of sand deposits as much as 100 feet thick south of the Pistol River and minor dune deposits inland from active foredunes in the Rogue River and New Lake areas.

Stable dune sand consists of fine- to medium-grained unconsolidated sand with indistinct bedding. Other than in the Pistol River area the deposits are thin. Pan deposits and other soil features are poorly developed. Locally the sand may overlie peat deposits especially in the New River area.

Engineering characteristics: Stable dune sand is easily workable, exhibits little compressibility, and is essentially noncohesive. It may overlie layers of compressible organic-rich or clay-rich material. Large construction projects should be preceded by adequate subsurface investigations to assure against settling.

Soils developed on stabilized sand are generally a few inches thick or less and consist of sandy loam and loamy sand. Infiltration rates are high and there is no surface runoff. Older deposits of stabilized dune sand on terraces are discussed under the appropriate terrace headings.

Where vegetation is removed, wind erosion and deposition may be initiated (see Unstable dune sand). In areas of prolonged construction, temporary means of sand stabilization in exposed areas should be considered. Structures placed in excavations can act to inhibit sand migration in a very local sense and can be expected to be plagued by undesirable sand deposition. In areas of high or fluctuating water table, caving of excavations is a major hazard owing to saturation and lack of cohesion.

Resource potential of stable sand includes ground-water production in areas of thick sand accumulation and wildlife habitat. South of the Pistol River care should be exercised to assure that the potential ground-water resource is not contaminated by septic tanks or other means of waste disposal. Sand is well-suited to use for many types of fill. Owing to the high susceptibility to liquefaction, however, well-sorted dune sand is not suitable for fill in areas of future saturation, such as wetland areas or areas where roadfills impound or retard surface runoff.

Marsh deposits (m)

Geology: Fine-grained wetland deposits rich in organic matter and exposed at the surface are designated as marsh. Organic-rich layers in the subsurface are termed peat. The marsh is widely distributed in low-lying areas of Quaternary lower marine terrace deposits and Quaternary alluvium in the northern parts of the County, along stream channels in the Quaternary middle marine terrace deposits surrounding Garrison Lake near Port Orford, and along the mouths of many coastal drainages such as Euchre Creek.

As alluviation continues, the marsh deposits are commonly buried so that the subsurface distribution of organic-rich material is significantly greater than the surface distribution. In the New Lake area, for example, natural processes of alluviation and draining of the area by man have significantly reduced the extent of the lake and marsh since the turn of the century.

Units which may include interbeds of peat in the shallow subsurface include Quaternary alluvium, unstable dune sand, and stable dune sand. Although the distribution of peat in the subsurface can often be anticipated in a general way, actual site evaluations require on-site subsurface investigations.

Engineering characteristics: Under light to moderate loads, the spongy to fibrous material making up peaty soils compresses and expels water to produce hazardous settling over prolonged periods of time. An additional hazard in areas of larger fills and developments is that of spreading of unconsolidated material in the subsurface in response to the increased load. Impacts may include soil dislocations, formation of ridges and mounds along original developments, and damage to structures.

Where necessary, the severe restrictions posed by marsh and peat can commonly be overcome by 1) excavation and backfilling with a more suitable material, 2) preloading, 3) the use of piles or spread footing, and 4) the use of counterweights or drains. For small structures, the use of fill needed to avoid projected flooding may be sufficient to overcome the settling hazard. Where peat is present in the subsurface, the extent of the hazard can be accurately determined only by subsurface study.

Additional hazards associated with marsh are flooding and high ground water. Because of the low cohesion and saturated conditions associated with marsh and peat, caving is a significant hazard in excavations. Major resource values include wildlife and marginal agricultural potential. Large marshes in the New Lake area have been drained by a series of canals and are now in agricultural use.

Quaternary alluvium (Qal)

Geology: Unconsolidated deposits of poorly sorted gravel, sand, silt, and clay in the flood plains and channels of major rivers and streams is assigned to the Quaternary alluvium. Thicknesses vary from a few feet to an estimated 50 feet in some estuarine areas. Gravel and sand predominate along the Rogue and Chetco Rivers, and numerous commercial operations for sand and gravel are located in these areas (see Mineral Resources - Construction Materials).

Quaternary alluvium and other surficial deposits such as marsh, Quaternary lower marine terrace deposits, and Quaternary fluvial terrace deposits are locally transitional, and boundaries are difficult to locate. This is particularly true in the broad, flat-lying lowlands north of Floras Lake. Along major drainages, Quaternary alluvium, which represents ongoing deposition on flood plains, is difficult to

distinguish from Quaternary fluvial terrace deposits, which rarely if ever flood (see. Geologic Hazards – Stream Flooding). Generally, however, the boundaries selected in this study are meaningful.

Engineering characteristics: Lithology, engineering properties, and hazard potential of the Quaternary alluvium vary considerably. Generally, the Quaternary alluvium is easily excavated and exhibits moderate foundation strength. Where compressible soils are present at the surface or at depth, the potential for settling should be considered for any developments (see Marsh). Of particular concern is the potential for settling of roads and highways which must pass over alluvium with high organic content.

Flood-plain alluvium generally consists of silt and clay near the surface and coarser grained material, such as sand and grovel, at depths of a few feet or more. The fine-grained surficial material is deposited by slow-moving flood waters and is not strictly a product of weathering, although immature true soils ore developed locally where weathering is not totally masked by deposition. The texture of alluvium at the surface is not representative of the alluvium at depth.

Infiltration rates are slow, and a major hazard during the wet season is panding. Related hazards include high water table and flooding. Consequently effluent disposal systems generally are not practical. Additional hazards include stream-bonk erosion and the relatively high potential for caving in excavations. Resources include ground water, sand, grovel, wildlife, open space potential, and potential for agricultural use. Residencial use is generally not recommended. Necessary structures may require use of piling to avoid flood damage or settling.

Quaternary fluvial terrace deposits (Qft)

Geology: Alluvial terraces are formed when continued uplift of the land or a drop in sea level prompts the stream to cut downward through its flood-plain deposits to form a new flood plain at a lower elevation. The dissected remnants of the former flood plain are seen as terraces along the sides of the valley. Quaternary

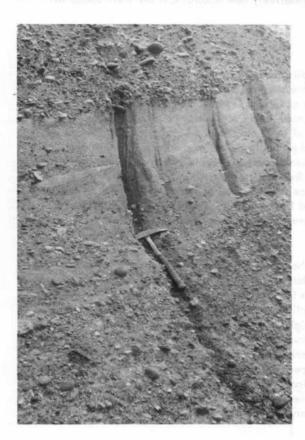


Figure 8. Gravel and sand of a fluvial terrace exposed in a roadcut on Floras Creek.

fluvial terrace deposits are developed locally along the major rivers of the study area. Like the adjacent alluvium of the present-day flood plains, they consist primarily of sand and gravel (Figure 8). Thicknesses generally do not exceed 30 or 40 feet. Well-log data near the mouth of the Pistol River indicate a minimum thickness of 35 feet in that area. Although a late Pleistocene age is assigned to all the fluvial terraces, they are not all precisely the same age.

Engineering characteristics: The Quaternary fluvial terraces are poorly to moderately consolidated and are excavated with ease or with moderate difficulty. Blasting is not required. The terrace material is compacted and is not compressible. Foundation strengths are moderate to high.

The fluvial terraces generally consist of silt or clay near the surface and coarser grained material, such as sand or gravel, at depths of a few feet or more. The fine-grained surficial material represents flood-plain deposits and soil. Locally low infiltration rates and surface depressions combine to produce a ponding hazard during the wet winter months. Septic tanks are not practical in these areas. Danger of caving is low to moderate. In areas of dissected and semicompacted fluvial terrace material, deep cuts are very stable. An example is the roadcut through terrace gravels along the lower reaches of the Sixes River. Elsewhere, where elevations above the water table are small, or where broad, flat areas in fine-grained soils are developed, the hazard of caving is greater.

The fluvial terraces are subject to occasional flooding in places (see Geologic Hazards - Stream Flooding). Near Agness, flood waters have reached 90 feet above the low-flow elevation of the river, and at the mouth of the Rogue River surfaces mapped as fluvial terrace have histories of flooding. Elsewhere, the distinction between terraces and flood plains are equally unclear depending upon the data available and the frequency of flooding under consideration.

An additional hazard of the fluvial terraces is the variable thickness of the deposits. Where knobs of hard bedrock are near the surface, septic tanks, basements, and roadcuts must be evaluated in terms of the underlying bedrock. Generally the terraces exhibit relatively few hazards and are well-suited to a variety of uses including residences and pastureland.

Quaternary lower marine terrace deposits (Qmtl)

Geology: The Quaternary lower marine terrace deposits underlie the flat lowlands north of Floras Lake. Elevations are generally between 20 and 40 feet above sea level. In the northern part of the County the terrace is equivalent to the Whiskey Run terrace of Griggs (1945). Long-range correlations of terraces assigned to the unit in the southern part of the County are uncertain.

The Quaternary lower marine terrace deposits consist of sand and silt and basal gravels. Thicknesses are probably similar to other marine terraces in the area and probably do not exceed a few tens of feet. The terrace deposits are transitional with Quaternary alluvium along major drainages and are covered with marsh deposits in broad low-lying areas immediately inland from the stable and unstable dunes.

The terrace was probably formed during a late Pleistocene high stand of sea level such as the one reported to have occurred 35,000 years ago by Milliman and Emery (1968). Radiocarbon dates of about 30,000 years have been obtained from parts of the lower terraces in southern Coos County (Kent, 1975 oral communication).

Engineering characteristics: In the northern part of the County the lower marine terrace deposits are excavated with little difficulty, exhibit moderate foundation strength, and are compressible in places depending upon the nature and distribution of marsh deposits (see Marsh Deposits).

The flat surface, low elevation, and relatively low infiltration rates of the terrace surface in the northern part of the County produce a severe ponding and high water-table hazard over much of the lower marine terrace. In addition, the lower reaches of several small drainages pass over the terrace and generate a severe flood potential. Delineation of the precise boundaries of the flood hazard is difficult owing to the gentle topography. Excavations are prone to caving, especially during the wet season.

Additional hazards include a possible potential for minor liquefaction in some places during major earthquakes and shallow depths to bedrock locally. Major resource potentials include wildlife habitat and open space. The lower marine terrace is suitable for very low-density and properly located residential use.

Quaternary middle marine terrace deposits (Qmtm)

Geology: The Quaternary middle marine terrace deposits form the gently warped table lands east of Cape Blanco (Figure 9) and also are present in the Gold Beach area and at Brookings. Elevations vary between 20 and 200 feet above sea level. In the northern part of the County the unit is equivalent to the Pioneer terrace of Griggs (1945). Equivalence of the middle terrace in southern Curry County is uncertain. The Quaternary middle marine terrace is gently to moderately dissected.

The deposits consist of 10 to 40 feet of basal gravel and overlying sand in the Cape Blanco area. Northerly trending beach ridges (dunes) north of Port Orford record former shorelines. In the Port Orford area, coarse-grained sands and gravelly lenses predominate and dune forms are absent. Gravels are locally abundant near stream channels. Knobs of hard bedrock, which formed sea stacks when the unit was being deposited, now protrude through the terrace deposits.

Deposition of the Quaternary middle marine terrace deposits probably occurred during the last major interglacial high stand of sea level approximately 100,000 years ago. Janda (1969) reports radiocarbon evidence for an age of greater than 45,000 years.

Engineering characteristics: Although deposits of the Quaternary middle marine terrace unit vary considerably in composition, the engineering properties of the unit generally include moderate foundation strength, absence of compressible horizons in the subsurface (except in areas of dune sand), and relative ease of excavation.

The flat upper surface of the middle marine terrace is dissected to sea level by major streams and rivers and is transected to depths of ten feet or so by marsh-lined smaller streams (see Marsh Deposits). Dune sands north of Port Orford and gently sloping soils south of Brookings are well-drained. Broad, flat areas and gentle depressions in the Cape Blanco and Brookings areas are poorly drained and in places are underlain by impermeable iron-cemented pans. Soils are fine grained and include silty loams, clay loams, and silty clays.

Hazards include wave erosion, poor drainage in places, and potential for caving in excavations in poorly drained areas. Where bedrock protrudes through the terrace material or is buried at shallow depths, it must be considered in evaluating septic tanks, road cuts, pipeline routes, and other excavations. Because the terrace material is coarser grained than the overlying soil, waste disposal evaluations may require considerable care. Land use includes general agriculture, open space, cranberry and lily production, homesites, urban development, and domestic ground-water productions. Land use conflicts will escalate in the future. A major concern will be between the need for subsurface disposal of wastes and the need to preserve the ground-water resource.

Quaternary upper marine terrace deposits (Qmtu)

Geology: The Quaternary upper marine terrace deposits form sloping surfaces against the uplands overlooking the middle marine terrace east of Cape Blanco area and also are present in the Brookings area. In northern Curry County the unit consists of semiconsolidated sand and silt with basal gravel and is roughly equivalent in age to the Seven Devils terrace of Griggs (1945). The unit mapped immediately east of Port Orford consists of 200 to 300 feet of massive sand which stands out in high, vertical cliffs along road cuts and streams. Pliocene fossils reportedly have been recovered from some of these deposits (Dott, 1971), and much of the unit here may ultimately be reassigned to an older unit. A middle Pleistocene age is generally interpreted for the Quaternary middle marine terrace deposits in the Cape Blanco and Brookings areas.

Engineering characteristics: The upper marine terrace deposits are deeply dissected, well-drained, noncompressible, easily excavated, and capable of supporting small to moderate-sized structures. Soils are clay loams, silty loams, and silty clays; iron-cemented pans are not present. Potential for liquefaction during earthquakes or caving in excavations is small. Depth to bedrock is variable and commonly shallow, and should be considered in evaluating all developments involving excavations. During the wet months, shallow ground water accumulates at the base of the unit and promotes sliding of terrace materials off headlands.



Figure 9. The middle marine terrace rises from near sea level in the Port Orford area to 200 feet in the Cape Blanco area (left background). Upper marine terrace deposits cap The Heads (foreground). (Oregon Highway Division Photo)

Quaternary higher marine terrace deposits (Qmth)

Geology: The Quaternary higher marine terrace deposits cap flat ridges greater than 1,000 feet above sea level and are located in the uplands of northern Curry County and north of Brookings. Distinction from the upper marine terrace deposits is somewhat arbitrary in places and depends primarily on the degree of dissection, elevation, and the identity of adjacent terraces. In the northern part of the County the unit is roughly equivalent to the higher terraces of Griggs (1945).

The Quaternary higher marine terrace deposits consist of sand and silt with local basal gravels and gravelly lenses. Exposures east of Port Orford may include a presently unrecognized Pliocene unit. An early Pleistocene age is generally interpreted (Janda, 1969).

Engineering characteristics: The unit has moderate foundation strength, is excavated with ease or only moderate difficulty, and is noncompressible. Soils are clay-rich and are finer grained and less permeable than the underlying parent material. Potential for caving and liquefaction is minimal. Where deposits are thin, the underlying bedrock may be deeply weathered and may not display its typical engineering properties (see Bedrock Geologic Units). In such areas, the nature of the underlying bedrock should be considered in evaluating all developments which involve excavations. Land-use potentials include residential development and possible domestic supplies of ground water.

Soils

General

2

Unconsolidated mineral material at the Earth's surface formed in place by weathering is termed soil. This definition is less restrictive than that employed by many agronomists, who limit soil to material capable of supporting plant growth. It is more restrictive than the concept of soil used by soil engineers, because it does not include surficial geologic units. It is consistent with most of the methods of sampling (limited to the upper 5 or 6 feet) employed by the U. S. Soil Conservation Service, and it emphasizes the unique characteristics of the weathered zone.

Weathering processes of the Earth's surface include chemical breakdown of minerals, chemical reconstitution to form new minerals (clays), physical disintegration, and leaching. During the initial stages of soil development the composition of the parent material is a dominant factor in determining soil type. Climate determines the kinds and rates of chemical reactions and also the nature and distribution of vegetative cover. Slope intensity influences drainage and mass movement, and slope orientation partly determines the balance of soil-forming processes within a given area. As time increases, climate becomes increasingly more important in determing soil development.

Horizons of differing composition and texture are developed within a mature soil because physical and chemical conditions vary with depth. The surface horizon (A horizon) is the zone of most intense organic activity, leaching, and downward percolation of fines. Commonly iron, carbonates, and clay are removed to be deposited in the next lower, or B, horizon. This zone is characterized by relatively high concentrations of silicated clay minerals, iron, or other materials. At greater depths the underlying C horizon consists of partially weathered and decomposed bedrock. Variations in the balance of the five soil-forming factors (parent rock, climate, topography, vegetation, and time) produce the many variations in soil type observed in Curry County.

Systems of soils classification

The National Cooperative Soils Survey of the U. S. Department of Agriculture adopted the Seventh Approximation Systems of Soils Classification in 1965. In it soils of the nation are grouped into order (based on regional climate), suborder (based on physical setting), group (uniformity and types of horizons), subgroup (nature of gradations between horizons), families (broad textural and compositional features related to plant growth potential), series (parent material and genetic horizons), and type (based on surface texture). At the top of the scheme, soils of coastal Oregon are called Utisols because of the moist, temperate climate.

At the bottom of the scheme, local soils are named according to soil profiles and textures. For instance, Blacklock fine, sandy loams are characterized by a distinct soil profile and by fine, sandy loam at the surface. Field recognition of soil textures is summarized in Appendix A.

All soils mapping is conducted using the system of classification adopted by the U. S. Department of Agriculture. Two other major systems of classification include the Unified Soils Classification (Appendix B) used by the U. S. Army Corps of Engineers and the U. S. Bureau of Reclamation and the AASHO (American Association of State Highway Officials) System (Appendix C) used in highway construction. Comparison of the particle-size boundaries recognized by the three systems is given in Appendix D.

The U. S. Department of Agriculture system of soils classification is based primarily on grain-size distribution and lends itself well to regional mapping. The Unified System is more rigorous and places emphasis on the engineering properties of the soil, including plasticity index (a measure of the water content at which the soil behaves as a plastic), liquid limit (a measure of the water content at which the soil behaves as a liquid), and organic content. The AASHO System is used to classify soils according to those properties that affect use in highway construction and maintenance.

Distribution

The soils of Curry County are generally young and are strongly influenced by landform and parent material. Little published on-site data are available. Table 5, showing the generalized engineering properties, was derived by matching soil units of the U. S. Department of Agriculture System with equivalent soil classes and their properties in the Unified System. Approximations given on the table are consistent with observations obtained in the field.

The soils data of this section applies only to the soils and not to the underlying geologic units, which may be present at shallow depths. Thus, foundation ratings do not apply to bedrock. Wearing strength applies strictly to the suitability of soils for road surfaces and does not consider roads cut to bedrock or use of soil material for road base. Internal drainage refers to infiltration and does not consider runoff. The California Bearing Ratio is on a scale of 100 with the highest figure equivalent to a standard of high-quality crushed stone.

The soils of Curry County are generally fine grained. Upland soils exhibit wide variations of thickness and texture over short distances as a function of topography and parent material. Bedrock of the uplands is typically hard and weathers very slowly to form clay-rich textures, especially in the B horizon. Terrace soils overlie unconsolidated to semiconsolidated surficial geologic units and generally consist of finer-textured soils which grade downward into coarse-grained, well-drained parent material. Lowland soils are highly variable both vertically and laterally, and reflect varied ages and environments of deposition. Many of the lowland soils are not true soils because they are depositional units rather than zoned products of weathering.

<u>Upland soils:</u> Soils of the uplands consist primarily of silty and clay loams on gentle to moderate slopes, and loams and gravelly loams on steep slopes. Typically the soils are characterized by clay-rich B horizons and coarser C horizons which are gradational with the bedrock. The most striking aspect of the upland soils is the extreme variability of texture, thickness, and engineering properties over short distances both laterally and vertically. Major factors are the extreme variabilities of parent material, slope, mass movement, and erosion. Generally the soils have low to moderate corrosivity, variable liquid limit, variable plastic limit, and variable organic content. The soils are leached and moderately acidic, especially under conifer cover.

Soils over basalt are thin and clay-rich. Those over serpentine are rubbly, thin, and commonly iron-and clay-rich. Soils over sedimentary rock are of variable thickness depending on the slope, degree of shearing, and the degree of consolidation of the parent material. Soils on long moderate slopes of the Dothan Formation are generally thick. Soils over rocks of the Colebrooke Schist are generally clay-rich and rubbly at depth. Soils over diorite are siltier and sandier than soils over other less quartz-rich parent materials.

Engineering properties of the upland soils are summarized in Table 5. The uplands are used for timber production, water production, recreation, wildlife, and open space. In future years increasing demands will be placed upon the uplands for homesite development. The available soils mapping (Buzzard and

Table 5. Generalized engineering properties of soils in Curry County, Oregon*

	Text	ural classes			Engineering properties							
Landform	U.S.D.A.	Unified	AASHO] Ē	Foundat i on	Wearing	Shrink-swell	Inter. drainage	Cal. Bearing Ratio			
	Silt loam	SM, ML	A-4	∏ F	air to poor	Poor	Low to med.	Fair to poor	6-25			
	Silty clay loam	ML-CL	A-6,7	F	air to poor	Poor	Medium	Fair to very poor	4-25			
	Clay, silty clay	MH	A-4,6,7	F	Poor	Poor	High	Fair to poor, very	6			
Uplands								poor				
	Gravelly loam	SM-SC	A-4	T E	xcellent to	Very	Low	Fair to poor	20-60			
					good	good	*	¥				
	Sandy clay	ML-CL	A-4	∏ F	air to poor	Poor	Medium	Fair to very poor	4-25			
	Loam	ML	A-4	F	air to poor	Poor	Medium	Fair to poor	6 - 25			
	Silty clay loam	ML-CL	A-4	F	air to poor	Poor	Low to med.	Fair to very poor	6 - 25			
Terrace	Silty clay	CH	A-6,7	\sqcap	ery poor	V. poor	Medium	Very poor	6			
	Sandy Ioam	SM	A-2,4	∏ F	Poor to good	Good	Low	Medium to good	20-60			
	Loamy sand	SM	A-2,4	F	Poor to good	Good	Very low	Good to high	20-60			
	Sand	Sp-SM	A-2,3	F	air to good	Poor	Low	Excellent to good	10-30			
	Sandy Ioam	SM	A-4	l le	oor to fair	Good-	Low	Good to medium	20-60			
Low lands						poor						
	Silt loam	ML	A-6	F	air to poor	Poor	Medium	Fair to poor	6 -2 5			
v	Silty clay loam	ML	A-4	F	air to poor	Poor	Medium	Fair to poor	6-25			
	Silty clay	CL	A-7,6	F	air to poor	Poor	Medium	Very poor	4-15			

^{*}Adapted from U.S. Soil Conservation Service Soils Sheets

Bowlsby, 1970) does not adequately represent the extreme variability of the soils of the uplands, and increasing demands on the staff of the Sanitarians Office can be anticipated.

Use of upland soils is restricted by moderate to severe erosion potential, variable mass movement potential, and shallow depths to bedrock over large areas. Logging requires careful management, and intense development or cultivation generally are not possible. Potential use for septic tanks is limited by high clay content, steep slopes, and shallow depths to bedrock over large areas.

Terrace soils: Soils of the terraces consist primarily of sandy and silty clay loams and silty clays. Generally the soils are coarser grained with depth; nearer the poorly cemented, coarser grained parent material, engineering properties vary accordingly. Owing to the uniformity of topography and parent material over relatively large areas, the soils of the terraces do not display the extreme variability over short horizontal distances noted on the upland soils.

Soils of the Quaternary lower marine terrace deposits are generally poorly developed and contain horizons rich in organic material. Soils of the Quaternary middle marine terrace unit are moderately developed and contain iron pans of low to very low permeability at shallow to moderate depths. Soils of the Quaternary upper marine terrace: deposits generally do not contain pans owing to the greater slopes, greater stream dissection, and better drainage. Soils of the Quaternary higher marine terrace deposits are characterized by a clay-rich B horizon and by crumbly pebbles. All terrace soils are generally moderately corrosive, acidic, and of variable liquid and plastic limit.

The gentle slopes of the terraces are well-suited to a wide variety of uses including timber, pasture, recreation, wildlife, homesites, and urban development. Cranberries are grown locally where drainage is poor, and lily bulbs are grown on the Harbor Bench where drainage is good. Conflicts of land use will escalate in the future. A primary concern will be the protection of the ground-water resource from contamination by septic tanks. Other restrictions include coastal retreat, ponding in areas of low permeability, and caving in deep excavations.

Lowland soils: On the lowlands, ongoing deposition produces a variety of surficial geologic units including beach sand, marsh, stable and unstable dune sand, and Quaternary alluvium. These units are discussed in greater detail under Surficial Geologic Units. Weathering is minimal, and soils are best developed where depositional and erosional processes are the least active. Flood-plain deposits, for example, commonly have minor leaching of the A horizon and contain clay-rich B horizons. Soils of the stable dunes generally consist of only a few inches of sandy loam in the root zone. Soils are not developed on beach or channel deposits.

The true soils of the lowlands and the depositional units commonly are treated as soils by the soils scientist. Because weathering, environment of deposition, and organic content vary greatly, the corrosivity, liquid limit, plastic limit, and engineering properties (Table 5) of the lowland soils and surficial geologic units are highly variable. Major lowland uses include sand and gravel production along streams, wildlife habitat, pastureland, and ground-water production. Flooding and high water table severely restrict more intensive use in most areas, especially in the lower reaches of streams.

TECTONIC SETTING

General

Bedrock deformation in Curry County is extremely complex. It is briefly reviewed here to provide the geologist with the information necessary to assist the planner in 1) delineating the distribution of rock units as they relate to the engineering characteristics of the ground, 2) interpreting the mechanisms of mineralization as they relate to mineral potential, and 3) identifying possible active faults as they relate to earthquake potential. Major structures are shown in Figure 10 and on the geologic maps.

Regional Onshore Structure

Insights provided by plate tectonic theory (see Regional Offshore Structure) allow the identification of six major episodes of deformation in Curry County. These are: 1) subduction of the Rogue and Galice rocks beneath the North American continent in Jurassic times, 2) shearing of the Otter Point Formation in Late Jurassic times, 3) thrusting of the Rogue-Galice thrust sheet over the Otter Point and Dothan Formations in medial Cretaceous times, 4) thrusting of the Colebrooke Schist into the area at a slightly younger date also in medial Cretaceous times, 5) block faulting in early Cenozoic times, and 6) extensive shearing along prominent shear zones in late Cenozoic times.

Rogue-Galice subduction

The fine-grained sediments of the Galice Formation and the basalts and andesites of the Rogue Formation (not exposed in study area) may represent part of the deep sea floor of the Pacific Ocean subducted or thrust beneath older rocks of the Klamath Mountains in Jurassic time. The two units were later involved in a thrust sheet that brought them westward above younger formations, as discussed below.

Otter Point and Dothan deformation

Otter Point and Dothan rocks compose the lowermost structural unit of the study area and are exposed north of the Sixes River in northern Curry County, in southern Curry County along the coast, and in the Chetco River drainage. The formations are approximately equivalent to the Franciscan Assemblage of California. The units represent continental shelf deposits (Dothan Formation) and island arc deposits (Otter Point Formation), that were laid down in Late Jurassic times.

A prominent shear zone (Dott, 1971; Hunter and others, 1970; and Koch, 1966) consisting of sheared bedrock and serpentinite separates the Dothan Formation from the Otter Point Formation in the Cape Ferrelo-Carpenterville area. The shear zone, here named the Carpenterville Shear Zone, and the regional pervasive shearing of the Otter Point Formation are poorly understood. They may have formed in Late Jurassic times during possible thrusting of the Otter Point Formation eastward beneath the Dothan Formation or other units. Alternatively, they may have formed in mid-Cretaceous times during thrusting of the Rogue-Galice thrust sheet (see below). The shear zone and related faults are no longer active. The nature of the shear zone to the north beneath the Colebrooke thrust sheet is unclear.

Rogue-Galice thrust sheet

The Rogue-Galice thrust sheet overlies the Dothan and Otter Point Formations along a regional thrust fault characterized by serpentinite intrusions and shearing, and also local pods of phyllonite (highly sheared rock) in the upper Chetco drainage (Ramp, 1975). The thrust fault is coextensive with the Great Valley Fault in California for which a mid-Cretaceous age has been interpreted (Hotz, 1969). Although

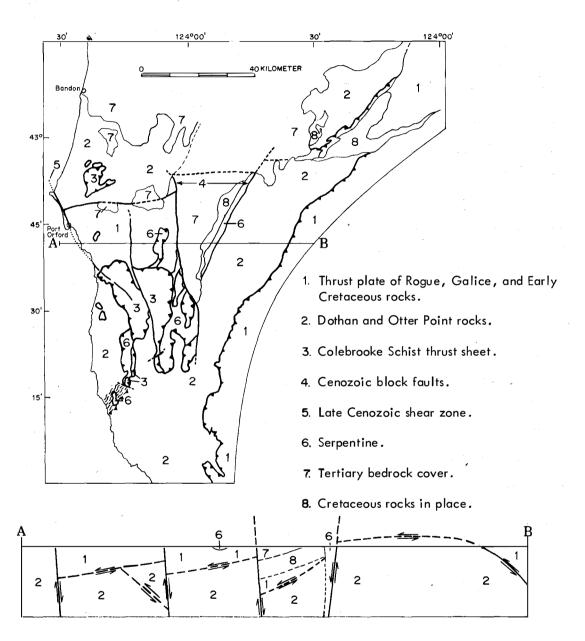


Figure 10. Major geologic structures of Curry County area in southwestern Oregon.

the thrust fault in Oregon may be an extension of the Great Valley Fault, patterns of metamorphism around the zone in Oregon differ from those in California (Loney and Himmelberg, 1976).

Rocks in the Pearse Peak area probably were thrust faulted into the area as part of the Rogue-Galice thrust sheet. Age of thrusting is unclear but probably extended into or was restricted to the middle Cretaceous. The Galice Formation and Pearse Peak Diorite, which intrudes it, are structurally out of place, being located far to the west of all other Nevadan intrusions in the Klamath Mountains. The Early Cretaceous strata (Humbug Mountain and Rocky Point Formations) in this area are depositional upon the Galice Formation and Pearse Peak Diorite and are part of the thrust sheet. They set a lower limit for the age of thrusting.

The base of the thrust sheet in the Pearse Peak area is believed to be a thrust fault above the Dothan and Otter Point Formations. The northern boundary of the structural unit in the Sixes River area is a prominent east-trending strike-slip fault which appears to be colinear with other strike-slip faults extending eastward into the Canyonville area (Figure 10). Possibly the faults represent mid-Cretaceous, large-scale faulting along the edge of a regional thrust plate. Deposits of Flournoy Formation (middle Eocene) overlying the fault in the Sixes River drainage are not displaced by the fault, indicating that faulting ceased prior to the middle Eocene.

Inland, in the Agness area, Late Jurassic and Early Cretaceous strata form north-south trending folds in large exposures of serpentinite. The beds contain no serpentinite pebbles and apparently are infault contact with the serpentinite. Also, the continental environment of deposition indicated by the composition of the beds is inconsistent with a sea floor of serpentinite. For these reasons, thrusting of the Late Jurassic and Early Cretaceous beds over the serpentinite is interpreted (see cross-section, Agness quadrangle).

Because these strata in the Agness area are surrounded almost entirely by serpentinite, their structural relationships with neighboring thrust sheets are unclear. In this study, large-scale vertical faulting is hypothesized in the serpentinite, further complicating regional structural interpretations. The strata may be structurally related to the Rogue-Galice thrust sheet, the Colebrooke thrust sheet, or to localized periods of thrusting that have not yet been identified.

Colebrooke Schist thrust sheet

The Colebrooke Schist forms a large thrust sheet, which overlies the Otter Point-Dothan structural unit and the Rogue-Galice thrust sheet in central Curry County, and a smaller thrust sheet, which overlies Otter Point Formation in northern Curry County. The lower contact of the northern thrust sheet is nearly horizontal and that of the southern thrust sheet ranges from nearly horizontal to steeply dipping. In places, serpentinite separates the Colebrooke Schist from underlying units.

Evidence for the age and direction of thrusting of the Colebrooke Schist is ambiguous. The thrusting clearly postdates that of the Rogue-Galice thrust sheet, which it overlies. It predates the Lookingglass Formation (middle Eocene), which is known to contain particles eroded from the Colebrooke Schist in Boulder Creek to the east (Baldwin, 1975). A late medial Cretaceous age of thrusting is generally interpreted. Baldwin and Lent (1972) and Brownfield (1972), however, present local evidence for thrusting as late as Eocene in the Langlois quadrangle.

Coleman (1972) infers that the Colebrooke Schist was thrust in from the west on the basis of petrologic data, and Dott (1971) interprets thrusting of the unit in from the east on the basis of local map evidence. An easterly source is more consistent with regional thrusting patterns summarized by Irwin (1964). Baldwin and Lent (1972) and Brownfield (1972) show that in the Floras Creek drainage the Colebrooke Schist is also thrust northward over Late Cretaceous strata and steeply dipping Eocene beds. Unlike earlier thrusting of the Colebrooke Schist, this possible episode of Eocene thrusting of the northern thrust sheet apparently left no internal folding on the rocks of the Colebrooke Schist.

The origin of the Colebrooke Schist is somewhat of an enigma. Geochemical evidence suggests that the Galice Formation is a more likely protolith than either the Dothan or the Otter Point Formations (Coleman, 1972). Alternatively, the protolith may have been a post-Galice (post-Nevadan) unit not yet identified in Oregon. For example, the Stuart Fork Mountain Schist of California is of favorable lithology (Irwin, 1966) and favorable age (Suppe, 1969). A Franciscon (equivalent to Otter Point and Dothan Formations) protolith is interpreted for this particular unit, (Blake, M.C., and others, 1967), however; such a protolith is inconsistent with structures presently interpreted for the Colebrooke Schist.

Block faulting of early Cenozoic age

North-south trending block faults cutting Mesozoic and early Tertiary strata were active in the early Tertiary. The Coquille River Fault displaces strata of the middle Eocene Lookingglass Formation in the Agness area and extends northward to the vicinity of Powers. The Mountain Well Fault displaces the Colebrooke Schist and Early Cretaceous strata east of Pearse Peak but is overlain by rocks of the Flournoy Formation in the Sixes River area. A pre-middle-Eocene age is indicated for that fault.

Outside the study area north-trending vertical faults do not truncate Flournoy strata (Baldwin, 1975). Southeast of Bone Mountain, however, an east-trending vertical fault cuts the Flournoy Formation (Baldwin, 1975). The fault is colinear with regional faults of Mesozoic age and may represent early Cenozoic adjustments along an older zone of weakness in the Earth's crust. The zone of weakness probably represents strikeslip faulting on a regional scale (see Rogue-Galice thrust sheer, above).

Shear zones of late Cenozoic age

North-northwest shear zones and faults cut bedrock of Mesozoic through Pliocene age and were active in late Cenozoic times. Circumstantial evidence onshore (below) and offshore (see Regional Offshore Structure) suggests that the shear zones may still be active, although available records indicate no definite seismicity in historic times (see Earthquakes). The Port Orford Shear Zone is 1 to 2 miles wide (Figure 11) and was first noted by Koch (1966) and Dott (1971). It extends from Cape Blanco on the north, where it cuts Pliocene strata (Figure 12), through Port Orford, and south through the Humbug Mountain area into the interior where it is lost in poorly accessible terrain underlain by the Colebrooke Schist. South of Gold Beach an additional set of north-northwest trending faults bounds Late Cretaceous strata and apparently terminates against the Carpenterville Shear Zone. It may also be Tertiary in age.

An upper age limit of shearing and faulting of Pliocene age or younger is established by the faulting of Pliocene beds at Cape Blanco. A lower limit of mid-Tertiary is suggested by major changes in sea floor spreading patterns in the middle Miocene (Atwater, 1970; Beaulieu, 1972). The shear zone conforms geometrically with ongoing deformation off the coast of California, Washington, and Oregon.

Active faulting of Pleistocene terraces is interpreted by Janda (written communication, 1975), but was not conclusively demonstrated in this study. Thick, localized deposits of Pleistocene and Pliocene age immediately east of the Port Orford Shear Zone (see Surficial Geologic Units - Quaternary upper and higher marine terrace deposits) in the Port Orford area indicate possible Pleistocene offsets. Terrace deposits on either side of the Port Orford Shear Zone at Cape Blanco, however, are essentially of the same elevation.

Apparent offsets of terrace material against pre-Tertiary bedrock in highway cuts near Whalehead Creek are tentatively interpreted as depositional features (buttress unconformities) rather than faults. The terrace material was deposited around sea stacks of pre-Tertiary rock in Pleistocene times. Numerous boulders set in the terrace material near the pre-Tertiary rocks in the exposures are consistent with deposition near sea stacks. In addition, the terrace deposits display no shearing, and shearing in the pre-Tertiary bedrock is probably of pre-Tertiary age.

To the north in Coos County, possible faulting of terrace materials (Janda, written communication, 1975) occurs along a northwest-trending linear near South Slough (Beaulieu and Hughes, 1975). The significance of this feature is unclear and warrants further study.

Regional Offshore Structure

According to plate tectonic theory, the crust and upper mantle of the Earth are subdivided into a series of semi-independent slabs or plates, each of which is moving laterally in response to deep-seated activity in the earth. Boundaries between the plates are sites of 1) sea-floor rises in areas of divergence, 2) trenches in areas of convergence, and 3) transform or transcurrent (large scale strike-slip) faults in zones of parallel movement.

In the northeastern Pacific Basin, a relatively complex border zone has developed between the Pacific Plate (floor of the Pacific Ocean) and the North American Plate (North American continent, Greenland, and the Arctic). As the Pacific Plate moves north relative to the North American Plate, a

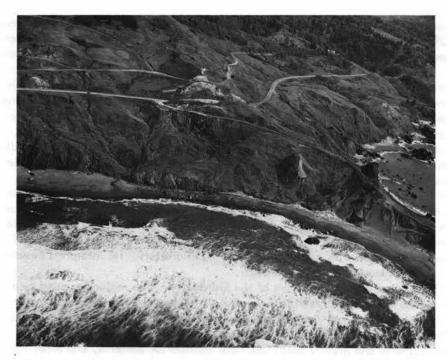


Figure 11. Regional shearing of Jurassic and Cretaceous rocks in the Port Orford Shear Zone has resulted in extensive londsliding.

Note the irregular topography and numerous heodscorps. (Oregon Highway Division Photo)



Figure 12. Pliocene rocks (white) ore cut by a fault at Cope Blanco.
Truncation of overlying Pleistocene terrace deposits (gray) cannot be demonstrated with certainty. (Oregon Highway Division Photo)

right lateral component of movement is experienced along the various faults and rises which separate the two plates. Off the coast of Oregon these include the Gorda Ridge and the Blanco Fracture Zone (Figure 13). To the south, the Mendocino Fracture Zone is the most active structure in the so-called Gorda Basin area.

Major structures of the Gorda Basin are the locus of considerable tectonism. High heat flow is reported along the rises (Dehlinger, 1969). Greatest seismic activity is concentrated along the transform faults, and most epicenters are fairly shallow (Northrop and others, 1968). Right-lateral fault plane solutions characterize both the Blanco and Mendocino Fracture Zones (Tobin and Sykes, 1968), and rates of displacement are several centimeters per year (Atwater, 1970). Seismic data also indicate a series of left-lateral epicenters (Silver, 1971a) radiating northwestward into the Gorda Plate from the juncture of the San Andreas Fault and the Mendocino Fracture Zone (Figure 13).

The most intense earthquakes on record for the study area originated on the Mendocino Escarpment within 200 miles of the coast of California (see Earthquake Potential). Although this observation is consistent with the general tectonic model of the region, more data are needed for a complete assessment of the potential seismic activity, and investigations continue. Silver (1971b) recently defined a large subsea fault off the coast of Oregon with a displacement of 70 kilometers. He interprets cessation of activity along the fault approximately 500,000 years ago.

Silver (1971a) describes the structure of the Gorda Basin (the region bounded by the continental shelf, the Gorda Ridge, the Mendocino Fracture Zone, and the extension of the Blanco Fracture Zone) and concludes that northeast trending left-lateral faults are presently active in the center of the basin. Disturbance of bottom sediments decreases eastward towards the continental slope.

Using geomagnetic and gravity data, sediment distribution patterns, and other information Silver (1971c) concludes that the Gorda Basin (Figure 13) is slowly being thrust beneath northern California. He identifies northwest trending faults cutting Mesozoic strata on the coast and inner shelf, and northwest trending faults cutting Cenozoic rocks on the continental slope. Recent earthquake data in the slope area indicates active strike-slip movement on faults along the continental slope.

The structural setting and orientation of the Port Orford Shear Zone in coastal Curry County is similar to those of the active faults off the coast of northern California described by Silver (1971c). This suggests that the Port Orford Shear Zone may still be active even though there as yet is no conclusive geologic seismic evidence for ongoing activity (see Earthquakes). Alternatively, Curry County lies north of the extension of the Blanco Fracture Zone, and all of the epicenters described by Silver lie south of the extension of the Blanco Fracture Zone.

Little information is available regarding the offshore geology of Curry County. Kulm (1967) interprets gently folded strata unconformable over crystalline basement on the middle and outer shelf offshore from Humbug Mountain, and a folded and faulted synclinal basin off the coast of the Rogue River. Nearer shore, Hunter and others (1970) interpret faults between the Otter Point Formation and Early Cretaceous rocks on the basis of sea stack geology (see Geologic Maps).

