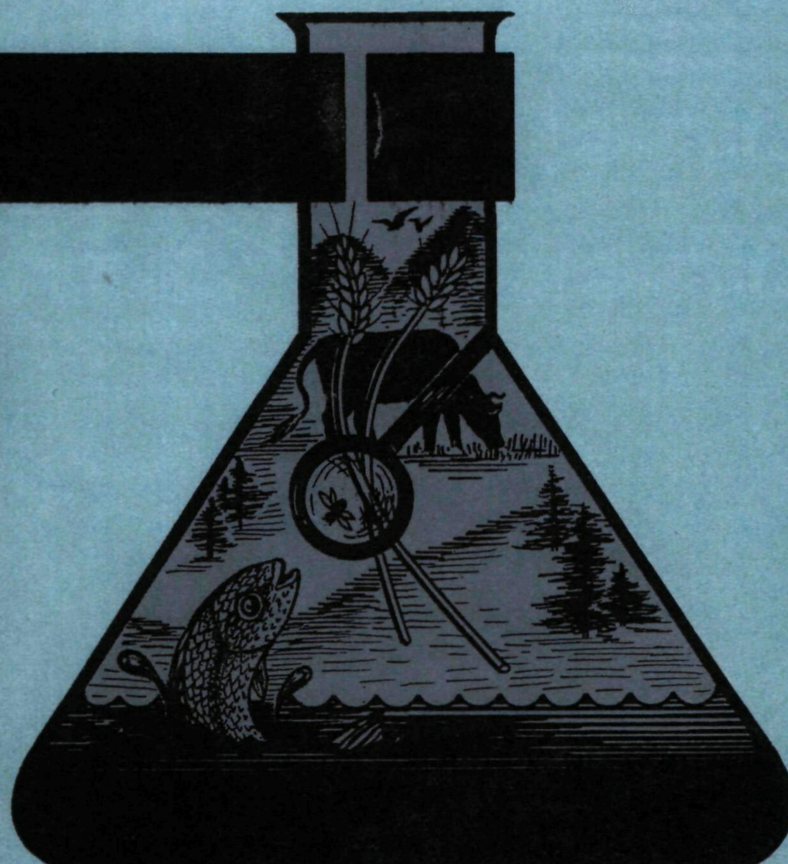
United States
Environmental Protection
Agency

Corvallis Environmental
Research Laboratory
Corvallis, Oregon 97330

EPA

ESTIMATING STREAMFLOW CHARACTERISTICS AT SPAWNING SITES IN OREGON

CERL--051
February 1980



ESTIMATING STREAMFLOW CHARACTERISTICS AT SPAWNING SITES IN OREGON

CERL--051
February 1980

An Analysis of the Hydrology of Sixteen Ungaged Test Sites, Established to Evaluate the Effects of Land Use on Spawning Gravels in Small Oregon Coastal Streams

By
John F. Orsborn
Consulting Engineer

Project for the
U.S. Environmental Protection Agency
Corvallis Environmental Research Laboratory
Corvallis, Oregon 97330
M. Shirazi, Contract Officer

ABSTRACT

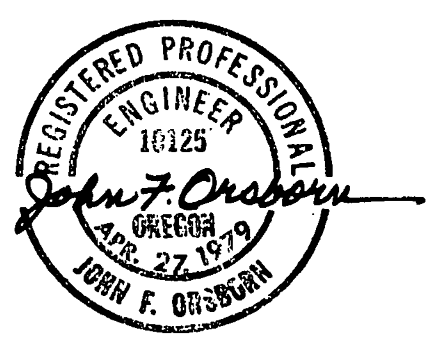
During the summer of 1978 numerous measurements of stream gravel composition and streamflow were made by EPA personnel in small Oregon streams which drain the coastal ranges. The measurements were made at sixteen (16) spawning sites on thirteen (13) streams to establish a monitoring procedure to determine the effects of natural flooding and the effects of road building and logging practices on the spawning habitats of salmonoids. These natural and man-caused activities influence the composition of the spawning gravels and the fine sediment content of those gravels.

The EPA measurements consisted of detailed channel cross-sections, longitudinal profiles, flow velocities and stream bed materials. From these data the average stream flows at the times of the measurements could be determined, but little could be determined about the flow regime of the sites.

The methods used in this study were to develop correlations between various characteristic flows at U.S. Geological Survey (USGS) gaging stations in the North and Middle Coast Basins of Oregon and their drainage basin characteristics. Then, by measuring the basin characteristics above the EPA gravel test sites, and using the gaging station correlations, the characteristic flows at the sixteen (16) test sites would be determined. The primary objectives of this study were to provide a first estimate of the flow regime of the thirteen streams at the EPA sites, and to provide a hydrologic framework within which planning of the monitoring program could be undertaken without expending much additional time, effort and finances on traditional stream-gaging programs.

AUTHORITY

This report was prepared under order number B0687NNEX dated March 21, 1979, between EPA Corvallis, Oregon Environmental Research Laboratory and the consultant.



TABLES OF CONTENTS

Topic	Page
ABSTRACT and AUTHORITY	i
TABLE OF CONTENTS	ii
LIST OF FIGURES	iii
LIST OF TABLES	vi
SUMMARY OF ESTIMATED CHARACTERISTIC FLOWS AT EPA GRAVEL TEST SITES	1
DATA SOURCES	3
EPA Data	3
USGS Data	5
US Weather Service Data	11
Oregon State Water Resources Board Data	11
DESCRIPTION OF THE EPA SITES	12
DATA ANALYSIS AND UNGAGED FLOW ESTIMATION	36
Characteristic Flows at USGS Gaging Stations	36
Basin Characteristics Above the Gaging Stations	38
Basin Characteristics of the EPA Sites	42
Low Flows	42
Average Annual Flows	49
Flood Flows	57
Duration Curves	63
OTHER ASPECTS OF THE STUDY	72
Channel and Flow Characteristics	72
Flood and Storm Characteristics	73
Anticipated Changes in Hydrologic Conditions	82
RECOMMENDATIONS	83
APPENDIX I. REFERENCES	86
APPENDIX II. GAGING STATION CORRELATIONS	89

LIST OF FIGURES

Figure No.		Page
OSWRB Map No. 1.6		Back Cover
OSWRB Map No. 18.6		Back Cover
Fig. 1.	Location Map of EPA Site No. 1 on Beaver Creek, Oregon	14
Fig. 2.	Location Map of EPA Sites No. 2 and 3, and USGS Gage 143036 on the Nestucca River, Oregon	16
Fig. 3.	Location Map for EPA Sites Nos. 4, 6A, 6B, 9A and 9B, and USGS Low Flow Station and OSGC Fish Life Stations on Indian Creek and USGS Regular Gaging Station on Lake Creek, Oregon	19
Fig. 4.	Location on EPA Site No. 5, North Prong Creek and Nearby Sweet Creek USGS Low Flow Station and OSGC Fish Life Station in Oregon	21
Fig. 5.	Location Map of EPA Sites Nos. 7 and 10 and USGS Gaging Stations, Oregon	25
Fig. 6.	Location Map of EPA Sites No. 8, Canal Creek and Site No. 11, West Creek Just South of the Alsea River, Oregon	27
Fig. 7.	Location Map of EPA Sites Nos. 12 and 13, Rock Creek and Big Creek, Respectively, Including USGS Regular Station on Big Creek, Crest-Stage Station on Sam Creek, Oregon	34
Fig. 8.	Total Stream Length and Average Annual Flow Related to Drainage Basin Area for USGS Gaging Stations on Oregon Coastal Streams	40
Fig. 9.	Total Stream Length Related to Drainage Area at 16 EPA Spawning Gravel Test Sites on Small Oregon Coastal Streams	44
Fig. 10.	Two-Year and Twenty-Year, 7-Day Average Low Flow Related to First-Order Stream Length, Basin Relief and Basin Area for USGS Regular Gaging Stations--Oregon Coastal Streams	45
Fig. 11.	Two-Year and Twenty-Year, 7-Day Average Low Flows at USGS Oregon Coastal Miscellaneous Low Flow Stations Related to Stream Length and Basin Relief	46
Fig. 12.	7-Day Characteristic Low Flows Related to Total Stream Length and Basin Relief for USGS Miscellaneous Low Flow and Regular Gaging Stations on Oregon Coastal Streams	47
Fig. 13.	Two-Year and Twenty-Year, 7-Day Average Low Flows, Q7L2 and Q720, Related to Combined Low Flow and Basin Characteristics	50

LIST OF FIGURES (Continued)

Fig. 14.	Seven-Day Average Low Flow Recurrence Interval Graphs for USGS Regular Gaging Stations--Oregon Coastal Streams	51
Fig. 15.	Seven-Day Average Low Flow Recurrence Interval Graphs for EPA Sites Numbers 1 through 7	52
Fig. 16.	Seven-Day Average Low Flow Recurrence Interval Graphs for EPA Sites Numbers 8 through 13	53
Fig. 17.	Average Annual Flow Related to Basin Area and Relief for USGS Gaging Stations in Oregon Coastal Drainage Basins	54
Fig. 18.	Average Annual Flow Related to Average Annual Precipitation and Drainage Area for North- and Mid-Coast USGS Gaging Stations for Oregon Coastal Streams	55
Fig. 19.	Two-Year and Fifty-Year Peak Floods at Regular USGS Gaging Stations Related to Average Annual Flows	58
Fig. 20.	Relationship Between Average Low, Annual and Flood Flows--Oregon Coast Basins at USGS Regular Gaging Stations	59
Fig. 21.	Flood Recurrence Interval Graphs for USGS Regular Gaging Stations in the Study Area	60
Fig. 22.	Flood Recurrence Interval Graphs for USGS Crest-Stage Gages on Small Watersheds in the Study Area	61
Fig. 23.	Two-Year and Fifty-Year Peak Flood Flows Related to Average Annual Precipitation Volume and Basin Potential Energy for Oregon Coastal Streams	62
Fig. 24.	Estimated Annual Peak Flood Recurrence Interval Graphs for EPA Sites Numbers 1-7	65
Fig. 25.	Estimated Annual Peak Flood Recurrence Interval Graphs for EPA Sites Numbers 8-13	66
Fig. 26.	Regular and Dimensionless Duration Curves for Four USGS Gaging Stations--Oregon Coastal Streams	69
Fig. 27.	Range and Seasonal Distribution of Flows for Needle Branch and Deer Creek (From Ref. 4)	75
Fig. 28.	Relationship Between Three- day Seven-Day Average High Flows Resulting from the Same Storm at Oregon Coastal Stream Gaging Stations	81
Fig. 29.	Correlation of Oregon State Game Commission Fish Life Flow--Station Flows in 1971 with Same Day Flows at USGS Gage 143036, Nestucca River Near Beaver, Oregon	91
Fig. 30.	Correlation of Miscellaneous Flow Measurements at Oregon State Game Commission Fish Life Flow Stations and USGS Low Flow Station with USGS Gaging Station 14307645, North Fork Siuslaw River Near Minerva, Oregon	92

LIST OF FIGURES (Continued)

Fig. 31. Correlation of Daily Flow in Sweet Creek at USGS Miscellaneous and Oregon Game Commission Fish Life Flow Stations with USGS Gaging Station 14307620, Siuslaw River near Mapleton ... 93

Fig. 32. Correlation of Indian Creek Flows at Miscellaneous Gaging Sites with USGS Gage on Lake Creek near Deadwood, Oregon ... 94

Fig. 33. Correlations of Flows Between Oregon State Game Commission Fish Life Flow Stations in 1971 and USGS Gage on Five Rivers near Fisher, Oregon ... 95

Fig. 34. Correlation of Short-Term USGS Gaging Stations with Long-Term Gage 3065 on Alsea River, Oregon

LIST OF TABLES

Table No.		Page
Table 1.	Summary of Estimated Flows at EPA Spawning Gravel Test Sites in Oregon	2
Table 2.	Stream Flows at Closest USGS Gages on Days EPA Site Flows Were Measured	4
Table 3.	Regular USGS Gaging Stations -- Oregon Coastal Streams	6
Table 4.	USGS Crest Stage Gages for Floods in Small Oregon Coastal Streams	8
Table 5.	Selected USGS Miscellaneous Low Flow Gaging Station Locations and Basin Characteristics	9
Table 6.	Oregon State Game Commission Fish Life Flow Stations	10
Table 7.	Index to EPA Site Summary Tables and Location Maps	12
	EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS	
Table 8.	Site No. 1, Beaver Creek	13
Table 9.	Site No. 2, Three Rivers	15
Table 10.	Site No. 3, Farmer Creek	17
Table 11.	Site No. 4, Green Creek	18
Table 12.	Site No. 5, North Prong Creek	20
Table 13.	Site No. 6A, North Fork Indian Creek	22
Table 14.	Site No. 6B, North Fork Indian Creek	23
Table 15.	Site No. 7, Savage Creek (Grant Creek)	24
Table 16.	Site No. 8A, Canal Creek	26
Table 17.	Site No. 8B, Canal Creek	28
Table 18.	Site No. 9A, Green River	29
Table 19.	Site No. 9B, Green River	30
Table 20.	Site No. 10, Cape Horn Creek (Gopher Creek)	31
Table 21.	Site No. 11, West Creek	32
Table 22.	Site No. 12, Rock Creek	33
Table 23.	Site No. 13, Big Creek	35
Table 24.	USGS Oregon Coastal Gaging Station Characteristic Flows	37
Table 25.	Basin Characteristics for Regular USGS Gaging Stations in the North- and Mid-Coast Basins of Oregon	39
Table 26.	Basin Characteristics for EPA Spawning Gravel Sampling Sites in the Siuslaw National Forest--Oregon Coastal Basins	43
Table 27.	Long Term Annual Flow for Alsea River near Tidewater, Oregon (14-3065), Area = 334 square miles	56

LIST OF TABLES (Continued)

Table 27A. Flood Flows and Basin Parameters in Oregon Coastal Streams for Ungaged Flood Prediction in Fig. 23 64

Table 28. Dimensionless Duration Curve Data for Four USGS Gaging Stations--Oregon Coastal Streams 68

Table 29. Data Points for Duration Curves for EPA Sites on Oregon Coastal Streams 71

Table 30. Stream Gaging and Precipitation Stations Used in Flood and Storm Characteristics Analysis 76

Table 31. Selected Period Precipitation for Water Year 1975 at Three Oregon Coast Range Stations 77

Table 32. Cumulative Three- and Seven-Day Flood Flows at Selected Gaging Stations in Water Year 1975 Corresponding to Periods of Heavy Precipitation 78

Table 33. Three-Day High-Flow Runoff for Flynn Creek, Needle Branch and Deer Creek (from Ref. 4) 81

Table 34. USGS Gaging Station Cross-Correlations of Daily Flows, Oregon Coastal Streams 90

SUMMARY OF ESTIMATED CHARACTERISTIC FLOWS AT EPA GRAVEL TEST SITES

The locations of the EPA gravel test sites, hereinafter referred to as the "EPA sites", are shown in a series of maps on pages 14-34. These location maps were drawn from 1:62,500 (15 min) scale USGS topographic maps. The USGS maps on which each EPA site and its watershed are located are listed on the site summary tables between pages 13-35. An index to these EPA site maps and summary tables is given in Table 7 on page 12.

The EPA sites, their locations and their characteristic flows are summarized in Table 1. The characteristic flows are defined as:

Q7L2:	the 7-day average low flow with a 2-year recurrence interval;
Q7L20:	the 7-day average low flow with a 20-year recurrence interval;
QAA:	the average annual daily flow;
VQAA:	the expected variation in the average annual flow based on records at USGS gaging stations;
QF2P:	the peak flood flow with a 2-year recurrence interval; and
QF50P:	the peak flood flow with a 50-year recurrence interval.

The two low flows (Q7L2 and Q7L20) are used to define the low flow recurrence interval graph and the two flood flows (QF2P and QF50P) define the flood recurrence interval graph at the ungaged sites. These flows, when combined with the average annual flow and the characteristic shapes of duration curves at gaging stations in the hydrologic province, are used to generate the duration curves of the streams at the ungaged EPA sites.

The data sources, methods of analyses and other study results are presented in the following sections. References with commentary are in Appendix I and the various cross correlations developed for miscellaneous and long-term gaging stations are presented as supplemental information in Appendix II.

For the 16 EPA sites the estimated results are presented in detail on the following pages:

Low flow recurrence interval graphs--Figs. 15 and 16 on pages 52 and 53.
Flood flow recurrence interval graphs--Figs. 24 and 25 on pages 65 and 66.
The values of the duration curve flows are in Table 29 on page 71.
An index to EPA site summary tables and location maps is given in Table 7 on page 12.

Table 1. Summary of Estimated Flows at EPA Spawning Gravel Test Sites in Oregon (All flows are in cubic feet per second)

Site No.	Site Name	Site Location	Q7L2 / Q7L20	QAA / VQAA	QF2P / QF50P
1	Beaver Creek	NW¼, Sec. 15 T3S, R9W	3.3 / 2.3	52 / ±33	1050 / 2860
2	Three Rivers	SW¼, Sec. 26, T4S, R9W	2.0 / 1.4	22 / ±14	540 / 1570
3	Farmer Creek	NE¼, Sec. 3 T4S, R10W	0.70 / 0.50	15 / ±9	270 / 860
4	Green Creek	NE¼, Sec. 5 T17S, R9W	0.45 / 0.25	8 / ±5	125 / 420
5	N. Prong Creek	NE¼, Sec. 1 T19S, R11W	0.90 / 0.60	7 / ±4	180 / 585
6A	N.F. Indian Creek[a]	NE¼, Sec. 2 T16S, R10W	1.10 / 0.65	20 / ±13	280 / 860
6B	N.F. Indian Creek[b]	SE¼, Sec. 11 T16S, R10W	1.80 / 1.15	40 / ±26	500 / 1470
7	Savage Creek	NW¼, Sec. 13 T12S, R9W	3.7 / 2.4	60 / ±39	1005 / 2740
8A	Canal Creek[a]	S½, Sec. 17 T14S, R10W	0.40 / 0.30	13 / ±8	180 / 590
8B	Canal Creek[b]	SE¼, Sec. 8 T14S, R10W	0.50 / 0.35	16 / ±10	230 / 730
9A	Green River[a]	NE¼SE¼, Sec. 24 T15S, R10W	1.10 / 0.75	20 / ±13	330 / 1010
9B	Green River[b]	S½, Sec. 19 T15S, R9W	2.25 / 1.50	37 / ±24	590 / 1710
10	Cape Horn Creek	W½, Sec. 20 T12S, R9W	0.85 / 0.60	9 / ±6	190 / 615
11	West Creek	NW¼, Sec. 8 T14S, R10W	0.70 / 0.50	8 / ±5	180 / 600
12	Rock Creek	SE¼, Sec. 10 T16S, R12W	3.0 / 2.0	40 / ±26	690 / 1970
13	Big Creek (Gage 3069)	NW¼, Sec. 19 T16S, R11W	6.0 / 4.0	96 / ±62	1280 / 3580

[a]Upper site; [b]Lower site

DATA SOURCES

EPA Data

The EPA office in Corvallis provided these data regarding the sixteen EPA sites:

1. field notes giving channel cross-sections, profiles, velocities and streambed material size composition;
2. a U.S. Forest Service (USFS) Siuslaw National Forest map showing the locations of the EPA sites; and
3. a table showing the area, forest practices and ownership of the watersheds above the sites.

In this report the following analyses were made of the EPA data:

1. stream flows were calculated from the cross-section and velocity data where adequate;
2. the mean channel slope along the thalweg profile was estimated;
3. channel cross-sections were plotted for those sites where a bankfull flow could be determined for channels with flood plains;
4. the sizes of the watersheds above the EPA sites were compared with those measured from the USGS topographic maps; and
5. the EPA office performed size distribution (mechanical) analyses of the bed material.

After the data analyses and map measurements were made the results were used as follows:

1. the single streamflow measurements were correlated with the average daily flows measured on the same days at nearby USGS gaging stations (see Table 2); these flows are to be used later to check ungaged flow estimates at the EPA sites);
2. the mean channel slope was used to estimate the bankfull flow conditions at several selected sites assuming that bankfull flows are approximately equal to the 2-year frequency floods;
3. for the selected streams with definite bankfull conditions the top width, flow area and mean depth were determined for use in estimating the bankfull flows;
4. the basin characteristics (stream lengths, relief and drainage area) of the EPA site watersheds were measured from the USGS maps; and

Table 2. Stream Flows at Closest USGS Gages on Days EPA Site Flows Were Measured

Date (1978)	EPA Site No.-Name	Flow Measured (cfs)	USGS Gage No. (14-)	USGS Gage River Name	Flow Gaged** (cfs)
July 25	1-Beaver Cr.	11.8	3036	Nestucca R.	132
July 27	2-Three Rivers	4.4E	3036	Nestucca R.	143
Aug. 21	3-Farmer Cr.	5.9	3036	Nestucca R.	198
July 20	4-Green Cr.	1.8	307580	Lake Cr.	70
July 18	5-N.Prong Cr.	1.0E	307645	N.F. Siuslaw R.	44
July 11	6A-N.F. Indian Cr.	9.4	307580	Lake Cr.	84
Aug. 24	6B-N.F. Indian Cr.	20.2	307580	Lake Cr.	100
Aug. 8	7-Savage Cr.	6.2E	3065	Alsea R.	150
June 15	8A-Canal Cr.	3.6E	3065	Alsea R.	476
Aug. 22	8B-Canal Cr.	2.2	3065	Alsea R.	333
Aug. 29	9A-Green R.	5.8E	3065	Alsea R.	141
June 29	9B-Green R.	8.9	3065	Alsea R.	272
July 7	10-Cape Horn Cr.	3.9	3065	Alsea R.	233
July 13	11-West Cr.	2.7E	3065	Alsea R.	200
Aug. 1	12-Rock Cr.	8.5	3069	Big Cr.	9.9
Aug. 3	13-Big Cr.	5.6*	3069	Big Cr.	9.5
Sept. 5	13-Big Cr.	8.4*	3069	Big Cr.	14.0

E = Estimate; *Both values 60% of average daily flow at Gage 3069.

**1978 USGS data obtained by personal communication; not published yet; average daily flow at gages for dates on which flows were measured at EPA sites.

5. the mean equivalent diameter of the streambed material (D50) was determined by the EPA office and used to estimate the mean velocity profiles at the selected sites for providing another estimate of the bankfull discharge.

There are some limitations on the EPA data which affected the results of this report including the following:

1. the very low velocities and wide channels at some sites did not lend themselves to accurate flow determinations and are noted as "estimates";
2. although detailed sketches were given for the EPA sites in the field notes, definite bankfull conditions could be determined at only a few sites; and
3. this limitation did not adversely affect the primary determinations of the characteristic flows at the EPA sites, only the verifying estimates of the 2-year floods.

U.S. Geological Survey (USGS) Data

The Portland regional office of the USGS provided:

1. access to files of statistical analyses on low flow and flood flow frequency data for gaging stations in the study area (12); and
2. a preliminary copy of a report updating flood frequency analyses in the study area (5); and
3. the annual water supply reports published by the USGS for the State of Oregon were used (12).

The USGS streamflow files and reports were used to:

1. determine some of the characteristic flows and duration curves at gaging stations in the study area (12);
2. update and broaden the application of the peak flood frequency analysis with crest-stage gage data for small watersheds and longer periods of record at regular gaging stations (5); and
3. determine flood hydrograph characteristics, average annual flows and their variability, miscellaneous low flow measurements on smaller watersheds, and gage locations.

The following limitations applied to the USGS streamflow data:

1. most of the low flow and 1-, 3- and 7-day flood frequency analyses had been run on data only through 1968;

Table 3. Regular USGS Gaging Stations--Oregon Coastal Streams

Station No.	Name	Location	Records Since*
14-3015[a,b]	Wilson River near Tillamook	SW¼ SE¼, Sec. 8, T1S, R8W	1938
-3029	Nestucca River near Fairdale	SW¼ NW¼, Sec. 15, T3S, R6W	1960
-3036[a]	Nestucca River near Beaver	SE¼ NE¼, Sec. 36, T3S, R10W	1965
-3055[a,b]	Siletz River at Siletz	NW¼ SW¼, Sec. 11, T10S, R10W	1924
-3061[a]	N.F. Alsea River at Alsea	SE¼, Sec. 1, T14S, R8W	1957
-3064[a]	Five Rivers near Fisher	W½, Sec. 19, T14S, R9W	1967
-3065[a,c]	Alsea River near Tidewater	NW¼ NW¼, Sec. 6, T14S, R9W	1939
-3069[a]	Big Creek near Roosevelt Beach	SE¼ SE¼, Sec. 13, T16S, R12W	1972
-307620[e]	Siuslaw River near Mapleton	SW¼ NW¼, Sec. 27, T17S, R10W	1967
-307645[e]	N.F. Siuslaw River near Minerva	NW¼ SW¼, Sec. 34, T17S, R11W	1967
-807580[e]	Lake Creek near Deadwood	NW¼ NW¼, Sec. 21, T17S, R9W	1967

*Currently in operation.

[a]Stations used in the analysis of characteristic flows and drainage basin characteristics.

[b]These two stations tend to generate larger floods than others in the study area.

[c]Used as the long-term base station for correlations with other stations and data extrapolations.

[e]Stations begun in 1967 but extrapolated by cross correlation with station 3065.

2. most of the newer gaging stations have been in operation for ten years or less, too short a period to analyze with any confidence; and
3. most of the regular gaging stations are on streams which drain larger watersheds of 100 square miles or more.

The list of available regular USGS gaging stations, their locations and periods of record are given in Table 3. Of the only three long-term stations in the study area, the Wilson and Siletz Rivers in the north tend to generate larger flows than do the Alsea and Suislaw* Rivers which bracket the geographic center of the EPA sites.

Additional stream-gaging data which were utilized in this analysis included data from:

1. selected USGS crest-stage gages for smaller Oregon coastal streams as listed in Table 4 (data from reference 5);
2. selected USGS miscellaneous low flow gaging sites and stations for smaller streams located closer to the EPA sites than the regular gaging station as shown in Table 5; and
3. Oregon State Game Commission (OSGC) fish life stations where miscellaneous measurements were made in 1970-71 for the purpose of establishing instream flow needs for fisheries (see Table 6). These flows were cross-correlated with regular USGS gaging station records on the same days and then used to check the predicted flows at EPA sites in the vicinity of the OSGC stations.

Another USGS data source was the 1:62500 scale topographic map series covering the entire study area. The maps were used to measure the drainage basin characteristics of perennial stream lengths, drainage area and relief for the watersheds above the USGS gaging stations and for the watersheds above the EPA sites.

The characteristic flows at the regular USGS gaging stations were correlated against certain combinations of their basin characteristics. Then, to estimate the characteristic flows of the streams at the ungaged EPA sites, the basin characteristics of the EPA watersheds were inserted into the correlations. Details of all the methods of analysis are discussed in later sections of this report.

---

*Short-term station.

Table 4. USGS Crest Stage Gages for Floods in Small Oregon Coastal Streams

Station	Name	Record	Area	Discharge for Selected Flood Frequencies 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
14-303700	Alder Brook (Salmon) SE½, Sec. 25 T.6 S., R.10 W.	1954-77	1.97	212	253	277	306	327	347
14-306700	Needle Br. (Drift Cr.) SW¼, Sec. 24 T.12 S., R.10 W.	1958-72	0.32	30	39	45	51	56	61
14-306830	Lyndon Cr. (Alsea) SE¼, Sec. 11 T.13 S., R.11 W.	1965-77	0.90	55	88	112	144	170	197
14-307610	Siuslaw Riv. Trib. NW¼, Sec. 27 T.17 S., R.10 W.	1957-77	0.42	25	37	46	57	66	75

Data from Refer. (5).

Table 5. Selected USGS Miscellaneous Low Flow Gaging Station Locations and Basin Characteristics

Station Name and Location	USGS Station No. and Maps	Drainage Area (sq mi)	Average Annual Precipitation P (in./yr)	1st Order Stream Length LS1 (mi)	Total Stream Length LST (mi)	Elevations Upper (ft)	Elevations Gage (ft)	Basin Relief H (mi)
<u>Deer Creek</u> (Trib. to Horse Cr.) NW¼, Sec. 11 T.12 S., R.10 W.	14306810 Toledo	1.17	88	1.1	2.2	950	600	0.066
<u>Drift Creek</u> (Trib. to Alsea R.) NE¼, Sec. 24 T.12 S., R.10 W.	* Toledo Tidewater	20.5	95	13.7	24.0	1500	450	0.218
<u>Indian Creek</u> (Trib. to Siuslaw R.) NE¼, Sec. 11 T.17 S., R.10 W.	14307600 Mapleton	37.0	98	47.3	79.0	1250	300	0.180
<u>Sweet Creek</u> (Trib. to Siuslaw R.) NE¼, Sec. 28 T.18 S., R.10 W.	14307630 Goodwin Peak	19.8	90	27.5	39.0	1250	40	0.230
<u>Condon Creek</u> (Trib. to N.F. Siuslaw R.) NE¼, Sec. 11 T.17 S., R.11 W.	* Heceta Head Mapleton	9.9	--	10	15.4	50	1200	0.218

*Miscellaneous low flow <u>sites</u> are <u>not numbered</u> unless they are converted to a regular, long-term, continuous record station.

Table 6. Oregon State Game Commission Fish Life Flow Stations

Name	Location	Basin
E.F. Beaver Cr.	Above Bear Cr. NE¼ NW¼, Sec. 18, T3S, R9W	Nestucca
Alder Cr.	At mouth NW¼ Sec. 25, T3S, R9W	Nestucca
Moon Cr.	At mouth NW¼ SW¼, Sec. 29, T3S, R8W	Nestucca
Little Nestucca R.	Below Louie Cr. NE¼ Sec. 28, T5S, R9W	Pacific
Neskowin Cr.	Below Prospect Cr. NE¼ SE¼, Sec. 6, T6S, R10W	Pacific
N.F. Yachats R.	Below Fish Cr. SW¼ Sec. 26, T14S, R11W	Yachats
School Fork	At mouth NE¼ NE¼, Sec. 1, T15S, R11W	Yachats
Green River	At mouth SE¼ Sec. 8, T15S, R9W	Five Rivers
Tenmile Cr.	River Mile 1.0 NE¼ NW¼, Sec. 35, T15S, R12W	Pacific
Big Cr.	River Mile 1.0 NE¼ NE¼, Sec. 23, T16S, R12W	Pacific
Cape Cr.	River Mile 1.0 SE¼ Sec. 34, T16S, R12W	Pacific
Indian Cr.	Below Velvet Cr. NW¼ Sec. 17, T17S, R9W	Siuslaw
Sweet Cr.	Below Cedar Cr. NW¼ Sec. 28, T18S, R10W	Siuslaw

Data for these stations are given in references 8 and 13.

