ORIGINAL
Single Sign

G322 - Geomorphology Lab
Field Techniques in Fluvial Analysis - Part 1 (Luckiamute Field Trip)

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INTRODUCTION

Rivers represent the primary conduits for surface drainage on the earth. Fluvial systems are efficient plumbing mechanisms that transport water and sediment. The kinetic energy of the system is driven by gravity and climate, with work completed in the form of erosion and transportation.

The amount of water a stream is carrying, or its discharge, is important for a number of reasons. The discharge may be used for domestic/industrial water supplies, agricultural irrigation, sewage disposal, or transportation. Knowledge of flood history is also vital for appropriate landuse planning and hazards mitigation. The U.S. Geological Survey has established over 9000 stream gaging stations across the country to collect vital river discharge information. In addition, many other streams are monitored by agencies such as the Natural Resources Conservation Service, Forest Service, and local water-management organizations.

OBJECTIVES

The objective of this exercise is to make basic field observations at a local stretch of river in the Upper Willamette watershed. We will visit the Luckiamute River, near Helmick State Park, to learn the basic principles of fluvial hydrology and flood analysis. The goals of this exercise are to:

1) Determine a spot discharge for the Luckiamute using basic channel geometry and the continuity equation for rivers.

2) Construct a transverse profile for the Luckiamute channel system where it crosses the iron bridge at Helmick Rd and Helmick State Park.

3) Determine theoretical flood discharge values for conditions at which the Luckiamute covers the bridge deck at Helmick Park.

4) Compare calculated spot discharge and flood discharge values with historical discharge data collected at a USGS gaging station.

5) Classify the Luckiamute according to its channel characteristics, and

6) Make some basic observations with respect to past flood activity at Helmick State Park and long-term evolution of the Upper Willamette watershed.

The field trip will provide an opportunity for data collection. Analysis will be conducted back at the classroom.

FIELD PROCEDURES
Team 1 - Bridge/Channel Transect

1) Use the railing of the bridge across the Luckiamute as a measuring datum from which to construct a profile of the valley bottom.

2) Measure the depth to channel bottom from the railing, using the tapes provided. Take a depth measurement at 1 m intervals across the bridge span, record data in field notebook (Refer to Figure 1).

A) make a sketch of the measuring stations and bridge for later reference.

B) Note the elevation of the bridge railing shown on the brass plate at the south end of the bridge.

C) At stations outside of the present active channel, just record depth to valley bottom from the bridge railing. At stations with flowing water in the active channel, have a team member observe the water level on the measuring tape. Use binoculars or spotting scope from the channel bank.

Record all data. We will use this later in lab to make some hydraulic calculations.

Team 2 - Wader-Team (Yes in the water!)

3) Stretch a tape across the active channel of the Luckiamute. Using a jacob's staff, measure the depth of the water at 0.5 - 1.0 m increments across the channel (See Figure 1). Record data, sketch the field layout and note which direction the river is flowing (looking upstream or downstream).

4) At the same stations in (3) above, determine the velocity of surface flow by using the "float" method.

A) Stretch two ropes across the channel at a known down-channel distance (e.g. 5 m between ropes).

B) Drop a fishing bobber or leaf in the stream, measure the time of travel between the two obervation points. Try to make a set of observations at each depth station.

1) Calculate stream velocity V = Distance/time (m/sec)

Record all data in table format. We will later use this data to calculate spot discharge.

All Class Members: Roughness and Slope Estimaters

Roughness is a measure of the variability of the channel bed. Roughness factors provide resistance in the form of friction and have an influence on velocity and discharge.

5) Using the roughness field guides shown in Table 1, estimate the roughness of the Luckiamute valley bottom

A) for the active channel that Team 2 is playing in, and

B) for the total valley bottom beneath the bridge deck.

6) Using the Monmouth-Quad topo sheet, calculate a stream gradient for the Luckiamute in this stretch of the river. Use two contour intervals above and below the bridge to make an average estimate of channel slope.

7) Using the Rosgen River classification guide shown in Figure 2, classify this stretch of the Luckiamute according to channel pattern and slope.

Record all observations and make sketches as necessary.

All Class Members: Paleoflood Analysts / Sedimentologists

8) With the instructor's help, identify evidence of flood history in this part of the Luckiamute. Look for:

a) fresh, unvegetated sediment
b) damaged vegetation / scarred bark
c) stunted or deformed vegetation
d) tilted trees
e) floodplain deposits
f) shrubs / disturbed vegetative zones.
g) flotsam / cultural objects

9) Make some observations of the type of sediment that the Luckiamute is transporting. Look in the active channel and cuts in the channel banks. Try to estimate relative percentages of: clay, silt, sand, gravel, woody debris.

A) Collect some channel and channel bank samples for later grain size analysis in the lab.

Record all observations, field sketches will be very helpful later.

All Class Members: Final Stop at the Farm Fields Just South of Helmick State Park

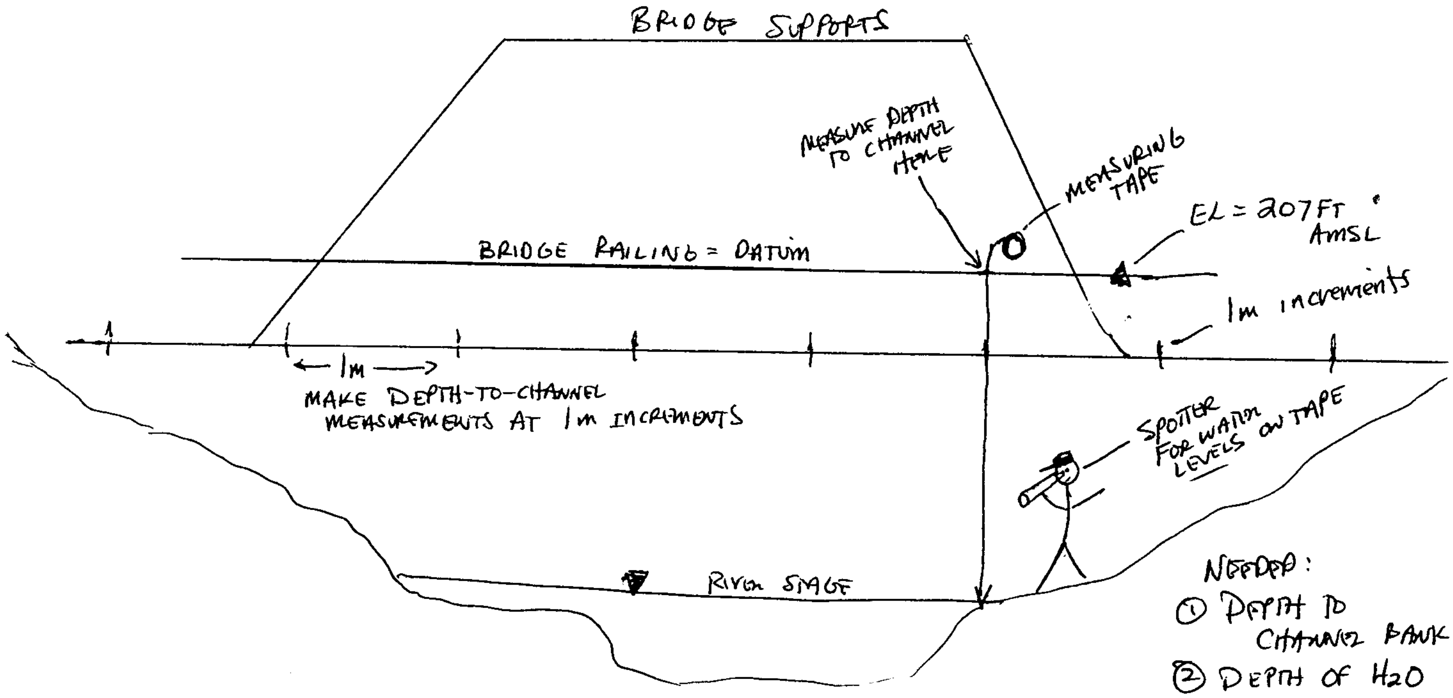
10) Make observations regarding variation in surface topography, slope, and land elevations. Record your observations.

11) Collect soil samples using the buck auger at various topographic positions. Bag and save samples for laboratory examination.

12) Make some general hypotheses regarding geomorphic surfaces adjacent to the Luckiamute River. Think in terms of landform, process, and age of surfaces.

FIGURE 1

1) SKETCH OF VALLEY PROFILE TECHNIQUE



2) SKETCH OF VELOCITY-DISCHARGE TECHNIQUE

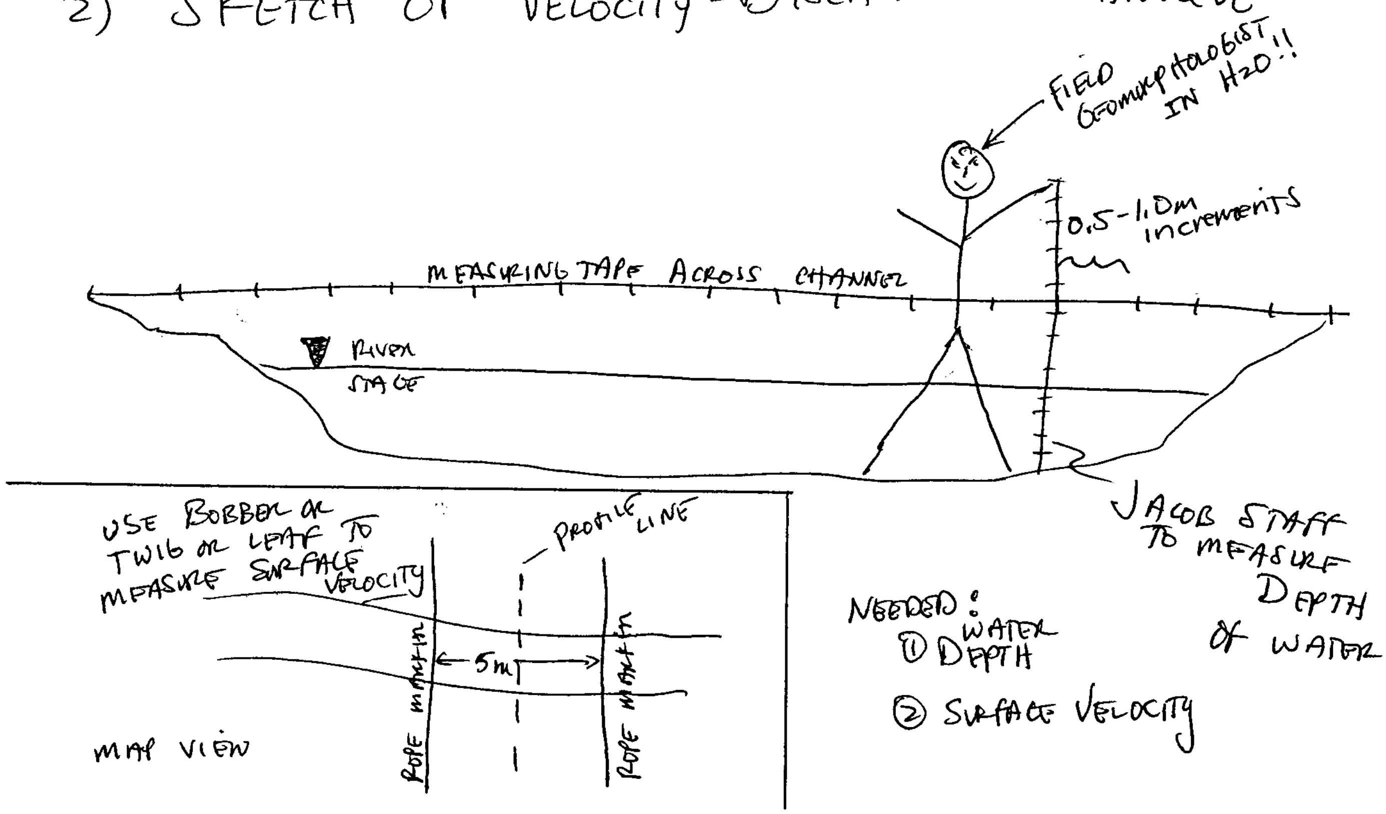


TABLE I — ROUGHNESS

A. [redacted] Values of Roughness, n

River Description	*Roughness, n*
Ordinary rivers:	
clean, straight channel, no riffles or pools	0.030
straight, weedy, boulders	0.035
clean winding channel, pools and riffles	0.040
weedy, winding, deep pools	0.070
Alluvial channels:	
vegetated, no brush, grassy	0.030–.035
vegetated, brushy	0.050–.10
no vegetation	
ripples, dunes	0.017–.035
plane bed	0.011–.015
antidunes	0.012–.020
Mountain streams: rocky beds	
no vegetation, steep banks	
bed of gravel, cobbles,	0.040
bed of cobbles and boulders	0.050

Compiled and adapted from Chow (1959 and 1964)

B.

[redacted] Manning roughness coefficients (n) for different boundary types.

Boundary	Manning n ($ft^{1/6}$)
Very smooth surfaces such as glass, plastic, or brass	0.010
Very smooth concrete and planed timber	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Vitrified clay	0.015
Shot concrete, untroweled, and earth channels in best condition	0.017
Straight unlined earth canals in good condition	0.020
Rivers and earth canals in fair condition; some growth	0.025
Winding natural streams and canals in poor condition; considerable moss growth	0.035
Mountain streams with rocky beds and rivers with variable sections and some vegetation along banks	0.041–0.050

Source: *Handbook of Applied Hydrology*, ed. by Ven T. Chow, copyright 1964 McGraw-Hill Publishing Co., Inc.

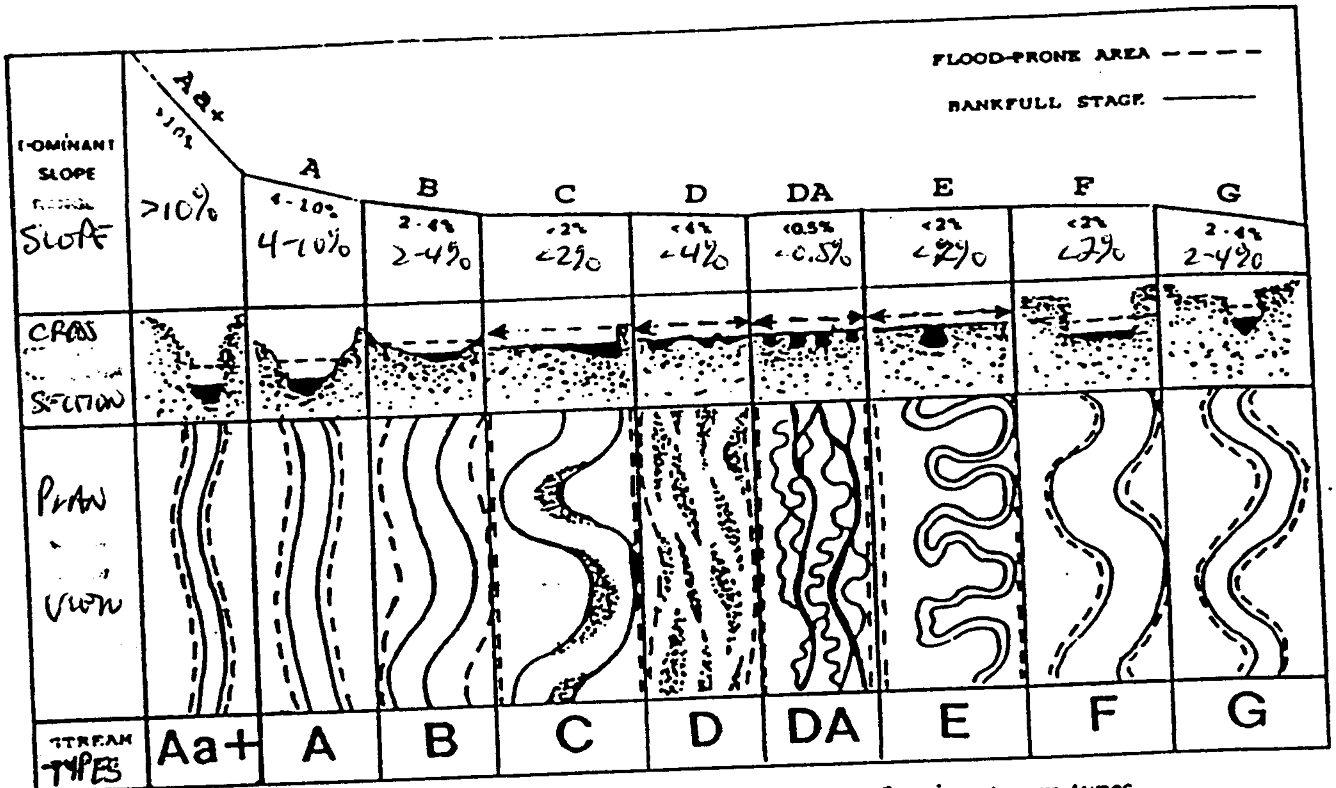


FIG. 2 ~~Fig. 1~~. Longitudinal, cross-sectional and plan views of major stream types.

