DOUGLAS COUNTY

Comprehensive Flood Hazard Management Plan

March 1995

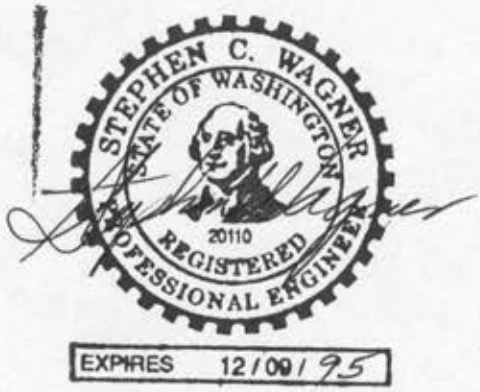
KCM

KCM, Inc.
1917 First Avenue, Seattle, WA 98101-1027

DOUGLAS COUNTY COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

MARCH 1995

Prepared for:
Douglas County Transportation and Land Services
470 Ninth Street NE
East Wenatchee, WA 98802



Prepared by:

KCM

KCM, Inc.
1917 First Avenue
Seattle, Washington 98101-1027
(206) 443-5300

Project #22425

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The primary authors of this document are Kerry Ritland, P.E., Dave Carlton, P.E., and David Bannon, P.E. of KCM, Inc. Roberta Johnson of KCM provided word processing support, and Dan Portman of KCM provided editorial review and supervised report reproduction. QA/QC review of this document was provided by Mort Thomas of KCM.

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PROJECT

CITIZEN ADVISORY COMMITTEE MEMBERS

George Aldaya
Dave Billingsley
Doug Button
Carolee Case
Mike Doneen
Greg Hovland
Steve Lacy
Robert Larse
Don Lund
Terry McKee
Duane Mikow
John Powers
Carroll Reid

Douglas County
Comprehensive Flood Hazard Management Plan
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EXECUTIVE SUMMARY

The Douglas County Comprehensive Flood Hazard Management Plan (CFHMP) has been prepared with joint funding provided by Douglas County and the State of Washington Flood Control Assistance Account Program (FCAAP) as established under the authority of the Revised Code of Washington (RCW) Chapter 86.26.

The purpose of this CFHMP is to respond to Douglas County's desire to solve recurring flooding problems in the East Wenatchee area, near the Palisades area of Moses Coulee, and the Jameson Lake area; to gain an understanding of flood hazard management options so that appropriate and informed land use management proposals and decisions can be made; to develop a Capital Improvement Plan (CIP); and to plan for future development.

The CFHMP is described as follows in its mission statement:

> *A systematic process to identify and prioritize areas and property susceptible to flood damages, select alternatives to solve identified flood problems, and implement solutions.*

Floods within Douglas County result mostly from extreme storm events of short duration caused by two distinct climatological patterns: summer thunderstorms or a warm rain-on-snow storm event. Thunderstorms occur primarily during the summer months and normally have high rainfall intensities over relatively small areas. Rain-on-snow events occur in the late winter or early spring, usually with smaller amounts of participation; however, with the ground frozen and infiltration prevented, the melting snow combined with rainfall can create a large runoff event.

Floods within the East Wenatchee area are compounded by extreme soil erosion and sedimentation. Soils in the area are chiefly fine sands that are highly erodible, particularly on steep and mostly barren slopes. In undeveloped areas, erosion problems are relatively rare because rain infiltrates the highly permeable soils reducing the amount of surface water runoff. Most undeveloped areas also have natural vegetative cover which helps strengthen the soil surface to reduce the transportation of sediment. However, within developed areas, streets and other impermeable surfaces can easily produce large volumes of runoff that rapidly erode the barren soils along the road margins (few roads within East Wenatchee have curbs and gutters). In addition to erosion problems in developed areas, a large amount of runoff and sediment is transported from three canyons and bare soils in the agricultural areas immediately above East Wenatchee.

Three major watersheds contribute to flooding within the East Wenatchee area. These watersheds are described as Canyon A, Canyon B, and Sand Canyon located in the Badger Mountain foothills. Floodwaters from these watersheds discharge directly into urban and orchard areas below the canyons. Because of the scarcity of drainage facilities below these canyons, floodwaters travel in streets and natural drainage depressions between the streets. The floodwaters, traveling toward the Columbia River, cause extensive erosion damage and fill the existing drainage systems with sediment.

Flooding within the Palisades area of Moses Coulee is primarily a result of a large snow pack melting over frozen ground. A sudden rise in temperature results in the snow melting rapidly and then flowing downstream. The largest floods occur when climatic conditions cause a rapid and simultaneous runoff from all parts of the watershed. These floodwaters travel through Moses Coulee, flooding farms, residences and roads. Residents have been isolated for over one week due to floodwaters completely inundating the valley bottom.

The level of Jameson Lake has risen more than 40 feet over the past 60 years. It has also risen dramatically during snowmelt events. At its peak in 1989 it caused extensive damage to the northern and southern access roads, the Wittig farm, the wildlife access, and resorts on both ends of the lake.

APPROACH

The CFHMP for Douglas County is a synthesis of available data relating to flood hazard management within the study area. The plan follows guidelines and requirements as described in Chapter 86.26 RCW and Chapter 173-145 WAC.

To have a successful CFHMP, local community members need to be involved throughout the project along with state and federal agencies. To accomplish this goal, several public meetings were conducted throughout the project. After the second CFHMP public meeting, the County formed a citizen advisory committee (CAC) to provide the public's perspective on the planning of the CFHMP and the decision-making process. The CAC was an integral participant and decision maker in identifying flood problems within the study area, helping to prioritize solutions to existing flood problems, proposing policies for flood hazard management, and establishing short- and long-term goals and objectives.

Long-term goals established for flood hazard management within the study area are as follows:

- Reduce flood hazards within the Greater East Wenatchee area
- Reduce long-term flood related costs to citizens of Douglas County.

The types of objectives required to accomplish long-term goals include the following:

- Establish strategies for flood hazard management that will balance engineering, economic, environmental and social factors in relationship to stated goals and objectives
- Maintain consistency between Douglas County and the City of East Wenatchee to require future developments to provide adequate stormwater control measures and promote the preservation of natural drainage areas
- Coordinate flood hazard planning with public and private parties including utilities, Department of Transportation, giving adequate opportunity for citizen input
- Establish a stable, adequate and publicly acceptable funding source

- Develop structural and nonstructural measures to prevent or minimize existing flood problems that are the responsibility of the City or County.

PREVIOUS INVESTIGATIONS

This CFHMP summarizes the studies developed for Douglas County throughout the past 20 years to assess flood problems. Potential solutions have been proposed in all these studies. Due to the lack of funds, only one major project has been constructed. This CFHMP pays particular attention to previously proposed flood control projects and alternatives because, with the proper funding, many of these solutions are viable and were considered as alternatives in the development of this plan.

COMPUTER MODELING ANALYSIS

A computer modeling analysis was conducted on Canyon A, Canyon B, Sand Canyon and the East Wenatchee urban area. Hydrologic and hydraulic models were used to simulate runoff and determine the resulting flood conditions from specific precipitation events. In addition, the models were used to provide data to map floodplains and determine the adequacy of existing hydraulic structures in conveying current and projected future flows for existing and future land use conditions. Existing land use was determined from an examination of recent aerial photographs. Future land use was defined for this study as the maximum development allowed under the 1993 zoning. For the purposes of this study it was assumed that none of the future development would be required to control their increased runoff.

The modeling analysis produced estimates for the 100-year flow for Canyon A, Canyon B, and Sand Canyon based on summer thunderstorms. The analysis for the East Wenatchee urban area produced flow estimates for runoff that enters the urban area from adjacent agricultural land, and combined agricultural and urban runoff along the principal drainage pathways within the urban area.

Detailed hydrologic and hydraulic analyses of the Palisades area of Moses Coulee and Jameson Lake areas were not performed. For the Palisades area of Moses Coulee, the 100-year flood flow was developed by the Federal Emergency Management Agency for the Flood Insurance Study. Their results were used for this study. For the Jameson Lake area, data from the 1989 storm event were used to determine runoff potential.

ALTERNATIVE SELECTIONS

Problem areas were identified by County staff, the Citizen Advisory Committee, people in attendance at the public meetings, and KCM staff using the results of the models. Several alternatives were developed to address each problem site. These were presented to the advisory committee which then selected preferred alternatives. The preferred alternatives have been compiled into a Capital Improvement Program which is discussed later.

RECOMMENDATIONS

The recommendations for this CFHMP, detailed in Chapter 11, are summarized below.

Regulatory Recommendations

- Show FEMA base maps and shoreline boundaries on zoning maps and new parcels.
- Show the floodplain on another map that is more legible than the FEMA base boundary maps and use the more legible maps in the administration of the flood hazard ordinance.
- Prohibit development of critical facilities within a floodplain to prevent the disruption of service during an major flood event.
- Identify alluvial fan hazards and areas of geologic hazards and prohibit development within these areas.
- Consider combining the floodplain ordinance and the shoreline ordinance to improve the efficiency of administration.

Development Standard Recommendations

- Establish clear ordinances that can be enforced by the County stormwater officials and not by conditions on the building permit.
- Define flow capacity criteria throughout the County to establish a predetermined level of protection.
- Define new runoff criteria that will give the County a greater level of protection throughout the basin.
- Avoid new drainage problems by prohibiting increased runoff from future development.
- Design stormwater systems for maximum buildout.
- Establish clear authority and responsibility between the City, County and developer for providing, controlling, and maintaining stormwater facilities and hazardous areas.

Land Use Recommendations

- Establish a plan to prioritize drainage projects based on the adopted Capital Improvement Plan.
- Preserve areas that currently infiltrate stormwater or are currently subjected to hazardous flooding conditions.
- Prohibit development within floodplain or hazardous drainage areas.
- Maximize the use of public land to include drainage corridors and floodplains.

- Down zone areas that are within the floodplain and revise property taxes accordingly.
- Promote infilling of existing parcels to maximize existing development.
- Provide incentives for developers to donate sensitive and hazardous areas to the County or allow the County to purchase these areas to preserve and maintain them for flood prevention.

Funding Recommendations

The recommendation of this CFHMP is to adopt a funding policy. The Citizen Advisory Committee for this study recommended that the City of East Wenatchee and Douglas County create either a Flood Control Zone District (FCZD) or a Surface Water Utility (SWU). An advisory committee should be established to help guide the activities of the FCZD or SWU. The committee should meet regularly to discuss flood hazard issues and remain abreast of public concerns and different funding opportunities.

Capital Improvement Recommendations

The Citizen Advisory Committee has recommended that the Capital Improvement Program shown in Table ES-1 be implemented. This program addresses all known problems and provides for flexibility in implementation. This flexibility allows for multiple funding sources or for the discovery of additional problem areas. The program includes major projects to address flooding in the Canyon A corridor and many smaller projects to address local flooding erosion and sedimentation problems.

Table ES-1
CIP PROJECT PRIORITY AND SCHEDULE

Overall Ranking	Basin Ranking	Project (1)	Description	Total Cost	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Canyon A																									
High	1	CA-11a	**Pipeline below Eastmont**	$1,925,000						140	415	490	440	440											
High	2	CA-9	Relocate channel in park	$53,000				53																	
High	3	CA-14	Ditch and culvert cleaning	$18,000				18																	
Medium	4	CA-7	Flood channel	$3,020,000										200	600	590	620	650	300						
Medium	5	CA-5	Dike at Kentucky	$123,000															123						
Medium	6	CA-3a	Upgrade culverts at Lyle & Kentucky	$105,000													105								
			Subtotal	$5,244,000																					
Canyon B																									
High	1	CB-6	25-yr channel below SR28	$923,000	155	350	418																		
Medium	2	CB-10	Check dams	$100,000					100																
Medium	3	CB-11	Detention at Fancher	$46,000							46														
Low	4	CB-5	Enlarge debris basin	$291,000																291					
Low	5	CB-8	Upgrade to 100-yr channel	$785,000																				490	295
			Subtotal	$2,145,000																					
Sand Canyon																									
Medium	1	CS-2	**Reinforce road fill**	$35,000											35										
Low	2	CS-3	**25-yr culverts**	$220,000																	65	155			
Low	3	CS-4	**Channel at mobile homes**	$70,000																		70			
Low	4	CS-5	**Relocate home**	$200,000																		200			
			Subtotal	$525,000																					
Urban Area																									
High	1	UA-15	Fancher Hts. dry wells	$25,000	25																				
High	2	UA-9	**Infiltration area at 10th St.**	$400,000		20	280									100									
High	3	UA-13a	Intercept agricultural runoff (CA)	$946,000			25	250	250	421															
High	4	CS-6	Badger Mt. road drainage	(separate RID)																					
Medium	5	UA-14	Autumn Drive dry wells	$18,000				18																	
Medium	6	UA-23	8th St. drainage and infiltration	$247,000									247												
Medium	7	UA-19	8th and Kentucky culverts	$85,000				85																	
Medium	8	UA-17	Lyle Ave. ditch to Canyon A	$73,000				73																	
Medium	9	UA-16	Vista View/Ski View drainage	$108,000					105																
Medium	10	UA-21	S. Mary and Alice dry wells	$12,000				12																	
Medium	11	UA-22	**Grover Ave. dry wells**	$18,000				18																	
Medium	12	UA-24	**Eastmont at 11th/10th pipe**	$63,000													35	28							
Medium	13	UA-25	Ongoing improvements	$200,000		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Low	14	UA-18	Eastmont at 3rd/4th culverts	$78,000																55	23				
Low	15	UA-13b	Intercept agricultural runoff (CS)	$2,158,000																100	628	280	600	150	400
			Subtotal	$4,431,000																					
Moses Coulee/Palisades																									
High	1	MC-4	Roadway & Channels	$851,000		30	810	11																	
High	2	MC-1	Flood warning plan	$20,000			20																		
Medium	3	MC-2	Floodproofing	$200,000			20	40	40		60	40													
Low	4	MC-3	Road & access improvements	$500,000					20													30	150	150	150
			Subtotal	$1,571,000																					
Jameson Lake																									
Low	1	JL-1	Outlet pipeline	$269,000		20	200	49																	
			Subtotal High	$5,410,000																					
			Subtotal Medium	$4,253,000																					
			Subtotal Low	$4,302,000																					
			Total	$13,965,000																					
					$180	$430	$1,783	$637	$528	$571	$531	$540	$697	$650	$645	$660	$670	$688	$633	$456	$726	$745	$760	$800	$855

CIP Schedule

Cost ($1000)

(1) Projects within City of East Wenatchee are shown in bold

CHAPTER 1.
INTRODUCTION

PURPOSE

This Comprehensive Flood Hazard Management Plan (CFHMP), was prepared to address recurring flooding problems around East Wenatchee, in the Palisades area of Moses Coulee, and the Jameson Lake area; to gain an understanding of flood hazard management options; to create appropriate land use management proposals; to develop a Capital Improvement Plan; and to plan for future development. These needs are consistent with long-range planning objectives described in the Greater East Wenatchee Comprehensive Plan (Douglas County 1988).

