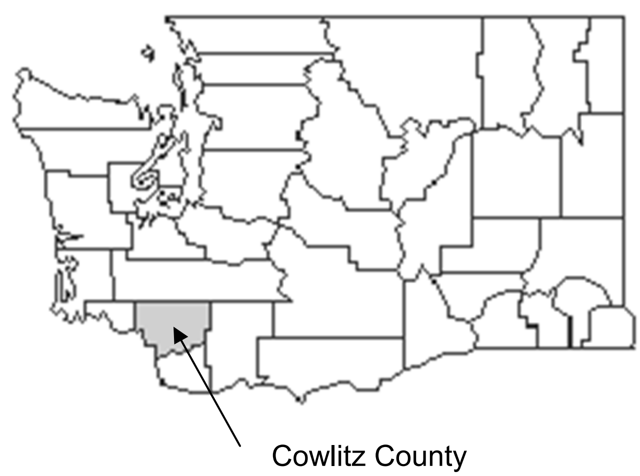
FLOOD INSURANCE STUDY

VOLUME 1 OF 3

COWLITZ COUNTY, WASHINGTON
AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
CASTLE ROCK, CITY OF	530277
COWLITZ COUNTY, UNINCORPORATED AREAS	530032
KALAMA, CITY OF	530289
KELSO, CITY OF	530033
LONGVIEW, CITY OF	530034
WOODLAND, CITY OF	530035



EFFECTIVE DATE: DECEMBER 16, 2015

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
53015CV001A

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) report may not contain all data available within the Community Map Repository. Please contact the Community Map Repository for any additional data.

The Federal Emergency Management Agency (FEMA) may revise and republish part or all of this FIS report at any time. In addition, FEMA may revise part of this FIS report by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS report. Therefore, users should consult with community officials and check the Community Map Repository to obtain the most current FIS report components.

Selected Flood Insurance Rate Map (FIRM) panels for this community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map (FBFM) panels (e.g., floodways, cross sections). In addition, former flood hazard zone designations have been changed as follows:

Old Zone(s)	New Zone
Al through A30	AE
B	X
C	X

Initial Countywide FIS Effective Date: December 16, 2015

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FLOOD INSURANCE STUDY
COWLITZ COUNTY, WASHINGTON
AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Cowlitz County, including the Cities of Castle Rock, Kalama, Kelso, Longview, and Woodland; and the Unincorporated Areas of Cowlitz County (referred to collectively herein as Cowlitz County).

This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

The City of Woodland is located in both Cowlitz and Clark Counties, Washington. The City of Woodland will be shown in its entirety in this FIS report.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State or other jurisdictional agency will be able to explain them.

The Digital Flood Insurance Rate Map (DFIRM) and FIS report for this countywide study have been produced in digital format. Flood hazard information was converted to meet the Federal Emergency Management Agency (FEMA) DFIRM database specifications and Geographic Information System (GIS) format requirements. The flood hazard information was created and is provided in a digital format so that it can be incorporated into a local GIS and be accessed more easily by the community.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

This FIS was prepared to include all jurisdictions within Cowlitz County into a countywide format FIS. Information on the authority and acknowledgements for each of the previously printed FISs for communities within Cowlitz County was compiled, and is shown below.

Castle Rock, City of	For the original January 19, 1982 study, the hydrologic and hydraulic analyses were performed by Tudor Engineering Company, for FEMA, under Contract No. H-4025. That study was completed in September 1978 (Reference 1). For the September 30, 1993 restudy, the hydrologic and hydraulic analyses were performed by the U.S. Army Corps of Engineers (USACE), Portland District, for FEMA under Interagency Agreement No. EMW-90-E-3263, Project Order No. 12, dated August 3, 1990. The restudy was completed in May 1991 (Reference 1). For the December 20, 2001 restudy, the hydrologic and hydraulic analyses were prepared by the USACE, Portland District. Floodway and additional hydraulic analyses were prepared by Michael Baker Jr., Inc., the Technical Evaluation Contractor, for FEMA (Reference 1).
Cowlitz County, Unincorporated Areas	For the original October 1980 study, the hydrologic and hydraulic analyses were performed by Tudor Engineering Company, for the FEMA, under Contract No. H-4025. This work, which was completed in June 1979, covered all significant flooding sources affecting Cowlitz County (Reference 2). For the September 2, 1993 restudy, the hydrologic and hydraulic analyses were performed by the USACE, Portland District, for the FEMA under Interagency Agreement No. EMW-90-E-3263, Project Order No. 12, dated August 3, 1990. This work was completed in May 1991 (Reference 2). For the June 2, 1995 restudy, the hydraulic analyses were performed by Northwest Hydraulic Consultants, Inc. (NBC), for the FEMA under Limited Map Maintenance Program Contract No. EMW-90-L-3134. This work was completed in November 1992 (Reference 2). For the July 7, 1999 restudy, the hydrologic and hydraulic analyses were performed by NBC, for FEMA, under Limited Map Maintenance Program Contract No. EMW-93-C-4152. This work was completed in July 1994 (Reference 2). For the December 20, 2001 restudy, the hydrologic and hydraulic analyses were prepared by the USACE, Portland District. Floodway and additional hydraulic analyses were prepared by Michael Baker Jr., Inc., the Technical Evaluation Contractor, for FEMA (Reference 2).

Kalama, City of	For the original December 1, 1980 study, the hydrologic and hydraulic analyses were performed by Tudor Engineering Company, for the Federal Insurance Administration (FIA), under Contract No. H-4025. This work, which was completed in October 1979, covered all significant flooding sources affecting the City of Kalama (Reference 3).
Kelso, City of	For the original August 1, 1980 study, the hydrologic and hydraulic analyses were performed by the USACE, Portland District, for the FIA, under Interagency Agreement No. IAA-H-16-75, Project Order No. 19. That study was completed in July 1978 (Reference 4). For the September 2, 1993 restudy, the hydrologic and hydraulic analyses were performed by the USACE, Portland District, for FEMA, under Interagency Agreement No. EMW-90-E-3263, Project Order No. 12, dated August 3, 1990. This study revision was completed in May 1991 (Reference 4). For the December 20, 2001 restudy, the hydrologic and hydraulic analyses were prepared by the USACE, Portland District. Floodway and additional hydraulic analyses were prepared by Michael Baker Jr., Inc., the Technical Evaluation Contractor, for FEMA (Reference 4).
Longview, City of	For the original August 1, 1980 study, the hydrologic and hydraulic analyses were performed by the USACE, Portland District, under Interagency Agreement No. IAA-H-16-75, Project Order No. 19. This work, which was completed in August 1978, covered all significant flooding sources affecting the City of Longview (Reference 5). For the September 2, 1993 restudy, the hydrologic and hydraulic analyses were performed by the USACE, Portland District, for FEMA, under Interagency Agreement No. EMW-90-E-3263, Project Order No. 12, dated August 3, 1990. This restudy was completed in May 1991 (Reference 5). For the December 20, 2001 restudy, the hydrologic and hydraulic analyses were prepared by the USACE, Portland District. Floodway and additional hydraulic analyses were prepared by Michael Baker Jr., Inc., the Technical Evaluation Contractor, for FEMA (Reference 5).

Woodland, City of	For the original September 4, 1985 study, the hydrologic and hydraulic analyses were performed by the U.S. Geological Survey (USGS), for FEMA, under Inter-Agency Agreement No. IAA-H-20-74, project Order No. 17. This study was completed in 1976 (Reference 6). The hydrologic and hydraulic analyses for the Lewis River were revised by the USACE, Portland District, in 1978 to reflect 70,000 acre-feet of available flood control storage on the Lewis River at Merwin Dam (Reference 6).

For this countywide revision, the DFIRM database and mapping were prepared for Washington Department of Ecology and FEMA by STARR (a joint venture between Greenhorne & O'Mara, Inc., CDM, Stantec and Atkins) under the Joint Venture Contract No. HSFEHQ-09-D-0370, Task Order Number HSFE10-09-J-0002 and by Tetra Tech under Contract No. C0400289. Work on the countywide report was completed in January 2010.

Floodplain boundaries were remapped as part of the countywide update to reflect more recent or more detailed topographic and base map data for the county. The floodplain mapping updates consisted of a mixture of redelineation and rectification (refinement) of existing flood boundaries based on the best topographic data available at the time of the study, aerial photography, and digital road network base map data.

LiDAR data were acquired from Puget Sound LiDAR Consortium and topographic contours were developed for areas with new data available. Additional topographic data were acquired from Cowlitz County.

The digital base map information was provided by Cowlitz County. The coordinate system used for the production of the FIRM is Universal Transverse Mercator, North American Datum of 1983, Geodetic Reference System 1980. Differences in the datum and spheroid used in the production of FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information shown on this FIRM.

1.3 Coordination

An initial Consultation Coordination Officer's (CCO) meeting is held typically with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of a FIS and to identify streams to be studied by detailed methods. A final CCO meeting is held typically with the same representatives to review the results of the study. The initial and final meeting dates for the previous FIS reports for Cowlitz County and its communities are listed in Table 1, "Initial and Final CCO Meetings".

Table 1 – Initial and Final CCO Meetings

Community Name	Initial Meeting	Intermediate Meeting	Final Meeting
Castle Rock, City of	April 13, 1976	July 6, 1976 September 11, 1978 February 12, 1979 February 8, 1990 April 1990	October 26, 1992
Cowlitz County, Unincorporated Areas	April 14, 1976	July 6, 1976 April 24, 1979	November 18, 1999
Kalama, City of	April 14, 1976	July 6, 1976	June 10, 1980
Kelso, City of	February 1975	June 26, 1975 January 19, 1978 December 5, 1978 February 8, 1990 April 1990	September 29, 1992
Longview, City of	February 1975	June 26, 1975 January 19, 1978 December 14, 1978 February 8, 1990 April 1990	September 29, 1992
Woodland, City of	*	*	September 12, 1976

* Data Not Available

For this countywide report, the final CCO meeting was held on July 22, 2013, in the City of Kelso and attended by representatives of FEMA, STARR., WA Department of Ecology and the local communities of the cities of Castle Rock, Kalama, Kelso, Longview, Woodland and Cowlitz County. All problems raised at that meeting have been addressed.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Cowlitz County, Washington, including the jurisdictions listed in Section 1.1.

Table 2, "Areas Studied by Detailed Methods" lists the streams studied by detailed methods.

Table 2 – Areas Studied by Detailed Methods

Stream Name	Limits of Detailed Study
Abernathy Creek	From its confluence with Columbia River to a point approximately 320 feet upstream of its confluence of Erick Creek
Arkansas Creek	From its confluence with Cowlitz river to a point approximately 1.25 miles upstream of Cline Road
Coal Creek	From 1,850 feet downstream of its confluence with Harmony Creek to a point approximately 2.25 miles upstream of Carlon Loop Road
Columbia River	From 740 feet downstream of its confluence with Germany Creek to a point approximately 4.76 miles upstream of confluence of Kalama River
Coweeman River	From its confluence of Goble Creek to a point approximately 1.16 miles upstream of its confluence with Sam Smith Creek
Coweeman River (Lower Reach Near Kelso)	From its confluence with Cowlitz River to a point approximately 2.2 miles upstream of Kelso Drive
Cowlitz River	From its confluence with Columbia River to a point approximately 3.13 miles upstream of its confluence of Toutle River
Delameter Creek	From its confluence with Arkansas Creek to a point approximately 530 feet upstream of it confluence with Monahan Creek
Germany Creek	From its confluence with Columbia River to a point approximately 5.52 miles upstream
Goble Creek	From its confluence with Coweeman River to a point approximately 2,900 feet upstream of South Goble Creek Road
Harmony Creek	From its confluence with Coal Creek to a point approximately 4,600 feet upstream of Harmony Drive
Kalama River	From its confluence with Columbia River to a point approximately 2.87 miles upstream of Weyerhaeuser Bridge
Lewis River	From 3.45 miles downstream of confluence with East Fork Lewis River to a point approximately 1.2 miles upstream of confluence with Huskey Creek
Mill Creek	From its confluence with Columbia River to the Cowlitz-Wahkiakum County border
Monahan Creek	From its confluence with Delameter Creek to a point approximately 1,580 feet upstream
North Fork Goble Creek	From its confluence with Goble River to a point approximately 1.63 miles upstream of North Goble Creek Road

Table 2 – Areas Studied by Detailed Methods (Continued)

Stream Name	Limits of Detailed Study
Ostrander Creek	From 1585 feet upstream of confluence with Cowlitz River to a point approximately 500 feet upstream of Railroad
South Fork Ostrander Creek	From its confluence with Ostrander Creek to a point approximately 4,435 feet upstream of Railroad
Toutle River	From confluence with Cowlitz River to a point approximately 2,550 feet upstream of Tower Road

Several streams in areas of little or no development, in addition to streams designated by FEMA, were studied by approximate methods. These areas are listed in Table 3, "Areas Studied by Approximate Methods".

Table 3 – Areas Studied by Approximate Methods

Arkansas Creek	Ostrander Creek
Baxter Creek	Outlet Creek
Columbia River	Owl Creek
Coweeman River	McCorkle Creek
Cowlitz River	North Fork McCorkle Creek
Creek at Esoh Road	North Fork Owl Creek
Falls Creek	North Fork Toutle River
Fish Pond Creek	Schoolhouse Creek
Leckler Creek	Slide Creek
Lewis River	South Fork Toutle River
Little Kalama River	Toutle River
Olequa Creek	

Initially, McCorkle Creek, North Fork McCorkle Creek, North Fork Toutle River, and South Fork Toutle River were studied by detailed methods. However, due to the eruption of Mount St. Helens, it was decided by FEMA to study and delineate these areas by approximate methods, with the intention that a detailed study will be made of these streams at a later date.

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1984.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by FEMA, Cowlitz County, and Cowlitz County Consolidated Diking Improvement District (CDID) #1.

This countywide FIS incorporates the determinations of Letter of Map Revisions (LOMRs) issued by FEMA, for the projects listed by community in Table 4, "Letters of Map Change (LOMCs)".

Table 4 – Letters of Map Change (LOMCs)

Community Name	Case Number	Stream(s) / Project Identifier	Date
Cowlitz County, Unincorporated Areas	92-10-010P	Reflects updated hydraulic analysis based on updated topographic data along the North Fork of Lewis River through the Lewis River Golf Course	February 2, 1993
Cowlitz County, Unincorporated Areas	95-10-012P	Reflects updated floodplain and floodway boundaries within Cowlitz County based on updated topographic information along the Columbia River from just upstream to approximately 2.4 miles upstream of the confluence of Coal Creek Slough	February 13, 1995
Cowlitz County, Unincorporated Areas	01-10-401P	Modify base flood elevations (BFEs) of ponding areas along Ostrander Creek that results from the existing culvert system under Pleasant Hill Road, Interstate Highway 5 (I-5) and North Pacific Avenue	February 13, 2002
City of Kelso	05-10-0774P	Reflects updated detailed hydraulic analyses and more detailed topographic information along Coweeman River from just downstream of the Burlington North/ Union Pacific Railroad to just upstream of I-5	October 30, 2006

FIS Restudies

In 1978, a detailed study was made of flooding from the Columbia, Cowlitz, and Coweeman Rivers. Approximate study methods were used to identify ponding from interior drainage inside the levees of the CDID #1 and #3 and the Cowlitz County Drainage Improvement District No.1.

In the 1989 restudy, the BFEs and flood boundary delineations for the Lewis River were updated, and a flooding mismatch between Cowlitz County, Washington and the City of Woodland, Washington (based on data prepared by the USACE, Portland District) was corrected.

In the September 2, 1993 restudy, approximately 23 miles of the Cowlitz River and 3.6 miles of the Toutle River were studied by detailed methods, in a re-analysis of the upstream changes in peak discharges and floodplain topography following the eruption of Mount St. Helens in May 1980.

The Cowlitz River and portions of the Toutle River were studied by detailed methods prior to the eruption. Those data were not included in the Cowlitz County Flood Insurance Study dated August 1, 1980, due to the eruption occurring on May 18, 1980, just prior to the scheduled publication. Since then the USACE has completed two engineering projects designed to stabilize the floodplain regime of the Cowlitz River: the construction of a SRS at RM 13.2 on the North Fork Toutle River, and the final post-eruption dredge of the Cowlitz River. However, both the sedimentation in the channel bottom and the deposit of dredge spoils in the floodplain tended to increase 1-percent-annual-chance flood elevations.

The water-surface profiles for Coweeman River were updated to reflect the changes in its lower reach as a result of the changes in the Cowlitz River peak flood elevations. Approximately 4.8 miles above the mouth of the Coweeman River were affected by the changes.

In the June 2, 1995 restudy, BFEs were added, Special Flood Hazard Areas (SFHA) changed, and zone designations for the Toutle River, from approximately 3.15 miles upstream of the confluence with Cowlitz River to approximately 0.5 mile upstream of Tower Road, were changed.

In the July 7, 1999 restudy, the 1-percent-annual-chance floodplain boundary for the Toutle River system was delineated, using approximate methods, to reflect the changes to the river system that resulted from the May 18, 1980, eruption of Mount St. Helens. The main channel was studied from River Mile (RM) 6.6 to the confluence of the North and South Forks. The North Fork reach extends from the confluence to approximately 11.7 miles upstream at the base of the USACE Sediment Retention Structure (SRS). The South Fork begins at the confluence and extends upstream 8.6 miles. The effective FIRM dated September 2, 1993, does not reflect the flood risk of the present channel configuration because it was created prior to the eruption of Mount St. Helens.

In the December 20, 2001 restudy, the 1-percent-annual-chance flood boundary delineation was updated along the Cowlitz River from the confluence with the Columbia River to approximately 1-mile downstream of Miekler Road. This restudy also includes the USACE-recertified Cowlitz River Levee system, which protects the Cities of Castle Rock, Kelso, and Longview. Revised BFEs and floodplain boundary delineations are included in this restudy for the Cowlitz River from the mouth to RM 23.

2.2 Community Description

Cowlitz County is located in the southwestern corner of Washington; approximately midway between the mouth of Columbia River and the City of Portland, Oregon. The County is bordered to the north by Lewis County, Washington; to the east by Skamania County, Washington; to the south by Clark County, Washington; to the southwest by Columbia County, Oregon; and to the west by Wahkiakum County, Washington. The County seat is the City of Kelso, and its largest city is the City of Longview. The County has a land area of approximately 1,140 square miles. The population of Cowlitz County in the year 2000 was 92,948 (Reference 7). Cowlitz County is also home to the famed Mount St. Helens volcano.

Cowlitz County has mid-latitude, west coast, marine-type climate with cool and relatively dry summers; and mild, wet, mostly cloudy winters. The climate in Cowlitz County is influenced by the flow of air along the Columbia River valley. In the fall, freezing temperatures can be expected after the middle of October, with minimum winter temperatures of from 5°F to 10°F. The lowest recorded temperature was 1ºF in 1950 (Reference 8). In the spring, the last freezing temperatures can be expected in mid-April in the lower valleys and mid-May in the colder localities. Maximum July temperatures average from 75°F to 80°F, but have occasionally reached from 100°F to 105°F, generally during periods of dry easterly winds (Reference 9). The highest recorded temperature was 108ºF in 1981.

Average annual precipitation ranges from 40 inches near Columbia River to 90 inches at the 1,000-foot elevation in the Cascade Range foothills. Annual snowfall is in the range of from 10 to 50 inches at lower elevations and as much as 250 to 350 inches in the upper Cascade Range. However, normal annual precipitation varies between 43 and 48 inches. Most of the precipitation occurs between November and January (Reference 10). The average annual snowfall is 1ight and seldom remains on the ground longer than one week or reaches a depth in excess of 8 to 12 inches (Reference 9).

Forest products provide the mainstay of the economy of Cowlitz County with 37.2 percent of wage and salary earners employed in lumber and the manufacture of wood products, paper, and allied products (Reference 11). The volume of timber harvest is the largest of any county in the state. The 1974 total of 729 million board feet represented 10.6 percent of the state total (Reference 11). Although forest products and allied industries (such as chemical plants producing plywood adhesive and paper-bleaching compounds) are predominant in the economic base, a number of other industries make an important contribution. Among these are aluminum smelting and the manufacture of pleasure boats and mobile homes. Agriculture is confined to 70 square miles of farmland, on which dairy and poultry products are predominant.

Soils generally consist of rich, organic surface material underlain by accumulations of clay. The vegetation in the area consists predominantly of Cedar, Hemlock, and Douglas-fir forest.

There is generally only minor residential development along some of the Cowlitz County floodplains. Other floodplains have no development within the county.

Drainage within Cowlitz County is southerly and westerly to Columbia River. (A 5-square-mile area in the northwestern corner of Cowlitz County is in the catchment of Chehalis River in Lewis County, Washington.) The principal river systems are the Columbia, Coweeman, Cowlitz, Kalama, Lewis, and Toutle Rivers.

Upstream of the Wahkiakum/Cowlitz County limits at RM 52.0, Columbia River drains approximately 256,000 square miles on the western slope of the Continental Divide in the northwestern part of the United States and southwestern Canada. Major parts of the States of Washington, Idaho, and Oregon, and small parts of the States of Montana, Wyoming, Utah, and Nevada, in addition to southeastern British Columbia, are within the Columbia River drainage basin.

The Columbia River basin terrain varies from flat or gently rolling farmland to high, rugged, wooded mountains. The watershed boundaries throughout the basin are a series of rugged mountains. The highest elevation in the basin is 13,766 feet, and the average elevation of the basin is approximately 4,200 feet. The total fall of Columbia River from the Canadian border (RM 745.0) to the mouth is 1,304 feet, or an average fall of 1.75 feet per mile. Within the study area, Columbia River has an average fall of 0.3 foot per mile at flood stage. At low water, tides reverse the slope of the river during a 24-hour period (Reference 12).