FLUVIAL FIELD TRIP
EQUATION LIST

$F < 1$ = TRANQUIL FLOW
$F = 1$ = CRITICAL FLOW
$F > 1$ = SUPER CRITICAL FLOW

FROUDE NO. – DESCRIBES FLOW TYPE

$$Fr = \frac{V}{\sqrt{dg}}$$

V = velocity m/sec
d = depth m
g = gravity acc. = $9.8\ m/sec^2$

MANNING'S EQUATION – TO CALCULATE STREAM VELOCITY

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

V = VELOCITY m/sec
R = HYDRAULIC RADIUS = $\frac{A}{P}$ — A = CHANNEL AREA m^2; P = WETTED PERIMETER m
S = SLOPE
n = ROUGHNESS

$$T_c = \gamma R S$$ = CRITICAL STREAM FORCE FOR EROSION

γ = SPECIFIC WT. OF H_2O = $9800\ N/m^3$
R = HYDRAULIC RADIUS = $\frac{A}{P}$
S = SLOPE

STREAM POWER = KINETIC ENERGY AVAILABLE FOR WORK

TOTAL POWER $\Omega = \gamma Q S$ (WATTS)

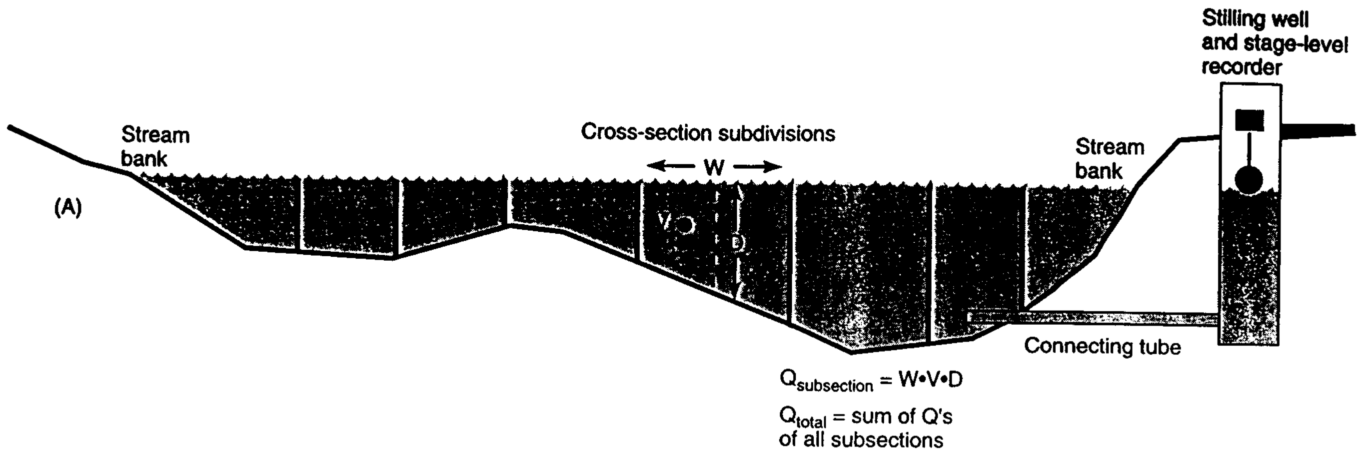
UNIT POWER $\omega = \frac{\gamma Q S}{w}$ (WATTS/m)

γ = SP. WT. H_2O = $9800\ N/m^3$
Q = DISCHARGE = m^3/sec
S = SLOPE
w = width m

CONTINUITY EQUATION

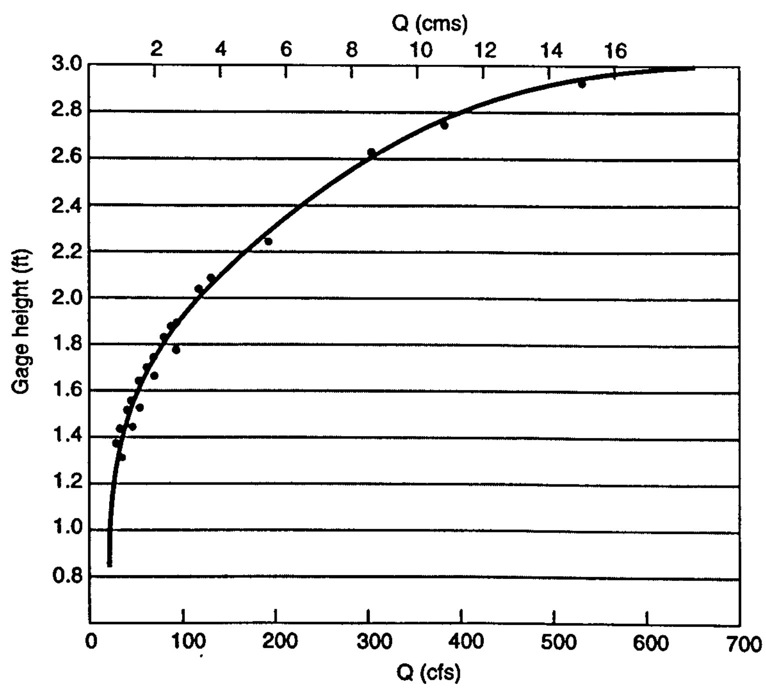
$$Q = VA$$

Q = DISCHARGE m^3/sec
V = VELOCITY m/sec
A = AREA OF CHANNEL m^2



(D)

FIGURE 5.33
Rating curve for low flow. Rock Creek near Red Lodge, Mont.



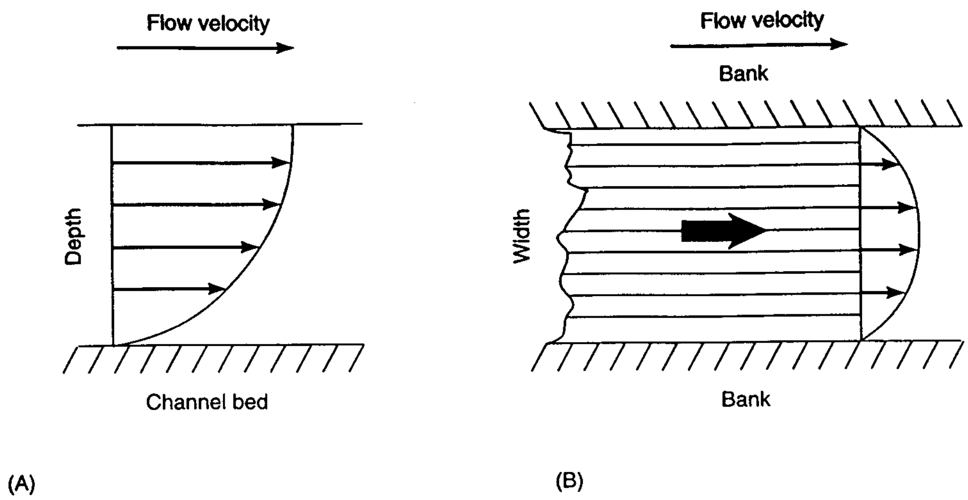
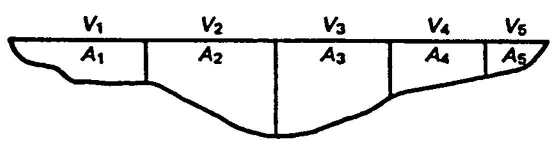


FIGURE 6.1

Diagram showing the changes in flow velocity with (A) flow depth and (B) flow width. Resistance to flow along the bed and banks allows the greatest velocities to occur toward the center of the channel near the water surface.



subareas of velocity domains.

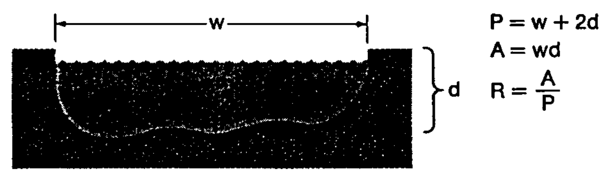


FIGURE 6.2

Cross-sectional measurements of a stream channel: w = width, d = depth, A = area, R = hydraulic radius, P = distance along wetted perimeter.

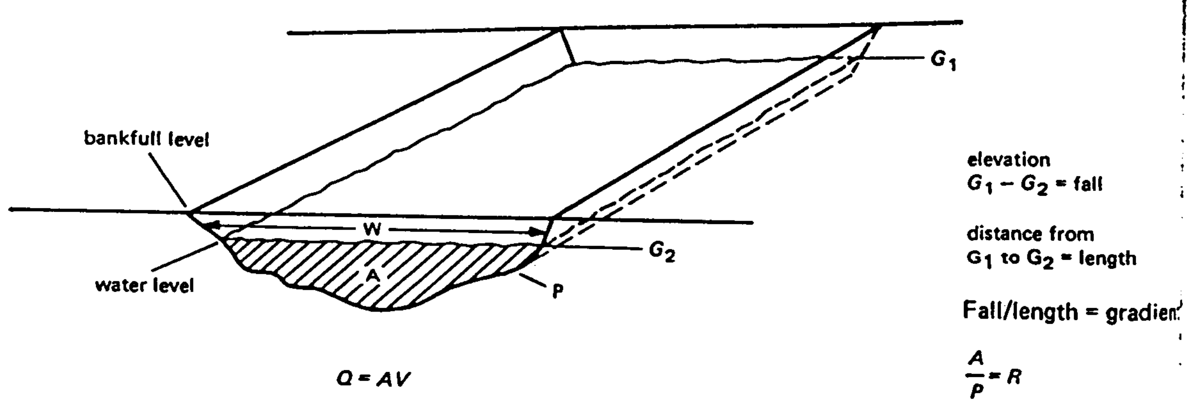


Figure 9.2. Nomenclature of channel morphology.

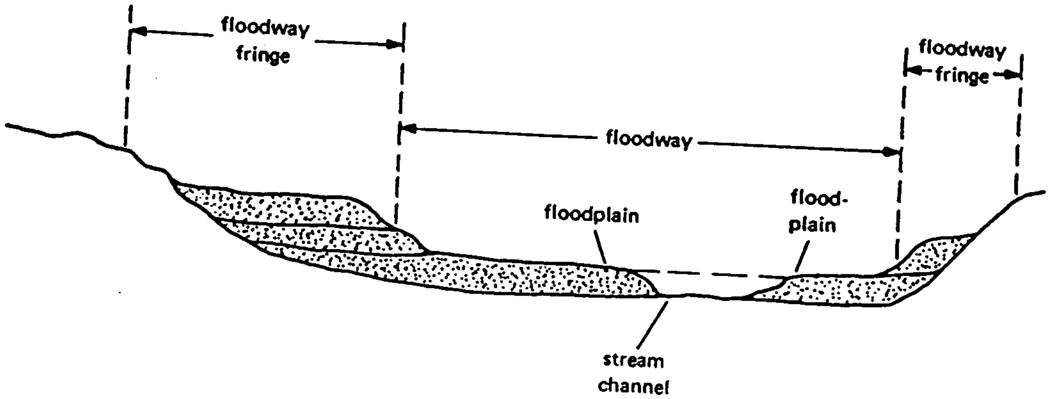


Figure 11.1. View across a river. The floodway is the area along the river which is frequently flooded, an area over which the flood discharge moves with great velocity. The floodway fringe includes areas which are further from the actual channel and which are infrequently flooded by rare events. The floodway fringe is that area flooded by the "100-year" flood.

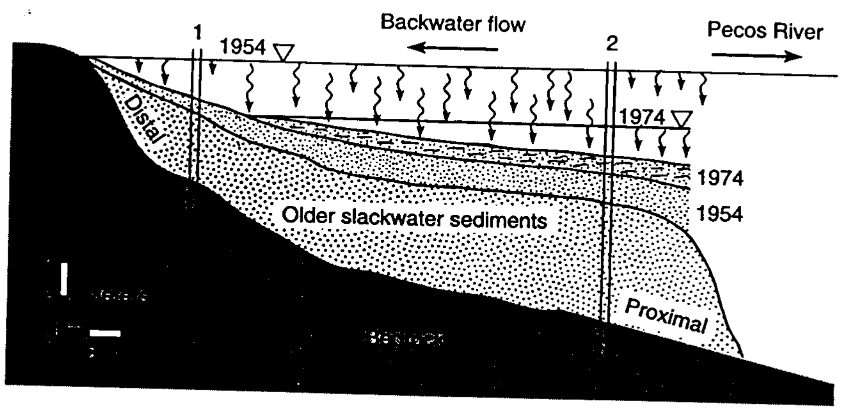
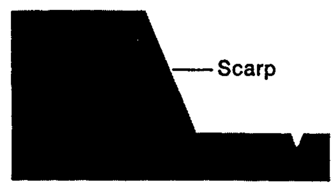


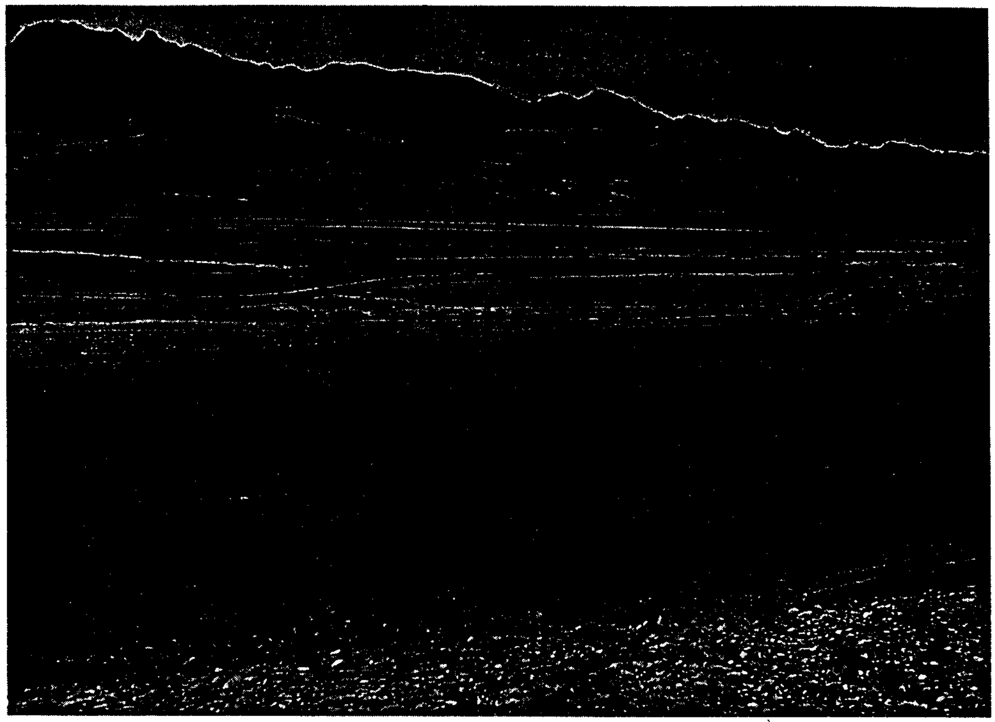
FIGURE 5.37

Schematic of on- and off-lap sequences and peak flood stage in a tributary valley for the 1954 and 1974 floods on the Pecos River, Texas. Sections in the proximal region (area 2) contain both floods, while distal regions (area 1) farther up the tributary record only the larger 1954 flood. Paleostage reconstructions are based on the elevation of the most distal sediments of each flood unit.

(Kochel et al. 1982)



(A)



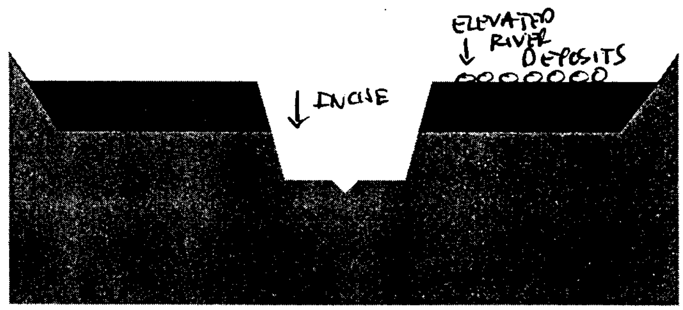
(B)

FIGURE 7.10
(A) Parts of a fluvial terrace.
(B) Terraces along the Madison River upstream from Ennis, Mont.

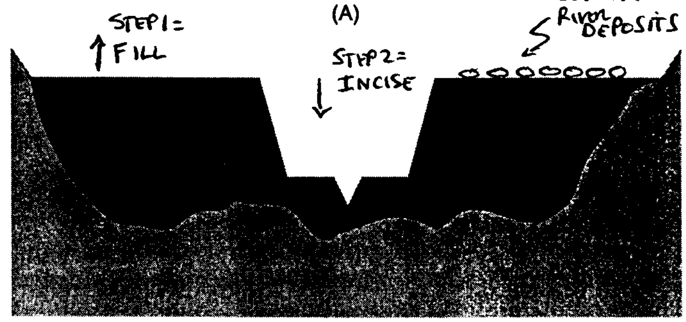
abandoned floodplain surface (tread) must have previously been at a higher level. In fact, the presence of a terrace demands an episode of downcutting (channel entrenchment), and indicates that some significant change must have occurred between the conditions that prevailed during development of the tread and those that produced the scarp. Usually the downcutting phase begins as a response to climatic or tectonic changes, but these are not always necessary. The tread surface normally is underlain by alluvium of variable thickness, but these deposits are not a true part of the terrace. To avoid confusion, it is better to limit the term to the topographic form and refer to the deposits as fill, alluvium, gravel, and so on.