U.S. Weather Service Data (NOAA)

The Weather Service provided the information on average annual precipitation in the form of an isohyetal map of the State of Oregon. Portions of this chart were later extrapolated to a copy of Map No. 18.6 of the Mid-Coast Basin (OSWRB). Average annual precipitation was used to develop correlations with average annual flows and drainage areas at the regular USGS gaging stations.

Oregon State Water Resources Board (OSWRB) DATA

The OSWRB provided the study area maps (numbers 1.6 and 18.6) and an isohyetal map of the North Coast Basin which contains EPA Sites Nos. 1, 2 and 3.

The isohyetal maps were used to estimate the average annual precipitation on the watersheds above the regular USGS gaging stations and the EPA sites. The average annual precipitation, when multiplied by the drainage area, gives the average annual volume of precipitation falling on the watershed. This is the only "input" component used in this analysis of the flow regimes of thirteen ungaged, small, Oregon, salmon spawning streams.

DESCRIPTION OF THE EPA SITES

The summary of basin characteristics, EPA field data (channel characteristics), reference gaging stations and location maps for each of the EPA sites are given in Tables 8 through 23 and Figures 1 through 7. The index of the EPA site summary tables and location maps is given in Table 7.

Table 7. Index to EPA Site Summary Tables and Location Maps

EPA SITE		SUMMARY		LOCATION MAP	
No.	Name	Table No.	Page	Figure No.	Page
1	Beaver Creek	8	13	1	14
2	Three Rivers	9	15	2	16
3	Farmer Creek	10	17	2	16
4	Green Creek	11	18	3	19
5	N. Prong Creek	12	20	4	21
6A	N.F. Indian Creek	13	22	3	19
6B	N.F. Indian Creek	14	23	3	19
7	Savage Creek	15	24	5	25
8A	Canal Creek	16	26	6	27
8B	Canal Creek	17	28	6	27
9A	Green River	18	29	3	19
9B	Green River	19	30	3	19
10	Cape Horn Creek	20	31	5	25
11	West Creek	21	32	6	27
12	Rock Creek	22	33	7	34
13	Big Creek	23	35	7	34

Under "Basin Characteristics" each term is defined and was measured from a 1:62500 scale USGS topographic map. The channel characteristics were derived from the EPA site data. If only the long-term USGS gaging station is listed this means that this station was used to determine all the flow characteristics. Characteristic flows are summarized at the bottom of each table.

Table 8

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 1 Site Name BEAVER CREEK

Location NW¼ Sec. 15, T. 3 S., R. 9 W. (USGS 62,500 scale maps) Tillamook, Blaine

Tributary to: Nestucca River ; Nestucca (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	10.7	mi
First Order Stream Length (LS1):	4.3	mi
Basin Drainage Area (A):	9.57	sq mi
Average Annual Precipitation (P):	105	in./yr
Basin Relief (H):	0.26	mi
Upper Elevation:	1800	ft
Outlet Elevation:	440	ft

Channel Characteristics (Date of Measurements: 7/28/78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ___ ; D50 = 5.2 in.; Slope 0.0061

EPA Velocity Data:

Complete x ; Incomplete ___ ; Analyzed x ; FLOW 11.8 cfs

Bank Full Conditions:

Top Width 70 ft; Mean Depth 4.2 ft

Reference USGS Gaging Stations

Long Term: No. 143036 ; Name Nestucca River

Crest-Stage: No. ___ ; Name ___

Low Flow: ___ ; Name ___

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

E.F. Beaver Creek ; Moon Creek ; ___

Notes: EPA Drainage Area 9.50 sq mi

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
1050 (cfs)	2860	52 (cfs)	3.3 (cfs)	2.3

E: Estimated Value

JFOrsborn
5/79 (792)

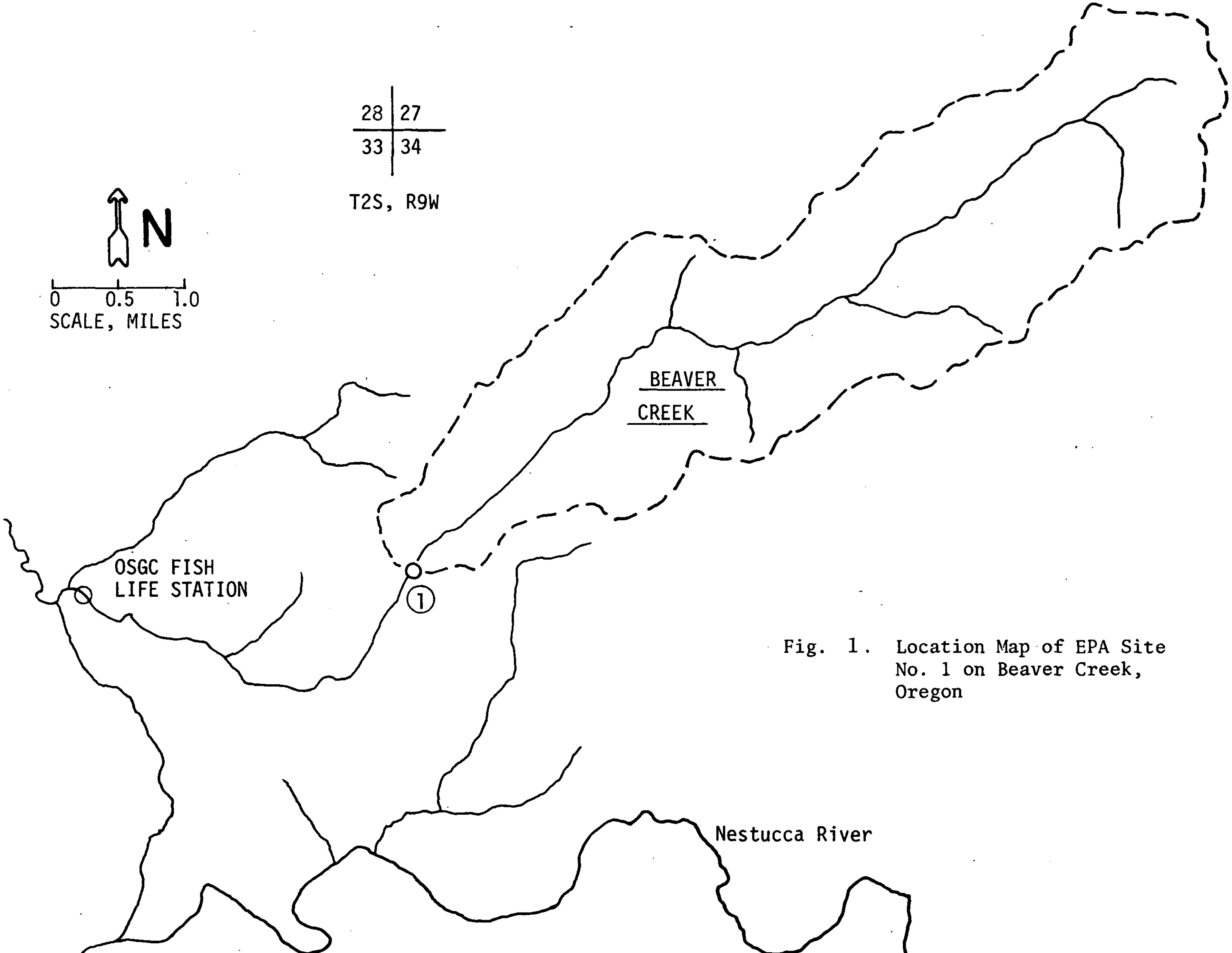


Fig. 1. Location Map of EPA Site No. 1 on Beaver Creek, Oregon

Figure 1

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 2 Site Name THREE RIVERS

Location SW¼ Sec. 26, T. 4 S., R. 9 W. (USGS 62,500 scale maps) Hebo, Grand Ronde

Tributary to: Nestucca River ; Nestucca (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	6.4	mi
First Order Stream Length (LS1):	4.5	mi
Basin Drainage Area (A):	4.71	sq mi
Average Annual Precipitation (P):	95	in./yr
Basin Relief (H):	0.27 (0.265)	mi
Upper Elevation:	2400	ft
Outlet Elevation:	1000	ft

Channel Characteristics (Date of Measurements: 7/27/78)

EPA Cross-Sectional Data:

Complete ____; Incomplete x ; D50 = 4.50 in.; Slope 0.0360

EPA Velocity Data:

Complete ____; Incomplete x2 ; Analyzed x ; FLOW 4.4E cfs

Bank Full Conditions:

Top Width 28E ft; Mean Depth NA ft

Reference USGS Gaging Stations

Long Term: No. 143036 ; Name Nestucca River

Crest-Stage: No. ____; Name ____

Low Flow: ____; Name ____

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

____; Moon Creek ; Neskowin Creek

Notes: EPA Drainage Area 1.0 sq mi. No flood plain.

2: Only 2 velocity measurements in 27-ft width, one in slack water.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
540 (cfs)	1570	22 (cfs)	2.0 (cfs)	1.4

E: Estimated Value

JFOrsborn
5/79 (792)

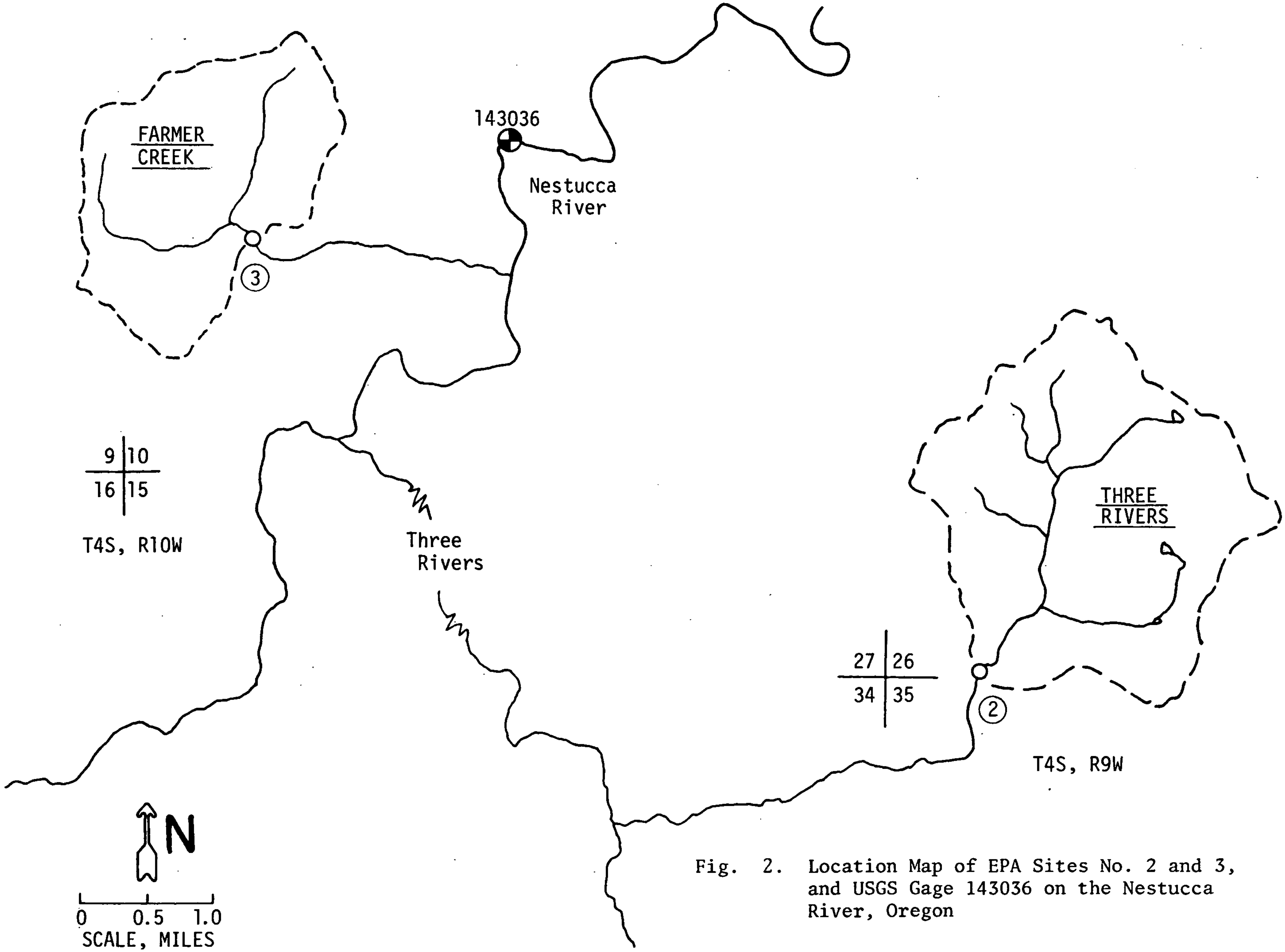


Fig. 2. Location Map of EPA Sites No. 2 and 3, and USGS Gage 143036 on the Nestucca River, Oregon

Figure 2

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 3 Site Name FARMER CREEK

Location NE¼ Sec. 3 , T. 4 S., R. 10 W. (USGS 62,500 scale maps) Hebo, Tillamook

Tributary to: Nestucca River ; Nestucca (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	3.2	mi
First Order Stream Length (LS1):	2.9	mi
Basin Drainage Area (A):	2.96	sq mi
Average Annual Precipitation(P):	102	in./yr
Basin Relief (H):	0.12 (0.117)	mi
Upper Elevation:	960	ft
Outlet Elevation:	340	ft

Channel Characteristics (Date of Measurements: 8 / 21/ 78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ___; D50 = 3.8 in.; Slope *

EPA Velocity Data:

Complete ___; Incomplete x ; Analyzed x ; FLOW 5.9 cfs

Bank Full Conditions:

Top Width 31 ft; Mean Depth 1.5 ft

Reference USGS Gaging Stations

Long Term: No. 143036 ; Name Nestucca River

Crest-Stage: No. ___; Name ___

Low Flow: ___; Name ___

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

Moon Creek ; ___ ; ___

Notes: EPA Drainage Area 3.46 sq mi. *Profile not available.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
270 (cfs)	860	15 (cfs)	0.70 (cfs)	0.50

E: Estimated Value

JFOrsborn
5/79 (792)

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 4 Site Name GREEN CREEK

Location NE¼ Sec. 5 , T. 17 S., R. 9 W. (USGS 62,500 scale maps) Mapleton

Tributary to: Siuslaw River ; Siuslaw (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	2.3	mi
First Order Stream Length (LS1):	1.7	mi
Basin Drainage Area (A):	1.3	sq mi
Average Annual Precipitation (P):	105	in./yr
Basin Relief (H):	0.095	mi
Upper Elevation:	1000	ft
Outlet Elevation:	500	ft

Channel Characteristics (Date of Measurements: 7 / 20 / 78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ____ ; D50 = 2.8 in.; Slope 0.027

EPA Velocity Data:

Complete x ; Incomplete ____ ; Analyzed x ; FLOW 1.8 cfs

Bank Full Conditions:

Top Width 25 ft; Mean Depth 1.5 ft

Reference USGS Gaging Stations

Long Term: No. 14307580 ; Name Lake Creek

Crest-Stage: No. ____ ; Name ____

Low Flow: 14307600 ; Name Indian Creek

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

Indian Creek ; ____ ; ____

Notes: EPA Drainage Area 1.73 sq mi.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
125 (cfs)	420	8 (cfs)	0.45 (cfs)	0.25

E: Estimated Value

JFOrsborn
5/79 (792)

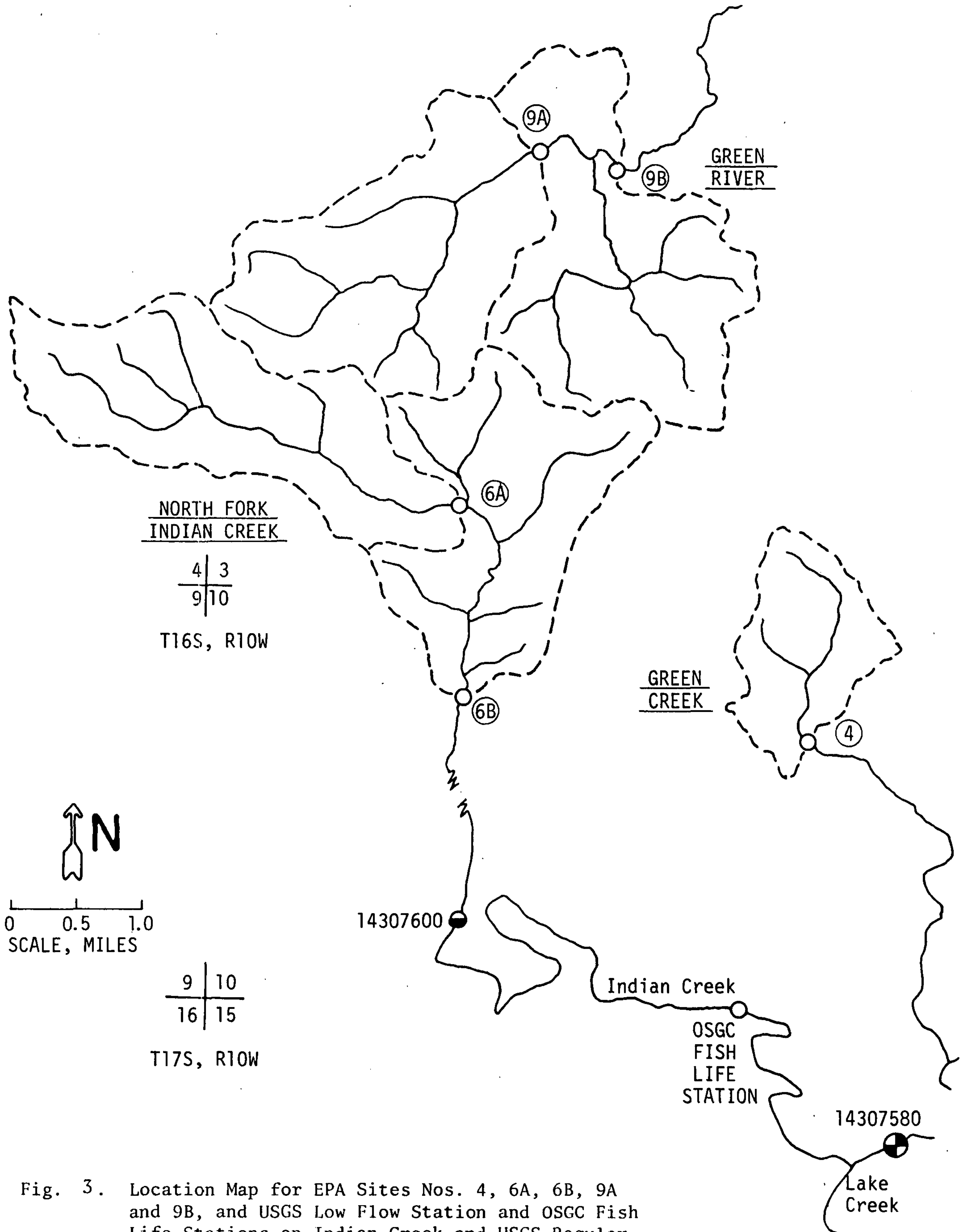


Fig. 3. Location Map for EPA Sites Nos. 4, 6A, 6B, 9A and 9B, and USGS Low Flow Station and OSGC Fish Life Stations on Indian Creek and USGS Regular Gaging Station on Lake Creek, Oregon

Table 12

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 5 Site Name NORTH PRONG CREEK

Location NE¼ Sec. 1, T. 19 S., R. 11 W. (USGS 62,500 scale maps) Goodwin Peak

Tributary to: Maple Creek ; Siltcoos River (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	3.6	mi
First Order Stream Length (LS1):	2.3	mi
Basin Drainage Area (A):	1.65	sq mi
Average Annual Precipitation (P):	88	in./yr
Basin Relief (H):	0.19	mi
Upper Elevation:	1100	ft
Outlet Elevation:	100	ft

Channel Characteristics (Date of Measurements: 7/18/78)

EPA Cross-Sectional Data:

Complete ___; Incomplete x; D50 = 2.00 in.; Slope 0.030

EPA Velocity Data:

Complete ___; Incomplete x; Analyzed E; FLOW 1.0E cfs

Bank Full Conditions:

Top Width 41 ft; Mean Depth 3.2 ft

Reference USGS Gaging Stations

Long Term: No. 14307645; Name North Fork Siuslaw River

Crest-Stage: No. ___; Name ___

Low Flow: 14307630; Name Sweet Creek

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

Sweet Creek ; ___ ; ___

Notes: EPA Drainage Area 1.65 sq mi.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
180 (cfs)	585	7 (cfs)	0.90 (cfs)	0.60

E: Estimated Value

JFOrsborn
5/79 (792)

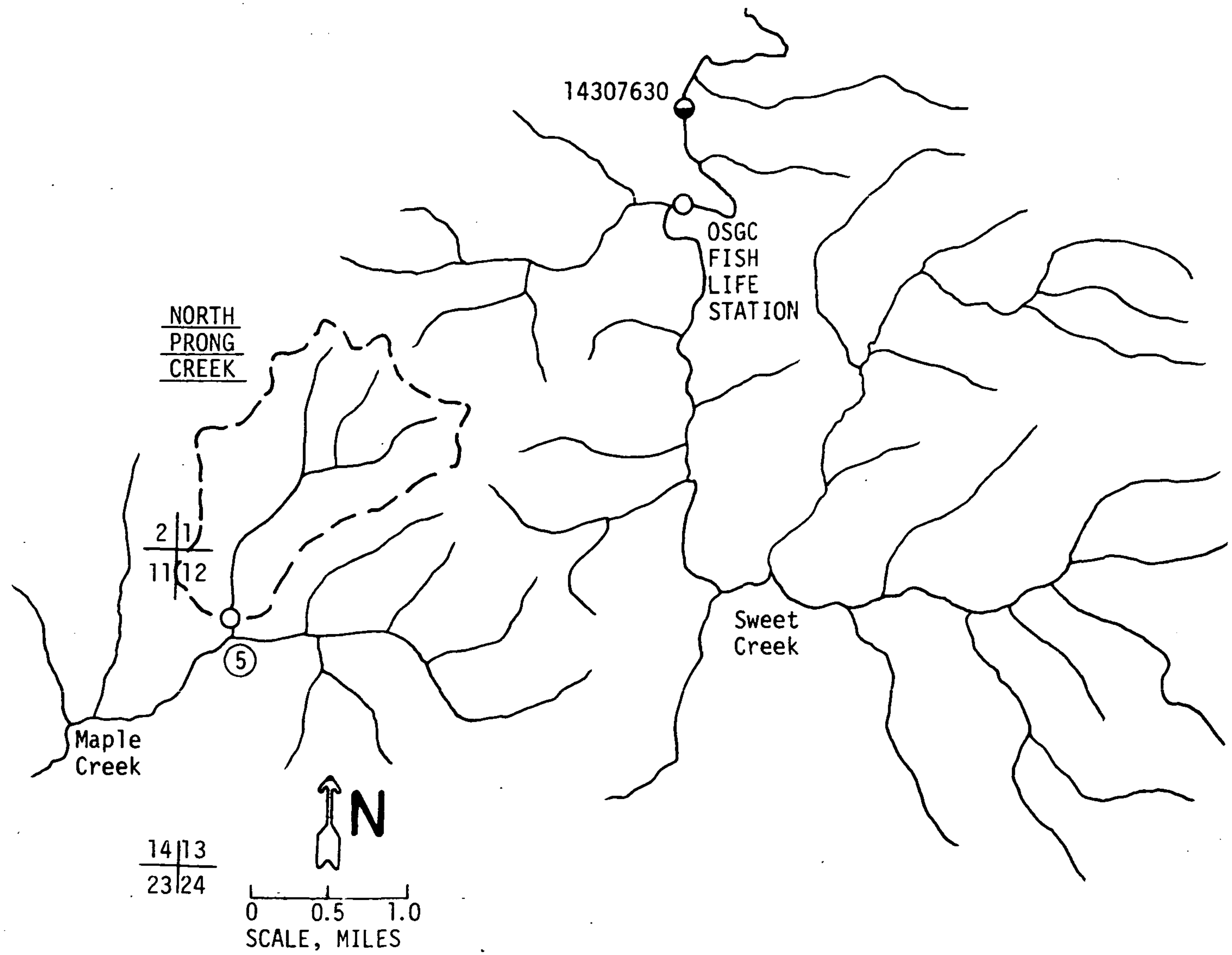


Fig. 4. Location Map of EPA Site No. 5, North Prong Creek, and Nearby Sweet Creek USGS Low Flow Station and OSGC Fish Life Station in Oregon

Table 13

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 6A Site Name NORTH FORK INDIAN CREEK

Location NE¼ Sec. 2 , T. 16 S., R. 10 W. (USGS 62,500 scale maps) Mapleton

Tributary to: Indian Creek ; Siuslaw (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	6.1	mi
First Order Stream Length (LS1):	3.7	mi
Basin Drainage Area (A):	3.18	sq mi
Average Annual Precipitation (P):	105	in./yr
Basin Relief (H):	0.10	mi
Upper Elevation:	1000	ft
Outlet Elevation:	475	ft

Channel Characteristics (Date of Measurements: 7/ 11/ 78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ___ ; D50 = 2.3 in.; Slope 0.0117

EPA Velocity Data:

Complete x ; Incomplete ___ ; Analyzed x ; FLOW 9.4 cfs

Bank Full Conditions:

Top Width 40 ft; Mean Depth 2.0 ft

Reference USGS Gaging Stations

Long Term: No. 14307580 ; Name Lake Creek

Crest-Stage: No. ___ ; Name ___

Low Flow: 14307600 ; Name Indian Creek

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

Indian Creek ; ___ ; ___

Notes: EPA Drainage Area 4.05 sq mi.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
280 (cfs)	860	20 (cfs)	1.10 (cfs)	0.65

E: Estimated Value

JFOrsborn
5/79 (792)

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 6B Site Name NORTH FORK INDIAN CREEK

Location SE¼ Sec. 11, T. 16S., R. 10 W. (USGS 62,500 scale maps) Mapleton

Tributary to: Indian Creek ; Siuslaw (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	10.5	mi
First Order Stream Length (LS1):	8.8	mi
Basin Drainage Area (A):	6.41	sq mi
Average Annual Precipitation (P):	105	in./yr
Basin Relief (H):	0.11	mi
Upper Elevation:	1000	ft
Outlet Elevation:	450	ft

Channel Characteristics (Date of Measurements: 8 / 24/ 78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ___ ; D50 = 0.86 in.; Slope -

EPA Velocity Data:

Complete x ; Incomplete ___ ; Analyzed x ; FLOW 20.2 cfs

Bank Full Conditions:

Top Width 47 ft; Mean Depth 2.6 ft

Reference USGS Gaging Stations

Long Term: No. 14307580 ; Name Lake Creek

Crest-Stage: No. ___ ; Name ___

Low Flow: 14307600 ; Name Indian Creek

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

Indian Creek ; ___ ; ___

Notes: ___

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
500 (cfs)	1470	40 (cfs)	1.80 (cfs)	1.15

E: Estimated Value

JFOrsborn
5/79 (792)

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 7 Site Name SAVAGE CREEK (GRANT CREEK)

Location NW¼ Sec. 13, T.12 S., R. 9 W. (USGS 62,500 scale maps) Alsea, Mary's Peak, Tidewater, Toledo

Tributary to: Drift Creek ; Alsea (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	8.4	mi
First Order Stream Length (LS1):	6.2	mi
Basin Drainage Area (A):	9.49	sq mi
Average Annual Precipitation (P):	100	in./yr
Basin Relief (H):	0.26	mi
Upper Elevation:	1650	ft
Outlet Elevation:	300	ft

Channel Characteristics (Date of Measurements: 8/ 8/ 78)

EPA Cross-Sectional Data:

Complete ___; Incomplete x ; D50 = 2.8 in.; Slope 0.010

EPA Velocity Data:

Complete ___; Incomplete x ; Analyzed x ; FLOW 6.2E cfs

Bank Full Conditions:

Top Width - ft; Mean Depth - ft

Reference USGS Gaging Stations

Long Term: No. 14306800 ; Name Flynn Cr.; 14306810 Deer Cr.