Coweeman River (also spelled "Coweman") has a drainage area of 127 square miles at its mouth. Coweeman River joins Cowlitz River at RM 1.3. The stream flows westerly from its source on the northwestern slopes of Elk Mountain (at an elevation of 4,538 feet). Above RM 30, the river has a gradient greater than 100 feet per mile. Between RM 30 and RM 9, the gradient flattens from approximately 40 feet per mile to 25 feet per mile. Below RM 7, the gradient is less than 3 feet per mile. The average elevation is 1,230 ft. The entire watershed is within Cowlitz County and is kidney shaped, 25 miles long, and 8 -10 miles wide.

The headwaters section of the Coweeman River drainage basin is mountainous, and the streams flow through canyons with steep, rugged sides. High benches of comparatively level land exist in the middle and lower sections of the basin. The width of the valley through the study segment averages 1-mile. The widest floodplain is in the vicinity of Kelso, Washington.

Cowlitz River flows into Columbia River at RM 68.0, and its principal tributaries within Cowlitz County are Coweeman River (RM 1.3) and Toutle River (RM 20.3).

Cowlitz River, together with its tributaries upstream of City of Castle Rock, drains an area of approximately 2,480 square miles. The Toutle River, a tributary which joins Cowlitz River just upstream of Castle Rock, contributes significantly to the flood peak through the study reach. The headwaters of Cowlitz River are located on the steep, densely forested slopes of Mount Rainier, with an elevation of over 14,000 feet. Through the City of Castle Rock, the thalweg slope is mild, ranging from an elevation of 17 feet to 25 feet National Geodetic Vertical Datum of 1929 (NGVD29) , with an average gradient of approximately 6 feet per mile. Ground elevations within the city range from below 40 feet to over 80 feet NGVD29.

Within Cowlitz County, two other major streams enter Cowlitz River from the west. Cowlitz River is joined by Arkansas and Olequa Creeks. Arkansas Creek and its tributaries, the principal of which is Delameter Creek, drain an area of approximately 48 square miles entirely within Cowlitz County. In the segment 5 miles upstream of the mouth of Arkansas Creek, the slope flattens from more than 100 feet per mile to less than 10 feet per mile.

Kalama River, with a drainage area of 205 square miles at its mouth, joins Columbia River at RM 73.0. The watershed is rectangular in shape, 30 miles long and 6 miles wide. Nearly all of the drainage area is in Cowlitz County. The stream flows westerly from its source on the southwestern slope of Mount St. Helens and joins Columbia River approximately 2 miles north of the City of Kalama.

Canyons in the headwaters of Kalama River are well defined, steep, rugged and forested. Topography of the watershed is mountainous. High benches of comparatively level land exist in the middle and lower sections. The average elevation of the basin is 1,880 feet.

The fall averages 215 feet per mile over the entire length of the Kalama River. Toward the mouth, the gradient flattens; below RM 8, the fall averages 10 feet per mile; from RMs 8 – 20, 30 feet per mile.

Forming the boundary between Cowlitz and Clark Counties, Lewis River, with a drainage area of 1,046 square miles at its mouth, flows into Columbia River at RM 87.0. Approximately 25 percent of the total drainage area is in Columbia National Forest, and 10 percent of the total drainage area lies in Cowlitz County. The stream flows southwesterly from its source on the northwestern slopes of Mount Adams and is joined by East Fork Lewis River at RM 3.5, approximately 3 miles south-southwest of the City of Woodland. The watershed is boot shaped, 40 miles long, 30 miles wide at the downstream end, and 15 miles wide at the upstream end. A small portion of the basin is used for agricultural or related purposes.

The Lewis River originates in the Cascade Range and falls over 12,000 feet before emptying into the Columbia River. Topography of the basin is mountainous, and the watershed divides consist of rugged, well-defined ridges. The highest elevation in the basin is 12,307 feet (Mt. Adams); average elevation is 2,360 feet. High benches of comparatively level land are in the middle and lower sections of the basin. The total fall of Lewis River from its headwaters to its junction with Columbia River is 7,900 feet, an average of 112 feet per mile. In the 20 mile segment between the mouth and Lake Merwin Dam, Lewis River has an average fall of 2 feet per mile, and an average valley width of 1-mile. The average annual runoff is more than 90 inches. Reservoirs have been created along the main stem of the river by darns located approximately at RM 20 (Merwin Lake), RM 34 (Yale Lake), and RM 47 (Swift Reservoir).

Significant tributaries to these principal river systems of Cowlitz County are Abernathy Creek, Arkansas Creek, Coal Creek, Delameter Creek, Germany Creek, Goble Creek, Harmony Creek, Mill Creek, Monahan Creek, North Fork Goble Creek, Ostrander Creek, and South Fork Ostrander Creek.

2.3 Principal Flood Problems

Major floods usually result from a combination of intense rainfall and snowmelt after the watershed has been saturated from prior rainfall. Columbia River floods generally are an annual event which occurs in the spring when the snow melts in the mountains. However, there has been winter flooding through the study reach of magnitudes comparable with the larger spring freshets.

Flooding from rivers and smaller creeks within the Cowlitz, Kalama, and Lewis River basins generally occurs during the winter months of November through January.

Although there was widespread flooding throughout Cowlitz County in 1964, 1972, 1975, and 1977, very little damage to major urban areas was incurred. Nevertheless, damage to county highways and bridges, and to telephone and electrical services could cause considerable loss of income and inconvenience to those urban areas which would be cut off and isolated for any length of time. Domestic water-intake structures and sewage treatment plants located in the floodplain would be subject to damage if large amounts of heavy debris were transported by floodwaters. In the rural areas, the prime concern is damage to farmhouses and machinery, cattle and other livestock, and isolated residences within the floodplain. Damage to crops and the erosion of prime topsoil from agricultural land could result in extensive, long-term economic loss. Many low-lying areas which are protected by levees from riverine flooding may be subject to shallow ponding of interior runoff which cannot escape through normal drainage channels. This situation could be very acute in residentially developed lowlands where there is no provision for storage and pumping out of excess runoff.

The historical record of flooding in Cowlitz County is available only for the period since substantial population centers became established. In December 1933, the County experienced one of the worst and most extensive floods in memory when Cowlitz, Coweeman, Kalama, and Lewis Rivers peaked well in excess of their current estimated 1-percent-annual-chance discharge. Damage to the area was estimated at more than $3 million, occurring mainly within the populated urban centers of the Cities of Kelso, Castle Rock, and Woodland when protective dikes were washed out and nearly 3,000 people were forced to evacuate their homes because of the high water. Several major bridges were destroyed and considerable damage to rural highways and farmland was incurred. In June 1948, Columbia River swelled to a peak discharge of more than 1 million cubic feet per second (cfs) and caused an estimated $7.2 million in damages, $6 million of which was to farm property, in the region from the City of Woodland to Willow Grove. Flooding was intensified by high tides which affected Columbia River elevations within Cowlitz County. The largest flood on Columbia River in recorded history occurred on June 7, 1894. The following is an excerpt from the Cowlitz County Historical Quarterly, Volume 2, No.4, p. 9:

> The floods of 1876 and 1884 had been bad but the flood of 1894 forced the vacating of all the business district and steamboats came up the streets of Kalama. The railroads were all under water and the ferry "Tacoma" was loaded with passenger cars to meet the trains at Kelso and transport the passengers direct to Portland. Business was carried on in private homes and in tents. Houses could be seen floating down the river and anxiety ran high as to whether the town's business district could withstand the strain. When the water finally subsided the grade level of the railroad was raised to its present level. In 1918 the dredges filled in the whole Kalama area to a high level with silt from the Columbia (Reference 13).

During spring floods, Columbia River remains above flood stage for from 30 to 90 days, while the winter flood-stage periods are of much shorter duration (Reference 12). Flood stages which have been recorded on Columbia River since 1858 were correlated with discharges at The Dalles, Oregon (RM 119.0), USGS Stream Gage (No. 14105700), which have been recorded since 1878.

Table 5, "Peak Discharges on the Columbia River", lists peak discharges at The Dalles, Oregon stream gage and corresponding water-surface elevations (WSELs) at the City of Kalama (RM 75.0) and the City of Longview for six major floods on Columbia River (References 12 and 14). Elevations are referenced to the North America Vertical Datum of 1988 (NAVD88).

Table 5 – Peak Discharges on the Columbia River

Date	Peak Discharges (cfs)	WATER SURFACE ELEVATION (feet NAVD88) At Kalama	At Longview
June 7, 1894	1,240,000	30.81	27.01
June 1, 1948	1,010,000	27.21	23.91
June 24, 1876	958,000	26.71	23.71
June 4 and 5, 1956	823,000	23.91	20.91
June 19, 1933	722,000	22.71	19.71
December 24, 1964	364,000	24.61	21.81

The estimated return periods for the 1948 and 1956 floods were 48 years and 18 years, respectively.

For the winter flood of 1964, the most recent flood on record, the peak discharge listed is not representative of flow at the City of Kalama because of large inflow below The Dalles stream gage. The addition of many storage projects along Columbia River since 1973 has changed the drainage such that a recurrence interval for this flood is not known.

The Castle Rock gage has a period of record from 1926 to the present time. Approximately six city blocks were completely washed away under the December 1933 flood as the river ripped through the dike and gouged out the channel which it now occupies. Other major floods occurred on Cowlitz River in December 1946, December 1964, January 1972, February 1996, November 2006, and January 2009.

Table 6, "Peak Discharges on Cowlitz River," show the largest Cowlitz River floods at the Castle Rock (Gage No. 14243000).

Table 6 – Peak Discharges on the Cowlitz River

Date	Peak Discharges[1] (cfs)	Gage Height[2] (Feet)	Approximate Recurrence Interval (Years)
January 8, 2009	106,000	54.64	*
November 7, 2006	77,300	49.78	*
February 8, 1996	112,000	32.11	*
December 23, 1933	139,000	31.60	*
December 4, 1975	86,700	24.53	150
December 2, 1977	86,500	24.48	100
December 10, 1933	111,000	*	40

[1] Discharge affected by regulation or diversion

[2] (Reference 15)

* Data Not Available

The May 18, 1980, mudflow has a peak gage height at Castle Rock about 3.3-feet higher than the peak of the 1933 flood.

Although the levees held during the 1933 flooding, severe bank erosion endangered the system at several points.

In the past, ponding inside the levee system has not been a serious problem. This situation is changing as residential developments encroach on lowlands in the northwest portion of City of Longview. Heavy rains in December 1977, caused ponding in the Mint Valley Golf Course and residential areas between 36th and 38th Avenues from Oak Street to Pennsylvania Street; north of Ocean Beach Highway from 37th to 40th Avenues; and in the area of 32nd Avenue and Pershing Way. Residents in the latter area were forced to evacuate as Drainage Ditch No.6, which intercepts runoff from high ground outside the city, overflowed near 32nd Avenue (Reference 16). It was estimated that damages to streets and public utilities during the December rains would cost the City of Longview approximately $80,000 (Reference 17).

The largest known flood on the Coweeman River occurred in December 1933, before the USGS established the gage near the City of Kelso (Gage No. 14245000). The estimated discharge for that flood is 12,000 cfs. The largest recorded discharge on the Coweeman River since the gage was installed in July 1950 occurred in November 1962 and was 9,720 cfs. The estimated return intervals for the 1933 and 1962 floods are 200 and 40 years, respectively. Those floods caused little damage because of the levee system along Coweeman River.

Heavy rains in December 1977 resulted in shallow flooding in several low-lying areas of the City of Kelso. Flooding primarily occurred in the upper reaches of the stormwater collection system, where the system lacked the capacity to convey local runoff to larger downstream conduits. The majority of the flooding was between Second and Cresecent Avenues; north of Donation Street; and between Allen Street and the Coweeman River, east of Interstate Highway 5. The City of Kelso estimated damages to streets and public utilities from the December 1977 flooding on the Coweeman River at $35,000 (Reference 18).

During the December 1964 flood, the Cowlitz River reached crest stage in 48 hours and remained above bankfull stage for 45 hours. The maximum rate of rise was 0.45 foot per hour, with an average rate of rise of 0.28 foot per hour (Reference 9). Average channel velocities during the 1-percent-annual-chance flood are estimated to range from 6 to 10 feet per second, with overbank velocities of up to 3 feet per second. Small portions of the City of Castle Rock, to the east and south of the downtown area, are subject to inundation from the collection and ponding of local runoff which cannot escape through natural drainage routes when the Cowlitz River is at flood stage.

The largest flood on Kalama River occurred in December 1933. During that flood, it is estimated that velocities in the channel in the vicinity of the City of Kalama reached 15 feet per second, with overbank velocities up to 6 feet per second (Reference 12).

Table 7, "Peak Discharges on the Kalama River", shows the peak discharges and corresponding elevations, below Italian Creek (Gage No. 14223500), for the six largest recorded floods on Kalama River.

Table 7 – Peak Discharges on the Kalama River

Date	Elevation (feet NAVD88)	Estimated Peak Discharges (cfs)	Approximate Recurrence Interval (Years)
December 23, 1933	52.54	45,000	*
January 20, 1972	40.94	17,900	15
December 12, 1977	40.44	16,900	10
November 20, 1962	40.44	16,600	10
November 23,1942	40.14	16,250	9
December 9, 1953	40.14	16,000	8

* Data Not Available

On the Lewis River, the largest flood in recorded history occurred in December 1933. During that flood, the river rose at an average rate of 0.2 foot per hour for 48 hours and remained above bankfull stage for 30 hours. During the flood of November 1962, the third largest flood of record, the river rose at an average rate of 1.5 feet per hour for 9 hours as a result of opening the spillway gates at Ariel Dam. A maximum rate of 6 feet per hour was experienced during that rise, and the river remained above bankfull stage for 18 hours (Reference 12).

Table 8, "Peak Discharges on the Lewis River," shows a list of peak discharges and corresponding elevations, at the Ariel Dam (Gage No. 14220500), for eight major floods on Lewis River.

Table 8 – Peak Discharges on the Lewis River

Date	Elevation (feet NAVD88)	Estimated Peak Discharges[1] (cfs)	Approximate Recurrence Interval (Years)
December 22, 1933	82.39	129,000	240
February 8, 1996	*	86,400	*
December 18, 1917	73.89	81,500	25
November 20, 1962	73.09	75,500	19
December 2, 1977	*	71,900	*
December 13, 1946	71.39	67,300	13
December 4, 1975	69.99	64,500	11
November 25, 1927	69.59	62,600	9

[1] Discharge affected by regulation or diversion

* Data Not Available

During the May 18, 1980 eruption of Mount St. Helens, a debris avalanche deposited some 3 billion cubic yards of material in the upper 17 miles of the North Fork Toutle River Valley. Mudflows incorporating melted snow, glacial ice, rock and other debris coursed down the Cowlitz and Toutle Rivers, damaging structures, causing flooding along the lower Cowlitz River and depositing 50 million cubic yards of sediment in the Cowlitz River channel and overbank areas. Cowlitz River bankfull capacity decreased from 70,000 cfs to less than 13,000 cfs. The mudflow discharge is not known because it destroyed the recording stream gage for Toutle River near Silver Lake (Gage No. 14242500). At its peak, it is estimated to have been about 28 feet higher than the flood of record.

Table 9, "Peak Discharges on Toutle River," show the five largest Toutle River floods at the two Silver Lake gages.

Table 9 – Peak Discharges on the Toutle River

Date	**Peak Discharges (cfs)**
May 18, 1980 (mudflow)	Not Recorded
December 2, 1977	43,200
March 2, 1910	37,600
December 23, 1933	34,300
December 11, 1946	29,800

Following the Mount St. Helens eruption, a stream gage along Toutle River near Silver Lake at Tower Road (Gage No. 14242580) was installed to replace the destroyed gage. The largest flood recorded at this gage was February 8, 1996. The peak discharge was 61,800 cfs (Reference 15).

In 1986, Cowlitz County experienced two major flooding events. In February 1986 heavy rains combined with a warming trend and heavy snowmelt in the mountains causing $5 million in damage to public facilities and private property (Reference 19).

Two hundred people were evacuated in the Lexington area; 100-120 homes were destroyed or damaged. (Reference 20). In November 1986, a major storm with near continuous rainfall saturated the ground. At one point, 1.8 inches of rain fell in 24 hours (Reference 20).

The February 1996 flood produced the most widespread flooding in the state's history. Mudslides and water over the road caused numerous roads to be closed, downtown Kalama flooded, Ostrander park was evacuated and inundated with water, I-5 Northbound near Woodland closed due to a rockslide and the dike in Woodland was breached causing major flooding and evacuations in the City. The County received a Presidential Declaration of Emergency (Reference 20).

2.4 Flood Protection Measures

The reduction of damage in major urban areas during the 1964, 1972, 1975, 1977, 1986, 1996 and 2006; flooding was due in part to dams and other flood-control structures constructed since the devastating 1933 and 1948 floods, including an extensive levee system designed to provide protection against 0.2-percent-annual-chance flooding. Levees extend 4.6 miles along the Cowlitz River, 8.0 miles along the Columbia River, and approximately 2.0 miles near Coal Creek Slough (Reference 21). Levee projects have also been completed at various locations along Coweeman, Kalama, and Lewis Rivers.

Further protection is provided by numerous bank protection and levee projects maintained by the CDID #1 and #3, as well as the Cowlitz County Drainage Improvement District No.1. Some of these levees were constructed entirely by local interests. Others were either constructed or improved with Federal funds in cooperation with local interests.

In addition to the levees, the districts maintain a network of drainage ditches, sloughs, drains, and pump stations to remove local runoff. Some of these facilities remove surface drainage and levee seepage from approximately 9,500 acres, including the Cities of Kelso and Longview. Runoff from the eastern portion of the City of Longview is directed towards the Industrial Way pump station near the Longview-Rainer Bridge (also known as the Lewis and Clark bridge). The southwest portion of Longview drains toward the Reynolds pump station at the former Reynolds Aluminum Smelter south of the city. The Longview's diking district CDID#1 is located northwest of the City of Longview, at the north end of Cutoff Slough, along Coal Creek Slough. This station not only drains northern Longview, but also nearly 5,000 acres north of the city. The City of Longview has an additional four pump stations that help prevent local flooding: 48th Avenue, Oregon Way, Third Avenue and Pioneer pump stations (Reference 22).

The City of Longview has established Flood Damage Prevention Ordinances aimed at reducing future flood loss. The community requires building permits for all proposed construction and reviews those permits to assure that sites are reasonably free from flooding.

Cowlitz County is under State Flood Plain Management Regulations of the Washington State Flood Control Zone Acts of 1935, 1960, and 1969 and the Washington Water Resources Act of 1971, including shoreline management. Portions of the floodplain of Coweeman River, Cowlitz River and its tributaries are within Flood Control Zone No. 14 (Cowlitz), and the lower segment of Lewis River is within Flood Control Zone No. 15. These Flood Control Zones are established under Chapter 86.16 of the Revised Code of Washington. City and County governments are obligated to abide by the provisions of this statute and, under a 1973 amendment, may be authorized to administer it. Under the statute, permits must be obtained from the Washington State Department of Ecology for proposed developments within the floodplain. Such permits stipulate a permissible flood elevation, and are not issued if the proposed development is located within a floodway.

More than 50 storage projects on the Columbia River and its tributaries have a significant impact on flood peaks, including the 1- and 0.2-percent-annual-chance floods. It is estimated that the 1948 and 1956 floods, discussed in Section 2.3 of this study, could be regulated at The Dalles stream gage to 620,000 and 550,000 cfs, respectively, under present regulatory conditions (Reference 5).

There are no reservoirs on the Coweeman River to provide flow regulation.

On the east bank of the Cowlitz River, there are approximately 1.5 miles of levee which provide protection, up to and including the 0.2-percent-annual-chance flood, for all but a very small portion of the City of Castle Rock.

Several other projects lessen the impact of flooding on Cowlitz River. Riffe Lake at RM 65.5 (storage began in 1968) and, to a lesser extent, Mayfield Reservoir at RM 52.0 (storage began in 1962), provide significant flood storage capability. Both projects, owned and operated by the City of Tacoma under a Federal Power Commission license, regulate flood peaks at Castle Rock in coordination with the USACE, Portland District. The Mayfield Reservoir and Davisson Lake provide 360,000 acre-feet of flood regulation storage. This storage is sufficient to reduce the estimated 1-percent-annual-chance discharge at the City of Castle Rock from 130,000 cfs to 80,000 cfs (Reference 23).

Following the May 1980 Mount St. Helens eruption, the lower Cowlitz River and Toutle River channel capacities were severely reduced by deposited sediment. With about 3 billion cubic yards of gradually eroding sediment in the Mount St. Helens blast area, the deposition in the study reaches was expected to progressively increase flood risks and damages for many years in the future. To prevent disastrous flooding, the USACE conducted a massive program of improvement to the Cowlitz River levee systems and dredging the deposited sediment from Cowlitz and Toutle River channels.

In order to stop the continuous downstream movement of sediment and to protect against future mudflows, a SRS was constructed on the North Fork of the Toutle River at RM 13.2. The SRS is designed solely to trap sediment eroded from the upper North Fork Toutle Basin. It has little effect on day-to-day flows; but it significantly reduces the peaks of moderate floods up to about the 2-percent-annual-chance flood. As sediment fills the SRS's storage, its effect on flood peaks will gradually diminish. Besides the SRS, there are no other significant flood protection measures that exist or are planned for the Toutle Rivers.

No flood regulation is provided by the three power projects on Lewis River. They are operated exclusively for power generation.

A combination floodwall and dike along the west bank of the Lewis River protects most of the City of Woodland from the 1-percent-annual-chance flood. The 0.2-percent-annual-chance flood will overtop the floodwall and dike, pass through the freeway underpass, and inundate the entire city. Flow over the floodwall and dike may cause some scour to the roadway and the base of the dike, and velocities will be quite high in the area just downstream from the underpass.