Types and Classification

Howard and his coauthors (1968) categorize terraces as erosional or depositional. **Erosional terraces** are those in which the tread has been formed primarily by lateral erosion. If the lateral erosion truncates bedrock, the terms *bench, strath,* or *rock-cut terrace* are commonly used. If the erosion crosses unconsolidated debris, the terms *fill-cut* or *fillstrath* may be used (Howard 1959). **Depositional terraces,** the second major grouping, are terraces where the tread represents the uneroded surface of a valley fill. Figure 7.11 illustrates both types.



Erosional terrace
(A)



Depositional terrace
(B)

FIGURE 7.11
(A) Erosional terrace. Thin alluvial cover with truncation of underlying bedrock along smooth, even surface.
(B) Depositional terrace. Terrace scarp underlain by alluvium that is highest level of fill deposited in valley. Note thickness of alluvium and irregular bedrock surface beneath the fill.

APPENDIX 9.A.
Conversion Tables

Length

Unit	Equivalent[1,2]					
	millimeters	inches	feet	meters	kilometers	miles
millimeters	1	3.937×10^{-2}	3.281×10^{-3}	1×10^{-3}	1×10^{-6}	6.214×10^{-7}
inches	25.4	1	8.33×10^{-2}	2.54×10^{-2}	2.54×10^{-5}	1.578×10^{-5}
feet	304.8	12	1	0.3048	3.048×10^{-4}	1.894×10^{-4}
meters	1,000	39.37	3.281	1	1×10^{-3}	6.214×10^{-4}
kilometers	1×10^{6}	3.937×10^{4}	3,281	1,000	1	0.6214
miles	1.609×10^{6}	6.336×10^{4}	5,280	1,609	1.609	1

Area

Unit	Equivalent[1,2]						
	square inches	square feet	square meters	acres	hectares	square kilometers	square miles
square inches	1	6.944×10^{-3}	6.452×10^{-4}	1.594×10^{-8}	6.452×10^{-8}	6.452×10^{-10}	2.491×10^{-10}
square feet	144	1	9.29×10^{-2}	2.296×10^{-5}	9.29×10^{-9}	9.29×10^{-8}	3.587×10^{-8}
square meters	1,550	10.76	1	2.471×10^{-4}	1×10^{-4}	1×10^{-6}	3.861×10^{-7}
acres	6.273×10^{6}	4.356×10^{4}	4,047	1	0.4047	4.047×10^{-3}	1.563×10^{-3}
hectares	1.55×10^{7}	1.076×10^{5}	1×10^{4}	2.471	1	0.01	3.861×10^{-3}
square kilometers	1.55×10^{9}	1.076×10^{7}	1×10^{6}	247.1	100	1	0.3861
square miles	4.014×10^{9}	2.788×10^{7}	2.59×10^{6}	640	259	2.59	1

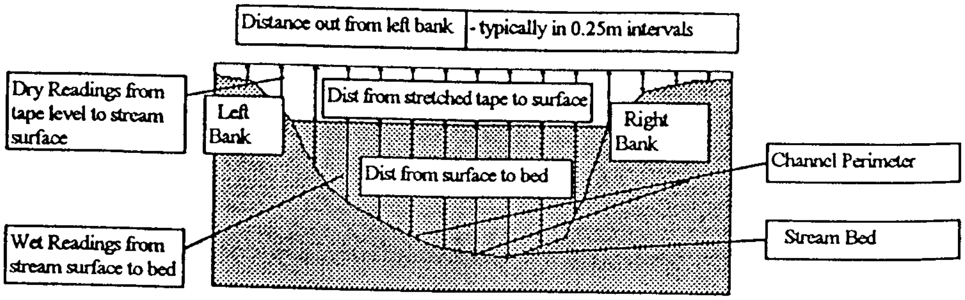
Volume

Unit	Equivalent[1,2]						
	cubic inches	liters	gallons	cubic feet	cubic yards	cubic meters	acre-ft
cubic inches	1	1.639×10^{-2}	4.329×10^{-3}	5.787×10^{-4}	2.143×10^{-5}	1.639×10^{-5}	1.329×10^{-8}
liters	61.02	1	0.2642	3.531×10^{-2}	1.308×10^{-3}	0.001	8.106×10^{-7}
gallons	231.0	3.785	1	0.1337	4.951×10^{-3}	3.785×10^{-3}	3.068×10^{-6}
cubic feet	1,728	28.32	7.481	1	3.704×10^{-2}	2.832×10^{-3}	2.296×10^{-5}
cubic yards	4.666×10^{4}	764.6	202.0	27	1	0.7646	6.198×10^{-4}
cubic meters	6.102×10^{4}	1,000	264.2	35.31	1.308	1	8.106×10^{-4}
acre-ft	7.527×10^{7}	1.233×10^{6}	3.259×10^{5}	4.356×10^{4}	1,613	1,233	1

Discharge (flow rate, volume/time)

Unit	Equivalent[1,2]				
	gallons per minute	liters per second	acre-feet per day	cubic feet per second	cubic meters per day
gallons per minute	1	6.309×10^{-2}	4.419×10^{-3}	2.228×10^{-3}	5.45
liters per second	15.85	1	7.005×10^{-2}	3.531×10^{-2}	86.4
acre-feet per day	226.3	14.28	1	0.5042	1,234
cubic feet per second	448.8	28.32	1.983	1	2,447
cubic meters per day	1.369×10^{9}	8.64×10^{7}	6.051×10^{6}	3.051×10^{6}	1

Figure 8 - Measuring & Plotting the Channel Cross-Section



4.3 Calculating Stream Discharge

In section 3.1 it was demonstrated (Figure 2) that :

DISCHARGE (Q) = Cross -Sectional Area x Flow Velocity

So, if the cross-sectional area of a channel was 1 m^2 and the rate of flow was measured at 1 m/s, then the Discharge Q would be 1m^3/s (1 cumec). If, after heavy rain the channel area increased to 2 m^2 and the flow velocity to 1.5 m/s then the Discharge (Q) would be 3 m^3/s or 3 cumec. Discharge is a very important variable. Unfortunately, it is not always easy to measure.

Figure 9a Semi-Circular Channel

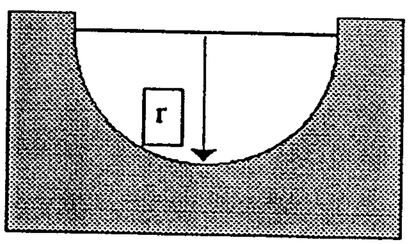
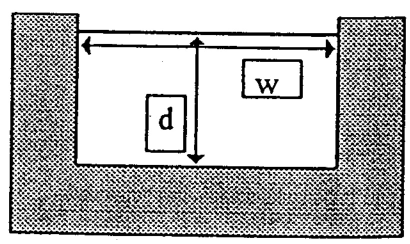


Figure 9b Rectangular Channel



Calculating discharge in the case of either the semi-circular channel (Figure 9a) or the rectangular channel (Figure 9b) is relatively simple.
In the semi-circular channel, if we take :

Radius of Channel (r)	=	1 m
Cross-sectional area (Δ)	=	$\pi r^2 \div 2$
	=	1.57 m^2
Mean Velocity (V)	=	1 m/s
Discharge (Q)	=	Δ x V
	=	1.57 m^3/s

Similarly, in the rectangular channel, if the :

Depth (d)	=	1 m
Width (w)	=	1.5 m
Cross-sectional area (Δ)	=	1.5 m^2
Mean Velocity (V)	=	1 m/s
Discharge (Q)	=	Δ x V
	=	1.5 m^3/s

#	Out		Minute (C)	(v)	#	Out		Minute (C)	(v)
1					51				
2					52				
3					53				
4					54				
5					55				
6					56				
7					57				
8					58				
9					59				
10					60				
11					61				
12					62				
13					63				
14					64				
15					65				
16					66				
17					67				
18					68				
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38					88				
39					89				
40					90				
41					91				
42					92				
43					93				
44					94				
45					95				
46					96				
47					97				
48					98				
49					99				
50					100				

V.1 For use with the MJP Flowmeter for Stream Velocity
(users may copy this sheet)

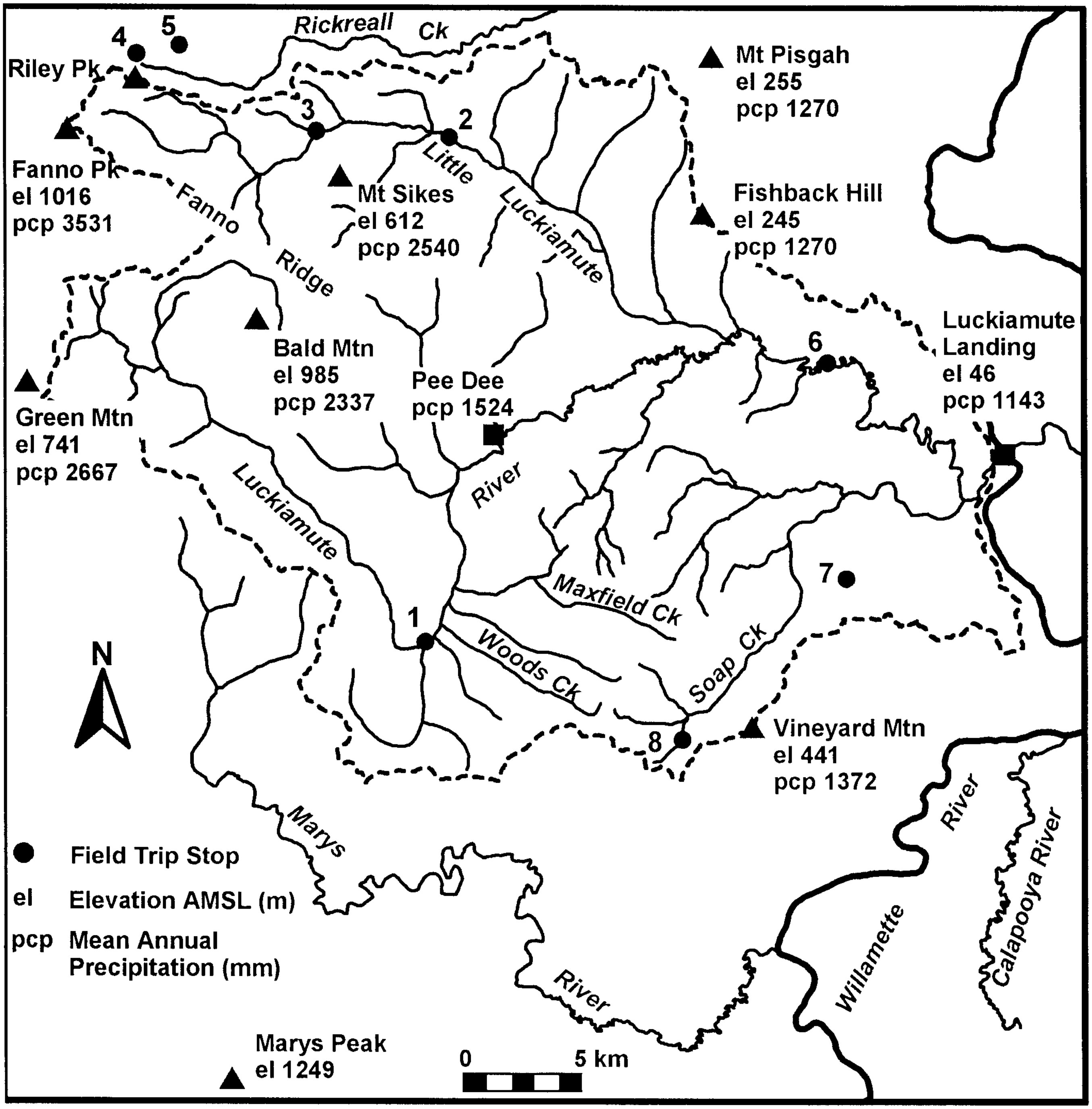


Figure 2. Physiographic map and spot annual precipitation for the Luckiamute Watershed.

Physiographic Setting of the Luckiamute Watershed

- Boundaries
  - Crest of Coast Range to West (headlands)
  - Willamette River to East

- Drainage Area = 815 km^2

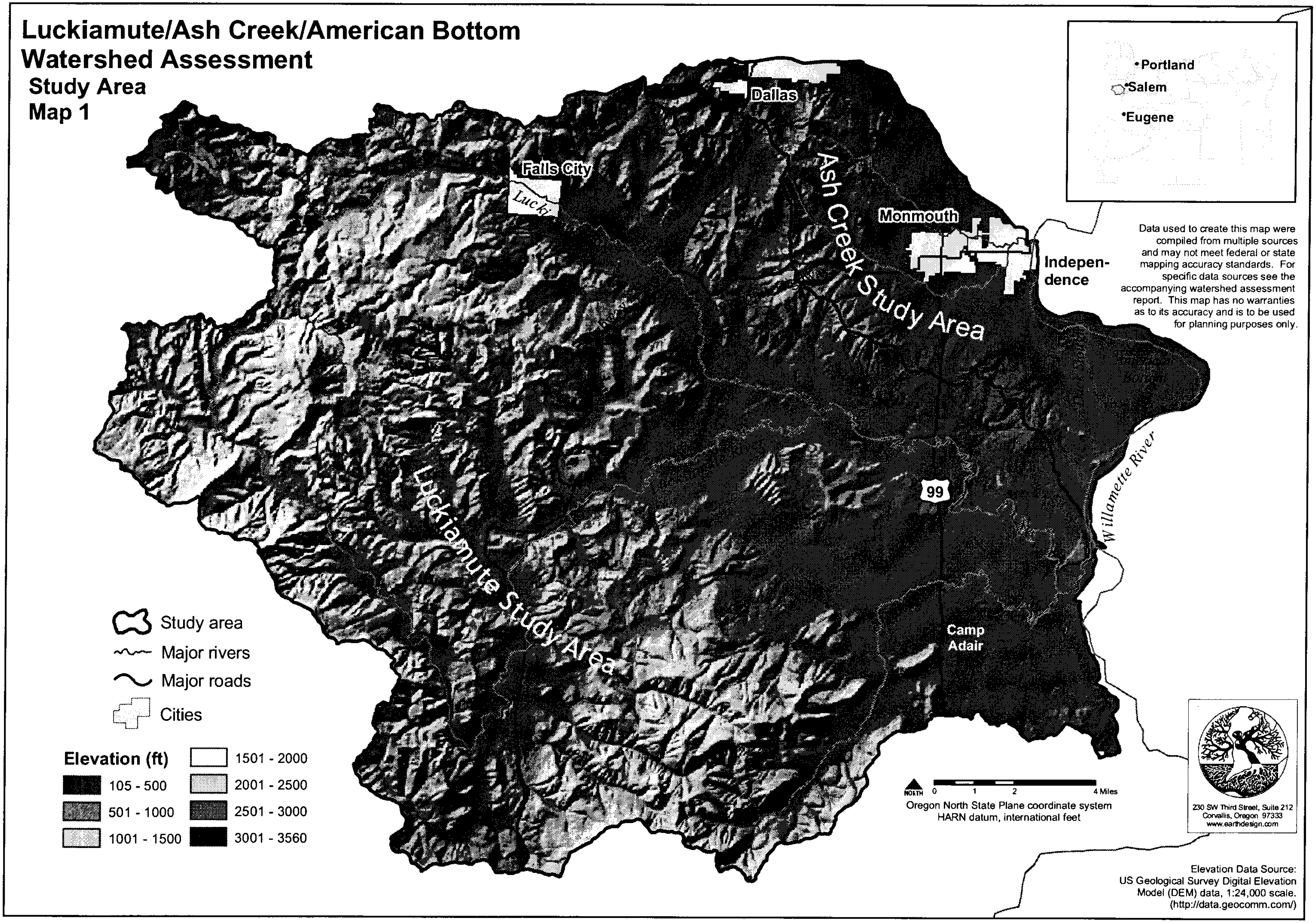
  - Largest Fifth-Field Watershed in central and northern Coast Range

  - Primary Tributaries
    - Little Luckiamute – northern watershed
    - Luckiamute – southern watershed

  - Secondary Tributaries
    - Soap Creek, Maxfield Creek, Woods Creek, Teal Ck

- Elevation Range:
  - Min: 46 m (150 ft) at Willamette
  - Max: 1016 m (3333 ft) at Fanno Peak
  - Avg. Basin Elevation: 277 m (910 ft)