Crest-Stage: No. 143067 ; Name Needle Branch*

Low Flow: 143067 ; Name Needle Branch*

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

___; None ___; ___

Notes: EPA Drainage Area 9.6 sq mi. Banks not shown in field notes. Location of Needle Branch on Map No. 18.6 incorrect; runs south into Meadow Cr.; see Ref. (4) and Fig. 5. on next page.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
1005 (cfs)	2740	60 (cfs)	3.7 (cfs)	2.4

E: Estimated Value

JFOrsborn
5/79 (792)

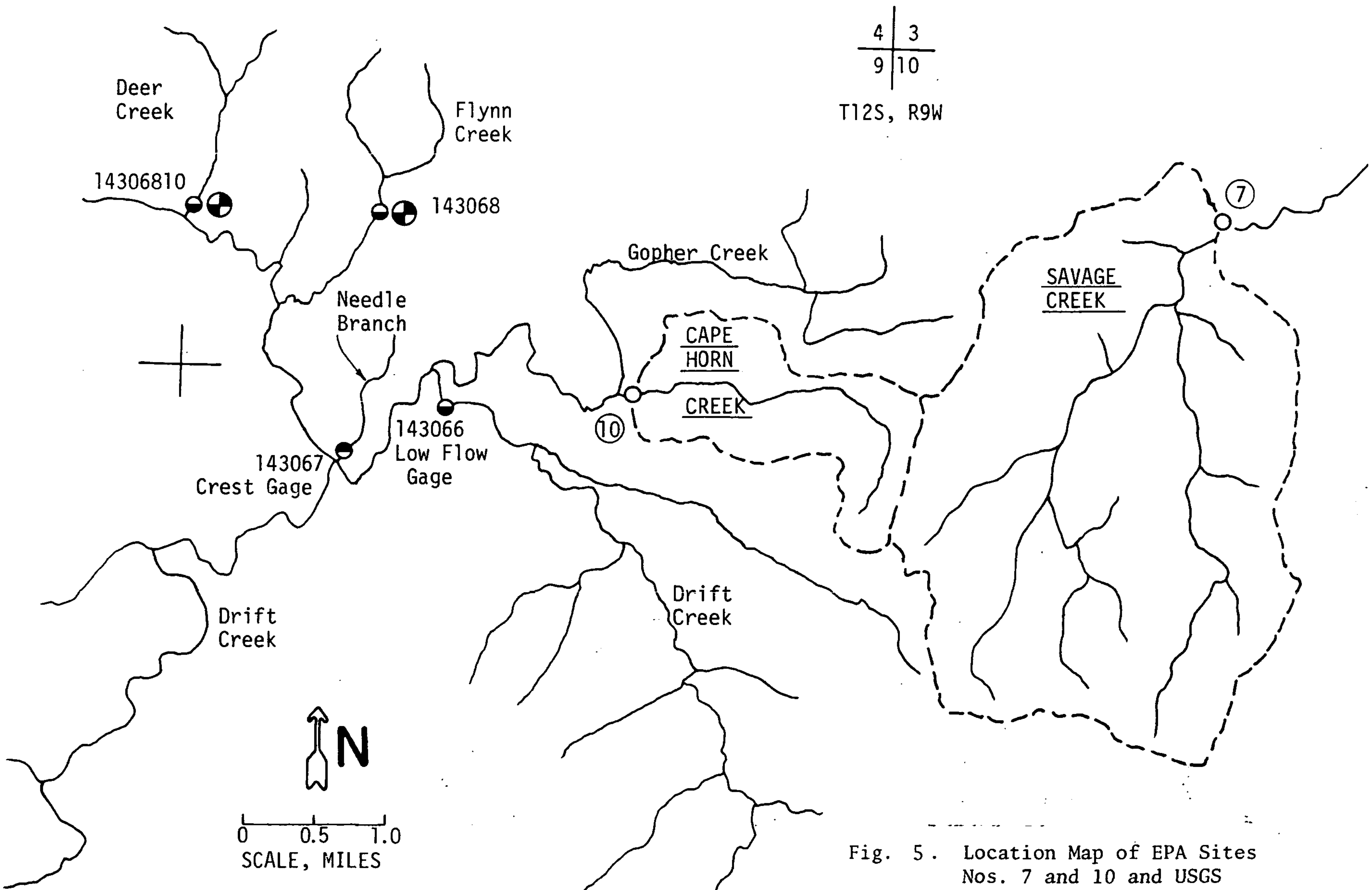


Fig. 5. Location Map of EPA Sites Nos. 7 and 10 and USGS Gaging Stations, Oregon

Figure 5

Table 16

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 8A Site Name CANAL CREEK

Location S½ Sec. 17, T. 14 S., R. 10 W. (USGS 62,500 scale maps) Tidewater

Tributary to: Alsia River ; Alsea (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	2.6	mi
First Order Stream Length (LS1):	1.5	mi
Basin Drainage Area (A):	2.36	sq mi
Average Annual Precipitation (P):	95	in./yr
Basin Relief (H):	0.076	mi
Upper Elevation:	650	ft
Outlet Elevation:	250	ft

Channel Characteristics (Date of Measurements: 6/15/78)

EPA Cross-Sectional Data:

Complete ___; Incomplete x ; D50 = 4.1 in.; Slope --

EPA Velocity Data:

Complete ___; Incomplete x ; Analyzed ___; FLOW 3.6E cfs

Bank Full Conditions:

Top Width - ft; Mean Depth ___ ft

Reference USGS Gaging Stations

Long Term: No. 143064 ; Name Five Rivers; 143065 Alsea River

Crest-Stage: No. 14306840 ; Name Lyndon Creek

Low Flow: - ; Name -

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

North Fork Yachats River; School Fork ;

Notes: EPA Drainage Area 3.16 sq mi.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
180 (cfs)	590	13 (cfs)	0.40 (cfs)	0.30

E: Estimated Value

JFOrsborn
5/79 (792)

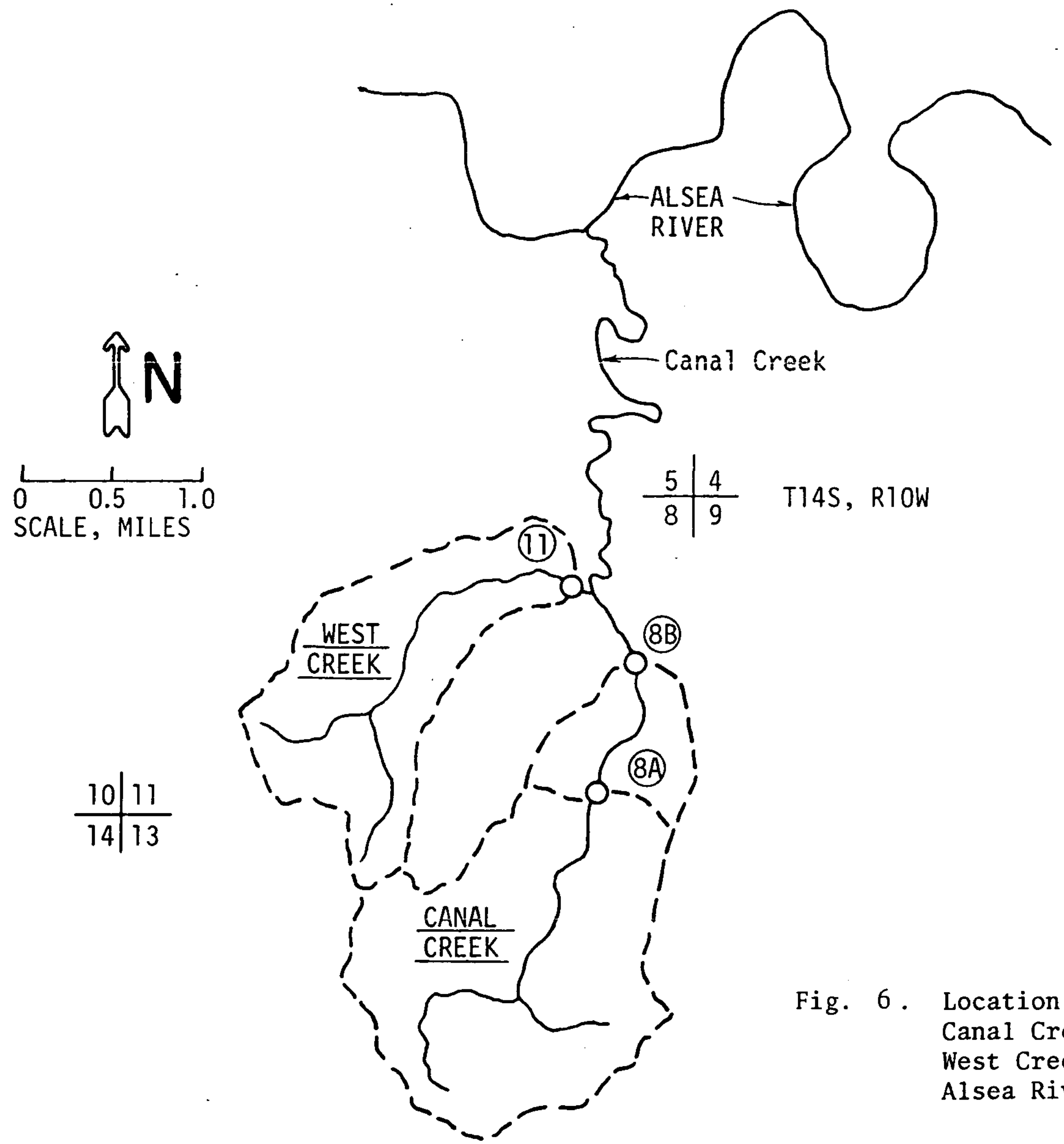


Fig. 6. Location Map for EPA Site No. 8, Canal Creek and Site No. 11, West Creek Just South of the Alsea River, Oregon

Figure 6

Table 17

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 8B Site Name CANAL CREEK

Location SE¼ Sec. 8, T. 14 S., R. 10 W. (USGS 62,500 scale maps) Tidewater

Tributary to: Alsea River; Alsea (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	3.3	mi
First Order Stream Length (LS1):	1.5	mi
Basin Drainage Area (A):	3.01	sq mi
Average Annual Precipitation (P):	95	in./yr
Basin Relief (H):	0.085	mi
Upper Elevation:	650	ft
Outlet Elevation:	200	ft

Channel Characteristics (Date of Measurements: 8/22/78)

EPA Cross-Sectional Data:

Complete x; Incomplete ___; D50 = 3.1 in.; Slope -

EPA Velocity Data:

Complete x; Incomplete ___; Analyzed x; FLOW 2.2 cfs

Bank Full Conditions:

Top Width 32 ft; Mean Depth 3 ft

Reference USGS Gaging Stations

Long Term: No. 143064; Name Five Rivers; 143065, Alsea River

Crest-Stage: No. 14306830; Name Lyndon Creek

Low Flow: ___; Name ___

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

North Fork Yachats River; School Fork; ___

Notes: ___

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
230 (cfs)	730	16 (cfs)	0.50 (cfs)	0.35

E: Estimated Value

JFOrsborn
5/79 (792)

Table 18

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 9A Site Name GREEN RIVER

Location NE¼SE¼ Sec. 24, T. 15 S., R. 10 W. (USGS 62,500 scale maps) Tidewater, Mapleton

Tributary to: Five Rivers ; Alsea (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	6.4	mi
First Order Stream Length (LS1):	3.9	mi
Basin Drainage Area (A):	3.44	sq mi
Average Annual Precipitation (P):	105	in./yr
Basin Relief (H):	0.13	mi
Upper Elevation:	1050	ft
Outlet Elevation:	350	ft

Channel Characteristics (Date of Measurements: 8/29/78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ___ ; D50 = 2.8 in.; Slope (Var.) (0.0094-0.025)

EPA Velocity Data:

Complete ___ ; Incomplete x ; Analyzed ___ ; FLOW 5.8E cfs

Bank Full Conditions:

Top Width 49 ft; Mean Depth 3.5 ft

Reference USGS Gaging Stations

Long Term: No. 143064 ; Name Five Rivers

Crest-Stage: No. ___ ; Name ___

Low Flow: ___ ; Name ___

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

North Fork Yachats River ; School Fork ; ___

Notes: Not enough velocity measurements to be accurate; Irregular cross section.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
330 (cfs)	1010	20 (cfs)	1.10 (cfs)	0.75

E: Estimated Value

JFOrsborn
5/79 (792)

Table 19

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 9B Site Name GREEN RIVER

Location S½ Sec. 19, T. 15S., R. 9 W. (USGS 62,500 scale maps) Tidewater, Mapleton

Tributary to: Five Rivers ; Alsea (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	13.10	mi
First Order Stream Length (LS1):	7.6	mi
Basin Drainage Area (A):	6.60	sq mi
Average Annual Precipitation: (P):	105	in./yr
Basin Relief (H):	0.14	mi
Upper Elevation:	1050	ft
Outlet Elevation:	300	ft

Channel Characteristics (Date of Measurements: 6/29/78)

EPA Cross-Sectional Data:

Complete ____; Incomplete x; D50 = 1.6 in.; Slope 0.0067

EPA Velocity Data:

Complete x; Incomplete ____; Analyzed x; FLOW 8.9 cfs

Bank Full Conditions:

Top Width ____ ft; Mean Depth ____ ft

Reference USGS Gaging Stations

Long Term: No. 143064; Name Five Rivers

Crest-Stage: No. ____; Name ____

Low Flow: ____; Name ____

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

North Fork Yachats River; School Fork ; ____

Notes: ____

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
590 (cfs)	1710	37 (cfs)	2.25 (cfs)	1.50

E: Estimated Value

JFOrsborn
5/79 (792)

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 10 Site Name CAPE HORN CREEK (GOPHER CREEK)

Location W½ Sec. 20, T.12 S., R. 9 W. (USGS 62,500 scale maps) Toledo

Tributary to: Drift Creek ; Alsea (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	2.4	mi
First Order Stream Length (LS1):	2.4	mi
Basin Drainage Area (A):	1.63	sq mi
Average Annual Precipitation (P):	95	in./yr
Basin Relief (H):	0.19	mi
Upper Elevation:	1500	ft
Outlet Elevation:	500	ft

Channel Characteristics (Date of Measurements: 7 / 7 / 78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ___ ; D50 = 2.9 in.; Slope 0.015

EPA Velocity Data:

Complete x ; Incomplete ___ ; Analyzed x ; FLOW 3.9 cfs

Bank Full Conditions:

Top Width 27 ft; Mean Depth 2.2 ft

Reference USGS Gaging Stations

Long Term:	No. 143068	Name Flynn Creek; 14306810, Deer Creek
Crest-Stage:	No. 143067	Name Needle Branch
Low Flow:	No. --	Name Same as long term

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

___ ; ___ ; ___

Notes: ___

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
190 (cfs)	615	9 (cfs)	0.85 (cfs)	0.60

E: Estimated Value

JFOrsborn
5/79 (792)

Table 21

EPA STREAMFLOW ANALYSIS
AT SPAWNING GRAVEL TEST SITES
OREGON COASTAL STREAMS

Site No. 11 Site Name WEST CREEK

Location NW¼ Sec. 8, T. 14 S., R. 10 W. (USGS 62,500 scale maps) Tidewater

Tributary to: Canal Creek ; Alsea (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	3.2	mi
First Order Stream Length (LS1):	1.6	mi
Basin Drainage Area (A):	1.57	sq mi
Average Annual Precipitation (P):	95	in./yr
Basin Relief (H):	0.19	mi
Upper Elevation:	1250	ft
Outlet Elevation:	250	ft

Channel Characteristics (Date of Measurements: 7/13/78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ____ ; D50 = 3.6 in.; Slope 0.022

EPA Velocity Data:

Complete ____ ; Incomplete x ; Analyzed ____ ; FLOW 2.7E cfs

Bank Full Conditions:

Top Width 25 ft; Mean Depth -- ft

Reference USGS Gaging Stations

Long Term: No. 143064 ; Name Five Rivers; 143065, Alsea River

Crest-Stage: No. 14306830 ; Name Lyndon Creek

Low Flow: ____ ; Name ____

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

North Fork Yachats River; School Fork ; ____

Notes: EPA Drainage Area 1.81 sq mi.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
180 (cfs)	600	8 (cfs)	0.70 (cfs)	0.50

E: Estimated Value

JFOrsborn
5/79 (792)

Table 22

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 12 Site Name ROCK CREEK

Location SE¼ Sec. 10, T. 16 S., R. 12 W. (USGS 62,500 scale maps) Heceta Head

Tributary to: ______; Pacific Coast (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	6.5	mi
First Order Stream Length (LS1):	3.5	mi
Basin Drainage Area (A):	6.03	sq mi
Average Annual Precipitation (P):	96	in./yr
Basin Relief (H):	0.29	mi
Upper Elevation:	1700	ft
Outlet Elevation:	180	ft

Channel Characteristics (Date of Measurements: 8 / 1 /78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ____; D50 = 3.0 in.; Slope 0.0167 (Along Bank)

EPA Velocity Data:

Complete x ; Incomplete ____; Analyzed x ; FLOW 8.5 cfs

Bank Full Conditions:

Top Width -- ft; Mean Depth -- ft

Reference USGS Gaging Stations

Long Term: No. 143069 ; Name Big Creek

Crest-Stage: No. ______; Name ______

Low Flow: ______; Name ______

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

Big Creek ; Cape Creek ; Tenmile Creek

Notes: EPA Drainage Area 6.08 sq mi; No definite bankfull conditions.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
690 (cfs)	1970	40 (cfs)	3.0 (cfs)	2.0

E: Estimated Value

JFOrsborn
5/79 (792)

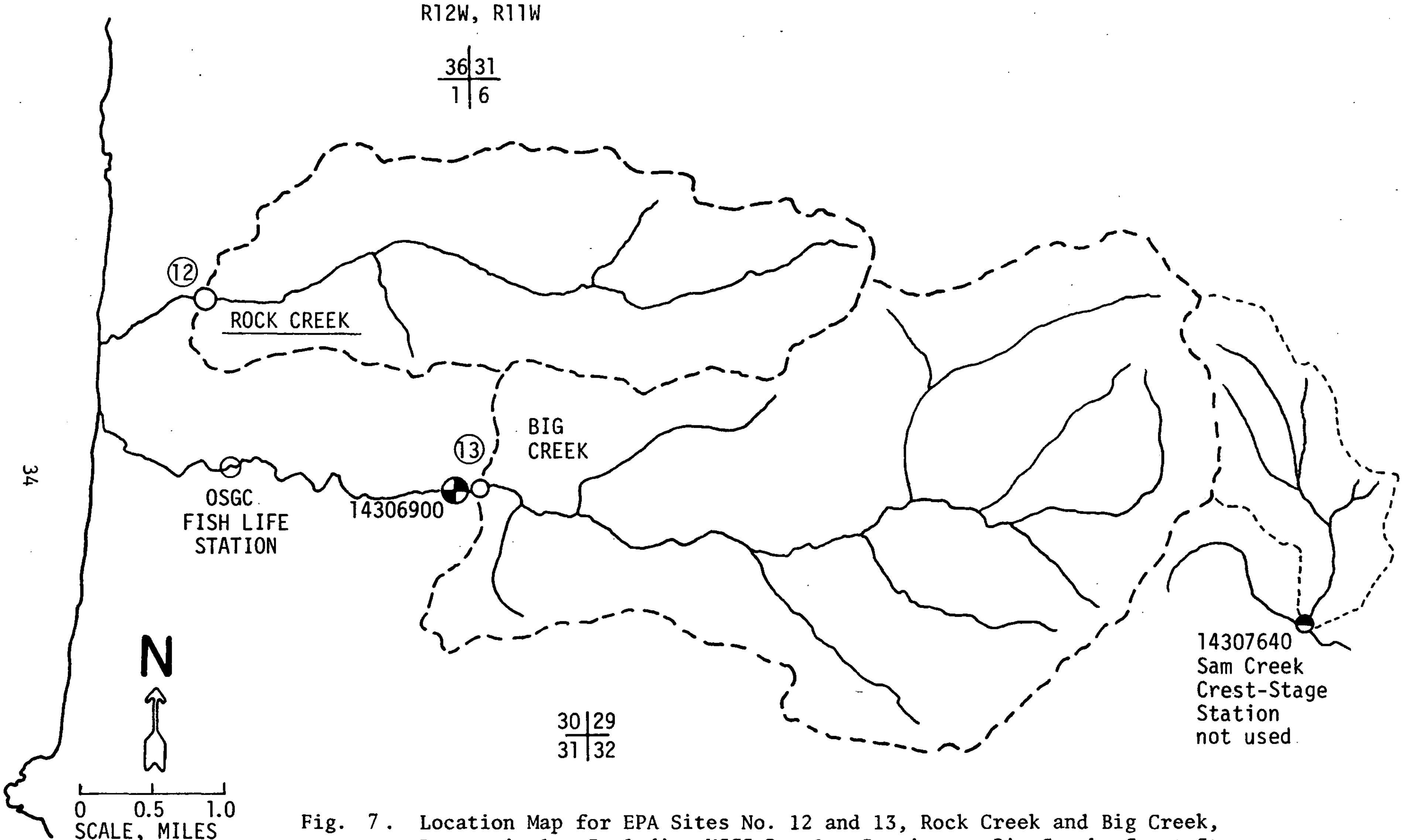


Fig. 7. Location Map for EPA Sites No. 12 and 13, Rock Creek and Big Creek, Respectively, Including USGS Regular Station on Big Creek, Crest-Stage Station on Sam Creek, Oregon

Figure 7

Table 23

EPA STREAMFLOW ANALYSIS AT SPAWNING GRAVEL TEST SITES OREGON COASTAL STREAMS

Site No. 13 Site Name BIG CREEK

Location NW¼ Sec. 19, T. 16 S., R. 11 W. (USGS 62,500 scale maps) Hecta Head, Mapleton

Tributary to: ____; Pacific Coast (Coastal Basin)

Basin Characteristics

Total Stream Length (LST):	17.7	mi
First Order Stream Length (LS1):	12.6	mi
Basin Drainage Area (A):	12.0	sq mi
Average Annual Precipitation (P):	102	in./yr
Basin Relief (H):	0.24	mi
Upper Elevation:	1500	ft
Outlet Elevation:	240	ft

Channel Characteristics (Date of Measurements: 1) 8 / 3 / 78); 2) (9/15/78)

EPA Cross-Sectional Data:

Complete x ; Incomplete ____; D50 = 1) 4.6 in.; Slope 1) 0.0068

EPA Velocity Data: D50 = 2) 3.5 in.; Slope 2) 0.0078

Complete x ; Incomplete ____; Analyzed x ; FLOW 1) 5.6 cfs

Bank Full Conditions: 2) 8.4 cfs

Top Width -- ft; Mean Depth -- ft

Reference USGS Gaging Stations

Long Term: No. 143069 ; Name Big Creek

Crest-Stage: No. ____; Name ____

Low Flow: ____; Name ____

Reference Oregon State Game Commission Fish Life Flow Measuring Sites

____; ____; ____

Notes: EPA Drainage Area 12.60 sq mi.; separate measurements made on 2 days.

FLOOD FLOWS 2-YR	FLOOD FLOWS 50-YR	AVERAGE ANNUAL FLOW	LOW FLOWS 2-YR	LOW FLOWS 20-YR
1280 (cfs)	3580	96 (cfs)	6.0 (cfs)	4.0

E: Estimated Value

JFOrsborn
5/79 (792)

DATA ANALYSIS AND UNGAGED FLOW ESTIMATION

In this section the correlations between the characteristic flows at the USGS regular and miscellaneous gaging stations, and their drainage basin characteristics will be developed. A comparison will be made between the basin characteristics above the USGS gaging stations and those of the basins above the EPA sites. Then the characteristic low, average and flood flows at the EPA ungaged sites will be estimated, and low flow and flood flow frequency curves will be developed. Also, the variability in the average annual flow will be estimated, and the data for a family of maximum, average, and minimum duration curves will be generated.

Characteristic Flows at USGS Gaging Stations

As was noted in Table 3 (page 6) there are only three long-term regular gaging stations in the study area. Most of the other USGS gaging stations have been started within the last ten years. Therefore, as shown in Table 24, only seven stations were selected to develop the regional (hydrologic province) correlation between basin and streamflow characteristics.

Because of its location and longest period of record, station 3065 on the Alsea River near Tidewater was selected as the base station. Some of the records at other stations (such as for Big Creek - 3069) were extended from correlations with the flows at Gage 3065. These correlations are in Appendix II.

Referring to Table 24, another limitation on stream flow data is the degree of regulation and diversion of the flows above the gaging stations. Fortunately, most of the stations have minor degrees of regulation and diversion. The amounts of regulation and diversion are not quantified by the USGS (12). If natural flows are to be estimated at ungaged sites, the flows at the gaging stations should be as natural as possible.

The average annual flow at each gaging station is based on the longest available record (12). The average maximum variability in the regional average annual flow for all stations is about ±65%. This variability will be discussed further in the section on average annual flows.

The low flows were derived from the USGS computer files based primarily on data taken until 1967. To extend the analysis to include data through 1977, the frequency analyses were rerun on the base station (Alsea River - 3065) and then the original values of the characteristic flows at the other gages were

Table 24. USGS Oregon Coastal Gaging Station Characteristic Flows

River	USGS Gage No. 14-	Basin on USGS Map 1:62500 scale	Average Annual Flow, QAA (cfs)	7-Day Avg. 2-Yr Low Flow, Q7L2 (cfs)	7-Day Avg. 20-Yr Low Flow, Q7L20 (cfs)	2-Yr Peak Flood, F QF2P (cfs)	50-Yr Peak Flood QF50P (cfs)
Wilson SW¼SE¼, Sec. 8 T.1 S., R.8 W.	3015 d	Blaine Enright Timber	1215	73.0	53	17400	33200
Nestucca nr Beaver SE¼NE¼, Sec. 36 T.3 S., R.10 W.	3036 d	Tillamook Hebo Blaine Grand Ronde Sheridan Fairdale	1110	79.0	58	14500	32600
Siletz at Siletz NW¼SW¼, Sec. 11 T.10 S., R.10 W.	3055 r,d	Toledo Euchre Mary Peak Valsetz	1578	79.7	57.5	20900	37300
N.F. Alsea at Alsea SE¼, Sec. 1 T.14 S., R.8 W.	3061 D	Alsea Monroe Mary Peak	310	16.0	11.4	5120	12400
Five Rivers nr Fisher, W½, Sec.19 T.14 S., R.9 W.	3064 -	Mapleton Tidewater Blachly Alsea	602	30.0	20.0	8680	19200
Alsea nr Tidewater NW¼NW¼, Sec. 6 T.14 S., R.9 W.	3065 D	Monroe Blachly Alsea Tidewater Mary Peak	1571	80.0	56.0	20600	41000
Big Cr. nr Roosevelt SE¼SE¼, Sec. 13 T.16 S., R.12 W.	3069 -	Heceta Head	96	6.0	4.0	1280	3580

d = small diversions above station, D = large diversions, r = minor regulation.

checked by cross-correlation against the base station.

The flood flows in Table 24 (except for Big Creek) were taken directly from the recent USGS report on floods in western Oregon (5).

Basin Characteristics Above the Gaging Stations

The basic and derived linear basin characteristics and the average annual precipitation on the basins above the seven (7) USGS gaging stations are summarized in Table 25. The linear characteristics were measured on 1:62500 scale USGS topographic maps.

In Table 25 the various terms are defined as follows where there is not a standard procedure of determination. In Cols. 3, 4, and 8 stream length is the length of the perennial streams noted by solid blue lines on the maps. These are used because of the ease and consistency of determination, and because perennial stream length is used to predict low flows. Drainage density (DD - Col. 8) is really the perennial stream density in this context. It should be noted that in the area east of the center of Range 9 West the streams are shown as intermittent. Personal communication with U.S. Forest Service personnel indicates that this interpretation is due to heavy logging debris and that the streams are perennial to the same elevation as those to the west.

Basin relief (H - Col. 7) is the difference in elevation between the highest, continuous contour in the basin and the USGS gage (or the EPA site). Relief represents the potential energy in the basin which causes flow out of the basin. Basin length (LB - Col. 9) is measured from the basin outlet along its major axis to the topographic divide. Basin width (WB - Col. 10) is the equivalent rectangular width of the basin found by dividing drainage area (A) by the basin length (LB). The aspect ratio (LB/WB - Col. 11) is a measure of the concentration time for analyzing flood flows. Although basin length, width and aspect ratio were determined as part of "basin characteristics", they were found to give poorer correlations for gaged flood flows than other factors, and therefore aspect ratio was not used for predicting flood flows at the EPA sites.

The various combinations of terms in Cols. 12-16 are correlated with the gaged characteristic flows in the following sections to generate the equations needed to predict the ungaged characteristic flows at the EPA sites.