On August 18, 1983, FEMA and the Pacific Power and Light Company agreed to make 70,000 acre-feet available for flood control storage at Merwin Dam on the Lewis River, thus reducing the 1-percent-annual-chance discharge at the City of Woodland from l28,000 cfs to 102,000 cfs.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 2-, 1-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 2-, 1-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent-annual-chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent-annual-chance (100-year) flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the communities in Cowlitz County.

Pre-countywide Analyses

Table 10, "Floodflow-Frequency Data," shows the floodflow-frequency data for Coweeman, Cowlitz, Kalama, and Lewis Rivers were based on statistical analysis of discharge records at the following gaging stations maintained by the USGS.

Table 10 – Floodflow-Frequency Data

Stream Name	Gage Number	Location	Period of Record
COWEEMAN RIVER			
Near Kelso, WA	14245000	3.4 Miles Southeast of Kelso High School	1950 – 1979
COWLITZ RIVER			
At Castle Rock, WA	14243000	A Street Bridge in the City of Castle Rock	1926 – present
Below Mayfield Dam	14238000	1.4 Miles Downstream from Mayfield Dam	1934 – present
Near Randle, WA	14233400	0.5 Mile Downstream of Cispus River	1947 – present
KALAMA RIVER			
Below Italian Creek	14223500	2.8 Miles Northeast of the City of Kalama	1946 – 1979
LEWIS RIVER			
Near Amboy, WA	14219500	5 Miles Northeast of Amboy	1912 – 1931
At Ariel Dam	14220500	0.5 Miles Downstream from Ariel Dam	1923 – 1979
TOUTLE RIVER			
Near Silver Lake, WA	14242500	4.9 Miles Northeast of Silver Lake	1929 – present

The stage-discharge relationship on Columbia River through the study area is influenced by ocean tides; thus, frequencies are more reliably determined for river stages than for discharges. Stage-frequency curves for seven locations on Columbia River between RMs

50.0 and 123.0 were prepared using existing data for fall, winter, spring, and summer flood seasons. The fall and winter curves (Reference 24), and spring and summer curves (Reference 25) at each location were then combined by statistical methods to obtain combined stage-frequency curves. Those stage-frequency curves are the basis for the Columbia River water-surface profiles.

Water surface elevations for the Columbia River are shown in Table 11, "Summary of Elevations".

Table 11 – Summary of Elevations

	Elevation (feet NAVD88)			
FLOODING SOURCE AND LOCATION	**10%-ANNUAL-CHANCE**	**2%-ANNUAL-CHANCE**	**1%-ANNUAL-CHANCE**	**0.2%-ANNUAL-CHANCE**
COLUMBIA RIVER				
At Kalama, Washington (RM 75.0)	19.01	21.71	22.51	24.71

Analyses for the Columbia River were performed in accordance with standard log-Pearson Type III methods as outlined by the U.S. Water Resources Council (WRC) (Reference 26). Adjustments to compensate for contributing drainage areas upstream and downstream from gages were made using a runoff-routing computer model incorporating design recurrence for 24-hour storm precipitation.

The 24-hour duration storm precipitation volumes for 10-, 2-, and 1-percent-annual-chance return storm frequencies were obtained from the National Oceanic and Atmospheric Administration Atlas 2 (Reference 27). Precipitation volume for the 0.2-percent-annual-chance storm was obtained by extending the Atlas 2 frequency curve on normal distribution probability paper. Rainfall intensity distribution patterns were based on precipitation gages located at the Cities of Castle Rock, Cougar, and Longview.

Stream gage records for the Coweeman River were statistically analyzed, using the standard log-Pearson Type III methods, as outlined by the WRC (Reference 26). Natural frequency curves for the Coweeman River near the City of Kelso, WA (USGS stream gage No. 14245000) were developed using data from 1950 – 1974, respectively (Reference 28).

Gage data were available from 1928 – 1996 along the Cowlitz River. However, since 1969 Mossyrock Dam has provided significant regulation of peak discharges. Conversion of the gage data to natural peak flow values for the period was accomplished by determining a relationship between natural and regulated peak flows at Mossyrock Dam. Upon completion of estimating a series of natural peak flows for the years 1928 – 1978 and 1988 – 1995, the 59 data points were input into the HEC-FFA computer program to compute a natural discharge frequency curve. This natural discharge was then modified to the regulated values to develop the hydraulic model.

Lewis River streamflow is affected by storage in Lake Merwin Reservoir and Yale Reservoir. Analyses were performed by the USACE as part of the Clark County, Washington FIS (Reference 29) and the USGS for a FIS for the City of Woodland, Washington (Reference 6). The resulting frequency curves were made available and verified by independent analysis performed by the study contractor.

The Lewis River stream gage records were statistically analyzed, using the standard log-Pearson Type III distribution, as outlined by the WRC. Natural and regulated discharge frequency curves were developed for the USGS gage for the Lewis River at Ariel and Amboy, using data from 1912 – 1978. Peak annual flows used in deriving the natural discharge frequency curve were calculated by combining observed flows at the gage and by correlating adjacent gauging stations in the Lewis River basin and working downstream to Merwin Lake. The regulated flow-frequency relationship was developed by comparison of natural versus regulated discharges for six flood events in the basin. The regulated discharges for these floods were based on the Pacific Power and Light Company's plan of flood control operation, considering 70,000 acre-feet of flood control storage at Merwin Dam.

Analyses of data from gage Nos. 14233400 and 14242580 (unregulated discharges) were performed in accordance with standard log-Pearson Type III methods as outlined by the WRC (Reference 26). Discharge frequencies below Mayfield Dam were based on Mayfield Dam operational criteria and a cumulative frequency curve developed by the USACE, Portland District, dated February 1972. Discharges at the City of Castle Rock include the contributions from the Toutle River. Since 1980 the discharges at Castle Rock became outdated after the eruption of Mount St. Helens. Hydrologic analyses were carried out again in 1990 to update the peak discharge frequency relationships for the study reaches of Cowlitz and Toutle River.

The May 18, 1980 eruption of Mount St. Helens changed the runoff characteristics of Toutle River Basin. Since that date, the basin has been attempting to return to pre-eruption conditions. The present hydrologic analysis updated the 10-, 2-, 1-, and 0.2-percent-annual-chance peak discharges for the study reaches to December 1990 conditions. The pre-and post-eruption hydrology of the Toutle River Basin was studied to determine to what extent hydrologic characteristics had been altered by the eruptive blast, volcanic ejecta, and debris flow. The HEC-l was then adjusted to model the present (December 1990) condition. The Toutle River Basin is slowly healing and stabilizing, new vegetation is apparent, channels are increasingly incised in the sediment, the main channels are showing signs of armoring with the deposition of various size rocks. The devastation and healing process occurred mainly in the North and South Forks of Toutle River. The healing process in the Green River Basin and the South Fork Toutle River Basin is far enough along that pre-eruption HEC-l variables were used for the December 1990 HEC-l runs. The North Fork Basin is assumed to be about fifty-percent back to its normal hydrologic state that existed before the eruption.

The SRS provides some flood storage which was considered in the HEC-l models for December 1990. The final HEC-l models for pre-eruption and December 1990 were used to develop peak discharges at key locations in Toutle River Basin.

Hydrographs for the mouth of Toutle River were routed to Castle Rock to get the Toutle River contributions to Cowlitz River peak discharges at Castle Rock. The difference in the pre-eruption and December 1990 Toutle River Contributions were added to the pre-eruption peak discharges at Castle Rock for each flood.

Countywide Analysis

No new hydrologic analyses were conducted as part of this countywide FIS.

Peak discharge-drainage area relationships for the streams studied by detailed methods are shown in Table 12, "Summary of Discharges".

Table 12 – Summary of Discharges

		PEAK DISCHARGES (CFS)			
FLOODING SOURCE AND LOCATION	**DRAINAGE AREA (SQ. MILES)**	**10%-ANNUAL-CHANCE**	**2%-ANNUAL-CHANCE**	**1%-ANNUAL-CHANCE**	**0.2%-ANNUAL-CHANCE**
ABERNATHY CREEK					
At confluence with Columbia River	29.1	3,350	4,900	5,650	7,020
Approximately 1.1 miles upstream of Abernathy Road Bridge	12.8	1,740	2,370	2,760	3,420
ARKANSAS CREEK					
At confluence with Cowlitz	45.5	4,320	6,260	7,200	9,530
Upstream of Delameter Creek	20.3	1,860	2,760	3,110	4,220
COAL CREEK					
At confluence with Coal Creek Slough	26.1	3,250	4,430	5,220	6,460
Approximately 2.25 miles upstream of Carlon Loop Road Bridge	8.2	1,160	1,530	1,730	2,120
COLUMBIA RIVER					
Downstream of Cowlitz River	256,000	*	*	*	*
COWEEMAN RIVER					
At confluence with Cowlitz River	127.0	8,000	10,500	11,600	14,400
At Kelso Gage	119.0	7,500	9,800	10,900	13,500
Upstream of Goble Creek	82.5	5,800	7,700	9,200	11,100

* Data Not Available

Table 12 – Summary of Discharges (Continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ. MILES)	PEAK DISCHARGES (CFS) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
COWLITZ RIVER					
Downstream of Coweeman River	2,448	84,300[1]	103,300[1]	114,500[1]	179,100[1]
Downstream of Ostrander Creek	2,313	78,300[1]	94,400[1]	104,300[1]	165,600[1]
Downstream of Arkansas Creek	2,271	76,400[1]	91,600[1]	101,100[1]	161,400[1]
At Castle Rock	2,217	74,000[1]	88,000[1]	97,000[1]	156,000[1]
DELAMETER CREEK					
At confluence with Arkansas Creek	23.4	2,380	3,370	4,010	5,060
GERMANY CREEK					
At confluence with Columbia River	23.5	2,920	3,920	4,550	5,620
Approximately 5.5 miles upstream of State Route 4 Bridge	17.9	2,480	3,280	3,800	4,640
GOBLE CREEK					
At confluence with Coweeman River	26.5	2,590	3,610	4,090	5,040
HARMONY CREEK					
At confluence with Coal Creek	6.2	860	1,190	1,390	1,750
KALAMA RIVER					
At confluence with Coweeman River	205.0	16,500	22,450	25,000	31,500
Approximately 2.9 miles upstream of Weyerhaeuser Bridge	129.2	13,900	18,300	21,600	26,800
LEWIS RIVER					
At confluence with Columbia River	1,046	75,000[1]	114,100[1]	132,700[1]	181,000[1]
At CC Street Bridge	820	54,400[1]	86,300[1]	102,000[1]	142,000[1]
At USGS Gage No. 14220500	731	49,000[1]	79,000[1]	94,000[1]	132,000[1]

[1] Regulated by Mossyrock Dam

Table 12 – Summary of Discharges (Continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ. MILES)	PEAK DISCHARGES (CFS) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
MILL CREEK					
At confluence with Columbia River	28.6	3,170	4,520	5,190	6,620
Approximately 130 feet upstream of Cowlitz/Wahkiakum County boundary	12.7	1,680	2,260	2,540	3,140
MONAHAN CREEK					
At confluence with Delameter Creek	10.6	1,150	1,640	2,000	2,430
NORTH FORK GOBLE CREEK					
At confluence with Goble Creek	11.5	1,170	1,660	1,850	2,250
OSTRANDER CREEK					
At confluence with Columbia River	26.4	1,790	3,030	3,580	4,660
SOUTH FORK OSTRANDER CREEK					
At confluence with Ostrander Creek	9.3	570	1,080	1,300	1,790
TOUTLE RIVER					
At confluence with Cowlitz River	512	26,900	43,500	51,100	65,900

There were little or no streamflow data available for the remaining streams in Cowlitz County. Estimates for design discharges for these streams were derived from a combination of regional analyses using the aforementioned gages and the runoff-routing model.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Flood profiles were drawn showing computed WSELs to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2). Unless specified otherwise, the hydraulic analyses for these studies were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

For those study reaches subject to tidal inundation, the flood profiles were extended downstream to the limit of the coastal velocity zone or to where the mean high tide exceeded normal depth from a riverine only flood, whichever occurred farthest upstream.

All elevations shown on the Flood Profiles and FIRM (Exhibits 1 and 2) are referenced to the NAVD88.

Pre-countywide Analyses

Cross sections for Columbia River and Lewis River were provided by Towill, Inc., were derived photogrammetrically. All bridges and culverts were surveyed to obtain elevation data and structural geometry. The USACE, Portland District, had previously developed the physical data and determined loss coefficients used to derive step-backwater computer models for Columbia River (RMs 62.4 – 67.2) and Lewis River (RMs 0.0 – 14.4). The Columbia River study was related to community FISs (References 4 and 5) while Lewis River was carried out for purposes of the Flood Plain Information report (Reference 30).

Cross sections for the Columbia River (as described above) were based on a USACE condition survey, dated August 1974 and 1978; and Cowlitz County topographic maps at a scale of 1:2,400, with a contour interval of 2 feet, dated 1963 and July 1968 (References 31 and 32). USGS topographic maps at scales of 1:24,000 and 1:62,500, with contour intervals of 20 feet and 50 feet, respectively, were used for a few overbank points on the Oregon side of the Columbia River (References 33 and 34). Relevant portions of these maps were field checked to verify conditions.

Coweeman River cross sections were based on the 1968 Cowlitz County topographic maps and USACE field survey made in February 1976.

The Cowlitz River channel geometry was determined based on 53 cross section and 4-foot topographic maps based on aerial photography for RMs 0 – 20. Cross sections for RMs 20.3 – 23.0 were surveyed by the USGS in February 1984 (Reference 35). Bridge data were available from previous USACE HEC-2 analyses. Orthophoto maps were used to develop the overbank cross sections. Five of the six bridges were modeled as normal bridges. The Allen Street Bridge was modeled as a special bridge due to possible pressure and weir flow during high flows.

Lewis River cross section data, in the Unincorporated Areas of Cowlitz County, were based on USACE mapping performed in 1973 (Reference 36). Cross section data for the Lewis River, in the City of Woodland, were obtained from field surveys. Cross sections were taken at points of natural as well as manmade control. Additional cross sections were taken above and below bridges to determine the significant backwater effects of the structures.

The Toutle River channel cross sections were obtained from a USGS publication (Reference 37) that contained surveyed cross sections. The USGS surveyed only the channel portion of each cross section. The floodplain topography was approximated using USGS 7.5-minute topographic maps having a contour interval of 20 feet. Additional cross sections were field surveyed in October 1992 by NHC for bridge scour studies of two State Route 404 bridges. Fourteen cross sections were surveyed. Tower road crosses the Toutle River near the upstream limit of detailed study.

The starting WSELs for Columbia River are based on the appropriate stage-frequency curve.

Starting WSELs for the Coweeman River, and the South Fork Toutle River was determined by the HEC-2 model using the slope-area method.

Starting WSELs for the Cowlitz River were computed based on the 1-percent-annual-chance BFE for the Columbia River at the confluence of the Cowlitz River.

For Lewis River in the Unincorporated Areas of Cowlitz County, the starting WSELs were obtained from a USACE Flood Plain Information report (Reference 30). Starting WSELs, in the City of Woodland, were taken from the FIS for Clark County, Washington (Reference 38).

Starting WSELs for the Toutle River was obtained from the 1-percent-annual-chance flood profile in the September 2, 1993 FIS (of the Unincorporated Areas of Cowlitz County). The North Fork was treated as a continuation of the main channel, while the South Fork was treated as a tributary.

WSELs, for all streams studied in detail, were computed through use of the USACE HEC-2 step-backwater computer program (References 31, 39, 40 and 41). Discharges, for the Columbia River, used in the analyses were correlated (based on records from the USGS gate at The Dalles stream gage) to yield WSELs similar to the combined stage-frequency curves.

Channel and overbank roughness factors used in the hydraulic computations were estimated by field observation, engineering judgment and publications (References 42 and 43) at each cross section and adjusted with known high-water marks and stream gage rating curves where possible. Table 13, “Manning’s “n” Values”, shows the channel and overbank “n” values for the streams studied by detailed methods.

Table 13 – Manning's "n" Values

Stream	Channel "n"	Overbank "n"
Columbia River	0.020 – 0.032	0.080
Coweeman River	0.032 – 0.040	0.050 – 0.100
Cowlitz River		
RMs 0 – 6.7	0.023	0.050
RMs 6.7 – 12.2	0.025	0.050
RMs 12.2 – 13.7	0.025	0.050 – 0.120
RMs 13.7 – 20	0.025	0.050
Cowlitz River (Continued)		
RMs 20 – study limit	0.035	0.050
Lewis River	0.035 – 0.045	0.045 – 0.055
North Fork Toutle River	0.035	0.050 – 0.100
South Fork Toutle River	0.035	0.050 – 0.100
Toutle River	0.035	0.050 – 0.100

Channel and overbank roughness factors, for streams studied in detail in the Unincorporated Areas of Cowlitz County, were based on field inspection and photographs at each cross section location. Channel roughness coefficients ranged from 0.025 – 0.060; overbank coefficients ranged from 0.070 – 0.150.

Roughness factors for Cowlitz River are based on field inspections and photographs at each cross section. Channel "n" value coefficients were adjusted by comparison of HEC-2 produced WSELs with observed elevations. Particular emphasis was placed on data from the large flood which occurred on January 10, 1990. These relatively low "n" values are for the present sand beds created by the May 1980 eruption of Mount St. Helens. The Cowlitz and Toutle River channels can be expected to gradually return to their original coarse-gravel bed conditions as the sand bed scours and coarser material is deposited.

A limited area of shallow flooding extends across the eastern corporate limits. Ponding in this region is attributed to an underground stream which travels through the area. The stream is unnamed, has no known headwaters, and has no definable boundaries. The stream sustains a high, localized water table, so heavy rains during flood periods cannot percolate into the ground. The resulting surface water flows toward a culvert beneath Huntington Avenue, but is backed up by the constriction, resulting in ponding. A 1977 storm brought rains that were representative of a 1-percent-annual-chance flood. The depth of the ponded water was recorded by the study contractor and was used to approximate the depth of ponded water during a 1-percent-annual-chance flood, which ranges from 1 to 3 feet.

An approximate analysis was performed on a flood area north of RM 13 on Lewis River; Backwater from Lewis River is supplemented by flooding from Houghton Creek east of Niemi Road between State Highway 503 and Old Lewis River Road. Using Road elevations and eyewitness accounts of the 1977 flood, a WSEL of 53 feet was estimated for the 1-percent chance flood in this area. Most of the streams selected for approximate analysis were investigated using discharges for detailed analysis, but for the 1-percent-annual-chance recurrence interval only. Flood depths were estimated in the field by use of a hand-held programmable calculator using the normal-depth method.

For areas studied by approximate methods (in the City of Longview), data were obtained by reviewing pumping records and from interviews with local residents and officials. Review of this data determined that there would be several shallow 1-percent-annual-chance flooding areas of less than 1 foot depth adjacent to Cutoff Slough. In addition several areas near the intersections of 36th Avenue and Pennsylvania Street and 32nd Avenue and Pennsylvania Street are areas of approximate 1-percent-annual-chance flooding with less than 1 square mile drainage area.

Most of the streams selected for approximate analysis (in the Unincorporated Areas of Cowlitz County) were investigated using discharges for detailed analysis, but for the 1-percent-annual-chance recurrence interval only. Flood depths were estimated using the normal-depth method.

For the remaining streams studied by approximate methods, flooding limits for McCorkle Creek, North Fork McCorkle Creek North Fork Toutle River, and South Fork Toutle River were established using field investigation, engineering judgment, and topographic maps (Reference 44).

<u>Countywide Analysis</u>

No new hydraulic analyses were performed for this countywide report. However, this entire study was updated to the NAVD88.

All qualifying benchmarks within a given jurisdiction that are catalogued by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First or Second Order Vertical and have a vertical stability classification of A, B or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.

Benchmarks catalogued by the NGS and entered into the NSRS vary widely in vertical stability classification. NSRS vertical stability classifications are as follows:

- Stability A: Monuments of the most reliable nature, expected to hold position/elevation (e.g. mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation (e.g. concrete bridge abutment)
- Stability C: Monuments which may be affected by surface ground movements (e.g. concrete monument below frost line)
- Stability D: Mark of questionable or unknown vertical stability (e.g. concrete monument above frost line, or steel witness post)

In addition to NSRS benchmarks, the FIRM may also show vertical control monuments established by a local jurisdiction; these monuments will be shown on the FIRM with the appropriate designations. Local monuments will only be placed on the FIRM if the community has requested that they be included, and if the monuments meet the aforementioned NSRS inclusion criteria.

To obtain current elevation, description, and/or location information for benchmarks shown on the FIRM for this jurisdiction, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their Web site at www.ngs.noaa.gov.

It is important to note that temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the NGVD29. With the completion of the NAVD88, many FIS reports and FIRMs are now prepared using NAVD88 as the referenced vertical datum.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. Some of the data used in this revision were taken from the prior effective FIS reports and FIRMs and adjusted to NAVD88.

To accurately covert flood elevations from the current NGVD29 datum to the newer NAVD88 datum, the following procedure was implemented. Locations at the upstream and downstream ends of each study stream, as well as a point to represent the intermediate point between the two end points, were evaluated using the USACE's CORPSCON datum conversion software (Reference 45). The resulting values for each of the three points were the computed difference between the NGVD29 and NAVD88 elevations. Individual conversion factors at the upstream end, the downstream end, and intermediate point were averaged to determine a conversion factor for the stream. The NAVD88 elevations provided for each stream were computed by adding the calculated conversion factor to the existing NGVD29 data.

The data points used to determine the conversion are listed in Table 14, "Vertical Datum Conversion Values".