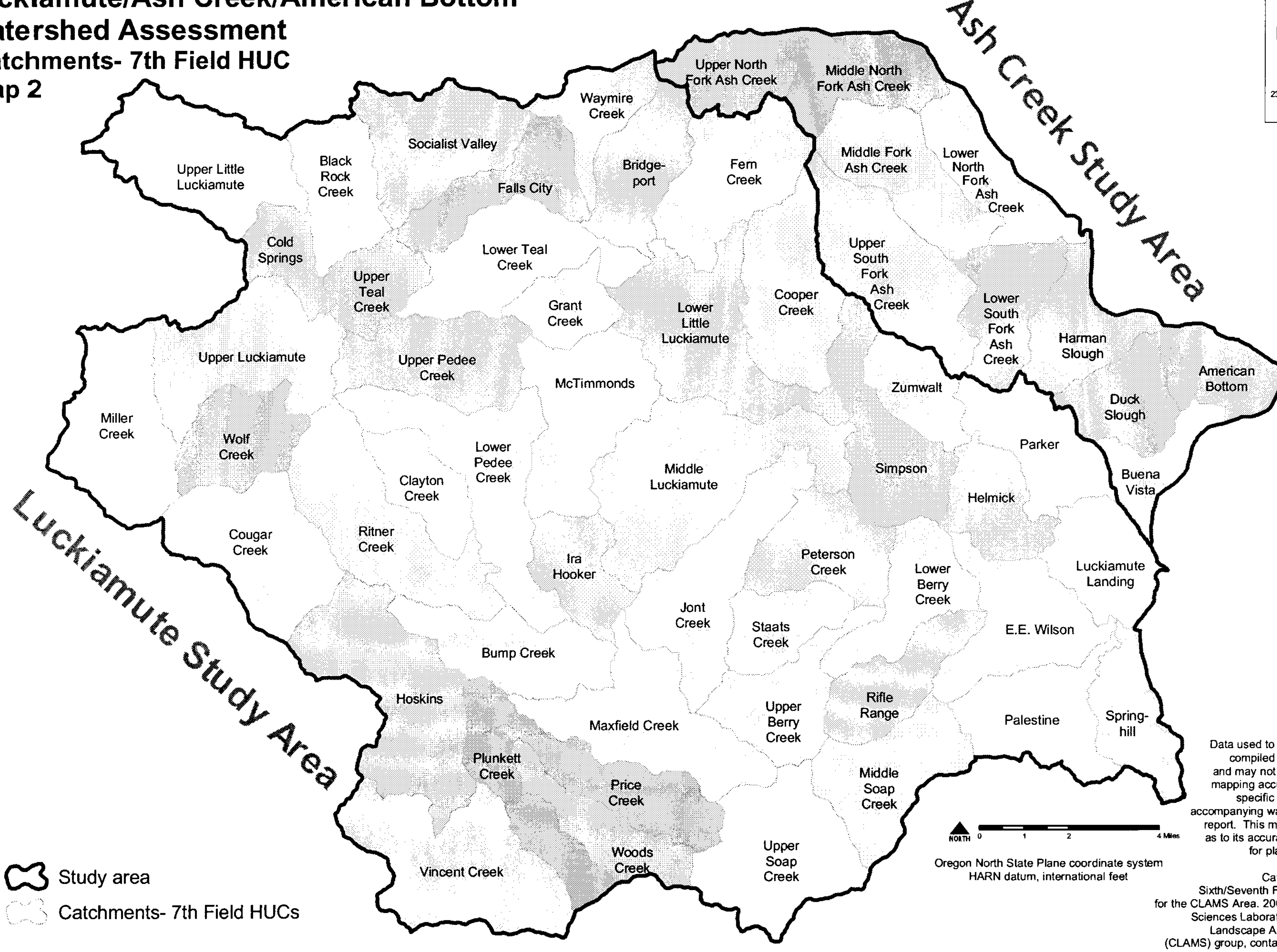
- Basin Morphometry
  - Average Stream Gradient: 3 m /km
  - Total Stream Length: 90.7 km


Luckiamute/Ash Creek/American Bottom
Watershed Assessment
Study Area
Map 1
Portland
Salem
Eugene
Dallas
Falls City
Monmouth
Indepen-
dence
Ash Creek Study Area
Luckiamute Study Area
99
Camp
Adair
Willamette River
Data used to create this map were compiled from multiple sources and may not meet federal or state mapping accuracy standards. For specific data sources see the accompanying watershed assessment report. This map has no warranties as to its accuracy and is to be used for planning purposes only.
Study area
Major rivers
Major roads
Cities
Elevation (ft)
105 - 500
501 - 1000
1001 - 1500
1501 - 2000
2001 - 2500
2501 - 3000
3001 - 3560
NORTH
0
1
2
4 Miles
Oregon North State Plane coordinate system
HARN datum, international feet
230 SW Third Street, Suite 212
Corvallis, Oregon 97333
www.earthdesign.com
Elevation Data Source:
US Geological Survey Digital Elevation Model (DEM) data, 1:24,000 scale.
(http://data.geocomm.com/)

Luckiamute/Ash Creek/American Bottom Watershed Assessment

Catchments- 7th Field HUC

Map 2



230 SW Third Street, Suite 212
Corvallis, Oregon 97333
www.earthdesign.com

Oregon North State Plane coordinate system
HARN datum, international feet

Data used to create this map were compiled from multiple sources and may not meet federal or state mapping accuracy standards. For specific data sources see the accompanying watershed assessment report. This map has no warranties as to its accuracy and is to be used for planning purposes only.

Catchment Data Source:
Sixth/Seventh Field Hydrologic Units for the CLAMS Area. 2000. Corvallis Forestry Sciences Laboratory (USDA)- Coastal Landscape Analysis and Modeling (CLAMS) group, contact: Z. Rickenbach, S. Clarke, et al.
(http://www.fsl.orst.edu/clams/data_index.html)

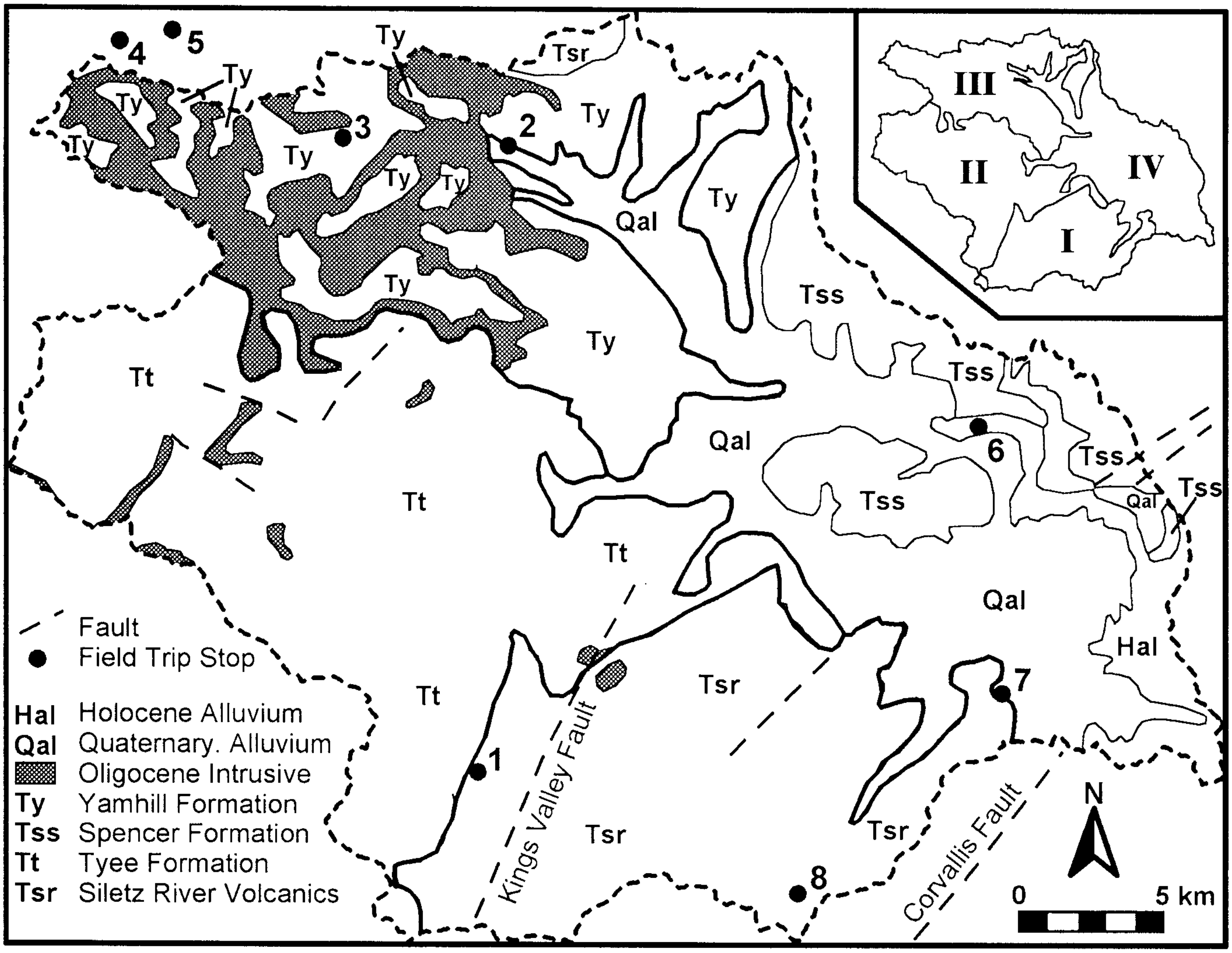
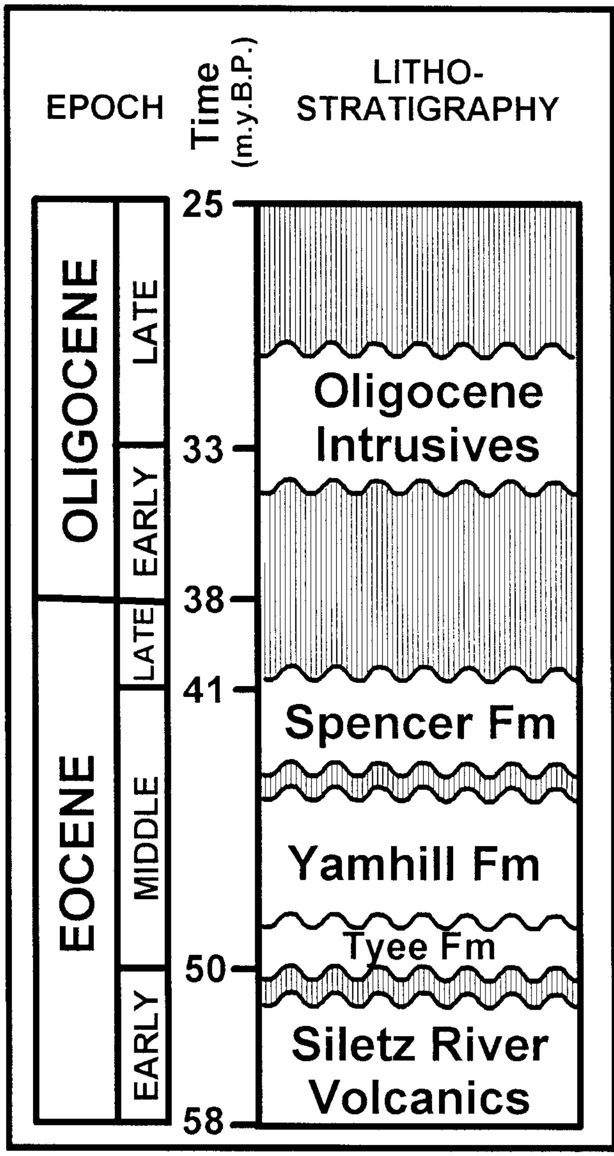


Figure 3. Bedrock geology of the Luckiamute Watershed (after Walker and MacLeod, 1991). Inset map shows grouping of recognized lithospatial domains: I = Siletz River Domain, II = Tyee Domain, III = Yamihill-Ti (Tertiary Intrusive) Domain, IV = Spencer-Valley Fill Domain.

Bedrock Geology of the Luckiamute Watershed



Qal – Quaternary Alluvium

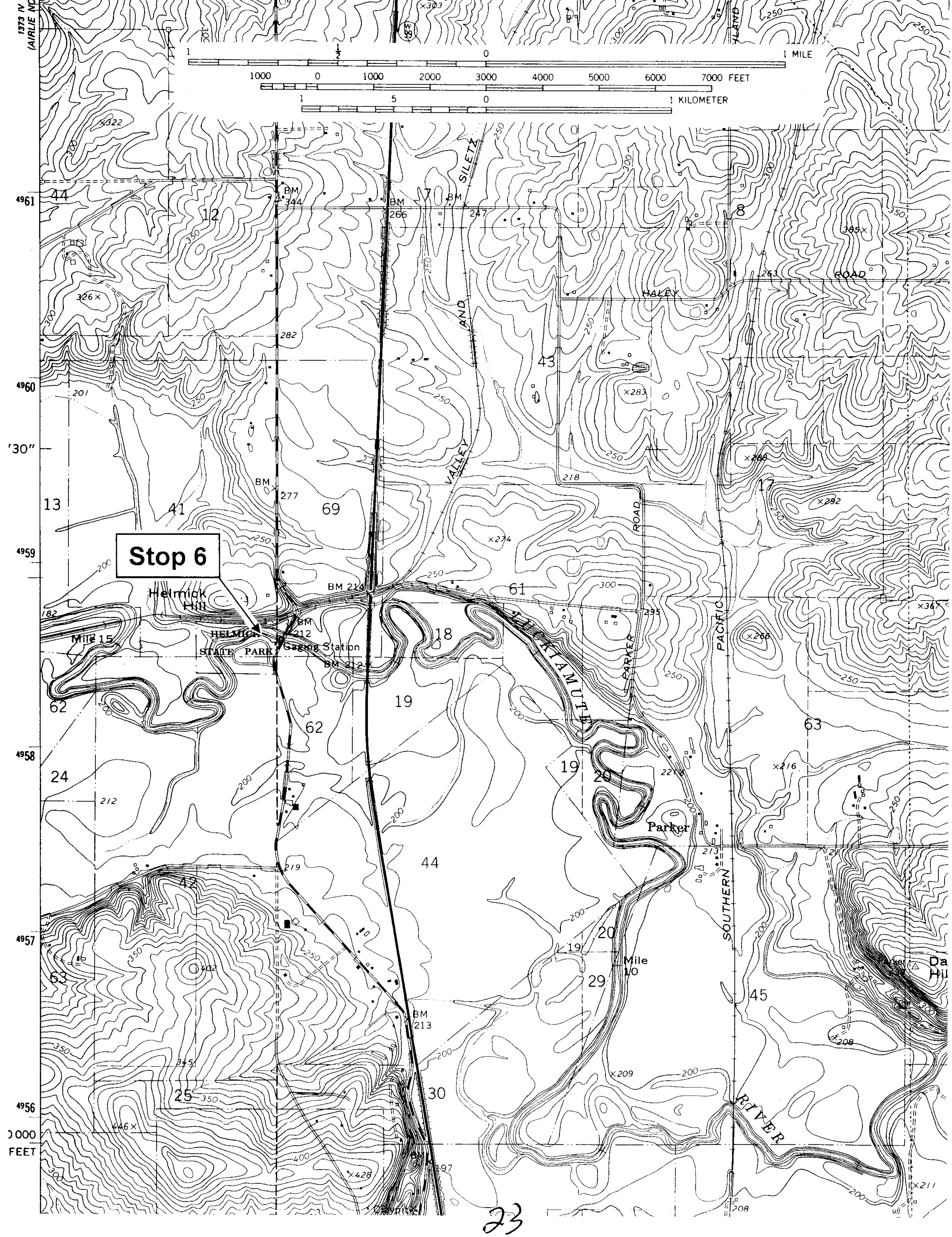
Ti – Oligocene Mafic Intrusives: Sheets, sills, and dikes of massive gabbro.

Tss – Spencer Formation: Thick- to thin-bedded marine tuffaceous sandstone, siltstone, and mudstone.

Ty – Yamhill Formation: Massive to thinly bedded marine silstone and sandtone interbeds. Locally includes interlayered basalt lava flows.