Historical flooding in Douglas County areas has resulted in significant property damage and economic impacts on residents, businesses, landowners, and public facilities. Rapid urban development in the East Wenatchee area has increased the urgency to develop mechanisms to accommodate growth pursuant to recently enacted state and local regulations. Past flood control proposals, which relied primarily on structural means to solve flooding problems, were not implemented partly because they were not comprehensive, did not have public support, had high costs, and lacked an equitable funding source.

To address these problems, a comprehensive study of all significant surface water related hazards in the study areas was performed. This comprehensive approach addresses structural solutions, nonstructural solutions, and funding strategies to attain the goals and objectives of flood hazard management within the County. The environmental, fiscal, and social impacts of the potential solutions are addressed within a comprehensive framework as part of identification, prioritization, and selection of alternatives.

AUTHORITY AND SCOPE

In December 1992, Douglas County entered into an agreement with KCM, Inc., to develop a CFHMP for Douglas County. This agreement initiated the first phase of the project, existing conditions and background analysis, which ended on June 30, 1993. The second phase of the project, flood hazard management alternatives and recommendations analysis, began in July 1993 and resulted in the draft CFHMP. Following the review process, approval by the Washington State Department of Ecology (Ecology), and adoption by Douglas County, the final CFHMP will be completed.

Funding for the development of this CFHMP was provided to the County under a 75 percent Flood Control Assistance Account Program (FCAAP) grant from Ecology, with the remaining 25 percent funded by Douglas County. A variety of agencies, interest groups, and members of the public were involved in the development of the Plan. The analysis of existing conditions, the development of alternatives, and recommendations for flood hazard management in Douglas County are presented in the CFHMP in accordance with FCAAP requirements as stated in the Revised Code of Washington (RCW) Chapter 86.26 and Washington Administrative Code Chapter (WAC) 173-145.

BACKGROUND

Douglas County is located in north central Washington, east of the Cascade Mountains along the Columbia River (Figure 1-1). The County encompasses 1,831 square miles, bordered by the Columbia River to the west and north, Moses Coulee on the south, and Banks Lake on the east. This CFHMP focuses on the East Wenatchee area, the primary urban area in the County, on the Palisades area of Moses Coulee, and on Jameson Lake. These areas were selected for inclusion in this CFHMP because they experience frequent flooding problems, and because the magnitude and scope of the problems have prevented previous implementation of flood control measures.

Flooding Problems in Douglas County

Flooding in Douglas County is caused by a variety of climatological and physical conditions. In general, the conditions that cause flooding in the three study areas (East Wenatchee, the Palisades area and Jameson Lake) are distinctly different, although occasionally a single event can cause widespread flooding in all areas (as occurred in March 1989). This CFHMP targets specific areas in Douglas County that experience recurring flooding problems. These areas, shown in Figure 1-2, include the following:

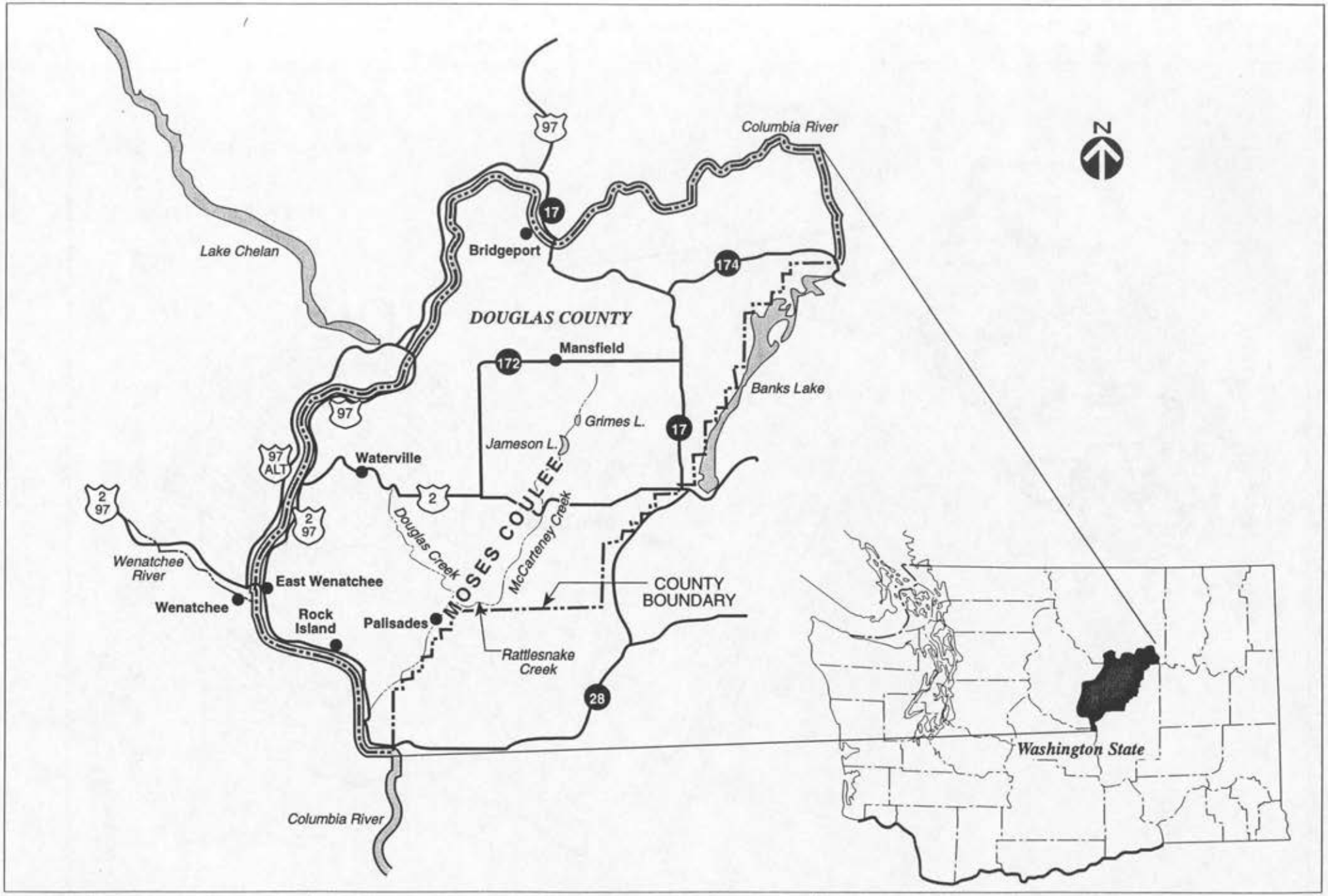
- East Wenatchee urban area, including Canyon A, Canyon B, Sand Canyon, and the urban drainage area
- The Palisades area of Moses Coulee
- Jameson Lake.

These problem areas are particularly difficult to deal with because flooding conditions can be severe and widespread. Because of these conditions, flood hazard management options identified in previous studies have generally not been implemented due to high construction costs and a lack of public acceptance of individual projects. An overview of flooding causes and problems is provided below. Chapter 4 contains documentation of historical flooding events.

East Wenatchee Area

Flooding in the East Wenatchee area is typically caused by two types of storm events: summer thunderstorms and late winter-early spring rainstorms combined with snowmelt. Although both types of storms can cause extensive flooding, summer thunderstorms have resulted in the most damaging floods. Major thunderstorms typically have peak rainfall intensities as high as 0.5 inches in 15 minutes, 1.25 inches in 1 hour, and 2.0 inches in 90 minutes. Major floods causing significant damage have occurred about every 10 years, although smaller storms causing localized damage are more frequent. The largest floods in recent history occurred in 1972 and 1989, when damages in the County exceeded $1 million. Several smaller events occurred in 1957, 1973, 1975, 1976, 1991, and 1993.

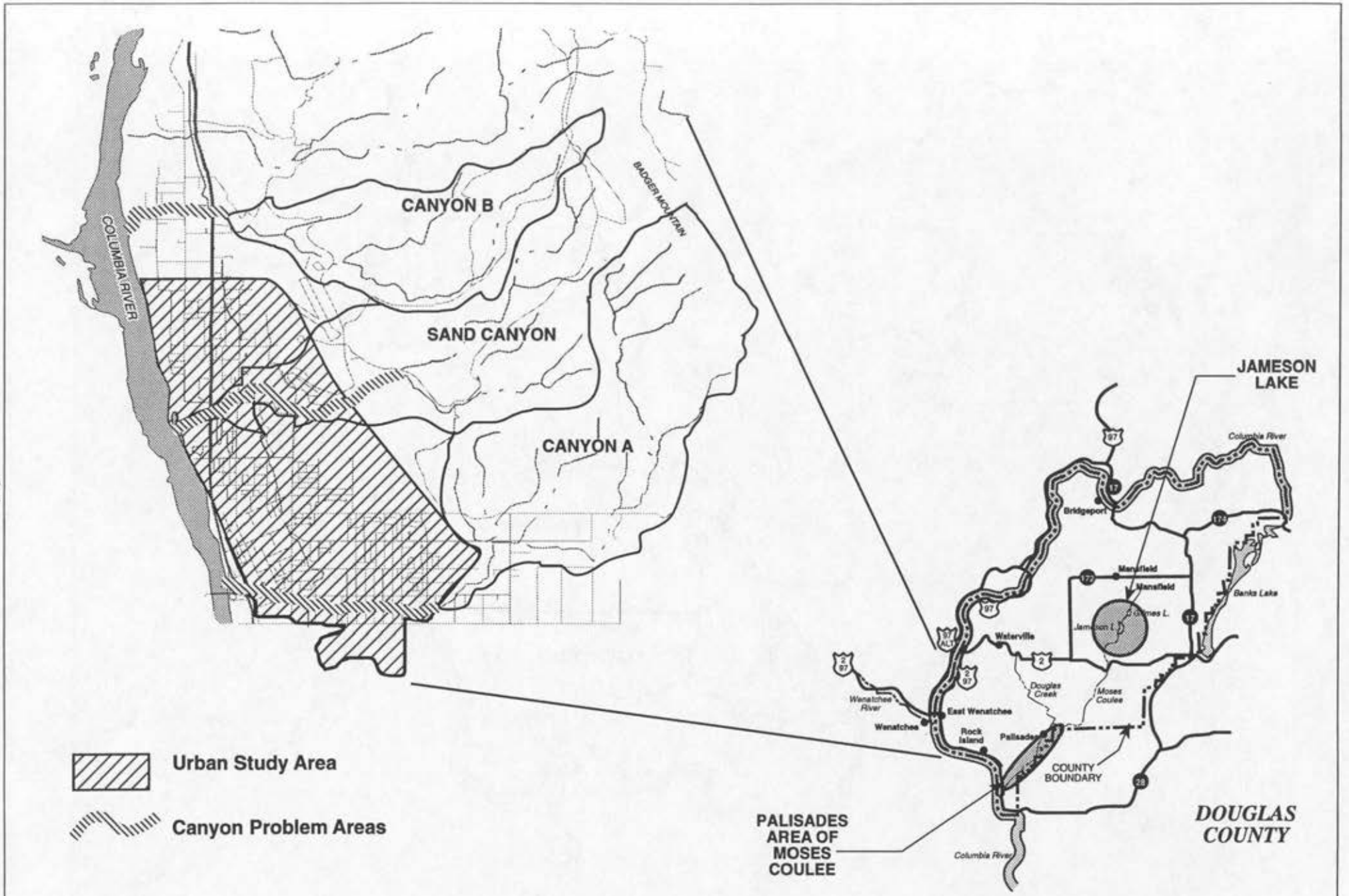
Stormwater that impacts East Wenatchee includes both uncontrolled urban runoff and runoff from drainage basins in the Badger Mountain foothills. These basins, which include Canyon A, Canyon B, Sand Canyon, Bluegrade, McNeal and other smaller drainages, range in size from less than 1 square mile to approximately 6 square miles. The upper portions of



KCM
1917 First Avenue
Seattle, Washington 98101

Douglas County
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 1-1.
DOUGLAS COUNTY LOCATION MAP



KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 1-2. TARGET FLOOD PROBLEM AREAS IN DOUGLAS COUNTY

the drainages consist primarily of wheat lands that lie fallow between crop rotations. Minimal vegetative cover during the fallow period results in soils being particularly susceptible to erosion. The canyons descend from the uplands to the terraces where urban areas and orchard lands are located. Canyon B and Sand Canyon also contain active and potential slide zones caused by oversteepened and undercut slopes.

Floodwaters emanating from the uplands flow directly into the urban and orchard areas below. Because few constructed drainage facilities exist, the floodwaters tend to follow streets and natural drainage depressions between the streets. Floodwaters cause extensive soil erosion along the flow pathways. Existing drainage culverts and pipe systems are rapidly filled and plugged with sediments during these runoff events, rendering them nonfunctional. Many streets have become torrents as floodwaters accumulate and travel westward toward the City of East Wenatchee. During major storms, the Wenatchee Reclamation District canal, which bisects the urban area, frequently intercepts the runoff and becomes filled with sediment in several locations, causing a disruption of service and requiring an expensive effort to remove the sediment. The runoff eventually passes over the Sunset Highway (SR 28) and then into the Columbia River, causing extensive damage to roadways, shoulders, and culverts in the process.

The Palisades Area of Moses Coulee

The principal cause of flooding in the Palisades area of Moses Coulee is spring snowmelt over frozen ground. Winter snowfall is retained until a sudden rise in temperature results in rapid melting and runoff. Usually, the earliest runoff is from the flat sagebrush lands, followed by runoff from the southwestern portion of Badger Mountain, and then by runoff from cultivated areas near Waterville. Potential flood problems also occur when late fall rains saturate the surface soil and then freeze. The largest floods occur when climatic conditions cause rapid and simultaneous runoff from all parts of the watershed. In Moses Coulee, floods occur when freezing temperatures during the night are followed by daily thawing. This results in a series of nightly peaks followed by lesser flows during the day (FEMA 1981).