Earthquakes

General

The shaking of the Earth's surface which accompanies the release of energy at depth is called an earthquake. Associated with the release are displacements along planar surfaces called faults. The specific locations of the displacement within the Earth is called the focus and the geographic location above the focus on the Earth's surface is called the epicenter. The crustal structure and tectonic behavior of the northwestern United States is very complex and the historic record is short. Knowledge of future tectonic activity and earthquake potential is incomplete.

Intensity and magnitude are measures of the energy released by an earthquake. On the Modified Mercalli Intensity Scale, observations of the effects of the quake on the Earth's surface serve as indicators of its relative severity. Determinations made in this way are subject to inaccuracies owing to the distance from the epicenter, the nature of the subsurface where the observations are being made, and the subjectivity of the viewer. The Mercalli scale tends to be imprecise for these reasons. It is widely used, however,

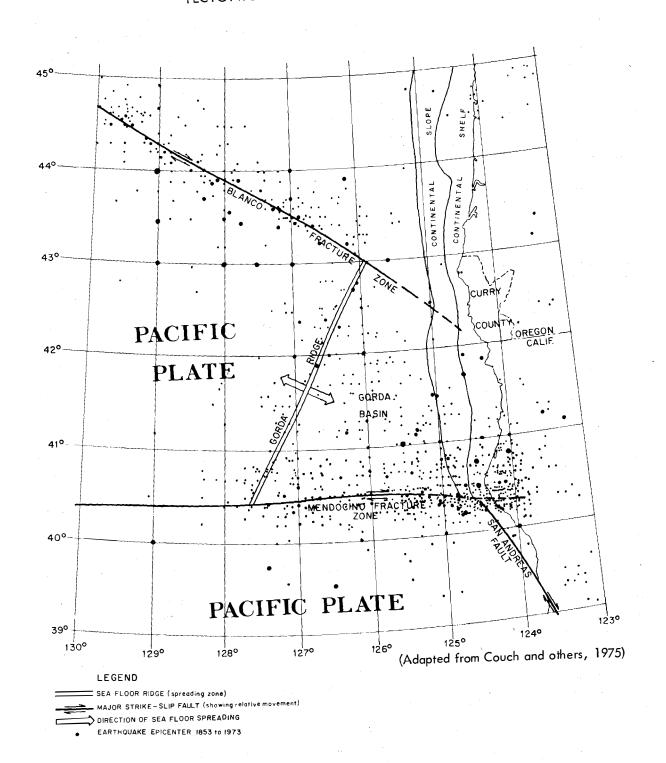


Figure 13. Tectonism of the Gorda Basin

owing to its universal applicability and no need for equipment. Also, the gathering of numerous observations allows the identification and elimination of inconsistent and inaccurate data.

The Richter scale is based on recordings from seismometers rooted in bedrock. It gives a more direct measure of energy released during an earthquake and is less subject to errors through local variations of the subsurface. Instead of indicating "intensity" with Roman numerals (I to XII), as used on the Mercalli scale, the Richter scale indicates "magnitude" with decimal numbers (Table 6) on a logarithmic scale. Each digit represents a 10-fold increase in the amplitude of the seismic waves and an approximate 31-fold increase in the amount of energy released. Thus, an earthquake of magnitude 5.0 is 31 times greater than an earthquake of magnitude 4.0. The scale ranges from less than 1 for small quakes to slightly less than 9 for the largest possible quake.

To convert observations on the Mercalli scale to magnitudes on the Richter scale, several equations are available, including:

$$M_B = (2/3)I + 1$$
 (Gutenberg and Richter, 1965)
 $m = 0.43I + 2.9$ (Stacey, 1969)

M values are Richter magnitudes and I values are the Mercalli intensities. The relationship defined by Stacey (1969) is based on shallow quakes and is particularly applicable to quakes originating off the southern Oregon Coast, and was adopted for completing parts of Table 7.

Earthquake potential

Earthquake hazard is determined by the location and magnitude of probable earthquakes, ground response, and type of construction. An analysis of these factors for the study area is given below.

Possible locations and magnitudes: Geologic mapping in Curry County indicates that all faults in Curry County with the possible exception of the Port Orford Shear Zone are inactive (see Regional Onshore Structure). Structures analogous to the Port Orford Shear Zone off the coast of northern California are active (see Offshore Bedrock Structure). Historic seismicity of Curry County (Table 7, Figure 13) indicates that major tectonic activity affecting the area occurs offshore. There have been no epicenters in the Klamath Mountains for over 20 years (Couch and Lowell, 1971).

Berg and Baker (1963) list an epicenter for the Port Orford area for the 1873 earthquake (Table 7). Because the severity of the quake was far greater in the Crescent City area (Table 7), it is here inferred that the epicenter was not in the Port Orford area. Couch and others (1975) list a large quake on the Mendocino Fracture Zone 5 minutes prior to the "Port Orford Earthquake." Similarly a small quake is listed for Cape Blanco in 1896. Subsequently five moderate quakes have occurred off the coast of Curry County; possibly the Cape Blanco quake was a local observation of an offshore disturbance.

Although active faulting within Curry County cannot be conclusively demonstrated or refuted on the basis of presently available geologic and seismic evidence, the balance of historic information information seems to suggest that the Port Orford Shear Zone is no longer active. Allen (1975) demonstrates, however, that a conservative approach must be taken in assessing potential seismicity even in areas of good data. Thus, in Curry County where geologic evidence is ambiguous and historic data are limited, the possibility of future faulting of undefined magnitude remains.

Couch and Deacon (1972) determined that the recurrence interval of an earthquake of magnitude 8.0 (intensity XII) in the southwest Oregon and northern California coastal and offshore area was approximately 130 years. Quakes as great as Richter 7.3 have been recorded off the coast of northern California along the Mendocino Fracture Zone, and as great as 6.6 have been observed on land. Vibrations generated by quakes in this area have affected the southern Oregon (Table 7) coast. Large quakes from the Puget Sound area have not been felt in the study area.

Effect of distance: As seismic waves are radiated through the earth from the point of origin (focus) they are attenuated (diminished with distance) as a function of dispersion, friction, depth, bedrock structure, and other factors. For areas of moderate to possibly high earthquake hazard from external sources, such as the study area, attenuation is a critical factor in determining the possible severity of future earthquakes.

Table 6. Scale of earthquake intensities and magnitudes*

Mercalli Intensity	Description of effects	Equiv. Richter magnitude
-	Not felt except by a very few under especially favorable circumstances.	
П	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.	3.5
Ш	Felt quite noticeably indoors, especially on upper floors of buildings, but	to
•••	many people do not recognize as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.	4.2
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building; standing motor cars rock noticeably.	4.3
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. A	to
·	few instances of cracked plaster; unstable objects overturned. Some disturbance of trees, poles, and other tall objects noticed. Pendulum clocks may stop.	4.8
VI	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.	4.9-5.4
VII	Everyone runs outdoors. Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.	5.5-6.1
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.	
IX	Damage considerable in specially designed structures; well-designed frame struc-	to
	tures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.	6.9
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.	7.0-7.3
ΧI	Few if any (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.	7.4-8.1
XII	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.	Max.re- corded 8.9

^{*}Adapted from Holmes (1965) and U.S. Geological Survey (1974)

Table 7. Historic seismicity - major earthquakes affecting Curry County, Oregon

	Magnitude and		Comments -
Date	Intensity (I)	Location	(I represents Intensity)
1873	VII-VIII observed	Crescent City	Nearly all buildings in Crescent City damaged;
Nov. 22	on land	41°45'N,	chimneys as far north as Port Orford toppled (Mer-
		124°10'W	calli VII-VIII); cited time in Port Orford 5 minutes
			later than in Crescent City (Couch and others, 1975).
			No data for Brookings (named in 1913). Greatest
100/	1) / 1	lic Di li	Intensity (VIII) observed at Crescent City(Smith1920).
1896	IV observed on	"Cape Blanco"	Local geology consistent with active faulting; no
June 5	land		other quakes in area; possibility of true epicenter offshore.
1909	VIII observed on	Humboldt Co.,CA	All chimneys and concrete structures destroyed at
Oct. 28	land	40°35'N,	Rohnerville, Calif.; felt with I = I-IV in Oregon
		124°10'W	as far north as Marshfield (Coos Bay).
1922	VI observed on	Mendocino	Felt over an area of 400,000 square miles; maxi-
Jan. 31	land; mag. 7.3-	Escarpment;	mum I = VI at Eureka; V experienced at Coos Bay;
a ^s	7.6;	41°N,125½°W	felt in Eugene and Roseburg.
	I = X calc.		
1923	VII-VIII observed	Mendocino	Felt with I = VII-VIII in parts of coastal Calif.,
Jan. 22	on land; 7.2;	Escarpment	where houses and chimneys were damaged; not felt
	I = X calc.	40½°N, 124½°W	in Coos Bay according to local newspaper accounts.
1931		Off coast of Curry	_
Oct. 1		Co.; 42°54'N,	
1000	\/III	124°46'W	
1932	VIII observed on	Off coast of Hum-	Chimneys and water mains damaged in Eureka;
June 6	land; 6.4; = VIII - IX calc.	boldt Co.,CA; 40.8°N, 124.3°W	small houses downed in Arcata; cracks in ground hundreds of feet long in places. Felt I = IV at
	I - VIII-IA Caic.	40.6-19, 124.5-10	Agness, Brookings, Wedderburn, and parts of Coos
			County; I = III at Port Orford.
1938	VI observed on	Cape Mendocino	I = VI in many coastal Calif. communities; felt
Sept. 11	land	40.3°N, 124.8°W	with I = I-IV in Brookings.
1941	5.3	Off coast of Curry	-
June 9		Co; 42°30'N,	
		125°00'W	
1949	VIII observed on	Puget Sound area	Not felt in Curry County, but felt as far south as
Apr. 13	land; 7.1		Bandon.
	I = X calc.		•
1950	4.2	Off coast of Curry	
Aug. 31		Co.; 42°N, 125°W	D. I.
1954	VII observed on	Eureka-Arcata area	Buildings cracked, chimneys and windows destroyed
Dec. 21	land; 6.6	40.8°N,124.1°W	in Eureka. Pipelines broke in poorly consolidated
			ground and settlement totaled 2-6" in Eureka.
			Intensity VI at Brookings, plaster and concrete walls cracked; I = IV at Gold Beach, Selma and
:	•		Pistol River; I = I-III at Ophir. (Brookings impact
		,	probably result of poor ground conditions or
			construction.)
1966	4.0	42°06'N,	,
July 12		125°00'Ŵ	
1966	4.3	42°30'N,	
Dec. 30		124°48'W	•

A review of the records for past earthquakes (Table 7) shows that large quakes along the Mendocino Fracture Zone attenuated to small to moderate quakes in the study area. Assuming similar attenuation for the largest possible quake (I = XII) along the Mendocino Fracture Zone (see above), a maximum possible future quake of approximately Mercalli intensity VIII can tentatively be assigned to parts of Curry County (Table 9). This is equivalent to or slightly greater than the severity of the earthquake felt in Port Orford in 1873 (Tables 6 and 7).

The attenuation of earthquakes occurring onshore in northern California is apparently very small in some instances. The 1954 quake (Table 7) that was felt with intensity VII in Eureka was felt with intensity VI at one locality in Brookings, possibly partly in response to unfavorable construction or ground conditions. With similar attenuation properties, quakes of intensity X (Richter magnitude 7.0 – 7.3) in the Eureka area could possibly be felt with intensity VIII in parts of Brookings. The largest quake on record for Eureka occurred in 1865 and had an intensity of IX (equivalent to magnitude 6.7 to 6.9 on the Richter Scale).

Large earthquakes affecting parts of Curry County have epicenters 100 kilometers or more from the County line (see Table 7). Using data involving all magnitudes of quakes and all types of local ground conditions, Page, R. A., and others (1975) graphically summarize the local ground accelerations that can be expected. They show that at this distance from the epicenter, accelerations do not exceed 0.1 g (one-tenth the acceleration of gravity). Maximum velocities and distances of displacement are 30 centimeters per second and 10 centimeters respectively.

Ground response: Ground response depends largely on the nature of the bedrock or surficial material beneath the site. Evernden and others (1973) show that on the Mercalli scale the impacts of earthquakes on granitic bedrock is approximately $2\frac{1}{2}$ points less than that on unsaturated alluvium. Other types of bedrock have intermediate values, and saturated alluvium has values greater than that for unsaturated alluvium. In general, Mercalli ratings for earthquakes represent the response of semicompacted alluvium.

Elastic response occurs in material in which there is no damping and in which competent particles maintain the same position relative to each other during the quake. Elastic response is almost universal during small quakes and is most common in consolidated bedrock and dry semiconsolidated surficial units during moderate earthquakes. Where competent bedrock units occupy precarious hillside positions and are detached in moderate to strong quakes, the response is said to be brittle. Clay-rich soils and weathered bedrock with appreciable immobile water on moderate to steep slopes may deform plastically in response to seismic activity to produce earthflow. Such response is termed viscous response and may occur in the clay and silty clay soils overlying weathered bedrock units.

Fine-grained granular soils with high water content may undergo a total loss of strength upon repeated shaking to give fluid response, or liquefaction. Basically, liquefaction occurs when seismic shaking causes a reorientation of sediment grains during which time the load normally borne by grain contacts is transferred to the pore water, resulting in flow. Saturated clay-free sediments such as silt or sand are most apt to undergo liquefaction. Youd and others (1975) demonstrate that saturated, uncompacted Holocene estuarine deposits in the San Francisco Bay area have a relatively high potential for liquefaction during quakes of Richter magnitude 6.5 or greater. Saturated lowland deposits of the study area are similar to those of the Bay area. Sims (1974) demonstrates that saturated lakebed deposits undergo small-scale liquefaction during earthquakes of intensities VI to VIII on the Mercalli scale.

It is concluded that the maximum possible quakes of the study area are capable of initiating liquefaction in areas of clay-free, saturated ground. These may include marshlands, low-lying alluvium, and other areas of perpetually wet ground. Also of possible concern are pockets of saturated soil on steep slopes and other areas of slide-prone terrain.

Type of construction: Damage to structures by earthquakes is closely related to the size of the construction, the nature of the frame and floor suspension, and the presence or absence of facing. Generally, small wood-frame buildings of three stories or less are the most resistent to earthquake damage. Earthquake resistance is progressively less for larger buildings with frames of steel, reinforced concrete, wood, unreinforced concrete, and brick. Construction of unreinforced adobe, hollow concrete block, and hollow clay tiles are the least resistant and may collapse in moderate shakes (Mercalli VII). Facings of unreinforced masonary, brick, or concrete block are relatively susceptible to damage. The ratios of repair costs to replacement costs for wood and nonwood structures in quakes of varying intensity are summarized on Table 8.

Table 8. Repair ratios for earthquakes of varying Intensity*

	Repair costs/replacement costs (in perce								
Intensity	Wood structures	Non-wood structures							
VI	0.2 or less	1							
VII	2	5							
VIII	5	15							
IX	8	35							
X	12	50 or greater							

^{*} Adapted from Page, R. A., and others (1975)

Impact

The historic impact of earthquakes affecting Curry County is summarized in Table 7. A maximum probable earthquake of Mercalli VIII is inferred for Curry County (see Possible locations and magnitudes) and the probable impacts of such a quake are summarized on Tables 8 and 9. In general, low to moderate damage can be expected on firm ground such as terrace deposits; minor damage can be expected on solid bedrock except in areas of potential mass movement; and severe damage is possible on areas of unstable ground. Because of the flood potential, areas of unstable ground and areas where the probability of slides is great are generally not developed. Earthquakes of Mercalli intensity VIII probably have a very low frequency of occurrence in Curry County.

Table 9. Probable impacts of an earthquake of Mercalli intensity VIII in Curry County, Oregon

	Mercalli	Ground	
Setting	Intensity	response	Description*
Unconsolidated to semi-consolidated unsaturated ground Qal, Qft, Qmtl, Qmtm, Qmtu, Qmth	VIII	Elastic	Destructive, car drivers seriously disturbed, masonry fissured, chimneys fall, poorly constructed buildings damaged, possible minor wave amplification
Hard consolidated bedrock All bedrock units	VI-VII	Brittle	Rockfall and rock slide in steep uplands (indicated as debris slide terrain on haz- ards maps generally)
with thin or no soil		Elastic	Suspended objects swing, damage by over- turning of loose objects or by falling objects, walls crack, plaster falls
		Plastic of	Initiate activity in landslide terrain
		liquefaction	(indicated on hazards maps)
Saturated unconsoli- dated material m, Qal (part),	IX	Elastic	Amplification of seismic waves and possible resonance vibrations with structures over thick deposits (Nichols and Banks, 1974)
possibly Qmtl in places		Liquefaction	Loss of structural support, sand swells, lateral spreading, slides on extremely low gradient slopes possible (but not probable in Curry County)

^{*}See Table 6

Recommendations

Western Curry County is a region of low urbanization and low-rise construction in which earthquake danger is primarily, if not entirely, a function of external seismicity and local ground conditions. Zoning regulations, building codes, and policies should proceed toward the multiple goal of 1) promoting construction design capable of withstanding potential earthquake activity, 2) directing the location of critical structures to solid or firm bedrock, 3) assuring the safety of individuals in structures of high occupancy (office buildings and schools), and 4) assuring the continued operation of critical structures such as hospitals in the event of an earthquake. Poor construction practices should be discouraged (see Table 8), and construction in areas of poor ground response is not recommended (Table 9). Seismic considerations should be included in engineering reports for large structures.

Specific regulations and their implementation in specific areas require additional technical information including more detailed information on earthquake attenuation, thickness and saturation of surficial geologic units, local seismicity, and specific ground response characteristics of the various geologic units. In the absence of this local data, adoption of the relevant provisions of the Uniform Building Code is recommended. Section 2314 specifies broad building requirements to accommodate base shear during an earthquake. Factors considered in the calculations include 1) type of frame and structure, 2) structural elements of the building including facing, walls, and ceilings, 3) the fundamental period of vibration of the building, 4) the weight of the building, and 5) the degree of earthquake hazard. Specifications are broad and generalized, and figures used in the calculations are derived from tables or simple equations.

In the Uniform Building Code the area is designated as Zone 2 (for which earthquakes of intensity VII can be expected) and Zone 3 (for which earthquakes of intensity VIII or greater can be expected). Although this figure corresponds in general to that determined in this study for Curry County, the Uniform Building Code as it is now formulated does not take into consideration ground response. In view of the developmental patterns and the nature of the terrain of most of Curry County, these factors do not appear to be of major concern at the present time.

The Uniform Building Code also discusses chimney anchorage and reinforcement (Section 3704), anchorage of walls (Section 2313), elevator construction, standby power facilities, and electrical and fire-fighting installations in high-rise structures (Section 1806 k).

MINERAL RESOURCES

General

Mineral resources are natural deposits which can be extracted profitably under present economic conditions and with existing technology. Where the deposit has been sampled, tested, and evaluated the resource is termed "proved reserve." Where the deposits lie near proved reserves but are less rigorously defined, the term "probable reserve" is used. Where geology and other factors suggest the possible presence of mineable deposits the term "possible reserve" is used. In Curry County much of the detailed information necessary for classifying deposits is lacking and only a history of piecemeal production on varying economic and technological conditions is available. Nevertheless, the record of prior mining activity, as summarized here, and the geologic maps are important tools to be used in making preliminary assessments of potential mineral wealth and in formulating general policy.

The mineral resources of western Curry County are grouped into four major headings: Construction Materials, Metallic Ores, Nonmetallic Deposits (including fuel), and Ground Water. As consumption continues to accelerate, the need for the recognition and proper management of the resource base of the County will continue to grow. Recognition should be given to the facts that 1) minerals can be mined only where they occur naturally, 2) minerals play a very important role in most aspects of our life, including construction, manufacturing, transportation, and others, and 3) many mineral deposits are often associated with the more scenic geologic areas.

Improper resource management can result in scarred landscapes and pollution. State legislation aimed at minimizing these impacts are administered by the State Department of Environmental Quality, the Mined Land Reclamation Division of the Oregon Department of Geology and Mineral Industries, the Department of Fish and Wildlife, and others. On a broader scale, improper land use may lead to the loss of a critical resource through lack of its consideration in the planning process. Thus, ground water may become polluted in areas of inadequate waste disposal, and sources of gravel may easily be covered by residential developments or otherwise zoned out of existence. Proper planning recognizes the need to use land for its mineral resources as well as for other purposes and avoids future clashes between conflicting land uses by directing growth accordingly. Where potentially economic deposits are known to exist, land use decisions generally should not preclude recovery of the resource.

Construction Materials

General

Construction materials in western Curry County include many types of stone with wide ranges of size, shape, composition, and weathering characteristics. These materials include sand, gravel, and quarry stone. The flood plains and channels of major streams and rivers are sources of large quantities of high-quality sand and gravel. The resource potential of a particular deposit is determined by its physical characteristics, volume, and location and by the specific requirements of its intended use. Construction material is a critical resource in western Curry County owing to heavy reliance of the tourism and logging industries to well-maintained roads, the necessary construction of additional roads, and the trend towards urbanization, which traditionally is associated with increased per capita consumption of sand and gravel.

Quarry stone is generally angular and hard and is well-suited for use in paved or unpaved roads. Where jointing is coarse, it is suited for use in riverbank protection (riprap to control erosion). It is not well-suited for use in concrete as aggregate, and it is more costly to produce than sand and gravel. Jetty-stone can be produced from some occurrences of basalt, intrusive igneous rocks, or blueschist, by stockpiling large boulders and by using specialized blasting techniques to minimize shattering. Sand and gravel are used for the construction of highways, streets, roads, foundations, and many other types of structures.

Statistically for every housing start, approximately 175 cubic yards of concrete is needed for the individual structure and for the numerous other projects it generates, including streets, sewers, schools, shopping centers, and industrial facilities.

Consumption

The annual consumption of stone and sand and gravel in Curry County is summarized on Table 10. Comparison with population figures indicates that the per capita consumption of stone was approximately 2 tons, 5 tons, 10 tons, and 17 tons in the 1940's, 1950's, 1960's, and 1970's respectively. Wide variations on given years are probably related to different levels of road-building activity. Likewise, per capita consumption of sand and gravel was 5 tons, 3 to 4 tons, 10 tons, and 8 to 9 tons in the 1940's, 1950's, 1960's, and 1970's respectively.

Future needs for construction materials are dependent largely on population trends and land use. A population increase of 15 percent is projected for Curry County between 1970 and 1990 (see Geography – Population and Economic Trends). Continued urbanization and road upkeep will probably maintain a 10-ton per capita annual consumption of sand and gravel and a 9-ton per capita annual consumption of stone. Using these figures, cumulative demand for sand and gravel will be greater than 2 million tons between 1975 and 1990, and cumulative demand for stone will also be greater than 2 million tons. These projections do not include large-scale jetty construction or road construction.

Sources

Large, active operations near major lines of transportation are summarized on Table 11. Generalized information on dormant sites can be inferred from the geologic maps. Detailed information on quarry operations of all sizes can be obtained from the Mined Land Reclamation Division of the Oregon Department of Geology and Mineral Industries. Stream channel operations are under the jurisdiction of the Division of State Lands.

The general characteristics of the various geologic units with regard to construction materials are summarized on Table 12. Bedrock units, with the general exception of the Colebrooke Schist and serpentine, are suited to use as fill or embankments. Fresh, hard rocks in the pre-Tertiary units including basalt, blue-schist (Figure 14), chert, intrusive rock, and possibly conglomerate are suited to uses with higher specifications including load-bearing aggregate and riprap. Where present in sufficient quantities and unweathered, gravel of the younger terraces may be suitable for use as concrete aggregate. Most terrace material is suitable for use in small fills or embankments. Sand and gravel of the flood plains and river channels is of high quality and suitable for many uses (Figures 15 and 16); however, roundness precludes use of uncrushed gravel in most fills and nonconcrete roads.

Planning considerations

Many of the geologic processes which effect the magnificent scenery and the fish runs of Curry County are the same processes that produce the unweathered bedrock exposures and excellent channel deposits of sand and gravel from which stone and sand and gravel are mined respectively. Associated aesthetic resource values, in turn, are major factors in tourism and the economic health of the community. Proper planning with regard to construction materials requires a balanced appreciation of the needs and desires of the community and the physical constraints within which the construction material industry must operate.

Construction materials, like other mineral resources, can be mined only where they occur naturally. Other limitations on production include hauling distances, weathering, thickness of overburden, and associated hazardous conditions such as flooding or high ground water. Further limitations are placed by the necessary specifications of the intended use.

Conflict with other resources provides additional constraints on the construction material industry. Commonly the preservation of fish spawning grounds and streamflows removes economic deposits from production. For example, it has been recommended that parts of Dry Creek in the Sixes River drainage and Bear Creek on the Winchuck River be removed from sand and gravel production (Thompson and others, 1972).

Table 10. Production of construction materials, Curry County, Oregon

	Stone	Sand and gravel			Stone	Sand and gravel	
Year	(short tons)	(short tons)	Population	Year	(short tons)	(short tons)	Population
1950	,	1,755	6,048	1963		2,417	
1951		2,079		1964	69,397	71,000	
1952		1,412		1965	60,868	271,000	
1953				1966	24,560	119,000	
1954	217,952	3,548		1967	23,546	203,000	-
1955		2,421		1968	357,326	207,000	
1956	1,854	99,105		1969	211,665	98,000	
1957	144,427	65,302		1970	235,104	128,000	13,006
1958	3,994	157,429		1971	81,473	1,000	,
1959	295,310	15,784		1972	123,839	111,350	
1960	536,117	10,978	13,983	1973	631,566	121,000	
1961	69,900	241,142		1974	78,586	101,852	
1962	9,446	161,395		1975	'		14,100

Table 11. Active construction material operations in western Curry County, Oregon

•		Location	
Commodity	Name	Legal	Geographic
Stone	Griffith Enterprises	S.E. ½ sec. 29, T. 32 S., R. 15 W.	Port Orford area (Otter Point Fm.)
Stone	Bullard Sand and Gravel	S.E. $\frac{1}{4}$ sec. 12, T. 31 S., R. 15 W.	Floras Creek drainage (Otter Point Fm.)
Stone	South Coast Lumber Co.	N.W. ½ sec. 24, T. 40 S., R. 13 W.	Chetco River drainage (Dothan Fm.)
Sand and gravel	ACCO Contractors	S.W. $\frac{1}{4}$ sec. 35, T. 40 S., R. 13 W.	Chetco River
Sand and gravel	Curry Co. Road Dept.	Sec. 35,T. 40 S., R. 13 W.	Chetco River
Gravel	Curry Co. Road Dept.	Sec. 21, T. 38 S., R. 14 W.	Pistol River
Gravel	Curry Co. Road Dept.	S.W. $\frac{1}{4}$ sec. 11, T. 32 S., R. 15 W.	Sixes River
Gravel	Curry Co. Road Dept.	N.E. $\frac{1}{4}$ sec. 36, T. 32 S., R. 15 W.	Elk River
Gravel	Curry Co. Road Dept.	S.E. $\frac{1}{4}$ sec. 34, T. 40 S., R. 13 W.	Chetco River
Gravel	Curry Co. Road Dept.	Sec. 19, T. 38 S., R. 14 W.	Pistol River
Gravel	Curry Co. Road Dept.	S.E. $\frac{1}{4}$ sec. 18, T. 37 S., R. 14 W.	Hunter Creek
Gravel	Curry Co. Road Dept.	Sec. 12, T. 36 S., R. 14 W.	Rogue River
Gravel	Curry Co. Road Dept.	Sec. 6, T. 41 S., R. 12 W.	Winchuck River
Gravel	Curry Co. Road Dept.	Sec. 10, T. 32 S., R. 15 W.	Sixes River
Gravel	Curry Co. Road Dept.	Sec. 9, T. 32 S., R. 13 W.	Sixes River
Gravel	Curry Co. Road Dept.	Sec. 7, T. 32 S., R. 14 W.	Dry Creek (of Sixes River drainage)
Gravel	Ferry Creek	N.W. $\frac{1}{4}$ sec. 32,T. 40 S., R. 13 W.	Chetco River
Sand and gravel	Pacific Rock and Paving	Sec. 33, T. 40 S., R. 15 W.	Chetco River
Sand and gravel	Pacific Rock and Paving	Sec. 21, T. 36 S., R. 14 W.	Rogue River
Sand and gravel	Western Builders Supply	Sec. 11, T. 32 S., R. 15 W.	Sixes River
			•



Figure 14. McVoy Rock, on the Horbor Bench, formerly a knobof blueschists, was excavated for use in jetty construction. (Oregon Highway Division Photo)

Aesthetic considerations include the noise, dust, increased turbidity, and general unsightliness of many construction material operations. For example, isolated terrace deposits with appreciable gravel at shallow depths probably will not be developed because extensive strip-mining would be required to extract the material and reclamation costs would be high.

Providing for the future construction-material needs of the community involves 1) setting aside sufficient volumes of sand, gravel, and stone, and 2) minimizing adverse impacts of its removal. In some instances channel removal of sand and gravel can be combined with flood-control measures (see: Geologic Hazards -Stream Flooding) or with dredging operations (see Geologic Hazards -Stream Erosion Deposition-estuaries) to serve a dual purpose. Visual and acoustic screening can reduce the impacts of quarries and pits. Abandoned pits con be adapted to a variety of uses including construction sites and landfills where cultural and physical settings are appropriate. Gravel operations in the channel of the Chetco River ore diked to eliminate adverse impacts on water quality.

Metallic Mineral Resources

General

Metallic minerals in Curry County occur in lode, laterite, and placer deposits and hove a long history of sporadic exploration and production extending from the 1850's through World War II. Since that time mining activity has been minimal. The rising cost of minerals, the need for new sources of supply, and new concepts of mineralization and tectonics suggest that future mining activity in Curry County is a distinct possibility. Although most deposits in the study area appear to be of limited extent, it is noteworthy that regional structural analyses and exploration techniques generally have not been applied.

Table 12. Potential sources of construction materials, western Curry County, Oregon

	Unit	Location	Materials	Quality	Use and comments
	Sedimentary Rocks of Late Tertiary Age (Tmp)	Sea cliffs and head- lands, northern Curry County	Semi-consolidated sandstone and conglomerate	Variable weathering and grain size	Fill and embankments; steep exposures and thick overburden limit excavation
	Sedimentary Rocks of Early Tertiary Age (Tef, Telg, Ter, Teu)	Uplands of northern Curry County	Clay-cemented sandstone and siltstone	Fresh to weathered	Fill or embankment material if properly sized; stream riprap where favorably bedded and jointed
	Sedimentary Rocks of Late Cretaceous Age (Kuh, Kuc)	Cape Sebastian and surrounding area	Hard sandstone and siltstone	Fresh to weathered	Fill or embankment; large blocks probably not sufficiently abrasion resistant for jetty use
	Sedimentary Rocks of Early Cretaceous Age (Kr, Kh, KJm)	and north of Euchre Creek	Hard conglomerate, sandstone and siltstone	Generally not signif- icantly weathered	Fill, embankments, and possibly stream rip- rap; conglomerate moderately well suited for load-bearing aggregate on low-use roads
ic units	Otter Point Forma- tion (Jop)	Coastal and north- ern Curry County	Highly varied; sheared to hard sedimentary and volcanic rock, pods of very hard blueschist,	Highly variable de- pending on lithology, shearing, and weath-	Chert and blueschist for load-bearing aggregate; other hard rocks for fill, embankment, and stream riprap; greenstone for load-bear-
geologic			serpentine, chert	ering	ing aggregate; blueschist has been used for jetty construction
Bedrock g	Dothan Formation (Jd)	Chetco River drainage	Blocky sandstone and siltstone, minor greenstone, and very minor chert	Fresh on steep slopes to weathered on mod- erate to gentle slopes	Fill, embankment and river riprap; some basalt and chert for load-bearing aggregate
	Galice Formation (Jg)	Interior uplands in the Pearse Peak area	Slaty mudstone with minor thin-bedded sandstone and greenstone	Fresh	Fill and embankment; greenstone may be suitable for load-bearing aggregate; isolation and overburden limit use
	Mount Emily Dacite (Tod)	vicinity	Syenite and dacite	Hard and fresh; fine to coarse jointed; weathered on ridge crests	Fill, embankment, and load-bearing aggre- gate; riprap and possibly jettystone where appropriately jointed; composition may pre- clude use as concrete aggregate
	Pearse Peak Diorite (Jpp)	Pearse Peak area	Diorite and quartz diorite	Generally fresh but weathered in places	Fill, embankments, stream riprap, and load- bearing aggregate; composition and angular- ity may preclude use as concrete aggregate
	Colebrooke Schist (Jc)	Central coast and inland	Phyllite and schist (both platy micaceous rocks) and related metamorphic rocks	Pervasive planar fabric	Generally not suited for construction mater- ial; some poorly schistose rocks suitable for fill and embankments
	Serpentine and peridotite (spp)	Widespread	Platy serpentine minerals and ultramafic minerals	Very hard to soft,de- pending on composi- tion and shearing	Poorly suited for fill or embankments; not suited for load-bearing aggregate or concrete aggregate

ment associated with unique management

annually not determined

problems (see text); volume of gravel renewed

Table 12. Potential sources of construction materials, western Curry County, Oregon (continued)

streams

	Unit	Location	Material s	Quality	Use and comments
	Quaternary higher marine terrace (Qmth)	Small upland areas to elevations of up to 1,000 feet	Weathered sand, silt, clay and gravel; includes semi-consoli- dated sand of possible Pliocene age	Weathered	Fill or embankments locally; weathering precludes use as load-bearing aggregate or concrete aggregate
	Quaternary upper marine terrace (Qmtu)	Scattered upland areas overlooking lower terraces	Sand, silt, and basal gravel, with some semi-consolidated sand of possible Pliocene age	Weathered to fresh	Fill or embankments; gravel may be suited for concrete aggregate if fresh and in sufficient quantities
units	Quaternary middle marine terrace (Qmtm)	Scattered coastal localities; Cape Blanco area	Sand, silt, and basal gravel, wind-blown sand north of Port Orford	Generally fresh, but with iron cementing in places	Fill and embankments; some gravel may be suitable for concrete aggregate if not weathered or iron-stained and if sufficient volume
ogic	Quaternary lower marine terrace (Qmtl)	North coastal plains of Curry Co.	Sand, silt, and basal gravel; also marsh and saturated ground	Saturated and with organic material over large areas	Fill or embankment material; associated hazards include flooding, high ground water and high organic content
icialae	Quaternary fluvial terrace (Qft)	Dissected bottom- land of major streams and rivers	Gravel and sand along rivers; sand, silt, and gravel along streams	Generally fresh	Suited for fill, embankment or possibly concrete aggregate, but generally inconsistent with other use priorities
Sur	Sand (su, ss, sb)	Coastline, Pistol River area	Well-sorted to moderately sorted unconsolidated sand	Fresh but with num- erous environmental constraints	Limited use as fill material in dry areas; not suited in areas of high water or possible drainage restrictions owing to potential for liquefaction
	Quaternary alluvium (Qal)	Flood plains of major streams and rivers; streambeds	Gravel and sand along rivers, silt and sand on flood plains; sand, silt, and clay along	Fresh and very good owing to stream action (see text)	Load-bearing and concrete aggregate; use for fill and embankments inconsistent with potential for better uses; stream develop-

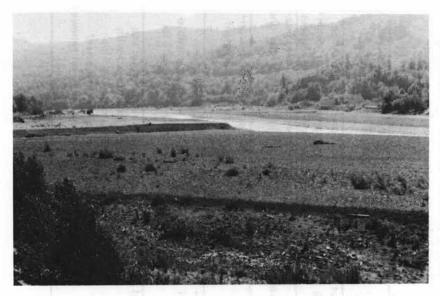


Figure 15. Planar deposits of gravel in the Rogue River flood plain are indicative of rapid bedload transport and high current velocities.



Figure 16. Bedload deposits of gravel along the Rogue River are characterized by high proportions of gravel and low proportions of sand or silt.

Lode deposits and laterite deposits:

Gold and silver: Gold and silver lode deposits mined in the Agness and Sixes River areas are associated with quartz veins and siliceous to intermediate dikes related to Nevadan Late Jurassic) plutonism. Accordingly, possible future discoveries of lode gold or silver should be expected in the Pearse Peak Diorite or Galice Formation. Dikes leading from the Pearse Peak Diorite penetrate the Galice Formation, which forms part of the same major thrust sheet (see Tectonic Setting). Very minor amounts of gold are reported from the Mount Emily area, a pluton of similar composition to the Pearse Peak Diorite, but of younger (mid-Tertiary) age.

Diller (1914) suggested that Early Cretaceous sedimentary rocks flanking Nevadan plutons in south-western Oregon, but post-dating the plutons, might contain placers of gold of Early Cretaceous age. Exploration activity since that time, however, has not yielded mines in these units, and future discoveries in them are not considered likely. The general character of the Early Cretaceous units is that of poorly sorted basinal deposits inconsistent with the development of placer deposits of economic grade.

Chromite: Lode chromite has been recovered from scattered claims northwest of Illahee, south of Agness, in the Signal Buttes area, and in various other parts of Curry County (Pearsoll Peak, Vulcan Rock) outside the study area. In addition, chromite float reported from a slope 3 miles north-northeast of Wedderburn (S. E. ¼, sec. 8, T. 36 S., R. 14 W.) by Ramp (1961) indicates that deposits (probably very small) occur in the immediate vicinity. All chromite deposits occur as segregation bands (oriented parallel to regional structures) or as disseminations in peridotite and serpentinite. The parent material is Late Jurassic sea-floor crustal material (see Engineering Geology - Serpentine and peridotite). It is unrelated in age to the Nevadan Orogeny. Thus, deposits associated with the Josephine Peridotite in the eastern parts of the County may predate Nevadan plutonism, and deposits inferred for the Otter Point Formation (north of Wedderburn) may post-date Nevadan plutonism. The chromite deposits are not directly related to the formation of granite intrusions in southwestern Oregon.

Platinum: Platinum has recently been detected in the ultramafic (peridotite and serpentinite) rocks of southwestern Oregon by means of sophisticated laboratory techniques (Page, N. J., and others, 1975). Concentrations are greatest in chrome-rich varieties of ultramafic rocks (chromitites) and average 150 parts per billion. These concentrations are very low in comparison to commercial concentrations elsewhere in the world, which average ten to twenty times that amount. The deposits have no economic potential at this time but may be of significance in terms of secondary recovery from possible future chromite operations. The detection and measuring of platinum in these rocks is also of significance because it explains the origin of platinum found in placers of southwestern Oregon, and it may provide clues regarding the locations of the most promising platinum placers.

Copper: Copper minerals, including cuprite, bornite, and native copper, occur in very localized pods and lenses in serpentinite in parts of Curry County. According to Butler and Mitchell (1916), 45 tons of bornite-rich rock were shipped to San Francisco from the Agness area in 1908. The copper occurs in shear zones in the serpentinite and may represent crustal segregations in ancient sea-floor deposits similar to the chromite deposits. Associations of this type are well-known in other parts of the world and in places are extremely rich. Alternatively, copper occurs in metavolcanic and other types of rock elsewhere in southwestern Oregon, and some may be the product of later periods of mineralization associated with Jurassic or Miocene plutonism, indicating that copper deposits of southwestern Oregon have more than one mode of origin.

Nickel: Red Flat is a relatively flat, deeply-weathered ridge crest located on the southern extremity of a large exposure of ultramafic (peridotite and serpentinite) rocks which extend from the Pistol River drainage to the Rogue River. The bedrock is covered with a mantle of lateritic soil and bouldery regolith that has been leached of magnesium and silicon. It has been correspondingly enriched in iron and other metallic materials which include uneconomic accumulations of gold, silver, chromite, and mercury, but potentially economic deposits of nickel. Concentrations of nickel vary from 0.27 percent to 1.46 percent (Libbey and others, 1947) and average an estimated 0.8 percent (Hotz and Ramp, 1969). The laterites

vary in thickness from a few inches to possibly as much as 50 feet (Hundhausen and others, (1954). The nickel deposits are not presently economic owing to isolation and relatively small size. The total extent measures approximately 3 miles long and 1/2 mile wide (L. Ramp, written communication, 1976). The deposits constitute an important resource that may be commercially exploitable in the future. They are presently under investigation by the State of Oregon Department of Geology and Mineral Industries as part of a regional assessment of the nickel resource of Oregon.

Other: Mount Emily has associated with it very limited deposits of zinc, molybdenite, gold, cobalt, and nickel (Butler and Mitchell, 1916). Descriptions of the site suggest that mineralized zones occur in brecciated rhyolite which caps the intrusive rock. If this is true, the erosion which has produced the adjacent valleys probably has removed potentially mineralized zones from the surrounding area.

Placer deposits

Placer deposits are concentrates of heavy minerals (usually dark in color) in wave- and current-deposited sediments on elevated marine terraces, on beaches, on river terraces, and on submerged wave-cut terraces. The deposits have a complex origin involving erosion from inland areas, transportation in streams, and sorting by wave or current action. Black beach sand deposits in Curry County contain chromite (chromium), ilmenite (titanium), platinum, and olivine derived primarily from peridotites, garnet derived from metamorphic terrain, and minor amounts of gold derived originally from Nevadan intrusive rocks and intruded country rock (see Lode deposits).

<u>Fluvial placers</u>: Fluvial, or river, placers include deposits in the stream bed, flood plains, and terraces of major streams and rivers. The most productive placers occur in the Sixes River area and include deposits in the Sixes and Elk River drainages. Gold is the predominant mineral of economic interest and is most abundant in streams draining Pearse Peak Diorite and Galice Formation terrain. The largest particles of gold are found in the South Fork of the Sixes River. Source of the material, as revealed by scattered lode mine activity, is quartz veins and siliceous dikes leading from the diorite into the country rock.