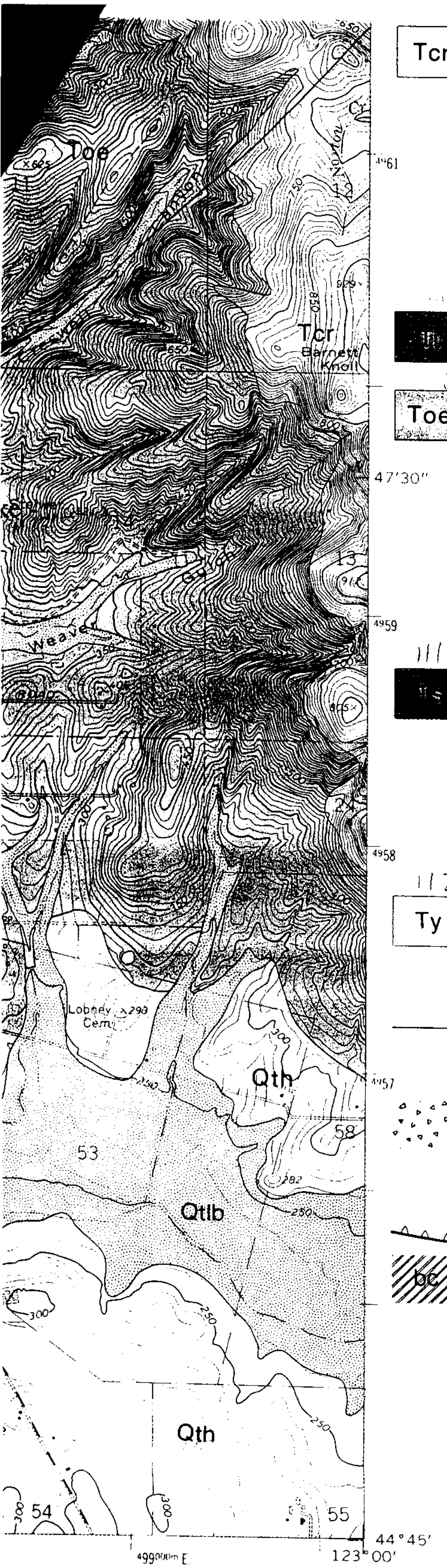
Tt – Tyee Formation: Rhythmically bedded, medium-grained feldspathic sandstone and carbonaceous siltstone. Interpreted as deposits of submarine turbidity currents and fans.

Tsr – Siletz River Volcanics: Aphanitic to porphyritic, vesicular pillow flows, tuff breccia, and lava flows. Local interbeds of basaltic siltstone and sandstone. Prevasively zeolitized and veined with calcite. Marine origin interpreted as accreted oceanic crust and seamounts.



1 MILE
7000 FEET
1 KILOMETER
Stop 6
Helmick Hill
HELMICK STATE PARK
Gaging Station
Mile 15
Mile 10
LUCKIAMUTE
RIVER
Parker
HALEY ROAD
PARKER ROAD
SOUTHERN PACIFIC
SILETZ VALLEY
BM 214
BM 212
BM 344
BM 266
BM 277
BM 213


Qth
Qtlb
Wigrich Spur
Ts
Qtm
Qtlt
Helmick Hill
HALEY
ROAD
PARKER
SOUTHERN
PACIFIC
HIGHLAND
Parker
Mile
Dawson Hill
8(Ts)
3(Ts)
2I?
BM 245
BM 344
BM 266
BM 277
BM 214
BM 213



Tcr

Columbia River Basalt Group (Miocene): *Medium-gray to black, fine-grained, even-textured to slightly porphyritic basalt; unweathered flows generally dense, fairly crystalline, exhibiting massive columnar jointing near base to diced or hackly jointing in entablature. Unit consists of weathered and unweathered basaltic lava flows with interflow zones characterized by vesicular flow-top breccia, ash, and baked soils. Maximum thickness generally ranges 400-600 ft, with thickness greatly modified by erosion and weathering in many places; individual flows range from 40 ft to more than 100 ft in thickness.*

Formations recognized within the Yakima Basalt Subgroup (Beeson, 1980, personal communication) include (1) Grande Ronde Basalt: two to four "low Mg" N_2 flows, including one to two "Winter Water" flow(s) at top (typical exposure at Dairy Queen, West Salem); one to two thick "low Mg" flow(s), 100-150 ft thick, extensively quarried throughout map area; one to two flow(s) of "high Mg" N_2 basalt, generally deeply weathered, occurring above the "Winter Water" flow(s); and (2) a thinner layer of younger Wanapum Basalt, represented by one to three flow(s) of the Frenchman Springs Member, observed only in South Salem within the study area, although it also occurs outside the map area in the vicinity of Turner.

Weathered flows consist of reddish-brown to grayish-brown, crumbly to medium-dense basalt. Weathering is variable and believed related to individual basalt flows; some exposures are altered to red clay (laterite) to depths of 30 ft, and occasionally as deep as 60-175 ft, while others are only slightly weathered at surface. Some locations in Salem Hills (generally between 500-900 ft elevation within area bounded by Pringle School-Prospect Hill-Jackson Hill) show extensive laterization which has resulted in deposits of bauxite (Corcoran and Libbey, 1956). Soils are reddish-brown, well-drained silty clay loams and gravelly silty clay loams. Unit yields small to large quantities of ground water from permeable rubbly zones between flows

Intrusive rocks (Oligocene): *Dense basalt, andesite, and gabbro dikes and sills of very limited extent within the map area (Roby Hill, Sidney quadrangle); Roby Hill quarry geochemically not part of Columbia River Basalt Group (Beeson, 1980, personal communication). Another limited exposure of porphyritic intrusive or possibly flow rock, with vertical columns 1-2 ft in diameter in contact with claystone along east bank of Luckiamute River near Buena Vista Road (river mile 3.2). Presumed post-Eocene (Oligocene?) age (Helm and Leonard, 1977)*

Toe

Eocene-Oligocene sedimentary rock (middle and lower Oligocene and upper Eocene): *Equivalent to tuffaceous marine sedimentary rocks (Tts) of Baldwin and others (1955), Illahe tuffs (Tit) of Mundorff (1939), Illahe Formation (Ti) of Thayer (1939), Eocene-Oligocene marine sedimentary rocks (Tm) of Price (1967), and undifferentiated Tertiary rocks (Tu) of Gonthier (in press). Consists of two lithologic and faunal units west of Willamette River (Baldwin and others, 1955) but undifferentiated in this map due to poor exposures. Older unit light-gray to tan sandy tuffaceous siltstone equivalent in age to early Oligocene Keasey Formation; thickest section near border of Amity-Rickreall 7½-minute quadrangles, where approximately 1,000 ft thick; other lower Oligocene strata well exposed in Yamhill River near Yamhill locks, where steeply dipping and complexly faulted. Younger unit is fine- to coarse-grained tuffaceous sandstone equivalent in age to middle Oligocene Pittsburg Bluff Formation; basal stratum approximately 150 ft of dark-gray, coarse-grained, calcareous cemented lithic sandstone, chiefly composed of detrital igneous rock fragments. White, fine-grained, massively bedded phase of pumiceous volcanic glass approximately 250 ft thick exposed for 3 mi along hillside south of Finzer (Salem West quadrangle); good exposures of pebbly tuff, tuffaceous conglomerate, and fine-grained platy tuff along Bunker Hill Road in Sidney 7½-minute quadrangle.*

Tuffaceous marine sandstone and siltstone of Oligocene sedimentary rock correspond to Oligocene Eugene Formation described by Hickman (1969), which contains early to middle Oligocene molluscan faunas. Recent foraminiferal analyses (McKeel, 1980) of oil and gas wells within the study area indicate unit contains almost 2,000 ft of upper Refugian and Refugian strata (Reichhold-Merrill #1, Sidney quadrangle) and 200-1,000 ft of basal siltstone, claystone, and shale of late Narizian (provincial West Coast late Eocene) age (Reserve-Bruer #1 and Reichhold-Merrill #1)

Upper Eocene sandstone: *Equivalent to Helmick beds (Thb) of Mundorff (1939) and Spencer (Ts) of Gonthier (in press); very fine- to medium-grained, thinly laminated (fissile) to thin-bedded, as well as prominently more massive, light-gray to yellowish-brown moderately well-sorted micaceous, calcareous, lithic arkosic marine (tuffaceous) sandstones; frequently interbedded with fine-grained marine tuffaceous siltstone, thinly laminated clay shale, and claystone; comprised of almost equal proportions of quartz, feldspar, and rock fragments cemented with calcite (in concretions); minor constituents include approximately 2% glauconite, 4% mica (biotite, muscovite, and chlorite), and less than 1% authigenic pyrite; well compacted; carbonaceous material consisting of plant stems, leaves, and other organic fragments common; calcareous concretions, fossiliferous or containing carbonaceous material, prominent along Willamette River south of Buena Vista (Monmouth quadrangle); pebbly lenses, abundant organic matter, and paleoecology indicate strandline environment; provenance from chiefly volcanic terrain. Weathered outcrops of massive, very fine- to medium-grained sands, generally friable, ranging in color from white to yellowish-brown, pale-brown, or yellowish-orange.*

According to McKeel (1980), this unit is bracketed by upper Narizian strata in the Reichhold-Finn #1 well (Amity quadrangle), by upper Narizian and Narizian strata in the Reserve-Bruer #1 well (Amity quadrangle), and by upper Narizian strata in the Reichhold-Merrill #1 well (Salem West quadrangle). Average thickness about 800 ft

Ty

Yamhill Formation (middle and upper Eocene): *Medium- to dark-gray, massive to faintly bedded, micaceous, tuffaceous shale and siltstone. Occasional beds of medium-gray to greenish-gray, fossiliferous, calcareous sandstone; minor limestone concretions.*

According to McKeel (1980), this unit contains 2,000-3,000 ft of Narizian and lower Narizian strata in the Reichhold-Finn #1 and Reserve-Bruer #1 wells, located in the Amity quadrangle. Shown only in the cross section

OTHER SYMBOLS

Lineament: *Selected major lineaments identified from 1:76,000 false-color infrared aerial photographs (U.S. Army Corps of Engineers, 1978), orthophotoquads, and topographic maps. Features include aligned ridges, major escarpments, concentric curvilinear drainages, aligned drainages across saddles, and parallelism; omitted are short linear segments along drainages of less than 1 mi length; general trends NE and NW, typical of lineament features observed in western Oregon*

Landslide topography: *Large areas of deep bedrock failure characterized by irregular topography, disrupted stratigraphy, overall anomalous moderate to shallow slope, prominent arcuate headscarps, backward-tilted blocks, springs, sag ponds, and disrupted drainage patterns. Most prominent along west side of Salem Hills and south and west side of Eola Hills, where undercutting of soft marine sediments (Eocene to Oligocene sedimentary rock, unit* **Toe***) has resulted in massive landsliding of blocks of more resistant unit* **Tcr***. Subject to rockfall and debris avalanche along oversteepened escarpments and to slump in some areas (bowed and tipped trees).*

Deep bedrock slides within upper Eocene sedimentary rock **(Ts)** *within Monmouth quadrangle are much smaller than those associated with units* **Tcr/Toe***; characterized by small knobby blocks of sedimentary rock within general hummocky terrain*

Landslide scarp: *Characterized by steep cliff, often arcuate, and backward-tilted block below*

bc

Basaltic colluvium and/or landslide debris: *Generally reddish-yellow or reddish-brown basaltic colluvium and/or landslide debris, deeply weathered, overlying Oligocene sedimentary rock* **(Toe)***, generally within landslide topography or beneath steep cliffs capped by Columbia River Basalt Group* **(Tcr)***; includes alluvial fans and some earthflow and debris-flow topography. Probably generally 6-35 ft thick but may include some blocks of basalt of greater thickness. Soils well-drained silty clay loams and gravelly silty clay loams overlying silty clay and clay*

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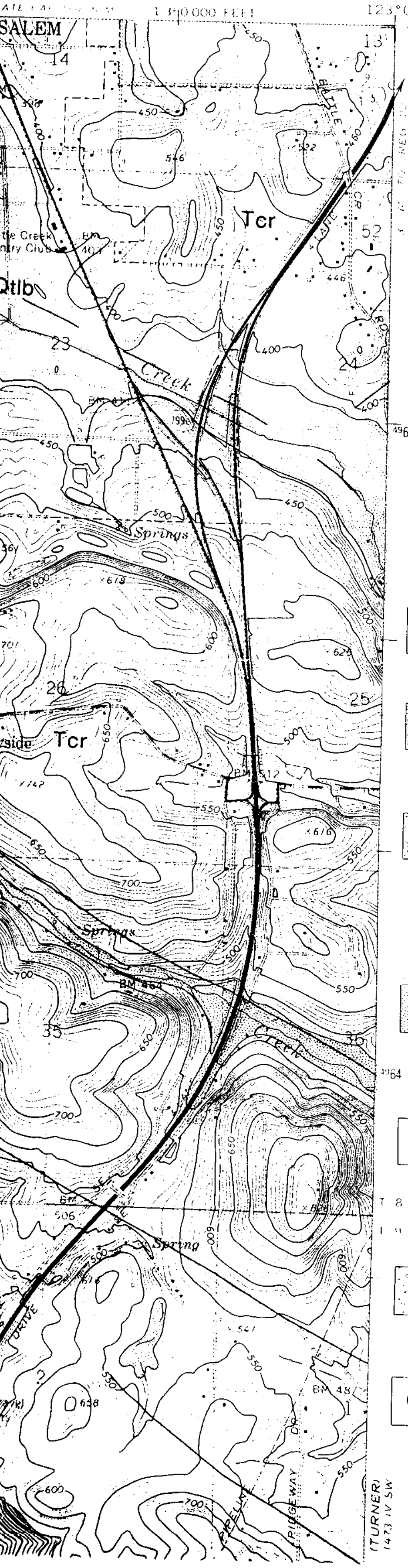
GEOLOGIC SYMBOLS

Contact

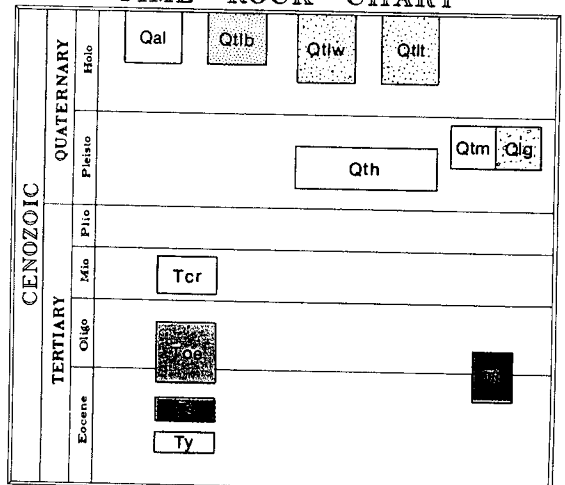
Strike and dip of beds

Abandoned oil and gas well

Abandoned oil and gas well with gas show



TIME ROCK CHART



Reflects traditional usage in Western Oregon, after: Gonthier, 1980; Bela, 1979; Helm and Leonard, 1977; Beaulieu, 1974; Hickman, 1969; Baldwin and others, 1955; Vokes and others, 1954.

EXPLANATION

SURFICIAL GEOLOGIC UNITS

Qal — **Recent river alluvium**: *Unconsolidated cobbles, coarse gravel, sand, and some silt and clay within active channels of Willamette River. Generally 15-45 ft thick, consisting of stratified sands and well-rounded pebbles, gravels, and cobbles of primarily basaltic and andesitic composition; often overlain by 3-15 ft of light-brown sand and silt overburden. Characterized by low relief, point-bar and channel-bar deposits; many areas unvegetated, others support dense stands of brush and phreatophytes, such as willows and cottonwoods. Subject to major flooding, critical stream-bank erosion, and lateral channel migration; includes many areas located between 1852 meander line and present channel that illustrate possible extent of future changes*

Qtlw — **Lower terrace deposits of the Willamette River (Quaternary)**: *Unconsolidated to semiconsolidated cobbles, gravel, sand, silt, clay, muck, and organic matter of variable thickness (30-50 ft) on the flood plain and lowland terraces immediately above the Recent river alluvium* (**Qal**)*; typically 5-20 ft of light-brown silt and clay or very fine sand overlying 10-45 ft of moderately well-sorted sand and locally cemented gravel. Surface topography characterized by a low, undulating, fluvial surface with abandoned channels, meander scrolls, oxbow lakes, and sloughs; subject to major and local flooding, some catastrophic channel migration of major scale, ponding, and high ground water. Flood-plain soils are predominantly well drained and somewhat excessively drained silty clay loams, silt loams, and sandy loams; good ground-water yields generally of 100-500 gallons per minute*

Qtlt — **Lower terrace deposits of tributary rivers and streams (Quaternary)**: *Unconsolidated to semiconsolidated gravel, sand, silt, clay, and organic matter generally 15-30 ft thick on lowland terraces and flood plains immediately above major tributary rivers of the Willamette River. Gravel deposits are very thin to variable in thickness, according to tributary drainage source, generally limited to active stream beds or former meander channels, and located at or near bed rock beneath 20-30 ft of sand, silt, and clay. Somewhat tortuous meandering streams entrenched 15-45 ft, often flowing on Tertiary sedimentary bed rock or semiconsolidated older valley-fill alluvium. Surface topography characterized by a low, undulating fluvial surface of swell and swale relief, abandoned meander loops, and oxbow lakes; subject to high ground water and ponding and major and local flooding; flood-plain soils are predominantly well drained and somewhat excessively drained silty clay loams, silt loams, and sandy loams. Some soft, compressible organic soils of low shear strength may occur locally, particularly within abandoned channels and oxbows. Major stream-bank erosion commonly occurs at outer bends of meander loops by shallow earthflow and slump due to undercutting. Ground-water yields generally small*