Floods in Moses Coulee frequently cause damage to cropland in the Palisades Irrigation District along Rattlesnake Creek and downstream from its confluence with Douglas Creek. Practically all flood damage in Moses Coulee is caused by the waters of Douglas Creek, but occasionally a relatively high flow is experienced from Rattlesnake Creek. In 1989, both areas combined to produce extreme flood conditions. Large quantities of silt and sand, washed from the upland wheat farms, and gravel and rock debris from the talus slopes in the canyon were carried downstream by the floodwaters. The bottom of Moses Coulee is relatively flat compared to either creek upstream of the Coulee. Floodwaters therefore spread over the farmland and Coulee bottom to depths of 1 to 3 feet, depositing large quantities of silt and sand, forming a low outwash delta at the confluence of Douglas Creek with Rattlesnake Creek. During severe floods, sediment deposits have exceeded 2 feet in depth over a large portion of the Palisades Irrigation District (Lee Johnson 1974).

Major floods occurred in Moses Coulee in 1938, 1948, 1957, 1960, 1973, and 1989. During these floods, the Palisades community was isolated due to flooded roads. In 1989, 28 families in Moses Coulee were isolated for a week and sustained damage to their buildings in varying amounts. The 1989 event also resulted in the County being declared a Federal Disaster Area due to the extensive flooding and damage.

Jameson Lake

Jameson Lake is located in upper Moses Coulee. It is in a natural depression that historically has not had an outlet. Since at least 1925, the lake has been experiencing a rise in lake level. The rising level has caused the loss of more than 100 acres of farmland along the north shore and damage to recreational facilities and roads on both ends of the lake.

In March 1989, rapid snowmelt caused the lake level to rise 88 inches in approximately four days. Outflow from the lake began to drain down Moses Coulee. Extensive damage occurred to the County's Jameson Lake Road and to the Washington State Department of Wildlife road closest to the lake, preventing access to the south end of the lake. The 1989 event seriously disrupted the opening day of fishing season, causing a large revenue loss to the County.

As of early 1994, the lake level was about 20 inches below the elevation of the outlet sill. A runoff event similar to the 1989 event may again flood properties and roads around the lake. It may cause significant overflow to Moses Coulee, possibly causing damage to the lower portions of Moses Coulee.

Flood Control Assistance Program

The Washington State program to assist local jurisdictions with comprehensive planning and flood control maintenance is described in *State Participation in Flood Control Maintenance* (RCW 86.26), originally enacted in 1951 and amended in 1984. Funds for flood control maintenance projects and for preparation of CFHMPs are available through the Flood Control Assistance Account Program (FCAAP). Administrative and procedural information relating to FCAAP and RCW 86.26 is in *Administration of the Flood Control Assistance Account Program* (WAC 173-145). Additional information on state statutes addressing flood hazard management is presented in Chapter 5.

Funding

Distribution of FCAAP grant money depends on the amount appropriated by the state Legislature each biennium and is based on eligibility of the applicant and the proposed project. Proposals are reviewed by several state agencies to ensure that appropriate resource issues and regulations are adequately addressed.

Legislative appropriations for the Flood Control Assistance Account, made each biennium, have varied from no funding (during the years 1975 through 1985) to the 1991-93 biennium's appropriation of $4 million. Restrictions on these funds include the following:

- Grants are limited to 50 percent of the total cost for nonemergency projects.
- The nonemergency FCAAP contribution is limited to $500,000 per county.
- Emergency funds of up to $150,000 per county per biennium are available on a first come/first served basis; the State will fund up to 80 percent of the cost of emergency projects.

- Unused emergency funds ($500,000 total emergency fund) can be disbursed on a discretionary basis by Ecology.
- The State can fund 75 percent of the cost for comprehensive flood hazard management plans.

Requirements for CFHMPs

To obtain funds for flood control maintenance through FCAAP, jurisdictions must prepare a CFHMP that, as discussed in RCW 86.26.105, accomplishes the following:

- Identifies the river's meander belt or floodway
- Establishes the need for flood control work
- Considers alternatives to in-stream flood control work
- Identifies and considers potential impacts of in-stream flood control work on the state's in-stream resources.

The CFHMP must also establish and prioritize appropriate structural and nonstructural measures to reduce flood damages. The study area may include the entire watershed or, at a minimum, the 100-year floodplain within a reach of the watershed. The reach must be of sufficient length that a comprehensive evaluation can be made of its flood problems. The completed CFHMP provides the technical foundation for future structural and nonstructural flood hazard management measures.

State law requires that a CFHMP describe the area where any proposed projects are located and the types and locations of existing flood problems. A complete description of the information that a CFHMP must include is contained in WAC 173-145-040. The law allows up to three years for local authorities to complete and adopt a plan. Applications for project funding under the FCAAP program require the county engineer to certify whether a CFHMP plan has been completed and adopted or is in preparation. Ecology must approve the final CFHMP, and the municipality must adopt the plan subsequent to approval.

Applicant Eligibility

Counties, cities, and other local municipal corporations with flood control responsibilities, such as flood control districts or diking districts, are eligible to receive state funding for flood control maintenance projects. Eligible corporations must file their flood control budget with Ecology by February 15 each year.

To receive funding for flood control maintenance projects, the county, city, or town having planning jurisdiction over the project area must have its floodplain management activities approved by Ecology. Among the requirements are participation in the National Flood Insurance Program (NFIP), certification of the local emergency response plan by the State Department of Emergency Management, and restriction of land uses to flood-compatible uses within a river's meander belt or floodway. Adoption of a Shoreline Master Program (SMP) may also be required.

Maintenance Project Eligibility

Evaluation of proposed FCAAP projects is based on cost-benefit relationships, local prioritization of projects, intensity of local flood hazard management problems, and consideration of information in the CFHMP. Flood hazard maintenance projects must be based on a comprehensive approach to flood hazard management planning and must meet specific guidelines with respect to project goals. Typical structural measures funded through FCAAP include installation of riprap on eroding stream banks, repair of riprap embankments, and construction and maintenance of levees.

The legislation describes in general terms the type of maintenance work eligible for funding. Eligible work includes "maintaining and restoring the normal and reasonably stable river and stream channel alignment and capacity... and... restoring, maintaining, and repairing natural conditions, works and structures." State participation can also include "restoration and maintenance of natural conditions, works, or structures for the protection of lands and other property from inundation or other damage by the sea or other bodies of water." (RCW 86.26.090)

Funding for enhancement of flood control facilities was authorized by Engrossed Senate Substitute Bill (ESSB) 5411, enacted in July 1991. This expands FCAAP project eligibility to include purchase of flood-prone properties or land to be used for flood storage, but only if these measures were identified in the applicable CFHMP (Ecology 1991).

Permits such as the Hydraulic Project Approval (HPA), Shoreline Substantial Development, and Conditional Use must be obtained before the project is funded by Ecology. All projects must be planned and designed consistent with applicable SMPs and CFHMPs, and must benefit the public, as opposed to strictly private interests.

Emergency Projects

A portion of the available FCAAP funding is reserved by law for emergency use. Projects considered emergencies are those that must be done immediately to provide immediate protection to life and property and are created by unusual or unforeseeable circumstances. Release of emergency funds is contingent on an emergency declaration by the appropriate authority. Depending on the emergency measure, a shoreline permit or HPA may be required.

Consultation with Other Agencies

A variety of state and federal agencies are involved in key stream and storm drainage issues such as fishery resources, wildlife habitat, water quality, soil stabilization and conservation, and public use/access. The presence of these resources is a key consideration in performing any flood control activities within the waters of the State of Washington. The potential loss of habitat as a result of construction work in and next to streams or rivers has been identified as a major concern by fisheries agencies, sports fishermen, and Native American groups. In addition, local agencies and jurisdictions that have an interest in flood hazard mitigation in Douglas County and the East Wenatchee area are involved. These include the City of East Wenatchee, the U.S. Department of Agriculture Soil Conservation Service (SCS), the Washington State Department of Transportation (WSDOT), and the Wenatchee Reclamation District.

To ensure that fishery resources are maintained, the Washington State Department of Fish and Wildlife (WDF) has review authority for most phases of the Flood Control Assistance Account Program. Ecology is required to consult with the WDF before approving any CFHMPs. Applicants for FCAAP project funds must review their proposals with the WDF, Washington State Department of Natural Resources (DNR), and any affected Native American group.

Construction work to be performed in or adjacent to navigable waters of the United States, including wetlands, must be approved by the U.S. Army Corps of Engineers (COE). The COE permit process ensures that all federal, state and local regulatory agencies with jurisdiction over the project are properly notified and approve the project. The COE will not approve a project that has been rejected by another permitting agency.

GOALS AND OBJECTIVES

The primary goal of this CFHMP is to identify and evaluate flooding problems in and around East Wenatchee, the Palisades area of Moses Coulee, and the Jameson Lake area, and to develop viable cost-effective alternatives for mitigation that are consistent with the County's long-term planning objectives, as stated in the Comprehensive Plan.

The Douglas County CFHMP is described as follows in its mission statement:

> *A systematic process to identify and prioritize areas and property susceptible to flood damages, select alternatives to solve identified flood problems, and implement solutions.*

Specific goals and objectives for the CFHMP were developed during the initial Citizen Advisory Committee meetings and are contained in Table 1-1. The goals of a CFHMP are defined as the broadest expression of a community's desire in preparing the plan; objectives are specific targets or results that achieve the intent of the stated goal.

PLANNING PROCESS

Plan Development

The CFHMP for Douglas County is a synthesis of all available data relating to flood hazard management in the identified study areas and it sets the guidelines for future flood hazard management. The plan follows the guidelines and requirements previously summarized relating to preparation of comprehensive flood hazard management plans. This document has been prepared in conformance with the procedures and steps described in Chapter 86.26 RCW and Chapter 173-145 WAC as follows:

1. Establish a citizen and agency participation process.
2. Set short- and long-term goals and objectives for flood hazard management.
3. Develop an inventory and analysis of physical conditions.

TABLE 1-1.
GOALS AND OBJECTIVES OF FLOOD HAZARD MANAGEMENT IN DOUGLAS COUNTY

Goals (General statements of jurisdictional desire or policy)	Objectives (Specific targets to achieve the stated goal)
Short Term[a]	
Identify flood hazards, propose alternatives, and select appropriate flood hazard management measures and funding plans.	Prepare a Comprehensive Flood Hazard Management Plan to address flooding problems in East Wenatchee, Jameson Lake, and the Palisades area of Moses Coulee. • At a minimum, permanent management measures shall be proposed for the following principal flood problems: — Lower Canyon A (below Eastmont Avenue) — Agricultural runoff entering East Wenatchee — Canyon A, Canyon B, and Sand Canyon floodways — Runoff from new development — Overall plan for stormwater in the greater East Wenatchee area — Rising of Jameson Lake — Flooding of highway in Palisades area • Criteria for selection of flood hazard management measures shall include: — Severity of problem — Effectiveness, with emphasis on solving regional problems — Cost — Public acceptance — Impacts • A Capital Improvement Program (CIP) shall be prepared from selected alternatives • Secure County and Ecology approval of the CFHMP
Implement short-term actions to help alleviate current flooding problems.	Implement interim measures: • Identify maintenance actions and other changes to existing City and County programs that can be achieved with existing resources • Implement interim flood hazard and stormwater ordinances that can provide benefits prior to full implementation of CFHMP

TABLE 1-1 (Continued).
GOALS AND OBJECTIVES OF FLOOD HAZARD MANAGEMENT
IN DOUGLAS COUNTY

Goals (General statements of jurisdictional desire or policy	Objectives (Specific targets to achieve the stated goal)
Short Term[a]	
Ensure that pending and near-term development proposals are consistent with goals and objectives of the CFHMP.	• The City and County should communicate with private developers to convey the results of interim CFHMP analyses affecting proposed development parcels • Development proposals should be reviewed to ensure consistency with flood hazard management alternatives that are likely to be developed in the CFHMP.
Long Term[b]	
Prevent the loss of life, creation of public health or safety problems, or damage of public and private property.	• Implement flood hazard management measures as approved in the CFHMP • Preference shall be given to nonstructural measures such as regulations and preservation of existing drainage corridors
Establish and adopt a systematic and comprehensive approach to flood hazard management.	• Strategies for flood hazard management should balance engineering, economic, environmental, and social factors in relation to stated goals and objectives • These goals and objectives should be evaluated at regular intervals (i.e., every 5 years) to maintain consistency with current policy • Maintain consistency with Douglas County and East Wenatchee Comprehensive Plans, GMA, and related policy plans, including: — Appropriate public services for new developments — Adequate stormwater control measures in future developments — Preservation of natural drainage areas, including known floodplains — Development codes that reflect policies on stormwater management • Coordinate flood hazard planning with all interested and affected parties in both public and private sections including: — Coordination with reclamation district, utilities, DOT, etc. — Cooperation between the City and County to solve mutual flooding problems — A Citizen Advisory Committee to provide input during the CFHMP development process — Public opportunity to comment on flood hazard management decisions • Public understanding of flood hazard management should be improved through public education

TABLE 1-1 (Continued).
GOALS AND OBJECTIVES OF FLOOD HAZARD MANAGEMENT
IN DOUGLAS COUNTY

Goals (General statements of jurisdictional desire or policy	Objectives (Specific targets to achieve the stated goal)
Long Term[b]	
Establish a stable funding mechanism.	• A necessary component of effective stormwater and flood hazard management is the establishment of a stable, adequate, and publicly acceptable long-term source of financing for the comprehensive management program • Determine flood hazard management funding needs and alternatives in the CFHMP (i.e., Capital Improvement Plan) • Establish a stormwater utility or other funding mechanism to help implement the CFHMP.
Minimize the expenditure of public funds, including funding of emergency measures, through effective flood hazard management.	• Develop structural and nonstructural measures to prevent or minimize existing flood problems that are the responsibility of the City or County • Promote the control of stormwater in a cost-effective manner • Adopt regulations to prevent new development from causing flood damage or from being susceptible to damage by floods • Prepare and adopt a drainage design guidance manual that includes uniform standards for design and construction of private facilities and minimum criteria for new development to mitigate the impact of development on water quality, flooding, and erosion
Maintain the varied uses of existing drainage pathways and floodplains within the County	• Stormwater management measures should preserve opportunities for uses within the floodplain that are compatible with periodic flooding. Land uses that are incompatible with periodic flooding should be discouraged from locating in the floodplain. • Flood control measures should preserve or enhance existing fishery, wildlife, and other natural uses of the riparian zone • Changes in land use in natural drainage corridors should restore the natural character wherever possible
Prevent the degradation of surface and groundwaters in Douglas County	• Minimize the impact of contaminants and sediment in stormwater runoff on receiving waters (Columbia River) and groundwater aquifers • Meet the requirements of potential NPDES stormwater discharge regulations for outfalls to the Columbia River • Integrate water quality control needs with drainage control needs to provide consistency in surface water management • Stormwater infiltration systems should be designed to limit contamination of drinking water supplies

a. Short Term: Activities and actions conducted prior to or immediately after approval of the CFHMP (i.e., during 1994 or 1995).
b. Long Term: Activities and actions to be implemented after approval of the CFHMP (after 1995).