Table 14 – Vertical Datum Conversion Values

Stream Name	Conversion from NGVD29 to NAVD88 (feet)
Abernathy Creek	3.09
Arkansas Creek	3.34
Coal Creek	3.14
Columbia River	3.21
Coweeman River	3.46

Table 14 – Vertical Datum Conversion Values (Continued)

Stream Name	Conversion from NGVD29 to NAVD88 (feet)
Coweeman River (Lower Reach Near Kelso)	3.38
Cowlitz River	3.36
Delameter Creek	3.30
Germany Creek	3.10
Goble Creek	3.51
Harmony Creek	3.10
Kalama River	3.44
Lewis River	3.39
Mill Creek	3.07
Monahan Creek	3.27
North Fork Goble Creek	3.53
Ostrander Creek	3.38
South Fork Ostrander Creek	3.39
Toutle River	3.38

NAVD88 = NGVD29 + conversion factor

The BFEs shown on the FIRM represent whole-foot rounded values. For example, a BFE of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, users that wish to convert the elevations in this FIS to NGVD29 should apply the conversion factor to elevations shown on the Flood Profiles and supporting data tables in this FIS report, which are shown at a minimum to the nearest 0.1 foot.

For additional information regarding conversion between the NGVD29 and NAVD88, visit the National Geodetic Survey website at http://www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

Vertical Network Branch, N/CG13
National Geodetic Survey, NOAA
Silver Spring Metro Center 3
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3191
(301) 713-4172 (fax)

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support

Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at http://www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides 1-percent-annual-chance (100-year) flood elevations and delineations of the 1- and 0.2-percent-annual-chance (500-year) floodplain boundaries and 1-percent-annual-chance floodway to assist communities in developing floodplain management measures. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles and Floodway Data Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps of varying scales based on the availability of data.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM. On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, and AO), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards (Zone X). In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are very close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations, but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2).

Pre-Countywide Analysis

For Columbia River (in the City of Kalama), the boundaries were interpolated using topographic maps at a scale of approximately 1:5,000, with a contour interval of 5 feet (Reference 46).

For Coweeman and Cowlitz Rivers; in the Cities of Castle Rock, Kelso and Longview; the boundaries were interpolated using topographic maps at scale of 1:2,400, and 1:6,000 with a contour interval of 2 feet and 5 feet, respectively (References 32 and 47).

Fill material added to the Cowlitz and Toutle River overbank since the eruption was field inspected and considered in developing the flood boundaries.

For Lewis River (in the City of Woodland), the boundaries were interpolated using topographic maps at a scale of 1:4,800, with a contour interval of 5 feet (Reference 48).

For the remainder of streams studied in detail, the boundaries were interpolated using topographic maps at scales of 1:4,800, with a contour interval of 4 feet (Reference 44); 1:4,800, with a limited contour interval (Reference 49); approximately 1:5,000, with a contour interval of 5 feet (Reference 46); 1:12,000, with a contour interval of 20 feet (Reference 50); and aerial photogrammetric maps at scales of 1:4,800 (Reference 36), and 1:12,000 (Reference 51).

Approximate flood boundaries in some portions of the study area were taken from the FIA Flood Hazard Boundary Map (Reference 52).

For the streams studied by approximate methods (in the Unincorporated Areas of Cowlitz County), the boundaries for the 1-percent-annual-chance flood were developed using topographic maps at scales of 1:4,800, with a contour interval of 4 feet (Reference 44); 1:24,000, with a contour interval of 10 feet (Reference 53): 1:24,000, with a contour interval of 20 feet (Reference 33); 1:62,500, with a contour interval of 40 feet (Reference 54); 1:62,500, with a contour interval of 50 feet (Reference 55); 1:62,500, with a contour interval of 80 feet (Reference 56); and aerial photogrammetric maps at scales of 1:4,800 (Reference 43) and 1:6,000 (Reference 57), in conjunction with the previously estimated elevations.

For the areas studied by approximate methods (in the Cities of Kelso and Longview), the boundary of the 1-percent-annual-chance flood was prepared on topographic maps (References 32 and 33) and is based on a review of pumping records and photographs of the December 1977 flooding, information provided by the CDID #3. Supporting information was obtained from the Washington Highway Department and interviews with local residents and officials.

In cases where the 1- and 0.2-percent-annual-chance flood boundaries are close together, only the 1-percent-annual-chance flood boundary has been shown.

Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitation of the map scale, such areas are not shown.

Countywide Analysis

This countywide FIS combined the FIRMs for Cowlitz County and incorporated communities into the countywide format. Under the countywide format FIRM panels have been produced using a single layout format for the entire area within the county instead of separate layout formats for each community. The single-layout format facilitates the matching of adjacent panels and depicts the flood-hazard area within the entire panel border, even in areas beyond a community's corporate boundary line. In addition, under the countywide format this single FIS report provides all associated information and data for the entire county area.

As part of this countywide FIS, the format of the map panels has changed. Previously, flood-hazard information was shown on both the FIRM and Floodway Boundary and Floodway Maps (FBFM). In the new format, all base flood elevations, cross sections, zone designations, and floodplain and floodway boundary delineations are shown on the FIRM and the FBFM has been eliminated. Some of the flood insurance zone designations were changed to reflect the new format. Areas previously shown as numbered Zone A were changed to Zone AE. Areas previously shown as Zone B were changed to Zone X (shaded). Areas previously shown as Zone C were changed to Zone X (unshaded). In addition, all Flood Insurance Zone Data Tables were removed from the FIS report and all zone designations and reach determinations were removed from the profile panels.

Floodplain boundaries were remapped as part of the countywide update to reflect more recent or more detailed topographic and base map data for the county. The floodplain mapping updates consisted of a mixture of redelineation and rectification (refinement) of existing flood boundaries based on the best topographic data available at the time of the study, aerial photography, and digital road network base map data.

Redelineation was limited to areas were new, quality topographic data was available and Base Flood Elevations were previously defined. This topographic data included Light Detection and Ranging (LiDAR) derived two foot contour data obtained from the Puget Sound LiDAR Consortium (Reference 58), digital contour data provided by Cowlitz County developed at scales of 1:1,200 and 1:2,400 with contour intervals of two and four feet, respectively (Reference 59, 60, 61 and 62) and digital contour data provided by the USACE with a contour interval of four feet (Reference 63). The redelineation process updates the floodplain extents based on the new topographic data, but does not make changes to the Base Flood Elevations or the engineering models used to develop those elevations.

Those reaches not covered by new topographic data, were converted to digital format by digitizing the effective FIRMs and refined by making small adjustments to fit the floodplains to new base map data, aerial photography, and 20’ interval contour data developed from USGS 10 meter Digital Elevation Models (DEMs) to ensure that they overlay the water course they represent (Reference 64).

The orthophotos used in these updates were provided by the Washington Department of Ecology and the digital road network information was provided by Cowlitz County.

For areas studied by approximate methods where new topographic data was available, the boundary of the 1-percent-annual-chance flood was updated by making adjustments to fit the floodplains to new base map data, aerial photography, and topographic data. Those approximate method reaches not covered by new topographic data were converted to digital format by digitizing the effective FIRMs and refined by making small adjustments to fit the floodplains to new base map data, aerial photography, and 20’ interval contour data developed from USGS 10 meter DEMs to ensure that they overlay the water course they represent.

Additionally, on portions of Coweeman River, Fall Creek, Leckler Creek, McCorkle Creek, Ostrander Creek, Owl Creek, Schoolhouse Creek, Slide Creek, Tributary to

McCorkle Creek, Tributary to Owl Creek, Tributary to Schoolhouse Creek, as well as several unnamed tributaries to Columbia and Cowlitz Rivers; the 1-percent-annual-chance flood elevations were determined using USGS Regression Equations (Reference 65) and the USACE HEC-RAS computer program (Reference 66). The peak flood discharges from the regression equations were input into a HEC-RAS model that included cross sections extracted from the new topographic data. Because this cross section information was not supplemented with field survey data and the models did not include bridge and culvert information, the resulting floodplain boundaries are considered approximate. Approximately 23.8 miles of stream were updated using this methodology.

Streams studied by approximate methods were converted and fitted based on the effective FIRMs, new basemap data, and orthophotos so that they overlay the water course they represent and fit the available aerial photography, base map data, and limited older topography.

In accordance with FEMA Procedure Memorandum 36 (Reference 67), profile baselines have been included in all areas of detailed study. Profile baselines are shown in the location of the original stream centerline or original profile baseline without regard to the adjusted floodplain position on the new base map. This was done to maintain the relationship of distances between cross sections along the profile baseline between hydraulic models, flood profiles, and floodway data tables.

The profile baselines depicted on the FIRM represent the hydraulic modeling baselines that match the flood profiles on this FIS report. As a result of improved topographic data, the profile baseline in some cases, may deviate significantly from the channel centerline or appear outside the Special Flood Hazard Area.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1-foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional flood way studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 15, "Floodway Data"). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the WSEL of the 1-percent-annual-chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1, "Floodway Schematic".

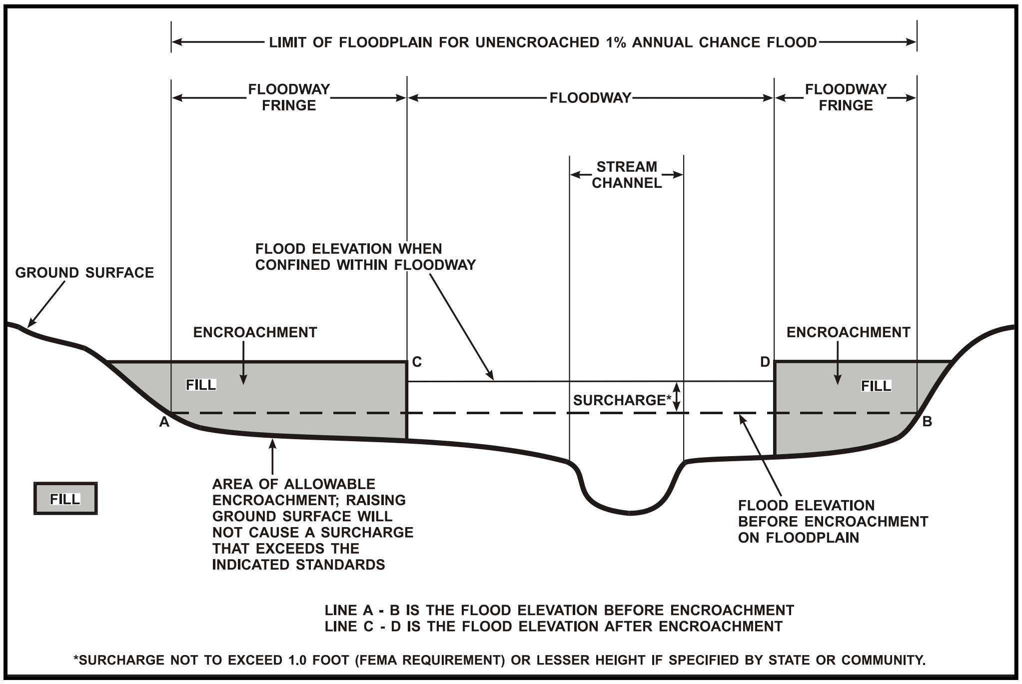

Figure 1 – Floodway Schematic

For floodway computations on the Columbia River, the HEC-2 hydraulic model was calibrated to match the combined stage 1-percent-annual-chance water-surface profile through the study reach. For most of Cowlitz River, the many cross sections with a zero or small rise in water surface are due to extensive filling with dredged materials following the eruption of Mount St. Helens.

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
ABERNATHY CREEK								
A	0.000	247	1,837	3.1	10.9	10.9	11.9	1.0
B	0.023	163	849	6.7	10.9	10.9	11.9	1.0
C	0.083	137	1,117	5.1	11.9	11.9	12.6	0.7
D	0.308	151	693	8.2	15.4	15.4	15.4	0.0
E	0.517	190	1,220	4.6	22.7	22.7	23.6	0.9
F	0.874	86	583	7.2	38.5	38.5	38.9	0.4
G	1.349	58	521	7.8	68.2	68.2	69.0	0.8
H	1.409	70	447	9.0	71.3	71.3	71.6	0.3
I	1.428	61	500	8.1	72.9	72.9	72.9	0.0
J	1.572	58	330	10.7	80.2	80.2	80.9	0.7
K	1.640	104	449	7.8	87.4	87.4	87.4	0.0
L	1.662	78	573	6.1	88.6	88.6	88.6	0.0
M	1.961	166	723	4.8	107.2	107.2	108.0	0.8
N	2.040	146	590	5.9	114.5	114.5	115.1	0.6
O	2.075	187	1,219	2.8	118.3	118.3	118.7	0.4
P	2.423	72	427	8.0	136.9	136.9	137.8	0.9
Q	2.552	69	418	8.2	144.4	144.4	145.0	0.6
R	2.599	44	311	11.0	148.5	148.5	148.5	0.0
S	2.617	142	748	4.6	151.6	151.6	151.6	0.0
T	2.973	70	398	8.5	177.6	177.6	177.7	0.1

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

ABERNATHY CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
ABERNATHY CREEK (Continued)								
U	3.044	37	304	11.1	183.6	183.6	183.8	0.2
V	3.104	74	380	8.9	189.6	189.6	189.6	0.0
W	3.500	70	281	11.8	220.4	220.4	220.4	0.0
X	3.575	37	326	9.0	230.8	230.8	231.2	0.4
Y	3.625	65	471	6.2	233.9	233.9	234.3	0.4
Z	3.854	89	327	8.8	252.7	252.7	253.0	0.3
AA	4.173	75	399	7.2	278.6	278.6	279.5	0.9
AB	4.483	147	673	4.3	296.3	296.3	297.3	1.0
AC	4.651	95	458	6.3	305.9	305.9	306.2	0.3
AD	4.737	46	227	12.7	314.2	314.2	314.2	0.0
AE	4.838	45	394	7.2	321.9	321.9	322.6	0.7
AF	4.981	83	335	8.5	331.1	331.1	331.9	0.8
AG	5.222	74	357	7.9	354.2	354.2	354.2	0.0
AH	5.489	74	355	7.9	373.5	373.5	374.3	0.8
AI	5.864	59	347	7.9	403.0	403.0	403.7	0.7

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

ABERNATHY CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
ARKANSAS CREEK								
A	0.601	38	717	10.0	51.3	46.0[2]	47.0[2]	1.0
B	0.615	276	3,050	2.4	51.3	48.2[2]	49.0[2]	0.8
C	1.047	247	1,955	3.6	51.3	49.2[2]	50.0[2]	0.8
D	1.098	101	1,280	5.5	51.3	49.5[2]	50.3[2]	0.8
E	1.134	300	2,789	2.5	51.3	50.1[2]	50.8[2]	0.7
F	1.434	480	2,549	2.7	51.3	50.9[2]	51.6[2]	0.7
G	1.828	245	2,975	2.3	51.9	51.9	52.6	0.7
H	1.902	326	757	4.1	52.4	52.4	53.1	0.7
I	1.928	938	4,958	0.6	53.0	53.0	53.8	0.8
J	2.121	1,593	9,405	0.3	53.0	53.0	53.9	0.9
K	2.387	1,100	4,983	0.6	53.0	53.0	53.9	0.9
L	2.708	1,070	3,493	0.9	53.2	53.2	54.1	0.9
M	3.066	216	1,194	2.6	53.8	53.8	54.8	1.0
N	3.238	106	660	4.7	54.9	54.9	55.9	1.0
O	3.346	75	776	4.0	56.1	56.1	57.1	1.0
P	3.387	90	957	3.2	56.5	56.5	57.4	0.9
Q	3.694	106	883	3.5	57.9	57.9	58.6	0.7
R	3.876	75	1,058	2.9	58.5	58.5	59.2	0.7
S	4.017	92	1,105	2.8	58.8	58.8	59.5	0.7

[1] Miles above mouth

[2] Water-surface elevation computed without consideration of backwater effects from the Cowlitz River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

ARKANSAS CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
ARKANSAS CREEK (Continued)								
T	4.087	279	1,747	1.7	59.1	59.1	59.8	0.7
U	4.165	100	934	3.1	59.2	59.2	59.9	0.7
V	4.417	81	774	3.8	60.2	60.2	60.8	0.6
W	4.572	90	932	3.2	61.0	61.0	61.5	0.5
COAL CREEK								
A	0.466	243	1,603	3.3	17.4	14.6[2]	15.6[2]	1.0
B	0.781	131	610	8.6	21.5	21.5	22.5	1.0
C	0.852	51	352	11.3	28.5	28.5	28.9	0.4
D	0.887	277	2,013	2.0	31.6	31.6	31.9	0.3
E	1.091	75	351	11.5	53.3	53.3	54.2	0.9
F	1.393	81	455	8.9	94.8	94.8	95.6	0.8
G	1.691	54	448	8.7	130.7	130.7	131.7	1.0
H	2.092	42	512	7.6	161.9	161.9	162.4	0.5
I	2.372	74	560	7.0	174.3	174.3	175.1	0.8
J	2.617	42	512	7.3	182.1	182.1	182.7	0.6
K	3.005	243	1,420	2.6	199.6	199.6	200.6	1.0
L	3.077	110	589	6.4	200.7	200.7	201.5	0.8

[1] Miles above mouth

[2] Water-surface elevation computed without consideration of backwater effects from the Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

ARKANSAS CREEK – COAL CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COAL CREEK (Continued)								
M	3.110	63	463	8.1	201.5	201.5	202.1	0.6
N	3.326	48	337	11.1	211.8	211.8	212.7	0.9
O	3.700	55	474	7.6	232.2	232.2	232.4	0.2
P	3.972	72	405	8.9	257.2	257.2	257.6	0.4
Q	4.188	64	505	6.3	266.7	266.7	266.9	0.2
R	4.337	78	290	11.0	277.9	277.9	277.9	0.0
S	4.387	76	337	9.5	283.5	283.5	283.5	0.0
T	4.607	75	598	5.3	293.4	293.4	293.5	0.1
U	5.100	56	383	8.3	317.5	317.5	318.1	0.6
V	5.417	91	433	6.4	334.9	334.9	335.4	0.5
W	5.800	67	278	10.0	375.4	375.4	375.5	0.1
X	6.032	59	226	11.2	407.3	407.3	407.3	0.0
COLUMBIA RIVER								
A	56.00	4,630/720[2]	230,440	3.7	16.1	16.1	16.7	0.6
B	56.76	5,530/470[2]	213,305	4.0	16.3	16.3	16.9	0.6
C	57.38	5,840/700[2]	215,754	4.0	16.5	16.5	17.1	0.6
D	58.00	3,770/1,100[2]	145,605	5.9	16.6	16.6	17.2	0.6

[1] Miles above mouth

[2] Width/width within Cowlitz County limits

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COAL CREEK – COLUMBIA RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COLUMBIA RIVER (Continued)								
E	58.38	3,750/1,920[3]	134,344	6.4	16.7	16.7	17.3	0.6
F	58.85	4,062/2,260[3]	130,453	6.6	17.0	17.0	17.6	0.6
G	59.57	5,864/4,650[3]	147,242	5.8	17.4	17.4	17.9	0.5
H	60.36	4,748/2,500	180,826	4.8	17.6	17.6	18.2	0.6
I	62.40	4,456/1,300	184,392	4.7	18.4	18.4	18.9	0.5
J	64.25	3,548/1,800	182,840	4.7	19.1	19.1	19.5	0.4
K	66.10	3,008/1,360	160,446	5.4	19.5	19.5	19.9	0.4
L	67.19	2,982/1,250	153,145	5.7	19.8	19.8	20.2	0.4
M	68.80	4,500/2,950[3]	194,686	4.8	20.7	20.7	21.0	0.3
N	70.17	4,415/2,800[3]	199,856	5.1	20.9	20.9	21.3	0.4
O	71.93	2,750/1,750	155,799	5.3	21.5	21.5	21.9	0.4
P	73.57	3,330/1,250	134,850	6.1	22.0	22.0	22.4	0.4
Q	74.19	3,720/600	157,217	5.2	22.4	22.4	22.8	0.4
R	74.76	3,450/590	153,408	5.3	22.6	22.6	23.0	0.4
S	75.57	4,198/288	173,273	4.7	22.8	22.8	23.2	0.4
T	76.28	4,480/720	179,684	4.5	22.9	22.9	23.3	0.4
U	76.95	2,835/980	144,245	5.7	22.9	22.9	23.3	0.4
V	77.76	2,500/860	122,449	6.7	23.2	23.2	23.6	0.4

[1] Miles above mouth

[2] Width/width within Cowlitz County limits

[3] Width does not include island

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COLUMBIA RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COWEEMAN RIVER								
A	11.066	268	1,644	7.4	144.3	144.3	145.3	1.0
B	11.201	55	681	13.5	160.4	160.4	160.4	0.0
C	11.244	138	1,351	6.8	164.5	164.5	164.5	0.0
D	11.630	169	1,057	8.7	174.2	174.2	174.2	0.0
E	11.938	192	1,598	5.8	180.5	180.5	180.5	0.0
F	12.189	224	1,166	7.9	185.7	185.7	185.7	0.0
G	12.568	314	1,292	7.1	200.2	200.2	200.2	0.0
H	12.842	201	1,370	6.7	208.0	208.0	208.0	0.0
I	13.110	174	1,386	6.6	212.9	212.9	212.9	0.0
J	13.193	130	1,130	8.1	214.4	214.4	214.4	0.0
K	13.231	297	2,052	4.5	216.1	216.1	216.1	0.0
L	13.311	225	1,516	6.0	217.2	217.2	217.2	0.0
M	13.500	331	1,509	6.1	220.7	220.7	220.7	0.0
N	13.765	172	1,030	8.9	225.6	225.6	225.6	0.0
O	14.227	173	1,110	8.2	238.3	238.3	238.3	0.0
P	14.310	72	710	12.9	240.9	240.9	240.9	0.0
Q	14.338	206	1,402	6.5	245.0	245.0	245.0	0.0
R	14.669	190	1,006	9.1	250.9	250.9	250.9	0.0
S	14.962	174	1,222	7.5	260.2	260.2	260.2	0.0