A basic geomorphic function relates total stream length (LST) to drainage area (A) and this is shown for the USGS gaging stations in Fig. 8. In addition

Table 25. Basin Characteristics for Regular USGS Gaging Stations in the North- and Mid-Coast Basins of Oregon

Col. (1) River and USGS Gage No.	(2) A Drainage Area (sq mi)	(3) 1st Order Stream Length LS1 (mi)	(4) Total Stream Length LST (mi)	(5) Upper Elev. (ft)	(6) Gage Elev. (ft)	(7) Basin Relief H (mi)	(8) Drainage Density DD (mi^{-1})	(9) Basin Length LB (mi)	(10) Basin Width WB (mi)	(11) Aspect Ratio LB/WB	(12) $(AH)^{0.50}$ $(mi)^{1.50}$	(13) $A(H)^{0.50}$ $(mi)^{2.5}$	(14) $LS1 \cdot H$ $(mi)^2$	(15) $LS1(H)^{0.5}$ $(mi)^{1.50}$	(16) $LST(H)^{0.50}$ $(mi)^{1.50}$	(17) Avg. Ann. Precip. P (in./yr)
Wilson River 14-3015	161	118.4	188.7	70	2400	0.44	1.17	18.0	8.9	2.02	8.42	107	52.2	78.2	125.2	107.3
Nestucca River near Beaver 14-3036	180	154.5	258.6	45	2200	0.41	1.44	22.0	8.2	2.68	8.59	115	63.4	99.5	165.6	98.0
Siletz River at Siletz 14-3055	202	180.7	281.8	100	2750	0.50	1.40	21.5	9.4	2.29	10.05	142	90.4	128.0	199.2	125.4
N.F. Alsea R. at Alsea 14-3061	63	45.4	75.0	270	1500	0.23	1.19	7.2	8.8	0.82	3.81	30	10.5	21.8	36.0	99.1
Five Rivers near Fisher 14-3064	114	81.0	152.6	130	1250	0.21	1.34	8.2	13.9	0.59	4.89	52	17.0	37.1	69.9	101.4
Alsea River near Tidewater 14-3065	334	231.2	410.0	50	1500	0.27	1.23	19.0	17.6	1.08	9.50	174	62.5	120.4	213.0	97.0
Big Creek 14-3069	11.9	14.1	18.4	140	970	0.21	1.55	4.9	2.4	2.43	1.58	6	3.0	6.5	8.4	102.4

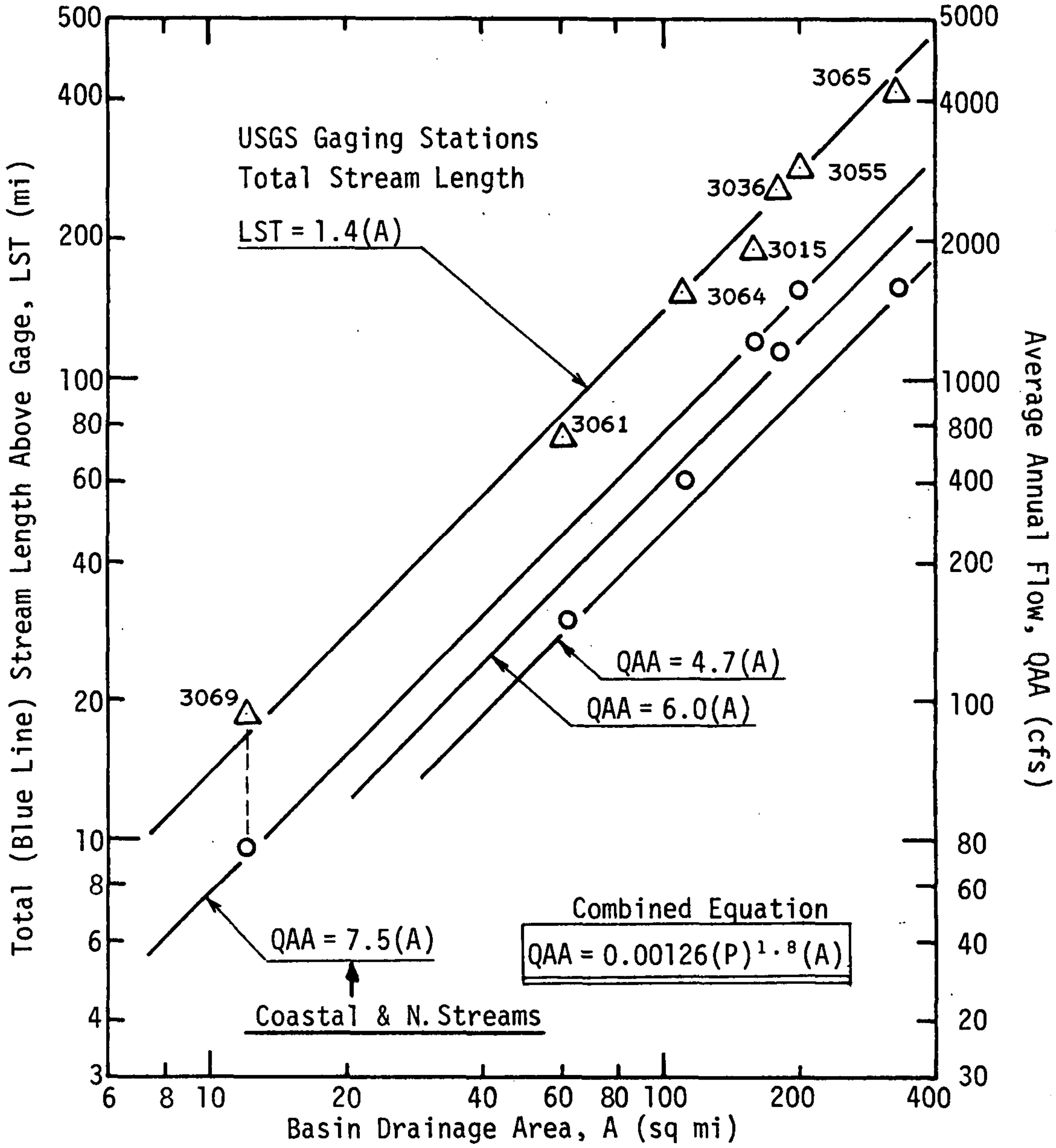


Fig. 8. Total Stream Length and Average Annual Flow Related to Drainage Basin Area for USGS Gaging Stations on Oregon Coastal Streams

there is a series of relationships between average annual flows and drainage areas.

$$LST = 1.4(A) \qquad (1)$$

The coefficient 1.4 (drainage or stream density, DD) varies between 1.0 and 1.6 for the basins upstream of the USGS gages.

$$QAA = 7.5(A) \quad \text{Big Creek, Siletz, and Wilson R.} \qquad (2)$$

$$QAA = 6.0(A) \quad \text{Five Rivers, Nestucca R.} \qquad (3)$$

$$QAA = 4.7(A) \quad \text{N.F. Alsea, Alsea R.} \qquad (4)$$

The streams represented by Eq. 2 are those with the highest average annual precipitation (Table 25). The Wilson and Siletz River Basins are 15-20 times larger than Big Creek and lie in a northeasterly direction. Big Creek, with its USGS gaging station located near EPA site 13, is typical of the shorter, steeper streams which receive high average annual precipitation in the near-coast range and drain directly into the ocean.

The Nestucca River gage is located near EPA sites 1, 2, and 3 and the Five Rivers gage between EPA sites 6, 8, 9, and 11 in the Mid-Coast Drainage Basin. The average annual flows in these vicinities are represented by Eq. 3 which has a lower coefficient than Eq. 2.

The Alsea River basin is represented by Eq. 4 and these watersheds tend to have less average runoff per square mile. There is an obvious decreasing trend in the coefficients in Eqs. 2, 3, and 4 from north to south except for Big Creek. But the interior gaging stations do show this decreasing trend and in gages in the Suislaw Basin farther to the south the coefficient decreases to 3.7. The stations in the Suislaw Basin have short periods of record so they were not used to develop the flow prediction correlations.

The coefficients in Eqs. 2, 3, and 4 are related to average annual precipitation and the equations can be combined into the one shown in the lower right corner of Fig. 8.

$$QAA = 0.00126(P)^{1.8}(A). \qquad (5)$$

More discussion of average annual flow is presented in a later section The discussion of Eqs. 2-4 and Fig. 8 was presented here to provide a general overview of how the hydrologic conditions vary over the portions of the North- and Mid-Coast basins which are in the EPA study area.

Basin Chracteristics of the EPA Sites

The basin characteristics, average annual precipitation, and major basins of the EPA sites are summarized in Table 26. When the stream length is plotted against drainage area (Fig. 9), it is seen that the average value is about,

$$LST = 1.5(A) \tag{5}$$

with the coefficient (DD) varying between 1.0 and 2.0. The higher stream density for these smaller basins, as compared with the larger USGS basins (1.0-1.6) is to be expected because drainage density tends to decrease as area increases in a basin.

A general guideline which can be derived from the analysis of stream density is that basins with higher densities tend to have higher floods and lower low flows when compared with other basins of similar area and precipitation. Conversely, low stream density indicates a tendency towards lower floods and higher low flows. There is no readily obvious factor which can be used to explain the consistency in the three distinctive relationships shown in Fig. 9.

Low Flows

The best sets of basin parameters for correlation with the characteristic low flows (Q7L2 and Q7L20) at the USGS gaging stations were found to be lengths of first-order streams, total length of streams, and basin relief as shown in Figs. 10, 11, and 12. In Fig. 10,

$$Q7L2 = 0.85(LS1)(H)^{0.50} \tag{6}$$

and

$$Q7L20 = 0.60(LS1)(H)^{0.50}. \tag{7}$$

Also,

$$Q7L20 = 0.18(A) \tag{8}$$

Table 26. Basin Characteristics for EPA Spawning Gravel Sampling Sites in the Siuslaw National Forest--Oregon Coastal Basins

Station Name	Station Number	Drainage Area A (sq mi)	Average Annual Precipitation P (in./yr)	Total Stream Length LST (mi)	1st Order Stream Length (mi)	Site Elev. (ft)	Head-water Elev. (ft)	Basin Relief H (mi)	Major Basin
Beaver Cr.	1	9.57	105	10.7	4.3	440	1800	0.26	Nestucca
Three Riv.	2	4.71	95	6.4	4.5	1000	2400	0.27	Nestucca
Farmer Cr.	3	2.96	102	3.2	2.9	340	960	0.12	Nestucca
Green Cr.	4	1.30	105	2.3	1.7	500	1000	0.09	Siuslaw
N. Prong Cr.	5	1.65	88	3.6	2.3	100	1100	0.19	Maple
N.F. Indian	6A	3.18	105	6.1	3.7	475	1000	0.10	Siuslaw
N.F. Indian	6B	6.41	105	10.5	8.8	450	1000	0.10	Siuslaw
Savage Cr.	7	9.49	100	8.4	6.2	300	1650	0.26	Drift Cr. Alsea R.
Canal Cr.	8A	2.36	95	2.6	1.5	250	650	0.08	Alsea R.
Canal Cr.	8B	3.01	95	3.3	1.5	200	650	0.09	Alsea R.
Green R.	9A	3.44	105	6.4	3.9	350	1050	0.13	Alsea
Green R.	9B	6.60	105	13.1	7.6	300	1050	0.14	Alsea
Cape Horn Cr.	10	1.63	95	2.4	2.4	500	1500	0.19	Drift Cr. Alsea
West Cr.	11	1.57	95	3.2	1.6	250	1250	0.19	Canal Cr. Alsea
Rock Cr.	12	6.03	96	6.5	3.5	180	1700	0.29	Coast
Big Cr.	13	12.0	102	17.7	12.6	240	1500	0.24	Coast

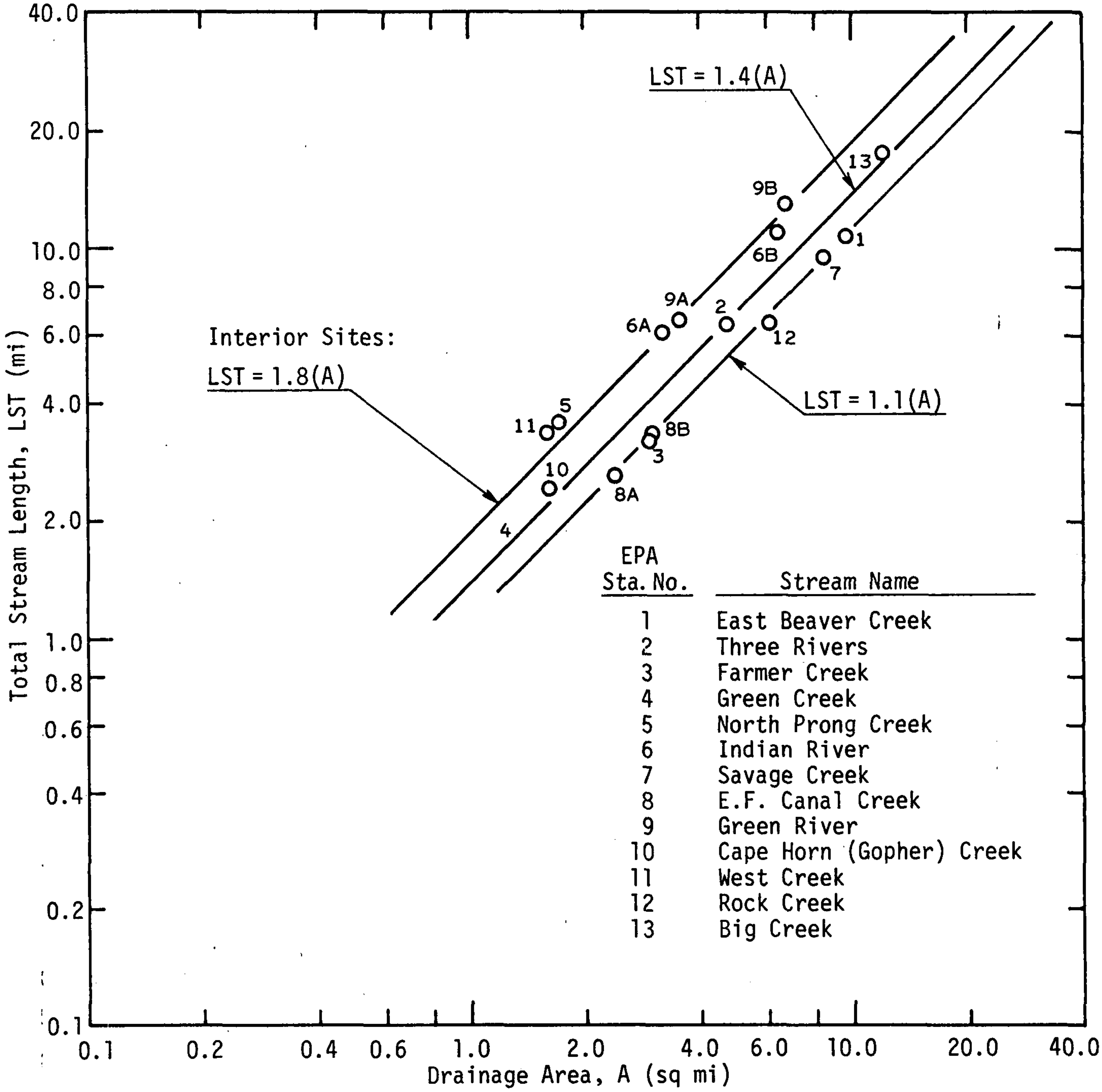


Fig. 9. Total Stream Length Related to Drainage Area at 16 EPA Spawning Gravel Test Sites on Small Oregon Coastal Streams

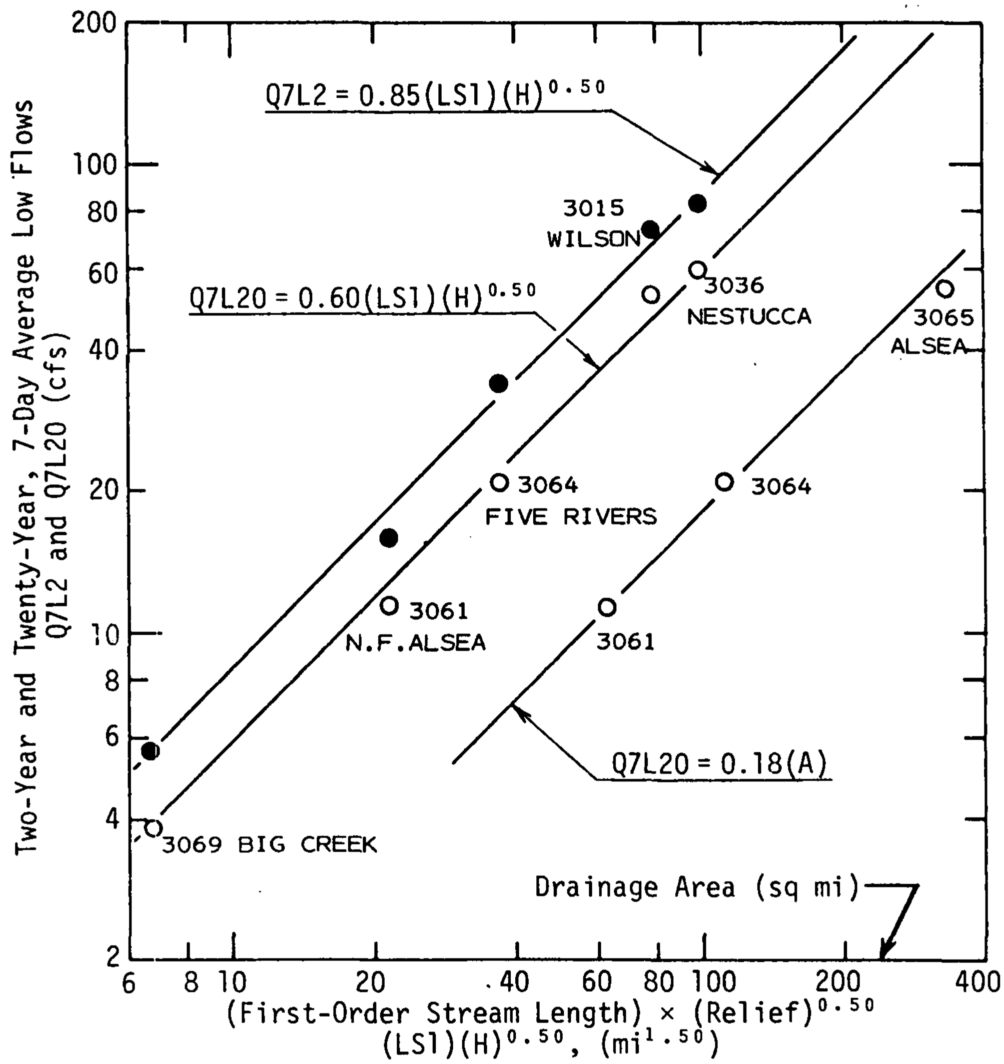


Fig. 10. Two-Year and Twenty-Year, 7-Day Average Low Flow Related to First-Order Stream Length, Basin Relief and Basin Area for USGS Regular Gaging Stations--Oregon Coastal Streams

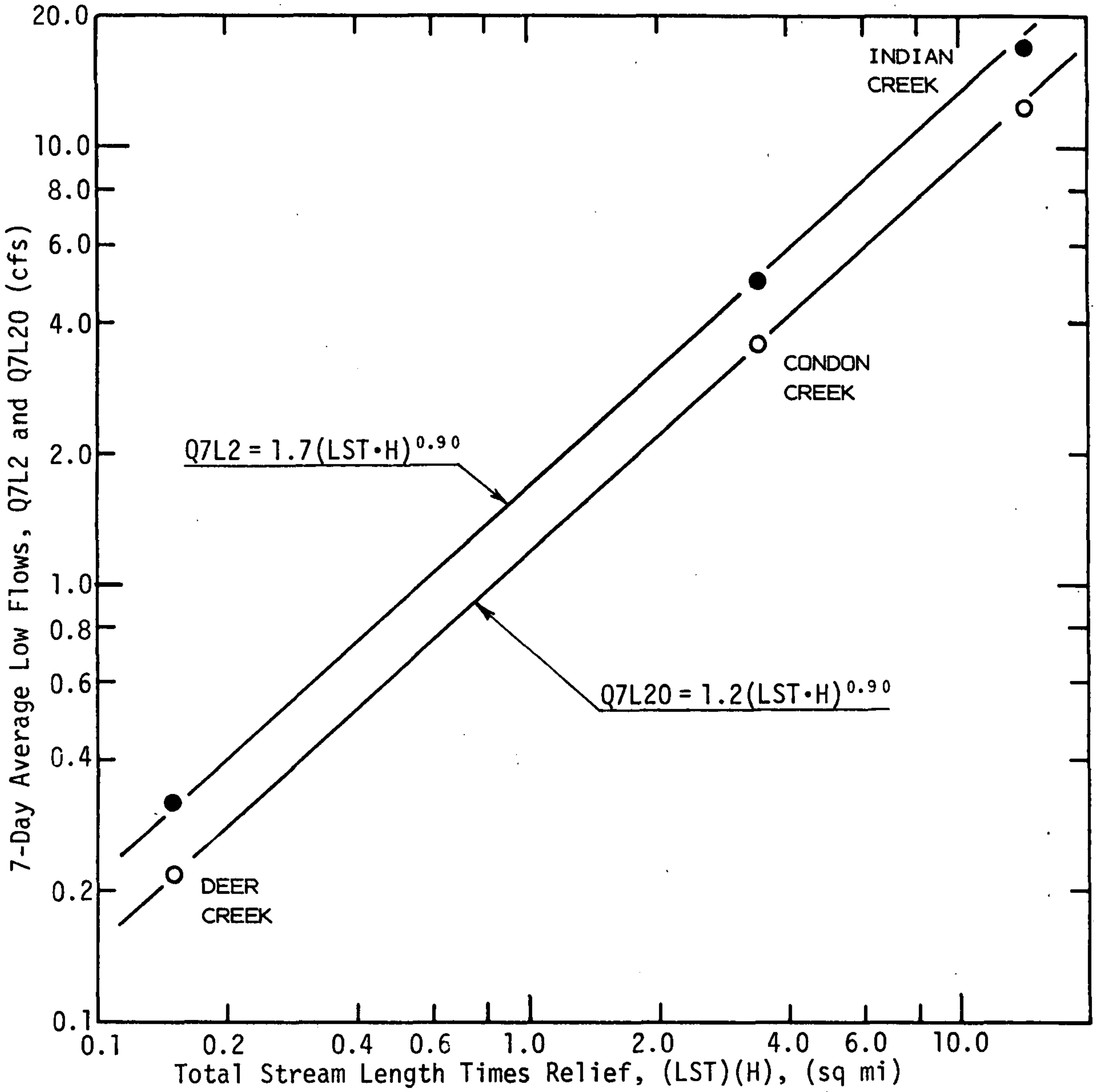


Fig. 11. Two-Year and Twenty-Year, 7-Day Average Low Flows at USGS Oregon Coastal Miscellaneous Low Flow Stations Related to Stream Length and Basin Relief

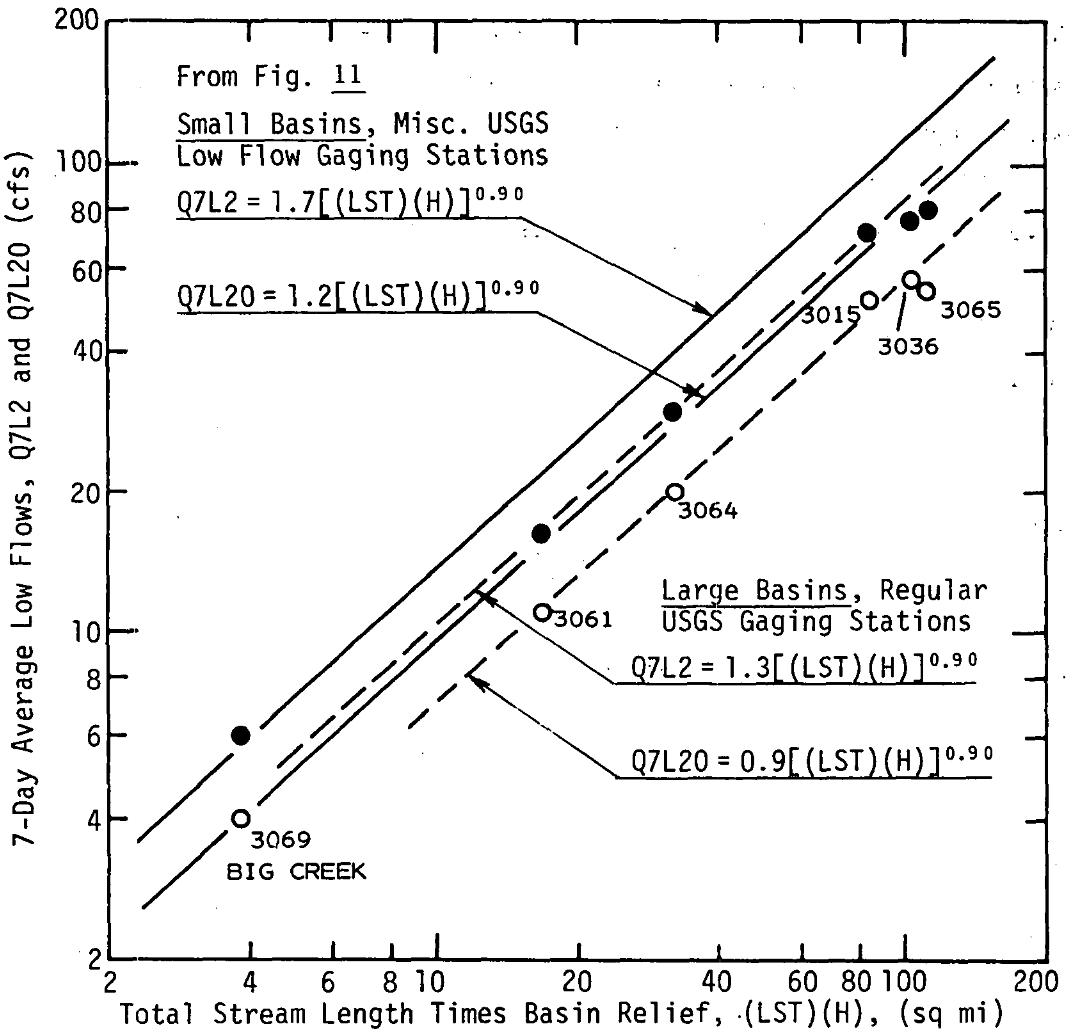


Fig. 12. 7-Day Characteristic Low Flows Related to Total Stream Length and Basin Relief for USGS Miscellaneous Low Flow and Regular Gaging Stations on Oregon Coastal Streams

for some of the gages. The 7-day average 20-year low flow tends to correlate well with drainage area in some hydrologic provices where the basin groundwater supply is provided quite uniformly during extended dry periods. In Fig. 10 the correlation of Q7L20 with drainage area is strong for the Alsea River Basin of which Five Rivers is a part.

A few of the USGS miscellaneous low flow stations (Fig. 11 and Table 5) showed a strong correlation between low flows, total stream length, and basin relief such that

$$Q7L2 = 1.7(LST \cdot H)^{0.90} \tag{9}$$

and

$$Q7L20 = 1.2(LST \cdot H)^{0.90}. \tag{10}$$

Condon and Indian Creeks show a relationship of

$$Q7L20 = 0.40(A) \tag{11}$$

but Deer Creek was logged during the period of record and probably changed its low flow to drainage area relationship. The coefficient of 0.40 in Eq. 11 is larger than 0.18 in Eq. 8 as would be expected for the smaller headwater streams at higher elevations.

In Fig. 12, the correlations from Fig. 11 have been plotted for the miscellaneous low flow stations with those for the large basins with USGS gaging stations. The results show

$$Q7L2 = 1.3(LST \cdot H)^{0.90} \tag{12}$$

and

$$Q7L20 = 0.9(LST \cdot H)^{0.90}. \tag{13}$$

Obviously the coefficients in these equations and Eqs. 10 and 11 show that the smaller watersheds tend to generate more low flow. This is confirmed in Fig. 12 for Big Creek (Gage No. 3069) with an area of only 11.9 square miles, because it lies on the graphs for the smaller miscellaneous low flow measuring sites from Fig. 11.

The correlations of gaged low flows and basin characteristics shown in Figs. 10-12 are used to make the first estimates of Q7L2 and Q7L20. Then these flows are combined with other terms as shown in Fig. 13 to solve for the slope of the low flow recurrence interval (RI) graph. The log-log, low flow RI graph nomenclature is shown in the upper left corner of Fig. 13. The log-log plot is used so that the equation of the line may be determined. The slope of this graph (p) is a measure of the low flow stability from year to year at a site. The low flow recurrence interval graphs for the regular USGS gaging stations are shown in Fig. 14 and the low flow values and slopes of the graphs are listed below the figure. The RI graph slopes vary between 0.12 and 0.18, while the slopes for the miscellaneous low flow station graph (not shown) vary between 0.14 and 0.21. Values of (p) in the range of 0.10-0.20 are typical for forested, mountainous basins.

After the slope of the low flow recurrence interval graph is estimated for an ungaged site, it is checked against those for the gages as shown in Fig. 14.

The predicted low flow RI graphs for the EPA sites are presented in Figs. 15 (Sites 1-7) and Fig. 16 (Sites 8-13). The plotted values are from Table 1. If the 7-day average low flow for a longer RI than 20 years is desired for any EPA site, the log-log graph should be transferred to a piece of log-Pearson III paper using five of six points between 2 and 20 years. Then the points can be fitted with a smooth curve and the RI graph can be extrapolated beyond 20 years. The log-log graph does not hold beyond 20 years.

Average Annual Flows

As was shown earlier in Fig. 8, average annual flow can be correlated with drainage area (A) in basins receiving similar amounts of precipitation. Average annual flow can be correlated with a number of other factors including basin relief (H - Fig. 17) and average annual precipitation (P - Fig. 18). Most of the correlation strength is dependent on drainage area (A), but the use of average annual precipitation in Fig. 18 allows a differentiation of subregions within the North- and Mid-Coast Basins. The similar decrease in coefficient from north to south that was noted earlier in Fig. 8 (Eqs. 2-4) is evident again in Fig. 18.