4. Determine the need for flood hazard management measures.
5. Identify alternative flood hazard management measures.
6. Evaluate alternative measures.
7. Hold public workshops for evaluation of alternatives.
8. Develop a flood hazard management strategy.
9. Complete the draft Comprehensive Flood Hazard Management Plan and State Environmental Policy Act (SEPA) documentation.
10. Submit the final Comprehensive Flood Hazard Management Plan to Ecology.
11. Hold a public hearing and pass intent-to-adopt resolution.
12. Notify Ecology of final plan adoption.

Public and agency involvement was accomplished through the formation of an advisory committee and subsequent input through meetings and document review. This report represents a consensus of the views of advisory team members achieved over the course of preparation of this document. Citizen involvement was accomplished through a series of public meetings and workshops. The following sections describe the procedure for data collection and sources of data that were used in this report, the approaches that were used to stimulate public involvement and incorporate public input, and the role of the project advisory committee.

Public Involvement

Public involvement was initiated at the project's inception and continued through its completion. In general, public involvement is critical to the success of a flood hazard management plan for the following reasons (Ecology 1991):

- Proposed measures will affect many local property owners and their support will be needed to take action.
- WAC 173-145-070 calls for the review of all Flood Control Assistance Account Program (FCAAP) projects by associated state agencies such as the State Department of Fish and Wildlife and the State Department of Natural Resources as well as affected Native American tribes and other public entities. All of these parties should be involved throughout the process for plan formulation and comments.
- The objectives of special interest groups such as citizen groups, real estate developers, and business organizations should be considered.
- Since the plan must ultimately be adopted by the local government, it is important to build support among the local constituency.

- The planning process offers an opportunity for educating the public on the issues, opportunities and public responsibilities of flood control management.

Public involvement was accomplished through formation of and interaction with a citizen advisory committee, and completion of several public meetings. Public meetings were held in June 1993 and continued through the duration of the study. These meetings were used to coordinate related County planning programs, such as updating the Comprehensive Plan, with the CFHMP. Short- and long-term goals and objectives for the CFHMP were developed and evaluated during the meetings, flood problems were identified and flood hazard management options were presented. Agency involvement occurred throughout the plan preparation during meetings and by contacts with appropriate personnel. Contacts were maintained with representatives of Ecology to ensure compliance with FCAAP requirements.

Citizen Advisory Committee

Following the second CFHMP public meeting, the County formed a citizens advisory committee to provide a public perspective on the CFHMP planning and decision process. The committee is an integral participant and decision maker in the following Plan components:

- Establishment of goals and objectives
- Identification of flood problems
- Development of criteria for flooding solutions
- Identification and prioritization of solutions to flooding
- Adoption of policies for flood hazard management

Nine citizen advisory committee meetings were held over the course of the CFHMP development. Table 1-2 summarizes the meeting dates and topics of discussion. Advisory committee members are listed in the beginning of this report.

Public Meetings

June 30, 1993

The first public meeting was held in East Wenatchee on June 30, 1993. The purpose of this meeting was to initiate public involvement in the CFHMP study, describe study activities to date (which consisted of preparing the existing conditions report), solicit public input on past flooding problems, request volunteers for the citizens advisory committee, and conduct an informal public discussion on flooding problems in Douglas County. The meeting was attended by two Douglas County Commissioners, the County Planning and Public Works directors, the City of East Wenatchee Mayor, County and City staff, KCM staff, and over 90 concerned citizens.

TABLE 1-2.
CITIZEN ADVISORY COMMITTEE MEETINGS

Meeting Date	Topic
October 27, 1993	Introduction, goals and objectives
December 1, 1993	Flood hazard management terminology, vision statement, overview of flood problems
January 26, 1994	Identification and discussion of flood problems
February 23, 1994	Selection criteria and review of potential solutions for East Wenatchee problems
March 23, 1994	Review of Canyon A alternatives and policies
April 27, 1994	Review of Canyon B, Sand Canyon, and urban area alternatives
June 1, 1994	Review alternatives, Capital Improvement Plan and financing options
July 13, 1994	Recommend Capital Improvement Program and formation of a utility to finance plan
March 8, 1995	Review and approve CFHMP

This meeting was preceded a month earlier, on Memorial Day, by a major runoff event that caused significant damage in the urban area of East Wenatchee (see discussion in Chapter 4). Public awareness of flooding problems in East Wenatchee and sentiments toward County officials were therefore highly charged during the meeting. Many citizens spoke of damages caused by the storm. One individual incurred $30,000 in damage and most others described some degree of impact on their property. Others expressed exasperation that 20 years of study (since the 1972 storm) had not produced any results.

The primary concerns expressed by the citizens included the following:

- Recent development on Fancher Heights and Manhattan Square is perceived to have caused new flooding problems. Citizens accused the County of neither inspecting the drainage facilities to ensure proper construction nor enforcing design standards.

- Most agreed that maintenance of existing facilities has been inadequate and should be viewed as one of the principal causes of flooding. Many complained of culverts and ditches that had not been maintained for years.

- Many citizens felt that relatively simple measures to solve localized flooding problems can be implemented immediately. Suggestions included

rerouting Canyon A through a short section of Eastmont Park and cleaning ditches and culverts. They wanted action soon, before the next flood event.

- Several wanted a moratorium on new development until drainage issues were resolved.
- A few were concerned that, since the people who experience flooding problems are a minority in the County, new taxes to pay for improvements would never get voter approval.

Actions presented by the public which they felt could be done included the following:

- Better maintenance
- Better inspection and enforcement
- Higher development standards
- More sensitivity of County crews to individual problems.

Public input from the meeting was used to review and update the flood problem area inventory, form the citizen advisory committee, and provide focus for Phase II of the study.

July 28, 1993

The second public meeting was held on July 28, 1993. Again, the focus of the meeting was on flooding from the May 31 storm. Much of the discussion dealt with drainage problems in the Fancher Heights subdivision and streets below it that received the resulting runoff. Fancher Heights was particularly hard hit by the storm, with up to 2 inches of rainfall in 90 minutes, and drainage facilities were not adequate to handle the runoff. Many citizens complained of undersized pipes, the small number and inadequacy of dry wells in the development, and the inadequacy of County drainage standards.

This testimony was used to determine problem areas and in the development of management alternatives. The philosophy that new development should not create new problems helped to prioritize actions and select alternatives.

CURRENT FLOOD HAZARD MANAGEMENT PROGRAMS, PROJECTS, AND FACILITIES IN DOUGLAS COUNTY

Douglas County currently relies on several programs, projects, and facilities to deal with surface water problems. Whereas the existing facilities are adequate to handle typical rainfall events, any storm with significant rainfall can result in serious localized flooding and damage. Future growth will compound these problems, and major storms, such as the 1972 event, will cause major regional flooding with damages likely to greatly exceed the $1 million cost that occurred in 1972 unless action is taken prior to the event.

Existing programs include a framework of ordinances and policies that regulate development projects such as subdivisions, a minimal storm drainage system, a flood control facility that was recently constructed in Canyon B, and soil conservation programs

that have been implemented in the past. These are briefly described below. Greater detail on these subjects is provided in subsequent chapters of this report.

Flood Hazard Management Regulations

Regulations that pertain directly to flood hazard and stormwater management include the following:

- **National Flood Insurance Program (NFIP)**—Establishes 100-year flood boundaries and floodways to identify Flood Hazard Areas within the County and the City of East Wenatchee. The program provides federally-subsidized insurance to all property owners in exchange for the County's and the City's adoption of a local flood hazard ordinance.

- **Douglas County and East Wenatchee Flood Damage Prevention Ordinances**—Satisfies FEMA requirements for participation in the NFIP by setting minimum standards and regulations for development in Flood Hazard Areas.

- **Douglas County Subdivision Ordinance**—Prescribes standards for developments, but is limited to stormwater facilities in new subdivisions.

These regulations pertaining to flood hazard management in Douglas County are basic ordinances that meet the minimum requirements for the County's participation in the NFIP. The NFIP typically forms the basis of most local flood hazard programs because it requires adoption of local flood hazard ordinances. In Douglas County, no other local ordinances regulate flood hazard areas except for the stormwater section of the subdivision ordinance.

The Greater East Wenatchee Comprehensive Plan (Douglas County 1988) establishes policy guidance for use by the County Commissioners in their decisions regarding future growth in the County. It is currently being revised as part of the Growth Management process. New ordinances and regulations will be needed to implement certain objectives of the plan.

Storm Drainage Facilities

Existing storm drainage systems are generally limited to a few primary streets in East Wenatchee. The storm drains lead to four outfalls to the Columbia River. These four systems are identified in this report as follows:

- Grant Road
- 4th Street/Valley Mall Parkway
- Baker Avenue/Valley Mall Parkway
- North Valley Mall Parkway

A few other isolated systems exist, such as the 13th Street Northeast and Fairmont Avenue area and the 2nd Street Southeast area, but these terminate in open fields or orchards rather

than at a river outfall. The remaining portions of the East Wenatchee area are served by open ditches and culverts or have no constructed or maintained systems.

These systems have been constructed piecemeal over the years and are not designed to any particular standard. Some systems are inadequate to handle even small storms. For example, the 4th Street/Valley Mall Parkway system not only collects runoff from the south end of the Mall and a segment of the Parkway, it must also convey water from Canyon A. The result is that flood problems in this area are frequent. (Floodwater problem areas are further described in Chapter 4.) In other areas, inadequate or nonexistent drainage facilities frequently cause street flooding, damage to road shoulders, and flooding of private property.

Flooding and Sedimentation Control Facilities

Canyon B Flood Control Project

In response to a severe runoff event in March 1989, Douglas County in 1990 designed and constructed flood and sedimentation control facilities in Canyon B and along Glendale Street. This area of Douglas County has had frequent flood and sedimentation problems, caused by runoff from agricultural lands, erosion of unconsolidated sediments within Canyon B, and deposition of sediments on the alluvial fan. The system is designed to convey Canyon B floodwaters through the Glendale neighborhood without the severe erosion, sedimentation, and flooding problems that typified previous events.

The Canyon B project included construction of the following features:

- French drains, an armored toe buttress, and drainage diversion pipes within Canyon B to stabilize active slide areas
- A debris basin at the mouth of the canyon, to detain and settle out coarse sediments
- A concrete-lined flood channel leading from the basin, alongside Glendale Street, to just above Highway 28.

The flood channel is designed for the 25-year flood event. Glendale Street was reconstructed with a sag (rather than a crown) to allow the road to act as a floodway when the capacity of the canal is exceeded.

The original design called for a 48-inch culvert to convey flows under the highway and irrigation canal to the orchard below. However, a construction easement for the orchard property could not be obtained from the owner and the project stopped just above the highway. The County plans to eventually extend the project to the Columbia River when the easements are secured.

Other Facilities

With the exception of roadway culverts, there are no facilities in Canyon A or Sand Canyon that are designed explicitly for flood control. Although flooding in the urban areas along Canyon A was severe in 1972 and 1989, and several previous studies proposed solutions to alleviate these problems, high cost projections resulted in no facilities being built. Many of

the road culverts along Canyon A require frequent cleaning to remove sediment particularly at Lyle Avenue, and residential developments are currently encroaching upon this floodway.

Soil Conservation and Watershed Programs

Stormwater runoff and associated sedimentation from agricultural lands immediately above East Wenatchee cause significant flood damage to the East Wenatchee urban area. As has been demonstrated many times since the urban areas were built, uncontrolled runoff from these dryland wheat farms discharges directly into residential neighborhoods, especially along 10th Street and North Kentucky Avenue between 5th and 10th Streets. The sediment-laden stormwater runoff that ends up in the urban area is particularly damaging because the sediment plugs storm drainage systems.

The U.S. Department of Agriculture Soil Conservation Service (SCS) and Agricultural Stabilization and Conservation Service (ASCS) are the primary agencies responsible for implementing soil conservation and stabilization programs in the United States. Programs that have been used to assist farmers and local governments to solve flooding and erosion problems include the following (SCS 1991):

- **Conservation Reserve Program (CRP).** The CRP is a voluntary program aimed at removing croplands with highly erodible soil from production by paying farmers (usually $45 to $50 per acre per year) to maintain a permanent vegetative cover. In the East Wenatchee area, some of the wheat lands are participating in the CRP. By fall 1996, the 10-year contracts on a majority of the land in this program will expire and land will probably return to production status because no additional funds are available.

- **Agricultural Conservation Program (ACP).** The ACP is a voluntary program that provides cost-sharing assistance to help farmers implement soil conservation practices and techniques. ACP can pay landowners a percentage of the cost, such as 50 percent, or a fixed unit price in dollars per acre to implement a conservation practice, such as strip cropping. Only limited funds are available through this program ($30,000 for the entire County in 1993).

- **Public Law 83-566 (PL566).** PL566 (the Watershed Protection and Flood Prevention Act) provides federal funding of flood control projects. Funds from PL566 can be used for preparation of studies and for construction of flood control projects. PL566 is a cost-sharing program that requires matching local funds. The East Wenatchee Watershed Project was conducted by the SCS under authority and funding of PL566 and was to be funded 75 percent by federal funds. This project was recently deauthorized to free up the funds for other SCS projects. However, the SCS is willing to again participate in the project if local matching funds can be secured beforehand (Bareither, M., personal communication, 23 February 1994).

CHAPTER 2.
PLANNING AREA CHARACTERISTICS

STUDY AREAS

Douglas County is located in North Central Washington, east of the Cascade Mountains along the Columbia River (Figure 1-1). This CFHMP focuses on the East Wenatchee area, including Canyon A, Canyon B, Sand Canyon, the Palisades area of Moses Coulee, and Jameson Lake.

Flooding from the Columbia River is not addressed in this CFHMP. Although floods on the Columbia River caused problems prior to construction of Grand Coulee Dam, regulation of the river by hydroelectric dams has essentially eliminated the potential of flooding along the river. Areas along the Columbia River that are subject to flooding under normal reservoir operations are owned by or are under flood easements granted to Chelan County Public Utility No. 1, Douglas County Public Utility District, and Grant County Public Utility District (owners of Wells, Rock Island, Rocky Reach, and Wanapum Dams). These areas are regulated to preclude inappropriate development.