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COWEEMAN RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COWEEMAN RIVER (Continued)								
T	15.523	190	1,043	8.8	276.0	276.0	276.0	0.0
U	15.778	212	1,368	6.7	282.2	282.2	282.2	0.0
V	15.873	172	1,094	8.3	284.0	284.0	284.0	0.0
W	15.896	145	1,048	8.7	284.5	284.5	284.5	0.0
X	16.240	150	1,171	7.8	293.7	293.7	293.7	0.0
Y	16.573	219	928	9.8	306.8	306.8	306.8	0.0
Z	16.668	100	869	10.4	312.0	312.0	312.0	0.0
AA	16.687	264	2,247	4.0	315.7	315.7	315.9	0.2
AB	16.994	166	1,114	8.1	318.9	318.9	319.2	0.3
AC	17.316	138	946	9.5	331.2	331.2	331.2	0.0
AD	17.563	133	930	9.7	338.0	338.0	338.0	0.0
AE	17.805	181	835	10.7	346.0	346.0	346.0	0.0
AF	18.095	325	1,105	8.1	359.1	359.1	359.1	0.0
AG	18.394	133	885	10.1	369.8	369.8	369.8	0.0

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COWEEMAN RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COWEEMAN RIVER (LOWER REACH NEAR KELSO)								
A	0.04	115	1,860	6.2	22.7	17.5[2]	17.5[2]	0.0
B	0.58	265	2,869	4.0	22.7	19.1[2]	19.3[2]	0.2
C	1.00	260	3,513	3.3	22.7	19.5[2]	20.2[2]	0.7
D	1.65	187	3,139	4.2	22.7	20.3[2]	21.2[2]	0.9
E	2.37	158	2,299	5.0	22.7	19.8[2]	20.2[2]	0.4
F	2.38	149	2,380	4.8	22.7	19.9[2]	20.2[2]	0.3
G	2.59	165	2,388	4.8	22.7	20.3[2]	20.6[2]	0.3
H	2.61	206	3,019	3.8	22.7	20.3[2]	20.7[2]	0.4
I	2.64	157	2,385	4.8	22.7	20.4[2]	20.7[2]	0.3
J	3.27	148	2,267	5.0	22.7	21.3[2]	21.8[2]	0.5
K	3.68	170	2,930	3.9	22.7	22.0[2]	22.5[2]	0.5
L	4.22	923	6,116	1.8	22.7	22.4[2]	23.1[2]	0.7
M	4.69	800	5,810	1.9	23.5	23.5	24.4	0.9

[1] Miles above confluence with Cowlitz River

[2] Water-surface elevation computed without consideration of backwater effects from Cowlitz River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COWEEMAN RIVER (LOWER REACH NEAR KELSO)

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COWLITZ RIVER								
A	2,112	989	17,461	6.6	21.5	21.5	21.5	0.0
B	4,886	826	14,835	7.7	22.0	22.0	22.0	0.0
C	7,244	740	15,888	7.2	22.6	22.6	22.8	0.2
D	8,466	647	11,985	8.7	22.6	22.6	22.8	0.2
E	11,045	1,121	18,615	5.6	23.9	23.9	24.1	0.2
F	13,567	931	14,988	7.0	24.3	24.3	24.4	0.1
G	16,117	610	12,174	8.6	24.8	24.8	24.9	0.1
H	18,954	734	13,981	7.5	25.9	25.9	26.1	0.2
I	21,358	746	14,461	7.2	26.6	26.6	26.7	0.1
J	23,608	746	14,116	7.4	27.2	27.2	27.3	0.1
K	25,921	600	13,003	8.0	27.8	27.8	27.9	0.1
L	29,105	742	14,670	7.1	29.5	29.5	29.6	0.1
M	32,930	598	13,254	7.9	30.7	30.7	30.8	0.1
N	36,145	580	11,995	8.7	31.7	31.7	31.8	0.1
O	38,085	462	11,558	9.0	32.4	32.4	32.4	0.0
P	39,214	512	12,309	8.5	33.3	33.3	33.4	0.1
Q	40,499	567	14,343	7.3	33.9	33.9	34.0	0.1
R	42,657	357	9,472	11.0	33.9	33.9	34.0	0.1

[1] Feet above confluence with Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COWLITZ RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COWLITZ RIVER (Continued)								
S	44,004	396	10,100	10.3	34.7	34.7	34.9	0.2
T	44,932	518	12,863	8.1	35.8	35.8	36.0	0.2
U	47,215	634	15,535	6.5	37.0	37.0	37.1	0.1
V	48,976	504	12,099	8.4	37.0	37.0	37.2	0.2
W	51,437	813	16,226	6.2	38.2	38.2	38.3	0.1
X	53,265	443	11,424	8.8	38.2	38.2	38.4	0.2
Y	54,133	401	10,434	9.7	38.3	38.3	38.5	0.2
Z	56,532	535	13,099	7.7	39.9	39.9	40.1	0.2
AA	60,322	642	13,972	7.2	41.1	41.1	41.3	0.2
AB	60,712	758	16,220	6.2	41.4	41.4	41.6	0.2
AC	61,632	603	13,218	7.6	41.4	41.4	41.6	0.2
AD	62,632	1,089	23,788	4.2	42.2	42.2	42.4	0.2
AE	63,942	565	10,971	9.2	42.2	42.2	42.3	0.1
AF	66,282	980	10,336	9.8	43.3	43.3	43.6	0.3
AG	67,262	818	18,406	5.5	44.7	44.7	45.0	0.3
AH	68,612	1,186	19,162	5.3	45.0	45.0	45.3	0.3
AI	70,362	782	16,116	6.3	45.1	45.1	45.5	0.4
AJ	73,312	467	10,975	9.2	45.7	45.7	46.1	0.4

[1] Feet above confluence with Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COWLITZ RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COWLITZ RIVER (Continued)								
AK	73,512	440	10,919	9.3	45.8	45.8	46.2	0.4
AL	76,328	565	11,534	8.8	46.9	46.9	47.3	0.4
AM	80,143	606	13,107	7.7	48.8	48.8	49.1	0.3
AN	82,823	604	13,582	7.4	50.6	50.6	50.9	0.3
AO	84,627	500	10,902	9.3	51.1	51.1	51.5	0.4
AP	86,401	655	13,701	7.1	52.4	52.4	52.6	0.2
AQ	89,379	438	9,703	10.0	54.3	54.3	54.5	0.2
AR	91,105	414	9,015	10.8	55.6	55.6	55.7	0.1
AS	92,605	512	12,686	7.6	58.0	58.0	58.0	0.0
AT	94,854	758	18,095	5.4	59.2	59.2	59.3	0.1
AU	97,676	830	17,139	5.7	59.6	59.6	59.7	0.1
AV	99,696	632	13,056	7.4	59.8	59.8	59.9	0.1
AW	102,150	574	10,947	8.9	60.8	60.8	60.9	0.1
AX	103,761	489	12,267	5.0	62.0	62.0	62.2	0.2
AY	105,206	451	11,292	5.4	62.1	62.1	62.3	0.2
AZ	107,782	376	10,593	5.7	62.4	62.4	62.5	0.1
BA	110,582	505	11,087	5.5	63.0	63.0	63.1	0.1
BB	112,582	439	11,213	5.4	63.5	63.5	63.6	0.1

[1] Feet above confluence with Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COWLITZ RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
COWLITZ RIVER (Continued)								
BC	116,182[1]	404	9,772	6.2	64.3	64.3	64.5	0.2
BD	119,382[1]	362	9,356	6.5	65.3	65.3	65.4	0.1
DELAMETER CREEK								
A	0.402[2]	142	1,502	2.7	52.4	52.4	53.1	0.7
B	0.495[2]	83	997	4.0	52.6	52.6	53.6	1.0
C	0.515[2]	274	2,197	1.8	53.0	53.0	53.9	0.9
D	0.709[2]	309	2,474	1.6	53.2	53.2	54.1	0.9
E	1.394[2]	80	961	4.2	54.5	54.5	55.5	1.0
F	1.724[2]	60	578	6.8	57.1	57.1	58.1	1.0
G	1.789[2]	25	446	8.8	60.8	60.8	61.8	1.0
H	1.825[2]	329	3,658	1.1	62.5	62.5	63.3	0.8
I	1.972[2]	156	1,384	2.8	62.7	62.7	63.5	0.8
J	2.119[2]	141	1,349	2.9	63.1	63.1	63.9	0.8
K	2.393[2]	62	380	9.7	66.0	66.0	66.8	0.8
L	2.583[2]	449	1,449	2.6	72.5	72.5	73.0	0.5
M	2.894[2]	118	633	5.5	82.3	82.3	82.4	0.1

[1] Feet above mouth

[2] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

COWLITZ RIVER – DELAMETER CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
GERMANY CREEK								
A	0.000	141	823	5.5	16.1	7.9[2]	8.9[2]	1.0
B	0.033	130	350	13.0	16.1	9.8[2]	9.8[2]	0.0
C	0.069	114	775	5.9	16.1	13.7[2]	13.7[2]	0.0
D	0.445	75	556	8.2	21.7	21.7	22.5	0.8
E	0.827	185	597	7.6	32.7	32.7	33.5	0.8
F	1.191	108	761	6.0	52.0	52.0	52.9	0.9
G	1.555	78	458	9.7	68.6	68.6	69.5	0.9
H	1.880	94	669	6.5	83.5	83.5	83.5	0.0
I	2.174	152	637	6.7	92.4	92.4	93.0	0.6
J	2.591	95	546	7.8	112.9	112.9	112.9	0.0
K	3.030	72	341	12.3	139.4	139.4	140.1	0.7
L	3.352	106	586	7.0	160.1	160.1	161.1	1.0
M	3.791	91	379	10.5	184.1	184.1	184.1	0.0
N	4.214	44	397	10.1	212.8	212.8	213.1	0.3
O	4.582	83	456	8.6	235.5	235.5	236.4	0.9
P	4.982	79	350	11.0	259.3	259.3	259.3	0.0
Q	5.383	65	412	9.2	292.3	292.3	292.6	0.3
R	5.520	61	497	7.6	298.2	298.2	299.0	0.8

[1] Miles above mouth

[2] Water-surface elevation computed without consideration of backwater effects from Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

GERMANY CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
GOBLE CREEK								
A	0.034	151	369	11.1	146.7	146.7	147.0	0.3
B	0.109	145	574	7.1	153.7	153.7	153.7	0.0
C	0.185	140	391	10.5	157.8	157.8	157.8	0.0
D	0.260	130	558	7.3	165.6	165.6	165.6	0.0
E	0.335	132	503	8.1	170.2	170.2	170.3	0.1
F	0.391	50	373	11.0	173.7	173.7	173.8	0.1
G	0.412	142	469	8.5	175.6	175.6	175.7	0.1
H	0.471	60	429	9.3	180.2	180.2	180.3	0.1
I	0.530	135	978	4.1	182.6	182.6	183.3	0.7
J	0.590	62	369	10.8	184.1	184.1	184.4	0.3
K	0.668	55	509	7.8	189.1	189.1	189.7	0.6
L	0.746	165	910	4.4	192.5	192.5	193.0	0.5
M	0.824	90	344	11.5	196.3	196.3	196.3	0.0
N	0.925	225	725	5.5	206.6	206.6	207.6	1.0
O	1.027	85	354	10.9	213.8	213.8	213.8	0.0
P	1.128	139	398	9.7	220.5	220.5	220.7	0.2
Q	1.248	80	334	11.5	229.5	229.5	229.5	0.0
R	1.367	100	413	9.3	237.9	237.9	238.6	0.7
S	1.487	120	549	6.8	245.6	245.6	246.5	0.9

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

GOBLE CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
GOBLE CREEK (Continued)								
T	1.600	125	404	9.2	254.6	254.6	254.6	0.0
U	1.700	150	506	7.4	260.3	260.3	260.5	0.2
V	1.728	31	166	11.4	262.1	262.1	262.1	0.0
W	1.757	118	461	4.1	265.9	265.9	265.9	0.0
X	1.800	85	368	5.2	266.8	266.8	266.8	0.0
Y	1.862	54	222	8.6	268.9	268.9	268.9	0.0
Z	1.923	71	246	7.7	275.2	275.2	275.3	0.1
AA	1.992	130	243	7.8	281.2	281.2	281.3	0.1
AB	2.061	80	223	8.5	288.5	288.5	288.5	0.0
AC	2.130	61	265	7.2	295.3	295.3	295.8	0.5
AD	2.207	70	268	7.1	300.5	300.5	300.7	0.2
AE	2.283	64	172	11.0	311.1	311.1	311.1	0.0
HARMONY CREEK								
A	0.258	21	127	11.0	101.0	101.0	101.1	0.1
B	0.428	21	120	10.4	182.0	182.0	182.0	0.0
C	0.637	25	132	9.4	240.6	240.6	240.8	0.2
D	0.989	53	286	4.3	281.7	281.7	282.4	0.7
E	1.041	30	136	6.9	293.3	293.3	293.9	0.6

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

GOBLE CREEK – HARMONY CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
HARMONY CREEK (Continued)								
F	1.092	69	512	1.8	298.3	298.3	298.9	0.6
G	1.408	12	74	11.8	316.2	316.2	316.2	0.0
H	1.832	40	91	9.0	339.6	339.6	339.6	0.0
I	2.091	42	161	4.7	363.6	363.6	364.6	1.0
KALAMA RIVER								
A	0.772	770	7,970	3.1	22.1	20.7[2]	21.1[2]	0.4
B	1.241	310	5,150	4.9	22.1	21.2[2]	21.6[2]	0.4
C	1.417	350	4,480	5.6	22.1	21.5[2]	22.5[2]	1.0
D	1.623	550	5,680	4.4	22.5	22.5	23.2	0.7
E	1.908	480	6,150	4.1	23.4	23.4	24.2	0.8
F	2.462	720	5,540	4.5	25.1	25.1	25.9	0.8
G	2.771	320	3,546	7.1	26.8	26.8	27.8	1.0
H	3.287	200	2,760	9.1	31.6	31.6	32.0	0.4
I	3.655	460	4,600	5.4	35.6	35.6	35.7	0.1
J	4.086	160	2,050	12.2	39.5	39.5	39.6	0.1
K	4.648	370	4,320	5.8	47.1	47.1	47.7	0.6
L	4.996	190	2,570	9.5	49.3	49.3	49.6	0.3

[1] Miles above mouth

[2] Water- surface elevation computed without consideration of backwater effects from Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

HARMONY CREEK – KALAMA RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
KALAMA RIVER (Continued)								
M	5.422	220	2,450	10.0	55.2	55.2	55.3	0.1
N	5.880	170	2,480	9.8	62.0	62.0	63.0	1.0
O	6.406	210	3,120	7.8	68.9	68.9	69.7	0.8
P	6.640	90	1,410	17.3	70.9	70.9	71.6	0.7
Q	6.929	190	2,970	8.2	79.4	79.4	80.4	1.0
R	7.480	200	2,960	8.2	88.8	88.8	88.9	0.1
S	7.991	180	2,330	10.4	94.5	94.5	94.6	0.1
T	8.567	170	2,370	10.2	105.2	105.2	105.3	0.1
U	9.014	170	2,290	10.5	113.8	113.8	113.8	0.0
V	9.480	150	1,470	16.4	130.1	130.1	130.3	0.2
W	9.634	170	2,440	9.9	139.3	139.3	139.9	0.6
X	9.872	110	1,560	15.3	146.6	146.6	147.4	0.8
Y	10.326	200	2,020	11.9	174.0	174.0	174.3	0.3
Z	10.500	90	1,170	20.4	186.7	186.7	186.8	0.1
AA	10.768	160	1,410	16.9	226.3	226.3	226.3	0.0
AB	10.889	190	2,640	9.1	236.3	236.3	236.3	0.0
AC	11.192	290	3,880	6.2	240.2	240.2	240.5	0.3
AD	11.492	250	3,480	6.9	242.6	242.6	243.0	0.4

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

KALAMA RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
KALAMA RIVER (Continued)								
AE	11.874	280	4,070	5.8	246.1	246.1	246.6	0.5
AF	12.263	250	3,260	7.2	249.9	249.9	250.4	0.5
AG	12.642	160	2,590	9.1	255.3	255.3	255.8	0.5
AH	12.866	180	2,830	8.3	259.6	259.6	259.8	0.2
AI	13.308	150	2,640	8.9	266.7	266.7	267.7	1.0
AJ	13.728	140	2,290	10.3	275.5	275.5	275.6	0.1
AK	14.024	220	3,610	6.4	280.7	280.7	280.8	0.1
AL	14.404	150	3,000	7.6	283.8	283.8	283.9	0.1
AM	14.768	250	3,960	5.8	286.8	286.8	287.0	0.2
AN	15.228	170	2,250	10.1	291.5	291.5	291.6	0.1
AO	15.458	130	1,570	14.5	298.1	298.1	298.1	0.0
AP	15.709	130	2,290	9.9	308.3	308.3	308.9	0.6
AQ	15.937	160	2,590	8.7	312.7	312.7	313.3	0.6
AR	16.073	140	1,280	17.7	317.2	317.2	317.2	0.0
AS	16.217	200	2,540	8.9	327.2	327.2	327.2	0.0
AT	16.432	120	1,290	17.6	336.3	336.3	336.7	0.4
AU	16.708	140	2,250	10.1	350.4	350.4	351.0	0.6
AV	16.859	140	2,280	9.9	353.5	353.5	353.8	0.3

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

KALAMA RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
KALAMA RIVER (Continued)								
AW	16.932	110	2,210	10.3	354.6	354.6	354.9	0.3
AX	16.951	120	1,790	12.7	354.6	354.6	354.9	0.3
AY	17.191	100	1,520	14.8	360.6	360.6	360.6	0.0
AZ	17.520	120	1,560	14.3	372.0	372.0	372.6	0.6
BA	17.907	130	1,920	11.6	383.9	383.9	384.3	0.4
BB	18.085	160	1,610	13.9	388.8	388.8	389.1	0.3
BC	18.385	100	1,260	17.5	400.1	400.1	400.6	0.5
BD	18.605	120	1,740	12.6	407.8	407.8	407.9	0.1
BE	18.898	180	1,890	11.6	412.8	412.8	413.3	0.5
BF	19.186	120	1,530	14.1	418.6	418.6	418.7	0.1
BG	19.496	130	2,000	10.8	424.2	424.2	424.8	0.6
BH	19.785	160	1,670	12.9	428.4	428.4	428.7	0.3
LEWIS RIVER								
A	0.670	969/178[2]	17,362	7.6	26.4	20.5[3]	21.5[3]	1.0
B	1.190	818/418[2]	15,387	8.6	26.4	21.9[3]	22.9[3]	1.0
C	1.700	788/388[2]	17,223	7.7	26.4	23.7[3]	24.4[3]	0.7
D	1.750	799/360[2]	16,955	7.8	26.4	24.1[3]	25.1[3]	1.0

[1] Miles above mouth

[2] Width/width within Cowlitz County

[3] Water-surface elevation computed without consideration of backwater effects from Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

KALAMA RIVER – LEWIS RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
LEWIS RIVER (Continued)								
E	2.380	884/545	17,318	7.7	26.4	25.9[3]	26.5[3]	0.6
F	2.980	636/396	14,395	9.2	27.1	27.1	27.9	0.8
G	3.180	536/362	12,769	10.4	27.6	27.6	28.3	0.7
H	3.380	1,090/902	16,615	8.0	28.5	28.5	29.2	0.7
I	3.700	1,130/665	19,165	5.3	30.3	30.3	30.8	0.5
J	3.900	655/335	15,104	6.8	30.5	30.5	31.0	0.5
K	4.290	1,151/245	19,207	5.3	31.1	31.1	31.6	0.5
L	5.010	715/400	17,108	6.0	32.0	32.0	32.6	0.6
M	5.270	547/300	12,906	7.9	32.0	32.0	32.6	0.6
N	5.350	660/452	15,763	6.5	32.6	32.6	33.2	0.6
O	5.420	581/308	14,943	6.8	32.7	32.7	33.3	0.6
P	5.480	511/256	14,815	6.9	32.7	32.7	33.3	0.6
Q	6.540	490/216	13,418	7.6	34.4	34.4	35.4	1.0
R	7.130	520/280	16,808	6.1	35.8	35.8	36.6	0.8
S	7.690	1,462/1,138	21,911	4.7	36.8	36.8	37.6	0.8
T	8.130	716/436	17,283	5.9	37.5	37.5	38.4	0.9
U	8.390	851/361	17,418	5.9	37.9	37.9	38.7	0.8

[1] Miles above mouth

[2] Width/width within Cowlitz County

[3] Water-surface elevation computed without consideration of backwater effects from Columbia River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