A quick method for determining the variation in average annual flow and its extremes is to prepare a table like Table 27 for the gaging station in the study area with the longest and least modified records. Using this table, the wetness or dryness of any shorter period of record at another gaging station can be quickly ascertained. Also, the variability in the average annual flow about

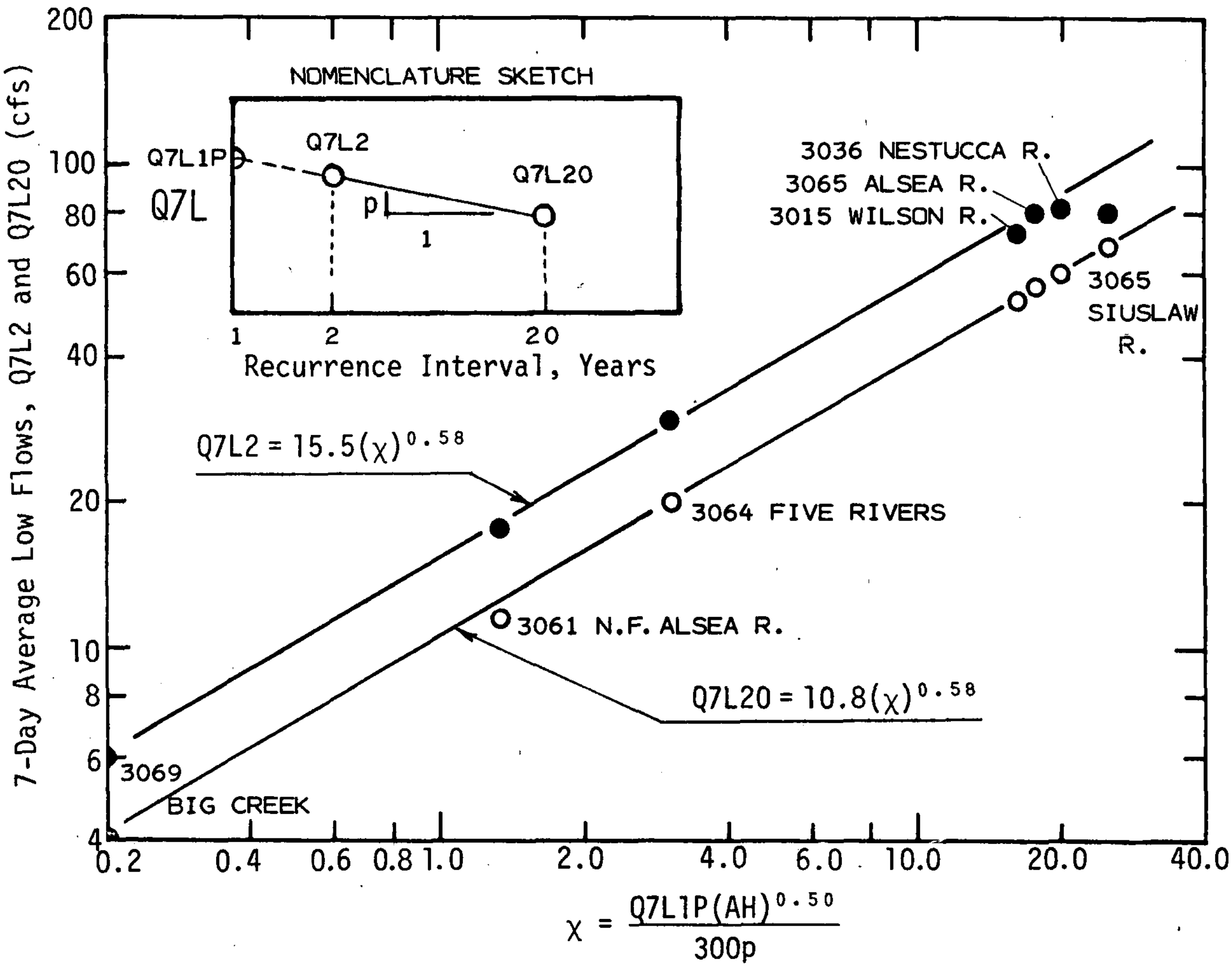
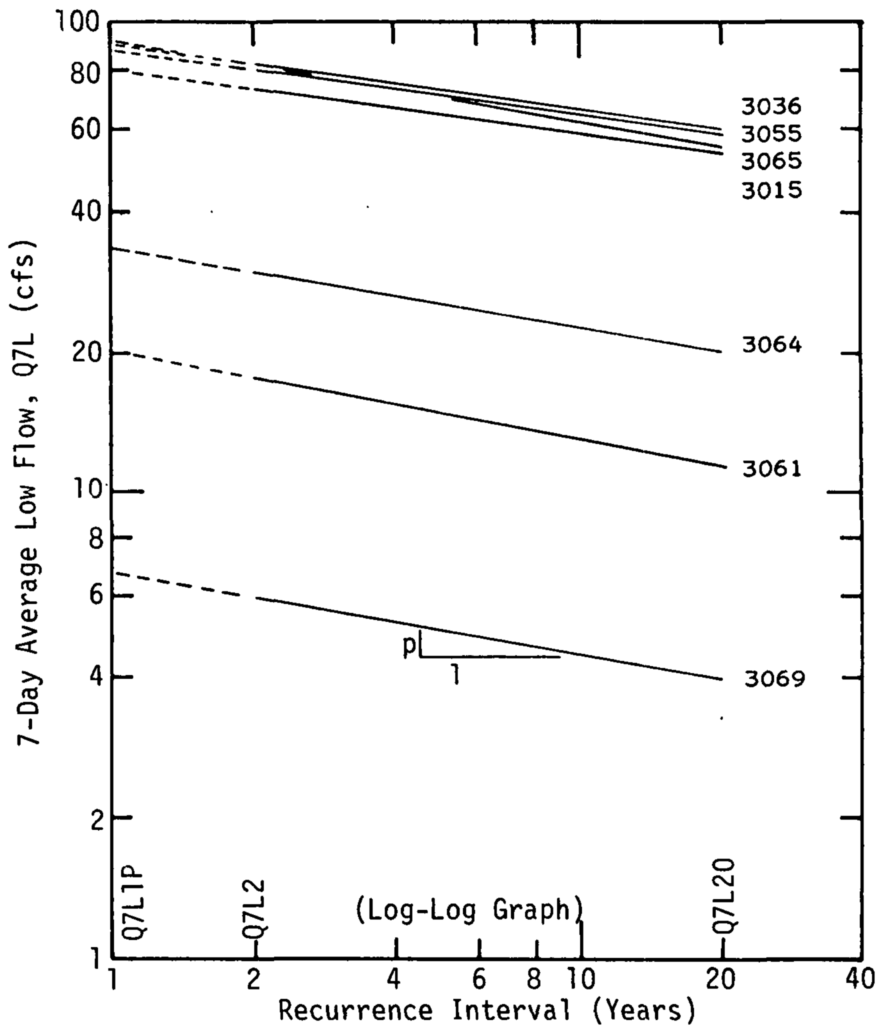


Fig. 13. Two-Year and Twenty-Year, 7-Day Average Low Flows, Q7L2 and Q7L20, Related to Combined Low Flow and Basin Characteristics



LEGEND

Gage	River	Q7L1P	Q7L2	Q7L20	Slope p
3036	Nestucca	87.0	79.0	58.0	0.14
3055	Siletz	90.0	80.0	58.0	0.12
3065	Alsea	92.0	80.0	56.0	0.17
3015	Wilson	80.0	73.0	53.0	0.14
3064	Five Rivers	34.0	30.0	20.0	0.18
3061	N.F. Alsea	17.8	16.0	11.4	0.15
3069	Big Creek	6.8	6.0	4.0	0.18

Fig.14. Seven-Day Average Low Flow Recurrence Interval Graphs for USGS Regular Gaging Stations--Oregon Coastal Streams

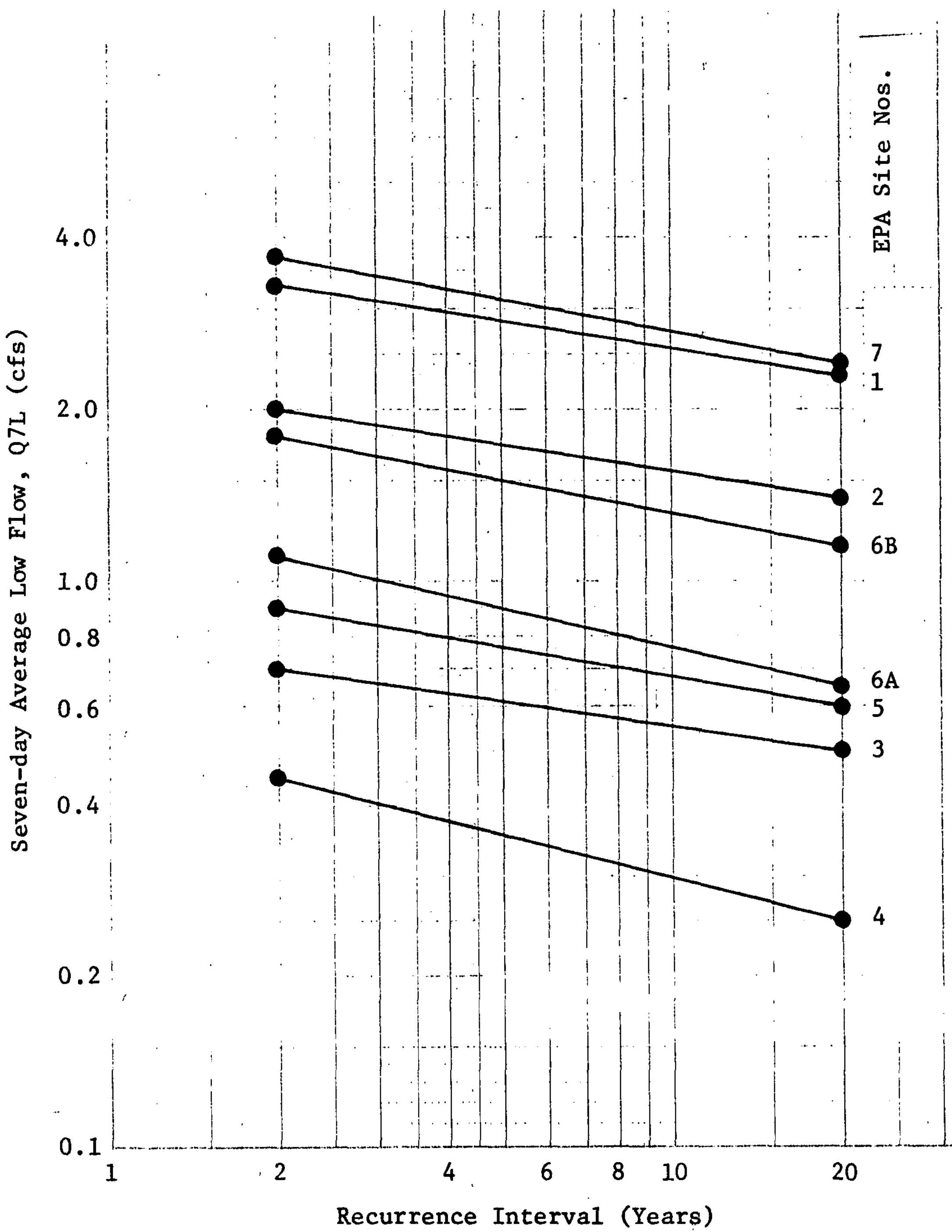


Fig. 15. Seven-day Average Low Flow Recurrence Interval Graphs for EPA Sites Numbers 1 through 7.

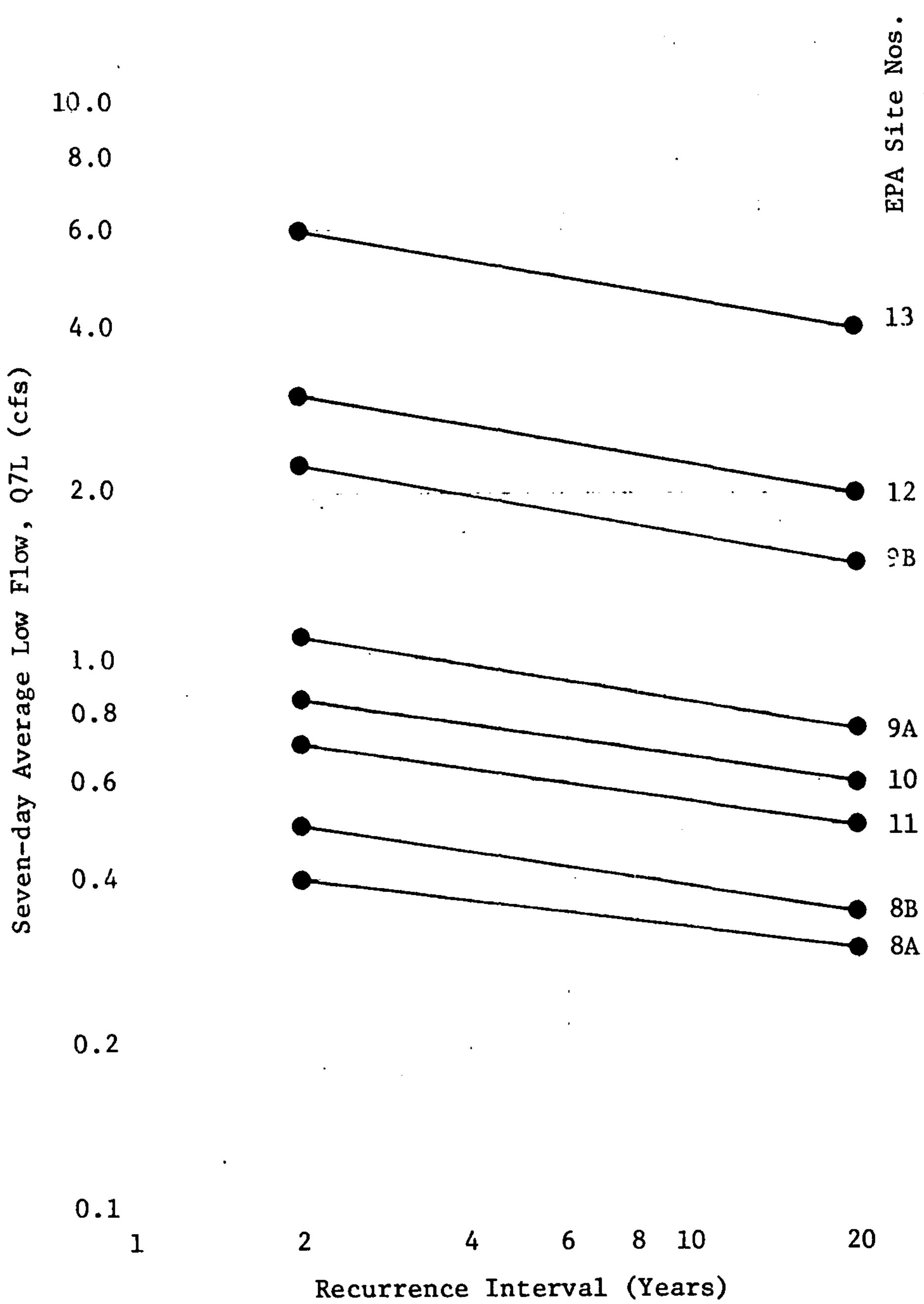


Fig. 16. Seven-day Average Low Flow Recurrence Interval Graphs for EPA Sites Numbers 8 through 13.

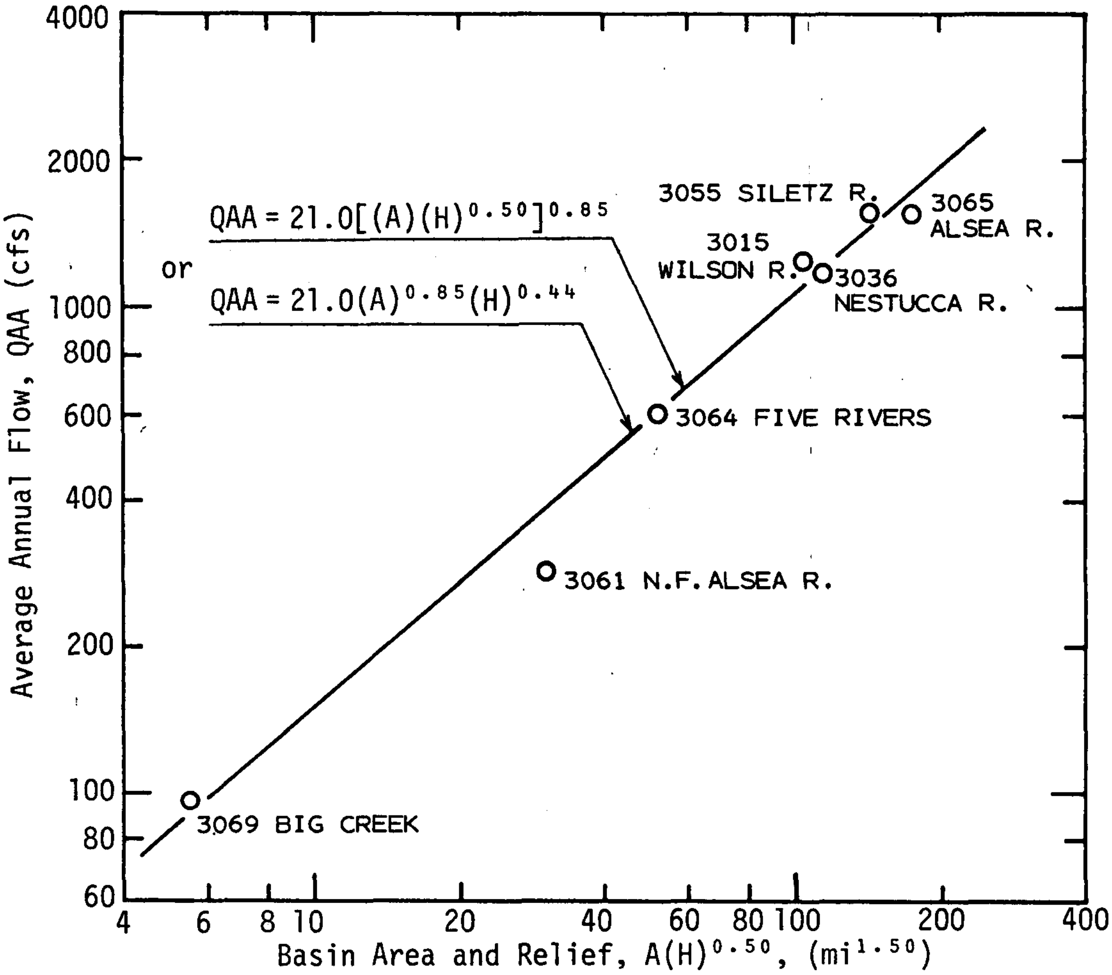


Fig. 17. Average Annual Flow Related to Basin Area and Relief for USGS Gaging Stations in Oregon Coastal Drainage Basins

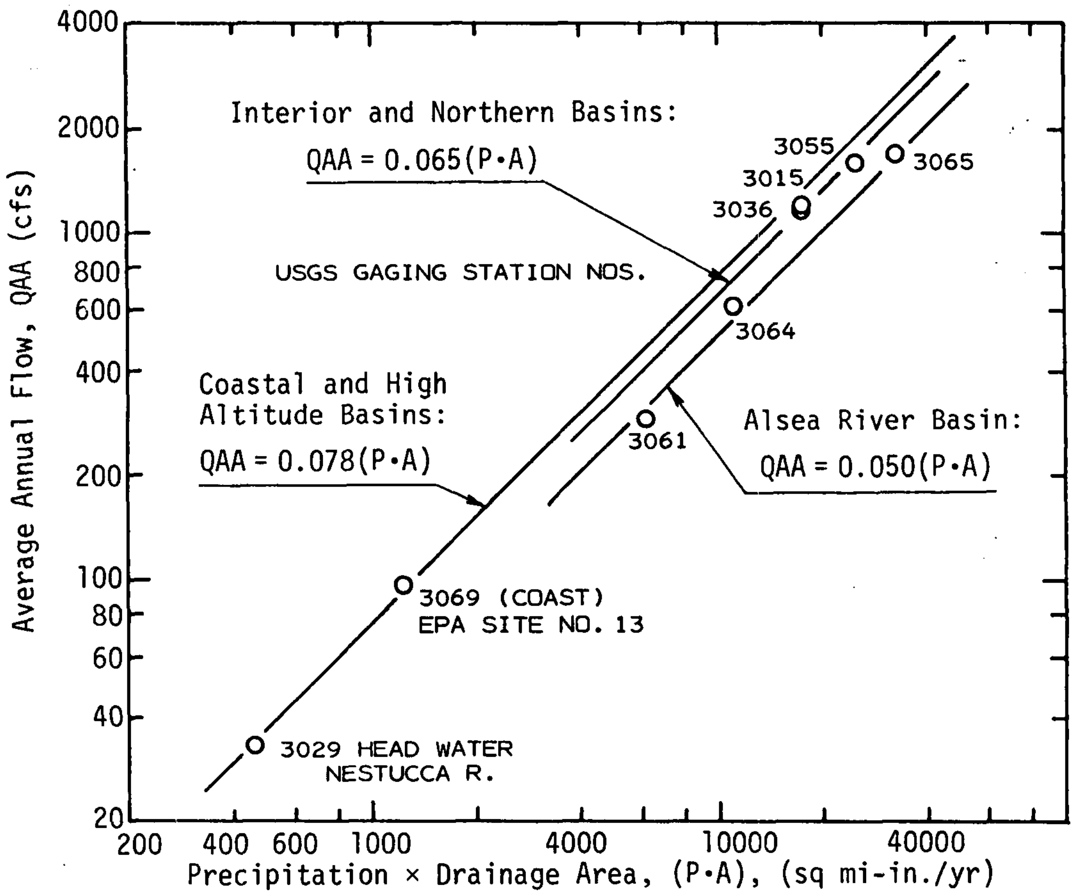


Fig. 18. Average Annual Flow Related to Average Annual Precipitation and Drainage Area for North- and Mid-Coast USGS Gaging Stations for Oregon Coastal Streams.

The highest line in Fig. 18 shows the equation QAA = 0.078(P·A). But, this is a physical impossibility because one (1.0) square-mile-inch of precipitation can generate a maximum of only 0.0737 cfs, even if there is 100% runoff of all annual precipitation. Therefore, both stations 3029 and 3069 should probably be on the middle line with the equation QAA = 0.065(P·A).

Table 27. Long Term Annual Flow for Alsea River near Tidewater, Oregon (14-3065), Area = 334 square miles

Year	Annual Daily Flow (cfs)	5-Year Average Flow (cfs)	10-Year Average Flow (cfs)	Ratio of Annual to Mean	5-Year Ratio to Mean	10-Year Ratio to Mean
1950	1745			1.13		
51	2094			1.36		
52	1842	1884		1.20	1.22	
53	1821			1.11	1.18	
54	2022	1878	1750	1.31	1.22	1.14
1955	1430	1755	1712	0.93	1.14	1.11
56	2384	1721	1686	1.55	1.12	1.09
57	1226	1615	1643	0.80	1.05	1.07
58	1542	1603	1583	1.00	1.04	1.03
59	1495	1494	1581	0.97	0.97	1.03
1960	1368	1504	1449	0.89	0.98	0.94
61	1838	1481	1471	1.19	0.96	0.96
62	1279	1464	1486	0.84	0.95	0.96
63	1427	1403	1465	0.93	0.91	0.95
64	1408	1325	1497	0.91	0.86	0.97
1965	1065	1345	1510	0.69	0.87	0.98
66	1449	1326	1516	0.94	0.86	0.98
67	1377	1406	1596	0.89	0.91	1.04
68	1332	1494	1546	0.86	0.97	1.00
69	1807	1582	1649	1.17	1.03	1.08
1970	1505	1723	1697	0.98	1.12	1.10
71	1892	1641		1.23	1.07	
72	2080	1788		1.35	1.16	
73	925	1777		0.60	1.15	
74	2541*			1.65		
1975	1450			0.94		
76	1454			0.94		
77	431*			0.28		
78	--			--		

Average = 1540 cfs (1950-77); Long-Term Average = 1535 cfs, 1939-77.

*Highest and lowest years of record.

the long-term mean can be easily selected from the table. The highest and lowest values of average annual flow during the period 1950-1977 occurred in 1974 (2541 cfs) and 1977 (431 cfs), respectively. These values show deviations of 65 and 72 percent, respectively, from the mean annual flow of 1540 cfs during the same period.

After checking the average annual flows and their variations at other gaging stations during 1974 and 1977, it was determined that a maximum average variation in annual flow can be expected to about ±65%. This value was used to estimate the variability in QAA at the EPA sites in Table 1.

Flood Flows

A difficulty arises in predicting flood flows because the periods of record are usually not long enough to predict floods of longer recurrence intervals. Therefore, in order to obtain the best estimate of QF50P, several correlations were developed.

The relationships between floods and average annual flows for the regular USGS gaging stations are shown in Fig. 19. The 2-year flood relationship is much more stable than for 50-year floods. The relationship between low, average, and flood flows, developed in an earlier study, is shown in Fig. 20. The relationship for 50-year floods was very scattered and is not shown in Fig. 20 (10). The flood frequency (recurrence interval, RI) graphs for the USGS regular and crest-stage gaging stations are plotted in Figs. 21 and 22, respectively.

One of the strongest correlations for predicting flood flows is shown in Fig. 23 where

$$QF2P = 5.25(P \cdot A \cdot \sqrt{H})^{0.85} \tag{14}$$

and

$$QF50P = 25.00(P \cdot A \cdot \sqrt{H})^{0.76}. \tag{15}$$

Similar equations were developed using just drainage area and basin relief, but the introduction of average annual precipitation reduced the variability.

$$QF2P = 275(A \cdot \sqrt{H})^{0.85} \tag{16}$$

$$QF50P = 930(A \cdot \sqrt{H})^{0.76} \tag{17}$$

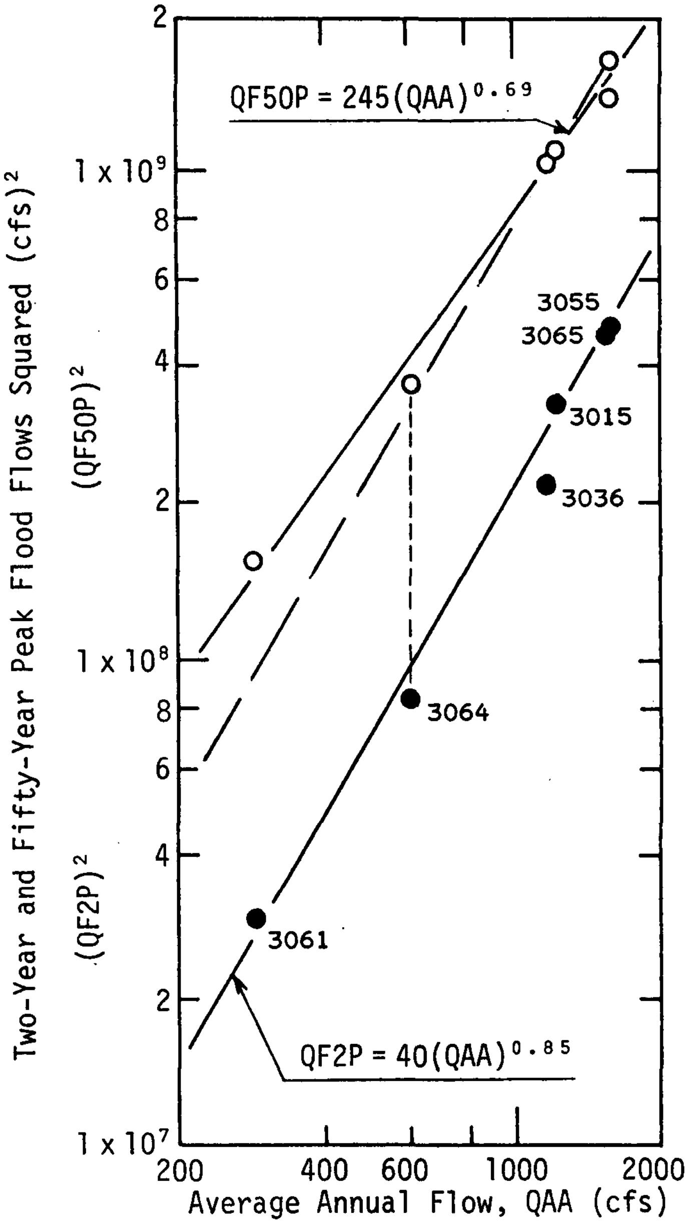


Fig. 19. Two-Year and Fifty-Year Peak Floods at Regular USGS Gaging Stations Related to Average Annual Flows

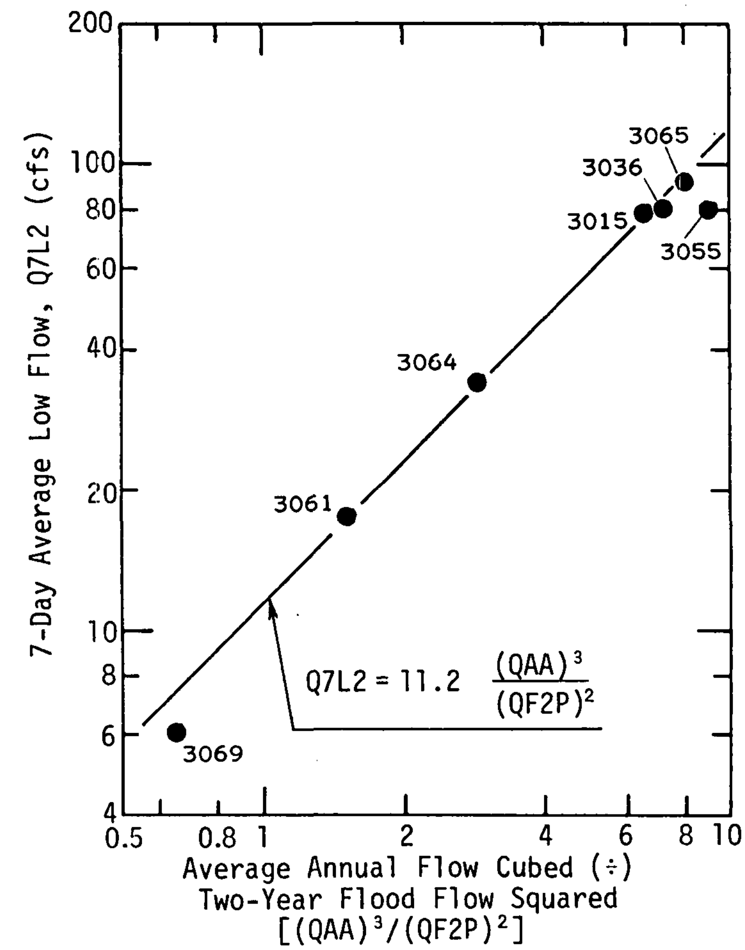


Fig. 20. Relationship Between Average Low, Annual and Flood Flows--Oregon Coast Basins at UGSG Regular Gaging Stations

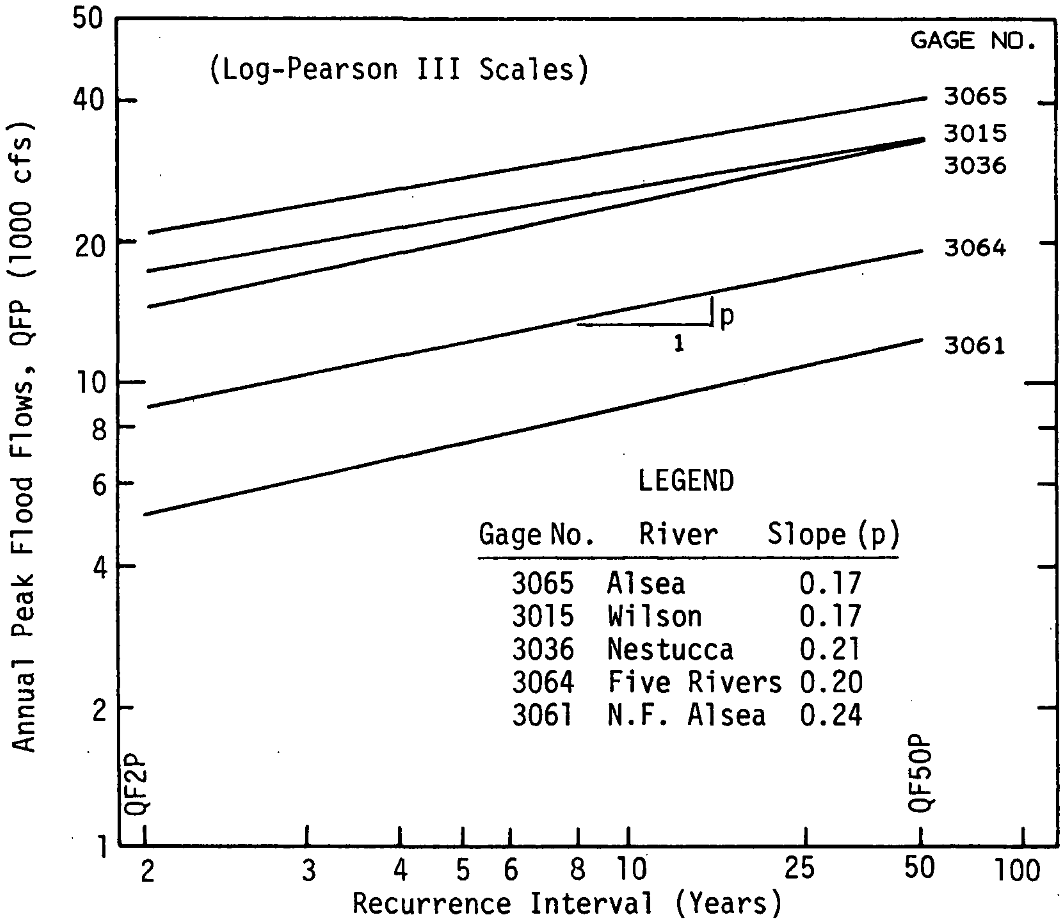


Fig. 21. Flood Recurrence Interval Graphs for USGS Regular Gaging Stations in the Study Area