Canyon A

Canyon A is an ephemeral water course (one with intermittent flows) draining a 4,250-acre (6.6 square mile) basin directly east of East Wenatchee (Figure 2-1). This canyon originates in the dryland crop and rangeland areas on the west slope of Badger Mountain. Upper Canyon A consists of several smaller drainages that combine in the vicinity of 8th Street and Nile Avenue to form the main Canyon A channel. This channel flows through the urban areas of East Wenatchee along an east-west path between 3rd Street and Grant Road. After passing under Eastmont Avenue, Canyon A crosses 3rd Street, passes through the commercial area of the City of East Wenatchee, and then over Highway 28 before draining into the Columbia River. Between 3rd Street and the Columbia River, the natural channel of Canyon A has been totally replaced by streets, parking lots, and commercial buildings.

Associated with Canyon A are several small sub-drainages between Canyon A and Sand Canyon that emanate from the dryland farm areas above East Wenatchee between 15th Street and Lyle Avenue. Runoff from the dryland farm area follows natural drainage pathways (as modified by roadside ditches and urban development) that run through the urban area of East Wenatchee. A portion of this drainage eventually reaches the Canyon A channel, and the remainder flows westward to the Columbia River or infiltrates into the ground. Because drainage from the agricultural land is closely associated with urban storm drainage, these sub-drainages of Canyon A are included in the analysis of urban storm drainage.

Canyon B

Canyon B is about two miles north of the East Wenatchee city limit and about one mile south of the Olds Station (Highway 2/97) bridge (Figure 2-1). Canyon B also originates in dryland crop and rangeland areas on the west slope of Badger Mountain. Canyon B drains 1,700 acres (2.7 square miles). A large alluvial fan is located at the base of Canyon B in the

KCM *1917 First Avenue* *Seattle, Washington 98101*	COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-1. STUDY AREAS IN THE EAST WENATCHEE VICINITY

vicinity of Glendale Street, and a concrete-lined drainage channel has been recently constructed along the length of fan, ending at Highway 28, to control persistent flooding on the fan. After passing over Highway 28, Canyon B drainage flows through several orchards before reaching the Columbia River or infiltrates into the ground. This orchard area is characterized by several gently sloped terraces where the Canyon B channel is a broad swale. Between these terraces, where the elevation drops quickly, Canyon B drainage flows through short but well-defined gullies.

Sand Canyon

Sand Canyon, between Canyon A and Canyon B (Figure 2-1), originates in dryland crop and rangeland areas like Canyon B and drains 2,900 acres (4.6 square miles). In contrast to Canyon A and Canyon B, Sand Canyon has a well-defined stream corridor between the base of the Badger Mountain foothills and the Columbia River. This stream corridor is large enough to contain all but the largest flood flows. Development in the East Wenatchee area has had little impact on flows in this corridor.

East Wenatchee Urban Storm Drainage Area

Although the urban area of East Wenatchee stretches nearly from Canyon B to south of Canyon A, the analysis of urban storm drainage in this CFHMP focuses on the area bounded by 27th Street NE on the north, Lyle Avenue on the east, and 4th Street SE on the south (Figure 2-1). This study area, which encompasses most of region defined by the East Wenatchee Urban Growth Boundary, includes most of the population and all of the existing storm drain systems in the East Wenatchee area. The storm drainage study area also includes the sub-drainages of Canyon A that emanate from the dry cropland areas above and between 15th Street and Lyle Avenue.

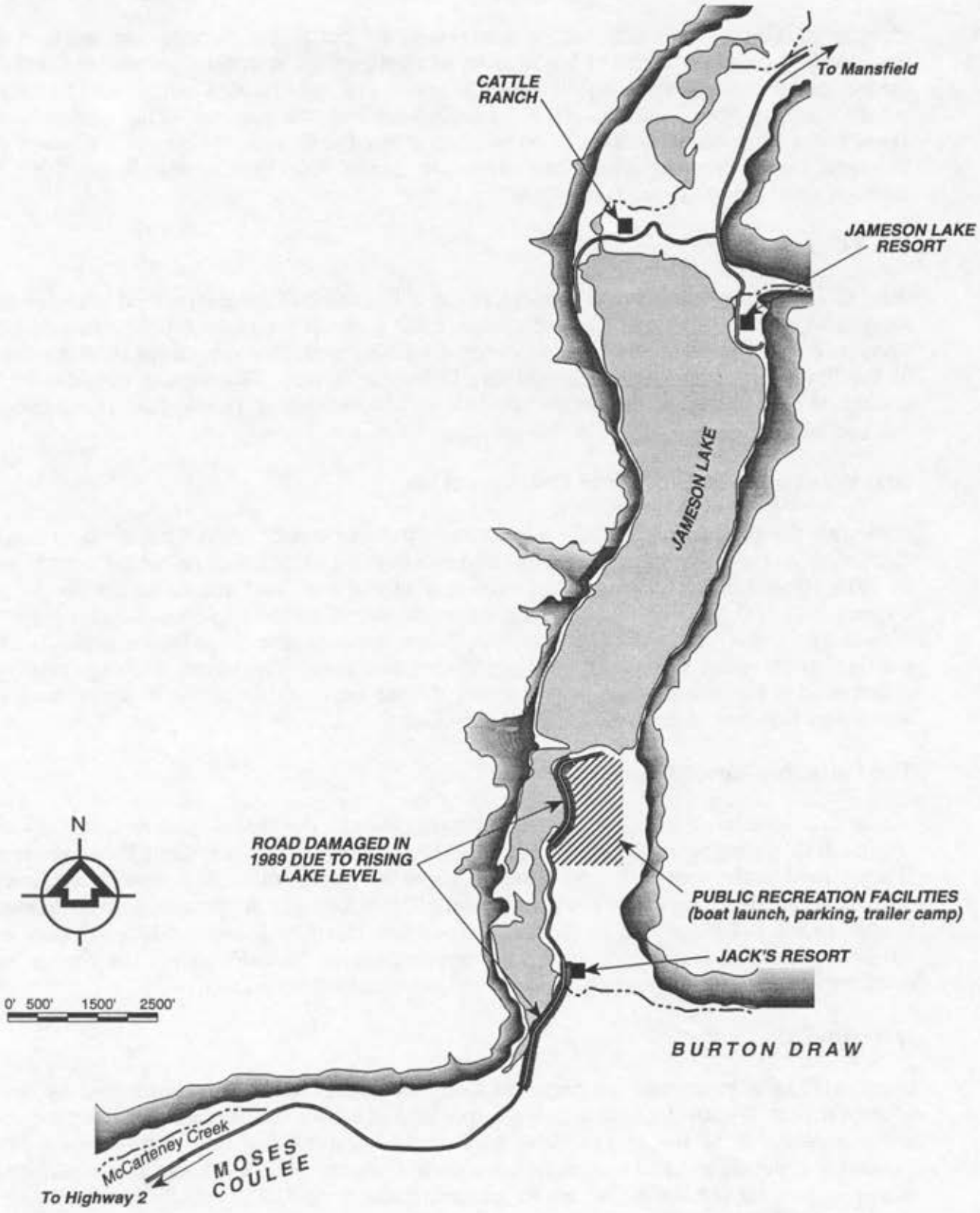
The Palisades Area of Moses Coulee

Moses Coulee extends for a considerable distance though the central part of Douglas County (Figure 1-1). Flooding problems along Moses Coulee are primarily around Palisades and the County road in the coulee that provides access to the community. This area is very isolated, dominated by rural agriculture with occasional farm homes. Approximately 55 homes are located in the Palisades area of Moses Coulee. Douglas Creek enters Moses Coulee a few miles above Palisades and continues for approximately 16 miles down the coulee before reaching the Columbia River about eight miles south of Rock Island.

Jameson Lake

Jameson Lake is located in the center of Douglas County in an area dominated by dryland wheat farming (Figure 1-1). It is in the upper end of Moses Coulee in a semi-arid sagebrush environment. It is the largest lake in Douglas County (except for reservoirs behind Columbia River dams) and currently has a surface elevation of 1,781 feet and a surface area of approximately 488 acres. Access to Jameson Lake is via U.S. Route 2 from the south and via Mansfield from the north.

The analysis of flooding problems at Jameson Lake focuses on the shoreline and on the potential for future flooding in Moses Coulee below the lake (Figure 2-2). Several year-



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-2. JAMESON LAKE VICINITY

round residents live on the north end of the lake, small fishing resorts occupy both ends (Jameson Lake Resort and Jack's Resort), and the state has developed extensive public recreational facilities on the south end. Jameson Lake, a popular fishing destination, particularly on opening day when 5,000 anglers flock to the lake, is considered one of the principal fisheries in the state.

PHYSICAL SETTING

Topography

Douglas County encompasses 1,831 square miles bordered by the Columbia River on the west and north, Moses Coulee on the south, and Banks Lake on the east. Elevations range from 570 feet in the southwest corner to 4,255 feet on the top of Badger Mountain, a geologic uplift along the western side.

The Columbia River cuts a deep gorge along the northern and western boundaries of the County. In most places along the river there are a series of nearly level to gently sloping terraces. Long, steep slopes lead from these terraces to a broad upland plateau. This plateau, underlain by basalt, occupies most of the County and has undulating and rolling topography and is interspersed by intermittent drainages.

Moses Coulee is a deep, wide, flat-bottomed valley between Badger Mountain and Beezley Hills. This coulee is a former channel of the Columbia River, formed when the river was diverted from its present course by glacial dams during the late Pleistocene era. The coulee gradually descends as it extends southwesterly from northeast Douglas County to its end on the bank of the Columbia River south of Rock Island. Steep side slopes rise about 600 feet from the valley floor before leveling off in the upper plateau. The valley bottom ranges from one-half to three-fourths of a mile wide. Dominating the valley floor are large fields of wheat and alfalfa interspersed with small orchards and pasture lands. Agricultural use has replaced most of the native sagebrush steppe vegetation (Adolfson 1993).

Jameson and Grimes Lakes are located within the upper portion of Moses Coulee. These lakes are formed in natural depressions that historically had no outlet. Jameson was formed by the terminal moraine at its southern boundary. However, since the early part of this century the elevation of Jameson Lake has risen steadily and in 1989 it reached the elevation of the outlet sill on the south end of the lake (see discussion in Chapter 4).

Climate

The climate of Douglas County is semi-arid. The mean annual rainfall is approximately 9 inches and temperatures range from an average low of 21°F in January to an average high of 88°F in July. Average annual snowfall is 30.7 inches (EarthInfo 1992).

A summary of climatological data for the Wenatchee area is contained in Table 2-1. Three weather stations are located in the Wenatchee area: the Wenatchee station in downtown Wenatchee, the Wenatchee Experimental Station on the western fringe of Wenatchee about 3 miles northwest of East Wenatchee, and Pangborn Field (or Wenatchee FAA), located about 4 miles east of East Wenatchee.

TABLE 2-1.
CLIMATOLOGICAL DATA FOR WENATCHEE AREA

Month	Temperature Wenatchee[a] Average (deg F)	Temperature Wenatchee[a] Average Daily Max. (deg F)	Temperature Wenatchee[a] Average Daily Min. (deg F)	Precipitation and Snowfall Wenatchee[a] Average Precip. (in.)	Precipitation and Snowfall Wenatchee[a] Maximum Daily Precip. (in.)	Precipitation and Snowfall Wenatchee[a] Average Snowfall (in.)	Precipitation Pangborn Field[b] Average (in.)	Precipitation Pangborn Field[b] Maximum Daily (in.)	Precipitation Wenatchee Experimental Station[c] Average (in.)	Precipitation Wenatchee Experimental Station[c] Maximum Daily (in.)
January	27.7	34.2	21.2	1.22	1.09	11.7	1.16	0.67	1.62	1.16
February	35.0	43.2	26.8	0.88	1.10	4.1	0.80	1.12	1.04	0.96
March	42.7	53.5	31.8	0.62	0.71	1.8	0.61	0.65	0.72	0.79
April	51.7	64.0	39.4	0.51	0.68	0	0.62	1.43	0.62	0.91
May	60.2	72.8	47.5	0.52	0.84	0	0.55	0.91	0.57	1.28
June	67.4	80.0	54.7	0.73	2.04	0	0.55	1.26	0.60	1.47
July	73.8	87.9	59.6	0.18	0.80	0	0.24	0.75	0.24	0.72
August	72.3	86.3	58.3	0.43	2.72	0	0.43	1.51	0.52	2.06
September	63.7	77.5	49.8	0.45	1.17	0	0.40	1.36	0.44	1.40
October	51.2	63.0	39.4	0.61	1.03	0	0.43	0.86	0.75	1.80
November	38.8	46.3	31.1	1.20	1.30	3.0	1.17	1.32	1.43	1.17
December	31.6	37.4	25.8	1.43	1.38	10.1	1.39	1.12	1.62	1.50
Annual	51.3	62.2	40.5	8.81	2.72	30.7	8.32	1.51	9.99	2.06

a. Station 459074. Period of record 1930-1990 for precipitation, 1951-1980 for temperature and snowfall. Source: EarthInfo (1992).
b. Station 459082. Period of record 1960-1990. Source: EarthInfo (1992).
c. Station 459079. Period of record 1948-1990. Source: EarthInfo (1992).

Weather patterns in Douglas County are influenced by the Cascade Mountains to the west, which block much of the moisture of Pacific storms. Most precipitation falls during the winter months as snow. The greatest snowfall occurs from storms having a southeastern circulation, causing upslope conditions on the east slopes of the Cascades. Once snow falls in early- to mid-winter, melting is slow and may not occur for weeks or months due to low temperatures and low sun angle.

As discussed in Chapter 4, summer thunderstorms and winter snowmelt combined with rain-on-snow events cause the most damaging floods. Table 2-2 summarizes the nature of storms during different times of the year. Even though the winter months have the highest occurrence of precipitation events (approximately once a week) and the highest total storm depths, they tend to have very low intensities. The greatest storm intensities occur in August, even though the frequency of storms in August is less than one-third of that in December. Significant runoff occurs during the winter when the combination of prolonged rainfall, warm Chinook winds, and frozen ground causes rapid snowmelt and runoff.