Stream sediment analyses indicate that some of the finer gold of less productive tributaries in the area is derived from conglomerates and sandstones of the Rocky Point Formation, the Umpqua Formation, and other post-Nevadan sedimentary units (Boggs and Baldwin, 1970). Baldwin (1968) reports black sands in the Umpqua Formation south of Agness. Much of this gold and associated metals were eroded from the Nevadan terrain and were deposited in younger sedimentary units. During the existing erosion cycle, the gold has again been eroded and deposited in the present-day placers.

Coastal placers: Wave action has sorted out lenses rich in heavy minerals at various stands of sea level (see Geologic Hazards - Ocean Flooding) to produce placer deposits on marine terraces, submerged terraces, and beaches. The beach deposits at Gold Beach, Ophir, Port Orford, and Cape Blanco experienced short-lived mining activity in the middle 1800's, apparently because the deposits were small and of low concentration. Analyses of heavy-mineral distributions on beaches and terraces show that the heavy minerals on the beaches were derived in part from nearby terraces by waves or stream action (Griggs, 1945) or were supplied by major streams from upland terrain farther in the interior. The beach material, including the heavy minerals, is not transported great distances laterally along the coast (see Geologic Hazards - Wave Erosion and Deposition).

Uplifted terraces represent former beaches and locally contain lenses of heavy minerals which trend parallel to the mountain front. Maximum dimensions of some of the lenses of southwestern Oregon include thicknesses of several feet, widths of 1,000 feet, and lengths of up to one mile (Griggs, 1945). These dimensions apply mainly to deposits in Coos County. Most of the Curry County terraces are smaller and the dimensions of the lenses are correspondingly less. Minor black sand deposits are noted in the Denmark area and in the Nesika Beach terrace. Neither deposit appears to be of economic significance at the present time.

Submerged terraces with heavy-mineral deposits occur off the coast of Cape Blanco and in a large offshore area between Cape Sebastian and the Rogue River Reef (Kulm and others, 1968). Individual deposits are aligned parallel to the coast and have dimensions similar to terrace deposits of black sand on

shore. Concentrations of gold range from 5 to 150 parts per billion at the surface. The deposits are not presently considered economic; however, greater concentrations may be present at depth (Clifton, 1969). Black sand deposits off the coast are being investigated in ongoing programs of sampling and geophysical exploration by the Office of Marine Hydrology of the U. S. Geological Survey and by the Department of Oceanography of Oregon State University.

Nonmetallic Mineral Resources

General

Nonmetallic mineral deposits, other than construction materials, have no economic significance at the present time. They include a variety of ultramafic minerals with several miscellaneous potential uses, scattered occurrences of priceite, minor seams of coal, and possible accumulations of oil or gos offshore.

Priceite

Priceite was first discovered in Curry County and was mined in 1872 from scattered deposits in serpentinite in the Lone Ranch area three miles north of Brookings. In 1873 the mineral was formally named; it is one of seven minerals discovered in Oregon. In 1890 the rights to the deposits were purchased by Borax Consolidated Limited of London and in 1950 the land was donated to Oregon for inclusion in a state park. The company retained the right to mine undersurface minerals at a later date. Production was 590 tons in the season 1891–1892, and total production by the year 1892 was probably 3,600 to 5,400 tons.

The priceite occurs as pea-size particles and nodules weighing up to 450 pounds. Its occurrence on the moist, mountainous slopes of Curry County is of interest because the great majority of borax deposits worldwide occur under evaporite conditions in desert areas. On the basis of geochemical evidence Staples (1948) concluded that the borax was derived from volcanic boric acid as it reacted with calcite-rich country rock during implacement of the nearby Miocene rhyolite dikes. The intrusions contain traces of copper, strontium, and boron similar to that of the priceite. The iron and magnesium in the priceite was derived from the surrounding serpentinite country rock.

Mining of the priceite on a commercial basis occurred at a time when competitive deposits of borax minerals in evaporite basins elsewhere in the west were poorly defined. Today, competition from these immense deposits precludes economic development of the priceite deposits of the study area. In addition, the priceite deposits are uneconomic in terms of size. Presently all of the United States' supply and 70 percent of the world's supply of boron is mined in southeastern California.

Ultramafic minerals

Olivine is a common rock-forming mineral of ultramafic (high in iron and magnesium) rocks such as peridotite. It is used for refractory purposes, foundary sands, gems, sand blasting, and other uses. Its value in sand blasting is that its use eliminates the dangers of silicosis associated with the use of quartz sand. Deposits of dunite (primarily olivine) are known to occur near Pearsoll Peak, outside the study area (Wagner and Ramp, 1969, p. 192). The possibility of other deposits of potential commercial value should be recognized.

Asbestos is a fibrous iron- and magnesium-rich mineral associated with some bodies of serpentinite. Owing to the abundance of serpentinite in the study area, potentially commercial deposits of asbestos may also be present. Exploration is difficult and costly, and no deposits have been reported to date. Serpentinite is sometimes used as a source of magnesium in fertilizers.

Coal

Scattered exposures of early Tertiary age in northern Curry County are the erosional remnants of large deltaic fans that were originally contiguous with the sandstone deposits and coal deposits at Eden

Ridge and Coos Bay. Thin discontinuous coal seams are exposed in the Middle Fork of the Sixes River, in the Eckley area, and near the mouth of Shasta Costa Creek near Agness (Diller, 1903). The seam at Shasta Costa Creek is 4 to 6 feet thick, and attempts to mine it commercially were first made near the turn of the century. The operation was not profitable, and it appears that commercial exploitation of the deposits today is not possible.

Thin seams of coal are also exposed locally in nearshore facies of the Lower Cretaceous sedimentary rocks. Thicknesses average about one foot in parts of the Rocky Point Formation at Coal Point a few miles south of Port Orford. The deposits have no commercial significance.

Oil and gas

The formation of recoverable oil or gas in nature requires 1) the accumulation of carbonaceous material in fine-grained source beds, 2) the presence of coarser grained porous reservoir rock upstructure, and 3) a structural or stratigraphic trap to confine the migrating oil or gas in the reservoir rock. Many of the most productive oil fields of the world are associated with basins having a history of rapid deposition and subsidence. The weight of the sediments accumulating in the center of the basin in the geologic past squeezed the oil into the reservoir rock, where it was trapped by surrounding structures.

The pre-Tertiary rocks of the study area are not suitable in terms of oil exploration for several reasons including 1) metamorphism after deposition, 2) inappropriate environments of deposition, 3) impermeability, and 4) thrusting, shearing, and other manners of deformation that have broken the rock into small structural pieces. Parts of the Rocky Point Formation, however, may have minor potential for oil and gas.

The geologic history of the Tertiary rocks on the continental shelf differs from that of the older rocks on the mainland. Recently the shelf has become subject to systematic investigation by oil companies, the U. S. Geological Survey, and the Department of Oceanography at Oregon State University. Research has included geophysical investigations and sediment sampling. McKay (1969) has tentatively correlated offshore bedrock units, defined by their seismic properties, to bedrock units exposed onshore in the Cape Blanco-Coos Bay area. A large, linear offshore basin between Bandon and Cape Blanco is filled with a thick deposit of Miocene and Pliocene sediments and may have potential for oil and gas production. The late Tertiary section offshore is generally thicker and more extensive than that onshore, a feature which contributes to the attractiveness of the shelf in terms of oil potential.

Ground Water

General

Ground water is water that fills the open spaces in rock and soil beneath the land surface. The top of the zone of saturation, called the water table, conforms in a general way with topography, so that it is relatively near the surface in depressions and rises beneath ridges. Perched water tables are localized zones of saturation resting upon impermeable material but situated above the regional water table and separated from it by aerated material. Porosity and permeability are key considerations in determining the capability of geologic materials to hold and transmit ground water.

Porosity is the percentage of open spaces per unit volume. Open spaces include pore spaces (openings between grains), fractures, and joints. The size, number, and arrangement of these open spaces is dependent upon shape, size, mineral constituents, and arrangement of the particles that make up the soil or the rock, as well as composition alteration and deformation of the rock or soil.

Permeability is the potential to transmit water and is dependent on porosity, the size of the pore spaces, and the degree of interconnection between the pore spaces. "The coefficient of permeability is the rate of flow (gallons per day) through a square foot of cross section under a hydraulic gradient of 100 percent at a temperature of 60° F." (Tolman, 1937).

Specific capacity is a more accurate measure of the capacity of a well to produce water over a prolonged period of time and is determined by dividing well production (gallons per minute) by the drawdown (drop in water table as water is produced) in feet. Materials such as sand with a relatively high porosity and permeability has a high specific capacity. In contrast, jointed bedrock may have high transmitting

potentials locally, but may have a low specific capacity. Likewise, clay may have high water content but may have low transmitting potential and hence a low specific capacity.

In areas where the geologic materials are both porous and permeable, and where hydraulic gradient is sufficient to generate flow, the ground water is in constant motion. Precipitation is absorbed into the soil, percolates to the water table, and flows slowly down-gradient to a point of discharge. This type of ground-water system can produce water with fairly constant chemical characteristics and low temperature and is generally a highly desirable resource. Because of local and regional variations in geologic conditions, however, ground-water quality and availability vary considerably in the study area.

Water-well records are on file at the State Department of Water Resources in Salem and are on file at the Office of the U. S. Geological Survey in Portland. Published reports include Oregon Water Resources Board, (1959, 1963).

Distribution

Potential for ground-water production is low in the uplands, low to moderate on most of the terraces, and moderate to very high locally in the lowlands. Within each landform ground-water production varies somewhat in yield, drawdown, and other characteristics depending on the local geology. Basic data for representative water wells throughout western Curry County is summarized on Table 13.

<u>Uplands:</u> Ground-water potential is low in the uplands, with wells generally producing less than 10 gallons per minute. Aquifers are sporadic in distribution and many wells are dry. There is no regional water table in the sense of a well-developed zone of saturation of regional extent. Ground water occurs locally in fractures, bedding planes, slides, and weathered zones and is bounded by impermeable rock rather than saturated rock.

Ground water is concentrated along joints, fractures, and bedding planes of thickly bedded, hard, sedimentary rocks, which include the sedimentary units of early Tertiary age (Ter, Tef, Telg), the Dothan Formation (Jd), the Galice Formation (Jg), the sedimentary rocks of Early Cretaceous age (Kr, Kh, Kjm), and the sedimentary rocks of Late Cretaceous age (Kuh, Kuc). Production is generally a few gallons per minute in these units (Table 13). Storage capacities are low and drawdown is generally large.

Ground-water potential is highly irregular in the Otter Point Formation owing to the marked variations of lithology, structure, slides, and shearing within the unit. Ground water is most abundant in the sheared bedrock and slides of the northern part of the County. In places, marshy side slopes are developed in regions of ground-water discharge. Ground-water potential is very low in the unsheared rocks mapped as Otter Point Formation south of Crook Point. Production and specific capacities for the unit as a whole are generally low.

Ground water occurs along joints, fractures, and contacts of the intrusive rock units (Tod, Jpp), and may also be present as perched water in zones of deep weathering. Very little well data are available for these units. Serpentinite and pyroxenite are highly impermeable and are not considered as favorable sources of ground water. On flat ridge crests at Red Flats, perched water accumulates in the soil and regolith above impermeable bedrock and discharges as springs in shallow cuts and ravines. The ground water is very close to the surface and movement is along joints and other structural discontinuities. The potential for pollution is high owing to the rangeland use of the terrain.

The numerous fractures and joints of the Colebrooke Schist provide for the infiltration and movement of relatively large quantities of water. The unit probably possesses the highest potential for ground-water production of all the upland units. Springs and seeps are relatively common in the unit, and streams flowing from it appear to have relatively uniform flows through the dry summer months. The few well records that are presently available for the unit indicate yields of 5 to 10 gallons per minute.

Terraces: Ground-water production is low to moderate on the terraces, with yields generally averaging 20 gallons per minute or less. Aquifers are commonly regional in extent but also include perched water tables in areas of iron-cemented sands. On the broader terraces in the Cape Blanco area, production also is derived from the gently dipping Pliocene sandstones and gravels situated beneath the terrace deposits (Cape Blanco State Park well, Table 13).

Table 13. Representative water wells, Curry County, Oregon

Well		Year			_	•			-bearin Thick-	ng zones			Perforn	nance Draw-	
location		com-	Depth	Dia.		sing Depth		to top	ness	Charac.	Wa	ter level	Yield	down	
number*	Owner	pleted	(feet)	(in.)	(in.)	(feet)	Finish	(feet)	(feet)	of mat.	Ft.	Date	(gpm)	(feet)	Use
NE ¹ ₄ SW ¹ ₄	A. McVay	1974	26	6	6	21	Open end	18	7	Gravel	11	3/15/74	20	2	Domes.
sec. 17	,						,			(Qal)		, ,			
T39S,R12W															
SE4SW4	A.H.Pace	1973	35	6	6	35	Perforated	30	5	Gravel	17	10/10/73	15	8	Domes.
sec. 34							25'-34'			(Qal)					
T40S,R13W												. / /			
S ½SW ¼	E. V. Nelson	1972	33	6	6	32	Open end	19	14	Gravel	9	6/28/72	12	1	Domes.
sec. 20										(Qal)					
T34S,R14W SE4SE4	L. Kreutzer	1973	30	_			Alamada ad	24	1	Sand and	20	4/11/73	2.0	Total	
sec. 3	L. Kreutzer	19/3	30	_	-	-	Abandoned	24	'	gravel	20	4/11/73	2.0	Ioiai	
T31S,R15W										(Qal)?					
Sec. 16	City of	1961	50	16	16	50	Perforated	2	48	Gravel	2	Apr.1960	2,200	2½	Public
T36S,R14W	Gold Beach	', ', ',	"			•	25'-50'	_		(Qal)	_		_,		
NW4NW4	Ore. State	1973	35	6	6	35	Open end	30	5	Washed	18	4/30/73	20	2	Domes.
sec. 20	Hwy. Div.									gravel					
T38S,R14W	well no. 3									(Qft)					
NW4NE4	W. Spencer	1972	24	54	46	24	Open hole	18	6	Fine sand	18	3/27/72	8.0	6	Domes.
sec. 16										(Qmtm)					
T31S,R15W		10-0		10				40		F: 1	40	10/11/70	22	10	
Sec. 32	Western	1970	62	12	8	45	Plastic screen	42	20	Fine grave	42	12/11/70	20	10	Domes.
T32S,R13W	Builders						6", 012 slot 42'-62'			(Qmtm)					
SW4NE4	W. Sypher	1967	50	6	6	42	Johnson 6"	42	4	Med. sand	22	7/3/67	1 5	Total	Domes.
sec. 26	w. Syphei	1907	30	0	٥	42	stainless steel	42	4	w/silt		7/3/07	4.5	Tolul	Domes.
T30S,R15W							.008 slot from			(Qmtm)		1			1
1005,11511	-						42'-46'			(Gillin)					:
SE4SW4	C. D. Watson	1971	36	_	6	35.5	Torch perfor-	32	3.5	Clay with	19	9/11/71	13	Total	Domes.
sec. 9					_		ated			gravel		, , ,			
T32S,R15W							26'-34.5'			streaks					
										(Qmtm)					
SE4SW4	C. Chapman	1958	27	8	8	23	Perforated	-	-	(Qmtm)	17	10/7/58	5	-	Domes.
sec. 4							15'-23'								, i
T41S,R13W		`													

MINERAL RESOURCES

Table 13. Representative water wells, Curry County, Oregon (continued)

						4			r-be <u>ar</u> ii	ng zones					
Well		Year				•	S	Depth	Thick-					Draw-	
location		com-	Depth	Dia.	Size	Depth	•	to top	ness	Charac.	Wa	ter level	Yield	down	
number*	Owner	p leted	(feet)	(in .)	(in.)	(feet)	Finish	(feet)	(feet)	of mat.	Ft.	Date	(gpm)	(feet)	Use
SW4SW4 sec. 9 T41S,R13W	A. E. Mik – kelsen	1962	26	8	8 .	26	Perforated 18'–26'	17	9	Med. to Ige gravel (Qmtm)		8/24/62	18	3	Domes.
NE¼NE¼ sec. 31 T32S,R15W	F. Roe	1972	104	6	6	104	Open hole	97	7	Sand and gravel (Qmtm)	49	12/6/72	13	23	Domes.
NW¼SW¼ sec. 1 T32S,R16W	Cape Blanco State Park	1971	174	6	6	52	Open hole	135	-	Sandstone (Qmtm/Tmp)	28	5/31/71	20	8	Public park supply
Sec. 12 T32S,R14W	U.S.Dept.Int (BLM) Sixes R. Rec. site		60	6	6	21	Open end			Shale bed- rock (Kh?)	7	7/25/63	2	31	Rec. site
NE¼NE¼ sec. 19 T35S,R11W	Int'l Growth Corp.	1973	360	6	6	36	Open hole	260	2	Sandstone (KJm)	61	8/16/73	10	310	Domes.
SW¼NW¼ sec. 16 T35S,R14W	Ted Swartz	1972	80	6	6	80	Perforated 50'-70'	52	-	Shale, fractured (Qft?/Jop)	38	8/7/ 7 2	3.5	42	Domes.
S E¼NE¼ sec. 13 T37S,R15W	W. Dubbs	1970	52	6	6	53½	Perforated 37'–52'	40	-	Black shale (Jop)	43	9/9/70	2.5	Total	Domes.

^{*} See Appendix E for diagram of well-numbering system.

In the terrace deposits, ground water occurs in permeable horizons overlying cemented zones or impermeable bedrock. Well depths are generally 50 feet or less, and the thickness of water-bearing zones is generally less than 10 feet. Drawdowns are variable between 3 and 25 feet. Pollution of ground water is a major potential problem on the Harbor Bench, where rapid urbanization and waste disposal may become incompatible, and also locally in the Port Orford area, where ground water is perched at shallow depths above impermeable horizons.

Terraces of regional extent, such as the Quaternary middle marine terrace unit (Qmtm), are the most productive. Higher marine terraces with their smaller extent, greater degree of consolidation, and more extreme dissection by streams probably have relatively low ground-water potential. On the terraces of coarse-grained fluvial material along major rivers and streams, such as the Rogue and Chetco Rivers, the potential for domestic production of ground water is very good owing to high permeabilities and storage capacities. The potential for production on river terraces is correspondingly less for terraces of smaller size and less sand and gravel content. The many farms and residences scattered along the valleys of most streams are indicative of generally good ground-water potential on the fluvial terraces.

Lowlands: The potential for ground-water production is low to moderate in the lowlands and is very high locally in the channel gravels of major rivers and streams. The lowland deposits are unconsolidated and the supplies of water, permeabilities, and specific capacities of given wells are closely related to the grain-size distribution of the deposits rather than to jointing or fractures as in the bedrock units of the uplands.

Channel gravels and sands are coarse-grained and have a high proportion of interconnected voids. Specific capacities are high; the city of Gold Beach well, for example, produces 2,200 gallons per minute from alluvium adjacent to the Rogue River. High rates of production from channel gravels of lesser streams may not be feasible owing to the potential adverse impacts on total stream flow and on fish runs.

Small to moderate supplies of ground water are available from the dune sands for domestic or recreational use. Major areas include dunes at the mouth of the Pistol River, beach and dune areas north of Floras Lake, and accreted sand areas on either side of the mouth of the Rogue River. At the latter two localities, where the sand deposits are generally 50 feet thick or less and near sea level, characteristics of the salt—water boundary in the subsurface are undefined. At the Pistol River locality, no large quantities of ground water are apt to be present. The sand lies above sea level and fresh water probably is discharged in a series of springs. There are no thick deposits of sand situated below sea level where large quantities of fresh water can accumulate and be stored against a hydraulic dam of sea water as in the Coos-Umpqua Dunes north of Coos Bay.

Most wells developed in the lowlands are located on alluvium away from major drainages and produce 20 gallons per minute or less. Producing horizons generally are gravel or sand and gravel. Permeabilities of finer grained materials, such as silt and clay, are far too low to allow significant production. Drawdowns in the alluvium are generally 10 feet or less.

Water quality

Water quality in the uplands is generally good. Possible problems include relatively high iron content in waters derived from serpentinites and schists, and high concentrations of hydrogen sulphide in waters associated with coal beds in Eocene or older sedimentary rocks. Hydrogen sulphide reported in the well for the Sixes River Recreation Site is difficult to interpret on a preliminary basis in terms of bedrock geology, which includes rocks of the Otter Point Formation and serpentinite. Where water occurs in the soil or at shallow depths in weathered bedrock, as in serpentinite, pollution from septic tank drain fields or rangeland use is a hazard.

Ground-water quality of the terrace units is generally good, with the exception of minor problems locally. A few cases of high-iron contents and slightly acid waters are associated with iron-cemented layers in the subsurface of the Quaternary middle marine terrace deposits (Qmtm) from Port Orford northward to the County line. Flammable gases have been reported in peat deposits on the Quaternary middle marine terrace unit (Qmtm) at several localities in the Brookings-Harbor area and in a well near Cape Sebastian. Pollution from drain-field sewage effluent may contaminate perched water in terrace deposits and may also constitute a major threat to water quality in areas of rapid nonsewered urban development such as that occuring on parts of the Harbor Bench.

Table 14. Drinking-water standards defined by the U.S. Public Health Service, 1962

Constituent	Recommended limit ppm	Maximum allowable limit ppm
Fe (Iron)	0.3	
Mn (Manganese)	0.05	
SO ₄ (Sulfate)	250.0	
CI (Chloride)	250.0	,
FI (Fluoride)	0.8-1.7	1.6-3.4
NO ₃ (Nitrate)	45.0	
As (Ärsenic)	0.01	0.05
Dissolved solids	500.0	

¹ Varies inversely with mean annual temperature

Table 15. Water quality of selected municipal wells, Curry County, Oregon*

			1		
	Wood water		Gold		Port
	system	Brookings	Beach	Langlois	Orford
Date	1/21/66	9/2/70	4/15/54	5/22/54	4/13/54
Turbidity	2.4	1	5	1	2
Total solids	66	68	84	90	90
Volatile solids	31	1 <i>7</i>	-	-	-
Carbon dioxide	2.8	1.6	6.1	1.5	8.0
pH	6.8	7.4	7.2	7.5	6.4
Total alkalinity	9	19	0	0	0
(CaCO3)					
Hardness (CaCO ₃)	21.6	17.4	39.0	16.0	15.0
Calcium	3.28	2.2	7.4	2.9	4.2
Magnesium	3.26	2.6	3.4	3.1	3 <i>.</i> 7
Total iron	.02	.06	.2	.12	.1
Manganese	.01	.02	0.0	.05	.05
Arsenic	.005	.005	_	-	-
Conductance	350	-	_	_	_
Chlorides	13.8	8 .7	8.7	9.0	20.0
Sodium	9.2	15.0	15.0	16.0	-
Potassium	2.3	-	_	_	-
Fluoride	.09	0.00	0.0	.3	.10
Phosphates (soluble ortho).01		.05	.05	.1	0
Sulphates	6.2	2.8	2.8	3.0	6.7
Silica	15.0	10.3	10.3	41	6.6
Aluminum	.01	.04	.04	0	.02
Nitrogen, ammonia	.32	-	_	-	-
Nitrogen, nitrite	.01	_	_	-	_
Nitrogen, nitrate	1.20	_	_	_	-
Source	Surface	Ferry	Rogue	Floras	Hubbard
	stream	Creek	River	Creek	Creek

^{*}Data provided by Oregon Department of Human Resources, Public Health Division

Lowland deposits of ground water in dune areas may be threatened by salt-water intrusion in areas of appropriate hydrology. However, to date this consideration is primarily academic owing to limited development of the resource and to the fact that most dune sand (Pistol River area and others) rests on bedrock which lies above sea level. Salt-water intrusion will become of greater concern in the future if accreted sand areas around jetties should be tapped for ground water. Aquifers in alluvial deposits immediately adjacent to streams and in hydraulic continuity with them will reflect any adverse quality problems of the streams. Included are municipal wells in channel gravels, which provide much of the water to urban areas. Comparison of available data on these wells (Table 14) to drinking water standards adopted by the U. S. Public Health Service (Table 15) shows that all channel deposit wells met or exceeded all standards and requirements at the time of testing.

Planning considerations

Management of the ground-water resource should be directed toward the multiple goal of 1) maximizing the use of the resource, 2) minimizing the adverse effects of withdrawal, and 3) maintaining or improving the quality of the ground water. Planning for development should be based on recognition of the limitations of the ground-water resource as defined above and on the kind and amount of development it can support.

Shallow supplies of ground water should be used with caution to avoid pollution from surface and near-surface disposal of wastes. Included are the ground-water occurrences in serpentinites and the perched water of the Quaternary middle marine terrace unit (Qmtm).

Future sources of ground water include modest supplies in the dunes near the mouth of the Pistol River, in the Colebrooke Schist, in the areas of accreted sand near jetties, and in channel gravels of the various streams. Potential problems include salt-water pollution of the water in the accreted dunes, if the salt-water/fresh-water interface is poorly defined or multiple, and the adverse impacts of ground-water withdrawal from the channels of smaller streams during periods of low flow.

Designs and plans for future wells should be based on a consideration of past wells on any given landform or rock unit (Table 13).

The proper spacing, construction, and location of wells are overseen by the Department of Environmental Quality, the State Water Resources Department, and County officials. The danger of overwithdrawal or contamination will be of increasing concern in the study area as development continues. Infectious hepatitis commonly occurs after the first periods of heavy rain in western Coos and Douglas Counties in areas of unsewered clustered developments similar to those on the Harbor Bench. It is postulated that during the rainy season perched and ponded water on the terraces moves laterally at shallow depths to enter the deeper water table along improperly sealed or constructed well casings or other avenues. Bacteria derived from septic tanks and pasture land travels with the water to enter the sources of domestic water.

GEOLOGIC HAZARDS

Geologic processes of concern to the planner are mass movement, ocean flooding, wave erosion and deposition, slope erosion, stream flooding, and stream erosion and deposition. Where these processes adversely affect the activities of man or threaten his safety or welfare they constitute geologic hazards. Each hazard is characterized by a unique distribution and unique sets of causes and impacts. Recommenda tions for treatment or mitigation are based upon a consideration of these, and are flexible to allow for variations in social, political, and economic settings. The distributions of geologic hazards based upon reconnaissance investigations are indicated on the accompanying geologic hazards maps.

Mass Movement

General

Mass movement is the movement of rock or soil material downslope in response to gravity. As summarized on Table 16, various kinds of mass movement are recognized on the basis of 1) type of movement, 2) rate of movement, 3) type of material, and 4) water content. Treatment of specific slides must be keyed to these parameters. Hence, in a general way the recognition of the type of mass movement is a key step in dealing with this hazard.

On steep to very steep slopes, planes of failure are generally parallel to the surface of the slope. Rockfalls and rockslides occur on near-vertical slopes. Debris slides, debris avalanches, and debris flows occur on less extreme slopes. Where a debris slide disaggregates into several pieces it is termed a debris avalanche. Where high-water content promotes flowing movement it is termed a debris flow. Because steep-slope failures generally involve shallow depths, their recognition in reconnaissance investigations in thickly vegetated terrain is not possible. On the geologic hazards maps, areas of very steep slope are interpreted as general areas of steep-slope failure potential.

On moderately steep slopes, surfaces of failure are generally not parallel to the surface of the slope, but rather are concave into the slope. Major types of mass movement include slump (rotational failures about a curved basal slip plane) and rapid to slow earthflow. Because these failures generally involve moderate to great depths, most of these slides are easily recognized on a site basis using topography as a guide. In reconnaissance studies such as this one, however, recognition is commonly more interpretative and is also based upon a consideration of rock unit, slope, topographic setting, and other factors. Where mass movement is slow or shallow, or where slope erosion also is significant, recognition is difficult.

Soil creep is the random, particle-by-particle movement of soil and rock material downslope in response to gravity and to other external factors including animal activity, freeze-thaw expansion and contraction, wet-dry expansion and contraction, and root action. The randomness of movement, the lack of shear planes, and the contribution of external forces besides gravity distinguish creep from the other forms of mass movement. Creep is shallow and occurs on convex to straight slopes. The significance of true creep to slope evolution is relatively minor compared to other processes (Kirkby, 1967); however, with time creep does overload slopes to generate other types of mass movement. Creep and slow, shallow earthflow commonly are closely associated on moderate slopes.

Causes

Mass movement occurs on slopes where the downslope component of gravity exceeds the shear resistance. In areas where slides are undesirable, therefore, the activities of man should be controlled to assure that the downslope component of gravity is minimized and that the shear resistance is maximized, or at least is maintained.

Table 16. Classification of mass movement, Curry County, Oregon

Slope	Туре	Water content	Velocity	LL 51. 111	Description
	Rockfall	Minimal, water in cracks may initiate slide	Extremely rapid		Falling rock wedged loose by roots, frost action or water; wedging action concentrated along joints, fractures, bedding, or faults
Very steep	Rockslide	Minimal	Rapid		Sliding and rolling rock resulting from wedging a above; includes talus; deposits often obscured by vegetation
	Debris slide	Low	Very rapid to moderately rapid	11/2	Sliding rock and disaggregated material; failure along a plane parallel to the slope; debris slides as a unit; includes sliding of thin soil mat over impermeable bedrock
Steep	Debris avalanche	Low to moderate	Very rapid	050	Sliding of rock and disaggregated material on a plane parallel to the slope; differs from debris slide in the breaking of the slide mass into pieces
	Debris flow	High	Very rapid		Flow of rock and disaggregated material on a plane parallel to slope; moves as a slurry because of high water content
1 1 1	Rapid earthflow	Variable	Rapid	1	Flow of rock and/or soil material along innumerable shear planes; characterized by irregularities of slope, drainage, and soil; sag ponds, etc.
Moderately steep	S low earthflow	Variable	Slow		Flow of rock and soil material along innumerable shear planes; irregularities of slope, drainage, and soil often obscured by weathering processes
415	Slump	Variable	Slow to rapid		Slip of rock and/or soil material along a curved basal shear plane; backward rotation of slide mass; sag ponds, prominent headscarp
Moderately steep to steep	Creep	Variable	Very slow		Random, particle by particle movement of soil and rock fragments downslope in response to gravity and other random and surficial external forces such as root action, freeze-thaw and wet-dry expansion and contraction, and animal activity; greatest displacement at surface; no slip plane; forms convex slopes

Downslope gravity component: Weight of the soil column is increased by the placing of fill for road construction or other purposes. Increased water content of the soil during the winter rains adds to the downslope gravity component of the soil. Obstructions to runoff, such as improperly designed roads, commonly direct surface water into the subsurface where it adds to the weight of the soil column. Debris flows and earthflows may result on steep and moderately steep slopes respectively. It is doubtful, however, whether increased soil moisture associated with logging has a measureable impact on slope stability. Slides generally occur in the winter when soils even under forest cover are saturated. Other factors discussed below are probably more significant in logged areas.

Models of slope failure presuppose that the weight of the soil column is perpendicular to the Earth's surface. Where nearby blasting is a factor, a horizontal acceleration is introduced along with the acceleration of gravity to produce an inclined direction of acceleration for the soil column. The net result is the same as if the slope were increased. For more distant blasting and for earthquakes of the magnitude possible in the study area, the effect of reoriented acceleration is secondary to other factors of sliding.

Shear resistance: Under saturated conditions water in the soil buoys up the soil particles, reduces internal friction, and thereby reduces shear resistance. Thus, where soil water is increased to the point of saturation by rainfall or drainage interference, the net result is to decrease shear resistance. Under conditions of heavy rain, infiltration may exceed the rate of subsurface drainage so that the liquid limit of the soil is actually exceeded (Campbell, 1975). Debris flows involving thin soils or pockets of colluvium over impermeable bedrock can be attributed in large part to these factors.

Cohesion, the bonding attraction of soil particles, varies with soil type and water content. Silts, for example, have low cohesion when dry, moderate cohesion when damp, and no cohesion when very wet; liquefaction characterizes saturated silts when disturbed. Clays, on the other hand, may accommodate extremely large quantities of water before gradually reaching their liquid limit. Other factors affecting cohesion include shrink-swell phenomena such as frost action and periodic wetting and drying. Cementation is commonly regarded as a special form of cohesion. Where weathering extends to considerable depths on gentle slopes or flat terrain, low cohesion along critical horizons may initiate sliding in deep cuts. Slides are common where pronounced bedding planes dip steeply into canyons or artificial cuts.

Other factors which contribute to shear resistance include independent means of support and the distribution of soil on the slope. Root support by trees is now recognized as a primary agent of stability on forested slopes. Root support declines rapidly after logging and many slides in logged areas are attributed to loss of root support through decay. Removal of the toe of slides through wave erosion, streambank erosion, or improper grading may initiate slides on slopes of any gradient. Logging roads commonly undercut slide material on steep slopes; deep cuts on moderate slopes commonly intersect critical joints in bedrock to initiate rockfalls; and cuts on flat terrain often result in caving of weathered bedrock.

Distribution

The distribution of the various types of mass movement is summarized on Table 17 and is indicated on the geologic hazards maps. The distribution of steep-slope failures is indicated only in a general way by regional slopes greater than 50 percent owing to the small size of many of the slides and the extreme difficulty of recognizing such hazards in reconnaissance investigations. Earthflow and slump topography is indicated for areas of greater than approximately 20 acres extent and can also be inferred for areas of headland and sea cliff retreat. The term "earthflow and slump topography" refers to areas for which earthflow and slump are inferred on the basis of drainage, slope characteristics, geology, structure, stereoscopic photo interpretation, and available field evidence (Figure 17). Detailed field investigations for all areas of earthflow and slump topography were not made, and not all areas of inferred earthflow and slump topography are actively undergoing mass movement at the present time. Many such areas are presently stable.

Rockfall, rockslide, debris slide, debris avalanche, and debris flow occur on slopes of approximately 100 percent (45°) or greater. Regional slopes indicated on the hazards maps are considerably less owing to the averaging effect of the small scale and the large contour interval. Bedrock units generally consist of unsheared, hard pre-Tertiary formations. Geographically, failures of steep slopes and very steep slopes are most common in the Pearse Peak and Mount Emily areas and along sea cliffs and headlands (Figure 18). North of Agness, bedding-plane slides on steeply dipping exposures of the Lookingglass Formation are common.

Туре	Slopel	Rock units ²	Geographic distribution
Rockfall	Vertical to near-vertical	Very hard pre-Tertiary bedrock including	Steep uplands of the upper Sixes River, Elk
	slopes; most pronounced in	Jg, Jpp, Kh, Kr, Kuh, and Kuc; favored	River, China Creek, and Euchre Creek; also
Rockslide	areas of stream-bank ero-	by jointing and absence of pervasive	canyon of Rogue River and steep canyons of
	sion, scarp retreat, or wave	shearing	central and south county, Mount Emily area;
,	erosion		sea cliffs as at Cape Sebastian and other areas
			of active undercutting
Debris	Steep slopes; generally	Hard pre-Tertiary bedrock including parts of	Uplands of upper Sixes River, Elk River, China
sli <u>de</u>	50–100% regional slope	Jg, Jpp, Kh, Kr, Kuh, and Kuc; commonly	Creek, and Euchre Creek; canyon of the Rogue
Debris	and 100% local slope	involves soil formed under forest cover with	River; steep canyons of central and south county;
ava lanch e		benefit of root support; also areas of collu-	parts of Chetco drainage;
Debris		vium characterized by sporadic episodes of	sea cliffs and other areas of active undercutting
flow		movement and quasi-stability	
Rapid	Moderately steep slopes;	Sheared pre-Tertiary bedrock including Jop,	Uplands of north county, Hunters Creek, and
earthflow	generally 20-50% regional	and along linear shear zones in Jop, Kh, Kr,	Pistol River drainages;
	slope; 100% slopes locally,	and in area of complexly sheared serpentine;	sea cliffs and slopes in sheared bedrock espe-
Slow	especially where there is	also along retreating sea cliffs of moderately	cially south of Humbug Mtn., south of Cape
earthflow	active undercutting	hard Tertiary bedrock; developed locally	Sebastian, and at Houstenader Creek;
		where recent erosion attacks thick weather-	sea cliffs of past and present coastal retreat in-
Slump		ing horizons	cluding Cape Blanco area;
			also includes sloughing of terrace material off
			stable headlands owing to influence of ground-
			water pore pressures
	Significant on many steep	All units, especially those with soil cover	Universal distribution on slopes of sufficient
Creep	to moderately steep slopes	or with closely spaced joints, bedding, or	gradient; passes laterally into earthflow terrain
		schistosity (Jc)	through zones of increasing movement on shear
*			planes; not indicated on hazards map; common
:			in Chetco drainage

¹See slopes on geologic hazards maps

²See geologic maps

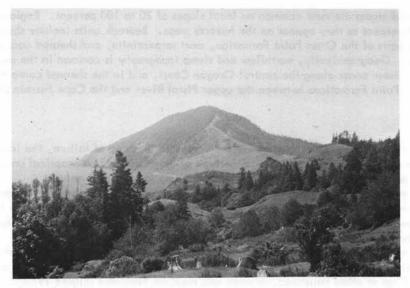


Figure 17. Extremely irregular topography in the Lookout Rock area south of Humbug Mountain indicates deep earthflow and a slump resulting from coostal undercutting of sheared bedrock.

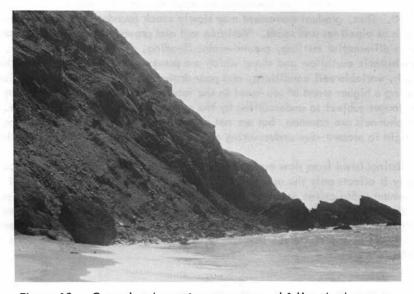


Figure 18. Coastal undercutting promotes rockfall and other steepslope failures in unsheared bedrock at Humbug Mountain.

Earthflow and slump are most common on local slopes of 20 to 100 percent. Regionally, slopes average 30 to 50 percent as they appear on the hazards maps. Bedrock units include sheared pre-Tertiary units, especially parts of the Otter Point Formation, most serpentinite, and sheared coastal exposures of Cretaceous strata. Geographically, earthflow and slump topography is common in the uplands of north Curry County, in shear zones along the central Oregon Coast, and in the sheared contact between the Dothan and Otter Point Formations between the upper Pistol River and the Cape Ferrelo area.

Impacts

Impacts of the various type of mass movement vary with the type of failure, the location within the slide, the degree of activity of the slide, and the type of development. A practical understanding of the types of impacts possible is essential to realistic planning and land management.

Steep and very steep slope failures are generally very rapid and catastrophic. Impacts include extreme damage to roads, destruction of timber, and increased turbidity and sedimentation in streams. Where slides produce unvegetated slopes of considerable extent, increased erosion leads to prolonged degradation of streams and also to the loss of valuable topsoil.

The impacts of earthflow and slump on moderately steep slopes varies with the depth of failure and the degree of activity of the slide. Where actively undercut by streams, the ocean, or construction, slides may destroy buildings or other structures, or warp and displace highways (Figure 19) and roads (Figure 20). Parts of the Houstenader Creek slide were displaced 165 feet during one episode of activity in 1958. Generally, however, earthflow activity does not involve more than a few feet of displacement per episode along the coast. Long stretches of U. S. Highway 101 along the coast are in need of almost continual maintenance as a result of sliding.

In areas of slow undercutting, rates of movement on active earthflows are very slow and may range from a few inches or less to several feet per year. They are particularly bothersome because thay are usually hard to recognize, and their effects are commonly not experienced for a considerable time after development has been completed. Thus, gradual movement may slowly crack foundations, destroy structures, and warp linear features such as pipelines and roads. Variable soil and ground-water conditions produced by the sliding may lead to differential settling, ground-water flooding, and septic tank failure.

Areas of prehistoric earthflow and slump which are presently inactive may also exhibit variable foundation strength, variable soil conditions, and poor drainage. Upland slopes immediately southwest of Harbor slid during a higher stand of sea level in the late Pleistocene. Now fronted by marine terraces, the slopes are no longer subject to undercutting by the ocean and the slides are inactive. Local slides into small stream channels are common but are not directly related to the initial regional sliding. Instead, they owe their origin to present-day undercutting of bedrock broken by the previous period of deep-seated sliding.

Creep, as distinguished from slow earthflow (see <u>General</u>), is relatively insignificant as a geologic hazard. Generally it affects only the upper few feet of soil and weathered bedrock and involves very slow rates of movement. Structures penetrating to shallow depths may be affected over prolonged periods of time. Thus it is sometimes common to see the lower few feet of tree trunks, old fences, power poles, fence posts, and tombstones tilted downslope in areas of soil creep. The forces behind soil creep may be quite large and it is not uncommon to see improperly designed or drained retaining walls cracked by the pressure of the soil.

Recommendations

Recognition of problem areas with regard to mass movement rests in one's viewing changes in slope, drainage, and other factors in terms of their potential effects on slope stability. In areas of previous failure landforms are useful guides; elsewhere slide potential must be inferred from rock type, bedding, jointing, weathering and other antecedent conditions.

The parts of this study dealing with mass movement are reconnaissance in nature and provide a tool for regional planning. They also are guides to on-site evaluations, but they are not substitutes for definitive on-site investigations and should not be used as such. For example, use of this bulletin to directly delineate mass movement areas not suitable for septic tank installation is invalid; regulations of the Depart-

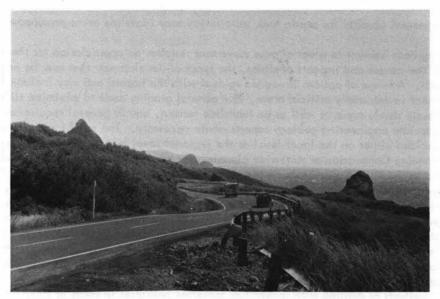


Figure 19. Continual movement of massive coastal landslides in western Curry County is the underlying reason for the dips and swales on the coastal highway.