Qtlb — **Lower terrace deposits of alluvial bottomlands (Quaternary)**: *Flat, moderately to poorly drained areas with soft, organic compressible soils of low shear strength locally; characterized by low relief, ponding, and high ground water. Deposits typically consist of somewhat stratified very fine sands, silty sandy clays, silty clays, and silty clay loams, with slight to moderate plasticity (ML-CL); 4-12 ft thick along bottomlands of interior drainages of low, rolling sedimentary bedrock units. Deposits locally may represent somewhat thicker accumulations of silt and silty clay materials of fluviatile and/or loessal origin derived in part from Willamette Silts. Similar deposits along creeks are associated with deposits of units* **Qtm** *and* **Qth** *and are often modified by ditching and field drainage for agriculture; typical examples are deep (more than 60 in.) clay (CH), silty clay (CH), and silty clay loam (CL or ML) black Bashaw clay soils of Baskett Slough (Rickreall quadrangle). Similar thicknesses of reddish-brown sandy silty material (ML-CH) in basaltic terrain* (**Tcr**)

Qtm — **Middle terrace deposits (Quaternary)**: *Semiconsolidated gravel, sand, silt, and clay forming very flat terraces of major extent along the Willamette River. Generally 10-30 ft of light-brown silty clay and interbedded very fine sand and silt (ML or CL-CH) surficial material; believed primarily related to Willamette Silts, including associated glacial erratics consisting of tiny fragments and pebbles up to boulders greater than 4 ft in diameter. Soils somewhat poorly drained and poorly drained silt loams and silty clay loams to moderately well-drained and well-drained silt loams subject to seasonal high ground water and ponding. Sand and gravel (GP, SM), where present, usually occur below 30 ft depth; locally more abundant near Monmouth-Independence and in the lower part of Ash Creek. Total thickness 0-85 ft, but often only 40-50 ft; within Rickreall 7½-minute quadrangle, 15-35 ft of brown clay or silt generally occurs above several to 30 ft of gravelly clay, black sands, and gravels. Generally small ground-water yields, except near Monmouth-Independence, where sand and gravel may yield up to 300 gallons per minute*

Qlg — **Linn gravel (Quaternary-upper Pleistocene)**: *Stratified fine to coarse fluvial gravels deposited as an alluvial fan in the Stayton-Turner-Salem areas during an early stage of the Santiam River; of limited extent within the map area; uppermost few feet of gravels extensively oxidized and weathered, often chalky; thickness ranges from 30-40 ft to possibly as much as 300 ft. Regionally, the upper foot or so of gravel is cemented by an impermeable clay pan locally, which restricts drainage. Composition of gravels (mostly basalt, but also andesite, dacite, rhyolite, quartz, and diorite) essentially uniform. Within map area near Salem, soils are well drained and somewhat poorly drained gravelly silt loam and gravelly loam. Extensively utilized as source of sand and gravel. Good ground-water yields greater than 100 gallons per minute*

Qth — **Higher terrace deposits (Quaternary-middle Pleistocene)**: *Generally semiconsolidated light-brown sand, silt, and clay of variable thickness (3-15 ft) on higher terraces and remnants of old higher terraces adjacent to sedimentary bedrock foothills; mantled by moderately well-drained and well-drained silt loam soils. Includes colluvium, slope wash, and alluvial fan deposits near sedimentary bedrock foothills; deposits thin where transitional with pediments. Material generally similar to unit* **Qtm**, *particularly in West Salem, containing glacial erratics related to Willamette Silt but also some gravelly alluvium. Some higher terrace deposits on west side of Salem Hills between Salem and Illahe Hill not shown due to scale. Also includes weathered (decomposed) cobbles and gravels which extend beyond the study area west of Rickreall (8-10 ft thick) and at southeastern margin of Sidney quadrangle (10-50? ft thick), where they are equivalent to the Leffler gravels of Allison (1953). These deposits also mantled by 3-15 ft of light-brown silt loam and silty clay loam soils. Generally little or no ground-water yield*

BEDROCK GEOLOGIC UNITS

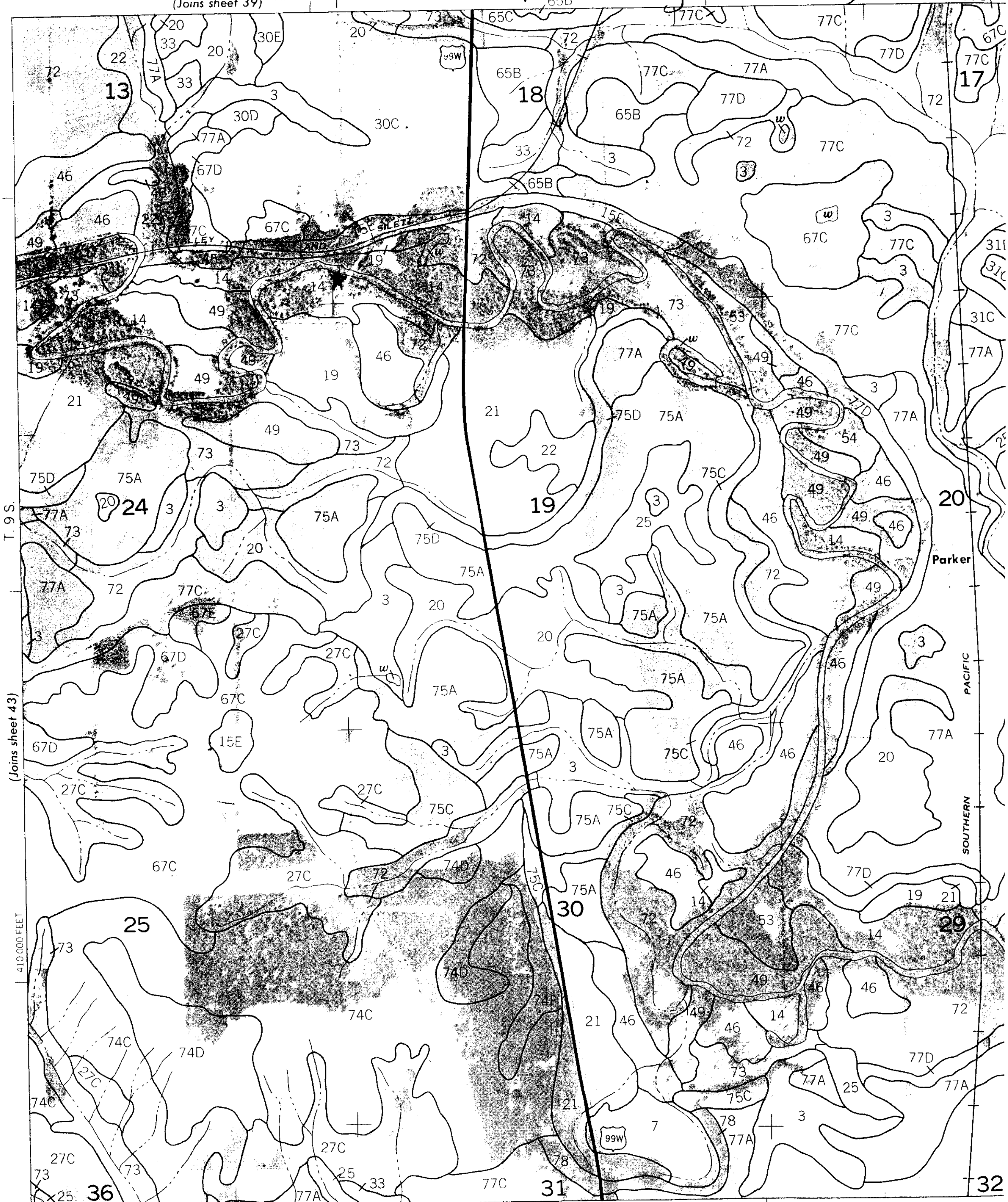
44

14, 19, 46

★ Helmick State Park
Polk County Soil Survey

N

(Joins sheet 39) R. 5 W. | R. 4 W.



(Joins sheet 49) 1 290 000 FEET

1 3/4

insure adequate growth. The soil is not generally irrigated because of the excessive slope.

Commercial stands of timber are not on this soil. It is limited for Christmas trees because of the slope that restricts management and harvest.

The crops produced on this soil provide food and cover for ring-necked pheasant, California quail and bobwhite quail. In wooded areas of Oregon white oak, Douglas-fir, poison-oak, snowberry, wild rose, and grass, ruffed grouse, mountain quail, and band-tailed pigeons are common. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

This soil has major limitation for all types of community uses because of the slope.

This soil is in capability subclass IVe.

13—Camas gravelly sandy loam. This excessively drained soil is on undulating alluvial bottoms. The soil formed in very gravelly alluvium. It is subject to overflow several times per year, and it is flooded about once every 3 or 4 years. The soil is traversed by overflow channels. It is underlain by gravel and sand at a depth of 12 to 20 inches. Slopes average about 2 percent. Elevation is 125 to 250 feet. The average annual precipitation is 40 to 45 inches, the average annual air temperature is about 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is dark brown gravelly sandy loam about 12 inches thick. The substratum is variegated dark yellowish brown very gravelly coarse sand that extends to a depth of 60 inches or more.

Included with this soil in mapping are areas of Pilchuck, Newberg, and Cloquato soils, which make up about 10 percent of this map unit.

Permeability is very rapid. Effective rooting depth is 12 to 20 inches. Available water capacity is 1.5 to 3.5 inches, and the water-supplying capacity is 10 to 15 inches. Runoff is slow, and the hazard of erosion is slight. The soil is subject to frequent flooding in fall, winter, and spring.

Most of the acreage of this soil is cultivated. The soil is used mainly for small grain and forage crops. If irrigated, it is used for vegetable, seed, and specialty crops. The soil is poorly suited to many of the crops grown, but it is used for crops because it often occurs as small areas within other soils.

Erosion can be controlled by winter cover crops. Cover crops planted early in fall allow adequate rooting and top growth before periods of overflow. Stubble and other plant growth left on the soil in winter before being incorporated into the soil help to control erosion from floodwaters. Fertilization and irrigation may be necessary in many years for early establishment of a cover crop. Management of crop residue and crop rotation help to maintain productivity and tilth and to control erosion. A crop rotation system that includes grasses and legumes at least 25 percent of the time helps to maintain fertility.

Because of the low available water capacity of this soil, frequent applications of irrigation water are necessary to prevent crops from wilting. Because the soil is commonly managed below the wilting point, the crops are stunted and yields low. The gravelly surface layer makes tillage and seedbed preparation difficult. Such crops as berries or hops which require installation of poles, increase the hazard of debris accumulation and in many cases cause severe gullying during floods.

No commercial stands of timber are grown on this soil.

The wide variety of grains, grasses, legumes, orchards, and vegetable crops; the fence rows; and wooded tracts of ash, cottonwood, Douglas-fir, and shrubs furnish good food and cover for ring-necked pheasant, California quail, bobwhite quail, and mourning doves. Black-tailed deer are permanent residents. Ducks and geese also feed on this soil. Streambank and roadway planting, grassed waterways, and fence rows and brushy areas improve cover and food for wildlife. Water is available from streams most of the year. Burning fields and fence rows and clearing wooded and brushy areas destroy both cover and food for wildlife.

This soil has major limitations for homesites, commercial buildings, or other community uses because it is subject to occasional flooding.

This soil is in capability subclass IVw.

14—Chehalis silty clay loam, occasionally flooded. This well drained soil is on gently undulating alluvial bottoms. The soil formed in mixed recent alluvium. It is subject to overflow several times in some years and is flooded about once every 3 to 4 years. The soil is traversed by overflow channels and sloughs. Slopes are 0 to 3 percent but average about 2 percent. Elevation is 125 to 300 feet. The average annual precipitation is 40 to 45 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is very dark grayish brown silty clay loam about 12 inches thick. The subsoil is dark brown silty clay loam about 35 inches thick. The substratum is dark yellowish brown silty clay loam that extends to a depth of 64 inches or more.

Included with this soil in mapping are areas of Cloquato, Newberg, McBee, and Camas soils, which make up about 10 percent of this map unit. Also included are a few areas of soils in which the upper 10 inches is fine sandy loam or loam, the result of recent deposition by flood waters.

Permeability is moderately slow. Effective rooting depth is more than 60 inches. Available water capacity is 10 to 12 inches, and the water-supplying capacity is 25 to 28 inches. Runoff is slow, and the hazard of erosion is slight. Flooding is common in winter and spring.

Most areas of this soil are cultivated. The soil is used for row crops, forage crops, small grain, seed crops, and orchards. It is irrigated for vegetables and many specialty crops (fig. 8). The soil is well suited to most crops grown in the area. The hazard of erosion from flood waters can be reduced by planting winter cover crops and installing dikes. Properly managing crop residue and using a cropping system in which grasses and legumes or green manure crops are grown at least 25 percent of the time help to maintain favorable fertility and workability. The crops grown on the soil respond well to fertilizers and amendments.

The use of this soil for orchards or such crops as berries and hops, which require installation of poles, increases the hazard of debris accumulation and may cause severe gullying during periods of flooding. This soil is irrigated from shallow wells, streams, rivers, and sloughs.

No commercial timber is produced on this soil.

The wide variety of grains, grasses, legumes, orchards, and vegetable crops; the fence rows; and wooded tracts of ash, cottonwood, Douglas-fir, and shrubs furnish good food and cover for ring-necked pheasant, California quail, bobwhite quail, and mourning dove. Black-tailed deer are permanent residents. Ducks and geese also feed on this soil. Gophers, ground squirrels, moles, nutria, and opossum are common pests. Streambank and roadway planting, grassed waterways, and fence rows and brushy areas improve cover and food for wildlife. Water from streams is available most of the year. Burning fields and fence rows and clearing wooded and brushy areas destroy both cover and food for wildlife.

This soil has major limitations for homesites, commercial buildings, or other community uses because it is subject to common flooding.

This soil is in capability subclass IIw.

15C—Chehulpum silt loam, 3 to 12 percent slopes. This well drained soil is on low foothills. The soil formed in material weathered from sedimentary rock. It is underlain by siltstone at a depth of 12 to 20 inches. Slopes average about 6 percent. Elevation is 300 to 500 feet. The average annual precipitation is 40 to 50 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is very dark grayish brown silt loam and silty clay loam 10 inches thick. The subsoil is dark brown silty clay loam about 6 inches thick. Partly weathered sedimentary bedrock is at a depth of 16 inches.

Included with this soil in mapping are areas of Steiwer, Hazelair, and Dupee soils, which make up about 10 percent of this map unit.

Permeability is moderate. Effective rooting depth is 10 to 20 inches. Available water capacity is 2 to 4 inches and the water-supplying capacity is 6 to 13 inches Runoff is medium, and the hazard of erosion is moderate.

This soil is used for hay and pasture, but it is mainly ir natural stands of grass and Oregon white oak. The soi is too shallow for cultivated crops. Improved varieties o grass are desirable for cover if they can be established Planting improved varieties of grasses early in sprin insures better cover than if these grasses are plante later. This cover helps to protect the soil from erosio the following winter. The soil is droughty. It generally i not fertilized extensively, but small amounts of fertilize are applied early in spring or in fall.

No commercial stands of timber are grown on this soi The soil is poorly suited to growing Christmas trees be cause of droughtiness.

In areas where this soil is intermingled with cultivate soils, ring-necked pheasant, California quail, and bol white quail may be present. Oregon white oak, gras poison-oak, and wild rose provide important food an cover for black-tailed deer and other wildlife.

This soil has major limitations for homesites, comme cial buildings, roads and streets, and other communi uses because of shallow depth to bedrock.

This soil is in capability subclass VIs.

15E—Chehulpum silt loam, 12 to 40 perce slopes. This well drained soil is on low foothills. formed in material weathered from sedimentary roc The soil is over siltstone at a depth of 12 to 20 inche Slopes average about 25 percent. Elevation is 300 500 feet. The average annual precipitation is 40 to inches, the average annual air temperature is 52 to degrees F, and the frost-free period is 165 to 210 day

In a representative profile, the surface layer is ve dark grayish brown silt loam and silty clay loam about inches thick. The subsoil is dark brown silty clay loa about 6 inches thick. Partly weathered sedimentary be rock is at a depth of 16 inches.

Included with this soil in mapping are areas of Steiw Hazelair, and Dupee soils, which make up about 10 p cent of this map unit.

Permeability is moderate. Effective rooting depth is to 20 inches. Available water capacity is 2 to 4 inch and the water-supplying capacity is 6 to 13 inch Runoff is rapid, and the hazard of erosion is high.

This soil is used for pasture. The vegetation is Oreg white oak and grasses. Erosion can be controlled maintaining a ground cover of natural vegetation.

No commercial stands of timber are grown on this s The soil is poorly suited to growing Christmas trees cause of droughtiness and the slope.

In areas where this soil is intermingled with cultiva soils, ring-necked pheasant, California quail, and b white quail may be present. Oregon white oak, grass dove. Black-tailed deer are permanent residents. Ducks and geese also feed on the soil. Gophers, ground squirrels, moles, nutria, and opossum are common pests. Streambank and roadway plantings, grassed waterways, and fence rows and brushy areas improve cover and food for wildlife. Water from streams is available most of the year. Burning fields, burning fence rows, and clearing wooded and brushy areas destroy cover and food for wildlife.

This soil has major limitations for homesites, commercial buildings, or other community uses because it is subject to occasional flooding.