TABLE 2-2.
STORM EVENT DATA[a]

Month	Events per Month	Mean Depth (inches)	Mean Intensity (in/hr)	Mean Maximum Intensity (in/hr)
January	3.8	0.29	0.02	0.09
February	2.8	0.27	0.03	0.10
March	2.3	0.17	0.02	0.07
April	1.5	0.24	0.03	0.10
May	1.5	0.21	0.03	0.13
June	1.5	0.22	0.04	0.13
July	0.5	0.13	0.02	0.06
August	1.3	0.28	0.04	0.21
September	0.8	0.18	0.02	0.07
October	1.9	0.22	0.03	0.11
November	3.4	0.25	0.02	0.11
December	4.5	0.27	0.02	0.11
Annual	26.0	0.24	0.03	0.11

a. Wenatchee Experimental Station 1948-1986. A storm event is defined as a precipitation event having at least 0.1 inch of accumulation. The mean maximum intensity is the average maximum hourly storm intensity for all storms. Source: Perrich (1992)

Geology

Douglas County occupies a portion of the extensive Columbia River Plateau, which was formed by the extrusion of basalt during the Eocene, Miocene, and Pliocene epochs, approximately 12, 30, and 60 million years ago, respectively. After basalt was extruded, the region was warped into broad basins in which several subbasins were formed by locally intense folding and faulting. In these subbasins, deposits of clay, silt, sand, and gravel accumulated during the Pleistocene (ice age) epoch approximately one million years ago. The thick lava sequence consists of an undetermined number of flows which, in places, are separated by sedimentary interbeds. Varying thicknesses of sediments overlie the basalt in nearly all locations, with basalt generally more deeply buried beneath the coulees than beneath the uplands.

The East Wenatchee area is on the western edge of the Columbia River Plateau. Geologic units exposed east of the Columbia River range in age from pre-late Cretaceous to Recent. In the vicinity of Canyons A and B, the oldest rocks are conglomerates, sandstones, siltstones, and shales of the Chumstick and Wenatchee formations. The Columbia River Basalt overlies these formations. A large portion of the highland area east of East Wenatchee and the Columbia River basalt cliffs along Badger Mountain consists of mass wasting debris including debris flows and talus from the Columbia River Basalt (Shannon & Wilson 1989).

Overlying both older sedimentary and volcanic rocks on the east side of the Columbia River are sand and gravel deposits that formed as giant bar deposits during the Spokane Flood. These deposits form the large flat terraces a few miles north and east of East Wenatchee in the Fancher Field area. Loess (wind-blown fine sand and silt) deposits overlie both the mass wasting debris and the Spokane Flood sand and gravel deposits (Shannon & Wilson 1989).

Moses Coulee was formed by the Columbia River in relatively recent Pleistocene time (10,000 years ago) when the river, diverted by a large ice lobe near the present day Grand Coulee Dam, cut though the thick basalt formations of the Columbia River Plateau. The basalt layers vary in thickness from 6,000 to 10,000 feet and date primarily from the Miocene epoch (30 million years ago). Erosion and formation of Moses Coulee and other river and meltwater channels in the region (including Grand Coulee) was augmented by enormous floods from Lake Missoula, a glacially dammed mountain lake east of Spokane, that was alternately blocked and opened by glacial fluctuations. The Spokane floods, as they are commonly termed, were responsible for many of the present-day landscape formations in the Columbia River basin. The flat-bottomed coulees are now filled with several hundred feet of glacial and river deposits.

Soils

Detailed mapping of soils in Douglas County has been performed by the Soil Conservation Service (SCS 1981). Additional detailed soil mapping is currently being conducted in areas that were not mapped in detail for the 1981 survey.

Soils in Douglas County closely follow the geologic patterns described above. In general, soils next to the Columbia River are predominately well-drained sands and gravels. Soils on the slopes and terraces leading up to the Badger Mountain foothills are predominantly loams and fine sandy loams, such as Burch and Cashmere, formed in colluvium and loess.

These soils are particularly susceptible to erosion in agricultural and urban disturbed areas. Soils found on the plateaus and upland areas are usually a silt-loam type, best adapted for dryland farming. This includes the Renslow-Zen association, which is formed in loess on the basalt plateaus between 2,000 and 3,200 feet. Renslow-Zen soils are typically deep and well-drained. The steeper slopes, along the basalt uplifts, are termed the Ralls-Renslow-Bakeoven association, and are formed in colluvium mixed with loess. These soils are very deep and well-drained, and are used primarily for rangeland and wildlife habitat.

The distribution of dominant soil groups in the East Wenatchee area are shown in Figure 2-3 in terms of common soil hydrologic group classifications. Soil hydrologic groups describe the infiltration capacity of the soil, which affects rainfall runoff rates, and are designated as A, B, C, or D. Group A soils have high infiltration capacities (greater that 6 inches per hour); group B soils have moderate infiltration (2.0 to 6.0 inches per hour); group C soils have low infiltration (0.6 to 2.0 inches per hour); and group D soils have very low infiltration (0.2 to 0.6 inches per hour). These classifications are based on the dominant soil texture only. Other factors, such as fine soils on the surface, vegetation, and land use development, may alter the infiltration characteristics of the soil. As shown in Figure 2-3, the area immediately around East Wenatchee consists of Quincy fine sands having an A soil hydrologic classification, and therefore a high water infiltration capacity. The remaining soils in the East Wenatchee area have B soil classifications, which means a moderate infiltration capacity. Because these soils have good drainage characteristics, light to moderate rainfall in the East Wenatchee area rarely produces runoff because infiltration rates are greater than the rainfall intensity. Rainfall produces runoff when the rainfall intensity is greater than the infiltration rate. In urban areas, the presence of impermeable surfaces causes runoff under nearly all rainfall intensities.

Vegetation

Natural vegetation in Douglas County is typical of semi-arid climate regions. Native vegetation in the open range areas, which make up 49 percent of the county, include bunchgrass, sagebrush, and widely scattered brush (SCS 1981). Native trees and forests in Douglas County are practically nonexistent due to the arid climate, with forested areas limited to the north side of Badger Mountain and in Pine Canyon. Agricultural land use constitutes 48 percent of the county area, with most of this in dryland wheat farms and only a small fraction (approximately 4 percent of total cropland) under irrigation. Urban, suburban, orchard, and other irrigated areas are well vegetated by non-native orchard fruit trees, ornamental trees and brush, grass and other urban landscaping.

With the exception of the river itself, there is very little open water along the shoreline of the Columbia River. However, high river water levels, groundwater, and irrigation overflow provide moisture levels sufficient to foster a dense, lush shrub-grass understory and stands of cottonwoods and poplars. The predominant vegetation along the Columbia and the lower canyons is willow, cottonwood, and reed canary grass.

Riparian areas occur intermittently along the Columbia River shoreline and in natural drainage corridors such as Sand Canyon. Vegetation in riparian areas generally consists of cottonwood, poplar, willow, dogwood, hawthorne, wild rose, snowberry, and reed canary grass association with moderate to heavy ground cover. In mature stands, cottonwood trees form a fairly complete canopy up to 70 feet in height.

LEGEND

- SANDY LOAM: Burch Cashmere, Cashmont, Pogue (B hydrologic soil group)
- FINE SAND: Quincy (A hydrologic group)
- MISCELLANEOUS WELL-DRAINED SOILS: Xerorthents (A hydrologic soil group)
- SILT LOAM: Renslow-Zen, Ralls-Renslow-Bakeoven (B hydrologic soil group)

KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-3. SOIL GROUPS IN E. WENATCHEE AREA

Upland steppe vegetation consists primarily of sagebrush, rabbitbush, and bunchgrass association. Smaller trees and shrubs such as black locust, Russian olive, Columbia River juniper, Ponderosa pine, and service berry also occur in these areas (Douglas County 1992b).

Wetlands

Numerous wetland areas were identified in the East Wenatchee area during a 1985 environmental review (Douglas County 1992b). Most of the wetlands were near the Columbia River. To further evaluate the potential presence of wetlands within the CFHMP study areas, a wetlands reconnaissance study was conducted for the CFHMP in 1993 (Adolfson 1993). The wetland study was conducted in two general areas. Study Area A included approximately seven square miles of East Wenatchee that encompass Canyon A, Canyon B, and Sand Canyon. Study Area B covered approximately 14 square miles of Moses Coulee.

Four wetlands were identified during the reconnaissance:

- Wetland A is a small (250 foot by 45 foot) wetland located in a natural gully of lower Canyon B between Empire and Cascade Avenues. This wetland is classified as a palustrine emergent wetland.

- Wetland B is a 0.3-mile long stream-associated wetland located in a natural gully of Sand Canyon extending above and below Sunset Highway. This wetland includes three classifications: palustrine emergent, palustrine scrub-shrub, and palustrine forested.

- Wetland C is a 350-foot long stream-associated wetland located in a natural gully of Sand Canyon between Eastmont and Baker Avenues. This wetland is classified as palustrine scrub-shrub/forested wetland.

- Wetland D is a small (less than 0.25 acres) wetland located at the confluence of Douglas and Moses Coulee Creeks approximately 2.5 miles above Palisades. This wetland is classified as palustrine emergent/scrub-shrub wetland.

Additional descriptions, maps, and ratings can be found in the wetlands reconnaissance study (Adolfson 1993).

Hydrology

The major drainage feature of Douglas County is the Columbia River. In addition, several tributaries to the Columbia River have sizable drainage areas. These include Coyote, Rattlesnake, Douglas and McCarteney, which all drain to Moses Coulee, and Pine Canyon, Foster, and Rock Island, which drain directly to the Columbia. Coyote Creek and Foster Creek, in the northern part of the County, are the principal perennial streams in Douglas County (other than the Columbia). With the exception of the Columbia River, streamflow records in Douglas County are minimal. The U.S. Geological Survey (USGS) has collected annual peak flow measurements for several of the major streams in the County, but records are short and dated.

Major natural lakes in Douglas County include Jameson and Grimes Lakes. Several smaller lakes (less than 100 acres) and seasonal "potholes" are scattered throughout the County. Man-made reservoirs are limited to impoundments behind Columbia River dams.

Water Quality

All streams within Douglas County, including the Columbia River, have been designated as Class A by the State of Washington. Water quality criteria for Class A and lake-class waters are shown in Table 2-3. In addition to the Water Quality Standards, antidegradation rules state that whenever natural conditions of a stream are of higher quality than specified by the criteria, the existing water quality shall constitute the water quality standard.

TABLE 2-3.
WATER QUALITY CRITERIA FOR CLASS A AND LAKE CLASS WATERS

1.	Water quality shall meet or exceed the requirements for all or substantially all uses.
2.	Fecal coliform organisms shall not exceed a geometric mean value of 100 organisms/100 mL, with not more than 10 percent of samples exceeding 200 organisms/ 100 mL.
3.	Dissolved oxygen shall exceed 8 mg/L.
4.	Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.
5.	Temperature shall not exceed 18.0° C. Temperature increases shall not exceed t=29/(T+7). ("t" represents the change across the dilution zone, and "T" represents the highest existing temperature in this water classification outside of any dilution zone.) When natural conditions exceed 18.0° C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3° C, provided that temperature increase resulting from nonpoint source activities shall not exceed 2.8° C, and the maximum water temperature shall not exceed 18.3° C.
6.	pH shall be within the range of 6.5 to 8.5 with a man-caused variation within a range of less than 0.5 units.
7.	Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.
8.	Toxic, radioactive, or deleterious material concentrations shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.
9.	Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.

Source: WAC 173-201-045(2)

Streams

Chemical analysis of streams in Douglas County is nonexistent with the exception of the Columbia River and Coyote Creek, which was briefly monitored in the 1970s (no exceedence of water quality criteria was found except for zinc in one sample). All streams have silting problems after precipitation and snowmelt events, with Douglas Creek having the severest problem (Lee Johnson 1974).

Lakes

Historically, Jameson Lake has had severe algae and dissolved oxygen problems. Prior to the late 1960s, heavy algae blooms and high winds resulted in depleted oxygen levels and extensive fish kills. Each year, heavy algae blooms develop during the summer on Jameson Lake. As blooms die and sink to the bottom of the lake, they decompose and consume oxygen. Hydrogen sulfide, which is very toxic to fish, is produced when decomposition forms anaerobic conditions. During the fall, surface and bottom lake temperatures become equal and rapid mixing of the water column (turnover) by winds causes oxygen-deficient water to rise to the surface, resulting in fish kills. Turnover in most lakes occurs over a period of several weeks, causing no fish mortality, but at Jameson Lake very rapid turnovers are common due to strong north winds in the fall.

Severe fish kills were reported during the early 1950s when the lake level rose due to irrigation. Stock fish were then introduced to the lake (Lee Johnson 1974). The drop off in fish kills is attributed to relocation of a cattle feeding area at the north shore of the lake in the late 1960s and better agricultural soil conservation practices. However, significant algae growth still occurs each summer, and monitoring in the 1970s indicated eutrophic conditions (high levels of nutrients for algae). Algae growth is probably enhanced by agricultural and livestock runoff and possible wastewater seepage from resorts located on the lake.

A reconnaissance investigation of water quality in Douglas County lakes was performed in the 1970s as part of a statewide project (Dion et al. 1976). Two water quality samples (one near the surface and one at depth) were collected from 16 lakes, including Jameson Lake. A subsequent analysis of eutrophication in Washington lakes concludes that most lakes in Douglas County would be classified eutrophic based on high concentrations of the nutrient phosphorus (Sumioka and Dion 1985). For example, Jameson Lake had a total phosphorus concentration of 56 micrograms/liter in the epilimnion (i.e., shallow lake depths) and 160 micrograms/liter in the hypolimion (i.e., deep lake depths). The general threshold indicating excessive enrichment (i.e., eutrophic conditions) in lakes is 20 micrograms/liter. Many small seasonal lakes and potholes also exist in Douglas County, most or all of them highly alkaline (i.e., high pH with high dissolved solids) (Lee Johnson 1974).

Fisheries and Wildlife

Canyon A, upper Sand Canyon, and Canyon B contain ephemeral streams that flow only during periods of snowmelt and rainfall. Therefore, no fish would be expected in these drainages. Lower Sand Canyon conveys irrigation water and return flows on a seasonal basis. The Columbia River Trail Project review by the Washington Department of Fisheries found fish in a lower section of Sand Canyon. This had both trout and small salmon (rearing, not spawning).

Principal habitat types in the East Wenatchee area include wetland and riparian zones along the Columbia River, and upland steppe, agricultural, and urban areas on the terrace (Douglas County 1992b). Key areas for wildlife habitat are within wetlands and riparian zones adjacent to the Columbia River, and in gullies and some upland areas. These areas are important due to their proximity to water, adequate food supplies, and cover for nesting, safety, and shelter.

Birds are the most common form of wildlife along the Columbia River corridor. Ground nesting birds, waterfowl, shorebirds, and birds of prey share the habitat with small mammals and fish that depend on such areas for food, nesting, and cover. California quail, cottontail rabbit, muskrat, striped skunk, beaver, raccoon, river otter, and meadow mice are the most abundant animals along the shoreline. Bald eagles use the mid-Columbia River as a wintering area from October to April. Mule deer are occasionally seen. In all, 160 bird, 35 mammal, seven reptile, and three amphibian species were recorded in the shoreline areas of the Rock Island pool.