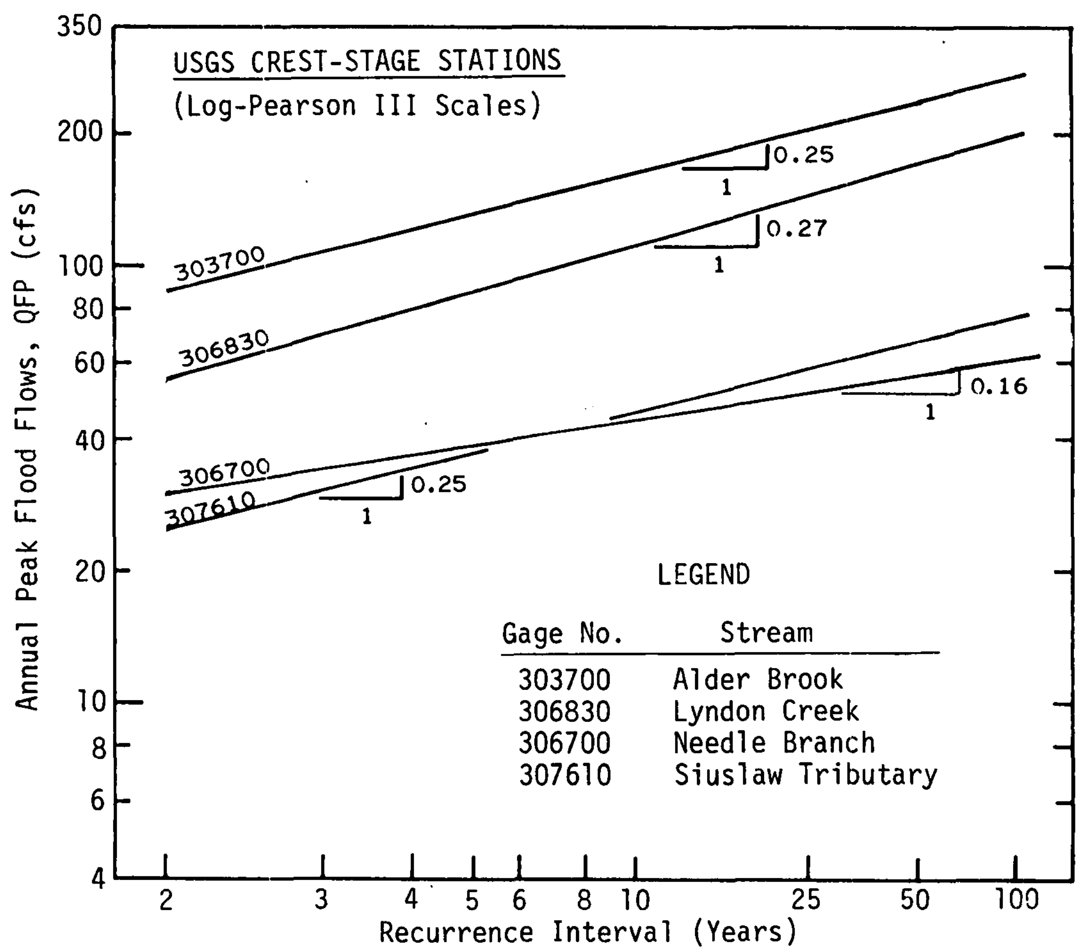


Fig. 22. Flood Recurrence Interval Graphs for USGS Crest-Stage Gages on Small Watersheds in the Study Area

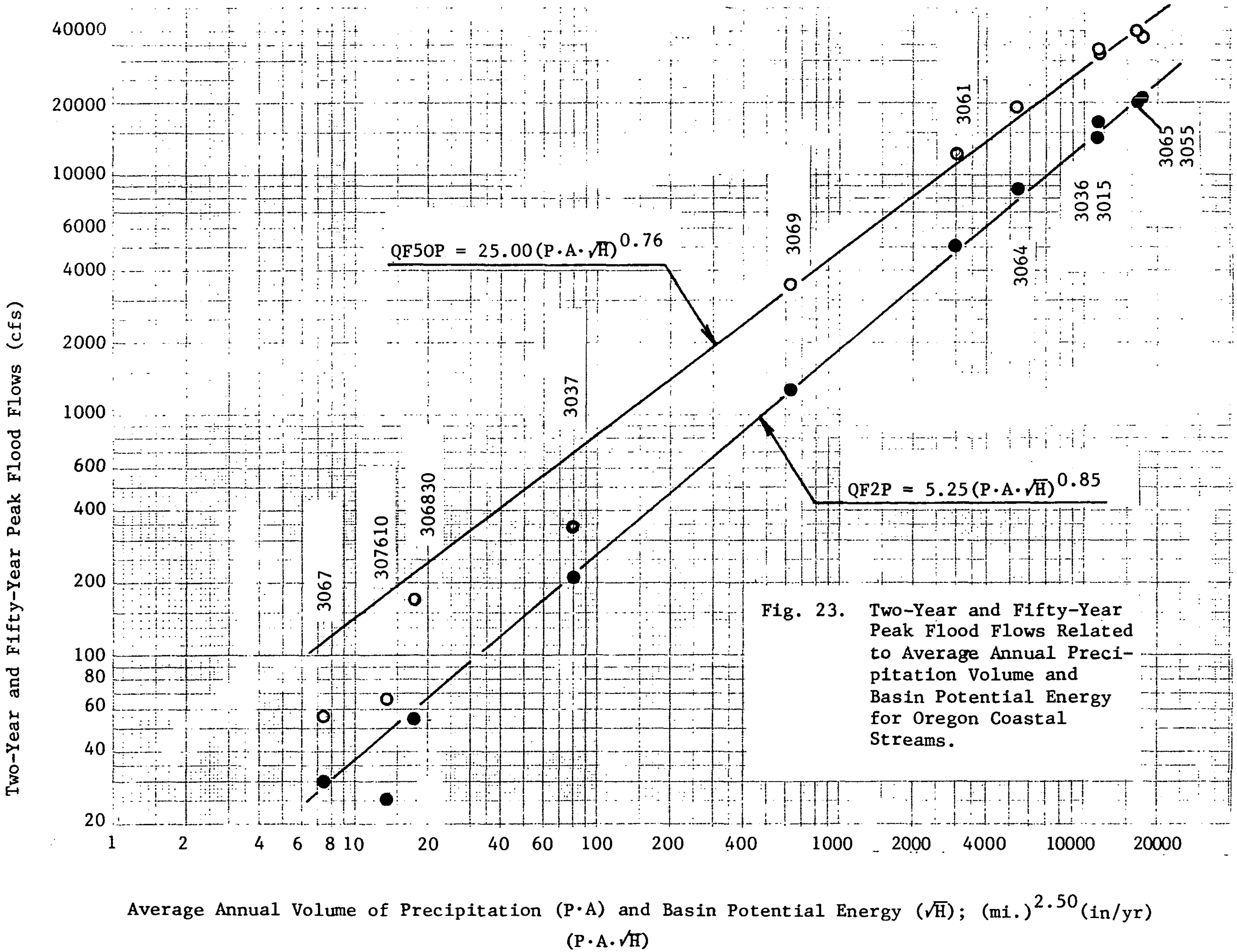


Fig. 23. Two-Year and Fifty-Year Peak Flood Flows Related to Average Annual Precipitation Volume and Basin Potential Energy for Oregon Coastal Streams.

The data and calculated values which went into Fig. 23 are given in Table 27A.

The 50-year floods for the crest-stage gages are based on only 12 to 23 years of record (Table 4). The consistency of the two year floods for both the regular, large USGS gaging station and the USGS crest-stage gages is good except for station 307610 on a small unnamed tributary to the Suislaw River.

Although Eq. 15 (upper graph in Fig. 23) may appear to predict 50-year flood values which are high according to crest-stages values, it is probably more accurate than the 50-year values based on 20-years of record. If one assumes that the 50-year flood peak is correct at crest stage station 306830, and draws the 50-year graph in Fig. 23 through this point, then Eq. 14 become:

$$QF50P = 16.1(P \cdot A \cdot \sqrt{H})^{0.82}. \quad (18)$$

If Eq. 18 is used instead of Eq. 15 (upper line in Fig. 23) then the largest reduction in the predicted QF50P value would be for EPA site 4 and would be about a 20 percent reduction.

The predicted values of QF2P and QF50P for the EPA sites are given in Table 1. The flood RI graphs for the EPA sites are in Figs. 24 and 25.

Duration Curves

The generation of an average duration curve for a site on an ungaged stream can be accomplished as follows:

1. Determine the duration curve characteristics of several gaged sites in the vicinity by:
   a. finding the percent of time that the average annual flow is "equalled or exceeded" (EOE);
   b. finding the percent of time the 7-day average 2-year low flow (Q7L2) is EOE;
   c. assuming the average annual daily flood flow (QF2D)* is EOE zero percent of the time;
   d. determining the ratios of QF2D/QAA and QAA/Q7L2 for preparing dimensionless duration curves and to check the homogeneity of the hydrology in the region; and

---

*Maximum annual average daily flows are used in duration curve analyses, not QF2P.

Table 27A. Flood Flows and Basin Parameters in Oregon Coastal Streams for Ungaged Flood Prediction in Fig. 23.

USGS Gaging Stations Name	Number	Aver. Annual Precip. (in/yr)	Drainage	Basin Relief H (mi)	Combined Parameters $P \cdot A\sqrt{H}$ $(mi)^{2.5}$in/yr	Peak QF2P (cfs)	Floods QF50P (cfs)
Wilson R.	14-3015	107.3	161.0	0.44	11481	17400	33200
Nestucca R.	-3036	98.0	180.0	0.41	11270	14500	32600
Siletz R.	-3055	125.4	202.0	0.50	17550	20900	37300
N.F. Alsea	-3061	99.1	63.0	0.23	2970	5120	12400
Five Rivers	-3064	101.4	114.0	0.21	5273	8680	19200
Alsea R.	-3065	97.0	334.0	0.27	16878	20600	4100
Big Creek	-3069	102.4	11.9	0.21	614	1280	3580
Alder Br.	-3037	95.0	1.97	0.182	80	212	327
Needle Br.	-3067	100.0	0.32	0.053	7.4	30	56
Lyndon Cr.	-306830	85.0	0.90	0.054	17.7	55	170
Suislaw R. Trib.	-307610	88.0	0.42	0.133	13.5	25	66

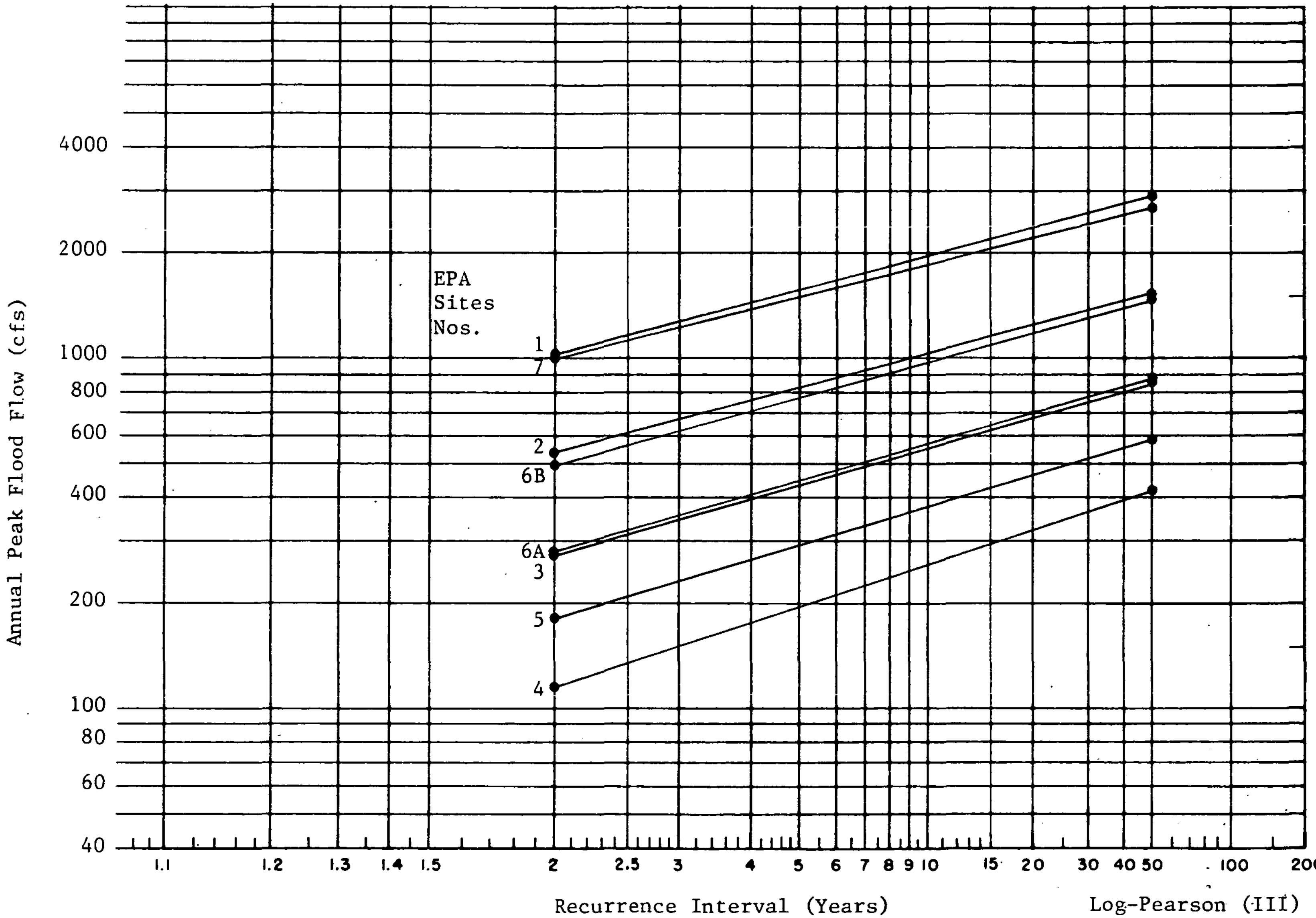


Fig. 24. Estimated Annual Peak Flood Recurrence Interval Graphs for EPA Sites Numbers 1-7.

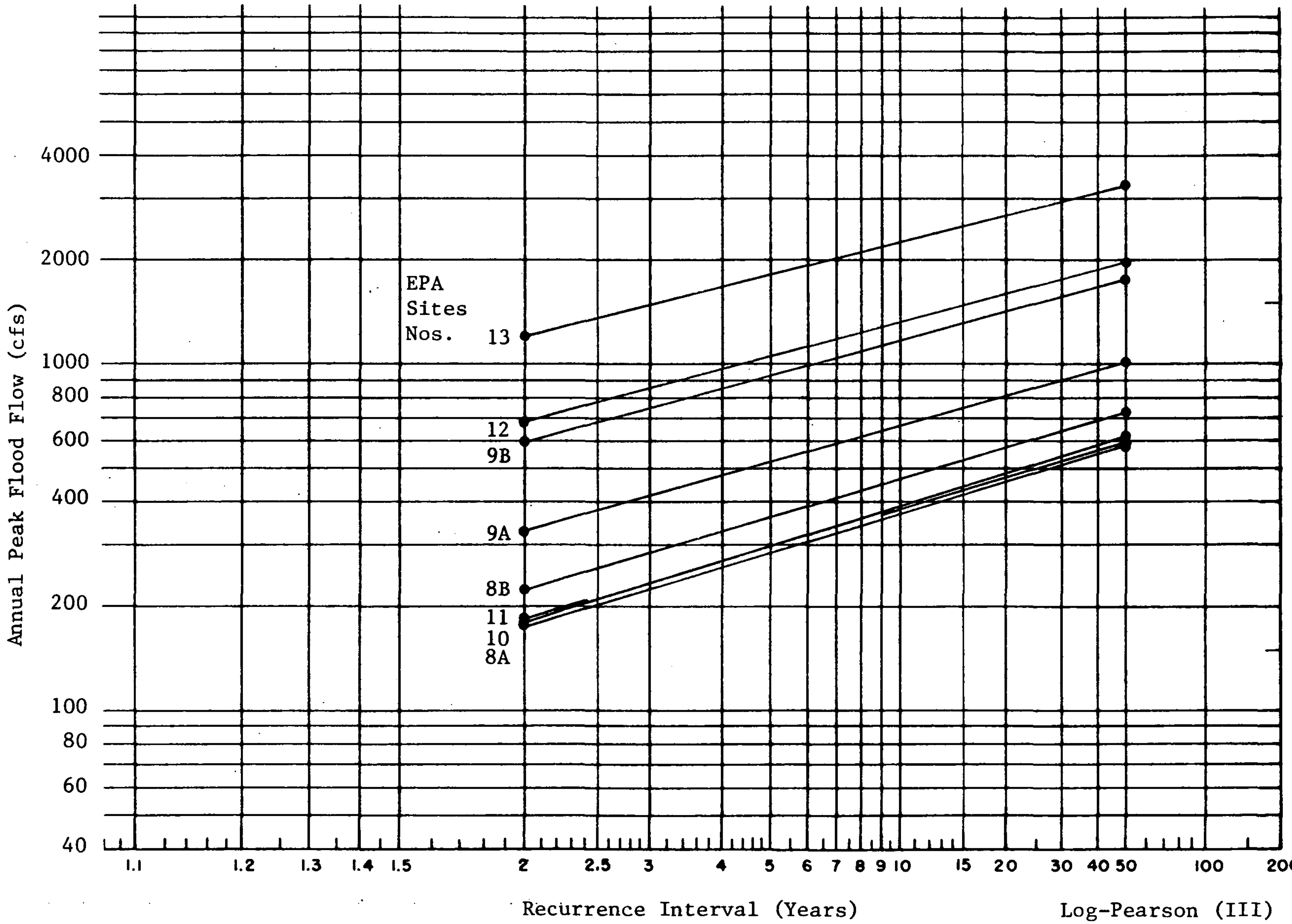


Fig. 25. Estimated Annual Peak Flood Recurrence Interval Graphs for EPA Sites Nos. 8-13.

e. plotting the duration curves for each station and their dimensionless curves.

2. Estimate the same characteristic flows for the ungaged site.
3. Plot the ungaged average duration curve for the ungaged site.

To generate the maximum and minimum duration curves at an ungaged site,

1. determine the maximum annual daily flow (flood) frequency curves at several gaged sites;
2. determine the low flow frequency curves for the same gages;
3. determine the variability in average annual flows at the gages;
4. plot daily flood frequency values of 1.10, 2, and 50 years RI on the duration curve graph at zero percent of the time;
5. plot the 7-day average low flow frequency values for 1*, 2, and 20 years RI at 90, 94, and 100 percent of the time (the percent of time they are equalled or exceeded at the gages);
6. plot the variability in the average annual flow above and below the average; and
7. connect the three maximum and three minimum plotting points to form the maximum and minimum estimated duration curves for the ungaged site, following the shape of the gaging station duration curve as a guide.

This procedure has been followed for four gaging stations in the Suislaw study area and for the EPA sites. The duration curve information for the four gaged sites was obtained from the USGS files. The data had been analyzed only through 1967, but were of sufficient length to be considered representative of the long-term duration curve. The duration curve characteristics for the gages are summarized in Table 28 and plotted in Fig. 26. Note that the duration curve used daily average flow values. Therefore, QF1.1P, QF2P, and QF50P for the ungaged sites must be converted to daily values by the equation,

$$QFD = 1.20(QFP)^{0.95} \quad (19)$$

where QFD is the maximum daily average flow of any RI.

This equation was developed in an earlier study of Oregon flood data and applies to flood flows of any recurrence interval. (10) Rather than plot 48 duration

*The 1-year value is from the log-log RI plot; use 1.10 RI flow value for log-Pearson III RI plot.

Table 28. Dimensionless Duration Curve Data for Four USGS Gaging Stations--Oregon Coastal Streams

Gage Name	Gage No.	2-Yr. Daily Flood QF2D (cfs)	Avg. Flow QAA (cfs) (% time ≥)	QF2D/QAA	Low Flow Q7L2 (cfs) (% time ≥)	Q7L2/QAA
Wilson River near Tillamook	14-3015	12800	1215 (30)	10.5	73 (95)	0.060
Nestucca River near Beaver	-3036	10800	1110 (*)	9.7	79 (*)	0.070
Siletz River at Siletz	-3055	15250	1578 (30)	9.7	80 (96)	0.051
N.F. Alsea River at Alsea	-3061	4010	286 (300E)	14.0 (13.4)	16 (94)	0.056
Alsea River near Tidewater	-3065	15050	1535 (30)	9.8	80 (94)	0.052

*% of time for duration curve not currently available.

E = Estimated average annual flow based on extension of 20 years of record at gage 3061.

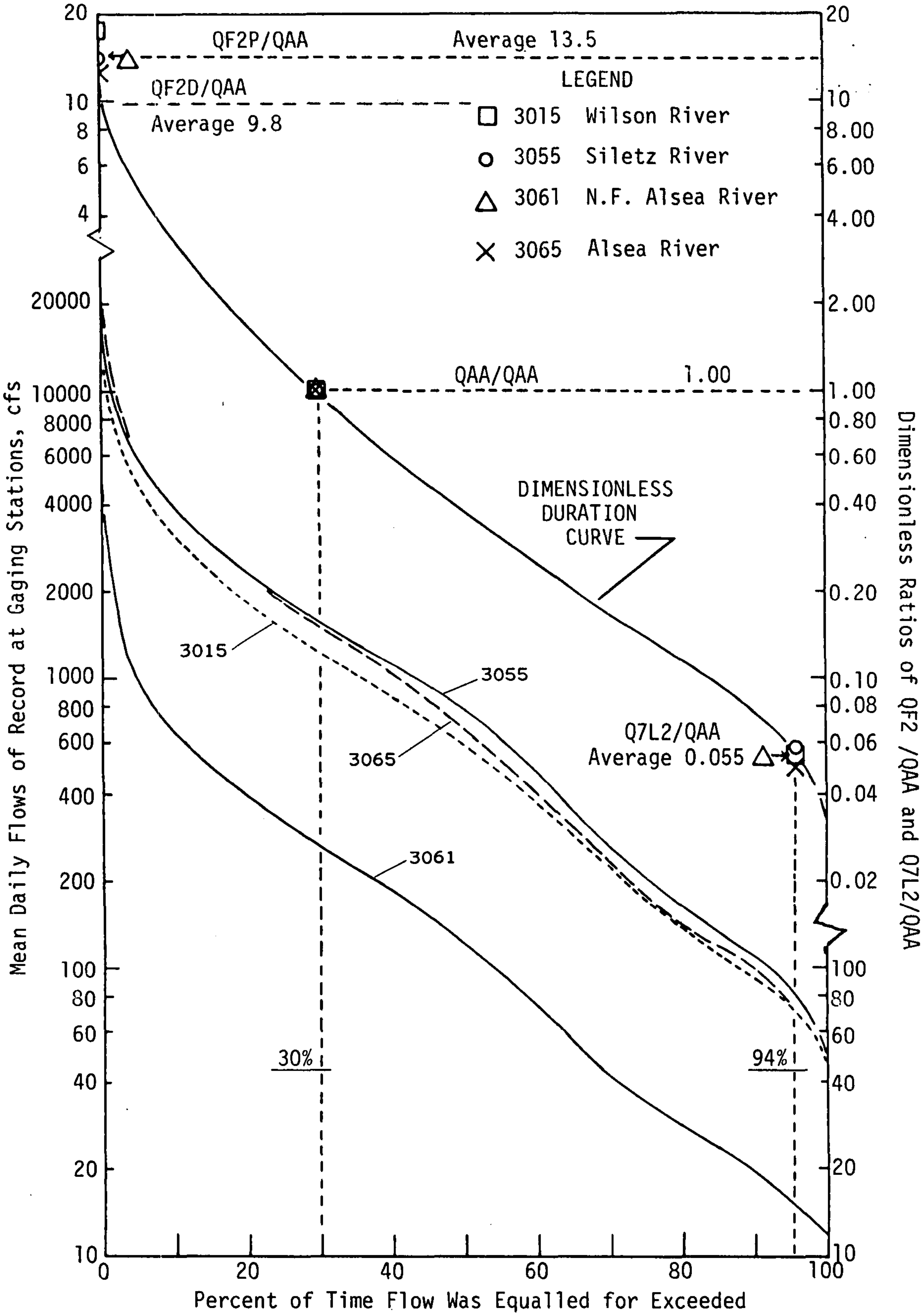


Fig. 26. Regular and Dimensionless Duration Curves for Four USGS Gaging Stations--Oregon Coastal Streams

curves, some of which would be overlapping, all the predicted values for the duration curves are summarized in Table 29.

Table 29. Data Points for Duration Curves for EPA Sites on Oregon Coastal Streams

Site No.	Site Name	FLOOD FLOWS			AVERAGE FLOWS			LOW FLOWS		
		1.10*	2*	50*	Min**	Aver	Max**	1*	2*	20*
1	Beaver Cr.	440	890	2305	19	52	85	3.70	3.30	2.30
2	Three Riv.	250	475	1305	8	22	22	2.30	2.00	1.40
3	Farmer Cr.	120	250	740	6	15	24	0.77	0.70	0.50
4	Green Cr.	50	100	375	3	8	13	0.54	0.45	0.25
5	N. Prong Cr.	75	165	510	3	7	11	1.00	0.90	0.60
6A	N.F. Indian	130	255	735	7	20	33	1.30	1.10	0.65
6B	N.F. Indian	210	440	1225	14	40	66	2.05	1.80	1.15
7	Savage Cr.	450	855	2215	21	60	99	4.20	3.70	2.40
8A	Canal Cr.	75	165	515	5	13	21	0.44	0.40	0.30
8B	Canal Cr.	95	210	630	6	16	26	0.56	0.50	0.35
9A	Green R.	160	295	860	7	20	33	1.20	1.10	0.75
9B	Green R.	260	515	1415	13	37	61	2.50	2.25	1.50
10	Cape Horn Cr.	75	175	535	3	9	15	0.94	0.85	0.60
11	West Cr.	80	165	525	5	8	13	0.78	0.70	0.50
12	Rock Cr.	305	595	1620	14	40	66	3.40	3.00	2.00
13	Big Cr.	530	1075	2855	34	96	158	6.80	6.00	4.00

*Recurrence interval in years; 1-year is based on log-log RI graph
**±65% of average, (QAA); ≥30% of the time

OTHER ASPECTS OF THE STUDY

The following aspects of this study have been completed in the previous sections:

1. Analysis of stream channel cross-sectional and flow data collected by EPA at the study sites;
2. Low flow frequency curves;
3. Flood flow frequency curves;
4. Average annual flows and their variability; and
5. Maximum, average, and minimum duration curves.

In addition the following areas of investigation were to be undertaken, because of either their relationships to the EPA field data or due to their relationships to planning future investigations and monitoring of the spawning gravel study sites:

1. An analysis of channel and flow characteristics with adequate cross-sectional data;
2. Flood hydrograph and storm characteristics; and
3. An analysis of anticipated changes in hydrologic conditions.

These last three aspects of the study are discussed in the next sections of the report.

Channel and Flow Characteristics

The relationships between water surface width (W), mean depth (D), mean velocity (V), and discharge (Q) at a site can be described in terms of the continuity equation at various stages of flow by

$$W = a(Q)^b \tag{20}$$

$$D = c(Q)^d \tag{21}$$

$$V = e(Q)^f. \tag{22}$$

Because of the continuity equation in which any discharge

$$Q = AV \tag{23}$$

and $A = WD$, then

$$Q = axcxe(WDV)^{b+d+f} \tag{24}$$

where axcxe = 1, and (b+d+f) = 1.

If channel cross-sections are measured at ungaged locations on streams, such as the EPA study sites, and if the flow conditions have been measured at a "low" flow, then one point on each of the graphical, log-log expressions of Eqs. 20, 21, and 22 has been defined. If another flow, such as the bankfull discharge (QBF) can be equated to the average flood peak (QF2P), then based on the channel cross-sectional data a second point on each of the graphical log-log expressions in the three equations for W, D, and V as a function of Q has been defined. The relationship can be verified if an intermediate flow, such as QAA, is inserted into the equations and accurately predicts W, D, and V.

Because the original EPA channel cross-section and flow data were not gathered with this purpose in mind, the determination of the bankfull elevation has had to be assumed.

Several trial solutions were made at various EPA sites, but nothing was conclusive. A detailed analysis of this type should probably be part of a more intensive study of channel morphology. This would require some additional field data, and the measurement of some channel characteristics in more stable sections at the EPA sites and away from man-made influences such as rock outcrops and roads.

The major benefit of this type of channel and flow characteristic analysis is that the results can be applied to the correlation of channel spawning areas and other habitat measures without doing additional measurements on site at several other discharges, thus saving considerable resources.