LEWIS RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
LEWIS RIVER (Continued)								
V	8.610	512/308	12,213	8.4	38.1	38.1	38.9	0.8
W	9.200	1,709/138	27,613	3.7	39.7	39.7	40.5	0.8
X	9.850	1,420/288	28,526	3.6	40.5	40.5	41.4	0.9
Y	10.690	3,021/140	33,021	3.1	41.4	41.4	42.3	0.9
Z	11.340	2,600/96	29,987	3.4	42.2	42.2	43.0	0.8
AA	11.670	724/35	15,044	6.8	42.7	42.7	43.4	0.7
AB	12.480	420/175	8,952	11.4	46.1	46.1	46.6	0.5
AC	12.950	386/192	9,516	10.7	50.1	50.1	50.4	0.3
AD	13.500	990/246	16,133	6.3	53.7	53.7	54.5	0.8
AE	14.440	691/104	19,586	5.2	57.3	57.3	58.3	1.0
AF	15.090	540/131	11,444	8.9	58.4	58.4	59.4	1.0
AG	15.360	493/0[3]	11,212	9.1	59.4	59.4	60.4	1.0
AH	15.670	499/127	10,651	8.8	60.6	60.6	61.6	1.0
AI	16.080	256/76	7,868	11.9	62.1	62.1	63.0	0.9
AJ	16.350	313/43	7,659	12.3	63.9	63.9	64.7	0.8
AK	16.690	438/171	10,160	9.3	66.2	66.2	67.2	1.0
AL	17.080	330/160	8,979	10.5	67.8	67.8	68.8	1.0

[1] Miles above mouth

[2] Width/width within Cowlitz County

[3] Floodway lies outside Cowlitz County limits

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

LEWIS RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
LEWIS RIVER (Continued)								
AM	17.540	362/191[2]	8,967	10.5	70.4	70.4	71.3	0.9
AN	17.910	257/117[2]	8,179	11.5	72.0	72.0	73.0	1.0
AO	18.260	339/145[2]	9,552	9.8	73.8	73.8	74.8	1.0
AP	18.650	272/160[2]	8,394	11.2	75.3	75.3	76.3	1.0
AQ	19.060	356/220[2]	11,511	8.2	78.0	78.0	78.9	0.9
MILL CREEK								
A	0.007	69	944	5.5	15.4	15.4	16.4	1.0
B	0.062	113	1,549	3.4	16.0	16.0	16.9	0.9
C	0.278	107	615	8.4	16.7	16.7	17.7	1.0
D	0.310	83	709	7.3	18.9	18.9	18.9	0.0
E	0.541	60	435	11.9	30.9	30.9	31.7	0.8
F	0.792	33	343	15.0	55.3	55.3	55.6	0.3
G	1.027	96	572	8.8	88.2	88.2	89.1	0.9
H	1.124	31	282	10.3	93.2	93.2	93.7	0.5
I	1.144	70	516	5.6	96.0	96.0	96.0	0.0
J	1.491	45	225	12.7	130.3	130.3	130.3	0.0
K	1.616	49	216	13.2	144.4	144.4	144.5	0.1

[1] Miles above mouth

[2] Width/width within Cowlitz County

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

LEWIS RIVER – MILL CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
MILL CREEK (Continued)								
L	1.634	131	590	4.8	147.9	147.9	147.9	0.0
M	1.828	109	337	8.3	163.4	163.4	163.4	0.0
N	1.897	58	276	10.2	169.7	169.7	169.7	0.0
O	1.928	146	413	6.8	172.1	172.1	172.1	0.0
P	2.027	35	226	12.4	183.1	183.1	183.1	0.0
Q	2.063	154	650	4.2	186.2	186.2	186.4	0.2
R	2.246	57	236	11.7	208.8	208.8	208.8	0.0
S	2.744	425	1,285	2.1	247.3	247.3	248.0	0.7
T	2.776	168	361	7.3	248.0	248.0	248.3	0.3
U	2.791	94	468	5.7	249.4	249.4	249.4	0.0
V	3.123	230	734	3.6	265.7	265.7	266.6	0.9
W	3.475	58	377	6.9	289.1	289.1	289.6	0.5
MONAHAN CREEK								
A	0.238	48	251	8.0	98.4	98.4	99.0	0.6

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

MILL CREEK – MONAHAN CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
NORTH FORK GOBLE CREEK								
A	0.000	70	265	6.9	262.0	262.0	263.0	1.0
B	0.037	10	101	18.2	269.0	269.0	269.0	0.0
C	0.075	144	779	2.4	277.6	277.6	277.6	0.0
D	0.100	85	414	4.4	277.6	277.6	277.6	0.0
E	0.127	39	156	11.8	280.0	280.0	280.0	0.0
F	0.143	80	390	4.7	283.1	283.1	283.1	0.0
G	0.211	82	334	5.5	284.9	284.9	284.9	0.0
H	0.266	70	243	7.6	287.4	287.4	287.4	0.0
I	0.279	69	180	10.2	290.8	290.8	290.8	0.0
J	0.473	96	260	6.6	306.8	306.8	306.8	0.0
K	0.539	115	192	8.9	314.5	314.5	314.5	0.0
L	0.604	55	228	7.5	321.7	321.7	321.7	0.0
M	0.670	52	220	7.8	325.0	325.0	325.0	0.0
N	0.861	154	243	6.5	337.2	337.2	337.2	0.0
O	0.939	40	155	10.2	346.6	346.6	346.6	0.0
P	1.001	85	174	9.1	352.3	352.3	352.3	0.0
Q	1.062	56	175	9.0	357.3	357.3	357.3	0.0
R	1.123	149	213	6.8	366.3	366.3	366.3	0.0

[1] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

NORTH FORK GOBLE CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
NORTH FORK GOBLE CREEK (Continued)								
S	1.218	120	222	6.5	378.2	378.2	378.2	0.0
T	1.314	89	163	8.1	388.0	388.0	388.0	0.0
U	1.409	135	278	4.7	397.6	397.6	397.7	0.1
V	1.496	60	143	8.3	404.0	404.0	404.1	0.1
W	1.583	60	122	9.7	413.2	413.2	413.2	0.0
X	1.627	107	297	4.6	416.8	416.8	416.8	0.0
Y	1.670	90	127	9.4	421.6	421.6	421.6	0.0
OSTRANDER CREEK								
A	0.312	22	501	7.2	36.4	35.8[2]	35.5[2]	0.2
B	0.323	102	1,541	2.3	36.4	36.5[2]	36.6[2]	0.1
C	0.662	113	1,545	2.3	36.4	36.8[2]	36.9[2]	0.1
D	0.750	48	560	4.3	36.4	36.9[2]	37.8[2]	0.9
E	0.778	220	1,293	1.9	37.4	37.4	38.2	0.8
F	1.008	76	455	5.3	39.6	39.6	40.0	0.4
G	1.074	50	358	6.7	47.6	47.6	47.6	0.0
H	1.328	41	229	10.5	66.0	66.0	66.5	0.5
I	1.604	55	223	10.8	106.5	106.5	106.6	0.1

[1] Miles above mouth

[2] Water-surface elevation computed without consideration of backwater effects from Cowlitz River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

NORTH FORK GOBLE CREEK – OSTRANDER CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
OSTRANDER CREEK (Continued)								
J	1.871	14	212	11.3	161.5	161.5	161.5	0.0
K	1.956	53	363	6.6	166.3	166.3	166.8	0.5
SOUTH FORK OSTRANDER CREEK								
A	0.098	60	291	4.5	43.6	43.6	43.8	0.2
B	0.192	61	154	8.4	46.0	46.0	46.1	0.1
C	0.205	35	125	10.4	48.4	48.4	48.4	0.0
D	0.209	55	213	6.1	49.9	49.9	49.9	0.0
E	0.396	35	219	5.9	59.9	59.9	60.4	0.5
F	0.628	25	126	10.3	73.1	73.1	73.1	0.0
G	0.896	58	161	8.1	96.9	96.9	97.2	0.3

[1] Miles above mouth

[2] Miles above mouth

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

OSTRANDER CREEK – SOUTH FORK OSTRANDER CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
TOUTLE RIVER								
A	0	812	6,977	7.3	61.4	58.4[2]	58.6[2]	0.2
B	400	450	4,750	10.8	61.4	59.1[2]	59.4[2]	0.3
C	630	320	3,452	14.8	61.4	59.6[2]	59.8[2]	0.2
D	1,202	274	4,604	11.1	65.1	65.1	65.1	0.0
E	2,952	633	8,610	5.9	68.3	68.3	68.4	0.1
F	3,952	230	3,857	13.2	70.4	70.4	71.2	0.8
G	4,478	262	4,510	11.3	73.3	73.3	73.7	0.4
H	5,700	328	5,480	9.3	76.4	76.4	76.6	0.2
I	7,350	296	5,171	9.9	79.0	79.0	79.1	0.1
J	8,950	397	6,036	8.5	81.5	81.5	81.6	0.1
K	10,800	829	10,588	4.8	83.4	83.4	83.5	0.1
L	12,080	708	7,445	6.9	84.2	84.2	84.3	0.1
M	14,390	1,320	9,939	5.1	87.1	87.1	87.1	0.0
N	16,630	408	3,214	15.9	91.3	91.3	91.3	0.0
O	18,430	458	4,807	10.6	100.3	100.3	100.3	0.0
P	19,830	347	3,783	13.5	103.8	103.8	103.8	0.0
Q	20,930	721	7,632	6.7	108.0	108.0	108.0	0.0
R	22,980	344	3,419	15.0	109.8	109.8	109.8	0.0
S	23,730	244	2,906	17.6	113.3	113.3	113.3	0.0

[1] Feet above confluence with Cowlitz River

[2] Water-surface elevation computed without consideration of backwater effects from Cowlitz River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

TOUTLE RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
TOUTLE RIVER (Continued)								
T	25,880	348	4,693	10.9	123.5	123.5	123.5	0.0
U	27,130	304	4,094	12.5	125.9	125.9	125.9	0.0
V	28,780	357	4,670	10.9	130.6	130.6	130.6	0.0
W	29,980	302	3,737	13.7	132.9	132.9	132.9	0.0
X	31,330	258	3,608	14.2	136.4	136.4	136.4	0.0
Y	32,330	271	3,435	14.9	139.4	139.4	139.4	0.0
Z	33,625	299	3,710	13.8	144.7	144.7	144.7	0.0
AA	34,825	649	6,354	8.0	149.3	149.3	149.3	0.0

[1] Feet above confluence with Cowlitz River

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

TOUTLE RIVER

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no (1-percent-annual-chance) BFEs or base flood depths are shown within this zone.

Zone AE

Zone AE is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance risk zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1-foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No BFEs or base flood depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance risk zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The countywide FIRM presents flooding information for the geographic area of Cowlitz County. Previously, FIRMs were prepared for each incorporated community of the County identified as flood-prone. This countywide FIRM also includes flood hazard information that was presented separately on FBFMs, where applicable. Historical data relating to the maps prepared for each community are presented in Table 16, “Community Map History”.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Castle Rock, City of	July 16, 1976	None	June 18, 1980	August 1, 1980 January 19, 1982 September 30, 1993 December 20, 2001
Cowlitz County, Unincorporated Areas	June 18, 1971	October 18, 1977	August 1, 1980	October 15,1980 March 30, 1982 September 2, 1993 June 2, 1995 July 7, 1999 December 20, 2001
Kalama, City of	July 11, 1975	None	June 1, 1981	
Kelso, City of	February 15, 1974	June 4, 1976	December 4, 1979	August 1, 1980 September 2, 1993 December 20, 2001
Longview, City of	June 28, 1974	December 10, 1976	December 18, 1979	September 2, 1993 December 20, 2001
Woodland, City of	November 2, 1973	June 11, 1976	February 1, 1978	September 4, 1985

TABLE 16

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

This FIS report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.

Countywide FIS report for the adjacent Washington Counties of Skamania and Wahkiakum are currently underway.

Countywide FIS report for Clark County, Washington (2000); Columbia County, Oregon (2010); and Lewis County, Oregon (2006) have already gone effective (References 68, 69, and 70).

This is a multi-volume FIS. Each volume may be revised separately, in which case it supersedes the previously printed volume. Users should refer to the Table of Contents in Volume 1 for the current effective date of each volume; volumes bearing these dates contain the most up-to-date flood hazard data.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, Federal Regional Center, 130 228th Street, SW, Bothell, Washington 98021-9796.

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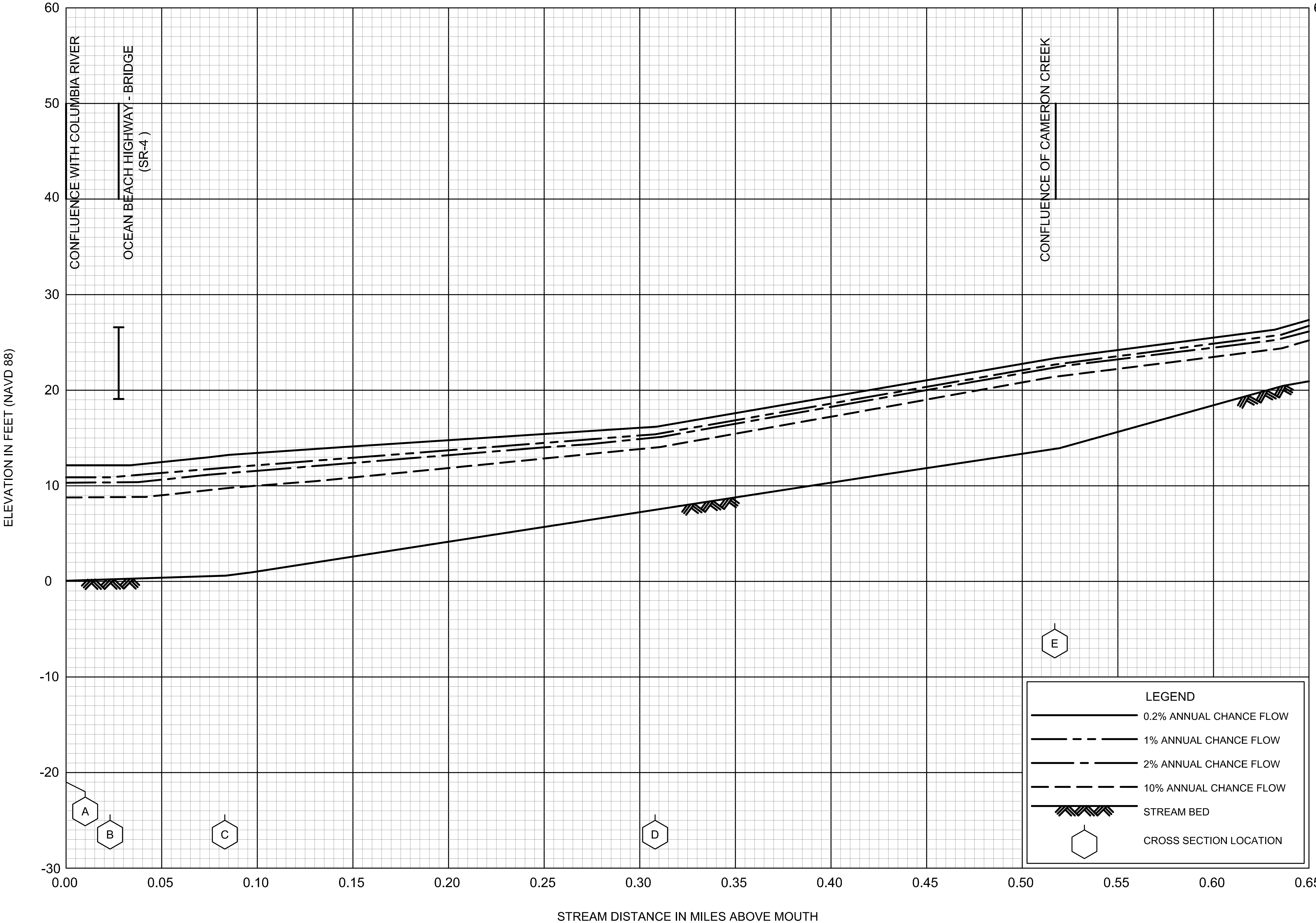


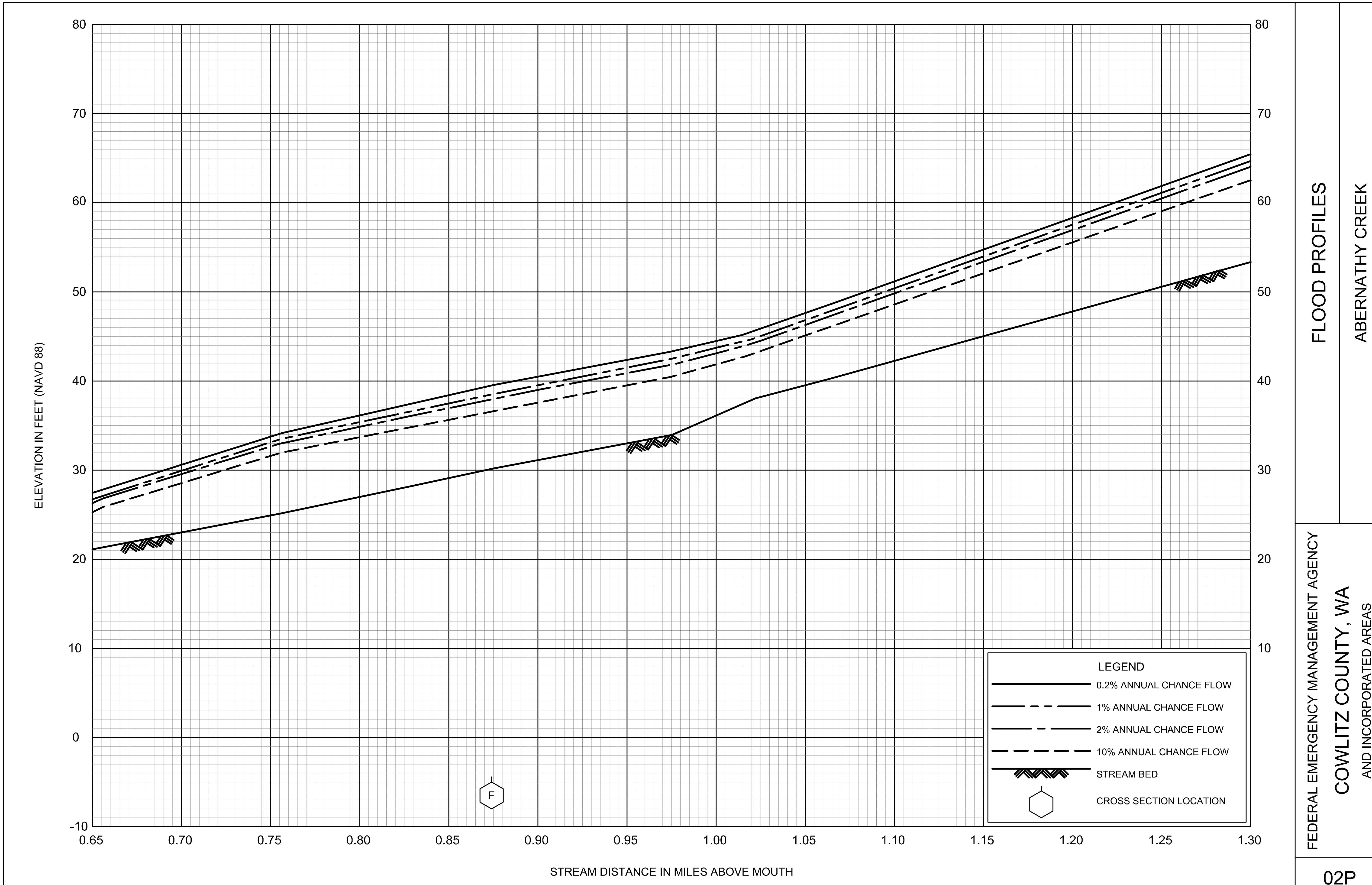
FLOOD PROFILES

ABERNATHY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

COWLITZ COUNTY, WA

AND INCORPORATED AREAS



ELEVATION IN FEET (NAVD 88)
STREAM DISTANCE IN MILES ABOVE MOUTH
LEGEND
0.2% ANNUAL CHANCE FLOW
1% ANNUAL CHANCE FLOW
2% ANNUAL CHANCE FLOW
10% ANNUAL CHANCE FLOW
STREAM BED
CROSS SECTION LOCATION
F
FLOOD PROFILES
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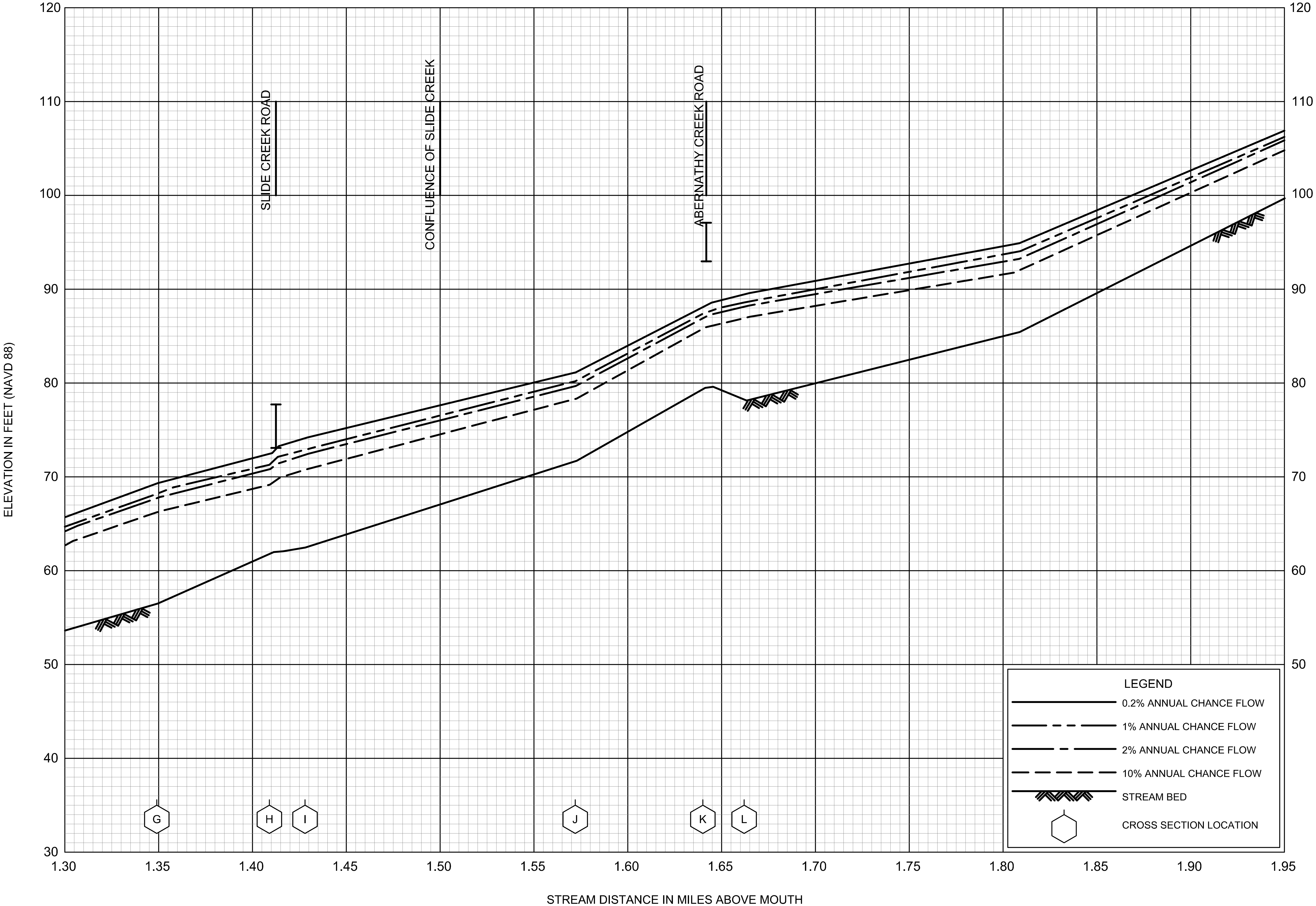
02P