POPULATION AND LAND USE

Local Government

Douglas County was formed in 1883 and Waterville is the county seat. The County has a commission form of government with three elected commissioners who meet every Monday, Tuesday and Wednesday at the courthouse. Douglas County offices are at the courthouse in Waterville and in multiple offices in East Wenatchee.

The City of East Wenatchee has a noncharter city code form of government. It has operated under a council-mayor system of government since 1935. The council consists of the mayor and five members elected from single member districts for four-year terms. Council meetings are on the first and third Mondays of the month.

Economy

The economy of Douglas County is primarily agriculturally based. Farming began in the 1870s and most of the County was settled in the 1880s. Agriculture is still the dominant industry in North Central Washington. Secondary industries of economic importance include industry, retail, medical services, and tourism.

Population History and Projections

Table 2-4 summarizes past and predicted population in Douglas County and the East Wenatchee area. Currently, 80 percent of Douglas County residents live in the greater East Wenatchee area. This compares with 72 percent in 1973 (Lee Johnson 1974). Since 1970, most of the County's population growth has occurred in the East Wenatchee area, with an average growth of 23 percent per decade. In contrast, population in other towns and rural areas of Douglas County increased by only about 5 percent per decade.

TABLE 2-4.
POPULATION HISTORY AND PROJECTIONS[a]

	1970	1980	1990	1992	2000[b]
City of East Wenatchee[c]	913	1,640	2,658	3,290[d]	3,898[d]
County	16,787	22,144	26,302	27,441	32,516[d]
Greater East Wenatchee Area (GEWA)	12,000[e]	—	—	20,073	23,998[d]

a. Source: 1988 Comprehensive Plan (Douglas County 1988) and East Wenatchee Chamber of Commerce (EWCC 1992).
b. Projections made in 1988 based on low and high housing trends (Douglas County 1988). Values are adjusted to correct mathematical error in reported estimates.
c. Rapid population increases in East Wenatchee are partly due to annexation of urbanized County areas.
d. Projections are based on Traffic Analysis Zones (TAZ) which don't exactly follow corporate boundaries, although TAZ #16 is close to the city limits.
e. Approximate value derived from 1973 estimate of 12,682 reported in Lee Johnson (1974).

Zoning

Current zoning for Douglas County and the City of East Wenatchee are summarized in Tables 2-5 and 2-6, respectively. These tables identify normal restrictions on land development, including minimum lot sizes, maximum density of dwellings, and types of structures. Figures 2-4 and 2-5 show the zoning boundaries in the East Wenatchee area of Douglas County and in the City of East Wenatchee, respectively.

The objectives of zoning are to encourage orderly growth, promote compatible uses of land, provide desired levels of population density and intensity of land use, facilitate adequate levels of community services and utilities, and provide workable relationships between land uses and the transportation system. The Douglas County Zoning Ordinance (Title 18), is adopted pursuant to state law, which empowers a county to enact a zoning ordinance and provide for its administration, enforcement, and amendment.

Zoning is extremely important for flood hazard management because it directly dictates the types of development allowed in areas subject to flooding. Douglas County does not have a zoning designation for special flood areas, so no limitations in the zoning ordinance reflect natural flood hazard areas. (However, other ordinances impose development restrictions in floodplains). East Wenatchee does have a zoning overlay that imposes additional standards to minimize flood damage. In the East Wenatchee area, the Canyon A, Canyon B, and Sand Canyon drainage corridors are mostly zoned for moderate to high density residential development.

TABLE 2-5.
DEVELOPMENT ALLOWED UNDER DOUGLAS COUNTY ZONING

Zoning District	Inside Urban Growth Boundary?	Minimum Lot Size (square feet)	Maximum Density	Allowable Structures
S-F Single Family	Yes	Single Family: 10,000	3.5 per acre	One single family
R-1 Residential Low	Yes	Single family: 7,000 Duplex: 9,000	6 per acre	One single family or one duplex
R-2 Residential Medium	Yes	Single family: 6,000 Duplex: 8,000 Multi-family: 10,735 (or more depending on number of units)	15 per acre	Single family, duplex, multi-family, and mobile homes
R-3 Residential High	Yes	Single family: 6,000 Duplex: 8,000 Multi-family: 9,270 (or more depending on number of units)	30 per acre	Single family, duplex, multi-family, manufactured homes, office buildings, and community recreation centers
S-R-1 Suburban Residential	Yes	Single family: 7,500 Duplex: 9,000	4.6 per acre	One single family or one duplex
S-R-2 Suburban Residential	No	Single family: 2 acres	1 per 2 acres	One single family
A-R Rural Agriculture	No	All dwellings: 1 acre	1 per acre	One single family or one duplex (except subdivisions), mobile homes, and agricultural packing houses and warehouses

TABLE 2-5 (Continued).
DEVELOPMENT ALLOWED UNDER DOUGLAS COUNTY ZONING

Zoning District	Inside Urban Growth Boundary?	Minimum Lot Size (square feet)	Maximum Density	Allowable Structures
A-CA Commercial Agriculture	No	Single family: 10 acres	1 per 10 acres	Single family and mobile home associated with agricultural activities, and agricultural packing houses and warehouses
A-SA Suburban Agriculture	No	Single family: 5 acres	1 per 5 acres	One single family
C-N Neighborhood Commercial	Yes	Any building: 7,000	None	Retail food and services, restaurants, offices, and public and community facilities
C-G General Commercial	Yes	None	None	All commercial except auto wrecking and industrial
T-R Tourist Recreational	No	None	15 per acre	Recreational facilities for traveling public, including motels, offices, RV parks, campgrounds, and multi-family dwellings
I-G General Industrial	Yes	None	None	All industrial except general commercial
I-H Heavy Industrial	Yes	None	None	All heavy industrial

TABLE 2-5 (Continued).
DEVELOPMENT ALLOWED UNDER DOUGLAS COUNTY ZONING

Zoning District	Inside Urban Growth Boundary?	Minimum Lot Size (square feet)	Maximum Density	Allowable Structures
R-S Rural Settlement Service Overlay	No	All uses: 10,000	None	Residential, neighborhood retail and services, and other rural uses except general commercial and industrial
R-O Recreational Overlay	No	None	None	Less-developed and primitive recreational areas

Source: Douglas County Zoning Ordinance (Title 18). This table is a general summary only; additional permitted, conditional, and prohibited uses and development standards are specified for each zoning district.

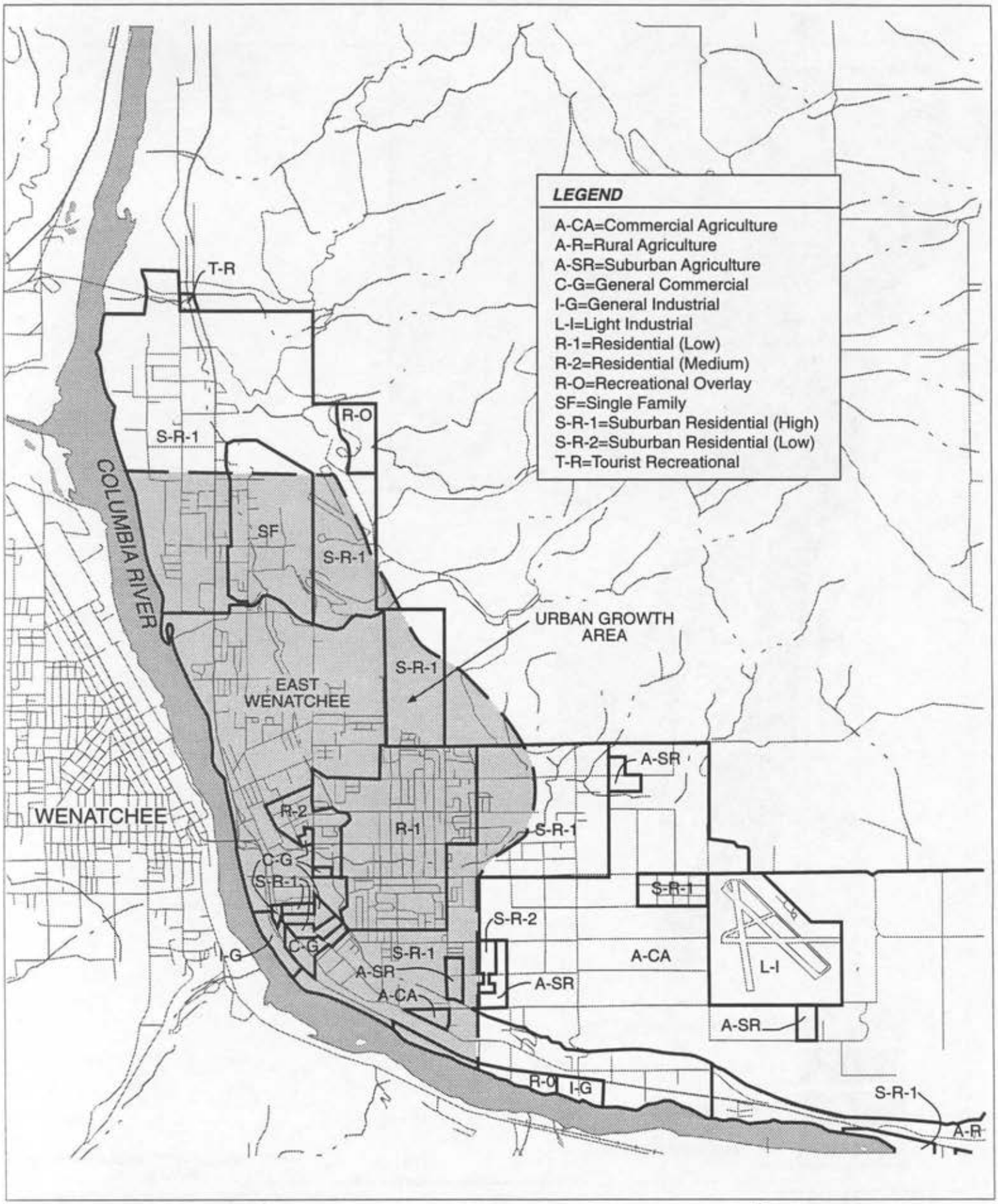
TABLE 2-6.
DEVELOPMENT RESTRICTIONS UNDER EAST WENATCHEE ZONING

Zoning District	Minimum Lot Size (square feet)	Maximum Density	Allowable Structures
SR-20,000 Suburban Residential	Single Family: 20,000	1 dwelling per lot	One single family
SR-12,500 Suburban Residential	Single family: 12,500	1 dwelling per lot	One single family
R-L Residential (low density)	Single family: 7,000	1 dwelling per lot	One single family
R-M Residential (medium density)	Single family: 7,200 Duplex: 8,200 Multi-family: 11,800 (or more depending on number of units)	12 dwellings per acre	Single family, duplex, or multi-family
R-O Residential Office	Single family: 7,000 Duplex: 8,200 Multi-family: 10,400 (or more depending on number of units)	18 dwellings per acre	Single family, duplex, multi-family, general and professional office buildings
C-L Neighborhood Commercial	2 acres	3 acres	Commercial (grocery, drug, bakery, laundry), medical and dental offices
C-M Commercial	None	None	Most commercial activities
C-H Commercial	None	None	Commercial uses consistent with smaller, pedestrian-oriented retail uses

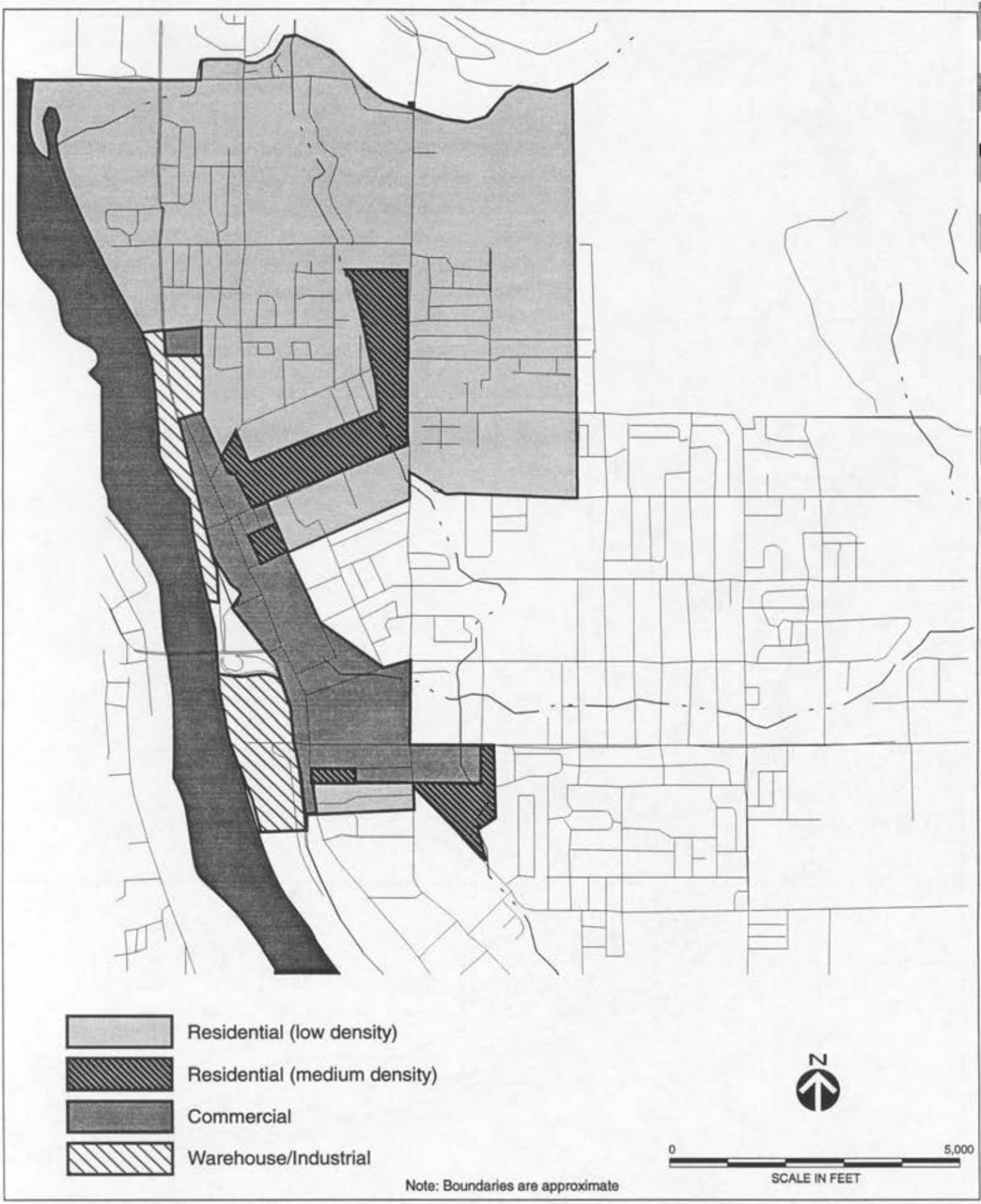
TABLE 2-6 (Continued).
DEVELOPMENT RESTRICTIONS UNDER EAST WENATCHEE ZONING

Zoning District	Minimum Lot Size (square feet)	Maximum Density	Allowable Structures
W-I Warehouse/Industrial	All: 5000	none	Warehousing, manufacturing, and processing
P Public	None	none	Schools, hospitals, churches, governmental buildings, parks, and cemeteries
FH Flood Hazard (Overlay)	-	-	All uses in underlying zoning district are allowed, but additional standards to minimize flood damage are specified
PLA Planned Area (Overlay)	-	-	Six areas in City where land use goals have been specified to guide future development

Source: East Wenatchee Zoning Ordinance (Title 17). This table is a general summary only; additional permitted, conditional, and prohibited uses and development standards are specified for each zoning district.