This soil is in capability subclass IIw.

18—Coburg silty clay loam. This moderately well drained soil is on terraces above the flood plain in the Willamette Valley. It formed in silty alluvial deposit. Slopes average about 2 percent. Elevation is 180 to 200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is very dark grayish brown silty clay loam about 15 inches thick. The subsoil is very dark grayish brown, dark brown, and dark yellowish brown silty clay that extends to a depth of 60 inches or more. Mottles are common in the subsoil and substratum.

Included with this soil in mapping are areas of Malabon soils, which make up about 10 percent of this map unit, and Chehalis soils, which make up 5 percent.

Permeability is moderately slow. Effective rooting depth is greater than 60 inches. Available water capacity is 10 to 12 inches, and the water-supplying capacity is 20 to 26 inches. Runoff is slow, and the hazard of erosion is slight. A seasonal high water table is at a depth of 18 to 30 inches in winter and spring.

This soil is well suited to pasture, hay, small grain, grass seed, and vegetable crops. Long-lived, deep-rooted deciduous fruit and nut trees, strawberries, caneberries, and alfalfa are adversely affected by a seasonal high water table, unless the soil is drained. Properly managing crop residues and using a cropping system in which grasses and legumes are grown at least 25 percent of the time help to reduce runoff and erosion and to maintain productivity and workability. Small grains and grasses respond to nitrogen; row crops respond to nitrogen and phosphorus; and legumes respond to phosphorus, sulfur, and lime. If residues are used, additional nitrogen is generally needed to prevent a decrease in yields.

The soil may be irrigated by sprinkler, furrow, or border irrigation. Sprinkler irrigation is the most common method and is very satisfactory. Irrigation water should be applied carefully at rates low enough to prevent runoff. Irrigation water is available from reservoirs or streams.

The soil has moderate drainage concerns that respond to a subsurface type of drainage. Drainage is needed for maximum use and production. Seepage from soils in higher areas can be controlled by interception and random drains. Runoff is controlled by grassed waterways and vegetative cover in some places.

No commercial stands of timber are grown on this soil. The soil is well suited to Christmas tree production.

The native vegetation of grass, hazel, poison-oak, wild blackberry, Douglas-fir, and Oregon white oak furnish good food and cover for ring-necked pheasant, California quail, bobwhite quail, and mourning doves. Black-tailed deer are permanent residents. Ducks and geese also feed in areas near water. Gophers, ground squirrels, moles, nutria, and opossum are common pests. Planting along streambanks and roadways, using grassed waterways, and preserving fence rows, woodlots, and brushy areas improve cover and food for wildlife.

This soil has some limitations for homesites, commercial buildings, and local roads and streets because of low strength. The major limitations for septic tank absorption fields are the moderately slow permeability and the seasonal high water table.

This soil is in capability subclass IIw.

19—Coburg silty clay loam, occasionally flooded. This moderately well drained soil is on broad low stream terraces above the active flood plain in the Willamette Valley. It formed in silty alluvial deposits. Slopes average about 2 percent. Elevation is 170 to 300 feet. This soil is subject to overflow in some years. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is very dark grayish brown silty clay loam about 15 inches thick. The subsoil is very dark grayish brown, dark brown, and dark yellowish brown silty clay that extends to a depth of 60 inches or more. Mottles are common in the subsoil and substratum.

Included with this soil are areas of Malabon soils, which make up about 10 percent of this map unit, and Chehalis soils, which make up 5 percent.

Permeability is moderately slow. Effective rooting depth is greater than 60 inches. Available water capacity is 10 to 12 inches, and the water-supplying capacity is 20 to 26 inches. Runoff is slow, and the hazard of erosion is slight except during flooding. The soil is occasionally flooded late in winter and early in spring. A seasonal high water table is at a depth of 18 to 30 inches in winter and spring.

This soil is well suited to pasture, hay, small grain, grass seed, and vegetable crops. Long-lived, deep-rooted deciduous fruit and nut trees, strawberries, caneberries, and alfalfa are adversely affected by the seasonal high water table, unless the soil is drained. Properly managing crop residue and using a cropping system in which grasses and legumes are grown at least 25 percent of the time help to reduce runoff and erosion and to maintain productivity and workability. The hazard of erosion from flood waters can be reduced by seeding winter cover crops. Small grain and grasses respond to nitrogen; row crops respond to nitrogen and phosphorus; and legumes respond to phosphorus, sulfur, and lime. If residues are used, additional nitrogen is generally needed to prevent a decrease in yields.

The soil is irrigated by sprinkler, furrow, or border irrigation. Sprinkler irrigation is the most common method and is very satisfactory. Irrigation water should be applied carefully at rates low enough to prevent runoff. Irrigation water is available from reservoirs or streams.

The soil has moderate drainage concerns that respond to a subsurface type of drainage. Drainage is needed for maximum use and production. Seepage from soils in higher areas can be controlled by interception and random drains. Runoff can be controlled by grassed waterways and vegetative cover in some places.

No commercial stands of timber are grown on this soil. The soil is poorly suited to Christmas tree production because of the flood hazard.

The native vegetation of grass, hazel, poison-oak, wild blackberry, Douglas-fir, and Oregon white oak furnish good food and cover for ring-necked pheasant, California quail, bobwhite quail, and mourning dove. Black-tailed deer are permanent residents. Ducks and geese also feed in areas that are near water. Gophers, ground squirrels, moles, nutria, and opossum are common pests. Planting along streambanks and roadways, using grassed waterways, and preserving fence rows, woodlots, and brushy areas improve cover and food for wildlife.

This soil has some limitations for homesites, commercial buildings, and local roads and streets because of low strength and flooding. The major limitations for septic tank absorption fields are the moderately slow permeability and the seasonal high water table.

This soil is in capability subclass IIw.

20—Concord silt loam. This poorly drained soil is on terraces of the Willamette River and its tributaries. It formed in silty and clayey alluvium of mixed mineralogy. Slopes average about 1 percent. Elevation is 150 to 300 feet. The average annual precipitation is 40 to 45 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is dark grayish brown silt loam about 8 inches thick. The subsurface layer is grayish brown mottled silty clay loam about 6 inches thick. The subsoil is dark grayish brown mottled silty clay about 17 inches thick. The substratum is dark brown mottled silty clay loam that extends to a depth of 60 inches or more.

Included with this soil in mapping are areas of Dayton and Amity soils, which make up as much as 10 percent of this map unit.

Permeability is slow. Effective rooting depth is greater than 60 inches. Available water capacity is 9 to 12 inches, and the water-supplying capacity is 20 to 26 inches. Runoff is slow to very slow or the soil is ponded, and the hazard of erosion is slight. A seasonal high water table is at a depth of less than 6 inches in winter and spring.

This soil is used for grass seed, cereal grain, hay, and pasture. Proper management of crop residues and a cropping system in which grasses or legumes or grass and legume mixtures are grown at least 25 percent of the time help to maintain fertility and tilth.

Small grains and grasses grown on this soil respond to nitrogen, and legumes respond to phosphorus and sulfur. Moderate to high applications of lime are needed to correct acidity.

Irrigation is needed for maximum production of all crops. Water should be applied carefully so that the soil is not overirrigated. Overirrigation causes a high water table. Water is available, at times, from streams and ponds.

This soil needs drainage for maximum production and use. Drainage is generally hard to establish because of poor outlets, seasonal overflow, and inundation from higher areas. The soil responds well to drainage if adequate outlets are provided.

This soil is poorly suited to commercial timber production.

Native areas contain grass, shrubs, and scattered Oregon white oak. A high water table limits the use of this soil to ducks and geese late in fall, in winter, and early in spring. Waterfowl feed on seeds and tubers from water plants and crop residues. The rest of the year, ring-necked pheasants, California quail, bobwhite quail, mourning doves, and black-tailed deer move into this area for food and cover. The soil is used mainly by some fur-bearing animals.

This soil has major limitations for homesites, commercial buildings, roads and streets, and other community uses because of shrink-swell potential and the seasonal high water table.

This soil is in capability subclass IIIw.

21—Cove silty clay loam. This poorly drained soil is on alluvial bottoms along tributary streams. It formed in mixed clayey alluvium. Slopes are 0 to 2 percent but average about 1 percent. Elevation is 125 to 300 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is very dark brown silty clay loam about 8 inches thick. The subsoil is black and dark gray clay about 29 inches thick. The substratum is dark gray mottled clay that extends to a depth of 60 inches or more. Mottles are common in the subsoil and substratum.

crop residues are used, additional nitrogen is needed to prevent decreased yields.

Water can be applied by means of furrow, border, or sprinkler irrigation, but sprinkler irrigation is most commonly used. Smoothing this soil for irrigation or for surface drainage is easier than on other soils, and it does no permanent damage. Streams are generally available for irrigation.

No commercial stands of timber are on this soil. The soil is well suited to Christmas tree production.

This soil supports a wide variety of grain, grasses, legumes, orchards, and vegetable crops which furnish good cover and food for ring-necked pheasant, valley quail, bobwhite quail, and mourning dove. If cover is sufficient, black-tailed deer are permanent residents. Ducks and geese also feed in areas close to water. Grouse, band-tailed pigeons, and mountain quail are not common. Gophers, ground squirrels, moles, nutria, and opossum are common pests. Planting along roadways, using grassed waterways, and preserving fence rows, woodlots and brushy areas improve the cover for wildlife

Low strength and moderate shrink-swell potential are limitations for homesites and commercial buildings. The moderately slow permeability of the soil is a limitation for septic tank absorption fields. The low strength is a major limitation for local roads and streets.

This soil is in capability subclass IIs.

46—Malabon silty clay loam, occasionally flooded. This well drained soil is on broad, low terraces along streams. It formed in silty and clayey mixed alluvium. Slopes are 0 to 3 percent but average about 2 percent. Elevation is 200 to 300 feet. This soil is flooded by overflow several times during the year about once every 10 years. The average annual precipitation is 40 to 50 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is very dark grayish brown and dark brown silty clay loam about 15 inches thick. The upper 10 inches of the subsoil is dark brown light silty clay, and the lower part is dark yellowish brown silty clay that extends to a depth of 60 inches or more.

Included with this soil in mapping are areas of Coburg and Willamette soils, which make up about 5 percent of this map unit.

Permeability is moderately slow. Effective rooting depth is more than 40 inches. Available water capacity is 9 to 12 inches, and the water-supplying capacity is 20 to 26 inches. Runoff is slow, and the hazard of erosion is slight, except during flooding. The soil is subject to occasional flooding in winter and early in spring.

This soil is used mainly for cereal grain, grass seed, hay, pasture, vegetable, and specialty crops. Properly managing crop residue and using a cropping system in which grasses and legumes are grown at least 25 percent of the time help to maintain favorable fertility and workability. The hazard of erosion from flood waters can be reduced by planting winter cover crops.

Small grain and grass respond to nitrogen; row crops respond to nitrogen and phosphorus; and legumes respond to phosphorus, sulfur, and, in many places, lime. If crop residues are used, additional nitrogen is needed to prevent a decrease in yields.

Water can be applied by means of furrow, border, or sprinkler irrigation, but sprinkler irrigation is most commonly used. Smoothing the soil for irrigation or for surface drainage is easier than on other soils, and it does no permanent damage. Water from streams is generally available for irrigation.

No commercial stands of timber occur on this soil. The soil is not well suited to Christmas tree production because of the hazard of flooding.

This soil supports a wide variety of grains, legumes, orchards, and vegetable crops, which furnish good cover and food for ring-necked pheasant, valley quail, bobwhite quail, and mouring dove. If cover is sufficient, black-tailed deer are permanent residents. Ducks and geese also feed in areas of this soil close to water. Grouse, band-tailed pigeons, and mountain quail are not common. Gophers, ground squirrels, moles, nutria, and opossum are common pests. Planting along roadways, using grassed waterways, and preserving fence rows, woodlots, and brushy areas improve the cover and food for wildlife.

This soil has major limitations for all community development uses, because it is subject to occasional overflow.

This soil is in capability subclass IIw.

47D—Marty gravelly loam, 3 to 25 percent slopes. This well drained soil is in the mountains of the Coast Range. It formed in residuum and colluvium weathered from igneous rock. Slopes average about 15 percent. Elevation is 1,200 to 1,900 feet. The average annual precipitation is 80 to 120 inches, the average annual air temperature is about 45 to 50 degrees F, and the frost-free period is about 150 to 160 days.

In a representative profile, the surface layer is dark reddish brown gravelly loam about 13 inches thick. The upper 21 inches of the subsoil is reddish brown gravelly loam, and the lower 12 inches is reddish brown gravelly clay loam. The substratum is strong brown clay loam that extends to a depth of 60 inches or more.

Included with this soil in mapping are areas of Hembre, Klickitat, and Blachly soils, which make up about 15 percent of this map unit.

Permeability is moderately slow. Effective rooting depth is greater than 60 inches. Available water capacity is 9 to 11 inches, and the water-supplying capacity is 20 to 26 inches. Runoff is medium. and the hazard of erosion is moderate.

This soil is used for timber production, and it is very well suited to the production of Douglas-fir. Western

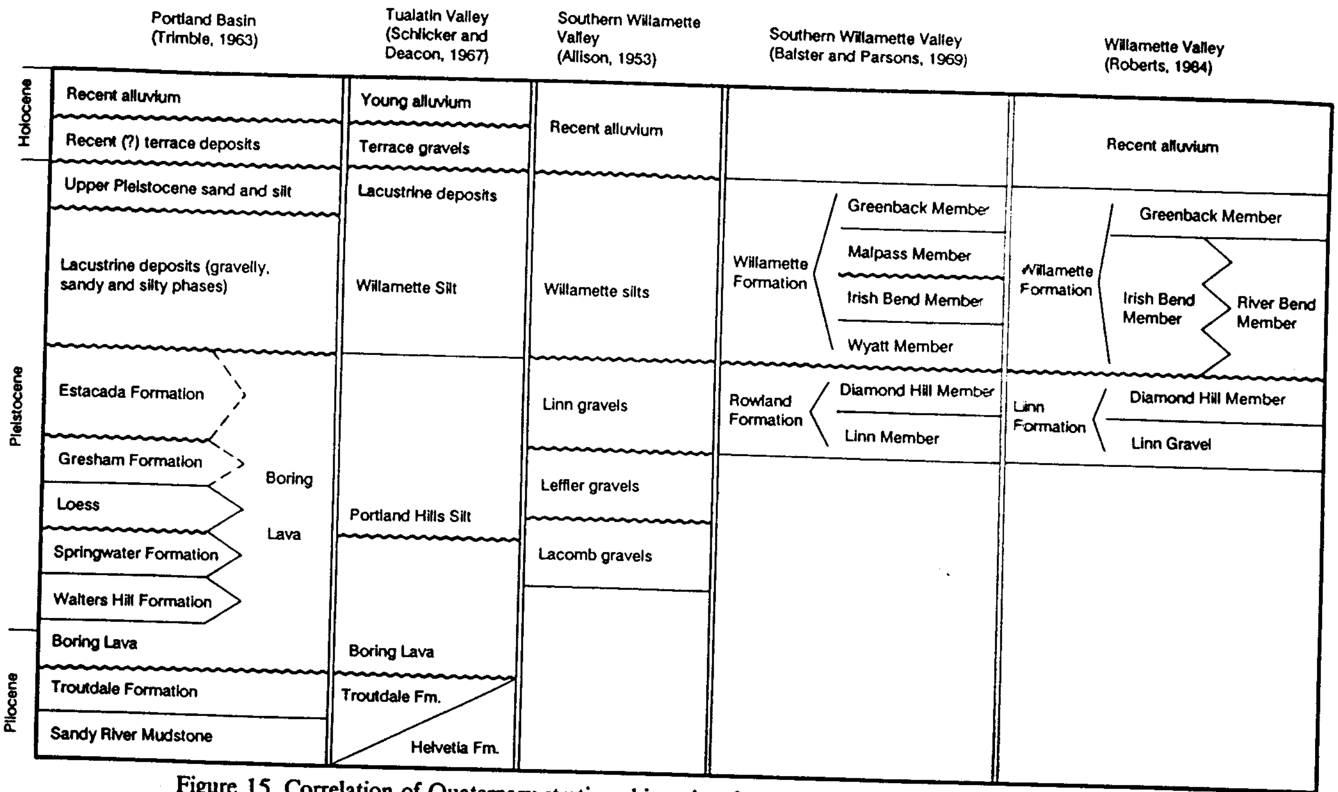


Figure 15. Correlation of Quaternary stratigraphic units of the Willamette Valley and adjacent areas. Alternative stratigraphic schemes for the Willamette Silt/Willamette Formation are shown in the three columns to the right.