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ABERNATHY CREEK

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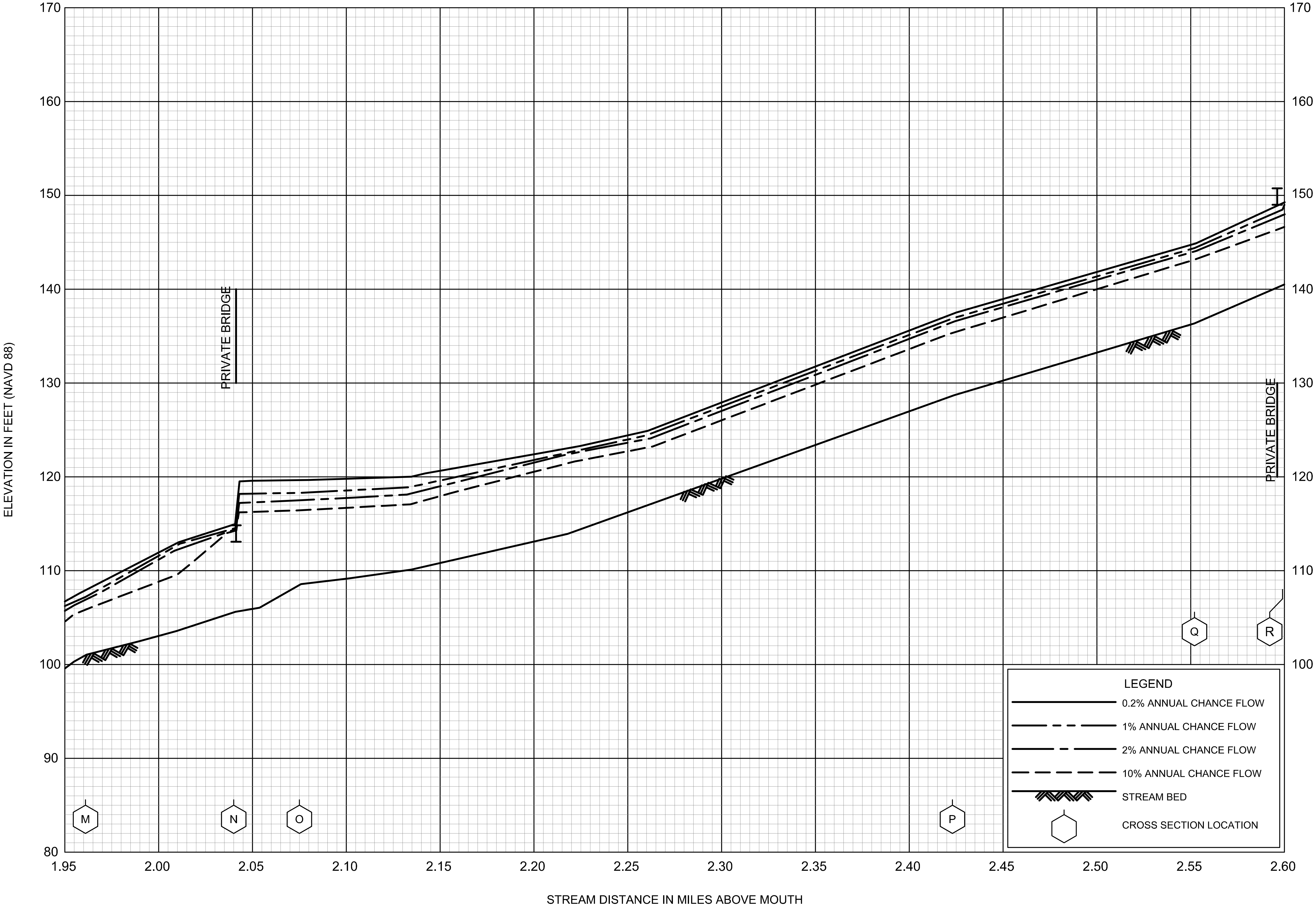

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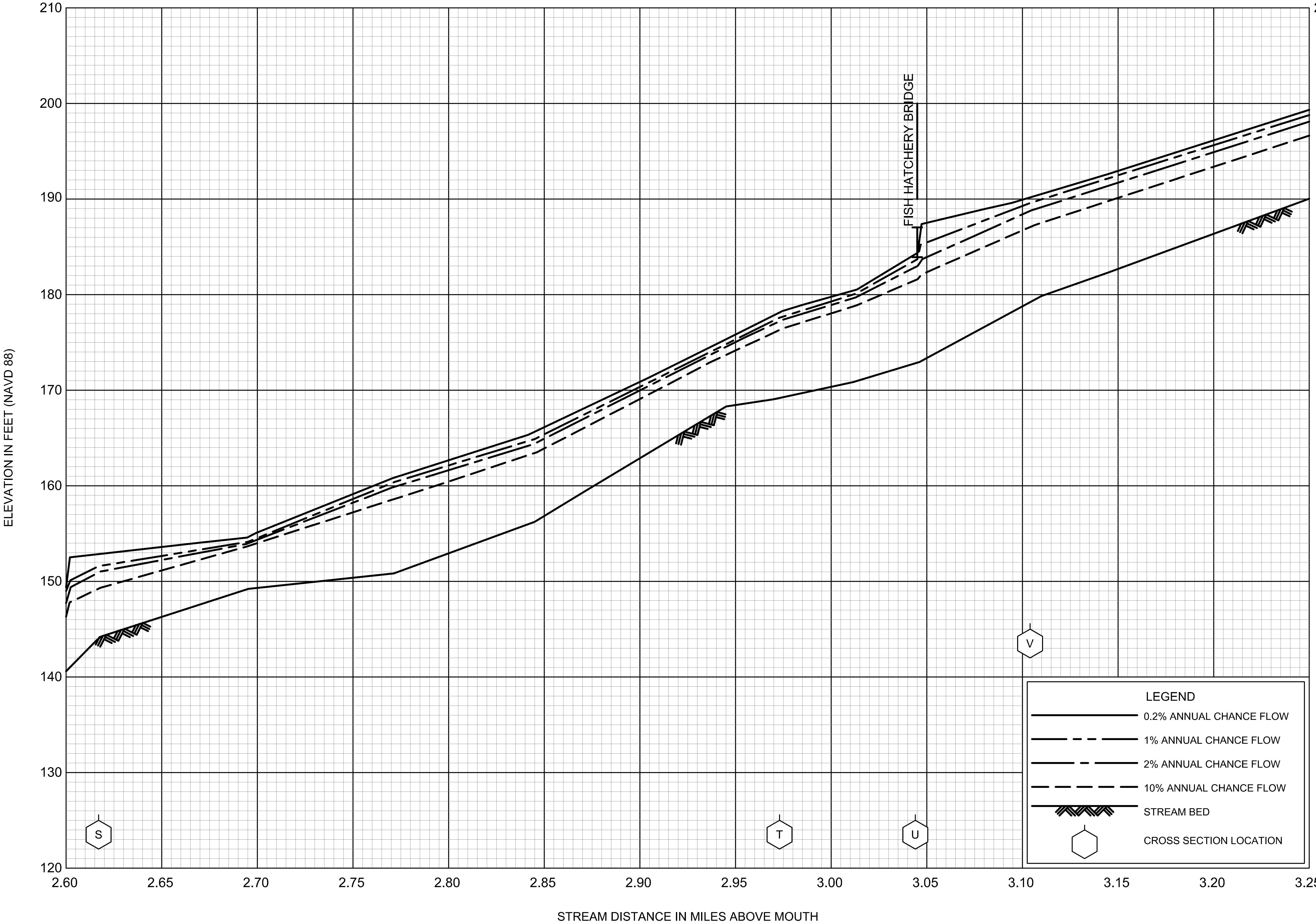

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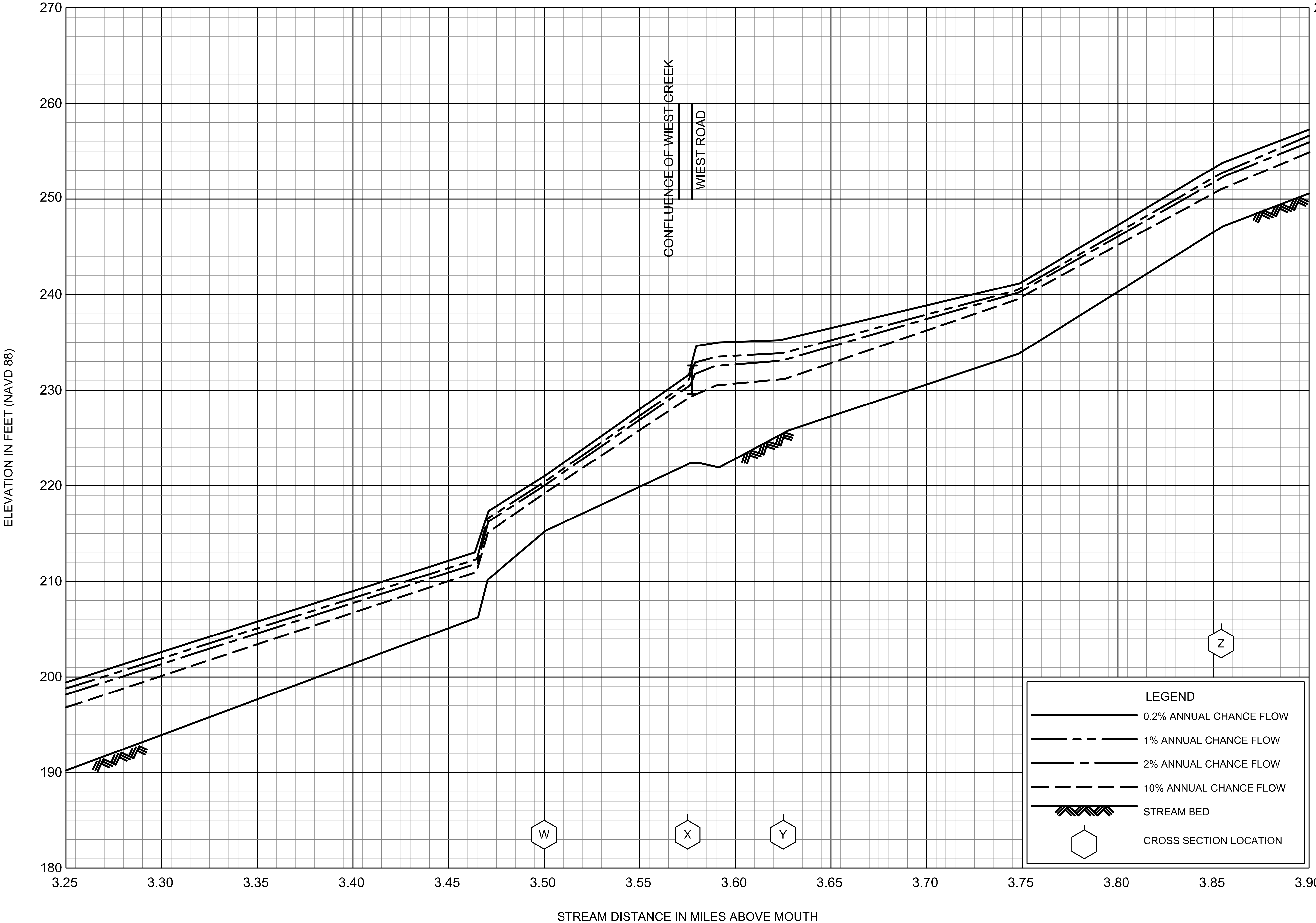

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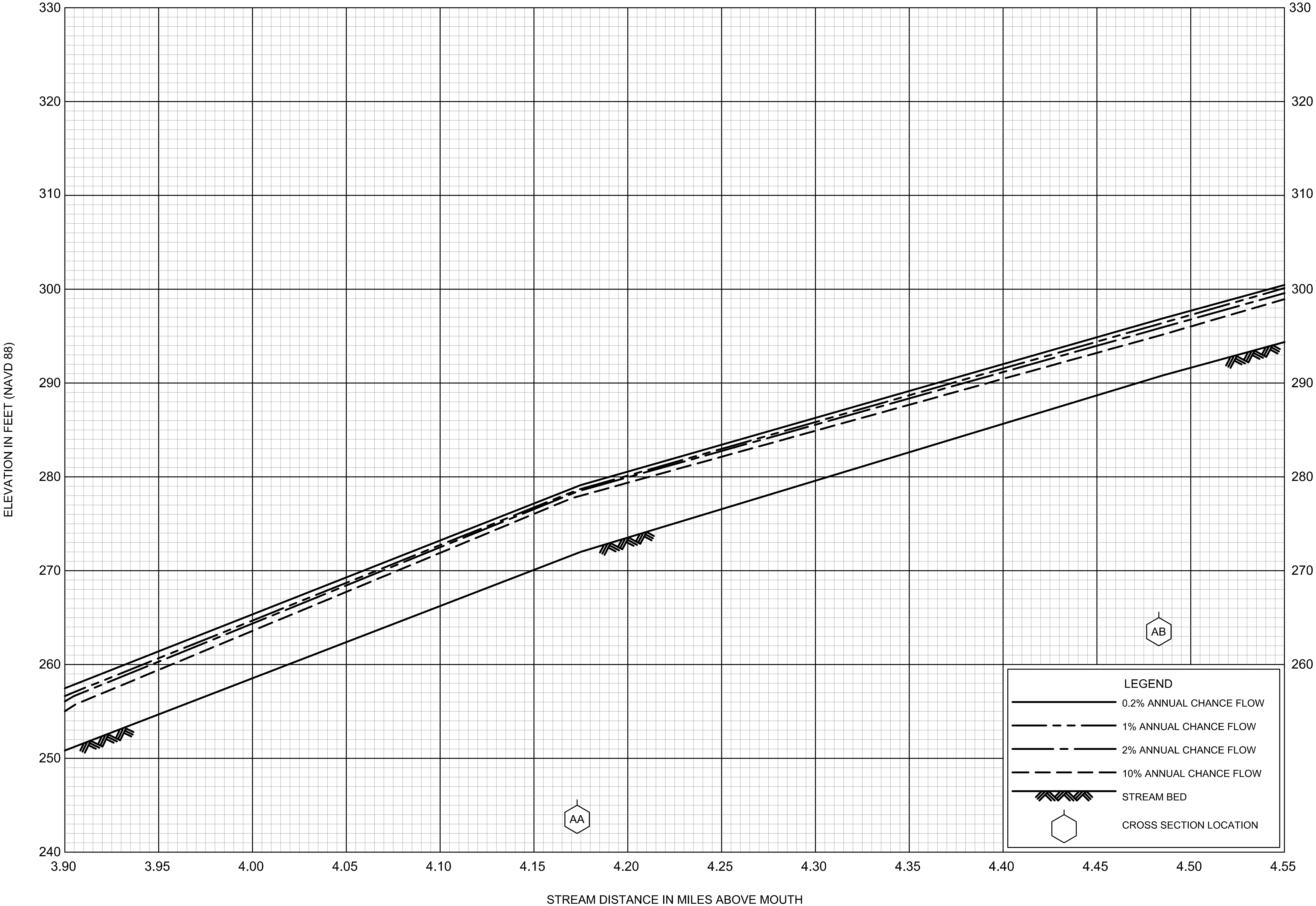

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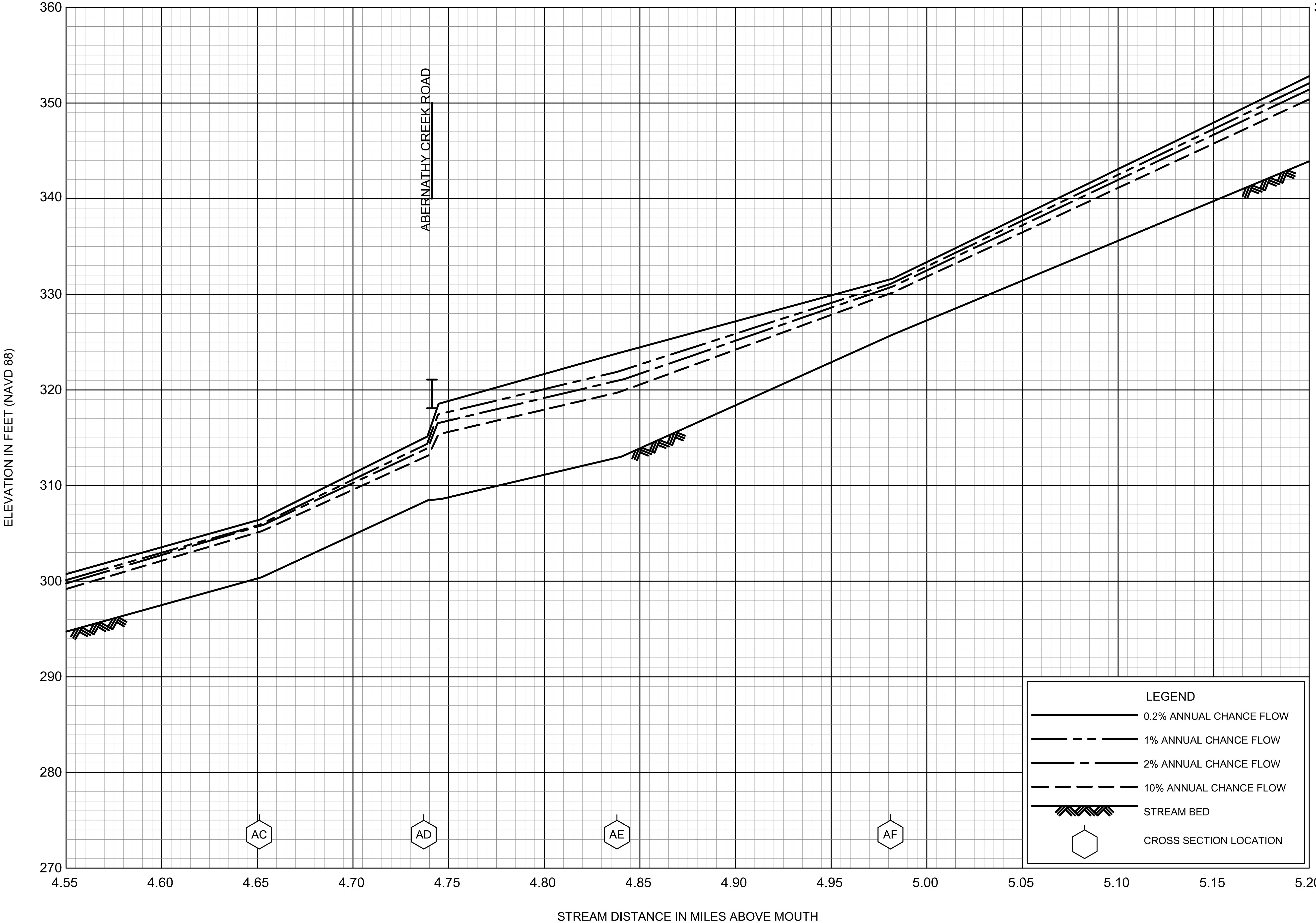