Figure 20. Slumps of road material are commonly caused by stream undercutting, saturation of the fill material, or simply failure of improperly placed fill material.

ment of Environmental Quality for septic tonk installation near landslide areas presuppose on-site investigations.

Regulating development in areas of mass movement requires on appreciation for the many variables associated with the causes and impacts of slides, the types of development that may be proposed, and community needs. A range of options is needed to deal with the hazard and may include 1) a ban on most or all development in extremely critical areas, 2) a general grading code to minimize sliding in developments on previously stable areas as well as on landslide terrain, and 3) general requirements for the preparation of appropriate engineering geology reports where necessary. The need for actual reports in specific areas can be decided either on the local level or the regional level by the appropriate governmental bodies (e.g. County Planning Commission or statewide planning agency respectively). In either case, the decision should be keyed to the actual conditions on the ground.

Four basic engineering techniques are available for the treatment of specific slides. They are 1) unloading the head of the slide, 2) loading the toe of the slide or controlling it with buttresses or retaining walls, 3) removing water from the slide or otherwise controlling infiltration, and 4) shifting the surface of failure to greater depths. The specific causes of the individual slide (see <u>Couses</u>) must be determined and the method of treatment should be selected and adjusted to fit the problem. To prevent the initiation of new slides on previously stable slopes, basic grading practices such as those outlined in the Uniform Building Code should be followed.

Specific methods of dealing with rockfall or rockslide potential in oreos of steep slope may also include 1) controlling blasting where vibrations may initiate sliding, 2) screening or scraping of slopeswhere there is danger to motorists or other persons below, (Figure 21), 3) constructing properly engineered retaining walls of the foot of active talus where rolling rocks might present o hazard, 4) placing warning signs of particularly critical localities along roads, hiking trails, and beach areas, and 5) grouting jointed cliffs when necessary.



Figure 21. Extremely high rockfall danger on parts of the Rogue River Highway necessitate screening to protect motorists. The hazard is greatest during the winter months.

Specific methods of dealing with debris slides, debris avalanches, debris flows, and earthflow and slump may also include 1) properly locating roads into bedrock where fill is not suitable, 2) adjusting logging techniques to the requirements of the terrain, 3) controlling blasting where liquefaction might initiate sliding, 4) controlling stream-bank erosion where it undercuts slopes, 5) controlling drainage. On many of the slower moving slides, cyclic soil phenomena such as shrink-swell or frost heaving may be dominant factors in sliding, and proper drainage could conceivably be effective in controlling sliding.

In extremely critical areas, where the cost is justified, a variety of equipment can be used to monitor pore pressure, rotation, slope noise (Blake, W., and others, 1974), and slope extension. During the slide season, when maintenance and repair work is anticipated, the slide areas should first be examined upslope for signs of continued activity, such as the development of tension cracks. Observations should continue throughout the maintenance program. Maintenance work is not recommended during storm activity. Occasionally a small slide at the base of a slope is followed by a much larger slope failure. An example is the slide of January 1974 near Canyonville, which claimed nine lives.

Ocean Flooding

General

Ocean flooding in terms of geologic time results from tilting of the Earth's surface or from melting of continental glaciers, which in turn release large quantities of water for the ocean basins. In Curry County, terrace levels provide clues to rates of tectonic uplift. The elevation (approximately 1,000 feet) and probable age (approximately 1 million years) of the higher terraces suggest a rate of uplift of about one inch per thousand years. Lower terraces, for which radiometric age dates are available (see Surficial Geologic Units), lie within or near the possible range of recent eustatic variations of sea level and cannot be used to estimate rates of absolute uplift. The elevation of the lower terraces is due in large part to changes in absolute sea level rather than tectonism.

Fluctuations of sea level induced by the growth and retract of continental glaciers during the Ice Age were relatively rapid compared to ongoing tectonic uplift. Submerged terraces off the coast of Curry County at depths of 300, 210, 150, and 60 feet (Kulm, 1967) probably formed during the final retreat of the glaciers. Sea level has risen approximately 400 feet during the past 15,000 to 20,000 years (Curray, 1965; Milliman and Emery, 1968). An average rise in sea level of one foot every 70 years is indicated. Sea level has remained relatively stable for the past 5,000 years (Curray, 1965). During prior interglacial periods sea level may have been about 50 meters higher than at present if all continental ice sheets were melted (Fairbridge, 1961).

Landforms subject to short-term ocean flooding by tidal action, storm surge, or tsunami include beaches, marshes, coastal lowlands, and low-lying interdune areas. The highest predicted tide is approximately 6 feet above mean sea level. The highest probable storm surge is 4 to 7 feet above prevailing tidal elevations. The highest probable tsunami is approximately 10 feet in the mouths of the estuaries and slightly higher on headlands and beaches. Because tidal flooding occurs daily, the effect of high tides is superposed on that of storm surges or tsunamis in determining the potential impact of these phenomena. The simultaneous occurrence of an extreme storm surge and an extreme tsunami is considered highly improbable and is not investigated.

Tidal flooding

Causes: Tides are the periodic rises and falls of sea level which occur approximately two times per day. Tides are caused by two bulges of water in the oceans formed in response to the gravitational attraction of the Moon and other factors. On the side of the Earth facing the Moon, the gravity of the Moon attracts the water to form a bulge, and on the side opposite the Moon a similar bulge is formed in response to centrifugal acceleration. The Sun exerts a similar effect on the Earth's oceans, but to a lesser extent (45 percent). The net result is a secondary set of tides superposed on those of the Moon. When the tides of the Sun and the Moon coincide (approximately bimonthly), observed tides are additive, giving extreme tides called spring tides (approximately biweekly). During other alignments the tides tend to cancel to various extents, giving less extreme tidal situations. When the Earth, Sun, and Moon are in quadrature (form a right angle) cancellation is the greatest and gentle neap tides result.

Tidal elevations: Tidal elevations at specific localities vary with the relative influence of numerous factors including the declination of the Sun and the Moon's orbits to the Earth's equator, the varying distances between the Earth and the Moon and Sun, and the physical characteristics of the various ocean basins. In the Pacific Ocean, daily high tides and daily low tides are unequal, giving rise to the so-called diurnal inequality. Thus, a higher and a lower high tide, and a higher and lower low tide are recognized. Various tidal elevations relevant to nautical charting, coastal engineering, and navigation are illustrated on Table 18. Although the figures apply specifically to Yaquina Bay, they can be regarded as approximate for the study area.

Mean lower low water is arbitrarily defined as 0.0 feet and is the base level of all other tidal elevations. Mean low water marks the boundary between submerged land and tidal flats. Mean sea level is based upon observations taken over a number of years and serves as the datum base for topographic maps produced by the U. S. Geological Survey. Mean sea level varies with location and is half a foot to one foot lower in Curry County than suggested on Table 18. Knowledge of mean sea level is required to interrelate land elevations and tidal elevations. Thus an 8-foot tide is only about 4 feet above mean sea level.

Mean high water is the average of all observed high tides, and for the Oregon Coast it is approximately $3\frac{1}{2}$ feet above mean sea level. Mean higher high water is generally less than a foot above mean high water. Mean high water is approximately equivalent to or slightly above the **ground** elevation of mature marshes with well-defined drainage.

The highest predicted tides flood the highest marshes and adjoining flood plains, and the highest observed tides (prevailing high tide plus storm surge) inundate the marshes, wash over low-lying dunes, and may flood other low-lying areas. According to Table 18 the highest tide in Yaquina Bay during the observation period was 12.6 feet, or nearly 5 feet above mean high water (the level of high marshes). Over considerably longer periods of time, maximum observed tides at the mouth of the Umpqua River were about 13 feet; adoption of a slightly lower figure for the study area is reasonable pending more precise determinations (see Table 18 - footnotes). At the mouths of the Chetco and Rogue Rivers, stream-flood elevations are somewhat higher (see Stream Flooding).

Impact and recommendations: Tidal action inundates beaches and marshes, enhances circulation at the mouths of rivers, aids navigation, influences sedimentation and deposition, and supports a complex of biologic activity. Modifications of tidal flow may influence these and other processes. All construction and fills in the tidal zone and below should proceed on the basis of careful planning and are subject to policy statements formulated by the Oregon Coastal Conservation and Development Commission and adopted in revised form by the Land Conservation and Development Commission. Permits are issued by the State Land Board and the U. S. Army Corps of Engineers. Hazards associated with tidal flooding are discussed under Storm Surge. Sedimentary processes associated with tidal flooding are discussed under Wave Erosion and Deposition.

Storm surge

General: Storm surge is the rise of sea level above predicted tides owing to low barometric pressure and wind. Local factors influencing the magnitude of storm surge include bottom gradient, shore slope, position of the coast relative to the storm center, and harbor configuration.

The low barometric pressures which accompany storm activity induce sea level to rise slightly at a rate of approximately 1 centimeter per millimeter drop in pressure. This is equivalent to about 1 foot per inch of mercury. During the Columbus Day storm (Oct. 12, 1962) the barometric pressure was 28.6 at Gold Beach. The maximum possible storm surge resulting directly from fluctuations in barometric pressure is 2 to 3 feet.

Wind set-up is the piling of water against a shore by wind shear acting upon the surface of the water. The effects of wind shear are most pronounced on large lakes and on funnel-shaped bays. On the coast of Curry County wind-shear impact probably does not exceed one or two feet. Wave set-up is the retarded return of waves to the sea caused by wind friction and is additive to wind set-up. Wave set-up is approximately 10 to 20 percent of wave height in extreme storms (Fairbridge, 1966). Thus, in regions where winter waves may exceed 20 feet near shore, as along the Oregon Coast (U. S. Naval Oceanographic Office, 1966), wave set-ups along the beaches may approach 2 to 4 feet. Within bays where tidal gages are located, however, wave set-ups are much less and recorded storm surges are therefore less.

Table 18. Representative tidal elevations of the Oregon Coast¹

Elevation (feet)	Tidal term ²	Description	
14.5	Extreme high tide ³	Highest projected tide that can occur and is the sum of the highest predicted tide and the highest observed storm surge. Very long recurrence intervals are assumed. It is the level used by engineers for the design of harbor structures.	
12.6	Highest measured tide	Highest tide measured on the tide staff.	
10.3	Highest predicted tide	Highest tide predicted by the tide tables. Storm surges and other climatic factors are not considered.	
8.4	Average height of the highest high tides observed of ific time interval. Time intervals are selected on the moon's many cycles and the degree of refineme This plane is used by the National Ocean Service in navigational clearances.		
7.6	Mean high water	The average of all observed high tides. It is the boundary between tideland and "upland," the land generally at or above the level of mature high marsh.	
4.6	Mean tide level	A level midway between mean high water and mean low water. The difference between mean tide level and local mean sea level reflects asymmetry between local high and low tides.	
4.5	Local mean sea level ⁵	The local average height of the water surface for all stages of the tide.	
4.1	Mean sea level	A regional datum based on observations taken over a number of years on the West Coast of the United States and Canada. It is the reference for elevations on U.S. Geological Survey topographic maps.	
1.5	Mean low water	The average of all observed low tides. It is the boundary between tideland and submerged land.	
0.0	Mean lower low water	The average height of the lower low tides.	
-2.9	Lowest predicted tide	The lowest tide predicted on the tide tables.	
-3.1	Lowest measured tide	The lowest tide actually measured on the tide staff.	
-3.5	Extreme low tide	The lowest estimated tide that can occur.	

1 Specific figures are based on 6 years of tide observations at the Oregon State University Marine Science Center dock on Yaquina Bay. Values vary from estuary to estuary, within an estuary, and with the interval of observation. Above figures vary slightly from values in study area (see below).

2 Adapted from Oregon Division of State Lands (1973).

^{312.3&#}x27; at the mouth of the Chetco River; 13 feet at Port Orford (U.S. Army, Corps of Engineers, 1975).
46.9' at the mouth of the Chetco River; 7.3' at Port Orford (U.S. Army, Corps of Engineers, 1975).
5Mean sea level at Port Orford, Wedderburn, and Brookings is 3.92 feet, 3.34 feet, and 3.48 feet respectively. Thus, elevations indicated above mean sea level are probably as much as one foot too high (see text).

Magnitude: Very little information is available on the magnitude of storm surges along the Oregon Coast. Presently there is no method for assigning probabilities to possible combinations of wave set-up, wind set-up and sea-level rise caused by low barometric pressure. Storm surges generally are less than one foot, however, and probably do not exceed 4 to 7 feet even in the most extreme storms. During a 45-year period the highest observed tide at Astoria was 3.8 feet above mean higher high water (U.S. Army Corps of Engineers, 1973). During a 6-year observation period at the Oregon State University Marine Science Center in Yaquina Bay, the highest observed storm surge was 4.2 feet. Both observations were made at locations of minimal wave set-up. Higher storm surges have been experienced on the open coast (see Impact, below). Along the Atlantic seaboard and the Gulf coastal zone, storm surges as high as 9 to 12 feet have been recorded over large areas. At Pass Christian, Mississippi, Hurricane Camille delivered a 25-foot storm surge in 1961. The city is situated near the narrow head of a wide-mouthed bay that faced directly into the storm.

Impact: Ocean flooding by storm surge and high tides can be predicted on the basis of tidal tables and weather predictions. Planning measures for long-range protection should include provisions for public disclosure of hazardous areas, most notably the foredunes and low-lying cove and beach areas. Because storm surge and stream flooding often coincide, storm surge should be considered in all models of stream flooding.

One of the most extreme storms along the Oregon Coast occurred in January of 1939. In Curry County, waves swept over the foredunes into Garrison Lake, flooded the lowlands at the mouth of the Elk River, and washed logs over the road at the mouth of Euchre Creek (Curry County Reporter, January 5, 1939). The level of the highway at Euchre Creek is now considerably higher. At Gold Beach, local flooding of the dunes proceeded up to the base of the terraces on which the city is built. Although the dune elevations in this area remain the same today, the threat of ocean flooding could be considerably less owing to beach accretion behind the recently constructed Rogue River jetty. No published information is available regarding storm surges associated with the Columbus Day storm in 1962.

Tsunami

General: Tsunamis are waves generated at sea by major earthquakes or particularly violent volcanic eruptions. Tsunamis are difficult to detect at sea, having wave lengths of a hundred miles or more and amplitudes seldom exceeding a foot. Velocity of the waves in the open ocean is determined by water depth and approaches 450 miles per hour in parts of the Pacific Ocean.

As tsunamis approach land, the shallower depths cause the water to pile upon itself, thus increasing the amplitude. In some coastal inlets of Japan, for example, tsunamis greater than 80 feet high have been generated by local seismic activity. The largest tsunami on record, an estimated 120 feet high, occurred on the coastal lowlands of Java during the eruption of Krakatoa in 1883 and killed approximately 30,000 people. The height of any given tsunami at any given locality is determined primarily by 1) the magnitude of the disturbance generating the tsunami, 2) attenuation, 3) bathymetry, and 4) run-up.

Magnitude of disturbance: Most tsunamis are generated by seismic activity. Factors favoring the generation of a destructive tsunami include a magnitude of 7.5 earthquake or greater on the Richter scale (see Tectonic Setting – Earthquakes), a shallow focus, a large area of displacement, and vertical displacement rather than horizontal displacement. Strike-slip faults (horizontal displacement) generally do not generate tsunamis (Balakina, 1970; Adams and Furomoto, 1970).

Wilson and Torum (1972) relate the maximum height of tsunamis to the magnitudes of the earthquakes which produced them. Data were collected for tsunamis at points within 500 miles or their respective epicenters. The equation they developed shows that for earthquakes with magnitudes of 8.7 (the largest possible quakes) the largest possible tsunami is approximately 100 feet in height. Similarly, quakes of magnitudes less than 6.7 on the Richter scale are shown to generate tsunamis of 3 feet in height or less. Tsunamis of this size probably would have no effect on structures, but could be a threat to people on the beach. These determinations are statistical and generalized; they do not fully consider the potential peculiarities of future tsunamis.

Major source areas for tsunamis along the Oregon Coast include the Aleutian Trench area, the west Pacific from Japan to the Phillipines, and a structurally complex area of earthquake activity off the coast of southwest Oregon and northwest California (see Tectonic Setting). Of the three, the Aleutian Trench along the coast of Alaska (see below) is the source area for tsunamis with greatest potential for damage to Curry County.

Attenuation: As waves move away from their point of origin, they diminish in size (attenuate) owing to friction, dispersion, and other factors. Where the mechanics of generation of a particular tsunami favor propagation in one direction over another, the propagation is said to be directional, and wave height is inversely proportional to the square root of the distance (a tsunami at distance 2x from origin is 1/2 as high as at point x) (Wiegel, 1969). Where propagation favors no direction over another, it is said to be nondirectional, and wave height is inversely proportional to the distance (a tsunami at distance 2x from the origin is 1/2 as high as at point x) (Wiegel, 1969); attenuation is seen to be more rapid.

The Alaska earthquake of 1964 produced a directional wave toward the eastern and southern margins of the Pacific Ocean and is analyzed by Li-San and Divoky (1972). In contrast to the gentle waves delivered to the Japanese Coast (1 to 2 feet high), the waves delivered to the coast of the United States were of major proportions owing to directional propogation and closer proximity to the point of origin. Likewise, the Tokachi-oki earthquake of May 16, 1968 in Japan registered 7.8 on the Richter scale but delivered a tsunami only 6 inches high to the Oregon Coast (Pattullo and others, 1968), owing in large part to attenuation.

Bathymetry: Much of the impact of tsunamis is determined by the extent to which water is piled upon itself or reflected as the tsunami approaches shore. This, in turn, is determined by subsea bathymetry in the deep sea, on the continental shelf, and near shore. Along the Oregon Coast, possible shoaling or reflecting areas include the gentle shelf off the coast of Clatsop County, the Heceta Bank off the central Oregon Coast, and Coquille Bank off the coast of southern Coos County. Too little information is available to determine the extent to which these features amplify or dissipate tsunamis. Likewise the effect of subsea canyons is undefined.

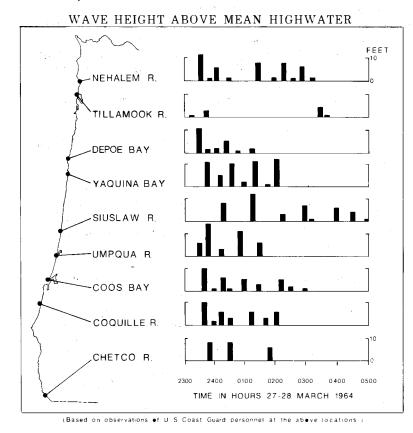


Figure 22. Wave heights of the 1964 tsunami above mean high water. (From Schatz, Curl and Burt, 1964)

Topographic features of more local extent along the coast of Curry County also may influence the effect of tsunamis. Generally the tsunamis tend to concentrate on the headlands and to dissipate in the estuaries as a result of the narrow, shallow entrances of the rivers. In other parts of the world, deep funnel-shaped harbor entrances are known to amplify tsunamis. The complexities introduced by local and regional bathymetry are illustrated by the various tsunami records shown on Figure 22.

Run-up: Run-up is the elevation on land that a tsunami may reach and is measured relative to prevailing sea level at the time of the tsunami. For instance, a tsunami with a 10-foot run-up occurring at a time of an 8-foot tide would reach an elevation of 18 feet above mean lower low water (tides are measured relative to mean lower low water). In Curry County this is approximately $14\frac{1}{2}$ feet above mean sea level.

Run-up is determined by local bathymetry and topography, angle of incidence, bottom slope, bottom permeability in shallow areas, and the nature of the material underlying the lowland areas. Generally, run-up is 1 to $1\frac{1}{2}$ times wave height (Wilson and Torum, 1972), but may approach 2 times wave height under ideal conditions (Torum, 1972). Along the Curry County coast run-up is probably equivalent to H (height of the wave as it breaks near shore). In flat low-lying areas and marsh lands, run-up is considerably less owing to the dampening effect of the terrain, but the extent of flooding can be very large.

Impact: Potential damage by tsunamis includes flooding of tidelands and peripheral marshes and lowlands, damage to moorings and vessels, and injury or drowning of persons on beaches, in isolated coves, and on low-lying terrain. This latter impact is particularly significant in view of increased tourism and extensive beach-related activities along the southern Oregon Coast.

The Good Friday Alaska earthquake of March 27, 1964 satisfied all requirements for the generation of a destructive tsunami along the Oregon Coast. It registered 8.3 to 8.6 on the Richter scale and involved vertical displacements of regional extent. The quake also occurred in a zone of tectonic convergence, a factor which favors the generation of destructive tsunamis (Isaaks and others, 1968). The tsunami was directed toward, the Oregon Coast and coincided with the high spring tides. The probability of larger tsunamis being directed toward. Oregon from the Alaska area appears rather remote.

Total damage along the Oregon Coast amounted to \$700,000 and four drownings. Losses would have been considerably higher had the tsunami arrived during a period of heavy tourist use rather than late at night. Wave heights of 4 to 14 feet above prevailing mean high water (Figure 22) were recorded in Oregon, and a wave greater than 20 feet high was recorded at Crescent City, California. There, analysis of tidal gage data has revealed a 100-year recurrence frequency for tsunamis of that size. In Curry County the tsunami was 9.4 feet high at Gold Beach, rose to within one foot of the land surface at the mouth of the Chetco River, and flooded at least three houses in the lowland areas of the lower Winchuck River. Damage to boats and moorings at Gold Beach totaled \$30,000 to \$40,000.

Because tsunamis deliver waves over a period of several hours, conservative estimates of the maximum probable tsunami for the study area should assume that the tsunami will be superposed on a high tide. Assuming a 10-foot wave and mean higher high water (8-foot tide, or $4\frac{1}{2}$ feet above mean sea level), inundation to elevations of 14 to 15 feet above mean sea level should be expected in some coastal areas. Remarkably, the tsunami generated by the Good Friday earthquake arrived during high spring tides and is an approximate measure of the highest probable tsunami. Run-ups to elevations of 20 feet or more are possible in some beach and headland areas. Superposition of tsunamis and extreme high tides (Table 18) is extremely unlikely and is not considered in this investigation.

Recommendations: The greatest threat of tsunamis in Curry County is injury or loss of life to individuals such as clammers, hunters, beachcombers, and beach campers in low-lying areas such as beaches, tidal flats, and marshes. Even small tsunamis may result in catastrophic results if they occur during a time of intensive lowland use by recreationists and tourists. It is imperative, therefore, that local warning procedures be efficient and comprehensive. Tsunamis are detected by the Seismic Sea-Wave Warning System at the Environmental Sciences Service Administration stationed in Honolulu. Warnings are relayed first to the Oregon State Emergency Services Office and then to county and city personnel along the coast. A tsunami watch means that conditions conducive to the generation of a tsunami have occurred. A tsunami warning means that an actual tsunami has been observed.

Once a tsunami warning has been received by local officials it must be relayed to the populace by radio and TV announcements and through the effective use of the police or sheriff's office. Because many isolated coastal areas and coves may be occupied, use of helicopters or other low-flying craft should be considered. The public should be informed that tsunamis involve many waves over a period of several hours. The first wave is often preceded by a pronounced withdrawal of the sea that may lure the unwary observer to his death. Moreover, tsunami warnings should not go unheeded merely because the area escaped damage during a previous tsunami warning. No two tsunamis behave in exactly the same way.

Wave Erosion and Deposition

General

Patterns of coastal erosion and deposition are ∞ ntrolled by tectonic uplift, worldwide fluctuations of sea level (see Ocean Flooding), bedrock hardness and structure, sediment grain size, the distribution and magnitude of sediment sources, and other more local factors. Off the coast of Curry County the lowest submerged terrace is 300 feet below present sea level and is located 10 nautical miles off the present coast-line. Using the sea level curves of Curray (1965) and Milliman and Emery (1968) an approximate age of 20,000 years is assumed for the terrace. An average rate of coastal retreat of as much as $2\frac{1}{2}$ feet per year is indicated. Because sea level has remained stable for the past 5,000 years, present rates of coastal retreat are considerably less.

Headland and sea-cliff erosion

Regional coastal erosion rates along the headlands and sea cliffs vary from less than one inch per year to several inches depending upon bedrock, structure, and other factors, as summarized on Table 19. Superposed on regional averages are local more sporadic phenomena resulting from local conditions.

Hard pre-Tertiary bedrock: Hard pre-Tertiary bedrock forms sea stacks and irregular sea cliffs from Brookings to Crook Point, and at Cape Sebastian, Sisters Rocks, Humbug Mountain, Port Orford, Cape Blanco, Blacklock Point, and Rocky Point (Figure 23). Wave erosion initiates sporadic steep-slope failures in these areas, and rates of coastal retreat are very slow, probably not exceeding a few inches per year.

At Cape Sebastian, widely spaced jointing has caused massive blockfalls along the northwesterly facing cliffs. Individual failures involving several acres of sharply downdropped bedrock now are extensively forested, indicating that durations between blockfalls may exceed hundreds or even thousands of years. If tension cracks should appear along the crest of Cape Sebastian on hiking trails or on the road, the area should be evacuated immediately pending detailed study.

Dicken (1961) reports that in the Pistol River area the southern edge of Sheep Rock has retreated 35 feet in 89 years, partly in response to lateral migration of the Pistol River. He also reports that sea stacks in the Myers Creek area have registered notable reduction since the first survey of the area was made in 1873 and that the northern part of the beach has grown 135 feet in the same period of time. Barring inaccuracies in the original survey, these observations illustrate the complexities of coastal retreat in the vicinities of major drainages.

Elsewhere along the southern Curry County coast, comparison of old photographs with the present seascape indicates little or no noticeable coastal retreat since the turn of the century. The apparent equilibrium involves very hard bedrock, however, and where road fills have been pushed short distances onto the beach, as at Hunters Cove, damage by waves has been rapid.

<u>Tertiary bedrock:</u> Moderately hard Tertiary bedrock and terrace material forms straight to gently curved cliffs fronted by narrow beaches north and south of Cape Blanco (Figure 24) and in the Nesika Beach area. Storm waves pass over those beaches to initiate slumps and earthflows of local extent which collectively result in coastal retreats averaging a few inches per year. Along the grass-covered slopes in the Sixes River area, rates of retreat are probably less at the present time.

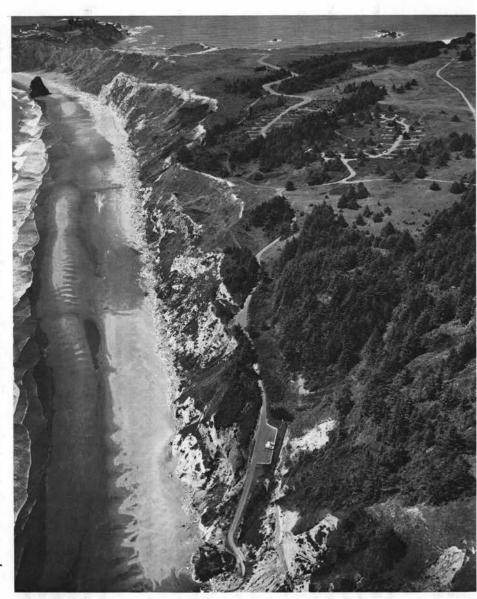
Table 19. Summary of coastal erosion, Curry County, Oregon

Regional				
landform	Geology and location	Physical features	Processes and rates	Factors controlling processes
;	Hard pre–Tertiary bedrock; Brookings to Crook Point, Cape Sebastian, scattered headlands north of Rogue River to Floras L.	Steep, irregular coastline with numerous sea stacks and coves	Rockslide and rockfall, also debris slides; slow rates of erosion, probably less than 1"/yr. but sporadic in local sense	Refracted waves direct erosion against headlands, retreat controlled by joints, bedding planes and faults
adland	Moderately hard Tertiary bed- rock and terrace material; Elk and Sixes River areas, Nesika Beach area	Straight to gently curved cliffs fronted by drift beaches	Debris slides, earthflow and slump; few inches or less per year; rate of retreat slower on vegetated slopes.	Storm waves pass over beaches to attack cliff; retreat by mass movement, slope erosion, and rain impact on bare slopes
Sea cliff and headland	Sheared pre-Tertiary bedrock; Lookout Rock to Sisters Rocks, Houstenader Creek area and others	Moderately steep slopes ex- tending for considerable dis- tances from the coastline inland; mass movement topography	Slow to rapid earthflow extending large distances inland; rates average few inches/year, but sliding may displace debris over 100' downslope in single episode	Wave erosion removes toe of slide causing episodic down-slope movement of slide material
	Terrace deposits over bedrock; Harbor bench and Brookings area, Port Orford to Floras Lake	Flat terrace deposits of variable thickness capping bedrock exposures along the sea cliff	S low retreat similar to that of hard pre-Tertiary bedrock; also sporadic local slumping of ter- race deposits	Retreat controlled by jointing, bedding, and faults; slumping of terrace material controlled by moisture and engineering properties
Beach	Swash beaches between local headlands; areas of hard, pre- Tertiary bedrock especially in south county	Convex, thin beach deposits couched between headlands; beach parallel to wave front	Generally stable and retreat- ing very slowly in harmony with adjacent headlands; ex- treme short-term fluctuations depending on storm activity	Sediment supplied by adjacent headlands and local drainages; beach form fluctuates with storm activity
	Drift beaches fronting more easily eroded sea cliffs and near major fluvial sediment sources	Gently arcuate to almost straight beaches oriented oblique to wave fronts	Slow retreat of few inches per year or less; cyclic variations in response to weather and sed- iment supply: northerly drift in winter, southerly drift in summer	Sediment supplied by large drainages and/or sea cliffs and transported by longshore drift; stability affected by jetties, dredging, and other activities



Figure 23. Coastal retreat at Rocky Point has almost totally removed old highway. New highway is bridged over the hazardous terrain at right of photograph.

Figure 24. Coastal retreat of Tertiary bedrock cliffs south of Cape Blanco results from massive slumps, slides, and slope erosion. (Oregon Highway Division Photo)



The Orford Reef, composed of Tertiary bedrock, is covered by very shallow water over large areas. Its surface probably formed since sea level stabilized 5,000 years ago and consequently is in equilibrium with present sea level.

Sheared pre-Tertiary bedrock: Wave erosion of sea cliffs composed of sheared pre-Tertiary bedrock between Lookout Rock and Sisters Rocks and at scattered localities south of the Rogue River has resulted in large areas of mass movement extending for considerable distances inland. Immediately north of Houstenader Creek a prominent shear zone underlies the coastal slopes. Pervasive shearing has so reduced the strength of the rocks that the slope is continually in motion, causing ongoing damage to the highway and rendering the entire area unfit for most forms of development. Dicken (1961) estimates that coastal erosion in this area averaged one foot per year between 1940 and 1953 and notes that in 1958 slides involving up to 165 feet of displacement occurred on the slope. A quarter-mile long stretch of the beach was elevated 25 feet as a result of rotational movement along the base of the slide. Later, an April storm eroded the elevated beach back a distance of 30 feet. Thus, even though the rate of coastal erosion in slide-prone terrain composed of sheared bedrock may average only a few inches per year, sporadic episodes of coastal erosion may involve large areas of sliding and temporary advance of the coastline.

Immediately east of Port Orford, wave erosion generates occasional mass movements onto the beach that reportedly have extended to the low water line and have involved depths of material as great as 25 feet (Dicken, 1961). Here again, sheared bedrock is involved. Presently the slopes are eroded back to storm-tide levels and exhibit a variety of mass movement characteristics including bowed trees and tension cracks. Coastal retreat since the turn of the century has totaled several tens of feet. Dredging of beach sand may constitute a future indirect threat to the area (see Beaches, below).

Bedrock in the Lookout Rock-Sisters Rocks area consists of sheared Cretaceous strata. Undercutting by wave erosion continues to generate deep-seated sliding over large areas (Figure 17) which continually damages the highway and precludes most forms of development. Dicken (1961) estimates that rates of coastal erosion at Whalehead Cove immediately north of Cape Ferrelo average 3 inches per year with local areas of retreat approximating 20 feet in 38 years. Immediately south of Hunter Creek, sheared bedrock slopes are presently fronted by beaches with well-developed berms and foredunes. Coastal sliding is presently inactive, but engineering problems associated with old mass movement areas are of considerable importance (see Mass Movement).

Terrace deposits over bedrock: The Harbor Bench and Brookings area are the locations of extensive terrace deposits overlying relatively impermeable bedrock. Long-range coastal retreat is similar to that of hard pre-Tertiary bedrock, as discussed above, and is controlled by joints, bedding, and faults. An additional hazard is the slumping of terrace material over the edge of the sea cliff in response to more local conditions. In the winter months groundwater accumulates in the terrace material along the interface with the impermeable bedrock and causes localized slumping. Magnitude of the slumps generally is less than two times the thickness of the deposits and is more or less independent of actual coastal retreat in the underlying bedrock. Extensive deposits of terrace material overlying bedrock north of Port Orford are not discussed here because their retreat behavior is similar to that of the underlying bedrock, which is more permeable there than elsewhere. (See discussion of Tertiary bedrock coastal retreat above.)

Impacts and recommendations: Wave erosion in Curry County is characterized by sporadic coastal retreat in hard pre-Tertiary bedrock, slow uniform retreat in Tertiary bedrock, large-scale mass movement in sheared pre-Tertiary bedrock, and local terrace slumping where terrace material overlies impermeable bedrock. These processes should be considered in all developments along the headlands and sea cliffs. Erosion rates can be derived from the study of sequential maps and photographs, examination of county and city records, interviews, on-site inspection, and actual monitoring. Factors to be considered in on-site inspection include distribution of vegetation, types of mass movement, degree of beach protection, bedding, and the presence of structural weaknesses such as joints, faults, and shear zones. Where development is on terrace material, adequate set-back should also be allowed for potential slumping of the terrace deposits, and care should be exercised in drainage control to assure that ground moisture is not increased needlessly.

Beaches

A beach is a sloping zone of sand or gravel situated between the ocean and other landforms such as terraces, sea cliffs, or dunes. Deposits tossed by storm waves to the backside of the beaches are called berms. Beaches in the study area consist of fine- to medium-grained sand and are coarser grained than bottom sediments short distances out to sea (Kulm and others, 1975). Locally gravel is also present around sea stacks and headlands. The beaches are of two types: 1) drift beaches situated north and south of Cape Blanco, north and south of the Rogue River, and at the mouth of the Chetco River; and 2) swash beaches situated north of Brookings to Crook Point and in the Humbug Mountain area.

The formation of a beach requires a source of sediment and is controlled primarily by the nature of 1) the source, 2) longshore drift, 3) surrounding topographic features, and 4) climatic activity. Variations in these determine the form of a given beach, and changes in any one of them can affect the stability of a given beach through time. An understanding of these parameters is fundamental in assessing probable beach adjustments to the activities of man (see Recommendations, below).

Drift beaches

Drift beaches are gently arcuate to almost straight and are oriented oblique to the oncoming wave fronts. They are located near the mouths of major drainages such as the Rogue River and along stretches of relatively easily eroded bedrock sea cliffs, as in the Cape Blanco area. It has been estimated that a flood with a discharge of 400,000 cubic feet per second delivers 1,000,000 cubic yards of sand and gravel to the ocean on the Rogue River (U.S. Army Corps of Engineers, 1975). In contrast, a coastal retreat rate of one inch per year on the sea cliffs north and south of Cape Blanco probably yields only 20,000 cubic yards of additional material per year (assuming average cliff heights of 100 feet over a 12-mile length of coastline).

Effect of longshore drift: Drift beaches are the product of longshore drift, the transport of sand along the coastline by waves and currents. As waves impinge obliquely on the coastline, sand is transported down the coast in the breaker zone. At greater depths, waves touch bottom at a depth equal to half the distance between crests and they transport sand if the energy supply (determined largely by wave height) is sufficient. Generally, significant longshore drift is restricted to depths less than 60 feet (Trask, 1955), although evidence for some transport at greater depths is available (Kulm and others, 1975). Off the coast of northern California, sand at depths greater than 90 feet is essentially immobile, and there is no significant transport of sand around headlands (Cherry, 1965).

Longshore drift along the Oregon Coast is northerly in the winter and southerly in the summer in response to prevailing winds. On the basis of heavy-mineral studies Kulm and others (1968) and Kulm and others (1975) identify a northerly component of drift and conclude that it is the predominant direction of transport in a regional sense. Determination of predominant directions of transport along specific beaches requires either detailed monitoring or rigorous analysis of wave patterns over a period of years. In Curry County, gross longshore sediment transport rates may exceed one million cubic yards per year in areas of adequate sediment supply, as along the Rogue River area (see Appendix F).

Farther offshore, currents may periodically transport sediments short distances at considerable depth. A study off the coast of Newport revealed mean velocities of 13 to 27 centimeters per second at depths of 20 to 75 meters at various times of the year (Komar and others, 1973). Kulm and others (1975) record velocities of 30 centimeters per second at depths of 36 meters in calm weather and 75 meters per second at a depth of 50 meters in severe storms. Very fine sand is rippled at depths of 90 to 200 meters off the Oregon Coast depending on local conditions. Relationships between current velocities and particle size and transport processes are summarized in Figure 25. Information of this sort is critical in evaluating offshore dredge disposal operations such as those proposed by the U. S. Army Corps of Engineers (1975) and offshore mining operations.

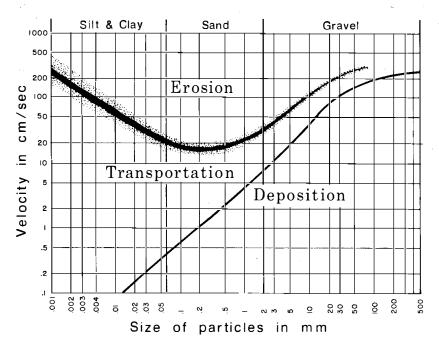


Figure 25. Erosion and deposition plotted as a function of particle size and current velocity. (After Dunbar and Rodgers, 1957)

Effect of topography: Topographic features which influence drift beach form include headlands, off-shore sea stacks, and rivers. The beach immediately north of the Rogue River is convex seaward, presumably in response to the wave protection afforded by the Rogue Reef offshore. Farther north the mouth of the Sixes River is located in a protected area of relatively moderate wave action behind Castle Rock, a nearshore sea stack. To the south, at the mouth of the Chetco River, a spit extended northward from the south bank prior to jetty construction; a north spit was not present because no sediment passed around Chetco Point from the north.

Terrain modifications which alter patterns of longshore drift or sediment supply may influence the stability of beach areas. Activities of this nature may include the removal of small sea stacks, the construction of jetties, dredging, construction of dams on larger drainages, and artificial protection of eroding sea cliffs in areas where this is the dominant source of sediment supply.

Effect of weather: Seasonal fluctuations of beach form and stability develop in response to the constructive and destructive wave types so commonplace along the Oregon Coast. Summer swells are characterized by long wave length and uniform size. They transport sand in the beach zone and are responsible for beach construction. Winter waves, by contrast, are short and choppy and have a destructive influence on coastal beaches and at shallow depths. Summer swells are generally from the northwest and winter waves generally are from the southwest, especially during gales. Bascom (1951) determined that for Pacific Coast beaches a ratio of 0.03 for wave height to length was the cutoff point between constructive waves at lower values and destructive waves at higher values.

Long-term fluctuations in the weather may influence the overall balance between constructive and destructive waves, resulting in longer term variations in beach stability. Although the specific pattern is unclear, recent research clearly demonstrates that short-term and long-term climatic fluctuations are a reality and that the earth is entering a period of significant climatic change. Scattered evidence suggests that Oregon beaches are fluctuating, possibly in response to this climatic activity. Rea and Komar (1975) show that Salishan Spit, for example, was much less extensive 35 years ago than at present and suggest that a long period of growth may now be passing into a period of beach retreat.



Figure 26. The sand spit and shools between the jetties at the mouth of the Rogue River present severe hazards to navigation.



Figure 27. The mouth of Floras Creek is blocked by beach material swept in from the south by longshore drift. New River is forced northward several miles before crossing the beach ridge to the ocean.

Gold Beach: Gold Beach is a nine-mile long accreting drift beach located on either side of the mouth of the Rogue River. The south segment of the beach is very gently arcuate and the northern segment is strongly convex toward the west owing to the wave protection offered by the Rogue Reef offshore. The headlands behind the beach are not presently eroding, and the source of sediment for the beach is the Rogue River. A flood with a discharge of 400,000 cubic feet per second on the Rogue River delivers approximately 1,000,000 cubic yards of sand and gravel to the sea (U. S. Army Corps of Engineers, 1975).

Gross longshore drift totals approximately 1,000,000 cubic yards per year (see Appendix F). Direction of drift varies with the seasons. Northerly drift in the winter has minimal impact on the dredged channel of the Rogue owing to the flushing capacity of the river during high winter flows. Southerly transport in the summer, in contrast, carries sand around the north jetty against the south jetty, where it forms a spit which migrates upstream as a result of wave action (Figure 26). Orientation of the jetties toward the southwest tends to minimize shoaling, but study of wave refraction patterns on aerial photographs suggests that the north jetty is not long enough. Dredging in the channel averages 112,000 cubic yards per year.

Prior to jetty construction, the mouth of the Rogue River was 200 feet wide and water depth varied from 2 feet below mean lower low water in the summer to 9 feet below mean lower low water in the winter. Between 1960 and 1964 (after the jetties were built) accretion north of the north jetty averaged 560 feet per year in places. Stembridge (1975) notes considerable beach accretion north of the jetty between 1939 and 1967. Conceivably some of the accretion during this time period could be attributed to long-range cyclic variations in beach stability. Future stability of the accreted areas is dependent upon climatic activity, storms, and upkeep of the jetty.