Floods and Storm Characteristics

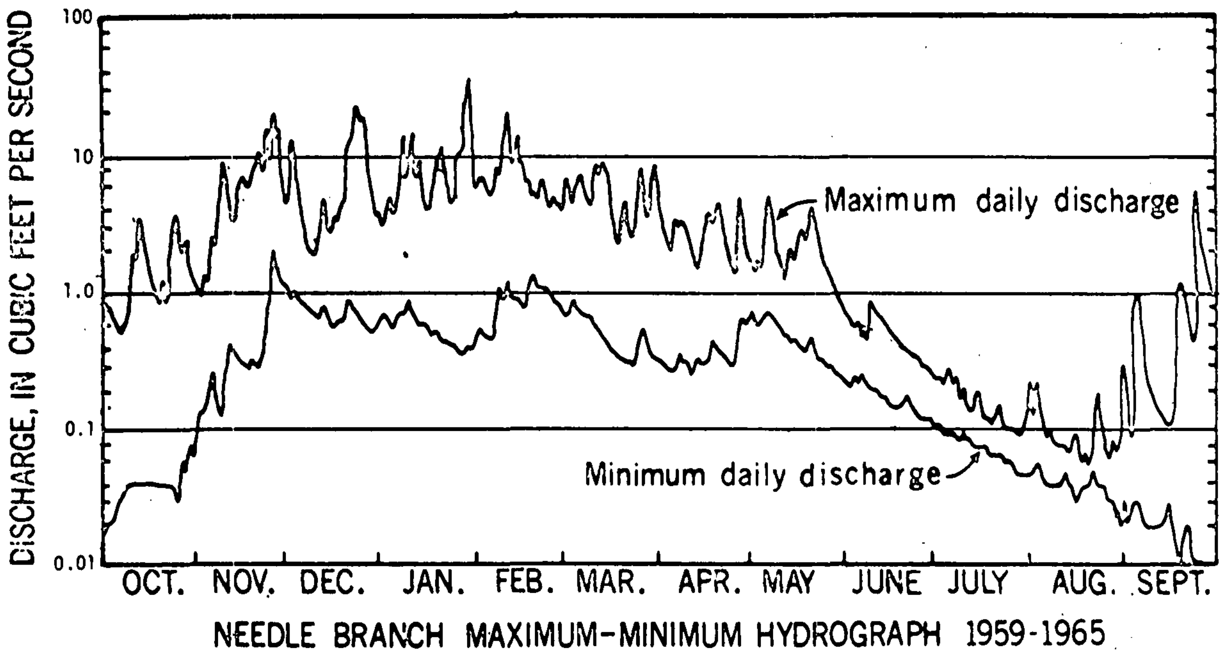
From September through May the EPA sites experience precipitation events which can cause rises in the average daily flow on the order of six to ten times the average annual flow. (The average annual maximum daily flow is about ten times the average daily flow as noted in the section on duration curves.) The general level of daily flow tends to rise, as shown in Fig. 27, to a higher winter level and the winter peak flows are superimposed on this base. Almost without exception the larger high flows and the annual peak floods tend to occur between December and March when heavy rainfall occurs on already saturated land and enters swollen streams.

Annual streamflow records for nine regular USGS gaging stations, and four crest-stage gages were examined to determine hydrograph characteristics for water years 1974, 1975, and 1977. These water years were selected because 1974 had the highest average annual flow of record, 1977 the lowest, and 1975 was near average. Also, 1974 and 1975 had numerous high flow periods, whereas very few high flows occurred in 1977 (12). Daily precipitation records at three stations were tabulated for water year 1975 for comparison with the high flows during that year. Other reports were examined for additional information (4)(5)(7)(10). The stations used and the precipitation records are summarized in Tables 30 and 31. Samples of three-day and seven-day average high flows (Q3H and Q7H) are summarized for three gaging stations in Table 32. Station 3015 (Wilson River), 3065 (Alsea River), and 3069 (Big Creek) represent the northern, middle, and southern parts of the Suislaw study area. Table 33 shows an example of high flow characteristics in the Alsea study area (4).

General observations about storm characteristics and attendant high flows are as follows:

1. Storms of shorter duration and less total precipitation occur in September, October, April, May, and in the summer, with resulting high flows which are considerably smaller than winter high flows (Table 31);
2. High-stage flows, which can cause maximum annual peak flows, occur predominantly between December and February (Fig. 27):
3. On numerous occasions during the period from October through May, the discharge will rise and fall in a few days or a week (Fig. 27);
4. The general tendency is for the receding limb of high flow hydrograph to rise again before it reaches the previous low between October and mid-February after which the "trough" discharges tend to recede (Fig. 27);
5. The average 3-day and 7-day high flows in any sequence of events involving a maximum daily flow (Q3H and Q7H) are related to each other by the equation

$$Q3H = 1.20(Q7H) \qquad (25)$$



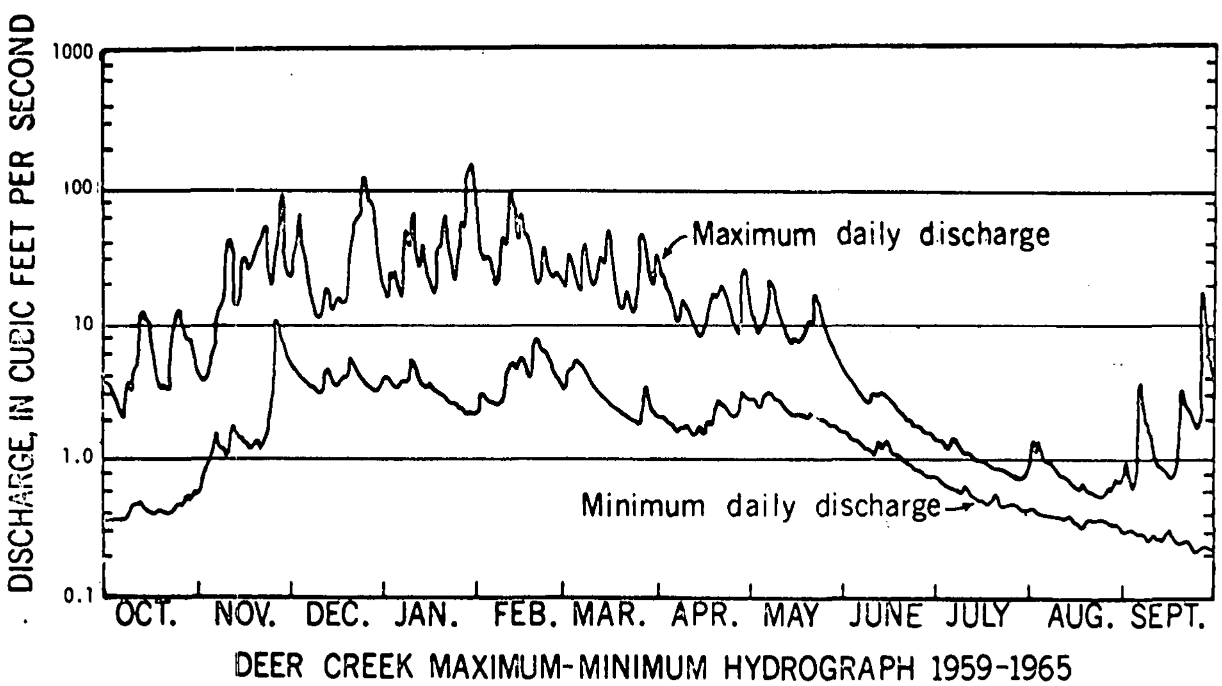


Fig. 27. Range and seasonal distribution of flows for Needle Branch and Deer Creek (from Ref. 4).

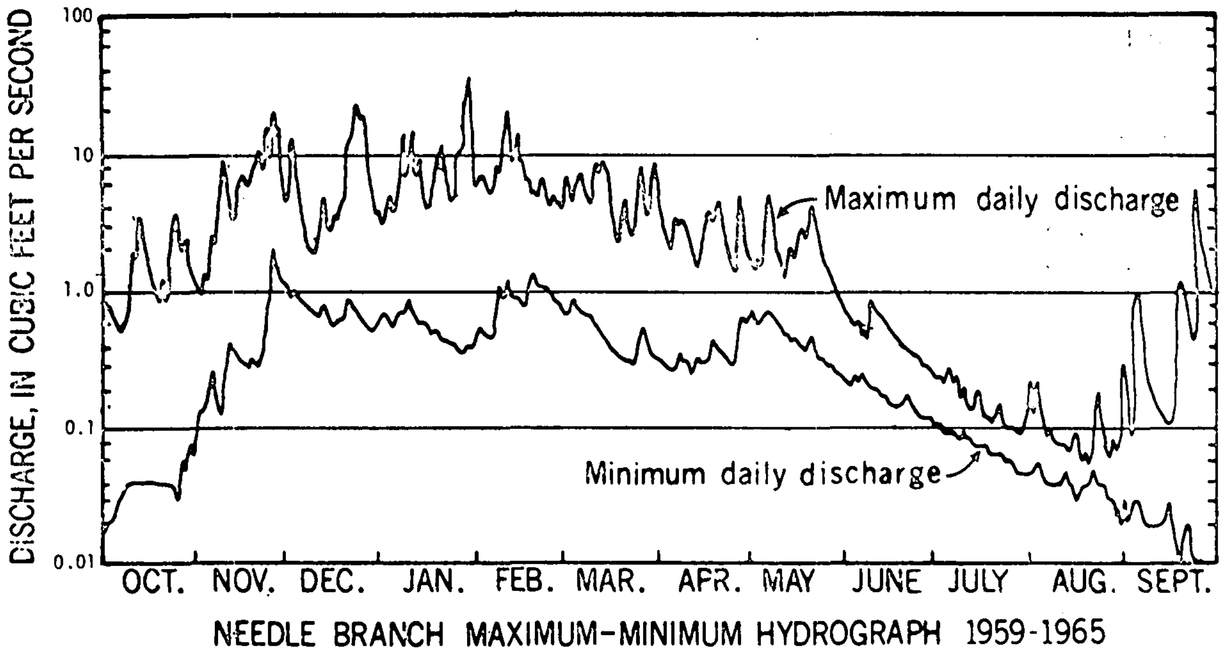
Table 30. Stream Gaging and Precipitation Stations Used in Flood and Storm Characteristics Analysis

USGS Gaging Stations No. (14-)		USWB Precipitation Stations Designation/Location
Regular Stations		
3015	Wilson River	Tilamook 11E - Just north and east of EPA sites 1-3; T1S, R8W.
3036	Nestucca River	
3061	N.F. Alsea River	Valzetz - Headwaters of the Siletz River; T8S, R8W.
3064	Five Rivers	
3065[a]	Alsea River	Drain 10NNW - Just south of the study area in the northern headwaters of the Umpqua River; T21S; R8W.
3069[b]	Big Creek	
307580	Lake Creek	
307620	Suislaw River	
307645	N.F. Suislaw River	
Crest-Stage Stations[c]		
3037	Alder Brook	
306830	Lyndon Creek	
307610	Suislaw Tributary	
307648	Condon Creek	

[a]Long-term reference station.

[b]At EPA Site 13.

[c]Same crest-stage stations as used in developing flood prediction equations.



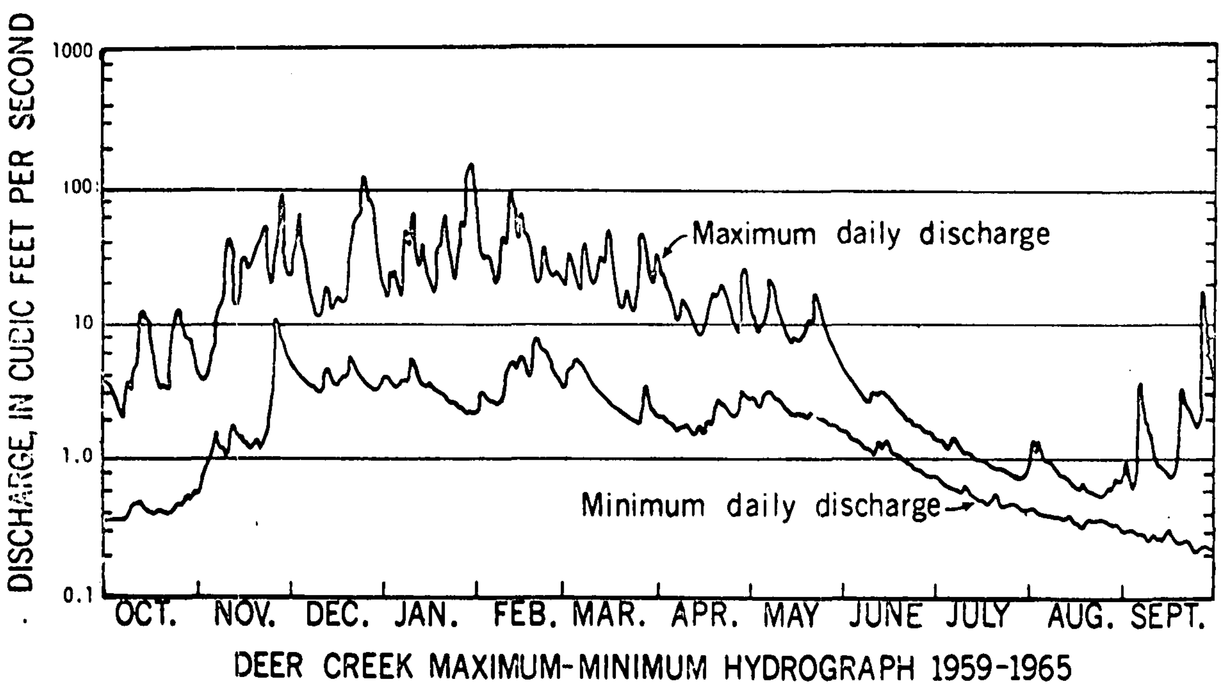


Fig. 27. Range and seasonal distribution of flows for Needle Branch and Deer Creek (from Ref. 4).

Table 30. Stream Gaging and Precipitation Stations Used in Flood and Storm Characteristics Analysis

USGS Gaging Stations No. (14-)		USWB Precipitation Stations Designation/Location
Regular Stations		
3015	Wilson River	Tilamook 11E - Just north and east of EPA sites 1-3; T1S, R8W.
3036	Nestucca River	
3061	N.F. Alsea River	Valzetz - Headwaters of the Siletz River; T8S, R8W.
3064	Five Rivers	
3065[a]	Alsea River	Drain 10NNW - Just south of the study area in the northern headwaters of the Umpqua River; T21S; R8W.
3069[b]	Big Creek	
307580	Lake Creek	
307620	Suislaw River	
307645	N.F. Suislaw River	
Crest-Stage Stations[c]		
3037	Alder Brook	
306830	Lyndon Creek	
307610	Suislaw Tributary	
307648	Condon Creek	

[a] Long-term reference station.

[b] At EPA Site 13.

[c] Same crest-stage stations as used in developing flood prediction equations.

Table 31. Selected Period Precipitation for Water Year 1975 at Three Oregon Coast Range Stations

Dates of Precip. Periods WY 1975	Cumulative Precipitation for Period		
	Tillamook	Valsetz	Drain
(1974)			
10/1 - 10/31		1.60	
10/27 - 10/31	0.90		1.06
11/17 - 11/27*	11.51	14.60	4.66
12/8 - 12/22		21.70	6.59
(1975)			
1/1-1/10	11.13	14.50	6.93
1/11 - 1/19	7.95	9.20	
1/22 - 1/26	6.44	7.40	1.90
2/1 - 2/20	13.44	18.90	8.53
2/25 - 2/28	1.90	2.50	1.10
3/1 - 3/9	2.77	3.50	1.46
3/13 - 3/24	10.00	13.70	7.98
4/1 - 4/4	1.65	2.30	0.95
4/18 - 4/28	3.21	5.40	2.62
5/2 - 5/5	3.69	4.40	1.52**

Further precipitation events not associated with large stream flows.

*Tillamook to 11/25/74
**to 5/8/75

Table 32. Average Three- and Seven-Day High Flows at Selected Gaging Stations in Water Year 1975 Corresponding to Periods of Heavy Precipitation

Dates of Runoff (Precipitation Gage)	Average Daily Flows (cfs) at					
	Sta 3015		Sta 3065		Sta 3069	
	3-Day	7-Day	3-Day	7-Day	3-Day	7-Day
	(Tillamook)		(Valsetz)		(Drain)	
3-Days (1974) 7-Days						
11/23 - 11/25*;11/20 - 11/26	4240	3213	1700	1408	283	218
12/20 - 12/22; 12/17 - 12/23	6917	4560	4273	3577	508	378
1/5 - 1/7; 1/4 - 1/10 (1975)	5310	4520	8400	7061	489	394
1/13 - 1/15; 1/12 - 1/18	10473	7046	----	----	422	317
2/12 - 2/14; 2/11 - 2/17	7597	4681	7640	5546	330	232
3/18 - 3/20; 3/17 - 3/23	3827	2947	6417	6154	328	302
4/2 - 4/4; 4/1 - 4/7	1080	994	1630	1581	99	92
4/25 - 4/27; 4/24 - 4/30	1223	1051	2060	1680	178	144

*Days are within one-day maximum variation in all instances; example: Sta 3065, 11/22 - 11/24.

Table 33. Three-Day High-Flow Runoff for Flynn Creek, Needle Branch, and Deer Creek (From Ref. 4).

Water year	Period of high flow	Runoff, in inches		
		Flynn Creek	Needle Branch	Deer Creek
1959	Nov. 19–21	3.58	4.19	3.94
	Jan. 8–10	4.86	5.36	4.70
	11–13	3.19	3.39	2.92
	27–29	3.86	4.41	4.16
1960	Feb. 6–8	3.39	3.07	3.56
	9–11	4.48	4.75	4.32
	15–17	2.19	1.86	2.03
1961	Nov. 23–25	5.82	6.29	5.69
	Feb. 10–12	6.06	6.27	5.97
	13–15	5.01	4.59	4.93
	Mar. 13–15	3.48	3.31	3.94
1962	Nov. 22–24	2.67	3.87	2.96
	Dec. 19–21	4.82	5.23	4.99
	Mar. 25–27	3.67	3.11	3.56
1963	Nov. 25–27	5.24	5.62	5.02
	Feb. 2–4	2.91	2.67	2.64
	Mar. 30–Apr. 1	2.77	2.80	2.26
1964	Jan. 6–8	3.34	3.84	3.27
	19–21	4.91	5.21	4.74
	24–26	4.48	4.41	4.70
	Mar. 11–13	2.53	3.07	2.45
1965	Nov. 30–Dec. 2	4.24	4.53	4.35
	Dec. 22–24	9.11	9.50	8.68
	25–27	4.77	4.42	4.80
	Jan. 27–29	11.11	11.71	11.82
Mean		4.50	4.70	4.50

as shown in Fig. 28.

6. Some trial solutions were made of the 3-day and 7-day high flow volumes as a function of precipitation for the streamflow and precipitation stations in Table 30. The results depend on the general nature and uniformity of storms, but between November and March the following relationships hold.

$$Q3HV = 1300 \text{ to } 1800[PS] \tag{26}$$

and

$$Q7HV = 2700 \text{ to } 4000[PS] \tag{27}$$

where Q3HV and Q7HV are the summation of average daily high flow volumes for 3- and 7-day periods (cfs - days) associated with the accumulated inches of precipitation in the storm (PS) period causing the high flows (inch - days) from a station in the region. The results under this section would be applicable only to the larger basins, but these relations could be developed for smaller USGS stations and then applied to the EPA sites later during verification.

7. Three regular USGS gaging stations have had recurrence interval analyses run on their average flow volumes of 3-day and 7-day high flows. These three data points for each average high flow (Q3H and Q7H) are for the yearly maximum peak hydrographs, but they do not have enough spread to define a definite relationship. If one refers to Fig. 23 (page 62) it appears that the relationship between these average cumulative high flows and $(P \cdot A \cdot \sqrt{H})$ are similar to those for annual peak flows of the same recurrence interval, such that

$$Q3H2 = 11.0(P \cdot A \cdot \sqrt{H})^{0.70} \tag{28}$$

and

$$Q3H50 = 65.0(P \cdot A \cdot \sqrt{H})^{0.60}, \tag{29}$$

where all terms are as previously defined. These equations could be used to estimate the 3-day high flow volumes for 2- and 50-year recurrence intervals at the EPA sites, and then the 7-day high flow volumes could be estimated using the equation from item 5, Q3H = 1.2(Q7H)

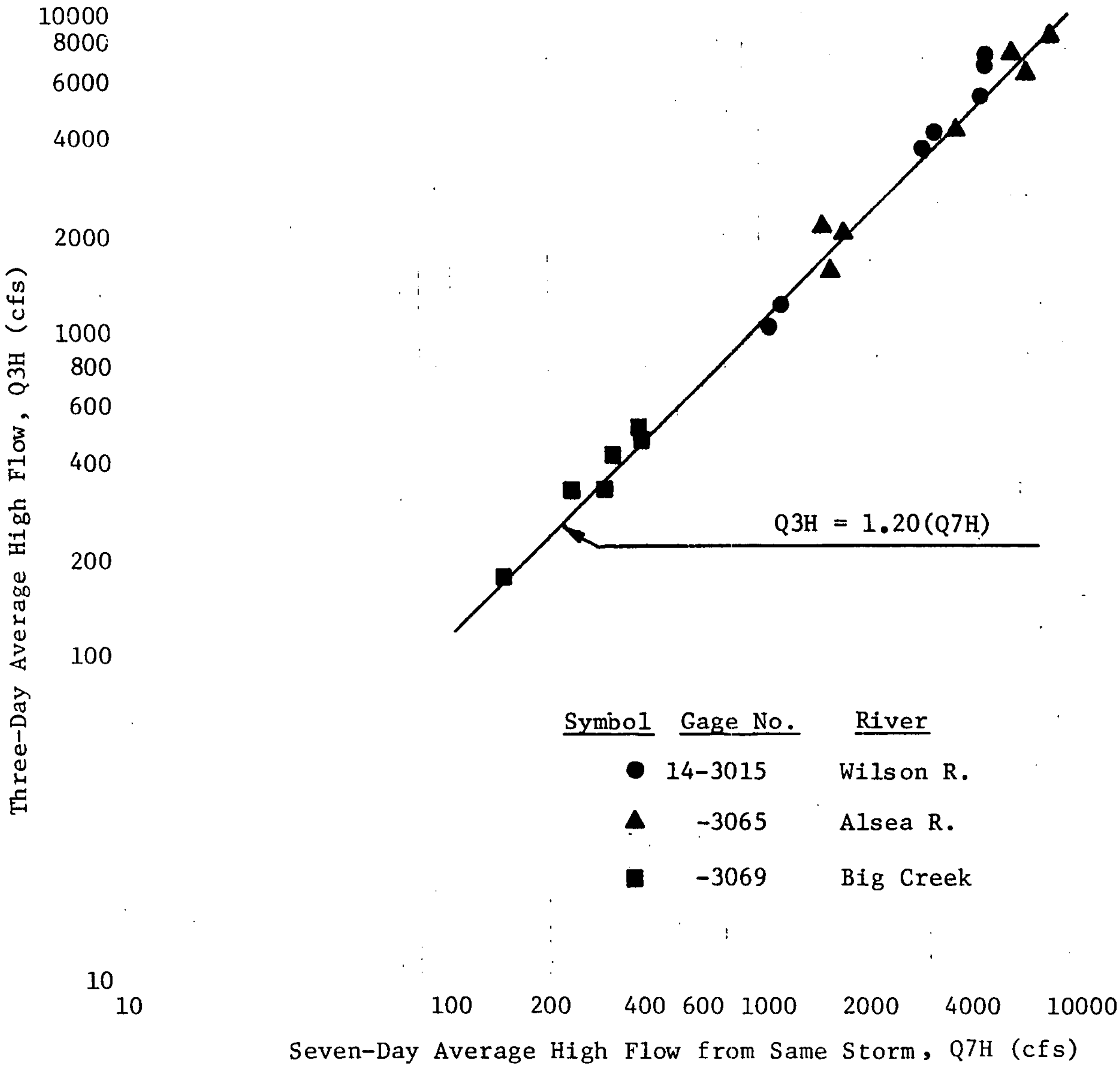


Fig. 28. Relationship Between Three- and Seven-Day Average High Flows Resulting from the Same Storms at Oregon Coastal Stream Gaging Stations.

which works regardless of the particular recurrence interval.

To verify this approach to average high flows over 3 and 7 days, the USGS could be requested to update the computer runs for the gaging stations in Table 30.

Anticipated Changes in Hydrologic Conditions

Voluminous amounts of literature have been written on the problems associated with the effects of logging in Oregon on streams and benthic conditions. A sample of this literature is cited in Appendix I - REFERENCES, and each entry includes some summary comments about the reference as it pertains to the particular EPA investigation on spawning gravel sites (1), (2), (3), (6), (7), (9), and (11).

Depending on the degree and type of logging-associated activity which is undertaken, and the geomorphic characteristics of the watershed(s) being affected, these general hydrologic changes can be anticipated assuming no significant departure from previous long-term precipitation conditions. There will be variability in the severity of these effects depending on the time when the land use activity was undertaken and the time of the related hydrologic event.

1. Roadbuilding associated with logging will cause a greater potential sediment hazard for spawning gravels than will logging;
2. If clearcutting is allowed along streambanks, summer temperatures will increase until bank brush returns and D.O. will drop both in the stream and intra-gravel;
3. If high flows do not occur soon enough following the deposition of sediments in the spawning gravels, vegetation may establish islands on bars and deny spawning areas until the watershed is healed and large floods occur;
4. Average monthly flows will increase following logging due to the decrease in evapo-transpiration and low flows may be increased enough to alter the correlations developed between EPA sites and USGS gaging stations in this study;
5. The flood hydrograph at the EPA sites will have a steeper rising limb and peak floods will be higher following logging than under existing conditions;
6. Semi-permanent to permanent channel changes may take place at the

EPA sites as a result of floods, debris load and increased sediment load above existing conditions.

A reference is included in the envelope on the back cover which describes the effects of forest density (debris) and stream channel geometry. The article is included in its entirety as Enclosure 1 as an input to future project planning on environmental impact assessments at the EPA sites. Depending on the amount of logging on these smaller watersheds, severe and long-term channel geometry changes could be the most significant impact.

RECOMMENDATIONS

1. Miscellaneous flow measurements should be made at a sample of the EPA sites in each geographic region to test the predicted flows.
2. The flow measurements taken in 1978 were taken on days when the flow was greater than the 7-day average, 2-year low flow (Q7L2); therefore some measurements should be taken at several sites during extended dry periods.
3. These miscellaneous measurements should be cross-correlated with the same day average flows (preferably against the flow at the same time) at USGS gages.
4. The USGS should be contacted about early access to their strip chart or telemetry data so that diurnal variations in flow, and the flow(s) at the time of the EPA site measurement can be determined at the gage(s).
5. Crest-stage gages should be installed at a sample of several EPA sites to obtain some flood data for verification of predicted values.
6. The crest-stage gage flows will have to be correlated against either other USGS crest-stage gages or regular gages to estimate the recurrence interval of the recorded peak flow; this must then be compared with the predicted flood RI graph for that EPA site.

7. A plan and handbook should be developed to establish procedures, timing, measurements, and applications for verification and utilization of the flows estimated in this study for the EPA sites.
8. Methods for defining and predicting flood hydrograph characteristics at the EPA sites should be explored and related to potential sediment load at a sample of sites so that land use impacts on the spawning gravels can be estimated.
9. A matrix of possible land-uses and effects on the gravel sites should be developed from the literature including data availability and analytical procedures.
10. A comparison should be made between the geomorphic drainage basin characteristics of the EPA sites and those under investigation by the U.S. Forest Service in the Suislaw National Forest; the results would be used to predict the impacts of land uses on the EPA basins and to design and guide the future monitoring programs at the EPA sites.
11. An investigation and assessment, including a photographic record (both overhead and ground-level) should be made of the stream characteristics at the EPA sites; this will provide the basis for evaluating morphological changes in channel conditions related to more than just the problems associated with accumulation of sediment in the spawning gravels.

APPENDICES

APPENDIX I. REFERENCES

APPENDIX II. GAGING STATION CORRELATIONS

APPENDIX I. REFERENCES

1. ALSEA WATERSHED STUDY-"Effects of Logging on the Aquatic Resources of Three Headwater Streams of the Alsea River, Oregon," Dept. of Fish and Wildlife, Corvallis, Oregon. Federal aid to Fish Restoration, Project AFS-58, Final Report in three parts.
   - Moring, John R. and Richard L. Lantz, "Part I--Biological Studies," October, 1975.
   - Moring, John R., "Part II--Changes in Environmental Conditions"
   - Moring, John R., "Part III--Discussion and Recommendations"

   (RESULTS OF THE 15-YEAR LOGGING STUDY, 1959-73, SHOWED SUMMER TEMPERATURES INCREASED UNTIL BANK BRUSH RETURNED, DISSOLVED OXYGEN CONTENT DROPPED, INTRA-GRAVEL D.O. DROPPED, MEAN MONTHLY STREAMFLOW INCREASED 27 PERCENT, AND SUSPENDED SEDIMENT INCREASED BY 205 PERCENT.)

2. Brown, George W. and James T. Krygier, "Clear-Cut Logging and Sediment Production in the Oregon Coastal Range," Water Resources Research, Vol. 7, No. 5, October, 1971.
   (SUMMARY REPORT AND DESCRIPTION OF THE ALSEA WATERSHED STUDY (Deer Creek, Flynn Creek and Needle Branch) NORTH OF DRIFT CREEK. INFORMATION ON SEDIMENT YIELDS CAUSED BY ROAD CONSTRUCTION AND VARIOUS OTHER LOGGING PRACTICES.)

3. Forestry, School of and School of Engineering, "Studies of the Effects of Watershed Practices on Streams," Oregon State University, EPA Grant No. 13010 EGA, February, 1971.
   (SUMMARIZES STATE OF THE ART FOR: 1) EFFECTS OF CLEARCUTTING ON STREAM TEMPERATURE; 2. PREDICTING EFFECTS ON PART 1; 3. HEAT LOSS FROM A THERMALLY LOADED STREAM; 4. HEAT FLOW IN STREAM BEDS; 5. CLEARCUT LOGGING AND SEDIMENT PRODUCTION IN THE OREGON COAST RANGE; AND 6. EVALUATION OF BED LOAD AND TOTAL SEDIMENT YIELD PROCESSES ON SMALL MOUNTAIN STREAMS.)