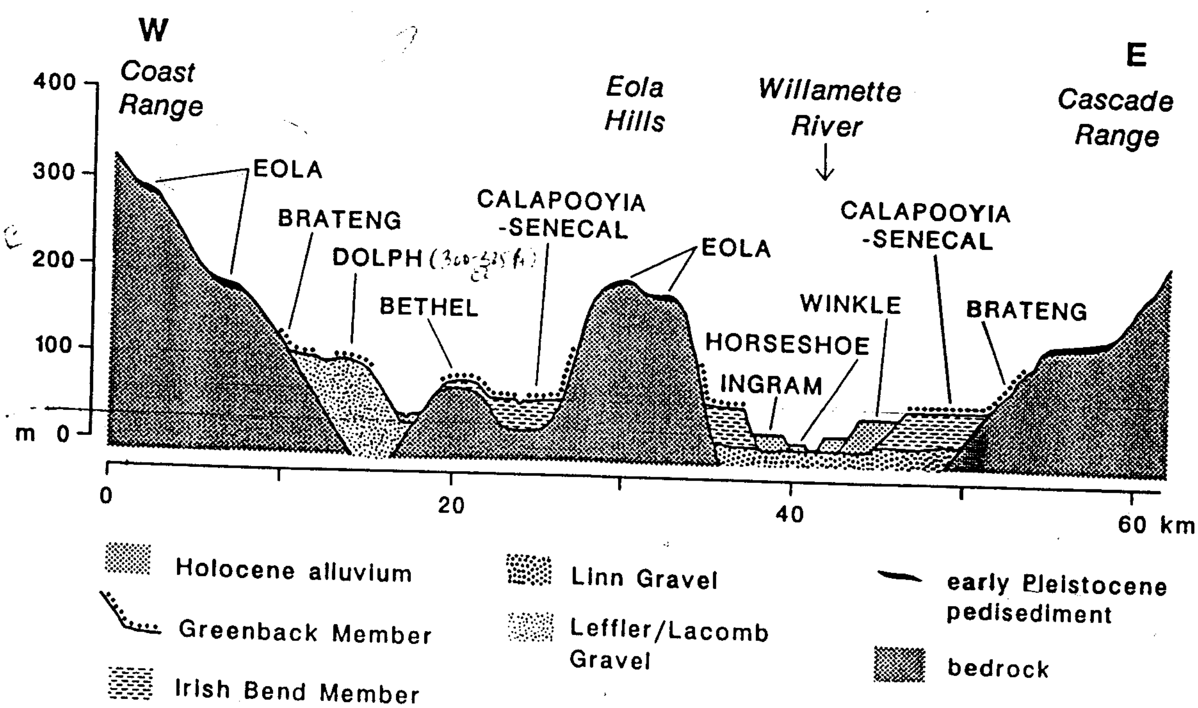


Figure 16. Generalized cross section of geomorphic surfaces at about the latitude of Salem. Subsurface distribution of the Linn Gravels shown here is speculative.

Table 3-5. Summary of Surficial Map Criteria for the Central Appalachians (after Kite, 1994).

E:TABLES:SRFMPTBL.DOC

A. Type I Criteria: Age, Origin, Landform, Material.

1. **Age of Surficial Material**
   - H = Holocene (< 10,000 years old)
   - W = Wisconsin (ca. 89 to 10 ka)
   - I = Illinoian
   - P = Pleistocene Undifferentiated
   - EP = Early Pleistocene
   - MPl= Middle Pleistocene
   - LP = Late Pleistocene
   - Q = Quaternary Undifferentiated
   - CZ = Cenozoic Undifferentiated
   - Q-CZ(?) = Quaternary to Cenozoic?
   - MZ = Mesozoic (applied to bedrock)
   - PZ = Paleozoic (applied to bedrock)

2. **Origin / Surficial Process**
   - A. Hillslope
     - r = residuum (in situ regolith)
     - c = colluvium (mass wasting)
     - ds = debris slide
     - rf = rock fall or topple
   - B. Valley Bottom
     - a = stream alluvium (normal flow)
     - hcf = hyperconcentrated flow
     - df = debris flow
     - sw = slackwater deposition
   - C. Lacustrine
     - l = lacustrine deposit, undiff.
     - lb = lake-bottom deposit
     - ld = lacustrine deltaic
     - ls = lakeshore deposit (incl. beaches)
   - D. Other
     - g = glaciofluvial, undifferentiated
     - go = glacial outwash
     - e = eolian
     - co = collapse (solution)
     - cr = cryoturbation
     - x = anthropogenic disturbance
     - f = artificial fill
     - rk = bedrock (continuous outcrop)

3. **Landform Units**
   - A. Hillslope
     - n = nose
     - sl = side slope
     - h = hollow
     - veneer = < 2m of regolith
     - blanket = > 2 m of regolith
     - bf = boulder field
     - bs = boulder stream
     - pg = patterned ground
     - tls = talus deposits
   - B. Valley Bottom
     - ch = channel
     - fp = floodplain (RI </= 2-3 yr)
     - t = terrace (t1, t2 ...tn; height AMRL)
     - f = fan
     - f-t = fan terrace (f1, f2 ...fn; height AMRL)
     - a = apron (footslope deposit)
     - lo = lobe
     - lv = levee
     - ox = oxbow, abandoned channel
   - C. Other
     - ft = flow track (debris flows)
     - hm = hummocky topography
     - rb = rock-block slide deposits
     - x = excavated, fill, disturbed ground
     - d = delta
     - du = dune
     - bedrock = exposed bedrock

4. **Material (Composition and Texture)**
   - b = boulders (>256 mm; clast supported)
   - c = cobbles (64-256 mm; clast supported)
   - p = pebbles (4-64 mm; clast supported)
   - g = gravel (>2 mm; clast supported)
   - sg = mixed sand and gravel
   - s = sand (0.05-2.0 mm)
   - st = silt (0.002-0.05 mm)
   - cy = clay (<0.002 mm)
   - l = loam (mix of sand, silt, clay)
   - d = diamicton undifferentiated
   - bbd = very bouldery diamicton
   - bd = bouldery diamicton
   - cd = cobbly diamicton
   - pd = pebbly diamicton
   - ds = sandy matrix diamicton
   - dt = silty matrix diamicton
   - dy = clayey-matrix diamicton
   - rk = bedrock (modify with lithology)
   - rs = rotten stone, saprolite
   - tr = travertine
   - tu = tufa
   - ma = marl
   - og = organic-rich sediment
   - w = water
   - u = unkown

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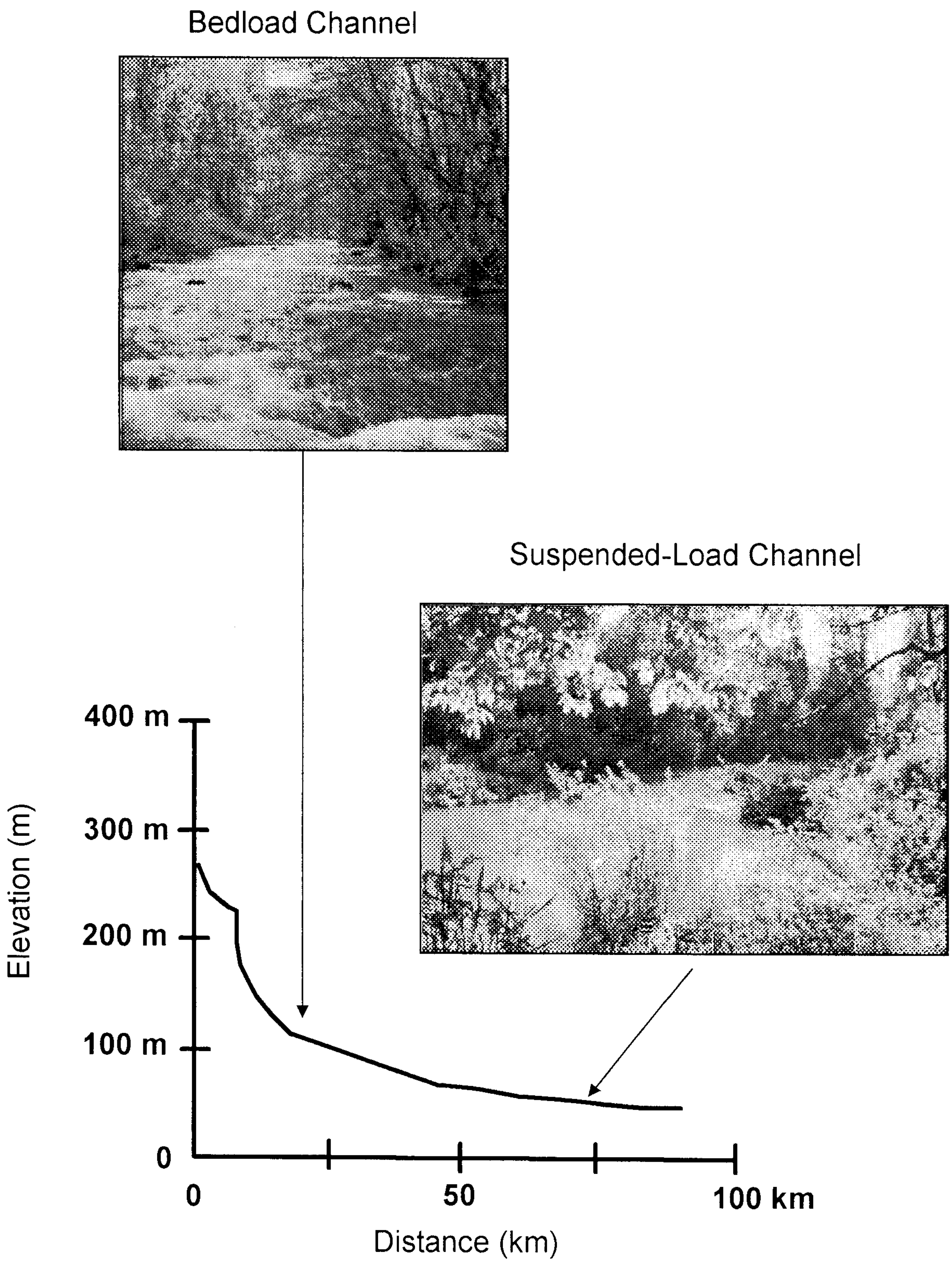
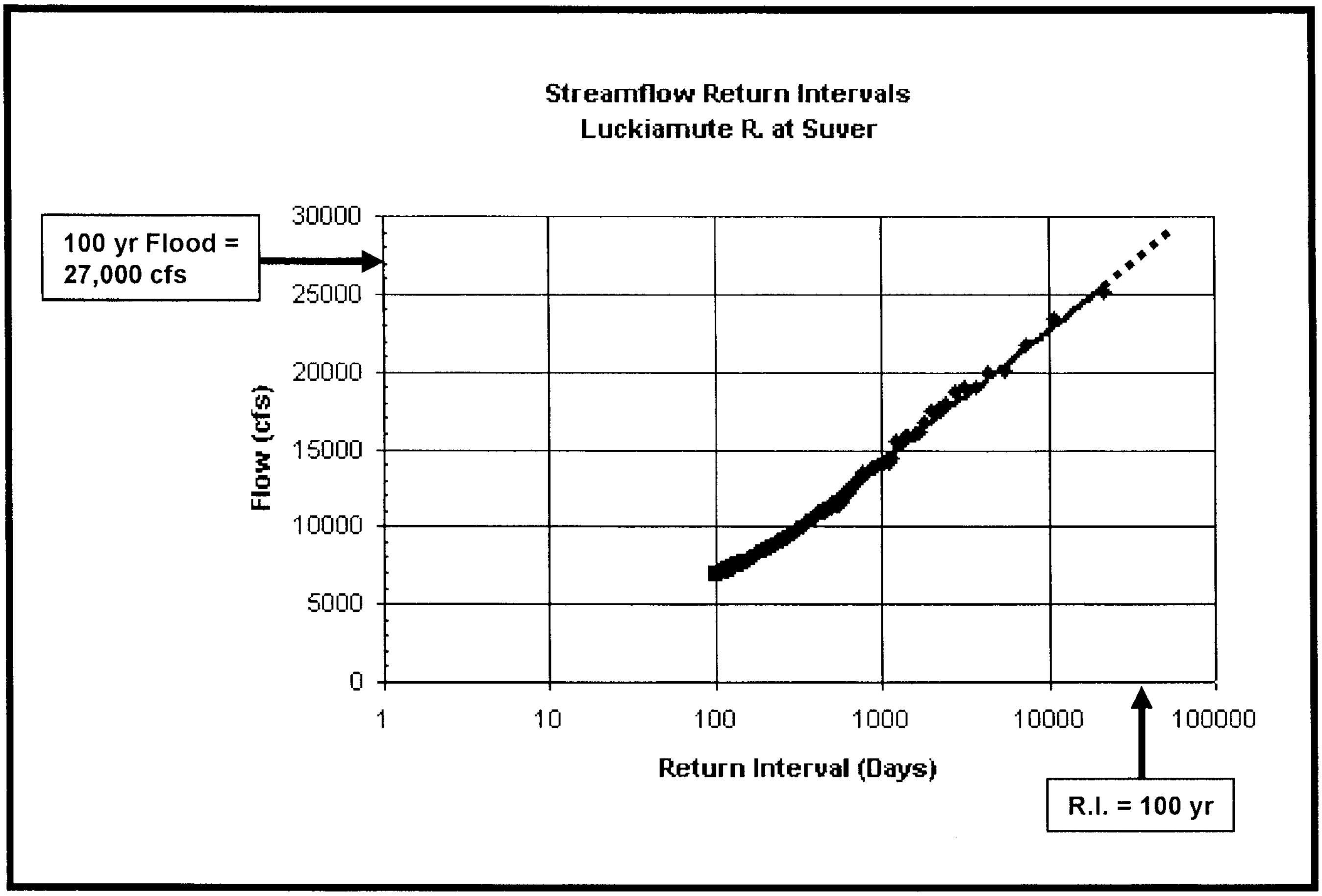
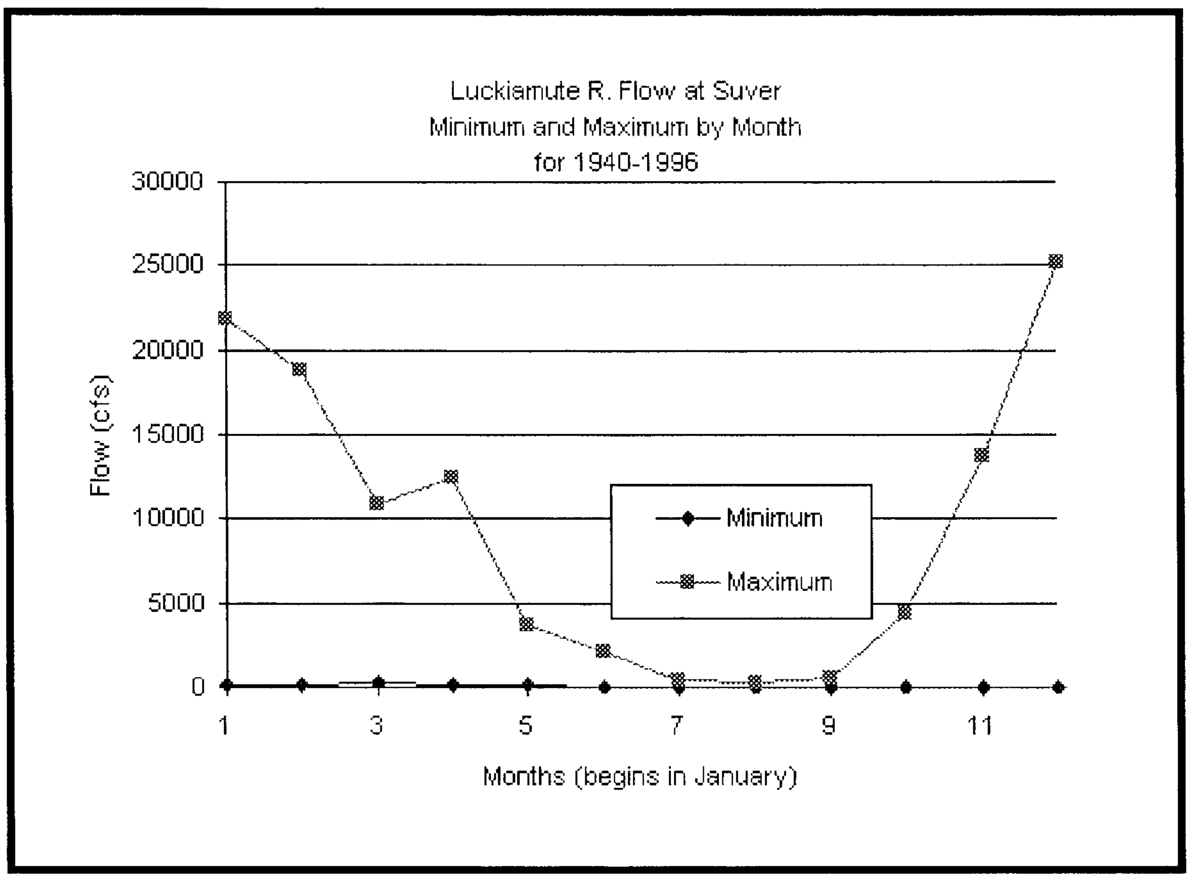


Longitudinal profile along the Luckiamute River (from Rhea, 1993).
Photos from Waichler and others (1997).





Discharge characteristics for Luckiamute River, Helmick State Park (from Waichler and others, 1997).