Port Orford beach: Port Orford beach is bounded on the northwest by The Heads and on the southeast by Rocky Point and for much of its length is backed by mass movement terrain (see Headland and sea-cliff erosion - Sheared pre-Tertiary bedrock). The major source of sediment for the beach is the sea cliffs, which may supply approximately 10,000 cubic yards of material per year (assuming $2\frac{1}{2}$ miles of cliff 100 feet high and an annual erosion rate of 4 inches per year). Hubbard Creek, the only drainage into the area, passes through marshy ground and probably delivers negligible sediment to the beach zone. Direction of drift varies with the seasons. In the Port Orford area net drift is probably to the north owing to the almost total elimination of south-moving waves by The Heads.

Owing to a history of storm-wave damage to Port facilities at Port Orford, a breakwater was constructed at The Heads in 1968. Subsequently, the quieter water around the docks resulting from breakwater construction also resulted in increased sedimentation (U. S. Army Corps of Engineers, 1975) so that now the equilibrium depth appears to be about 2 or 3 feet below mean lower low water. Dredging to maintain the turning basin has averaged over 12,000 cubic yards per year since 1971.

Scale model studies by the U. S. Army Corps of Engineers at Vicksburg, Mississippi indicated that shoaling of the turning basin is a result of reflected waves carrying sediment into the area from the beach. The possibility exists that increased dredging, as proposed for the future (U. S. Army Corps of Engineers, 1975), could result in increased rates of sand loss from the beaches. This, in turn, could trigger an increase in coastal erosion and mass movement in sea cliffs southeast of Port Orford.

Beaches north and south of Cape Blanco: North of Port Orford the marine terraces rise toward Cape Blanco and farther north decrease in elevation to near sea level in the vicinity of Floras Lake. Beaches fronting the sea cliffs receive sediment from the cliffs at an estimated rate of approximately 20,000 cubic yards per year (see Headland and sea-cliff erosion). Sediment supplied from the drainages of the Elk and Sixes Rivers is probably of secondary importance. Langbein and Schumm (1958) show that for forested areas of similar precipitation patterns, the rate of sediment production is 250 tons per square mile per year. The drainages total about 200 square miles, produce 50,000 tons (20,000 cubic yards) of sediment annually. Assuming that 25 percent is sand-size material deposited in the beach zone, the annual supply of beach sediment is 5,000 cubic yards per year.

Net longshore drift to the north is indicated by the northward growth of the spits at the mouth of Elk River and New River (Figure 27). The Sixes River maintains a relatively stable exit to the sea in an area of wave protection in the lee of Castle Rock sea stack. Rates of sediment transport to the south in the summer and to the north in the winter are probably great in comparison to the minor annual net transport to the north.



Figure 28. Jetty construction at the mouth of the ChetcoRiver has stabilized the spitand has prompted construction of diverse water-dependent focilities. (Oregon Highway Division Photo)

Chetco beach: The beach at the mouth of the Chetco River is very small and has been modified greatly by recent jetty construction (Figure 28). The cliffs are eroding very slowly and provide minimal sediment; the bulk of sediment for beach development is supplied by the Chetco River. Accretion is noted on both sides of the jetties but is more predominant on the south side of the south jetty than on the north side of the north jetty. During severe winter storms minor shoaling occurs in the channel along the outer ports of the south jetty as a result of littoral drift. Shoaling upstream in the vicinity of the boat basin is more extensive and results from stream deposition.

Other beaches: Nesika beach derives sediment primarily from headland erosion and to a very minor extent from Euchre Creek. Directions of longshore drift vary with the seasons. The Pistol River beach is located in an area of minimal coastal retreat and derives sediment from the Pistol River. Using the figures of Langbein and Schumm (1958) and assuming retention of 20 percent of the material in the beach zone, an annual rate of sediment supply of 2,500 cubic yards per year is estimated. The spits at the mouth of the Pistol River grow northward in the winter and southward in the summer over a total distance of several hundred feet in response to longshore drift.

Swash beaches

Swash beaches are concave beaches located between headlands and having shorelines parallel to the oncoming wave fronts. Swash beaches of Curry County are located in the many coves of hard pre-Tertiary terrain between Brookings and Crook Point and also in the Humbug Mountain area; they are generally a few hundred yards to a half mile in length.

Coastal retreat supplies a few hundred cubic yards of material to the typical swash beach annually, and sediment supplied by the local streams is essentially negligible. The beach deposits are generally thin; they are rich in heavy minerals and gravel-size fragments near headlands and sea stacks, reflecting the major sources of sediment supply. Active landslide areas provide considerably more material; but most of it is quickly washed away by the vigorous wave activity of the headlands environment.

Swash beaches retreat very slowly in harmony with the coastal retreat of the surrounding headlands. However, seasonal storm activity and large storms can destroy large parts of the beaches, only to have them quickly restored as longer swells wash the sediments back to shore during milder weather. Because wave fronts characteristically are parallel to the beachfront, rather than impinging at an angle as with drift beaches, there is essentially no supply of sediment by longshore drift from adjacent beaches. In addition, sediment transport from adjacent areas is hindered by water depth around the headlands.

Recommendations

The carrying capacity of waves is significantly altered by modifications of sediment source, bathymetry, coastal topography, longshore drift, and climate. Recognition of problem areas rests fundamentally on one's viewing of the coastline as a sediment-transport system which remains in equilibrium until any one of the above factors is changed.

Geologic investigations should precede all development in areas subject to coastal erosion and deposition. Goals, magnitude and probability of hazard, and economics largely determine the nature of the investigation and the method of treatment. In beach areas, provisions should be made to assure that modified patterns of erosion and deposition lie within acceptable limits. Development of foredune areas is potentially very hazardous.

Adverse impacts of coastal erosion and deposition can be minimized through a variety of techniques (Table 20). Impacts can be further minimized through proper design of the selected project. For example, the impacts of groins can be reduced by placing limits on their lengths, and the impacts of jetties can be reduced by developing designs most consistent with their natural setting.

Slope Erosion

Definition and causes

Slope erosion is the regional erosion of sloping ground which occurs as a result of sheet wash (uniform removal of soil with no conspicuous channels), rill erosion (removal of soil by numerous small rivulets), and gully erosion (removal of soil by larger more permanent channels). It does not include erosion of larger channels between slopes or stream-bank erosion, and ideally it does not include degradation by mass movement. Dominant factors controlling slope erosion are land use, slope, and soil type. These are related indirectly to rock type (Table 21).

Soil erosion is extremely sensitive to slope gradient and moderately sensitive to slope length (Young and Mutchler, 1969). The slope intensity factor in Curry County is the greatest in the very hard pre-Tertiary bedrock east of Port Orford in the Pearse Peak area and is less extreme on the shorter, more irregular and moderate slopes elsewhere in the uplands.

Soil erodibility varies greatly with land use and soil cover. In California, Knott (1973) demonstrated that the conversion of woodland to intensive agriculture and construction increased sediment yields 65 to 85 times. Yorke and Davis (1971) record a 90-fold increase in sedimentation during conversion of pastureland to townhouses in a small watershed in Maryland. In the H. J. Andrews Experimental Forest, uncontrolled clear-cut logging increased rates of sedimentation 67 times. Anderson (1971) reports similar results in a study in California. Langbein and Schumm (1958), in a pioneering effort to quantify sediment yield rates, determined that for areas of greater than 40 inches annual effective precipitation the sediment yield rate under natural vegetation was approximately 250 tons per square mile per year. This general figure is

Table 20. Engineering treatment of coastal erosion

Treatment	Purpose	Cost	Impact and other limitations
Beach nourishment	Mitigate erosion losses on beaches by storms or other short-term activity	Relatively low	Impact on borrow area; requires ongoing program if applied to areas with long-term threats of erosion
Dune stabilization	Reduce flooding or catastrophic shore regression; also, to minimize wind erosion	Relatively low	May starve inland dune areas leading to deflation and reduction of esthetic appeal
Breakwater	Protect shore areas from wave erosion	Moderate	Not suitable in deep water; promotes local deposition behind the structure and may lead to downdrift beach starvation
Jetty	Stabilize inlets and channels and mitigate large–scale erosion; promote large–scale deposition	High	Induces large-scale erosion or deposition of adjacent beach areas; benefits must out-weigh costs
Sea walls, revetments, and bulkheads	Protect high-value structures on cliffs or dunes	Variable with design	Unattractive, limited beach access; must be designed to prevent undercutting or flanking; access to suitable construction material often a limiting factor
Groins	Maintain or increase sand supply on beach at a particular site	Moderate to high	Promotes downdrift erosion if too long; not suited to beach areas with steep gradients
Relocate	Save structure from probable undercutting	Variable	Space availability; moving skill required

adopted in calculating sediment sources for beaches (see Wave Erosion and Deposition). Although sediment yield rates and slope erosion rates (below) are closely related, they differ in that slope erosion rates do not include a consideration of localized slope deposition (Wishmeier, 1976). Consequently slope erosion rates for a given area are greater than the sediment yield rates.

Soil erosion is also a function of the permeability, structure, grain size distribution, and organic content of the soil. Swanston and Dyrness (1973) show that quartz content of parent material is a good measure of soil erodibility. In the study area, soils overlying quartz diorite and quartzose sandstone have relatively high erodibility indeces. In areas of steep slopes or very shallow depths to bedrock soil erosion is greater owing to decreased infiltration and increased runoff.

Table 21. Calculated slope erosion, Curry County, Oregon¹

Landform and <u>R</u>	Rock units	Dominant soils and <u>K</u>	Typical slope intensity and LS (for slopes of 500' length)3	Land cover	Approximate tons/acre/year	rates of erosion tons/mile ² /year
	Jpp Ter Telg	Sandy loam Silty loam Silty clay	50% LS=30	.001	4.7 940	3,100 620,000
	Tef Kr	loam		. 200	740	020,000
	Kh	K=0.35	20%	.001	1.5	960
Up lands _	KJm Tod		LS=10	. 200	300	192,000
R=450	Kuh Kuc Jop	Silty clay Silty clay Ioam	20%	.001	1,1	705
	Jd Jg Jc	Silty loam Clay loam	LS=10	.200	220	141,000
	spp Qmtm	K=0.25		<u> </u>	1	ì
	Qmtu Qmth	Sandy Ioam Silty clay Ioam	2%	.001	.045	29.0
Terraces		Silty loam K=0.30	LS=0.5	. 200	9	5,800
R=300	Qmtl	Silty clay loam	1% LS=0.2	.001	.015	9
		K=0.25		. 200	3	192
	Qft	Sandy loam Silty loam	2%	.001	.053	34.0
		K=0.35	LS=0.5	.200	11	680
Low lands R=300	sb,su,ss, m,Qal	Variable K=0.1 - 0.5	0%	.001200	D eposi	tion

See appendix for derivation of constants (C, K, LS, and R).

²C=.001 for well-stocked and well-managed forest; 0.2 for no canopy and minimal ground cover.

³Figures for LS are extrapolated beyond empirical data and are used for speculative estimates.

Many of the diverse factors controlling soil erosion are brought together in the Universal Soil Loss Equation developed by the U. S. Department of Agriculture (1972):

$$A = (R) (K) (LS) (C) (P)$$

"A" refers to the annual soil loss in tons per acre; "R" is the rainfall intensity factor; "K" is a measure of soil erodibility; "LS" is a slope intensity factor which considers slope gradient and slope length; "C" is the land cover and land use factor; and "P" is a factor of conservation practices. Until very recently empirical data used in deriving the equation were based entirely on studies of flat to gently sloping agricultural land. Land-use figures now are extended to consider nonagricultural uses. Figures for steeper slopes are extrapolated beyond the range of empirical data and are used only for speculative estimates. The Universal Soil Loss Equation is appropriate for estimating potential soil losses for particular parcels of land.

The United States Geological Survey is now developing another technique for estimating potential soil losses on a regional basis (Brown and others, 1974; Rickert, oral communication, 1975). This method will employ series of overlays depicting slope, bedrock, land use, and other factors for specific regions and will define a range of erosion provinces. Collating these data with existing erosion data will produce semi-quantitative estimates of potential erosion. The technique will be appropriate for regional assessments of erosion and sedimentation potential.

Distribution

Table 21 was derived by using the Universal Soil Loss Equation to approximate the rates of soil erosion for the various landforms of Curry County under varying conditions. Values for the constants are derived in Appendix G. It is shown that slope erosion is most extreme on long steep slopes of the uplands. Included are areas of hard impermeable rocks such as diorite and Early Cretaceous sedimentary rock east of Port Orford, dacite at Mount Emily, and other scattered upland areas. Soil erosion rates are less extreme on the more moderate slopes underlain by the Otter Point and Dothan Formations, especially in shear zones characterized by short, irregular slopes and pockets of local deposition. Soil erosion is minor on the terraces, and deposition occurs in the lowlands. Although the alternative method of estimating soil erosion, the Erosion Province Method, does not treat rainfall intensity and soil texture directly, it would yield similar results in the study area and also would yield erosion province boundaries within the uplands. The technique was not used owing to time constraints and the general orientation of this study.

Impacts

Where extensive areas have been deforested by fires, clear cutting, road construction, or other activities, the increased rates of sedimentation downslope can adversely affect streams (Thompson and others, 1972). Gravel deposits can be rendered unsuitable for spawning, and silted stream channels can increase the threat of lowland flooding. In addition, the loss of topsoil in some areas may be so rapid that the necessary soil for forest regeneration is lost before new cover is established (Figure 29). Calculated rates of erosion for long, bare, steep slopes of 620,000 tons per square mile per year (Table 21) are equivalent to a loss of greater than 6 inches of top soil per year. Where allowed to continue to a point of pronounced gully formation these processes do irreparable damage to the landscape and probably also result in more rapid runoff of surface water.

Recommendations

Various governmental agencies are involved in the control of erosion and sedimentation. The U. S. Forest Service conducts hydrologic studies and investigates sedimentation and erosion resulting from forest practices on Federal lands. The Oregon State University Department of Forestry has an ongoing program of investigation of erosion, sedimentation, and stream flow related to various forest practices. The State Department of Forestry regulates forest uses through implementation of the Forest Practices Act of 1971. The U. S. Soil Conservation Service maps soils and advises local officials; and local Soil and Water Conservation Districts conduct surveys and promote conservation by managing Federal and State projects within their boundaries. The purpose of these programs is to apply knowledge of soils erosion to land use so that maximum benefits can be derived from the soil resource while erosion is kept within acceptable limits.



Figure 29. Severe gullying of an area originally exposed by sliding has removed topsoil, making this slope unsuitable for reforestation.

Slope erosion and deposition can be minimized by proper planning and management. Roads in the uplands should be located on benches, ridge tops, and gentle slopes rather than on steep hillsides or in narrow canyon bottoms. Vegetation removal and soil disturbances should be kept to a minimum during construction or logging. Where new land uses will measurably affect infiltration rates, adequate provisions should be made to handle runoff. Other techniques to minimize erosion and deposition include the use of buffer strips and settling ponds along drainages and the application of protective ground cover such as mulch, asphalt spray, plastic sheets, sod, or jute matting in critical erosion areas. Logged areas should be replanted where reseeding has been unsuccessful.

For the purposes of regional land-use management it is sometimes desirable to construct soil erodibility maps. With a knowledge of the relative significance of the various factors of soil erosion, meaningful soil-erosion provinces can be defined and can be delineated on maps, using overlay techniques. Relative soil loss potentials can then be predicted in advance for planned regional land uses, and corrective measures can be implemented beforehand where necessary.

Stream Flooding

General

As discharge of a stream increases, corresponding increases are noted in the width (stream-bank erosion), depth (channel scour and rise of water level), and velocity of the stream. Thus, at a given point on a stream, velocity increases with increasing discharge. In addition, velocity for most streams increases in the down-stream direction. This is in contrast to widely held notions of rapidly flowing mountain streams. Present information suggests that increasing depth and decreasing channel roughness and turbulence downstream

more than compensate for decreasing slope downstream and allow for the observed slight overall increase in velocity.

When rising water in streams spills out of the established channels into the surrounding lowlands, flooding occurs. Various subdivisions of flood areas include the flood plain (subject to inundation by larger floods), the floodway (stream channels or channels that convey fast moving waters), and floodway fringe (area of the flood plain out of the floodway but subject to periodic flooding).

The U. S. Army Corps of Engineers, U. S. Soil Conservation Service, and U. S. Geological Survey delineate areas subject to flooding with a variety of computor models. The programs are used to produce flood maps for a variety of desired frequencies. An Intermediate Regional Flood (also referred to as the 100-year flood) is the flood having a 1 percent probability of occurring in any given year. Flooding indicated for the lower Rogue River (see Geologic Hazard Map of the Gold Beach Quadrangle) is an Intermediate Regional Flood. The U.S. Soil Conservation Service prepared the original map in 1972.

In the absence of statistical models, maps showing past flooding can be assembled using flood records, high-water marks, interviews, newspaper accounts, and aerial and surface photographs. Such data are the basis of the flood-prone areas indicated for most of the streams of western Curry County (see geologic hazards maps). Although the period of observation is approximately 100 years, the indicated flood (see geologic hazards maps) differs significantly in kind from the Intermediate Regional Flood. It is a composite of many historical floods of undetermined frequency rather than the result of rigorous statistical treatment of flood data of known frequency.

For areas in which there is little or no recorded data, flood-prone regions can be deduced from topography, landforms, soils, vegetation patterns, and other natural features. Information of this sort is generalized and constitutes the basis for the delineation of flood-prone areas in the remote parts of the study area. In general the flood-prone areas indicated on the hazards maps are equivalent in distribution to the Intermediate Regional Flood.

In many upland areas, reaches of streams having little or no flood plain are the sites of an additional type of flooding characterized by catastrophic erosion and deposition. For lack of a better term these are termed flash floods or torrential floods. Owing to the limitations of scale they are not indicated on the geologic hazards maps, but they can be inferred for streams of steep gradient in steep interior uplands of moderate to high relief. These floods impose constraints on roads, fills, bridges, and other construction, and are discussed under Stream Erosion and Deposition.

Causes

Flooding is caused by large increases in discharge or by a wide variety of natural or man-caused modifications of the channel geometry which also increase the level of the water in a stream. The Manning equation of stream discharge provides a systematic basis for reviewing the causes of stream flooding and for qualitatively predicting the impacts of various possible channel modifications: $Q = (1.486/n) (A) (R)^{2/3} (S)^{1/2}$

where Q is the discharge (cfs), n is the channel roughness, A is the cross sectional area of the channel, R is the hydraulic radius (A divided by the wetted perimeter), and S is the slope (gradient) of the stream. Flooding can be caused by increasing Q or by holding Q constant and modifying factors on the right side of the equation so that depth (a factor in A and R) is increased.

Most natural flooding in Curry County is the joint result of heavy rainfall and possible rapid snowmelt (see Climate), low infiltration rates into bedrock (see Engineering Geology - Bedrock Geologic Units), steep slopes, steep gradients, and low water retention of many of the soils. Most local floods reach their crest within a matter of hours after peak precipitation.

Land use can also influence flooding by altering surface-water residence times and infiltration rates. In a recent study on part of Long Island, New York, urbanization of open land increased the volume of direct runoff by factors of 1.1 to 4.6, depending on local conditions, and peak runoff increased by a factor of 3 (Seaburn, 1969). A similar study of the Colma Creek drainage in California revealed a doubling of storm runoff, but no change in peak flow (Knott, 1973). A variety of modeling procedures is available for predicting runoff patterns in areas of changing land use (Rantz, 1971).

The impact of logging on stream flooding appears to be minimal. Studies in the Alsea drainage (Harris, 1973) and the H. J. Andrews Experimental Forest (Rothacker, 1970–a,b) show no increase in peak flows after clear-cut logging. These conclusions are based on a 95-percent level of confidence in their graphical comparisons, however, and a selection of a 67-percent level of confidence might yield different conclusions. Also, little attention has been given to the actual volume of storm-generated runoff (as opposed to peak flow in small watersheds) and the manner of its conveyance through lowland areas. The impact of increased sedimentation in channels downstream must be further investigated. A final consideration is the long-term change in runoff patterns in areas where denudation leads to accentuated gullying and loss of topsoil.

A beneficial impact of logging in many areas is increased streamflow during dry summer months when water consumption is at its peak. Removal of conifers has been shown to reduce summer evapotranspiration by approximately 18 inches in the H. J. Andrews Experimental Forest (Rothacker, 1970-a,b). As a result, summer streamflow after logging increased by about 30 percent (Moore, 1966). In regions of drier climate, thinner soils, and less uniform original conifer cover this beneficial impact of logging would be less dramatic.

If discharge (Q) is held constant, flooding can be generated or aggravated by modification of the cross-sectional area (A) or slope (S). Thus, artificial fill, other obstructions (road fill, bridges, structures) in stream channels or floodways, gravel deposition generated by increased slope erosion (see Slope Erosion), and channel blockage by landslides can contribute to flood potential. The Flood Insurance Act of 1968 administered by the U. S. Department of Housing and Urban Development and the Natural Hazard Goal adopted by the Land Conservation and Development Commission regulate obstructions in the floodway. Placing of fill in channels is regulated by the U. S. Army Corps of Engineers and the State Land Board.

Slope (S) is influenced by tides, storm surge (see Ocean Flooding), aggradation (see Mineral Resources – Sand and Gravel), spit development (see Wave Erosion and Deposition), and channel modifications. If slope (S) is decreased, then cross-sectional area (A) (and, therefore, depth) must be increased accordingly to accomodate a given discharge, and flooding may result. Other factors which influence flooding include water impoundment by log jams, and impoundment or stream diversion by snags.

The impact of channel modifications for flood control, aggregate removal, erosion control, or other purposes depends on the specific conditions at a given site. Thus, channel restrictions in middle reaches of a stream may aggravate flooding in an undesirable manner. In the estuarine reaches, however, restrictions may favorably increase velocity and reduce sedimentation. The training dike constructed along the south side of the mouth of the Rogue River (see Stream Erosion and Deposition) was designed specifically to direct currents against the north shore and to reduce shoaling in the North Bank turning basin. It is imperative that channel modifications be preceded by well-informed investigations of the hydrology of the particular reach of the specific stream in question.

Basin characteristics, flow data, tidal characteristics, current characteristics, and fish resources of the major streams and rivers of western Curry County are summarized on Table 22.

Distribution

The indicated distribution of potential flooding on the geologic hazards maps is based primarily upon statistical analysis along the lower Rogue River (U. S. D. A. Soil Conservation Service, 1972–a); physical features and records of the 1964 flood in the central and southern parts of the County; and physical features and numerous historical floods in the northern part of the County, where the impact of the 1964 flood was not exceptional. The flooding indicated for the lower Rogue River is for the Intermediate Regional Flood, and the flooding for other areas is generally equivalent to that of an Intermediate Regional Flood.

Surface elevation of an Intermediate Regional Flood at the mouth of the Rogue River is 18 feet msl and includes consideration of a high tide with an elevation of 6.3 feet msl. The Intermediate Regional Flood is 7.4 feet deeper than a 10-year flood downstream from Squaw Creek and is 11.0 feet deeper than a 10-year flood upstream from Squaw Creek. Distribution of the Intermediate Regional Flood (100-year flood) is approximately equivalent to the distribution of the 500-year flood.

General discharge data and recurrence frequencies for the major floods of the Rogue River are summarized on Table 23.

Steelhead

Cutthroat

Chinook

Cutthroat

Chinook

Cutthroat

Coho Steelhead

(critical summer flows)

(critical summer flows)

Coho

Coho Steelhead

in summer to two-

layered in winter

Well-mixed in sum-

mer to two-layered

Well-mixed in sum-

mer to two-layered

in winter

in winter

prior to

jetty con-

struction)

Flow (cfs) Drainage and Rainfall Tides area sq. miles inch/year Maximum Minimum Mean Mean Diurnal Tidal mixing Anadromous fish 52 No info., probably 1,700 5.1 6.9 Chinook Chetco River 80-120 65,800 1/16/71 10/14/70 Coho 359 well-mixed in summer to two-layered in Steelhead Cutthroat winter Elk River Blocked to well-Chinook 14,300 Coho 94 65-120 48 610 5 (est) mixed Steelhead Cutthroat (critical summer flows) Pistol River 80-115 5 (est) Blocked to well-Chinook (no information; undoubtedly 106 mixed Coho similar to Elk River) Steelhead Cutthroat (critical summer flows) Rogue River 290,000 Probably well-mixed 90-120 608 7,800 4.9 6.7 (5.5 Chinook

5 (est)

5 (est)

646

Table 22. Basic streamflow and tidal data for major streams, Curry County, Oregon*

study

area

60-110

80-105

12/23/64

23,800

(Gold Beach

est. 500,000)

7/68

18

3

9/34

5,100

129

70

Sixes River

Winchuk River

^{*}Adapted from Percy and others, 1974

High water mark data used by the U. S. Soil Conservation Service in developing the Intermediate Regional Flood for the lower Rogue River is on file in the Portland Regional Office of that agency. Water levels included elevations of 35 feet at the Saunders Creek Plywood Mill and 80 feet at Lobster Creek, where debris was deposited on the bridge deck. Farther upstream water elevations were 170 feet at Agness, where water rose to the foundation of Lucas Lodge and where water was 6 feet deep in the gift shop of Singing Spring Ranch. During the flood the water rose over 80 feet above the level of low water.

During the 1964 flood, water inundated several dwellings along the North Bank Road of the Chetco River (Figure 30) and extended to the Squaw Valley-Ophir Road Junction along Euchre Creek. Minor flooding occurred along the Sixes River, but it is noteworthy that the Post Office was not flooded and never has been flooded since its construction. Along the Elk River, flood waters flooded Marsh Ranch (SW_4^1 sec. 26, T. 32 S., R. 15 W.) and a trailer house (NW_4^1 sec. 27). Flooding of Floras Creek during the flood of 1964 was not considered noteworthy by local residents.

Table 23. Discharge and recurrence frequency of major floods of the Rogue River*

	Discharge in cfs	Recurrence
Year .	(at Grants Pass)	frequency
1861	175,000	
1890	160,000	63 years
1907	60,000	
1909	70,000	
1927	138,000	. 38 years
1942	54,000	•
1943	70,000	
1948	60,000	
1950	65,000	
1953	77,000	8 years
1955	135,000	37 years
1964	152,000	50 years
.1.		

^{*}Adapted from State Water Resources Board (1959)

Impacts

Flooding destroys structures through current action, siltation (see Stream Erosion and Deposition) and water damage. It inflicts losses on agricultural land by scouring topsoil, eroding streambanks, silting croplands (see Stream Erosion and Deposition), and killing livestock. It threatens people by isolating dwellings, damaging property, disrupting transportation, and polluting or disrupting water supplies. Impacts in Curry County include damage associated with standing water on the north coastal plains and damage associated with rapidly moving water in the lower reaches of the Rogue River.

The flood of 1964, resulting from torrential rains and a rapidly melting snowpack, did \$7 million worth of damage in Curry County. The Rogue River area was hardest hit. At Agness the Illinois River Bridge, which normally stood 90 feet above the water, and the swinging bridge were totally destroyed. Two dozen homes were damaged or destroyed. Locally, water rose 83 feet and flooded areas that were dry during the flood of 1890. The Rogue River bridge immediately upstream from Agness was undamaged, but was littered with water-borne debris. At Illahee, rainfall for the period December 19–23 totaled 21.9 inches, with 8.2 inches falling in one 24-hour period.

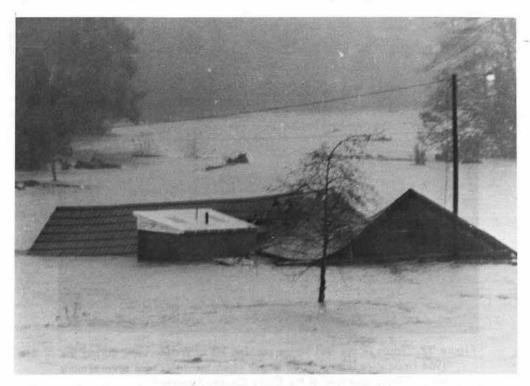


Figure 30. A small group of trees was all that prevented this house from floating out the mouth of the Chetco to the Pacific Ocean during the flood of 1964. View is on the west bank of the river looking north toward Snug Point. (Photo courtesy of the Brookings Harbar Pilot)



Figure 31. Rogue mail service boats were anchored in the driveway of Lex Fromm's boat house during the 1964 flood. (Photo courtesy of the Curry County Reporter)



Figure 32. Boats in the Del Rogue parking lot at Wedderburn during the 1964 floodwere later washed to sea when the water rose several more feet. (Photo courtesy of the Curry County Reporter)



Figure 33. Water rose to window sill heights at Angler's Resort and other establishments along the Rogue River at Wedderburn during the 1964 flood. (Photo courtesy of the Curry County Reporter)

Downstream, water flowed over the Lobster Creek Bridge and washed away Lucky Lodge on the north bank of the river 6 miles upstream from the mouth.

At Gold Beach, 24 commercial enterprises were flooded by as much as 15 feet of water (Figures 31, 32, and 33). Three industries were damaged by water up to 6 feet deep, and seven homes at the Kimble Kourt subdivision were washed off their foundations. Water rose to within one foot of the eaves of the Drift Inn Motel and was at window-sill heights at Jot's El Rio Vista Motel. Water crossed the road at the Rod 'n' Reel Restaurant. A total of 30 families were evacuated from their homes in the Gold Beach area. At the mouth the north jetty was undercut by eroding currents (see Stream Erosion and Deposition) requiring \$500,000 in repairs.

At the mouth of the Chetco River, water rose 5 feet above the 12-foot gage and flooded much of the port area with 6 feet of water. Boat basin damage (Figure 34) and flood damage along both banks of the Chetco River totaled \$500,000. Twelve feet of silt was deposited in the small boat basin and total remedial dredging was approximately 70,000 cubic yards. Damage along north coastal streams in Curry County was localized and was not considered notable in a regional sense.



Figure 34. Damage caused by the 1964 flood at the Port of Brookings exceeded several hundred thousand dollars. (Photo courtesy of the Brookings Harbor Pilot)

Recommendations

Flood conditions in Curry County are highly variable, and no regional guidelines are offered for dealing with the hazard. The greatest dangers are in the rapidly developing valley areas of the Chetco and Rogue Rivers, which are subject to rapidly moving flood water. The Rogue River is designated as zone V (high current velocity hazards in addition to high water) in an Intermediate Regional Flood analysis developed by the U. S. D. A. Soils Conservation Service (1972). Building codes, zoning ordinances, and management regulations must be the most stringent in these areas. Construction of dams in the headwaters of the Rogue River collectively would reduce the flood potential of the Rogue River. However, evaluation of regional proposals such as this must proceed on the basis of a systematic analysis of all of the potential benefits and adverse impacts.

Small levees of local extent in the smaller drainages are an effective defense against frequent small floods, but larger levees of more regional extent in the larger drainages probably would not be realistic owing to the high cost of construction and the difficulties of maintaining such structures against strong currents. Hazards of ponding and standing water of regional extent in the north coastal plains area may be handled in many instances by requirements for disclosure statements in land transactions, provision for the erection of flood-warning signs, and requirements for construction on fill or piling above the level of flooding in suitable areas. Designs for road fill in this area should allow for the passage of water. The removal of gravel from large and middle-sized rivers in western Curry County probably minimizes flooding by allowing for the more efficient conveyance of flood waters. Road and housing developments along the smaller drainages and creeks must be planned and engineered to accomodate runoff. Basic concepts of integrating basin size, infiltration rates, land use, and rainfall patterns into estimates of stream discharge are reviewed by Rantz (1971) in the San Francisco Bay area. Unfortunately similar guides are not available for Oregon. However, Wheeler (1971) provides graphical techniques for crudely determining the magnitude and frequency of flood peaks for ungaged basins of coastal Oregon.

Assistance in developing flood-plain management plans is provided by the Oregon Department of Water Resources, and broad policies are formulated by the Land Conservation and Development Commission. The U. S. Soil Conservation Service administers the Watershed Protection and Flood Protection Act of 1954 and provides technical assistance for channel protection and other flood-related projects.

Declaration of a flooded area as a disaster area by the Governor allows the release of funds for the restoration of public facilities, river-bank repair, and low-interest loans to individuals and small businesses. Assistance of this type is coordinated by the Office of Emergency Preparedness, the State Emergency Service Center, and local officials.

Emergency preparedness includes flood forecasting and flood warnings by the National Weather Service River Forecast Center in Portland. Flood fighting by local personnel is commonly supplemented by the U. S. Army Corps of Engineers and is coordinated by the State Emergency Operations Center. The Flood Insurance Act of 1968 is administered by the U. S. Department of Housing and Urban Development with the assistance of the State Department of Water Resources and provides flood insurance to individuals and businesses in regulated developments.

Stream Erosion and Deposition

General

Most streams and rivers exhibit a balance between velocity, discharge, sediment load, channel roughness, stream width, and stream depth. Changes in any one of these parameters inevitably leads to changes in one or more of the others. Thus changes in discharge are generally accompanied by changes in velocity, load, width, and depth. In addition, it is noted that although stream velocity generally increases in a downstream direction (see Stream Flooding), the capacity to transport large particles is greatest in the upper reaches. This apparent contradiction arises from greater turbulence of mountain streams as opposed to streams with flood plains. The potential energy of falling water is translated into turbulence, friction, and erosion in steep rugged channels, whereas it is directed into the kinetic energy of swiftly flowing water in the lower reaches. Slope alone does not control the size of particles being transported.

Sediment transported along a stream bed by bouncing, rolling, or sliding is termed bed load. The bed load of the major streams of the study area is dominated by gravel and coarse sand. Material suspended above the stream bed by turbulence is termed the suspended load. Clay and silt predominate, although sand also can be transported in suspension under favorable current conditions. Where stream velocities are reduced by obstructions or other channel features, deposition occurs.

Uplands

Severe storms generate torrential flows of high-velocity waters which greatly erode upland stream channels. Recent torrential flooding is easily detected on the basis of unvegetated, coarse, stream-bed deposits (Figure 35) and scattered debris. Where vegetation has reclaimed the channel, recognition of torrential flood potential is based upon observations of indirect features including steep side slopes, steep gradients, impermeable bedrock, narrow stream channels, and the absence of a flood plain. Channels characterized by torrential flooding and channel scour pass downstream into topographically more mature landforms such as flood plains or estuaries.

Torrential flooding in the uplands commonly destroys roads and bridges (Figure 36). Where torrential flood channels spill onto flat terrain, rubble and debris fans may quickly bury roads and clog culverts. In these areas periodic road maintenance and clearing often prove more economic than culvert repair and clearing. An example of the erosion and deposition associated with torrential flooding is provided by the Bradford Creek drainage midway between Gold Beach and Agness on the Rogue River. Large amounts of debris derived from upslope have formed a large debris fan against road fill for the Rogue River Road. A short distance to the east, torrential flooding in the winter of 1974–75 washed out the Rogue River Highway. Torrential flood damage to the Rogue River highway is a common winter occurrence.

Figure 35. Where torrential floods spill onto flatter terrain, debris scoured from upland areas is commonly deposited as debrisfans. Note the logged-off, steeply sloping terrain in the background.



Road fills along torrential stream channels should be discouraged in critical areas of scouring or stream-bank erosion. Where necessary, road fills should be cribbed or composed of adequately sized material (Figure 37) to resist erosion (Figures 38 and 39). Gully crossings should either be constructed with adequately sized and properly engineered culverts or should be bridged. Where culverts are used, periodic maintenance is recommended to assure that the culverts do not become blocked with debris. Also, careful land management of upslope areas can greatly minimize the magnitude of slope erosion (see Slope Erosion) and can greatly reduce potential hazardous deposition. Where residential construction is anticipated, provisions should be made to assure that no development is allowed in the actual flood channel and that bridge abutments and channel crossings do not significantly alter streamflow.

Flood plains

Streams and rivers with flood plains differ considerably from upland streams. Major differences include gentler gradients, broader valleys with higher bank-storage potential, and unconsolidated alluvial deposits beneath the stream and to the side as opposed to channels of bedrock. As a result, the hydrologic characteristics of flood-plain streams are considerably different from those of upland streams. The relative ease of erosion of the surrounding deposits allows greater flexibility of channel width, depth, gradient, and geometry in response to changes in discharge and velocity. Patterns of erosion and deposition are generally less catastrophic than those observed in the uplands, although the force of moving water on large objects can be considerable (Figures 40, and 41).

Erosion in the flood plains is restricted primarily to the channel and to the outer bends of meanders. Deposition includes the formation of bars on the inner bends of meanders, settling of bedload with decreasing carrying capacity, and general siltation of the flood plain as silt and clay settle from relatively slow-moving overbank floodwaters. Material transported by the streams includes suspended silt and clay (Figure 42), and bedload gravel and sand. Fine- to very fine-grained sand is transported either as bed load or in suspension, depending upon current velocity and turbulence. Colby (1963) shows that considerable amounts of fine-to very fine-grained sand are transported in suspension in the Mississippi River. High stream velocities during flooding and the relative paucity of fine- to very fine-grained sand in the channel deposits of the major streams of Curry County suggest transport of suspended sand of this size during flooding. The relation-ship between water velocity and general sediment transport is summarized in Figure 25.

Undercutting by stream-bank erosion is a hazard on all major meanders of large- to medium-sized rivers in coastal Curry County including the Rogue, Chetco, Sixes, Pistol, and Elk Rivers. Undercutting is a minor hazard on several major bends of larger creeks and streams including Floras Creek, Hubbard Creek, and Euchre Creek. Smaller scale undercutting is noted on smaller streams but is of minimal impact to land use. Undercutting by stream-bank erosion can destroy roads, remove land, and initiate landslides.

Impacts of stream-bank erosion can be minimized by properly locating structures away from areas of potential undercutting or by reinforcing threatened stream banks with adequately designed and placed rip-rap. Logiams and snags in channels may initiate local undercutting and should be removed where necessary. In planning for long-range development, rates of meander migration must also be considered to assure that undercutting does not become a critical problem at a future date.

Streams are balanced systems of sediment transport in which channel modifications unrelated to erosion control may possibly result in undesirable patterns of erosion or deposition. A careful consideration of all aspects of stream regimen is recommended prior to any major changes. Finally, the complexities of streams must be recognized. The impacts of a given activity or erosion-control technique on a stream may vary between streams and may also vary with specific location on a given stream.

Estuaries

Estuaries are characterized by low gradients, complex tidal currents, ocean flooding, and sedimentation from littoral drift as well as from stream deposition. Patterns of water circulation are controlled by the magnitudes of the tides, stream discharge, and storms, and also by the geometry of the bay. High tides, low stream flows, and shallow, wide bays promote water mixing. Low tides, high stream flow, and narrow deep bays promote two-layer and partially mixed water systems. Where wedge systems are developed, salt water flows into the bay along the bottom of the bay and commonly transports large quantities of littoral



Figure 36. The flood waters of 1964 destroyed the swinging bridge at Agness. (Photo courtesy of the Curry County Reporter)

Figure 37. Riprap is used to protect the county road on the outer bend of a meander along the Pistol River.





Figure 38. On the south side of Humbug Mountain an overflow channel has been carved out of the slope to direct excessive runoff of Brush Creek directly to the ocean.



Figure 39. The lower reaches of Brush Creek, downstream from the cutoff channel shown in photo above, are cemented to prevent undercutting of the highway.



Figure 40. This boot was left hanging from the trees by the flood of 1964 on the lower Rogue River. (Photo courtesy of the Brookings Harbor Pilot)



Figure 41. This two-bedroom home was moved a fourth of a mile downstream from its Kimble Kourt "mooring" before being deposited during the flood of 1964. (Photo courtesy of the Brookings Harbor Pilot)

sediment into the estuary. In Curry County the mouths of medium-sized streams commonly become clogged with littoral sand (see Wave Erosion and Deposition) in the late summer when low stream flows are insufficient to maintain open channels to the sea.



Figure 42. Warrenton Sea Food executive kneels in 4 inches of mud and silt to dramatize the problems of deposition associated with flooding. (Photo courtesy of the Brookings Harbor Pilot)

Rogue River: Current and tidol data for the Rogue River are summarized on Table 22. The 6.7-foat diurnal tidal range is considerably greater than the 5.5-foot range estimated for the bay prior to construction of the jetties. The extreme high tide of 14 feet (on tidal gage) is less than a computed 18-foot level for the Intermediate Regional Flood.

The estuary of the Rogue River is relatively narrow and deep and is characterized by two-layered to partially mixed current systems. Shooling is most rapid in the summer, when littoral drift delivers sand into the bay from the north and waves transport it upstream to form a prominent spit against the south jetty (see Wave Erosion and Deposition). Sediments consist of fine sand over coarse gravel. It has been estimated that a flood with a discharge of 400,000 cfs delivers one million cubic yards of sediment to the ocean. Gradients for the Rogue River average 4 feet per mile to river mile 26.5 and 12 feet per mile from river mile 26.5 to river mile 85.

Prior to jetty construction the mouth of the Rogue River was 200 feet wide and was characterized by depths of 2 feet in the summer and depths of 9 feet in the winter. The south jetty was completed in 1959 and the north jetty in the following year. A boat basin along the north jetty was completed in 1961.

Total amount of material dredged for these projects was 618,000 cubic yards. By September 1963 the boat basin was shoaled to a depth of only 2 feet.

A training dike was constructed along the south bank to direct current action against the north bank in an attempt to minimize shoaling. The flood of 1964 (500,000 cfs) destroyed the training dike, undercut parts of the north jetty, and in places scoured the channel to depths of 44 feet. The training dike was completed by local interests to protect the south bank turning basin. Channel work was completed in 1972 and the boat basin was redredged in 1974 with the assistance of the U. S. Army Corps of Engineers. For lack of use the north boat basin was abandoned. Dredging in the estuary averaged 112,000 cubic yards between 1962 and 1973. Dredging in the boat basin averaged 72,800 cubic yards.