4. Harris, D. D. and R. C. Williams, "Streamflow, Sediment-Transport, and Water-Temperature Characteristics of Three Small Watersheds in the Alsea River Basin, Oregon," U.S. Geological Survey, Circular 642, 1971. (BASIC HYDROLOGIC DATA ON DEER CREEK, FLYNN CREEK AND NEEDLE BRANCH 1959-65, CONDUCTED ON THE USGS AS PART OF THE COOPERATIVE ALSEA WATERSHED STUDY.)

5. Harris, D. D., Larry L. Hubbard and Lawrence E. Hubbard, "Magnitude and Frequency of Floods in Western Oregon," U.S. Geological Survey Open-File Report 79-553, Prepared in Cooperation with the Oregon Dept. of Transp. Hgwy. Div., 1979. (RESULTS OF NEWEST REGRESSION ANALYSIS TO DETERMINE FLOODS IN WESTERN OREGON, USING BASIN CHARACTERISTICS OF DRAINAGE AREA, PERCENT OF LAKES AND PONDS, PERCENT FOREST COVER AND THE 24-HR., 2-YEAR PRECIPITATION INTENSITY; AVERAGE STANDARD ERROR IS 34 PERCENT.)

6. Ketcheson, Gary and Henry A. Froehlich, "Hydrologic Factors and Environmental Impacts of Mass Soil Movements in the Oregon Coast Range," Dept. of Forest Engr., WRRI, Oregon St. Univ., OWRT Agreement No. 14-34-001-7078, Project Completion Report, Sept., 1977. (STUDY CENTERED AROUND AREA NORTH OF SIUSLAW RIVER AND N.F. SMITH RIVER; GOOD REFERENCE LIST AND DISCUSSION OF SEDIMENT SOURCES.)

7. Lantz, Richard L., "Guidelines for Stream Protection in Logging Operations," Research Division, Oregon State Game Comm., August, 1971. (REPORT ON THE RESULTS OF THE ALSEA WATERSHED LOGGING STUDY ON DEER CREEK, FLYNN CREEK AND NEEDLE BRANCH.)

8. Lauman, Jim, Allan K. Smith and Kenneth E. Thompson, "Supplement to the Fish and Wildlife Resources of the North Coast Basin, Oregon, and Their Water Requirements, April, 1968," Oregon State Game Commission, Federal Aid to Fish Restoration, Completion Report, Fisheries Stream Flow Requirements, Project 69409, Job No. 14, Portland, Oregon, Jan., 1972. (STREAM FLOW DATA FOR 1970-71 ON ALDER CREEK, EAST FORK BEAVER CREEK, MOON CREEK, LITTLE NESTUCCA RIVER AND NESKOWIN CREEK.)

9. Moring, John R. and Richard L. Lantz, "Immediate Effects of Logging on the Fresh-Water Environment of Salmonoids," Oregon Wildlife Commission, Anadromous Fish Project Job Final Report, Proj. No. AFS-58, Job. No. 1, June 30, 1974.
(INTENSIVE STUDY AND DETAILED REPORT ON 12 COASTAL STUDY STREAMS ALL DIFFERENT THAN THOSE ANALYZED IN THIS REPORT. COMPARED WITH THE THREE STREAMS IN THE ALSEA RIVER WATERSHED: SEE RECOMMENDATIONS AND SUMMARY PAGES 78-84: EXTENSIVE LITERATURE.)

10. Orsborn, John F. et al., "Relationships of Low, Average and Flood Flows for Streams in the Pacific Northwest," Dept. of Civil and Environmental Engineering, Washington State University, OWRT Project A-074-WASH Completion Report, June 30, 1975.
(PROVIDES RELATIONS BETWEEN LOW, AVERAGE AND FLOOD FLOWS IN OREGON COASTAL STREAMS; ALSO FOR THE REST OF OREGON, IDAHO AND WASHINGTON)

11. Paustian, Steven J. and Robert L. Beschta, "The Sediment Regime of an Oregon Coastal Stream," Water Resources Bulletin, AWRA, Feb., 1979.
(DISCUSSION OF OAK CREEK SEDIMENT STUDIES, CHANNEL CHANGES, AND CUMULATIVE STORM AND SEDIMENT MASS CURVES.)

12. U.S. Geological Survey, "Gaging Station Data Computer Analysis Files for Oregon," Portland, Oregon, and Annual Water Data for Oregon.

13. Smith, Allan K. and Jim E. Lauman, "Fish and Wildlife Resources of the Middle Coast Basin, Oregon, and Their Water Requirements (Revised)," Oregon State Game Commission, Federal Aid to Fish Restoration, Completion Report, Fisheries Stream Flow Requirements, Project F-69-R-8, Job. No. 15, Portland, Oregon, March, 1972.
(STREAMFLOW DATA FOR 1970-71 ON GREEN RIVER, N.F. YACHATS RIVER, SCHOOL FORK, TENMILE CREEK, BIG CREEK, CAPE CREEK, SWEET CREEK AND INDIAN CREEK.)

APPENDIX II. GAGING STATION CORRELATIONS

Because there were only three USGS regular gaging stations in the study area which had reasonably long-term records, numerous correlations were made to extrapolate short-term records and provide more information on floods, average annual flows and low flows. USGS gage 143065 for the Alsea River near Tidewater was used as the base station. As shown in Table 34 all the other regular USGS gaging stations have been correlated against 3065 for average daily flows. Some correlations show unique characteristics such as the N.F. Suislaw River (14307645) where the correlation changes as a function of the amount of flow.

The correlations given in Figs. 29-33 are for Oregon State Game Commission (OSGC) Fish Life Flow Stations and selected USGS gaging stations (8)(13). The OSGC stations were selected because most of them have smaller drainage basins closer in size to those of EPA sites, and they are closer to the EPA sites in many cases than the USGS gages. By knowing the characteristic flows at the USGS gaging stations, they were estimated for the OSGC stations and then compared with the predicted characteristic flows for the EPA sites. These correlations will be useful during verification and monitoring of the flows at the EPA sites.

The correlations shown in Fig. 34 were used to extrapolate the short-term data for the three gaging stations in the Suislaw Basin (307580, 307620, and 307645). They have been in operation for only eleven years and statistical analyses of their low and high flows have not been completed by the USGS. These gaging stations were used for predicting and verifying the flow estimates at the EPA sites.

Table 34. USGS Gaging Station Cross-Correlations of Daily Flows, Oregon Coastal Streams

Name	No.	Drainage Area (sq mi)	Equation
Wilson River near Tillamook	14-3015	161	$Q(3015) = 0.84Q(3065)$
Nestucca River near Beaver	-3036	180	$Q(3036) = 1.40Q(3015)^{0.94}$
N.F. Alsea River at Alsea	-3061	63	$Q(3061) = 0.20Q(3065)$
Five Rivers near Fisher	-3064	114	$Q(3064) = 0.38Q(3065)$
Alsea River near Tidewater	-3065	334	(Unity)
Big Creek near Roosevelt Beach	-3069	12	$Q(3069)\Big\|_{1}^{25} = 0.026Q(3065)^{1.25}$ $Q(3069)\Big\|_{25}^{Max} = 0.23Q(3065)^{0.85}$
Lake Creek near Deadwood	-307580	174	$Q(307580) = 0.20Q(3065)^{1.10}$
Suislaw River near Mapleton	-307620	588	$Q(307620) = 0.82Q(3065)^{1.07}$
N.F. Suislaw River near Minerva	-307645	41	$QA1(307645) = 0.22QA1(3065)^{1.00}$ $QL1(307645) = 0.022QL1(3065)^{1.50}$ $QF1(307645) = 0.0023QF1(3065)^{1.50}$

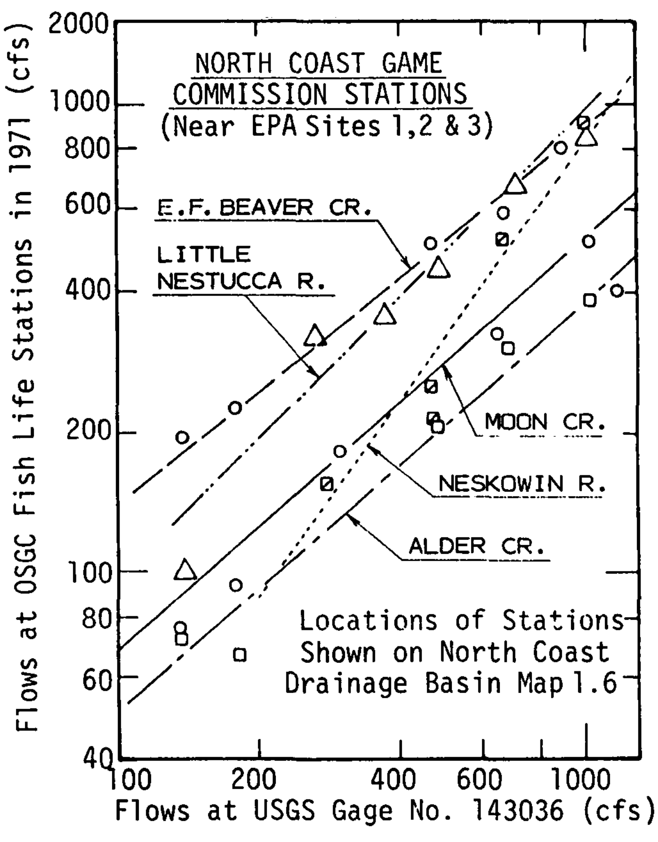


Fig. 29. Correlation of Oregon State Game Commission Fish Life Flow--Station Flows in 1971 With Same Day Flows at USGS Gage 143036, Nestucca River Near Beaver, Oregon

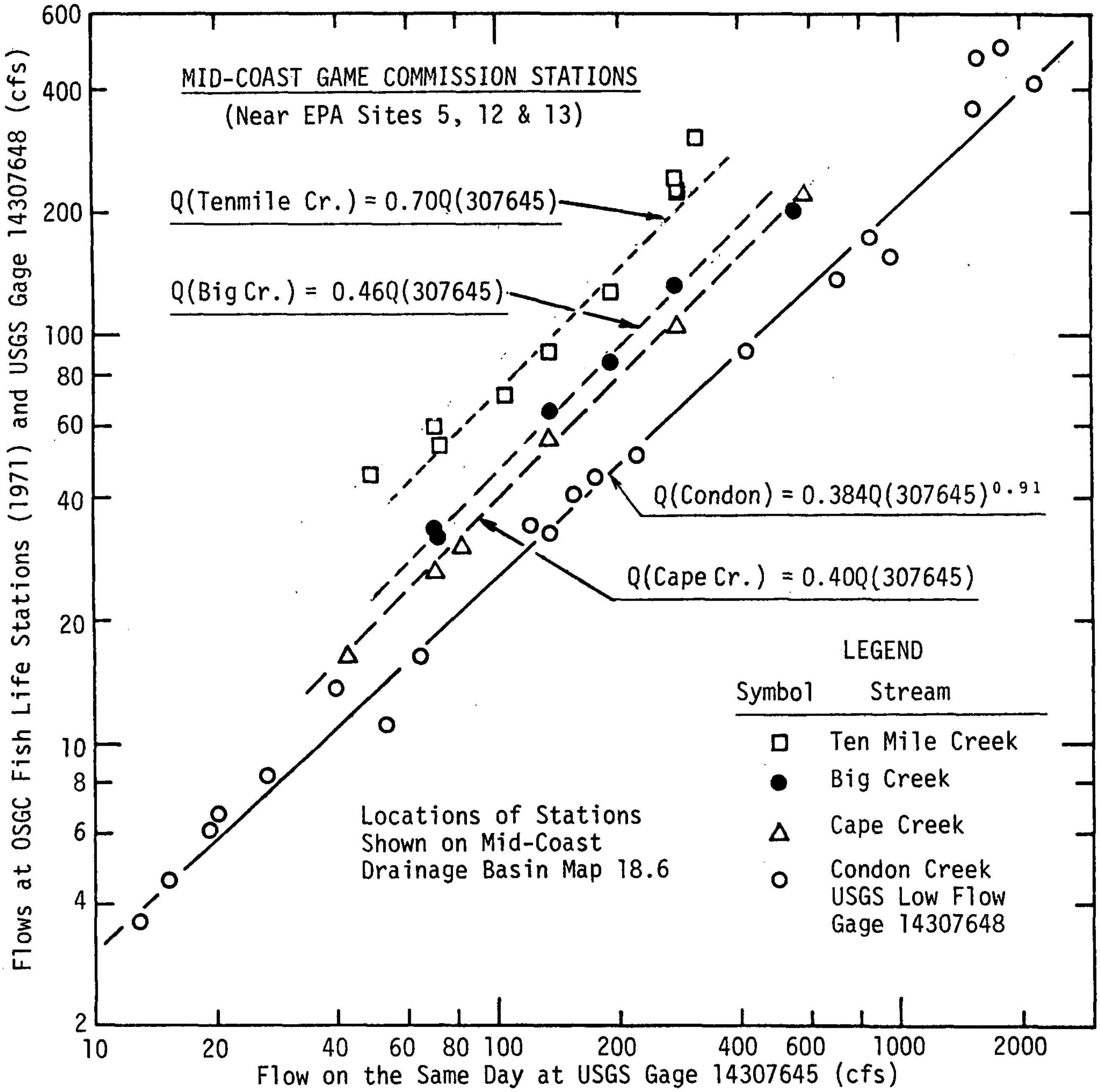


Fig. 30. Correlation of Miscellaneous Flow Measurements at Oregon State Game Commission Fish Life Flow Stations and USGS Low Flow Station with USGS Gaging Station 14307645, North Fork Siuslaw River Near Minerva, Oregon

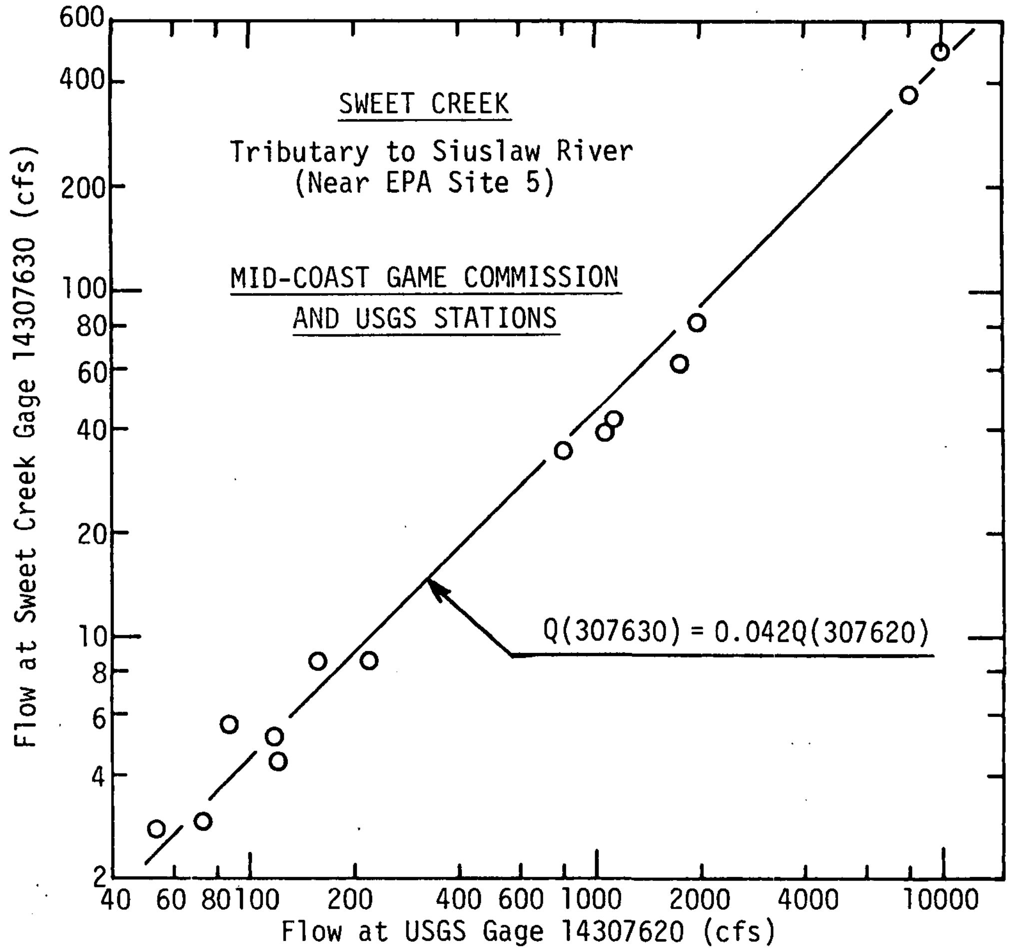


Fig. 31. Correlation of Daily Flow in Sweet Creek at USGS Miscellaneous and Oregon Game Commission Fish Life Flow Stations with USGS Gaging Station 14307620, Siuslaw River Near Mapleton

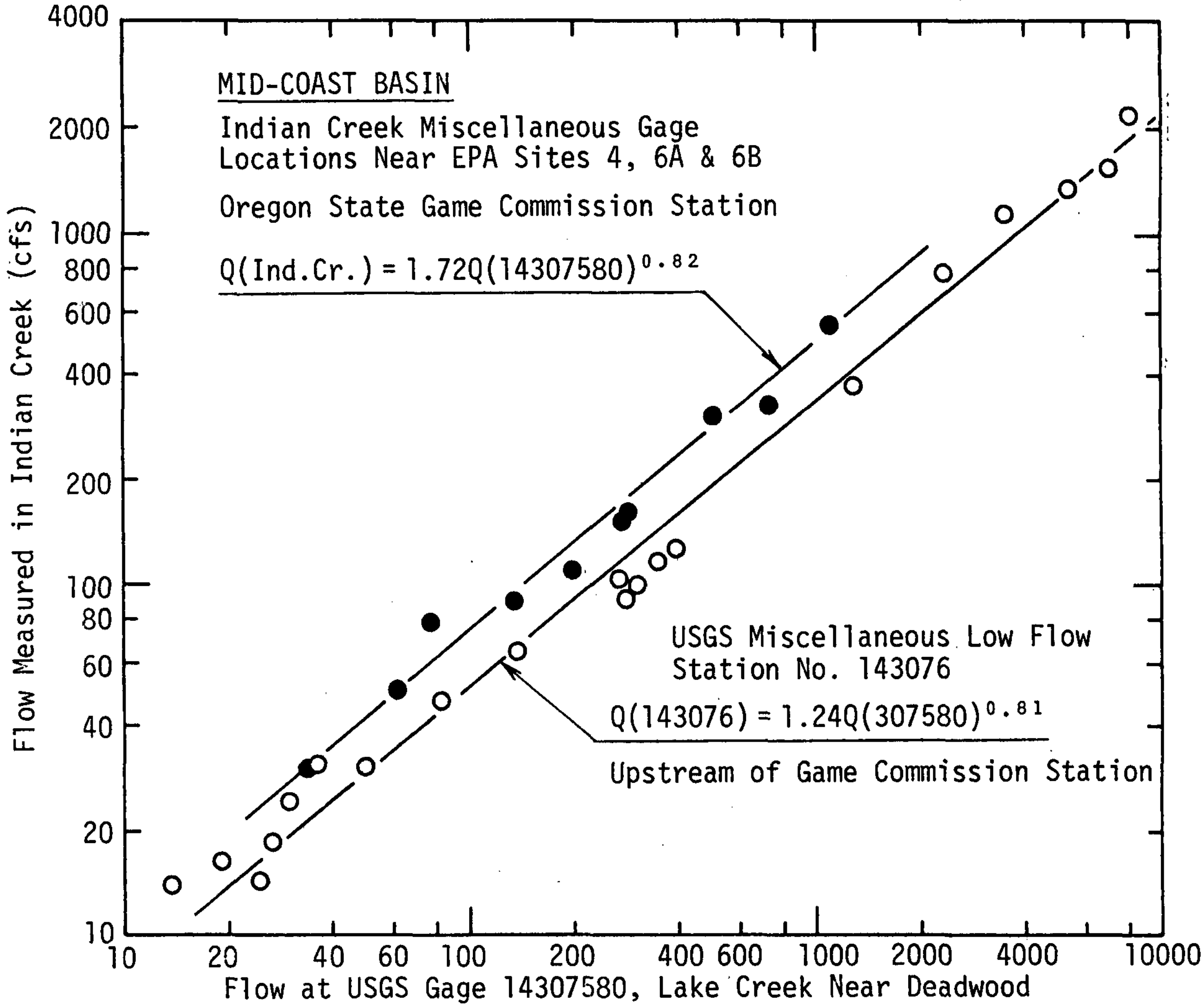


Fig. 32. Correlation of Indian Creek Flows at Miscellaneous Gaging Sites with USGS Gage on Lake Creek Near Deadwood, Oregon

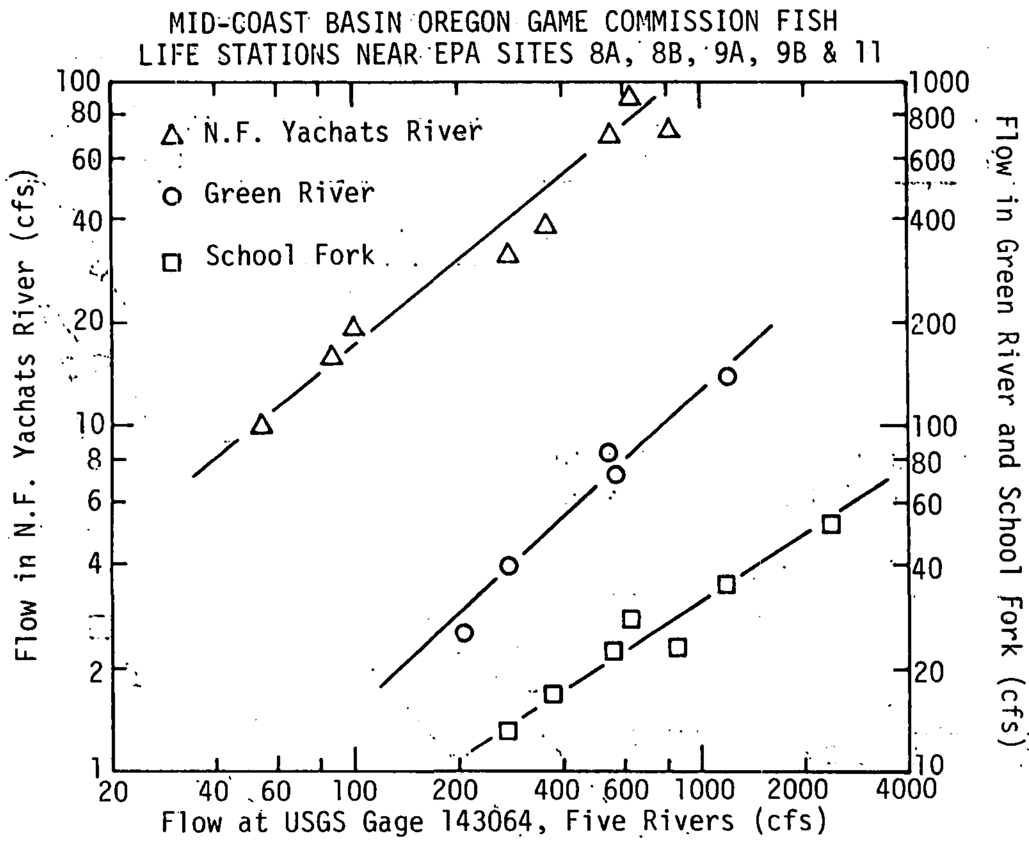


Fig. 33. Correlations of Flows Between Oregon State Game Commission Fish Life Flow Stations in 1971 and USGS Gage on Five Rivers Near Fisher, Oregon

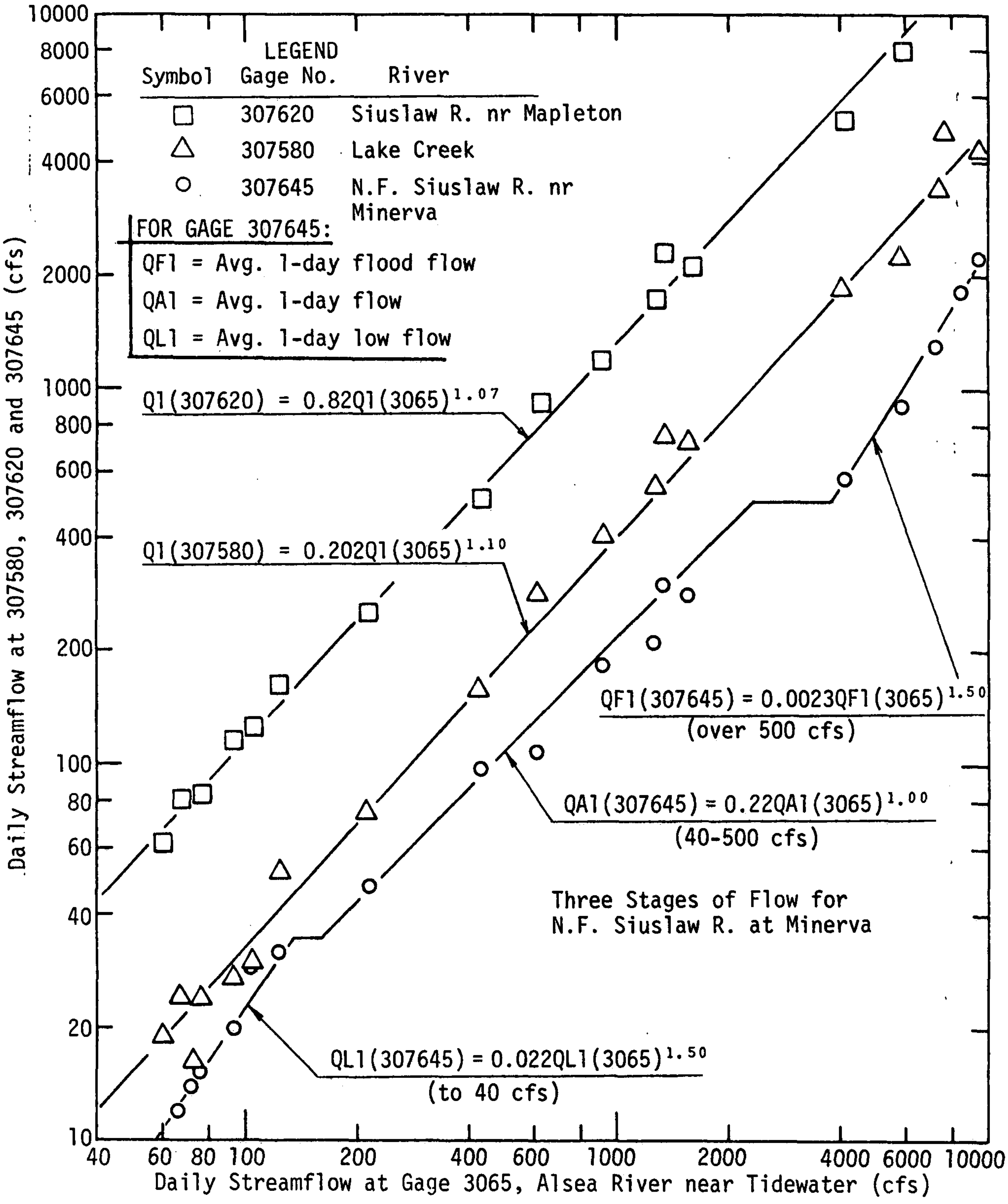


Fig. 34. Correlation of Short-Term USGS Gaging Stations with Long-Term Gage 3065 on Alsea River, Oregon

REVISIONS AND ERRATA IN REPORT

"Estimating Streamflow Characteristics at Spawning Sites in Oregon"

by John F. Orsborn, EPA-B0687NNEX/Shirazi

July 31, 1979

Page	Change
ii	Add p. 89 on last line. done
iii	Fig. 2, Mape to Map
1	First paragraph revised to read:

The locations of the EPA gravel test sites, hereinafter referred to as the "EPA sites", are shown in a series of maps on pages 14-34. These location maps were drawn from 1:62,500 (15 min) scale USGS topographic maps. The USGS maps on which each EPA site and its watershed are located are listed on the site summary tables between pages 13-35. An index to these EPA site maps and summary tables is given in Table 7 on page 12.

Add note to bottom of page:

An index to EPA site summary tables and location maps is given in Table 7 on page 12.

Page	Change
6	Delete portion of footnote "locations shown on Maps 1.6 and 18.6".
10	Delete asterisk (*) from heading "Location" and accompany footnote.
17	Change value under "Low Flows, 20-Yr" at bottom on page from 0.60 to 0.50.
19	Change OSCG to OSGC in figure caption.
37	Clarify footnote to read: d = small diversions above station, D = large diversion, r = minor regulation.
38	Delete phrase "(see Map 18.6)" in middle of second paragraph under subtitle "Basin Characteristics; Change "Bol." to "Col." in middle of third paragraph.
41	Under Eq. (4), delete portion of following sentence, "Referring to the Maps 1.6 and 18.6", capitalize the "T" of "The streams...", and change "and" to "are" in same sentence to read "Eq. 2 are those..." In second paragraph, delete phrases "(Map 1.6)" and "(Map 18.6)" at beginning and in the middle.

Page	Change
55	Add note under figure caption: The highest line in Fig. 18 shows the equation QAA = 0.078(P·A). But, this is a physical impossibility because one (1.0) square-mile-inch of precipitation can generate a maximum of only 0.0737 cfs, even if there is 100% runoff of all annual precipitation. Therefore, both Stations 3029 and 3069 should probably be on the middle line with the equation QAA = 0.065(P·A).
59	Change "Cubes" to "Cubed" in horizontal axis title.
63	Change "27" to "27A" in second line of page. Change "Q7LZ" to "Q7L2" in bottom paragraph, 1b and 1d.
67	In lower middle of page, change "was" to "were" to read, "...but were of sufficient length..." In last line of page before the footnote, add "(10)" following the end of the sentence, ..."recurrence interval. (10) Rather than..."
73	In last line of page, change "flow" to "flows" to read "...winter peak flows..."
78	Change title of Table 32 to read "Average Three- and Seven-Day..." instead of "Cumulative Three- and Seven-Day..."
81	Change "Storm" to "Storms" in middle line of figure caption to read "...the Same Storms..."