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ABERNATHY CREEK

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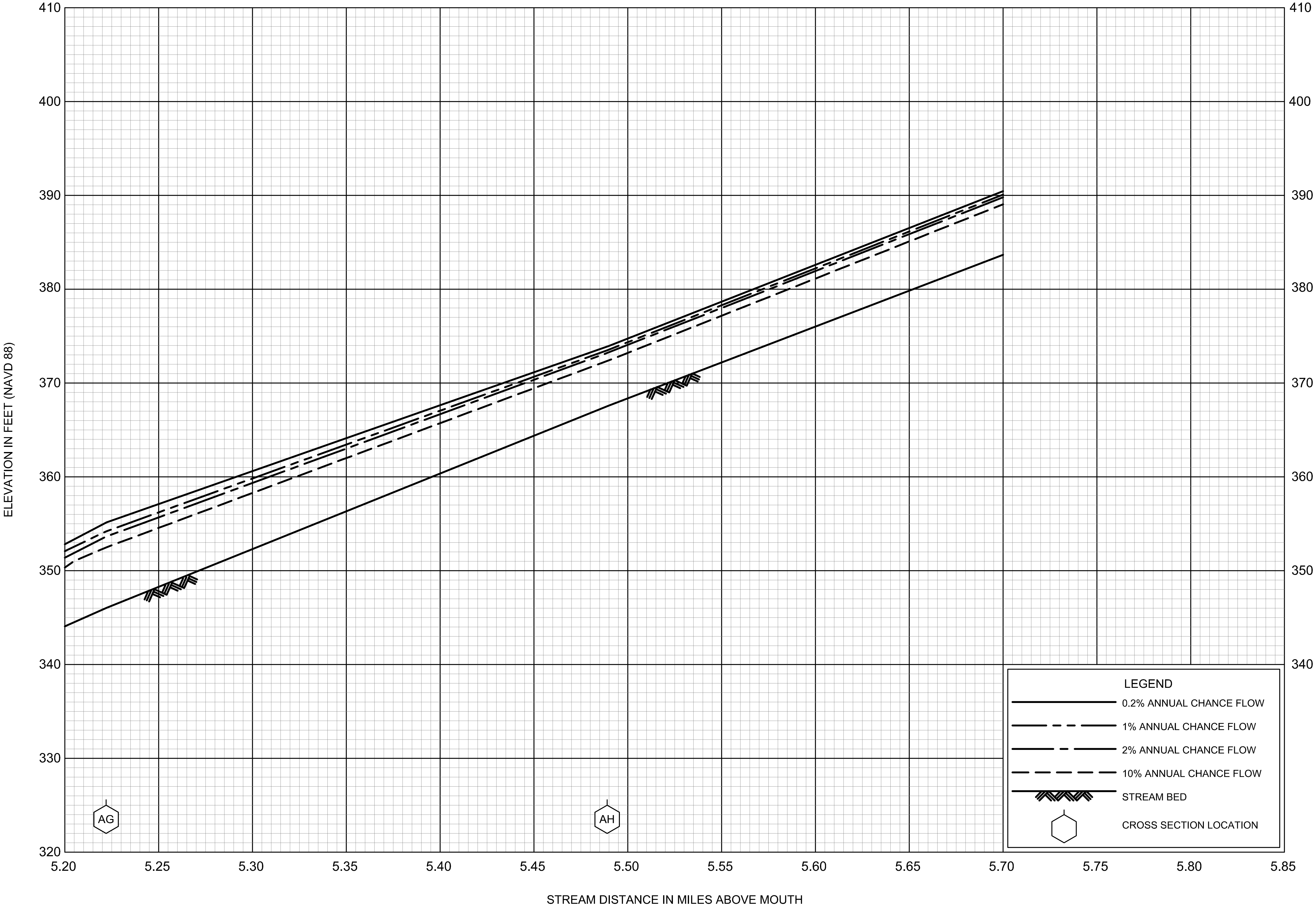

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ABERNATHY CREEK

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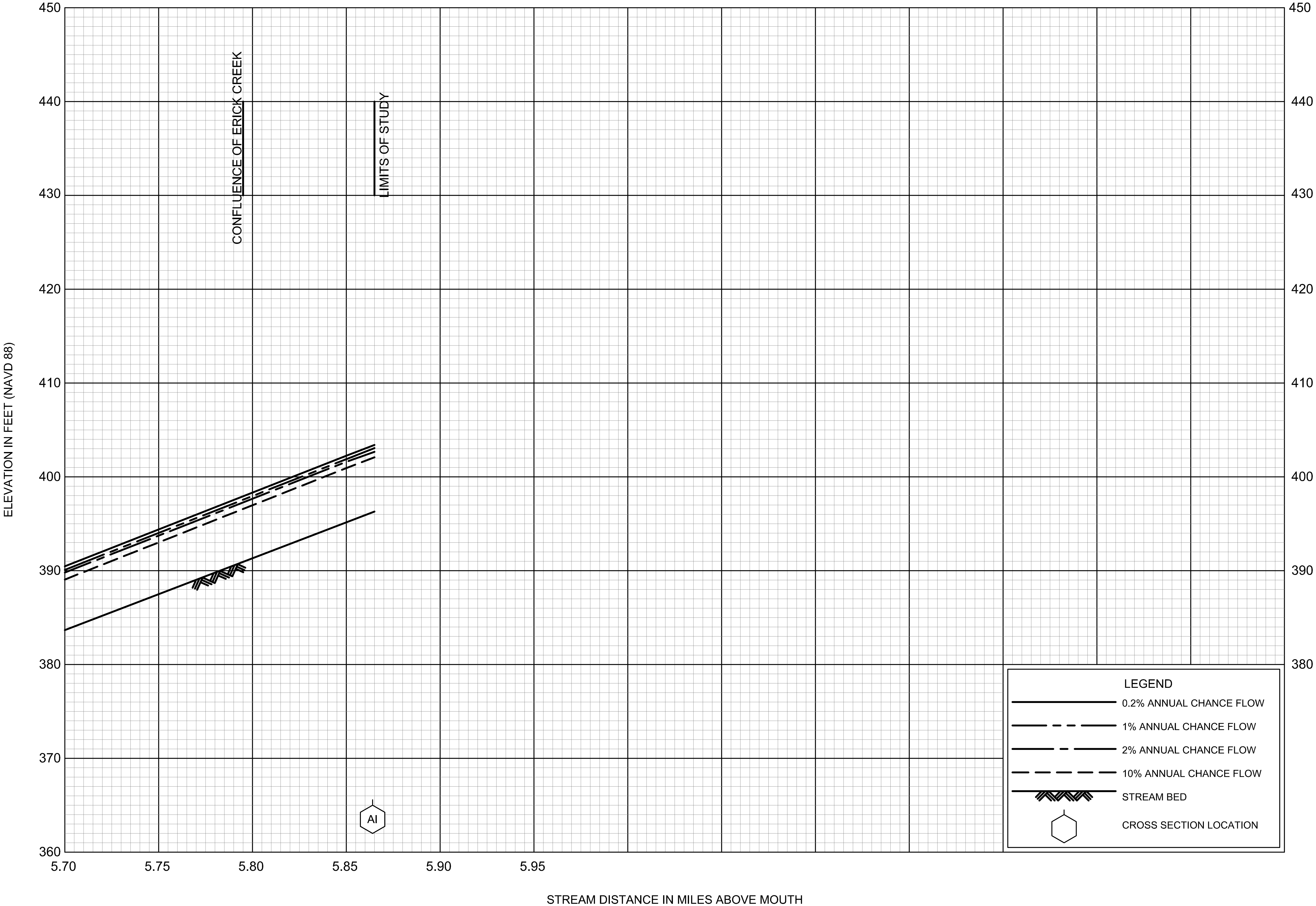

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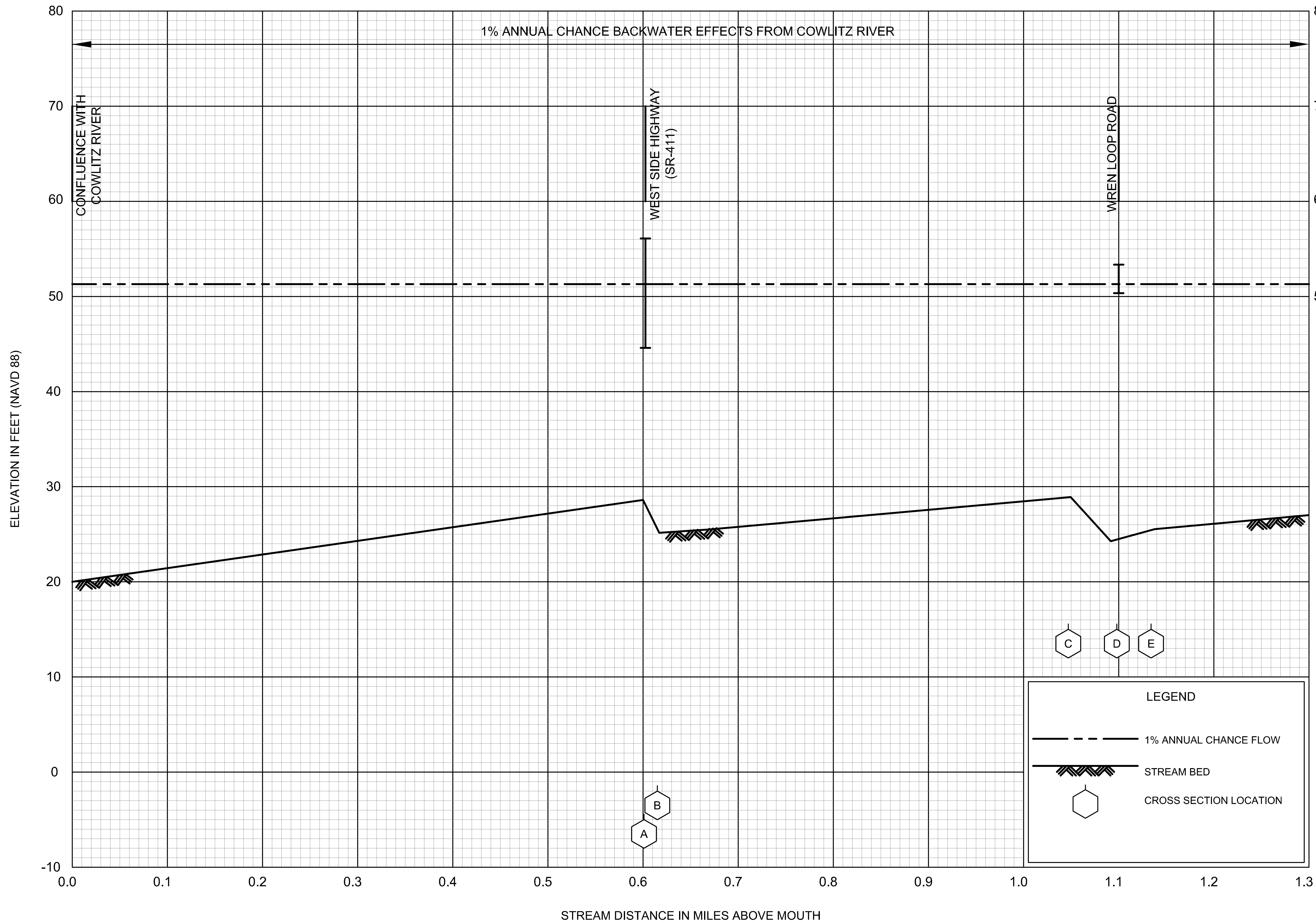

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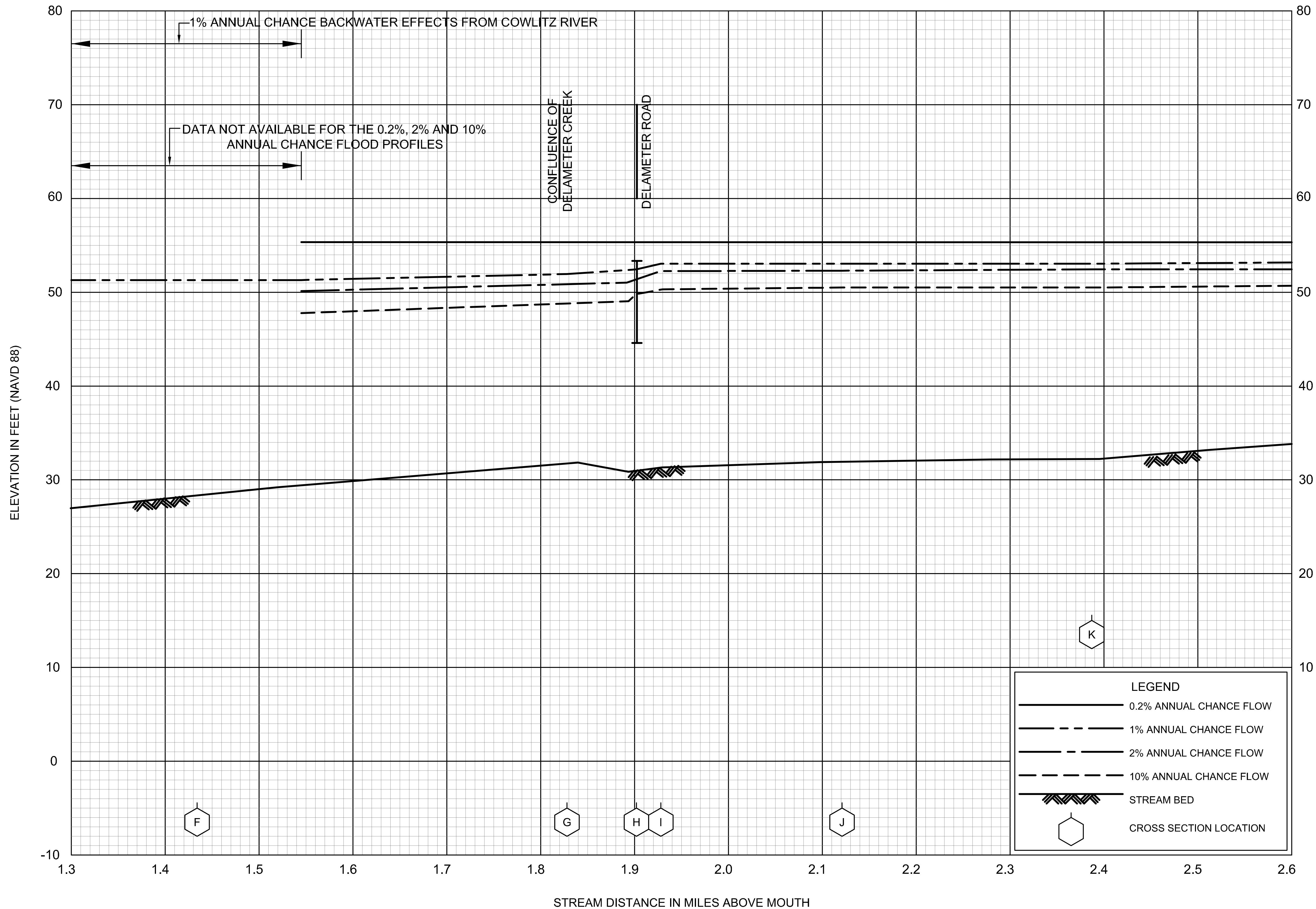

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ARKANSAS CREEK

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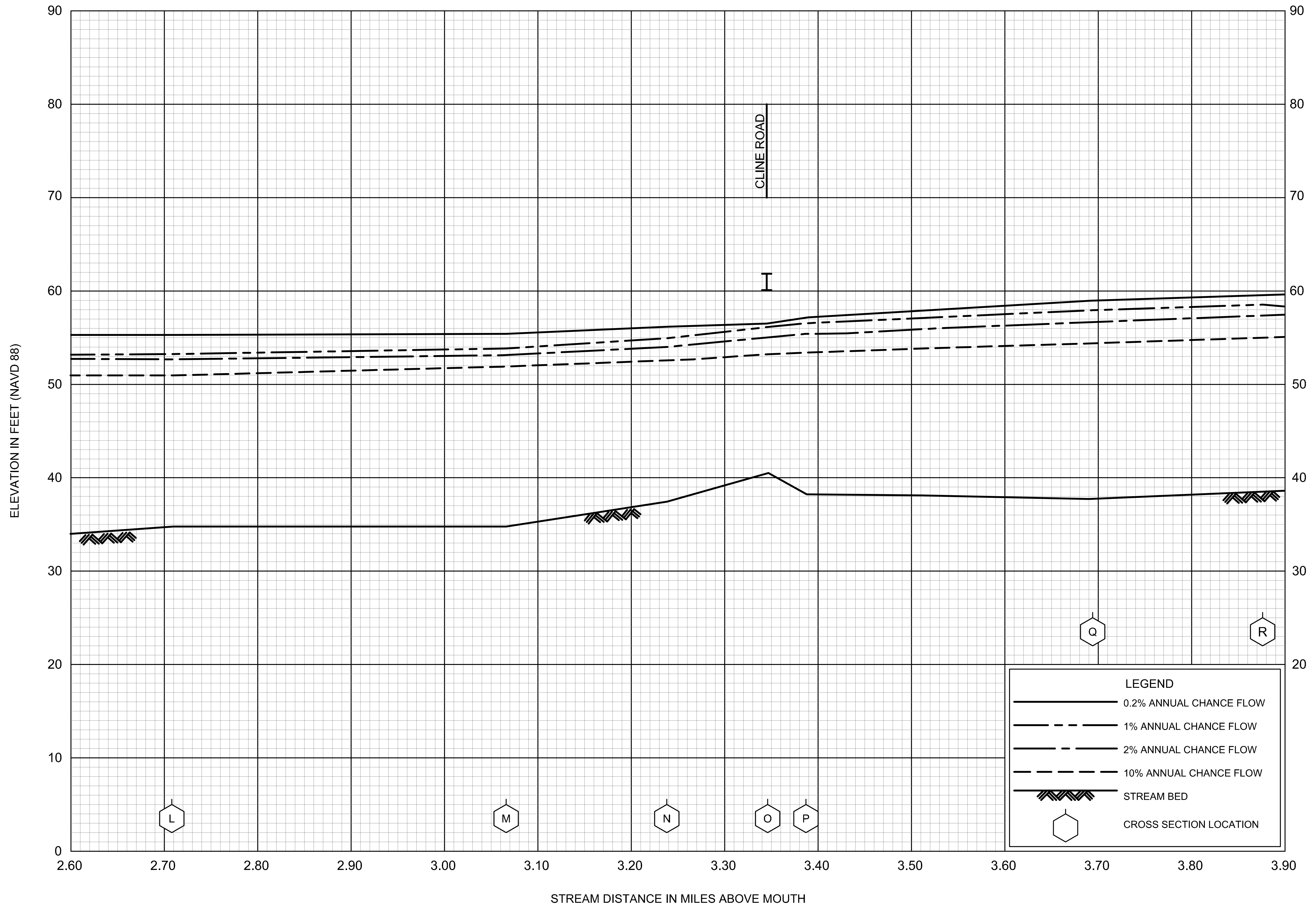

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ARKANSAS CREEK

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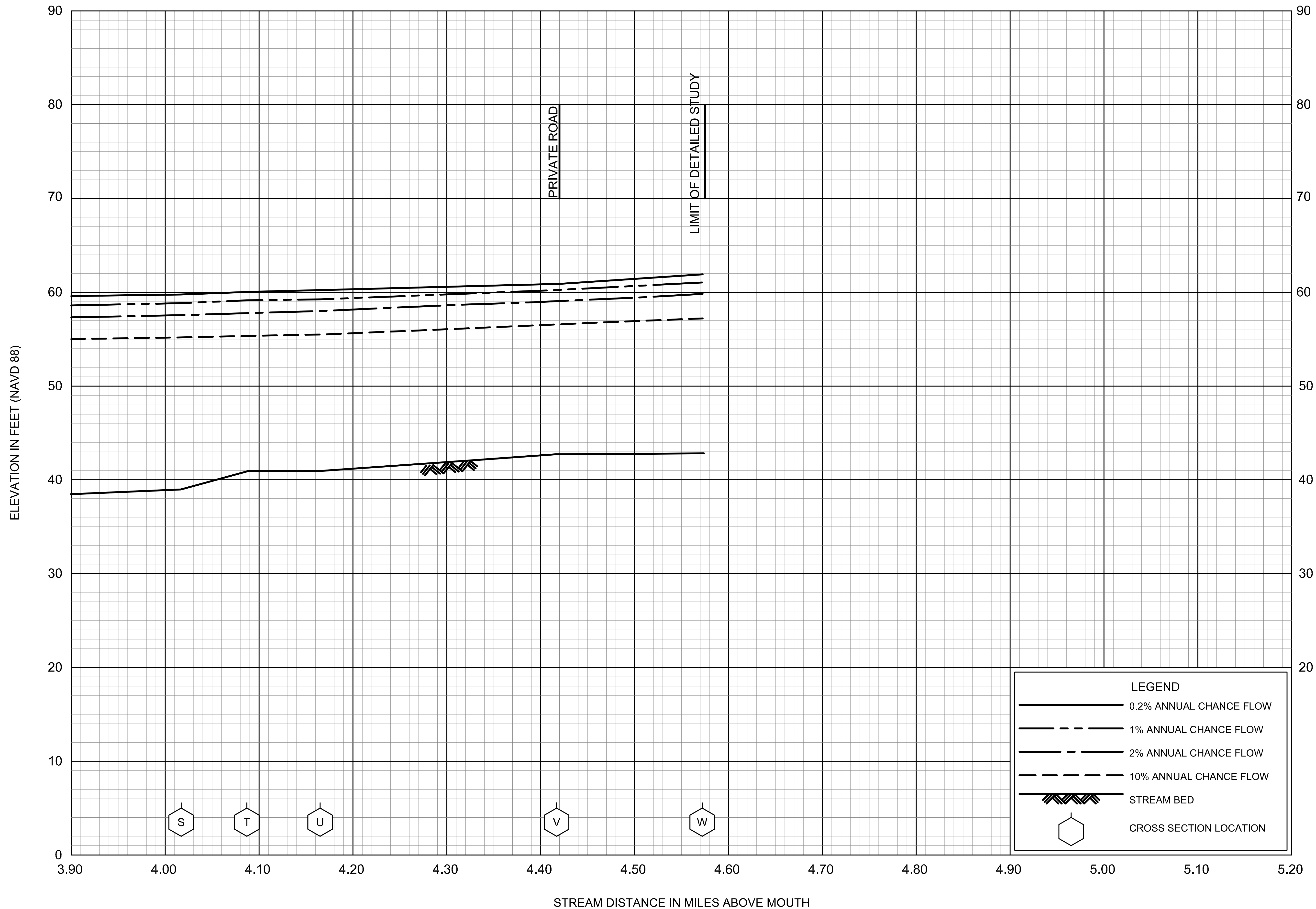

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