Wave refraction patterns, water depths, and patterns of deposition of littoral sand in the estuary indicate that the north jetty is too short. The south jetty extends 260 feet farther into the ocean than the north jetty. Extension of the north jetty for an additional 1,200 feet may be necessary (U. S. Army Corps of Engineers, 1970). Although water depths of 13 feet are authorized in the channel, depths of 3 to 4 feet are often obtained on the bar, and depths of 7 to 9 feet are often experienced on the channel. Authorized dredging of 200,000 cubic yards per year have not been realized, as is shown by the annual dredging average of 112,000 cubic yards per year.

Chetco River: Current and tidal data for the Chetco River are summarized on Table 22. The diurnal tidal range is 6.9 feet and the extreme high tide is 12.3 feet. The estuary of the Chetco River is characterized by two-layered and partially mixed current systems in the winter and by well-mixed waters in the summer. Rough water is experienced when southwest storm waves are reflected off the north jetty into the channel. Damage is generally not experienced, but shoaling is promoted around the ends of the jetties at these times. Shoaling by littoral drift from the north is not a problem because the estuary is protected by Chetco Point immediately north of the mouth.

All jetties and channel modifications were completed in 1957. A protective dike near the boat basin was also completed that year and was enlarged in 1959 and 1963. In 1970 the jetty was modified to reduce shoaling. It was lengthened 450 feet and was raised to an elevation of 16 feet. Other modifications included construction of a training dike and construction of channels and a turning basin.

Shoaling is restricted to deposition by northerly directed littoral drift near the end of the south jetty in the spring and to fluvial shoaling near the entrance of the mooring basin during floods. Dredging averaged 17,291 yards per year between 1963 and 1973. Dredged material consisted of medium-grained sand and fine gravel. Local dredging has not been required for the boat basin and barge slip operated by the Port of Brookings. Local interests provide bucket dredging of the entrance of the boat basin to allow passage of lumber barges.

GEOLOGY OF CITIES

General

The major communities of western Curry County are, from north to south, Port Orford, Gold Beach, and Brookings. Analysis of the geologic conditions for each of the communities with regard to land use parallels the technique outlined in Figure 1 and includes 1) use of the geologic maps to determine geologic units, 2) use of the geologic hazards maps to determine geologic hazards, 3) use of the text to develop more precise information where available, and 4) field investigations to develop on-site information. The discussion in this section does not take the place of additional on-site investigations needed for the evaluation of specific projects or plots of ground. It does, however, provide valuable guidance in the conducting of on-site investigations, and it demonstrates the systematic and proper use of this bulletin.

Port Orford

Geologic units

Geologic units in the Port Orford area include surficial terrace deposits of the Quaternary middle and upper marine terrace deposits, stabilized dune sand north of The Heads, beach sand deposits bordering the bay, marsh deposits along many of the major streams, and the Otter Point Formation exposed in sea cliffs (Figure 43).

The Otter Point Formation consists primarily of altered basalt, conglomerate, and sandstone, with minor serpentinite in shear zones. The unit has good foundation strength in the Port Orford area and is capable of supporting most structures. Locally it may be present very near the surface, which could result in high installation costs for underground utilities and in septic-tank failures. North of town a large block of blueschist assigned to the Otter Point Formation is quarried for aggregate (see Table 12).

The Quaternary middle marine terrace deposits form the flat terrain under most of the older parts of town, and the Quaternary upper marine terrace deposits form the dissected sloping areas immediately east of town and on The Heads. The units consist of horizontally bedded, semi-friable, fine- to coarse-grained sand with gravel lenses in places. Iron pans are present in the sub-surface of parts of the middle marine terrace unit.

Stable dune sand blocks the exit of local drainages on the northwest side of town and are responsible for the formation of Garrison Lake. The dunes are not acceptable for most forms of development because of wind erosion and deposition, coastal erosion, and ocean flooding. Compressible soils may be present in the subsurface.

Stream channels leading into Garrison Lake are flooded near their entries to the lake and are characterized by marsh deposits. These regions are not suitable for development. Roads placed upon fill passing over the marsh are susceptible to settling. Coring prior to construction is generally necessary to adequately define regions of potential settling, and special engineering is required to handle the problem.

Geologic hazards

Geologic hazards in various parts of Port Orford include mass movement, wave erosion, flooding, slope erosion, and earthquake potential. The hazards are localized in distribution and are generally not severe.

Mass movement includes 1) rock fall along coastal headlands, 2) sloughing of terrace material from headlands composed of massive, harder bedrock, and 3) massive earthflow along the broad shear zone that is exposed in sea cliffs from the marina eastward for a distance of approximately 1 mile. The sloughing

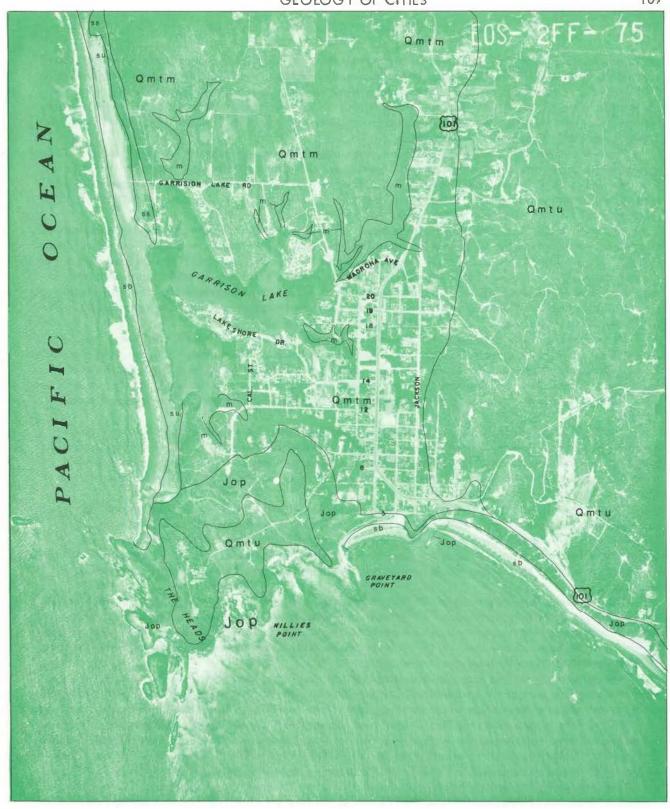


Figure 43. Port Orford aerial photo showing geologic units.

SYMBOL

Jop Qmtu Qmtm sb, ss, su m GEOLOGIC UNIT

Otter Point Formation Quat, upper marine terrace Quat, middle marine terrace beach sand, stable sand, unstable sand marsh

GEOLOGIC HAZARDS

slope erosion, mass inquement slope erosion, coastal retreat ponding, shallow bedrock shoaling, wave erosion, ocean flood, compressible soils, flooding of terrace material from headlands is caused in part by the accumulation of ground water along the interface between terrace material and underlying impermeable bedrock (see Geologic Hazards - Wave Erosion and Deposition - Headland and sea cliff erosion) and particularly dangerous to sightseers and hikers. The shear zone in the sea cliffs south of Port Orford is of late Cenozoic age and is characterized by hummocky topography inland from the beaches. Construction of permanent structures is not recommended, although stable areas within the slide region may exist.

Coastal retreat of sea cliffs provides most of the material for the beaches which line the bay. Slides generated by undercutting in the Port Orford Shear Zone (above) historically have carried material to the low tide line to be later eroded by waves. Sea cliff erosion in the Battle Rock area has removed several tens of feet of higher land since the turn of the century. In 1915 gently sloping pastureland extended seaward to within approximately 50 feet of Battle Rock.

Wave reflection and refraction from the beach at Port Orford draws sediment from the beach seaward to produce shoals around the piers and in the turning basin (see Wave Erosion and Deposition - Port Orford beach). If dredging of the turning basin is conducted on a long-term basis, and if the dredged material is disposed of at sea, it is conceivable that loss of material from the beach would lead to increased rates of mass movement in the sea cliffs east of Battle Rock. The Corps of Engineers should be advised to investigate this possibility at their Vicksburg facility prior to any dredging program. Possibly a series of groins on the beach would provide a solution to the problem of shoaling in the Bay.

No danger of ocean flooding exists within the inhabited parts of Port Orford. However, tsunami potential on the beaches constitutes a hazard to beachcombers and to the mooring facilities, and a reliable warning system is recommended. Storms inflicted considerable damages upon the mooring facilities and boats prior to construction of the jetty. Present shoaling problems are partly the result of jetty construction (see Geologic Hazards - Wave Erosion and Deposition). Extreme high tide for the bay is approximately 13 feet.

In general, the stream valleys have steep side slopes in their lower reaches and flat low-lying marsh areas upstream from their mouths along the various arms of Garrison Lake. The hydrology of the lake is such that the water level varies approximately 5 feet or less during the year. Consequently, areas subject to stream flooding are restricted to the marshes upstream from the ends of the sloughs, rather than along the banks of the sloughs.

Within the city limits, scattered low-lying areas of impermeable soil induce ponding and highground-water tables during the winter months, and basements and other excavations may be subject to flooding. The placing of fills in low-lying areas must be properly controlled to allow for proper drainage and to assure that saturation of the fills does not threaten the stability of the structures placed upon the fill. Where paving of large areas for parking lots is anticipated, the increased runoff should be directed into local drainages.

Port Orford is fortunate to have within its boundaries a lake such as Garrison Lake. Eutrophication and progressive deterioriation of such lakes commonly results from unrecognized long-term nutrient and sediment imbalances introduced by various aspects of urbanization, such as fertilizing, septic tank use, and construction (Rickert and Spicker, 1971). It is recommended that the community integrate basic concepts of lake preservation into their comprehensive plan.

The moderately sloping loamy soils of the presently developing east Port Orford area constitute the most erosion-prone area of the community. Soil erosion can be minimized by proper layout and design of roads, preservation of vegetation where possible, and efforts to minimize land disturbance during construction.

Port Orford is located on the Port Orford Shear Zone of late Cenozoic age. Although the structure is interpreted to be inactive on the basis of available geologic and seismic evidence (see Tectonic Setting-Earthquakes), an earthquake of Mercalli intensity VII-VIII is possible for the community. An earthquake of Mercalli VII was experienced in 1873 (Table 7). Damages associated with quakes of this intensity include cracked walls, toppled chimneys, and destruction of poorly constructed buildings. The recurrence frequency of quakes of this magnitude at Port Orford is probably very low, and recommendations for mitigative measures are difficult to define (see Tectonic Setting - Earthquakes).

Gold Beach

Geologic units

Geologic units of the Gold Beach area include Quaternary middle marine terrace deposits, Quaternary fluvial terrace deposits, beach sand, accreted sand south of the Rogue River jetty, sandstone and siltstone of the Otter Point Formation, and serpentinite (Figure 44).

The Quaternary middle marine terrace deposits consist of indistinctly bedded sand, silt, and clay, ranging in elevation from a few feet to greater than 50 feet. The deposits are gently sloping, well drained, and easily excavated. Foundation strengths are moderately high. Three major streams dissect the marine terrace and are bordered by Quaternary fluvial terrace deposits of gravel and sand. Foundation strengths are moderate, but drainage is poor locally.

Accreted sand south of the Rogue River jetty has high permeability but is poorly drained because of low elevations. The possible ground-water resource significance is minimal owing to the abundant ground water produced by community wells in the channel gravels of the Rogue River. Septic tanks are not an acceptable means of waste disposal in the dune sands.

The Otter Point Formation underlies the moderately steep to steep slopes of the more inland parts of Gold Beach. Soils vary greatly in thickness and texture. Bodies of serpentinite within the Otter Point Formation in the Gold Beach area are generally stable and are capable of supporting moderately sized structures. Soils over the serpentinite are very thin, and the serpentinite is not suitable for use as fill or embankment material.

Geologic hazards

The geologic hazards of the Gold Beach area include flooding, mass movement, wave erosion and deposition, slope erosion, and moderate earthquake potential. Each of the hazards is localized in distribution and with proper planning is generally not a severe threat to the community.

Flooding of the lowlands along the Rogue River is accompanied by fast-flowing currents, structural damage, and erosion and deposition. The flood of 1964 actually undercut part of the north jetty and scoured the channel to a depth of 40 feet. Dean, Riley, and Cuniff Creeks do not flood the adjoining fluvial terraces, but they require careful management along them to assure clear passage of runoff through culverts and ditches and to prevent improper placement of fill.

Ocean flooding by tsunamis and storm surge is a major threat to parts of accreted sand areas and beaches. The tsunami of 1964 brought waves 9 feet high into the mouth of the Rogue River and caused \$30,000 to \$40,000 damage. The distribution of logs in the accreted sand areas probably exceeds the present potential distribution of storm—wave damage because many of the inland logs were laid down before the accreted sand reached its present extent. Much of the inland parts of accreted sand are subject to seasonal ponding.

Areas of accreted sand north and south of the Rogue River have grown considerably since 1939 owing in part to their cyclic nature but primarily to jetty construction. The future stability of the accreted sand depends upon storms, cyclic climatic activity, and the upkeep of the jetty. Residential development below the levels of the terrace is generally not recommended at this time.

The shoaling and spit development between the jetties in the mouth of the Rogue River is the result of sand directed southward by wave action along the north beach and around the north jetty. An average of 112,000 cubic yards of littoral sand is dredged annually from between the jetties. Lengthening of the north jetty would provide more permanent partial relief (see Geologic Hazards - Wave Erosion and Deposition).

Areas of mass movement include terrain underlain by sheared bedrock of the Otter Point Formation in the middle reaches of Riley Creek east of Gold Beach and in Wedderburn. Large bodies of serpentinite immediately north of the Rogue River are actively sliding, but smaller bodies in the immediate Gold Beach area are stable. Deep cuts in all the upland units of the Gold Beach area can initiate slides.

The moderately steep to steeply sloping loamy soils of the uplands constitute the most erosion-prone terrain of the Gold Beach area. Changing land-use on a regional scale in the headwaters of Dean, Riley,

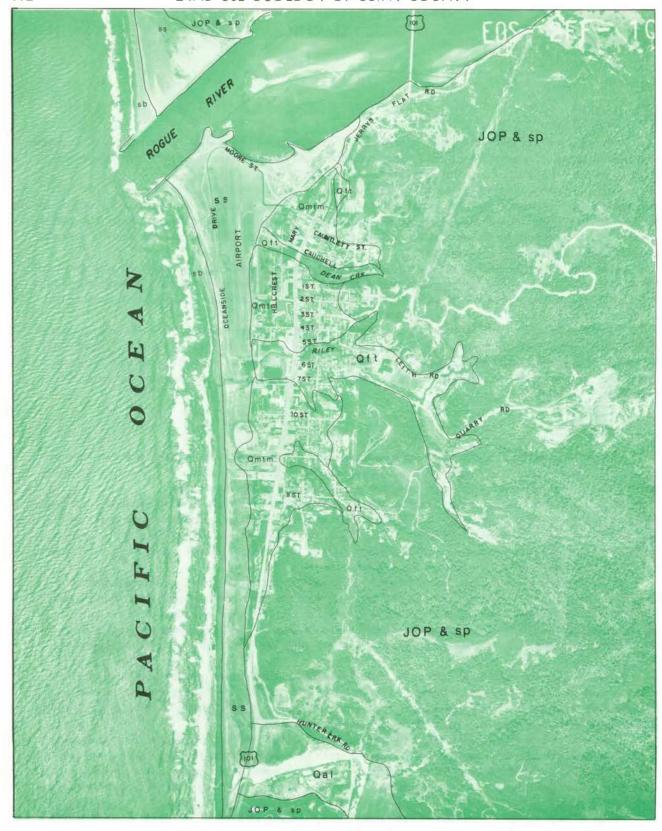


Figure 44. Gold Beach aerial photo showing geologic units.

SYMBOL

GEOLOGIC UNIT

Jop + sp Qmtm Qft ss. sb Otter Point Fm. + serpentine Quat. middle maxine terrace Quat. fluvial terrace stable sand, beach sand, fill GEOLOGIC HAZARDS

mass movement, slope erosion minimal possible stream flooding ocean flood., stream flood, wave erosion

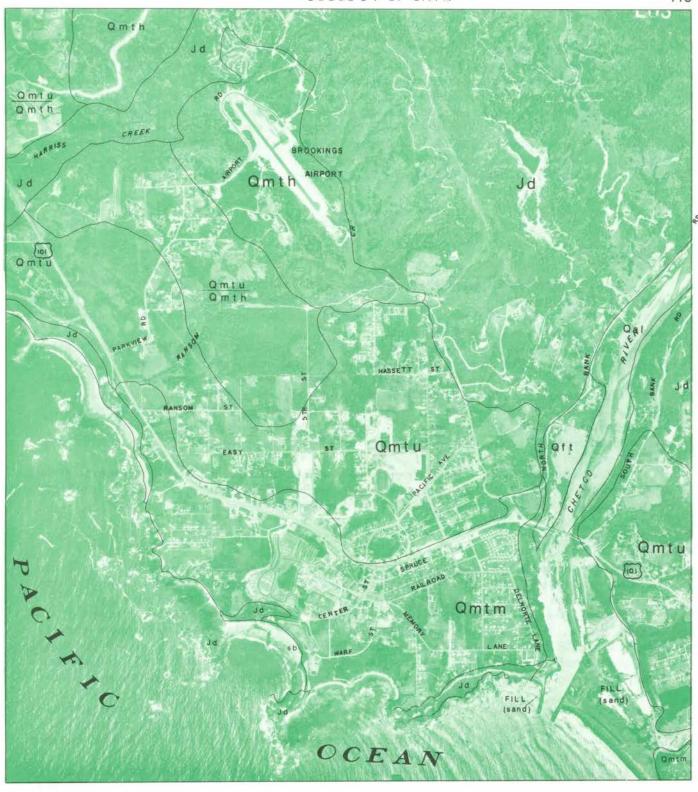


Figure 45. Brookings aerial photo showing geologic units

SYMBOL GEOLOGIC UNIT

Jd Omth Omth/Omtu Omtu Omtm Oft Oal

Dethan Formation
Quat. higher marine terraces
Quat. undiff. higher marine terraces
Quat. upper marine terrace
Quat. middle marine terrace
Quat. fluvial terrace
alluvium
sand and fill

slope erosion, local mass movement local stream-bank erosion local stream-bank erosion local stream-bank erosion ponding, near-surface bedrock stream flooding stream flooding, erosion, and deposit. ocean flooding

GEOLOGIC HAZARDS

and Cuniff Creeks could possibly initiate siltation of creek channels and adversely influence stream flooding in the Gold Beach area. Soil erosion can be minimized by proper layout and design of roads, preservation of vegetation where possible, and efforts to minimize land disturbance during construction.

Very little information is available regarding the earthquake history of Gold Beach. Because the community is constructed on solid bedrock and semiconsolidated terrace deposits, a possible future quake of Mercalli intensity VII-VIII is inferred (see Table 9). Damage associated with quakes of this intensity include cracked walls, toppled chimneys, and destruction of poorly constructed buildings. The recurrence frequency of quakes of this magnitude at Gold Beach is probably very low, and recommendations for mitigative measures are consequently difficult to define (see Tectonic Setting - Earthquakes).

Brookings

Geologic units

Geologic units of the Brookings area include the Dothan Formation, the Quaternary middle marine terrace, the Quaternary upper marine terrace, the Quaternary higher marine terrace, Quaternary alluvium, beach sand, and fill. The various terrace units cannot be equated with certainty with terrace units of the same names in northern Curry County (Figure 45).

The Dothan Formation consists of hard sandstone, siltstone, greenstone, and minor chert and is characterized by high foundation strengths, low infiltration rates, and variable soil conditions.

The terrace units are differentiated on the basis of relative elevation and relative degree of dissection. All are composed of indistinctly bedded sand and silt with basal gravel in places. Thicknesses vary from a few feet on parts of the middle marine terrace unit to several tens of feet on the higher terraces. Shallow depths to bedrock on parts of the middle marine terrace unit preclude the use of septic tanks for waste disposal and may also be major factors in the costs of installing underground facilities and in other excavations.

The Quaternary alluvium in the valley of the Chetco River consists of unconsolidated sand and gravel. Resource potential includes aggregate and ground water, and hazards include erosion, flooding, and deposition. Beach sand and fill is located south of the south jetty at the mouth of the Chetco River.

Geologic hazards

Geologic hazards of the Brookings area include flooding, wave erosion and deposition, slope erosion, mass movement, and earthquake potential. Each of the hazards is moderate to low in severity or is of local extent. The hazards generally do not pose severe threats to the community with proper planning.

Flooding of the Chetco River in 1964 inundated the port area with 6 feet of water and caused \$500,000 damage. Houses were washed from their foundations and gravel was deposited near the mooring area (see Geologic Hazards – Stream Flooding, Steam Erosion and Deposition). The tsunami of 1964 brought 9-foot waves into the bay and raised water levels to within 1 foot of the surface of the fill. The threats to safety during times of intense port use or beach use are of significance (see Geologic Hazards – Ocean Flooding).

Ponding and poor drainage on flat terrain of the middle marine terrace unit along the lower reaches of Macklyn Creek render large areas unsuitable for most development. Stream channels in the upper and higher marine terrace units are deeply entrenched and do not pose a threat of flooding. However, improper fill placement could cause stream undercutting locally.

Coastal retreat of sea cliffs averages less than h inch per year, but sporadic episodes of retreat can remove several feet of terrain at individual localities, especially in regions of terrace slumping (see Geologic Hazards - Wave Erosion and Deposition - Headland and sea-cliff erosion - Terrace deposits over bedrock). Adequate setbacks are recommended. Along the beaches south of the Chetco River, northflowing drift directs small quantities of sand into the channel, necessitating minor dredging. No sand drifts into the channel from the north in the summer, because of the headland barrier.

Mass movement in the uplands, along the Chetco River, and on the steeper slopes of the terrace units is localized and is commonly the result of oversteepening by erosion or excavation. The placing of

fill on steep slopes should be avoided. Slope erosion can be minimized by proper layout and design of roads, preservation and establishment of vegetation where possible, and efforts to reduce land disturbance during construction.

Very little information is available regarding the earthquake potential of Brookings. Because the community is constructed on bedrock and semiconsolidated terrace deposits, a possible future quake of Mercalli intensity VII-VIII is inferred (see Tectonic Setting - Earthquakes, and Table 9). The Eureka earthquake of December 21, 1954 registered 6.6 on the Richter scale (Mercalli VII) and was experienced with an intensity of IV-V over much of the Brookings area. Masonry damage and cracked plaster at Roy Brimm's Acacia Laundromat (Mercalli VII) was probably the result of local ground conditions, poor foundation, or poor construction. The recurrence frequency of large quakes in the Brookings area is probably very low, and mitigative measures are difficult to define (see Tectonic Setting - Earthquakes).

North of Brookings buttress unconformities with terrace deposits resting against solid bedrock in road cuts are easily mistaken for active faults; they are not interpreted as faults in this investigation owing to the lack of shearing along the contacts and to other geologic evidence (see Tectonic Setting - Shear Zones of Late Cenozoic Age).

Table 24. Land-use geology of geologic units in western Curry County, Oregon

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lExclusive of shear zones
Where exposed to ocean waves
Exclusive of torrential floods in the uplands
See geologic maps

SUMMARY

Use of This Bulletin

The information in this bulletin provides planners in western Curry County with information needed to make valid land-use decisions. It is a comprehensive and systematic synthesis of present thought regarding hazardous geologic conditions and mineral resources of the region. The information is general and reconnaissance in nature, however, and is subject to refinement based upon more detailed study.

The report proceeds through various levels of detail from map to tables to text and references. Or-ganized in this way, the report has a potential for a wide variety of uses including preliminary site evaluations, land-use capability analyses, projection of data, and policy formulation. It is emphasized that Table 24 of this section must not be used at the exclusion of the text.

Geographic Setting of Study Area

The study area encompasses the western third of Curry County and the Agness area and covers approximately 750 square miles. The climate is moist temperate with summer breezes from the northwest and winter gales from the southwest. Ocean currents are complex but generally are in response to the winds.

The three categories of landforms are uplands, terraces, and lowlands. Each is the product of specific geomorphic processes acting at different times on different materials under different conditions. A knowledge of landforms is valuable in deducing first approximations of hazardous geologic conditions.

The population of Curry County is (1975) estimated at 14,100. Populations of the major communities are 3,150 for Brookings, 1,600 for Gold Beach, and 1,040 for Port Orford. Data indicate modest increases in the future with the trend toward urbanization. Construction of more efficient transportation links to the Grants Pass area would have considerable impact on the inland areas over the years.

Engineering Geology

Three types of geologic units are recognized: 1) bedrock geologic units of consolidated material, 2) surficial geologic units of semiconsolidated to unconsolidated sedimentary Pleistocene and Holocene deposits, and 3) soils, the products of weathering. Soils overlie both the bedrock and surficial geologic units.

Bedrock geologic units include 19 stratigraphic, structural, and intrusive units grouped into 11 major categories on the basis of engineering properties: sedimentary rocks of 1) late Tertiary, 2) early Tertiary, 3) Late Cretaceous, and 4) Early Cretaceous age, 5) the Otter Point, 6) Dothan, and 7) Galice Formations, 8) the Mount Emily Dacite, 9) the Colebrooke Schist, 10) the Pearse Peak Diorite, and 11) serpentinite and peridotite. Local use limitations in the bedrock geologic units generally are determined by degradational hazards such as mass movement and erosion, related conditions such as thin soils, moderately steep to steep slopes, and various engineering properties (see Table 24).

Surficial geologic units include Quaternary 1) higher, 2) upper, 3) middle, and 4) lower marine terrace deposits; 5) fluvial terrace deposits; and five lowland units: 6) Quaternary alluvium, 7) marsh, 8) stable dune sand, 9) unstable dune sand, and 10) beach sand. Local use limitations are dominated by stream and wave erosion, stream deposition, flooding, and several adverse engineering properties (see Table 24). Submerged surficial deposits are not specifically treated but are discussed indirectly in sections dealing with marine terraces.

Soils are leached and acidic. In this report they are grouped into three major categories: upland soils, terrace soils, and lowland soils. Upland soils are characterized by steep slopes, rapid runoff, rapid erosion, and silty loam to silty clay textures. Gentle slopes and deep weathering are typical of the older

terrace soils. Younger terrace soils are moderately to poorly drained and locally contain high ground water, clay-rich horizons, or iron pans which impede infiltration. Bank failure in deep cuts is a hazard. Lowland soils occupy regions of stream flooding, ocean flooding, and ponding. Where depositional processes are dominant, lowland soils are indistinguishable from the surficial geologic units they overlie. The engineering properties of the upper 5 feet of these units generally are discussed under soils.

Mineral Resources

The information needed to classify the mineral resources of the study area according to production potential is not available. However, a consideration of the general history of production in the area indicates that in addition to construction materials and ground water, there are several mineral commodities which exhibit possible potential for future mining. The resource potential for each geologic unit is summarized on Table 24.

Construction materials

The cumulative demand for sand and gravel will be 2 million tons by the year 2000. The best sources of this material lie under the flood plains and in the river channels. Although the channel deposits appear to be renewed annually, no estimate of the annual renewal rate is available. An assessment of geologic constraints on the expansion of the sand and gravel industry in river channels is beyond the scope of this study. Sources of high-quality aggregate away from major rivers are of minimal significance.

The cumulative demand for quarry rock in Curry County will be 2 million tons by the year 2000. Quarry rock in the study area is mined from a number of rock units (Table 24) having a variety of characteristics and potential uses. Providing an adequate supply of construction materials for future use will require a well-informed balancing of aesthetic desires and material needs. Well-managed mining and sequential or multiple land use are possible measures for the planner to consider.

Metallic mineral resources

Gold and silver occur as placer deposits in the drainage of the Sixes River and as lode deposits in bedrock intruded by Late Jurassic veins and dikes. Chromite, platinum, and gold occur in subeconomic concentrations in black-sand placers on marine terraces, submerged marine terraces, and possibly in scattered placers in early Tertiary sedimentary units. Nickel occurs in the laterites at Red Flats. Although most metallic mineral deposits appear to be of limited extent or subeconomic tenor, it is noteworthy that regional structural analyses and explorations have generally not been employed in Curry County.

Nonmetallic mineral resources

Although the priceite deposits in the Brookings area are of historic interest and were profitably mined at one time, they are not now considered economic owing to limited distribution and increased competition from larger and higher grade deposits elsewhere in the country. Some of the ultramafic minerals of the study area may have a potential for several miscellaneous uses. There is no oil, gas, or coal of economic significance in western Curry County. Offshore deposits of oil north of Cape Blanco are suggested by major geologic structures.

Ground water

Ground-water potential is low in the uplands with production of individual wells generally being a few gallons per minute. There is no regional water table, and ground water is restricted to fractures, bedding planes, shear zones, and large landslides. Moderate infiltration rates and storage capacity in the Colebrooke Schist make it the best potential source of ground water in the uplands.

Ground-water production on the terraces is moderate, generally averaging 10 to 20 gallons per minute. Water is commonly perched, and depths to producing horizons are usually shallow. Consequently,

SUMMARY 119

the danger of pollution by inappropriate waste disposal or other means is relatively high.

Ground-water production in the lowlands is generally low to moderate. Shallow depths to producing horizons introduce pollution hazards in places. Production of water from channel gravels is extremely high locally, but to a certain extent the water produced reflects the pollution potential of the associated stream. Ground-water quality for the County is generally very good.

Geologic Hazards

Geologic processes that adversely affect the activities of man or threaten his safety or welfare are geologic hazards. Recommendations for treatment or mitigation must be based on a thorough understanding of the causes and magnitudes of particular hazards and the specific geographic, social, political, and economic setting of the hazard.

Mass movement

Mass movement on steep slopes is dominated by debris slides and rock fall and is most common on hard, steeply sloping bedrock; mass movement on moderately sloping terrain is dominated by earthflow and slump and occurs in shear zones, zones of deep weathering, and semiconsolidated bedrock. Impacts of mass movement are varied and may include personal injury and immediate or long-term destruction of property and buildings. Controlled development and engineering techniques keyed to the specific causes of particular slides are recommended for areas prone to mass movement.

Ocean flooding

Tidal flooding occurs two times daily and affects bars, beaches, and marshes to an elevation of approximately 6 feet above mean sea level. It aggravates stream flooding in coastal areas and should be integrated into all flooding models.

Storm surge is caused by low atmospheric pressure and wind and is additive to tidal flooding. Highest probable storm surge on the Oregon Coast is 4 to 7 feet above the level of predicted tides in an area of minimal wave set-up. When extreme storm surges are superposed on high tides, inundation of mature marshes by several feet of water and flooding of low fill areas are possible.

Tsunamis (seismic sea waves) generally are small and rare occurrences, but the historic record indicates possible amplitudes of 10 feet. Hazards are greatest to unwary persons on the beaches or in other low-lying coastal areas. A well-coordinated and thorough warning system is recommended.

Wave erosion and deposition

Coastal erosion of headlands and sea cliffs ranges from less than one inch per year to a few inches as a function of rock type, setting, and structure. Specific episodes of coastal retreat are dependent on local conditions and may involve 10 feet or more of land. Where wave erosion undercuts active slides, the impact of coastal retreat may affect entire hillsides. Prevention of coastal retreat in Curry County is generally not economic, and adequate setbacks are recommended for future developments.

Beaches in the study area are generally stable under present conditions. Future changes in sediment supply and wave dynamics resulting from natural or man-made causes could initiate erosion or deposition. Jetty construction, dredging, beach excavations, and groin construction are potential threats to beach stability. Natural processes which affect beach stability include cyclic changes in climatic activity, storms, migration of rhythmic topography, and others. All developments having influence on longshore drift should be evaluated prior to construction. Engineering treatments of beach instability vary with local conditions and goals.

Slope erosion

Slope erosion is primarily a function of slope intensity, land use, and soil type. Impacts may include loss of topsoil, increased runoff, and degradation of streams. A variety of governmental programs are

aimed at controlling slope erosion. Of critical concern to the planner is the anticipation and control of slope erosion in areas of changing land use or construction.

Stream flooding

When rising water in streams spills over the established channels into the surrounding lowlands, flooding occurs. Areas of flooding in most of the study area are defined on the basis of historic observations, landform, and soil, but also include a computor-derived Intermediate Regional Flood for the lower Rogue River. Impacts of flooding include structural damage, water damage, and health hazards. Protective and remedial measures may include appropriate zoning ordinances and building codes, insurance programs, disclosure policies, and local flood-prevention construction such as levees or dikes.

Stream erosion and deposition

Stream erosion includes scouring of upland channels during torrential floods, erosion of streambank and channel in the lowlands, and scouring of the estuaries. Stream deposition includes the formation of channel and point bar deposits in the flood plains, siltation away from the channels, and shoaling of the estuaries. Control of stream erosion and deposition involves the accurate assessment of stream hydraulics for specific problems and proper planning prior to major construction or land-use projects involving streams.

Earthquake potential

Geologic mapping in Curry County indicates that all faults in Curry County, with the possible exception of the Port Orford Shear Zone, are inactive. A review of the earthquake history of the area indicates that major tectonic activity in the areas occurs offshore and in northern California. A maximum possible future quake of Mercalli intensity VIII is tentatively assigned to parts of Curry County. Impacts associated with quakes of this intensity include fissured walls, tumbled chimneys, and extensive damage to poorly constructed building.

Zoning regulations, building codes, and policies should proceed toward the multiple goal of 1) promoting construction design capable of withstanding potential earthquake activity, 2) directing the location of critical structures to solid or firm bedrock, 3) assuring the safety of individuals in structures of high occupancy, and 4) the continued operation of hospitals in a disaster. In lieu of additional technical information, adoption of the relevant provisions of the Uniform Building Code is recommended.

Geology of Cities

The major communities of Curry County are underlain by pre-Tertiary bedrock, Quaternary marine terraces, and other surficial geologic units. Geologic hazards are of moderate to low severity in most areas and with proper planning are not major threats to the communities. Hazards include various types of mass movement, slope erosion, local ponding, flooding, and shoaling of the bay at Port Orford; river flooding and erosion, local mass movement, wave erosion and deposition, and slope erosion at Gold Beach; and stream flooding, ponding, slope erosion, near-surface bedrock and minor shoaling at Brookings.

Very little information is available regarding the earthquake histories of the communities. No definitely active faults are recognized, although recency of movement is a possibility on the Port Orford Shear Zone. Future earthquakes with Mercalli intensities of VII to VIII and very low frequencies of occurrence are inferred for the communities on the basis of regional tectonism and ground conditions. Quakes of this intensity are capable of severely damaging buildings that are placed on poor foundations or that are improperly constructed.

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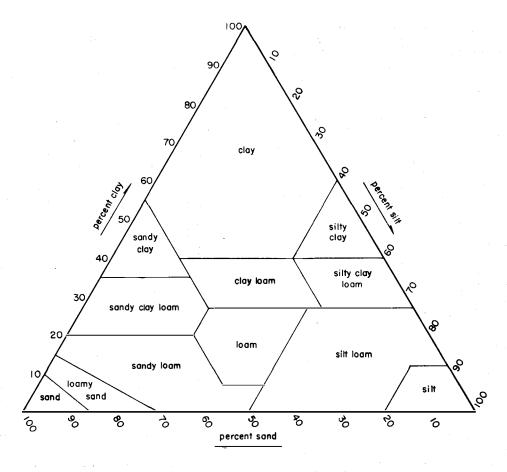
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APPENDIX

AND

GLOSSARY

APPENDIX A. GUIDE FOR THE TEXTURAL CLASSIFICATION OF SOILS



			Moist	$\frac{1}{2}$ "-1" wide, 1/8" thick mois' plas-	Moist 2"+ long plasticity
Texture	Dry feel	Moist feel	shine	ticity (ribbon)	(wire) 1/8"
Sand	Individual grains seen and felt	Individual grains seen and felt	None	Will not ribbon	Will not wire
Sandy Ioam	Individual grains appear dirty	Individual grains appear dirty	None	Will not ribbon	Will not wire
Loam	Gritty, floury feel	Gritty, smooth slick	Faint dull	Very weak ribbon, broken appearance	Very weak wire in broken segme nt s
Silt Ioam	Soft and floury	Smooth slick w/ some stickiness	Dull	Ribbon broken appearance	Weak wire easily broken
C lay loam	Slightly hard, little grittiness	Smooth slightly sticky w/some grittiness	Prom- inent dull	Ribbon barely sustains weight	Wire sustains weight
Silty clay loam	Moderately hard, no grittiness	Smooth sticky, feel some plasticity	Faint	Ribbon sustains weight & careful handling	Wire sustains weight & withstands gentle shaking
Silty clay	Hard, no grittiness	Smooth, sticky plastic, faint fin- gerprints visible	Shine	Ribbon withstands considerable move- ment & deformation	Wire withstands considerable s hak- ing and rolling
Clay	Very hard, no grittiness	Smooth very sticky – plastic fingerprints	Bright	Long thin ribbon	Wire withstands shaking, rolling, bending, 1/16"

LAND USE GEOLOGY OF CURRY COUNTY

APPENDIX B. UNIFIED SOIL CLASSIFICATION SYSTEM

M	ajor divis	ions	Group symbols	Typical names		Laboratory classification	criteria		
	(Mor	Clean (Little or	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine Depending soils are Less that More to	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; C, =	$= \frac{(D_{30})^2}{D_{10} \times D_{60}} \text{ between 1 and 3}$		
(Mor	Granger than N	Clean gravels ittle or no fines)	GP	Poorly graded gravels, gravelsand mixtures, little or no fines	Determine percentages of sand Depending on percentage of fi soils are classified as follows: Less than 5 per cent More than 12 per cent. 5 to 12 per cent	Not meeting all gradation rec	juirements for GW		
Coarse. (More than half of material	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Gravels (Apprecia	GM* d	Silty gravels, gravel-sand-silt mix- tures	es of sand and stage of fines follows:	Atterburg limits below "A" line or P.I. less than 4	Above "A" line with P.I. be- tween 4 and 7 are border-		
arse-grained serial is larger t	tion is	Gravels with fines (Appreciable amount of fines)	GC	Clayey gravels, gravel-sand-clay mixtures	gravel f (fraction	Atterburg limits above "A" line with P.I. greater than 7	line cases requiring use of dual symbols		
	(More	Clean sands (Little or no fines)	sw	Well-graded sands, gravelly sands, little or no fines	grain	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{10})^2}{D_{10} \times D_{60}}$ between 1 and			
o. 200 sieve	Sar than half of haller than N	sands no fines)	SP	Poorly graded sands, gravelly sands, little or no fines	in-size curve. than No. 200 sieve GW, GP, SW, SP GM, GC, SM, SC Borderline cases rec	Not meeting all gradation rec	quirements for SW		
size)	Sands (More than half of coarse fraction smaller than No. 4 sieve size)	Sands with fines (Appreciable amount of fines)	SM* d	Silty sands, sand-silt mixtures	han No. 200 sieve size), coarse-grained GW, GP, SW, SP GM, GC, SM, SC Borderline cases requiring dual symbols**	Atterburg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and		
	e) is	ith fines ble amount nes)	sc	Clayey sands, sand-clay mixtures	ymbols**	Atterburg limits above "A" line with P.I. greater than 7	7 are borderline cases requiring use of dual symbols.		
	S:		ML	Inorganic silts and very fine sands, rockflour, silty or clayey fine sands, or clayey silts with slight plasticity	60				
(More tha	(Liquid limit less than 50)	Silts and clays	Cı	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	50		СН		
Fine-grain (More than half of material is	in 50)		OL	Organic silts and organic silty clays of low plasticity	40 x				
	(Liquid li		мн	Inorganic silts, micaceous or diato- maceous fine sandy or silty soils, elastic silts	Plosticity and ex	, i tre	OH and MH		
than No.	id limit greater than	Silts and clays	СН	Inorganic cloys of high plasticity, fat clays	10	сі			
200 sieve)	han 50)		ОН	Organic clays of medium to high plasticity, organic silts	0 10	20 30 40 50 6	60 70 80 90 100		
	soils	Highly organic	Pt	Peat and other highly organic soils		Plasticity Cha	rt		

^{*}Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterburg limits; suffix d used when LL, is 28 or less and the P.I. is 6 or less; the suffix u used when LL, is greater than 28.

**Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols.

For example: GW-GC, well-graded gravel-sand mixture with clay binder.

APPENDIX

APPENDIX C. AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS AASHO SOILS CLASSIFICATION

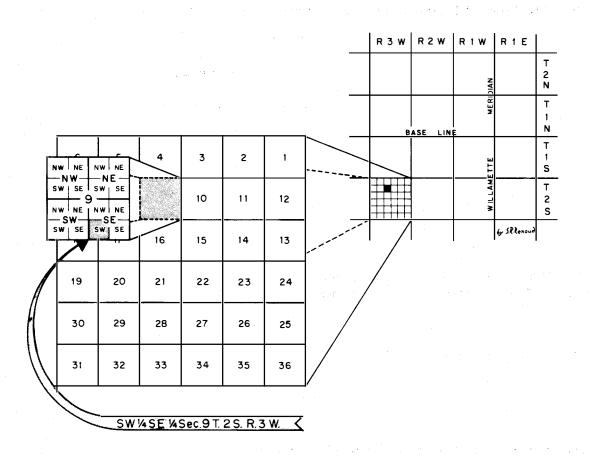
			Group symbols	Grain size (sieve)	Atterburg fraction pass Liquid limit		
. 200 sieve	Stone fragments gravel and sand	A-1	Α-1-α	50% max. passes No. 10 30% max. passes No. 40 15% max. passes No. 200		Plasticity index* Less than 6	<u>u</u>
Granular materials Less than 35% is smaller than No.	Sto		A-1-6	50% max. passes No. 40 25% max. passes No. 200		:	t subgraa
	Fine sand	A-3	A-3	50% min. passes No. 40		N.P.	Good to excellent subgrade
	>₽		A-2-4		Less than 40	Less than 10	ood te
	Silty or clayey gravel and sand	A-2	A-2-5	1	Greater than 40	Less than 10	, Q
Less	ty or velar	A-2	A-2-6	35% max. passes No. 200	Less than 40 Greater than 10		
	Silty grave		A-2-7	**	Greater than 40	Greater than 10	
ls naller ve	† \ ₹	A-4	A-4		Less than 40	Less than 10	rade
s is sn 0 sie	Silty soils	A-5	A-5	C	Greater than 40	Less than 10	gans
ay mc n 35% lo. 20	soils	A-6	A-6	Greater than 35% passes No. 200	Less than 40	Greater than 10	o fair
Silt-clay materials More than 35% is smaller than No. 200 sieve	Clayey so	A-7 A-7-5 and A-7-6			Greater than 40	Greater than 10	Poor to fair subgrade

^{*}The difference between liquid limit and plastic limit; the range of water content through which the soil behaves plasticly.

APPENDIX D. COMPARISON OF THREE SYSTEMS OF PARTICLE-SIZE CLASSIFICATION

American Association of State Highway Officials – soil classification	Colloids	Clay	Silt		Fine sand		Coarse sa	nd	Fine gravel	Medium gravel	Coarse gravel	Bou Iders
U.S. Department of Agriculture – soil classification	Clay		Silt	Very fine sand	Fine sand	Medium sand	Coarse sand	Very coarse sand	Fine gravel		arse avel	Cobbles
Unified soil classification U.S. Army Corps of Engineers Bureau of Reclamation, Dept. of Interior		Fines (si	It or clay)	:	Fine sa	nd .	Mediu	um sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles
Sieve sizes – U.S. standard			1 3 4	- 270	140))	- 20	0	X	4	ار ا
Particle size – millimeters			.00	40. %0.		ω. 4 .	9. 8.	1.0	3.0	3.0 0.0 10	20 30 40	08

APPENDIX E. GROUND-WATER WELL-NUMBERING SYSTEM



Wells are designated by symbols that indicate location according to the rectangular subdivision of public lands. Thus, in the above example:

2S refers to Township 2 south 3W refers to Range 3 west 9 refers to Section **9**

APPENDIX F. LONGSHORE DRIFT

Galvin and Eagleson (1965) provide the following equation for calculating gross velocities of longshore drift:

 $V = g m T 2 sin \theta_b$

where:

V is the velocity in ft/sec

g is gravity in ft/sec 2 (=16)

m is beach slope in ratio form x/y

x = vertical distance y = horizontal distance

T is the wave period in seconds

 $\boldsymbol{\theta}_{h}$ is the angle the wave crest makes with the beach

Galvin (1969) summarizes wave observation data for parts of the Oregon Coast and provides the following figure for a 10-year observation period at the mouth of the Umpqua River.

T = 8 seconds

Adopting this figure and assuming:

ment transport.

m = 0.05

 $\theta_b = 10^{\circ}$ (2 sin $\theta_b = 0.350$

Solving the equation yields a gross longshore drift velocity:

V = (16) (0.05) (8) (0.350)V = 2.2 ft/sec = 66 cm/sec

Caldwell (1966) provides a table for relating longshore drift velocities with gross rates of longshore sedi-

ft/sec	and the second s	c u yards/year
0.03		16,000
0.1		50,000
0.25		125,000
0.50		250,000
0.75		375,000
1.00		500,000
1.50		750,000
2.0		1,000,000
3.0		1,500,000
6.0		3,000,000

APPENDIX 141

The calculated velocity of longshore drift suggests a rate of longshore sediment transport of 1,100,000 cubic yards per year. The critical factor in the equation is the angle of the waves with the beach. This figure varies from beach to beach and with position on individual beaches not in equilibrium, as around recently constructed jetties.

Galvin (1972) provides a simple equation for relating mean wave height to gross sediment transport rates;

 $Q = 2H^2$

where:

Q is the gross transport rate in units of 100,000 cu yards/year

H is the mean wave height in feet

Galvin (1969) provides wave breaker height data for a 10-year observation period at the mouth of the Umpqua River that indicate that H = 3.3 feet.

thus:

 $Q = 2 (3.3)^2$

= 2 million cubic yards per year

This figure is similar to that determined using longshore drift velocities as a basis for calculations as described above.

The U. S. Army Corps of Engineers (1975) estimates rates of southerly longshore transport of 500,000 to 1,000,000 cubic yards per year on the basis of observed rates of infilling behind the north jetty at the mouth of the Rogue River.

Using accurate local data and sophisticated calculations similar to those described here it is possible to calculate accurate rates of longshore sediment transport under varying conditions. With the aid of computor simulations it is also possible to relate longshore sediment transport factors to varying types of jetty designs to aid in the selection of the most suitable jetty designs for specific locations.

APPENDIX G. CONSTANTS FOR CALCULATING SHEET AND RILL EROSION, CURRY COUNTY, OREGON

Soil loss by sheet and rill erosion can be calculated by the following equation:

A = (R) (K) (LS) (C) (P)

Where: A is soil loss in tons/year/acre

R is the rainfall intensity factor

K is the soil erodibility factor and is a function of:

silt and sand content of the soil organic content of the soil

soil structure soil permeability

LS is a measure of slope intensity and is a function of:

slope length slope gradient

C is a ground cover factor
P is an erosion control factor

Values for these constants were determined for Curry County as follows:

R = 300 in the lowlands and the terraces

R = 450 in the uplands

A 2-year 6-hour rainfall for the lowland areas of Curry County is 3.0 inches (Buzzard and Bowlsby, 1970), which corresponds to an R value of 300. Because mean annual rainfall of the more mountainous areas is 120 inches, as opposed to 80 inches for the lowlands, a figure of 450 is adopted for the value of R in these areas for lack of better data. The R figures are determined graphically using data from U.S. Department of Agriculture (1972).

K = 0.25 for sandy loam and silty loam soils

K = 0.35 for silty clay loam and clay loam soils

Review of K factors listed on Oregon Soils Sheets indicates that these figures are reasonably accurate for soils of the Oregon coastal zone. More accurate data could be derived with appropriate soils information, but would add little to the generalized calculations presented here.

LS is determined graphically from U. S. Department of Agriculture (1972).

Figures applicable to the study area are given below.

Landform	Gradient	Length	LS
Uplands	40%	500 feet	26
	20%	500 feet	10
Terrace	2%	5 00 feet	0.5
and	1%	500 feet	0.1
Low lands	0%		0.0

C is highly variable for the study area. It is a measure of land use.

For well-stocked woodlands (75% - 100% tree cover with thick forest litter and managed) C = 0.001. For no canopy and only 20% ground cover of grass or duff C = 0.200. Values for C lie within these extremes for most of the study area.

P is not applicable on a regional basis for most of the study area.

GLOSSARY

This is a listing of geologic terms used in the text which may be unfamiliar to the planner. The definitions and significance of many of the terms are developed more completely in the appropriate parts of the text (see Table of Contents).

amphibolite - a medium-grade metamorphic rock consisting mainly of the minerals amphibole (usually hornblende) and plagiculase.

argillaceous - composed largely of or containing clay minerals or clay-size minerals.

attenuation - to diminish with distance from the point of origin.

bedrock geologic unit - bedrock unit composed of hard rock that extends to depth.

berm - material thrown up by storm waves on backside of beach.

block fault - faulting characterized by vertical displacements of crustal blocks.

blueschist - a low-temperature, high-pressure metamorphic rock consisting in part of blue amphibole and related minerals.

breccia - volcanic rock consisting of large angular blocks indicative of violent eruption or flowage while cooling.

<u>brittle response</u> - fracturing of hard bedrock in moderately severe to severe earthquakes; may initia te rockfalls on steep slopes.

buttress unconformity - unconformity characterized by a highly irregular surface in local exposures.

clast - an individual particle in a sedimentary deposit; a pebble in conglomerate, for example.

coastal retreat - movement of the coastline slowly inland by wave erosion and related processes.

colluvium - soil and/or loose rock material deposited by mass movement.

concretion - hard mass in sedimentary rock formed by local cementation, usually by lime deposited in a concentric pattern around a nucleus.

continental - pertaining to sedimentary deposits laid down on the relatively stable continental shelf as opposed to the sea floor.

<u>creep</u> - random, gradual, particle-by-particle movement of soil and rock material downslope in response to gravity (see Table 16).

<u>debris avalanche</u> - rapid sliding of rock and soil masses on a slide plane parallel to the slope of the hillside (see Table 16).

<u>debris flow</u> - rapid flow of rock and soi! material down a steep slope in slurry-like fashion, owing to high water content (see Table 16).

- debris slide sliding of a block of soil or rock material down a slope along a plane parallel to the slope.
- dike a tabular intrusive body of igneous rock that cuts across other bedrock structures.
- diorite igneous rock having granitic texture and intermediate composition between acid and basic, which cooled at depth rather than on the surface.
- drift beach gently arcuate to almost straight beach oriented oblique to oncoming wave fronts; resultant littoral drift transports sand down the beach.
- earthflow flow of soil and rock material along innumerable shear planes in the manner of a viscous fluid; terrain characterized by irregularities of topography, drainage, and soil type.
- earthflow and slump topography areas for which high probability of earthflow or slump is inferred on the basis of drainage, slope characteristics, geology, structure, stereoscopic photo interpretation, and available field evidence.
- elastic response ground movement during an earthquake in which there is no damping and in which particles
 maintain their same relative position; common during small quakes and in semiconsolidated and consolidated bedrock during larger quakes.
- epicenter geographic locality on the earth's surface above the focus of an earthquake.
- eustatic change in sea level caused by change in the volume of sea water, as during ice ages.
- facies as used here, refers to level or degree of metamorphism.
- float block of bedrock material displaced downslope by mass movement.
- flood plain area subject to inundation by large floods.
- floodway stream channel or channels that convey fast-moving flood waters.
- floodway fringe area beyond floodway, but subject to periodic flooding.
- fluvial pertaining to a river or rivers.
- focus point of origin of an earthquake within the Earth.
- foliate having a planar arrangement of mineral grains or other textural features; of significance in interpreting metamorphism.
- gabbro a dark-colored basic intrusive igneous rock having granitic texture and chemical composition similar to basalt.
- geologic hazard a geologic process that threatens the safety, welfare, or activities of man.
- glaucophane a bluish metamorphic mineral of the amphibole group; of considerable significance in the interpreting of metamorphism.
- gneiss a relatively high-grade foliate metamorphic rock characterized by bands of elongate minerals and bands of granular minerals.
- graded bedding layers of sedimentary rock characterized by coarser grain sizes near the base and finer grain sizes near the top; commonly deposited by turbidity currents.

GLOSSARY 145

- greenstone metamorphosed basalt.
- ground response behavior of the ground during earthquakes; may include brittle response of hard bedrock, elastic response of firm ground, liquid response of saturated ground, and others.
- ground water water in the zone of saturation beneath the Earth's surface; applies to soil water or to water in bedrock, depending upon local conditions.
- igneous rock solidified from molten or partially molten material or magma.
- infiltration rate rate at which ground can absorb rain or melting snow under specified conditions.
- intensity a relative measure of the severity of an earthquake based upon observations of its effect at the Earth's surface (see Table 6).
- intermediate composition said of igneous rocks that are intermediate in composition between basic and acidic; silica content is between 54 and 65 percent; examples include diorite and syenite.
- Intermediate Regional Flood flood having a probability of occurrence of one percent for any given year.
- joint fracture in rock along which little or no movement has occurred.
- <u>landform</u> any physical form or feature of the Earth's surface having a characteristic shape and formed by natural processes.
- laterite highly weathered, red subsoil, rich in oxides of iron and aluminum and deficient in primary silicates. Of economic significance in Curry County owing to residual enrichment of nickel.
- liquefaction the transformation of unconsolidated saturated material into a fluid mass by vibrations or by the addition of water. Earthquakes of Mercalli intensity VI are believed to generate small-scale liquefaction (see Table 9).
- liquid limit water content beyond which soil behaves as a liquid.
- lithology the physical character of a rock.
- littoral drift movement of material along the beach by waves as they impinge at an angle to the beach.
- lode a mineral deposit occurring as a vein or series of veins in bedrock, as opposed to placer deposits.
- magnitude (earthquake) a measure of the energy released by an earthquake as determined by instruments grounded in bedrock (see Table 6).
- marine pertaining to the ocean as opposed to rivers or lakes.
- mass movement downslope movement of soil or rock in response to gravity (see Table 16).
- mélange a sheared mixture of rock material of regional distribution and tectonic origin (see Otter Point Formation).
- metamorphism mineralogic and structural adjustment of rock to conditions of temperature and pressure more extreme than those in the zone of weathering and different from conditions under which the rock was formed.

- msl mean sea level; average height of surface of the sea for all stages of tide over a 19-year period; the datum point for measurements of elevation on land (see Table 18).
- oceanic pertaining to sedimentary and volcanic rocks deposited on the floor of the ocean, as opposed to the continental shelf.
- ophiolite suite of rocks including peridotites, gabbros, basalts, and oceanic sediments, believed to represent deep-sea sediments and oceanic crust and mantle. Assemblages of rocks of the appropriate compositions on land are sometimes interpreted as oceanic crust and mantle that have been faulted into their present position (see Otter Point Formation).
- perched water table the upper surface of a zone of saturation in the ground; situated above the regional water table and separated by impermeable rock or soil.
- peridotite general term for coarse-grained plutonic rock consisting of olivine and pyroxene and related minerals. Many peridotites are interpreted as parts of ophiolites formed beneath the Earth's crust on the upper mantle.
- permeability a measure of the ease of fluid flow through rock or soil. The coefficient of permeability is the rate of flow (gallons per day) through a square foot of cross section under a hydraulic gradient of 100 percent at 60° F.
- petrography the description and systematic classification of rocks.
- petrology the study of rocks and their systematic classification as it relates to their origin.
- phyllite argillaceous metamorphic rock intermediate between slate and schist.
- plate tectonic theory the theory that the Earth's crust and upper mantle are divided into several discrete plates bounded by major zones of faulting, mountain building, and volcanism (see Tectonic Setting).
- plutonic pertaining to igneous rocks formed at depth, such as granite.
- porosity percentage of voids divided by bulk volume; a measure of the water-holding capacity of rock or soil.
- protolith unmetamorphosed rock from which a metamorphosed rock is derived.
- regolith zone of weathered rock and soil above fresh bedrock
- retrograde metamorphism metamorphism of a higher grade metamorphic rock into a lower grade metamorphic rock. The blueschist pods of the Otter Point Formation have undergone retrograde metamorphism.
- rhythmic bedding as used here, refers to a repetitious occurrence of thin layers of sandstone and siltstone beds within a geologic formation and indicative of a frequent and repetitive alternation of sedimentary conditions.
- rhythmic topography the systematic and repetitive occurrence of beach landforms along a coastline.

 Features may include bars, rip channels, cusps, and others. As the entire beach system migrates along a coastline, various locations on the shore may experience alternating coastal stability and instability.
- rockfall falling rock on a steep slope (see Table 16).

GLOSSARY 147

- rockslide sliding and rolling rock on a steep slope (see Table 16).
- run-up the elevation on land that a wave may reach measured in relation to prevailing sea level.
- schist strongly foliate crystalline rock formed from metamorphism under conditions of differential stress.
- schistosity strong foliation resulting from parallel planar orientation of mineral grains.
- seismicity the relative degree of earthquake activity of a given area.
- serpentine a group of rock-forming minerals composed mainly of magnesium, silicon, iron oxides, and water.
- serpentinite a rock consisting almost wholly of serpentine group minerals.
- shear plane surface of sliding in many forms of mass movement.
- shear zone (tectonic) a linear zone of sheared rock formed by extensive parallel faulting.
- slope erosion removal of soil from a slope by sheet wash, rill wash, or gullying.
- slump mass movement characterized by displacement on a curved basal slip plane (see Table 16).
- <u>soil</u> as used here, refers to unconsolidated mineral matter formed in place by weathering and characterized by various soil horizons.
- soil horizon a layer of soil distinct from other layers on the basis of physical properties and chemical composition.
- specific capacity a measure of the potential of a well to deliver water; incorporates a consideration of both production and drawdown.
- storm surge rise of sea level above predicted tides owing to low barometric pressure and wind.
- strike-slip fault near-vertical fault with horizontal displacement.
- structure the spatial arrangement and deformation of rock units in a given area; includes consideration of faulting and folding.
- <u>subduction</u> the process of one large crustal block descending beneath another as a result of plate collision (see definition of plate tectonic theory).
- surficial geologic unit as used here, refers to a mappable body of unconsolidated earth material formed by depositional processes and forming a relatively thin layer over bedrock units.
- swash beach concave beach located between headlands and having a shoreline parallel to oncoming wave fronts; differs from drift beach in the absence of significant littoral drift.
- syenite a group of plutonic rocks related to diorite but lacking in essential quartz and containing more alkali feldspar.
- terrace an elevated, relatively flat erosional and depositional surface, generally above the level of ongoing depositional processes (see Table 2).

thrust fault - fault with a dip of 45° or less along which the overlying block has moved over the underlying block.

thrust sheet - the block or plate overlying a thrust fault.

- the rhythmic rise and fall of sea level occurring twice a day on the Oregon Coast and resulting from the gravitational attraction of the Moon and the Sun (see Table 18).

torrential flood - flood characterized by rapidly moving water in a channel with no flood plain, as in a mountain ravine.

transcurrent fault - large-scale strike-slip faulting located where two crustal plates are displaced relative to one another.

tsunami - seismic or shock wave generated at sea by a major earthquake or particularly violent volcanic eruption; erroneously referred to as tidal wave.

tuff - rock composed primarily of small explosively erupted volcanic particles.

ultramafic - igneous rock composed chiefly of mafic minerals (magnesium and iron-rich) such as pyroxene and olivine; generally dark in color. (Examples - peridotite and serpentinite).

unconformity - surface of erosion between superimposed rock formations.

unconsolidated - a loosely arranged, uncemented sediment that generally can be disaggregated by hand.

upland - terrain above lowlands and terraces (see Table 2).

water table - upper surface of the zone of water saturation in the subsurface.

wave set-up - retarded return of waves to the sea owing to wind friction.

wind set-up - piling of water against a shore owing to wind shear acting upon the surface of the water.

BULLETIN 90 LAND-USE GEOLOGY OF WESTERN CURRY COUNTY, OREGON GEOLOGIC MAP

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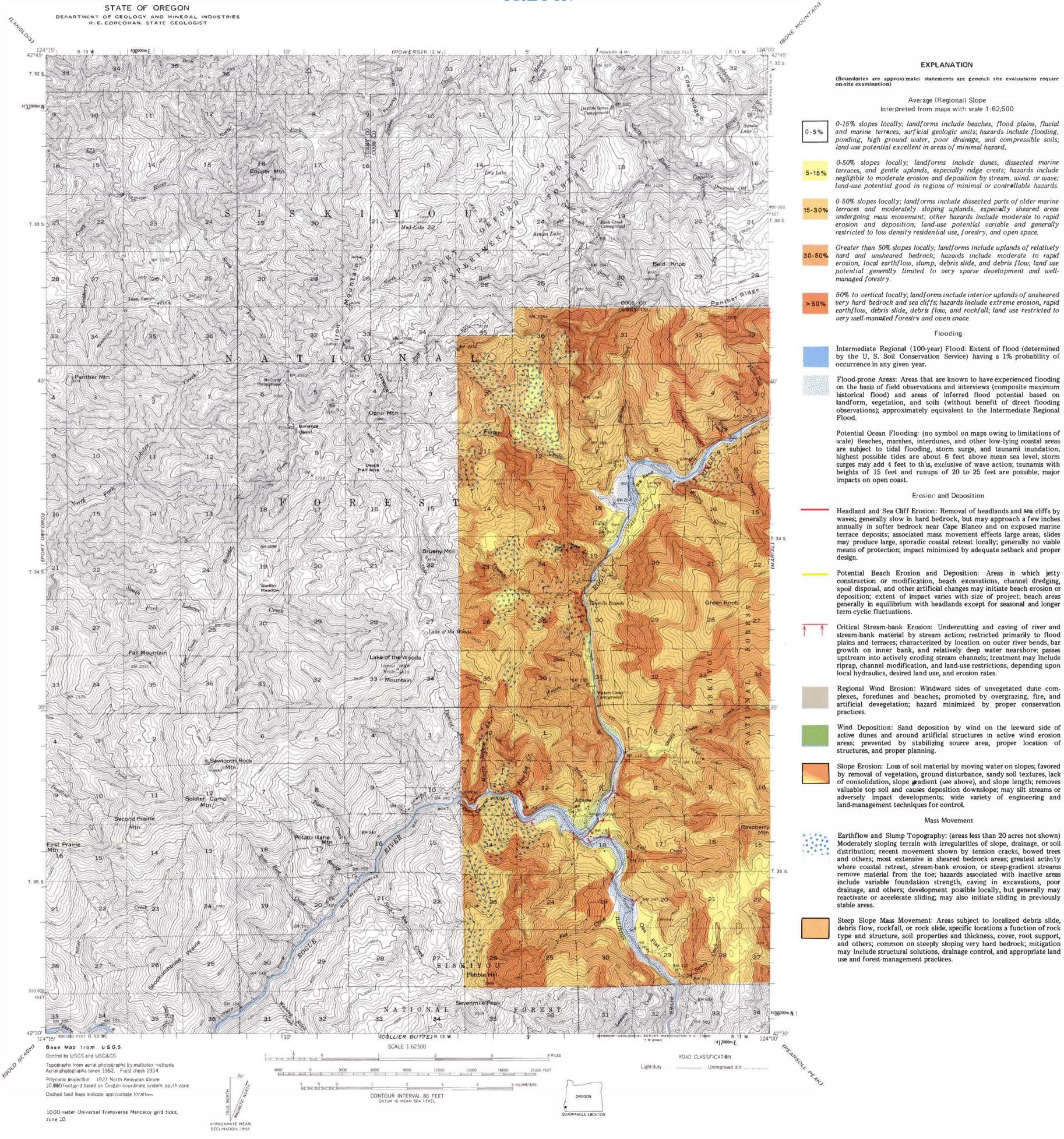
AGNESS QUADRANGLE (in part) The preparation of this map was financed in part through a project development grant under the Coestel Zone Management Act of 1972 administered by the Office of Coastal Zone Management; local STATE OF OREGON administration by the Land Conservation and Development Comm'ss DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES R. E. CORCORAN, STATE GEOLOGIST Research for this map sponsored in part by the U. S. Geological Survey, Department of the Interior, under USGS Grant No. 14-08-0001-G-135 Geology by John D. Beaulieu: modified after Coleman, 1972; STRATIGRATIGRAPHIC TIME CHART Qmtm Qmt u Tmp Tod Kuh - Kuc thrusting 135-140 protolith **EXPLANATION** (All statements are general; site evaluations require on-site examination) Surficial Geologic Units beach sand (Recent): Fine to medium grained unconsolidated sand; generally thin; very high permeability; not appropriate for development; includes narrow berm and foredune deposits; hazards include ocean flooding, wave erosion, and unstable dune sand (Recent): Unconsolidated fine- to medium-grained sand of dunes not protected by vegetation; generally thin except south of Pistol River; high permeability with modest ground-water potentiallocally; hazards include wind erosion and deposition, ocean flooding in places, and possible presence of compressible soils at depth. stable dune sand (Recent): Unconsolidated fine- to medium-grained dune sand protected from wind by vegetation; generally thin; hazards include ocean flooding and possible presence of compressible soils at depth; unit does not include stable sand overlying marine terrace deposits. marsh deposits (Recent): Unconsolidated organic-rich silt, clay, and sand in estuarine and low-tying fresh-water welland areas: abundant vegetation; hazards include ponding, high water table, very low foundation strength, and stream flooding; peaty deposits may underlie other alluvial and sand units. Quaternary alluvium (Recent and late Pleistocene); Unconsolidated sand, gravel. silt, and clay in stream beds and flood plains of major streams; grain size generally increases with depth; moderately high foundation strength; ground-water potential moderate; silty clay loom soils; hazards include Qal Quaternary fluvial terrace deposits (Pleistocene): Unconsolidated to semi-consolidated flat-lying alluvial deposits of sand, gravel, and silt overlooking present day flood plains; grain size generally increases with depth; moderate to high foundation strength; low to moderate ground-water potential; hazards include stream-bank erosion, local ponding, and occasional stream flooding in Quaternary lower marine terrace deposits (latest Pleistocene): Thin, poorly consolidated sand, silt, and clay 0 to 40 feet in elevation; equivalent to Whiskey Run terrace of Griggs (1945); sandy toam, silty loam, and silty clay Qmtl Quaternary middle marine terrace deposits (late Pleistocene): Thin (5 to 40 feet) semi-consolidated sand, silt, and gravet 40 to 200 feet in elevation; equivalent to the Pioneer terrace of Griggs (1945); beach ridge topography and stream dissection in places; sandy loam soil with imperneable tron pan at shallow depths locally; hazards include poor drainage, local ponding, and coastal retreat. Quaternary upper marine terrace deposits (middle Pleistocene): Thick, massive sand, silt, and basal gravel at elevations of 100 to 900 feet; possibly equivalent to the Seven Devils terrace of Griggs (1945); silty clay loam soils; dissected by 33 Mountain Quaternary higher marine terrace deposits (early Pleistocene?): Thick semi-consolidated sand and silt with basal gravels; elevation 250 to 1,000 feet; equivatent to higher terraces of Griggs (1945); sandy loam soits; generally cap ridges as isolated deposits; very deeply dissected near Port Orford. Bedrock Geologic Units Sedimentary Rocks of Late Tertiary Age
Empire Formation (early Phocene), Port Orford Formation (middle to late
Pllocene), and Miocene sedimentary rock (Tmp): Moderately hard sandstone
and conglomerate in steep sea cliffs and valley walls near Cape Btonco;
impermeable to permeable locally; hazards include coastat retreat and slope
erosion. Sedimentary Rocks of Early Tertiary Age
Flournoy Formation (Tef), Lookingglass Formation (Telg), Roseburg Formation
(Ter), and undifferentiated Eccene rocks at Cape Blanco (Teu) (all early to
middle Eccene): Rhythmically bedded hard sandstone and minor sillstone;
high foundation strength; impermeable but with local inflitration along faults,
joints and bedding planes; low ground-water potential; sandy loam and silty Tef loam soils of variable thickness; hazards include erosion, earthflow, and debris Teu Sedimentary Rocks of Late Cretaceous Age
Hunter Cove Formation (Kuh), and Cape Sebastian Sandstone (Kuc): Moderately
hard sandstone and shale; highly sheared south of Cape Sebastian moderately
high to low foundation strength and permeability as a function of shearing;
silty clay loam and silty loam soils; hazards include earthflow, slope erosion,
and coastal retreat. Kuh Telg Sedimentary Rocks of Early Cretaceous Age
Rocky Point Formation (Kr), Humbug Mountain Conglomerate (Kh), and Myrtle
Group undifferentiated (KJm): Hard rhythmically bedded sandstone and
siltstone with hard conglomerate in places; comprise part of a regional thrust
sheet; very high to high foundation strength; very low permeability and
ground, water potential; silty loam and gravelly loam soils of highly variable KJm thickness; hazards include slope erosion, debris slide and debris flow Sedimentary and Volcanic Rocks of Jurassic Age
Otter Point Formation (Late Jurassic): Heterogeneous assemblage of sandstone,
marine basalt, metamorphic blocks, confilomerate, and minorchert; regionally
sheared in the north and along linear shear zones along the coast; highly variable foundation strength and permeability; generally low ground-water potential; soil types, thicknesses, and properties highly variable; extensive earthflows consitute major hazard. Dothan Formation (Late Jurassic): Hard sandstone and moderately hard siltstone with minor greenstone and chert especially along the coast; high foundation strength; low permeability and ground-water potential; silty clay loam to gravelly loam soils of variable thickness; hazards include slope erosion and local mass movement. Galice Formation (early Late Jurassic): Hard slaty shale with minor sandstone, greenstone, and chert; unsheared but comprises part of a regional thrust sheet; moderate foundation strength; low permeability and ground water potential; silty clay loam soils; major hazards are slope eroston and local mass movement. Igneous and Metamorphic Rocks of Various Ages

Mount Emily Dacite (Oligocene): Mount Emily pluton and related dikes
distributed along zones of structural weakness; high foundation strength; low
permeability and ground-water potential; possibility of perched water tables
locally; sandy loam and gravelly loam soils of highly variable thickness; hazards
include rockfall, debris slide, and slope erosion. Colebrooke Schist (Late Jurassic origin, Cretaceous or later emplacement): Mica phyllite and schist derived from shale and sandstone; also includes marine lava, tuff, and chert; comprises a regional thrust sheet; moderate permeability and ground-water potential; clay loam soils of variable thickness; major hazards 124°15' Rase Map from USGS SCALE 1:62500 include slope erosion and mass movement locally. ROAD CLASSIFICATION Pearse Peak Diorite (Late Jurassic): Medium-to fine-fointed quartz diorite; forms part of a regional thrust sheet; low permeability, but possibility of perched water table locally; silty loam, sandy loam, and gravelly loam soils of highly variable thickness; major hazards are slope erosion, debris slides, and debris Topography from aerial photographs by multiplex methods Aerial photographs taken 1952. Field check 1954 ___ Unimproved dirt 000 0 3000 6000 9000 12000 15000 18000 21000 FEET Polyconic projection: 1927 North American datum 10,000-foot grid based on Oregon coordinate system, south zone Serpentine and peridotite (Late Jurassic): Primarily tectonic sheets within the Otter Po'unt Formation and as soles to overriding thrust sheets, but also present along vertical faults; time of final emplacements variable; very low to moderate foundation strength as a function of shearing and weathering; very low permeability; perched water tables locally on flat terrain; thin clay, clay loam, and rubbly so'ils, generally lateritic; major hazard is mass movement in shear zones. Dashed land lines indicate approximate locations CONTOUR INTERVAL 80 FEET OREGON 1000-meter Universal Transverse Mercator grid ticks, Cartography by C. A. Schumacher, 1976 Geologic Symbols Edited by S.R. Renoud 1976 Geologic Cross Sections **Folds** Contacts Definite contact Definite anticline Definite syncline Approximate contact 4000 Concealed contact Approximate anticline Approximate syncline 2000 2000 **Faults** - Definite fault (D, downthrown Sea Level Sea Level side; U, upthrown side) Strike and dip of beds Telg spp --- Approximate fault Strike and dip of vertical beds -2000 -2000 ---?-- Uncertain fault spp Strike and dip of overturned beds Teu? KJm? ····· Concealed fault **Foliations** Thrust fault Strike and dip of foliation Fault zone? Shear zone?? \mathbf{C} Strike and dip of vertical foliation Rock quarry Gravel pit 2000'-Sea Level

Leta

- 2000'-

GEOLOGIC HAZARD MAP of the AGNESS QUADRANGLE (in part) OREGON



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GEOLOGIC MAP of the

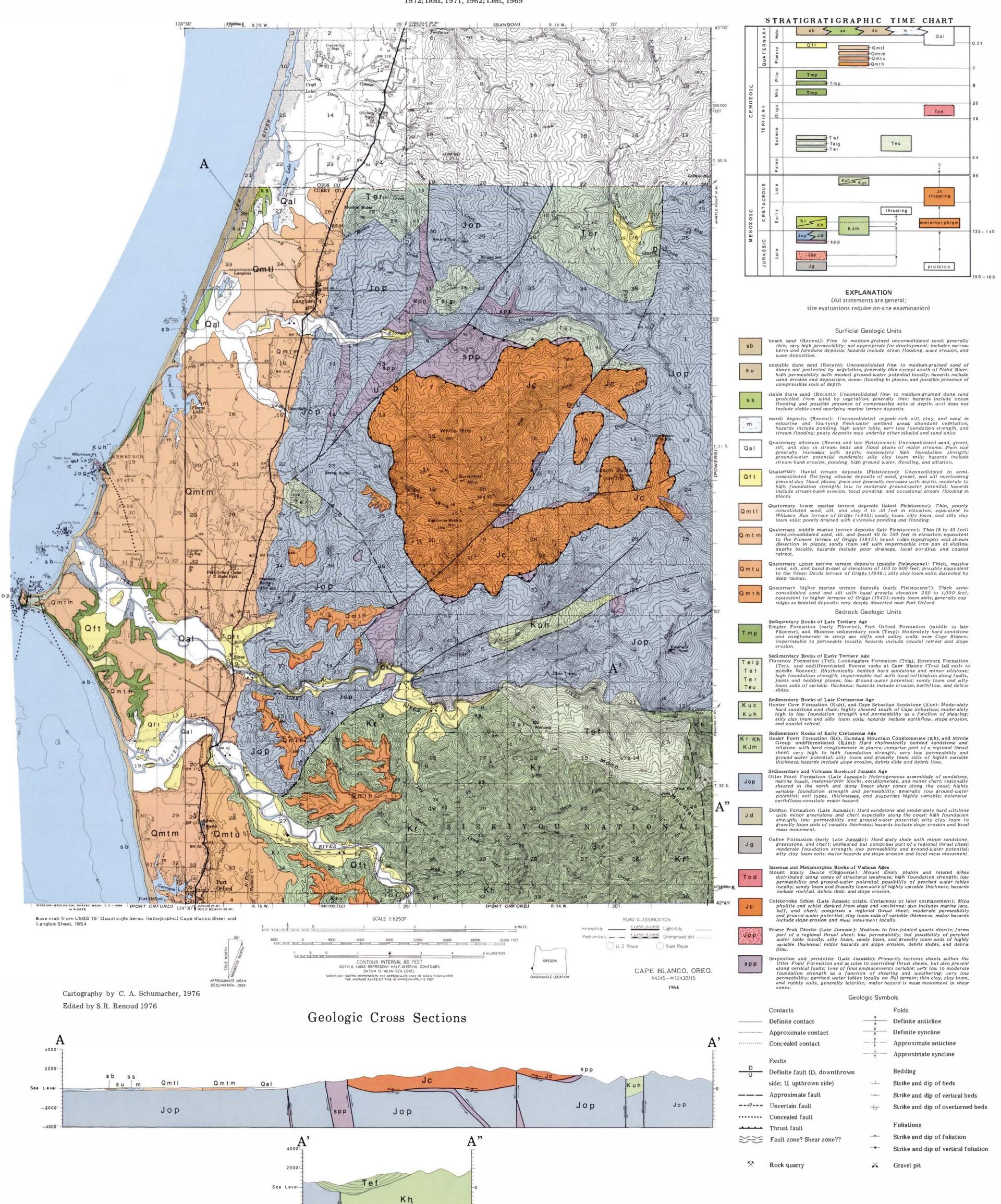
STATE OF OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES R. E. CORCDRAN. STATE GEOLOGIST

CAPE BLANCO & parts of LANGLOIS QUADRANGLES OREGON

Geology by John D. Beaulieu: modified after Brownfield, 1972; Dott, 1971, 1962; Lent, 1969

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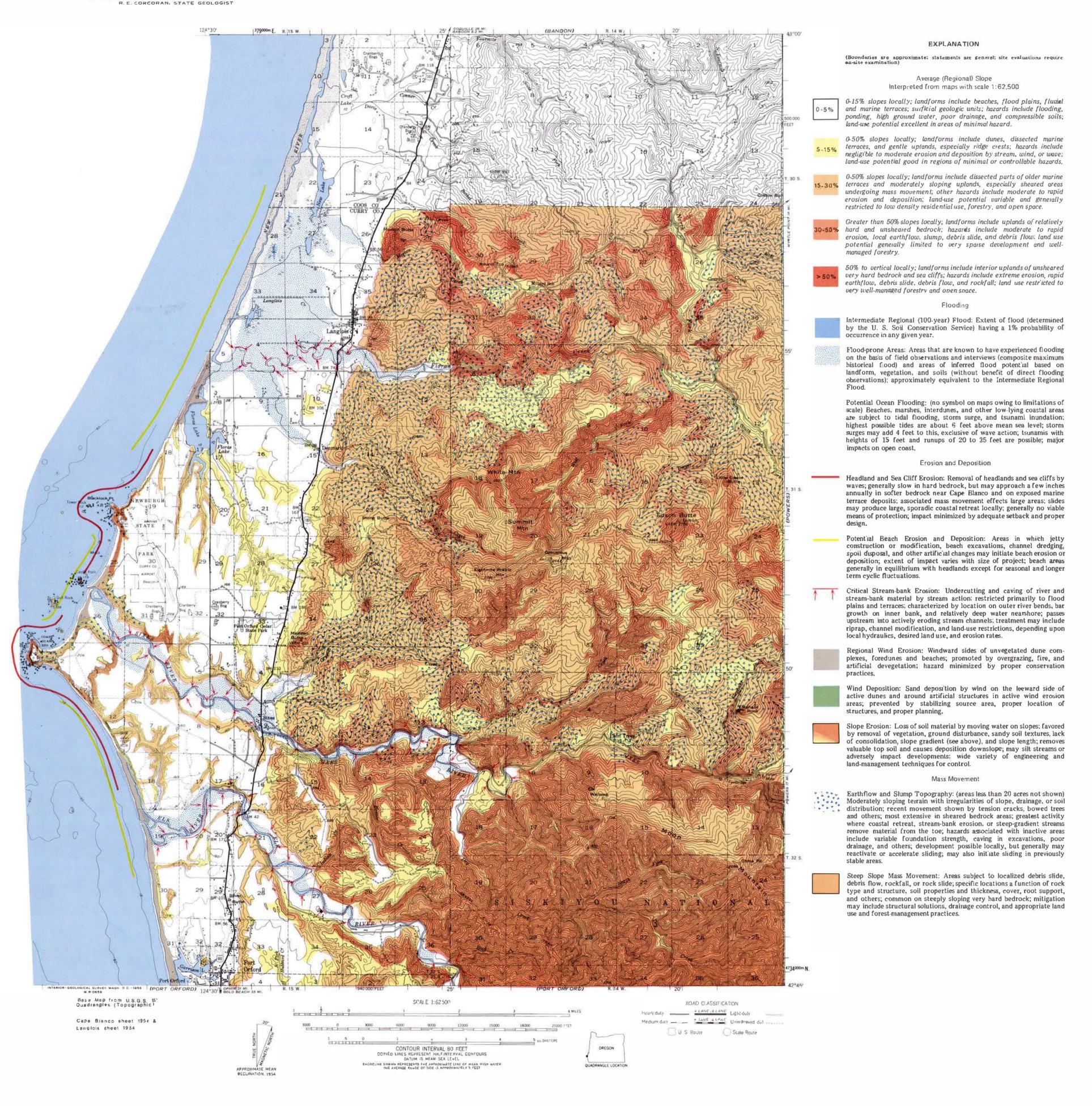
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CAPE BLANCO & part of LANGLOIS QUADRANGLES OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES



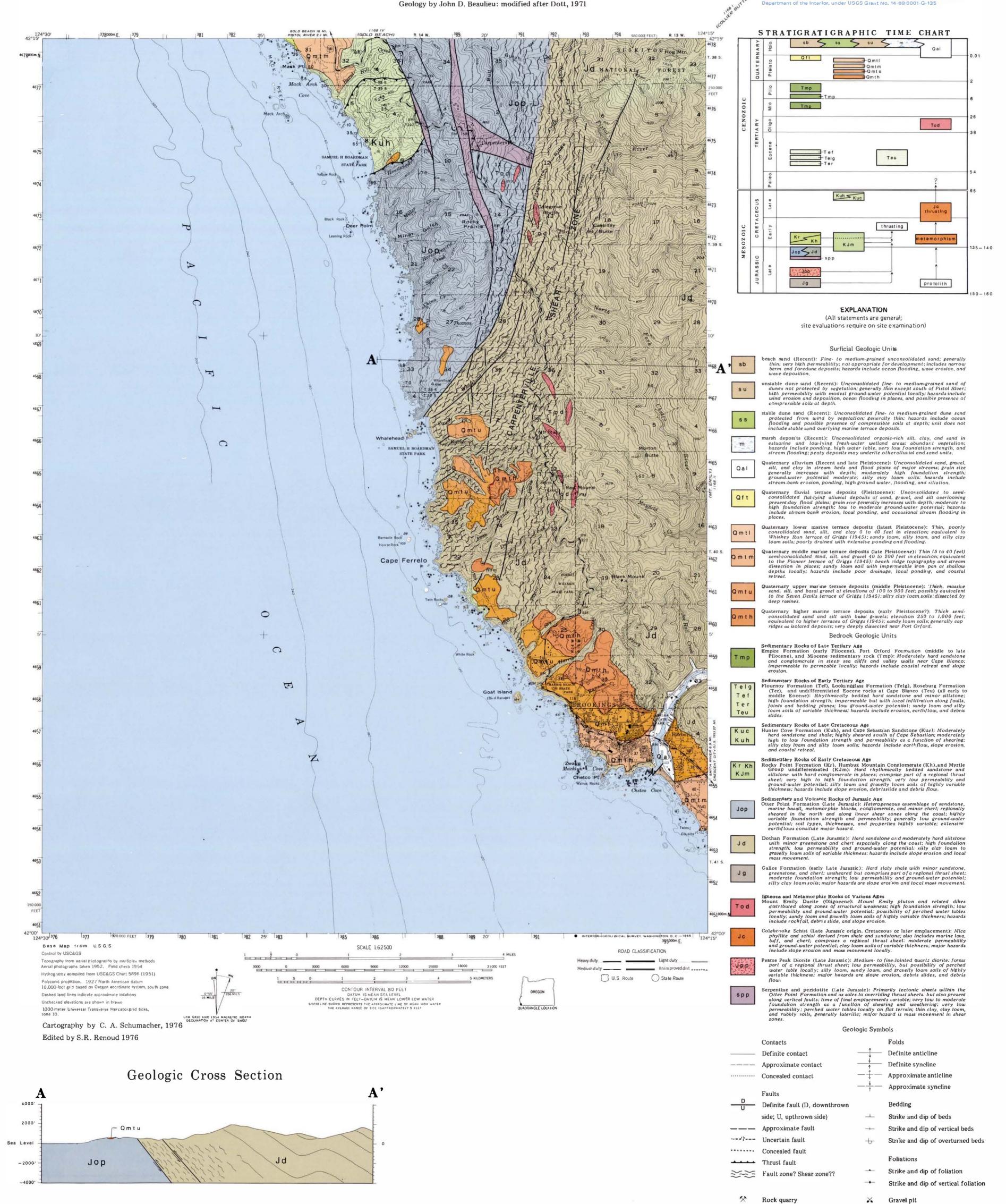
GEOLOGIC MAP CAPE FERRELO QUADRANGLE **OREGON**

STATE OF OREGON

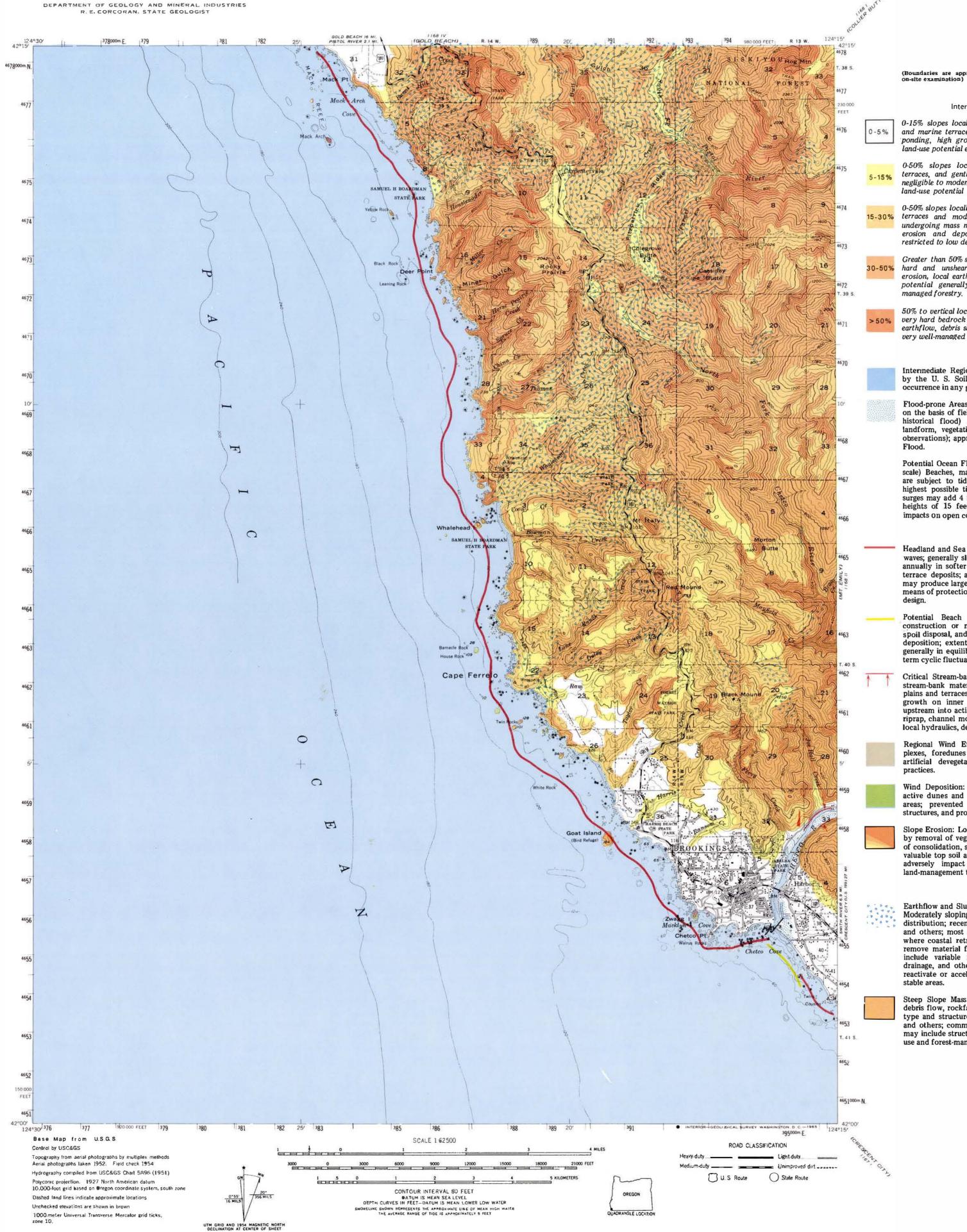
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CAPE FERRELO QUADRANGLE OREGON



EXPLANATION

(Boundaries are approximate; statements are general; site evaluations require on-site examination)

Average (Regional) Slope Interpreted from maps with scale 1:62,500

0-15% slopes locally; landforms include beaches, flood plains, fluvial and marine terraces; surficial geologic units; hazards include flooding, ponding, high ground water, poor drainage, and compressible soils; land-use potential excellent in areas of minimal hazard.

0-50% slopes locally; landforms include dunes, dissected marine terraces, and gentle uplands, especially ridge crests; hazards include negligible to moderate erosion and deposition by stream, wind, or wave; land-use potential good in regions of minimal or controllable hazards.

0-50% slopes locally; landforms include dissected parts of older marine terraces and moderately sloping uplands, especially sheared areas undergoing mass movement; other hazards include moderate to rapid erosion and deposition; land-use potential variable and generally restricted to low density residential use, forestry, and open space.

Greater than 50% slopes locally; landforms include uplands of relatively hard and unsheared bedrock; hazards include moderate to rapid erosion, local earthflow, slump, debris slide, and debris flow; land use potential generally limited to very sparse development and well-managed forestry.

50% to vertical locally; landforms include interior uplands of unsheared very hard bedrock and sea cliffs; hazards include extreme erosion, rapid earthflow, debris slide, debris flow, and rockfall; land use restricted to very well-managed forestry and open space.

Flooding

Intermediate Regional (100-year) Flood: Extent of flood (determined by the U. S. Soil Conservation Service) having a 1% probability of occurrence in any given year.

Flood-prone Areas: Areas that are known to have experienced flooding on the basis of field observations and interviews (composite maximum historical flood) and areas of inferred flood potential based on landform, vegetation, and soils (without benefit of direct flooding observations); approximately equivalent to the Intermediate Regional Flood.

Potential Ocean Flooding: (no symbol on maps owing to limitations of scale) Beaches, marshes, interdunes, and other low-lying coastal areas are subject to tidal flooding, storm surge, and tsunami inundation; highest possible tides are about 6 feet above mean sea level; storm surges may add 4 feet to this, exclusive of wave action; tsunamis with heights of 15 feet and runups of 20 to 25 feet are possible; major impacts on open coast.

Erosion and Deposition

Headland and Sea Cliff Erosion: Removal of headlands and sea cliffs by waves; generally slow in hard bedrock, but may approach a few inches annually in softer bedrock near Cape Blanco and on exposed marine terrace deposits; associated mass movement effects large areas; slides may produce large, sporadic coastal retreat locally; generally no viable means of protection; impact minimized by adequate setback and proper design.

Potential Beach Erosion and Deposition: Areas in which jetty construction or modification, beach excavations, channel dredging, spoil disposal, and other artificial changes may initiate beach erosion or deposition; extent of impact varies with size of project; beach areas generally in equilibrium with headlands except for seasonal and longer term cyclic fluctuations.

Critical Stream-bank Erosion: Undercutting and caving of river and stream-bank material by stream action; restricted primarily to flood plains and terraces; characterized by location on outer river bends, bar growth on inner bank, and relatively deep water nearshore; passes upstream into actively eroding stream channels; treatment may include riprap, channel modification, and land-use restrictions, depending upon local hydraulics, desired land use, and erosion rates.

Regional Wind Erosion: Windward sides of unvegetated dune complexes, foredunes and beaches; promoted by overgrazing, fire, and artificial devegetation; hazard minimized by proper conservation

Wind Deposition: Sand deposition by wind on the leeward side of active dunes and around artificial structures in active wind erosion areas; prevented by stabilizing source area, proper location of structures, and proper planning.

Slope Erosion: Loss of soil material by moving water on slopes; favored by removal of vegetation, ground disturbance, sandy soil textures, lack of consolidation, slope gradient (see above), and slope length; removes valuable top soil and causes deposition downslope; may silt streams or adversely impact developments; wide variety of engineering and land-management techniques for control.

Mass Movement

Earthflow and Slump Topography: (areas less than 20 acres not shown) Moderately sloping terrain with irregularities of slope, drainage, or soil distribution; recent movement shown by tension cracks, bowed trees and others; most extensive in sheared bedrock areas; greatest activity where coastal retreat, stream-bank erosion, or steep-gradient streams remove material from the toe; hazards associated with inactive areas include variable foundation strength, caving in excavations, poor drainage, and others; development possible locally, but generally may reactivate or accelerate sliding; may also initiate sliding in previously

Steep Slope Mass Movement: Areas subject to localized debris slide, debris flow, rockfall, or rock slide; specific locations a function of rock type and structure, soil properties and thickness, cover, root support, and others; common on steeply sloping very hard bedrock; mitigation may include structural solutions, drainage control, and appropriate land use and forest-management practices.

The preparation of this map was financed in part through a project development grant under the Coastel Zone Management Act of 1972 administered by the Office of Coastel Zone Management; local administration by the Land Conservation and Development Commission.

STATE OF OREGON

STATE OF OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES R. E. CORCORAN, STATE GEOLOGIST

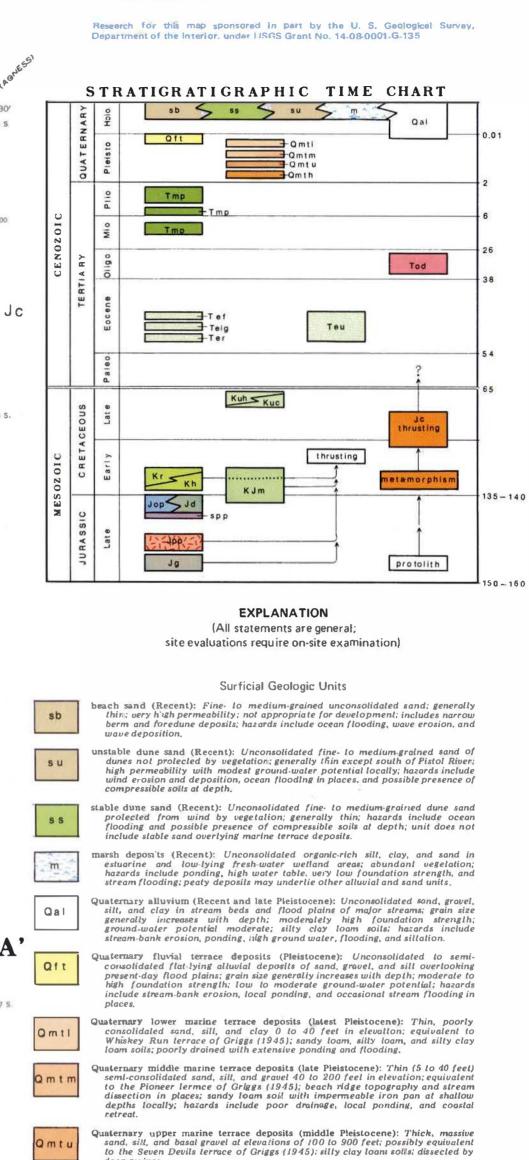
124°30′ 42°30′

GEOLOGIC MAP GOLD BEACH QUADRANGLE OREGON

Geology by John D. Beaulieu: modified after Coleman, 1972; Dott, 1971; Hunter and others, 1970; Koch, 1966

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124°15





Sedimentary Rocks of Late Tertlary Age

Quaternary higher marine terrace deposits (early Pleistocene?): Thick semi-consolidated sand and sill with basal gravels; elevation 250 to 1,000 feet; equivalent to higher terraces of Griggs (1945); sandy loam soils; generally cap ridges as isolated deposits; very deeply dissected near Port Orford.

Bedrock Geologic Units

Empire Formation (early Pliocene), Port Orford Formation (middle to late Pliocene), and Miocene sedimentary rock (Tmp): Moderately hard sandslone and conglomerate in sleep sea cliffs and valley walls near Cape Blanco: impermeable to permeable locally; hazards include coastal retreat and slope

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Rocky Point Formation (Kr), Humbug Mountain Conglomerate (Kh), and Myrtle
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Igneous and Metamorphic Rocks of Various Ages

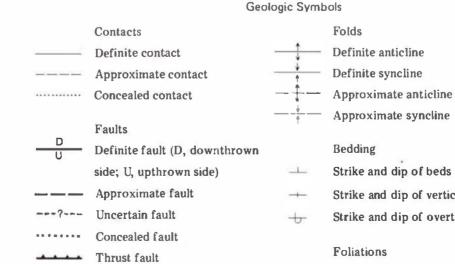
Mount Emily Dacite (Oligocene): Mount Emily pluton and related dikes distributed along zones of structural weakness; high foundation strength; low permeability and ground-water potential; possibility of perched water lables locally; sandy loam and gravelly loam soils of lighty variable thickness; hazards include rockfall, debris slide, and slope erosion.

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Serpentine and peridotite (Late Jurassic): Primarily tectonic sheets within the Otter Point Formation and assoles to overriding thrust sheets, but also present along vertical faults; time of finalemplacements variable; very low to moderate foundation strength as a function of shearing and weathering; very low permeability; perched water tables locally on flat terrain; thin clay, clay loam, and rubbly soils, generally lateritic; major hazard is mass movement in shear zones.



Fault zone? Shear zone??

☆ Rock quarry

Bedding Strike and dip of beds Strike and dip of vertical beds

Folds

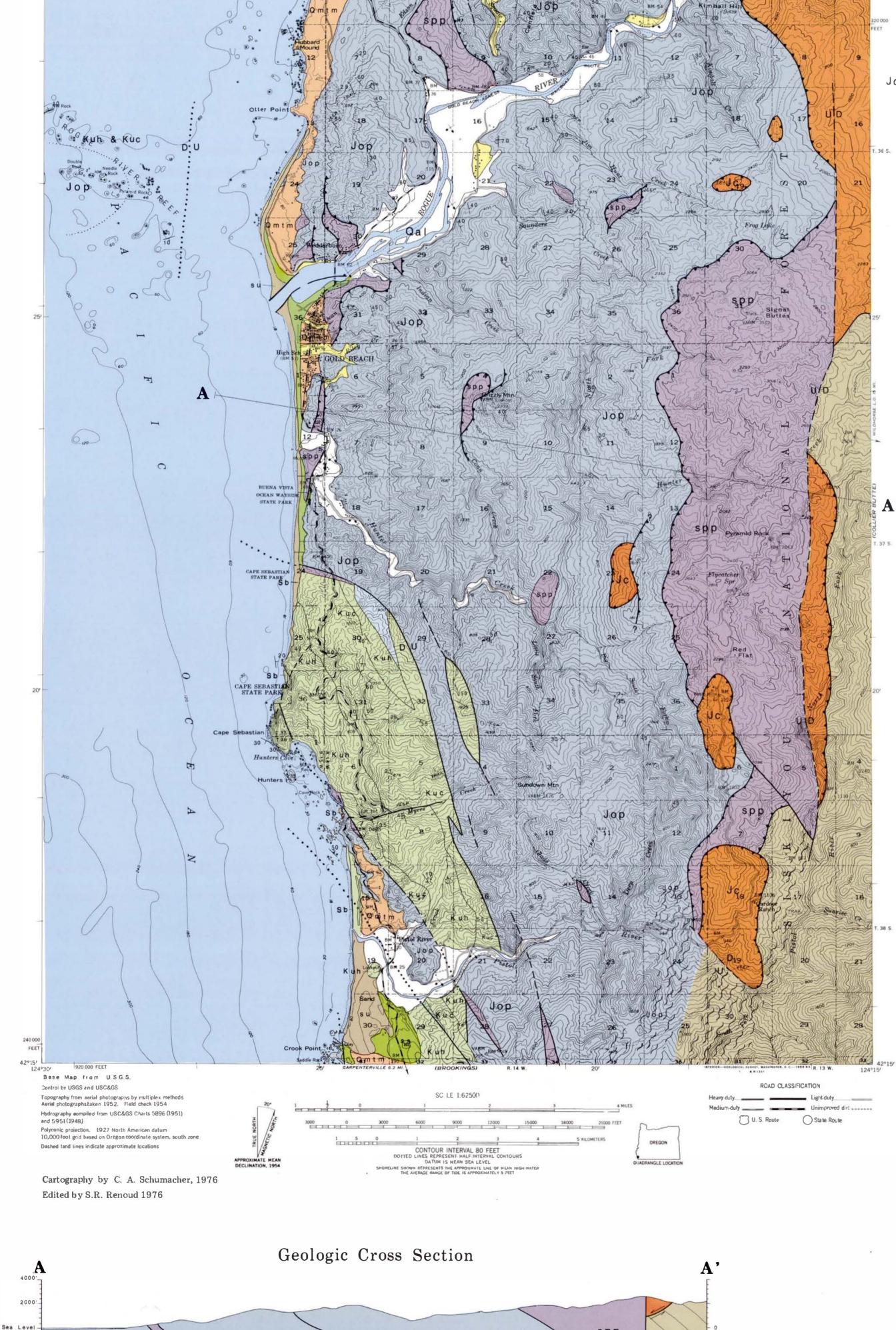
Definite anticline

Definite syncline

Strike and dip of overturned beds **Foliations**

Strike and dip of foliation Strike and dip of vertical foliation

Gravel pit



Jop

Jop

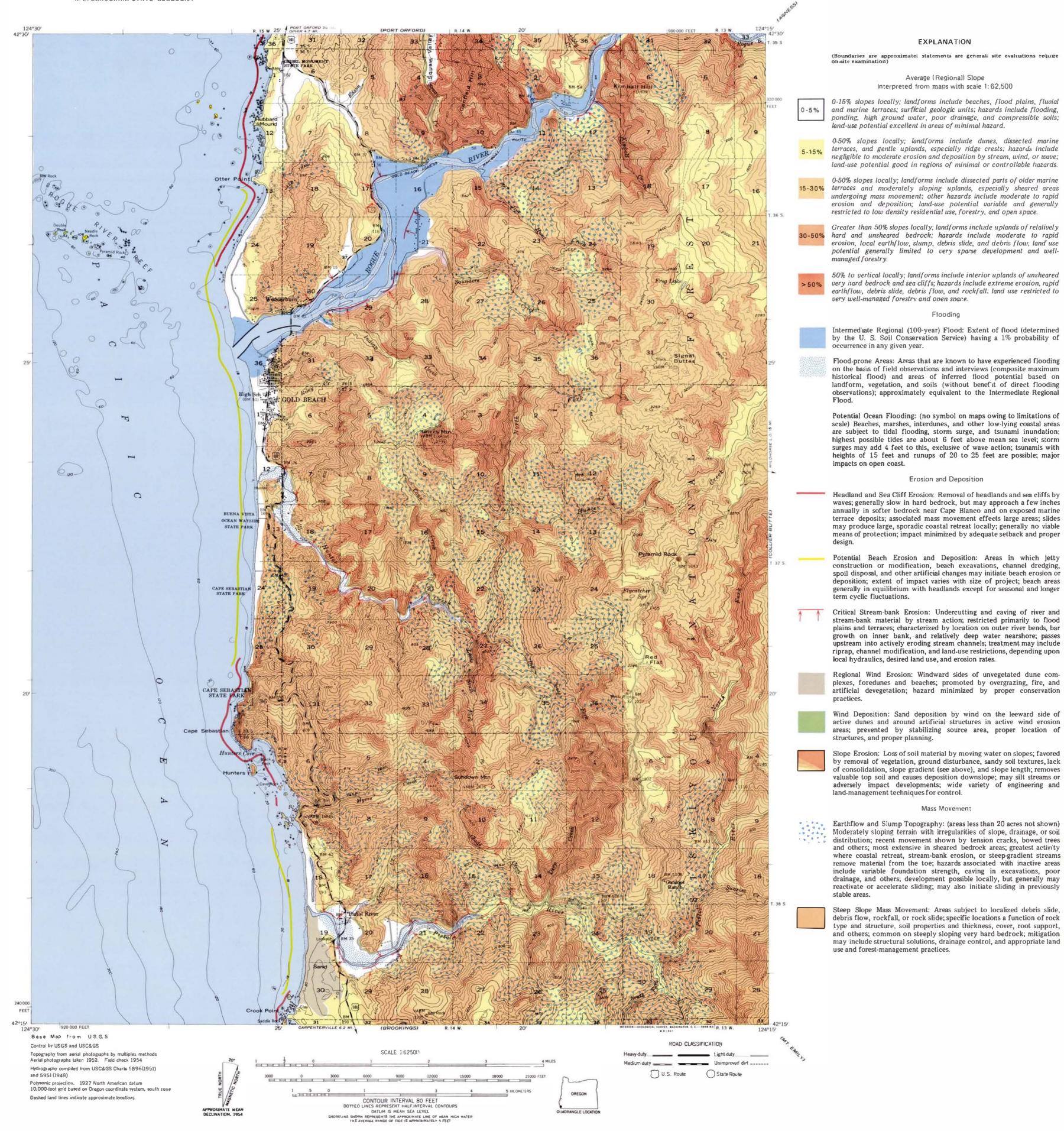
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GEOLOGIC HAZARD MAP of the GOLD BEACH QUADRANGLE OREGON

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

R. E. CORCORAN, STATE GEOLOGIST



The preparation of this map was financed in part through a project development grant under the Coastal Zone Management Act of 1972 administered by the Office of Coastal Zone Management; local administration by the Lend Conservation and Development Commission.

GEOLOGIC MAP MT. EMILY QUADRANGLE (in part)

STATE OF OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Qmtm

Control by USGS and USC&GS

Topography from aerial photographs by multiplex methods

10,000 foot grid based on Oregon coordinate system, south zone

Cartography by C. A. Schumacher, 1976

Aerial photographs taken 1952. Field check 1954 Hydrography compiled from USC&GS Chart 5896 (1951)

Polyconic projection. 1927 North American datum

Deshed land lines indicate approximate locations

Edited by S.R. Renoud 1976

150 000 FEET

124°15'

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2000

-2000

-4000

Sea Level

SCALE 1:62500

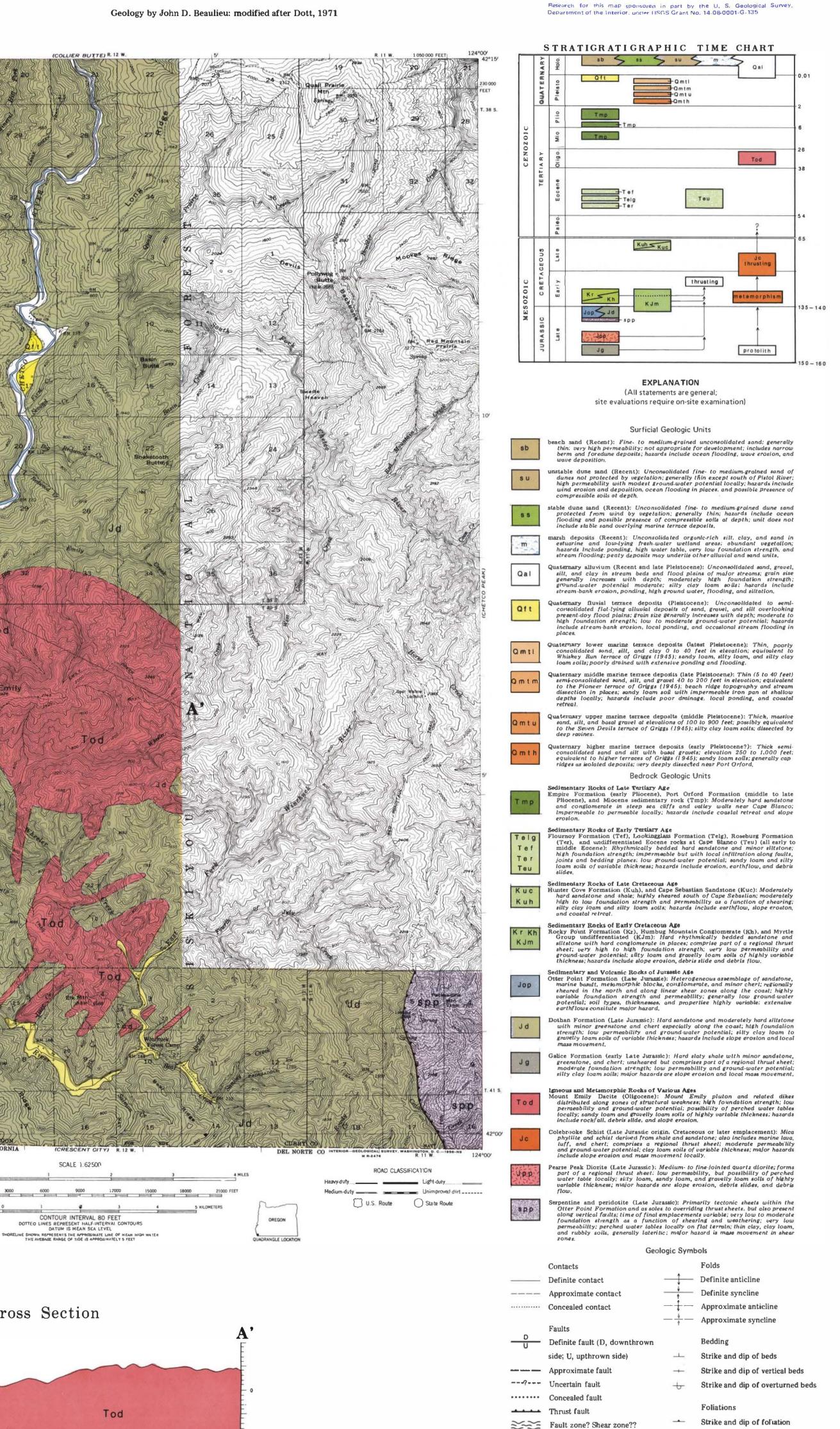
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Geologic Cross Section

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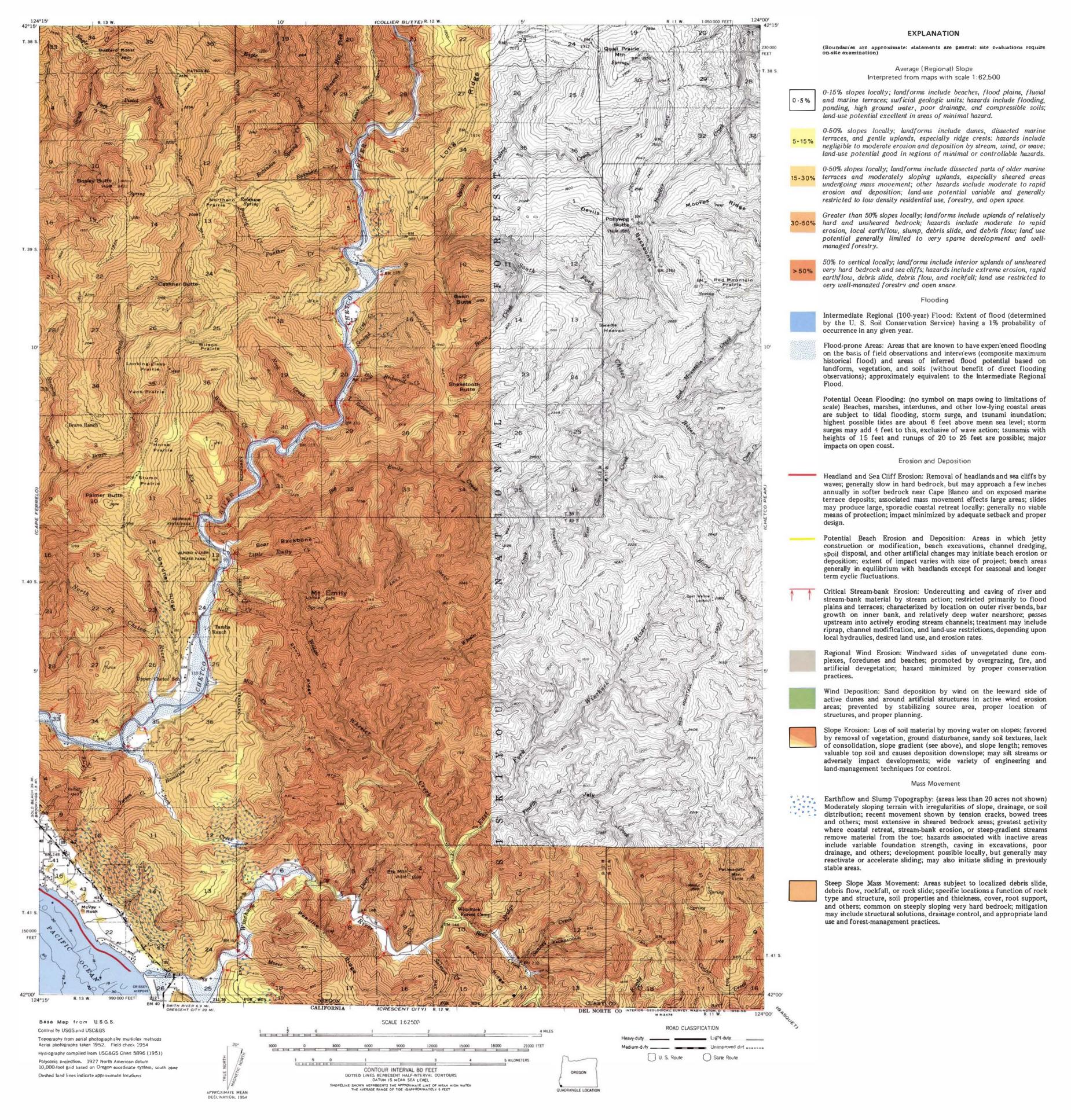
Strike and dip of vertical foliation

Rock quarry



GEOLOGIC HAZARD MAP of the MT. EMILY QUADRANGLE (in part) OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST



BULLETIN 90 LAND-USE GEOLOGY OF WESTERN CURRY COUNTY, OREGON $\begin{array}{c} \textbf{GEOLOGIC MAP} \\ \textbf{PORT ORFORD QUADRANGLE} \end{array}$ The preparation of this map was financed in part through a project development grant under the Coestal Zone Management Act of 1972 administered by the Office of Coastal Zone Management; local STATE OF OREGON administration by the Land Conservation and Development Commission. DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES **OREGON** R. E. CORCORAN, STATE GEOLOGIST Research for this map sponsored in part by the U. S. Geological Survey, Department of the Interior, under USGS Grant No. 14-08-0001-G-135 Geology by John D. Beaulieu: modified after Coleman, 1972; Dott, 1971; Hunter and others, 1970; Koch, 1966 STRATIGRATIGRAPHIC TIME CHART 990 000 FEET R. 13 W 124°15' R. 14 W. sb S ss S su S m Tmp Tmp Tod Kuh Kuc thrusting metamorphis 135-140 STATE PARK 70 protolith 150-160 **EXPLANATION** (All statements are general; site evaluations require on-site examination) Surficial Geologic Units beach sand (Recent): Fine- to medium-grained unconsolidated sand; generally thin; very high permeability; not appropriate for development; includes narrow berm and foredune deposits; hazards include ocean flooding, wave erosion, and wave deposition. unstable dune sand (Recent): Unconsolldated fine- to medium.grained sand of dunes not protected by vegetation; generally litin except south of Pistol River; high permeability with modest ground-water potential tocally; hazards include wind erosion and deposition, ocean flooding in places, and possible presence of compressible poils at death stable dune sand (Recent): Unconsolidated fine- to medium-grained dune sand protected from wind by vegetalton; generally thin; hazards include ocean flooding and possible presence of compressible soils at depth; unit does not include stable sand overlying marine terrace deposits. U·D marsh deposits (Recent): Unconsolldated organic-rich silt, clay, and sand in estuarine and low-lying fresh-water wetland areas; abundant vegetation; hazards include ponding, high water table, very low foundation strength, and stream flooding; peaty deposits may underlie other alluvial and sand units. 0 Quaternary alluvium (Recent and late Pleistocene): Unconsolidated sand, gravel, silt, and clay in stream beds and flood plains of major streams; grain size generally increases with depth; moderately high foundation strength; ground-water potential moderate; silty clay loam soils; hazards include stream-bank erosion, ponding, high ground water, flooding, and siltation. Qal B' Quaternary fluvial terrace deposits (Pleistocene): Unconsolidated to semi-consolidated flat-lying alluvial deposits of sand, gravel, and silt overlooking present-day flood plains; grain size generally increases with depth; moderate to high foundation strength; low to moderate ground-water potential; hazards include stream-bank erosion, local ponding, and occasional stream flooding in Quaternary lower marine terrace deposits (latest Pleistocene): Thin, poorly consolidated sand, sill, and clay 0 to 40 feet in elevation; equivalent to Whiskey Run terrace of Griggs (1945); sandy loam, silly loam, and silly clay loam soils; poorly drained with extensive ponding and flooding. Quaternary middle marine terrace deposits (late Pleistocene): Thin (5 to 40 feet) to the Pioneer terrace of Griggs (1945); beach ridge topography and stream dissection in places; sandy toam soil with imperneable iron pan at shallow depths locally, hazards include poor drainage, local ponding, and coastal 0 Quaternary upper marine terrace deposits (middle Pleistocene): Thick, massive sand, sill, and basal gravel at elevations of 100 to 900 feet; possibly equivalent to the Seven Devils lerrace of Griggs (1945); sillyclay loam soils; dissected by Quatervary higher marine terrace deposits (easily Pleistocene?): Thick semi-consolidated sand and silt with basal gravels; elevation 250 to 1,000 feet; equivalent to higher terraces of Griggs (1945); sandy toam soils; generally cap 0 ridges as isolated deposits; very deeply dissected near Port Orford. **Bedrock Geologic Units** E Sedimentary Rocks of Late Tertiary Age
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Otter Point Formation (Late Jurassic): Helerogeneous assemblage of sandstone,
marine basalt, metamorphic blocks, conglomerate, and minor chert; regionally sheared in the north and along linear shear zones along the coast; highly variable foundation strength and permeability; generally low ground-water potential; soil types, thicknesses, and properties highly variable; extensive 340 000 earthflows consitute major hazard. FEET Dothan Formation (Late Jurassic): Hard sandslone and moderately hard sillstone with minor greensione and chert especially along the coast; high foundation strength; low permeability and ground-water potential; silly clay loam to gravelly loam soils of variable thickness; hazards include slope erosion and local Galice Formation (early Late Jurassic): Hard slaty shale with minor sandstone, greenstone, and chert; unsheared but comprises part of a regional thrust sheet; moderate foundation strength; low permeability and ground-water potential; silty clay loam soils; major hazards are slope erosion and local mass movement. Igneous and Metamorphic Rocks of Various Ages

Mount Emily Dacite (Oligocene): Mount Emily pluton and related dikes distributed along zones of structural weakness; high foundation strength; low permeability and ground-water potential; possibility of perched water tables locally; sandy loam and gravelly loam soils of highly variable thickness; hazards include rockfall, debris slide, and slope erosion. Colebrooke Schist (Late Jurassic origin, Cretaceous or later emplacement): Mica phyllite and schist derived from shale and sandstone; also includes marine lava, tuff, and chert; comprises a regional thrust sheet; moderate permeability 42°30′ 124°30′ 930 000 FEET 124°15′ and ground-water potential; clay loam soils of variable thickness; major hazards include slope erosion and mass movement locally. ROAD CLASSIFIC TION Control by USGS and USC&GS SCALE 1:62500 Pearse Peak Diorite (Late Jurassic): Medium- to fine-jointed quartz diorite; forms Light-duty Topography from aerial photographis by multiplex methods part of a regional thrust sheet; low permeability, but possibility of perched water table locally; silty loam, sandy loam, and gravelty loam soils of highly variable thickness; major hazards are slope erosion, debris sildes, and debris Aerial photographs taken 1952. Field check 1954 Hydrography from USC&GS charts 5951 (1948) and 5952 (1950) Polyconic projection 1927 North American datum 10,000-foot grid based on Oregon coordinate system, south zone Serpentine and peridotite (Late Jurassic): Primarily tectonic sheets within the Olter Point Formation and as soles to overriding thrustsheets, but also present along vertical faults; time of final emplacements variable; very low to moderate foundation strength as a function of shearing and weathering; very low permeability; perched water tables locally on flat terrain; thin clay, clay loam, нинин п Dashed land lines indicate approximate locations CONTOUR INTERVAL 80 FEET OOTTED LINES REPRIBEINT HALF-INTERVAL CONTOURS DATUM IS MEAN SEA LEVEL and rubbly soils, generally lateritic; major hazard is mass movement in shear SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER THE AVERAGE RANGE OF TIDE IS APPROXIMATELY 5 FEET Cartography by C. A. Schumacher, 1976 Geologic Symbols Geologic Cross Sections Edited by S.R. Renoud 1976 **Folds** A' Contacts Definite anticline Definite contact 4000- Definite syncline — Approximate contact Approximate anticline Concealed contact 2000 Approximate syncline **Faults** Sea Level Definite fault (D, downthrown Bedding Jpp side; U, upthrown side) Strike and dip of beds -2000+ Jop

B"

Kr.Kh

 \mathbf{B}

4000

2000

-2000

Jop

JOP

--- Approximate fault

Fault zone? Shear zone??

Rock quarry

---?--- Uncertain fault

····· Concealed fault

Thrust fault

X

Strike and dip of vertical beds

Foliations

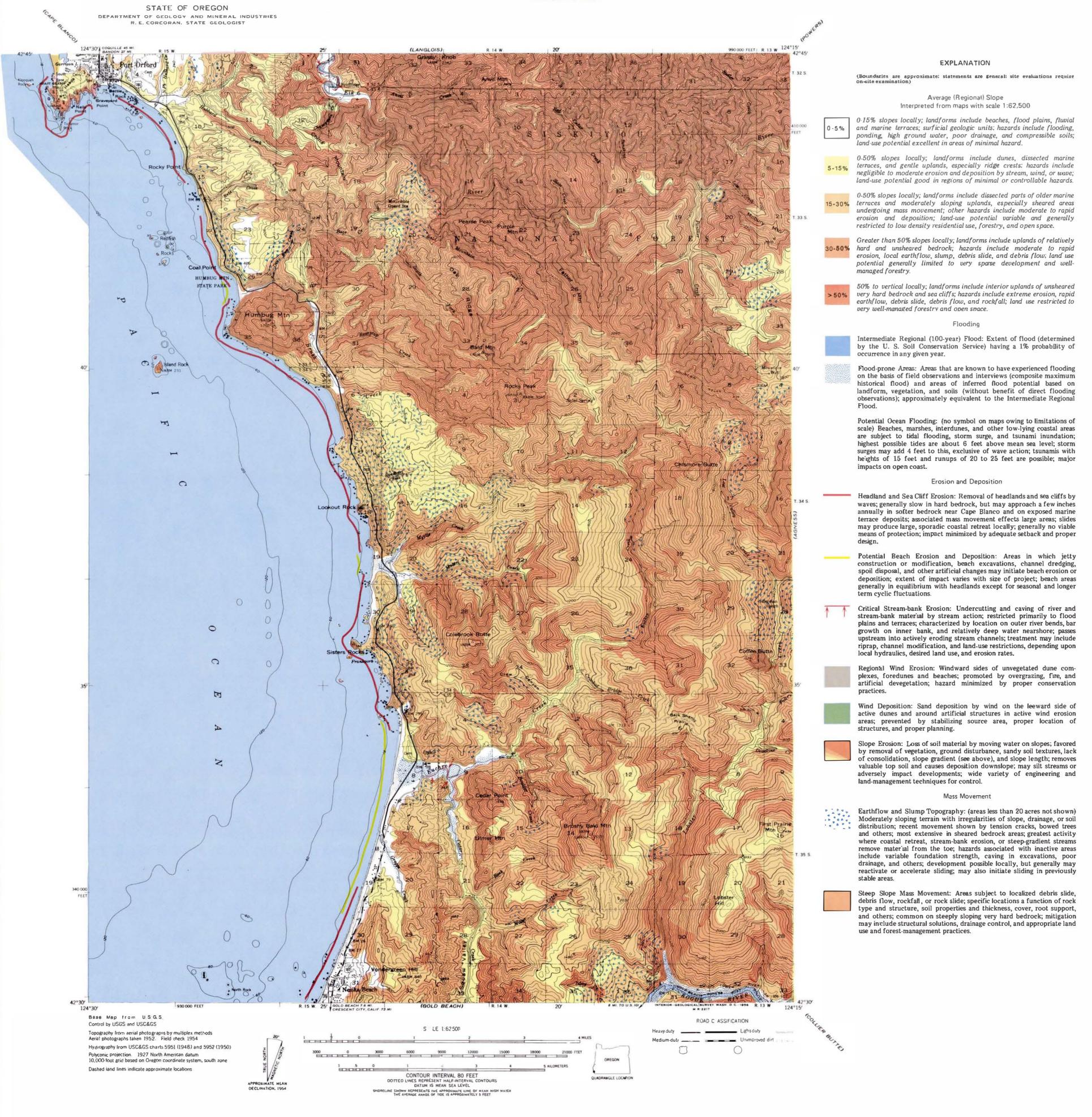
Gravel pit

Strike and dip of foliation

Strike and dip of overturned beds

Strike and dip of vertical foliation

GEOLOGIC HAZARD MAP of the PORT ORFORD QUADRANGLE OREGON



The preparation of this map was financed in part through a project development grant under the Coastal Zone Management Act of 1972 administered by the Office of Coastal Zona Management; local edministration by the Land Conservation and Development Commission.