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-4. CURRENT DOUGLAS COUNTY ZONING



KCM
1917 First Avenue
Seattle, Washington 98101

Douglas County
COMPREHENSIVE FLOOD HAZARD
MANAGEMENT PLAN

Figure 2-5.
CURRENT EAST
WENATCHEE ZONING

Land Use

The change in land use during recent years in the East Wenatchee area is mostly characterized by the conversion of agricultural land, primarily orchards, to urban uses. This transition has occurred erratically, rather than gradually, reflecting swings in the regional economy. The late 1980s and early 1990s were periods of rapid growth for the entire Wenatchee region.

Current Land Use

Table 2-7 summarizes the change in land use from 1977 to 1988. Land use classifications experiencing the greatest growth include irrigated agriculture, single- and multi-family housing, and commercial uses. These expansions were made at the expense of dryland farming areas and unused lands, which experienced declines. The net increase in irrigated land of 588 acres includes 900 acres of new orchards created by expansion of the irrigation district and conversion of dryland crop and unused areas, countered by the loss of 312 acres of other orchards due to conversion to residential and commercial use (Douglas County 1988).

TABLE 2-7.
LAND USE IN EAST WENATCHEE AREA IN 1977 AND 1988

	Area (acres)		Percent of Total		Percent Change
Land Use	1977	1988	1977	1988	1977 to 1988
Irrigated Agriculture	5,829	6,417	36.0	40.0	+10
Dryland Farming	1,337	1,137	8.2	7.0	-15
Single Family Residential	1,412	2,010	8.8	12.0	+42
Multifamily Residential	65	100	0.4	0.6	+53
Commercial	27	123	0.2	0.8	+455
Industrial	847	847	5.2	5.2	0
Public	375	375	2.3	2.3	0
Recreational	243	300	1.5	1.9	+23
Unused	6,066	4,892	37.4	30.0	-19

Source: Douglas County (1988)

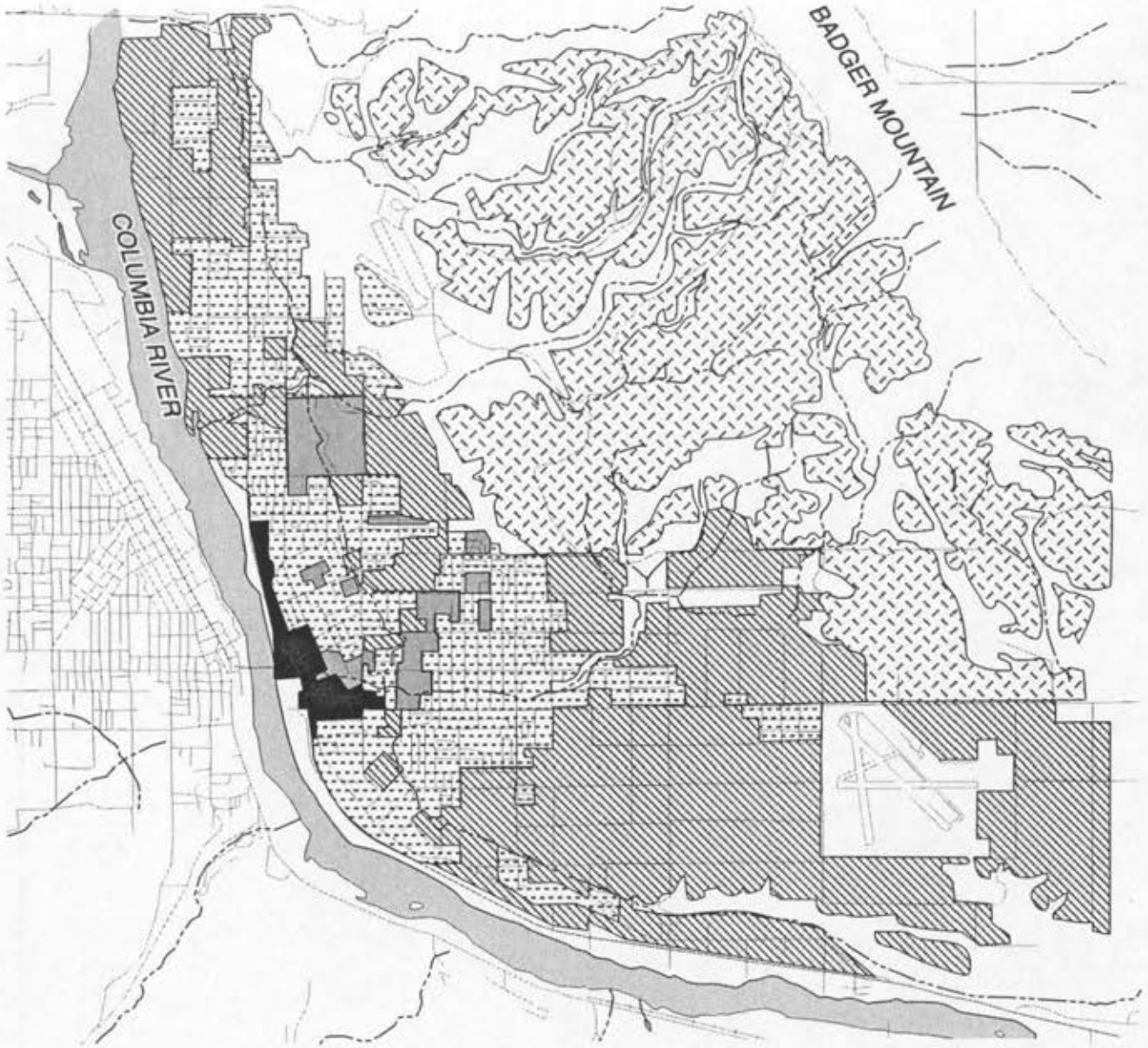
Current land use is illustrated in Figure 2-6. These broad land use patterns were determined from aerial photographs taken in 1986. Dry cropland and rangeland areas dominate the upper Canyon A, Canyon B, and Sand Canyon watersheds. Residential areas, which in this figure include all housing densities because of limitations of aerial photograph interpretation, are centered around the commercial areas of East Wenatchee but also extend north and east into the county areas. Irrigated orchard lands generally surround the residential areas, although large tracts of orchards are still located between residential neighborhoods.

Urban Growth Area and Future Land Use

Future land use patterns in the East Wenatchee area will be guided by policy developed by the GMA Regional Council. The Growth Management Act (Reengrossed Substitute House Bill 1025 and Engrossed Substitute House Bill 2929 of 1991) requires counties planning under it to adopt a countywide Planning Policy in cooperation with cities in the county. This is enacted in Douglas County by the GMA Regional Council as the Regional Policy Plan (Douglas County 1992a). The purpose of developing this planning policy is to attain consistency among comprehensive plans in the County.

An important aspect of the GMA Planning Policy is the designation of "Urban Growth Areas" (UGAs), which define future limits for existing urban areas by limiting expansion of municipal utilities to within the UGA. Outside the UGA, the retention of rural character and the preservation of farmland are facilitated by zoning and by the lack of such municipal utilities as water and sewers. Future growth in the UGA is to be accommodated by service capacities that already exist, or that are planned for and can be efficiently and economically provided by either public or private sources.

The interim UGA for the East Wenatchee area is defined as the 20-year Urban Growth Boundary that was prepared for the 1988 Greater East Wenatchee Area Comprehensive Plan (Douglas County 1988). The Urban Growth Boundary, which meets the requirements of the GMA, is shown in Figure 2-4. In this map, the Urban Growth Boundary contains most land zoned for urban residential development and follows existing residential development patterns that are shown in Figure 2-6. These designations defined current and future land use patterns for analysis of watershed conditions in the hydrologic analysis.



LEGEND

- Dry Cropland
- Orchard
- Urban Open Space
- Low- or High-Density Residential
- Commercial
- Rangeland, Undisturbed, or Other

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Douglas County
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 2-6.
CURRENT LAND USES

CHAPTER 3.
PREVIOUS INVESTIGATIONS

Many investigations have been conducted during the last 20 years to assess flood problems in Douglas County and develop potential solutions. These investigations covered most flood problem areas in the East Wenatchee area including Canyon A, Canyon B, and the urban area experiencing storm drainage problems. Several flood control alternatives were proposed in these studies, and one proposal, the East Wenatchee Watershed Project, led to an unsuccessful bond issue in 1983. With the exception of the Canyon B flood control project, no flood control improvements resulted from any of these studies, primarily due to lack of local funds and the difficulties of implementing new regulations in existing developed areas.

Most of these studies were prompted by the flood of June 1972, which caused extensive damage to urban areas of East Wenatchee, especially below Canyon A. The flood of March 1989, which resulted in the declaration of Douglas County as a Federal Disaster Area, caused renewed interest and additional studies, primarily in the Canyon B area. As a result, most studies of specific flood controls relate directly to Canyon A or Canyon B. Nonstructural methods for flood hazard management were evaluated but were dropped in favor of structural proposals.

Urban storm drainage problems associated with the 1972, 1989, and other flood events have also led to several reconnaissance-level studies on potential storm drainage systems. These studies were fairly wide in scope, covered the entire East Wenatchee urban area, and did not address individual flood problem areas. Few studies have been conducted outside the East Wenatchee area and documentation of these is very limited.

All previous studies dating back to 1973 that relate to flooding in Douglas County are summarized below. Flood control and stormwater facilities proposed in these studies are summarized in Table 3-1. In this plan, particular attention is paid to previously proposed flood control projects and alternatives because many of these ideas are viable and may be appropriate.

CANYON A

Comprehensive Storm Drainage Plan - 1973

This storm drainage report proposed a flood control system in Canyon A to reduce runoff entering the urban area (Futrell 1973). Because the focus of this report was urban storm drainage, it is described in the Urban Storm Drainage section below.

Kentucky Avenue Watershed Reconnaissance Report - 1974

Following the June 1972 flood, the Soil Conservation Service (SCS) became involved in a long-term program to assess flood and sedimentation hazards in and below Canyon A and to develop solutions. Initial studies, presented in the *North Kentucky Watershed*

TABLE 3-1.
SUMMARY OF PREVIOUSLY PROPOSED FLOOD CONTROL AND STORMWATER ALTERNATIVES IN EAST WENATCHEE AREA

Area	Year	Description of Alternative	Reference
Canyon A	1973	• Diversion channel above 10th and Kentucky • 50-foot dam and reservoir in Canyon A at Mary and 3rd • Channel and pipe system down Grant to Columbia River	Futrell (1973)
	1974	• Two dams and reservoirs in Canyon A: 35-foot high dam at 10th and Stark, and 40-foot high dam at Lyle Avenue • Terraces and diversions above 10th and Kentucky • Floodway improvement through urban area	SCS (1974)
	1983	• Diversions above 10th and Kentucky • Outlet pipeline along 3rd from diversions to Columbia River • Interception of Canyon A flow at Eastmont	SCS (1983)
	1983	• Diversion, outlet pipeline, and Canyon A interception (as above) • 38-foot high dam and reservoir below 8th and Nile	SCS (1983)
	1983	• Flood-proofing and floodplain ordinances • Acquisition of agricultural land above East Wenatchee and treatment to minimize erosion and runoff	SCS (1983)
Canyon B	1989	• Stabilization of slides • 10,000 cu yd debris basin at outlet of Canyon B	Shannon & Wilson (1989)
	1990	• Storage scheme: 25,000 cu yd debris basin • 200-foot long berm to direct floodwaters down channel	NHC (1990)
	1990	• Diversion Scheme: 400- to 900-foot long dike to divert waters to 9 acre area for sediment deposition	NHC (1990)
Sand Canyon	---	None proposed	
Urban Area	1973	Urban storm drainage system (Update of 1969 study by Munson-Nash-Futrell)	Futrell (1973)
	1977	Urban storm drainage system for 2,360 acre urban area	CH2M Hill (1977)

Reconnaissance Report (SCS 1974), were developed by the Waterville field office of the SCS with assistance from the East Wenatchee Conservation District. The term "North Kentucky Watershed" referred to Canyon A and its associated subdrainages in the Badger Mountain foothills immediately east of East Wenatchee between 15th Street and Grant Road. Subsequent SCS reports identified Canyon A as the "East Wenatchee Watershed."

This report documented the extensive damage that occurred during the 1972 flood. As discussed in Chapter 4, croplands experienced extensive erosion, orchards were completely destroyed by eroding floodwaters, irrigation facilities were damaged from deposition of silt, and homes built in the floodplain were damaged by silt and debris. Soil loss was as high as 500 tons per acre in dry cropland areas, and averaged 250 tons per acre over 500 acres. More than 350 residences experienced flood damage. Total damages from this flood exceeded $1 million.

Problems Contributing to Flooding

The SCS identified the following factors that contributed to the flood hazards in Canyon A:

- **Physical Characteristics of the Watershed.** The steepness of the watershed, coupled with its shape, results in high velocity runoff. In the upper portion of the watershed, water flows down narrow, steep, and rocky drainages. When floodwaters reach the wheat land, crop residues (on fallow fields) and contour farming practices are inadequate to protect the land. Drainages remain steep and narrow throughout the middle section of the watershed. Soils in these drainages are sandy and highly susceptible to erosion.

- **Dry-land Agricultural Land Use**. Specific problems on agricultural land include land use beyond it capabilities; inadequate land treatment; ineffective crop, soil, and livestock management practices; and lack of water control structures.

- **Orchard Land Use**. While cover crops on orchard lands successfully control erosion from irrigation water, they were inadequate to prevent soils from being seriously eroded by floodwaters. Poorly established stands, lack of cover crop management, and access roads caused extensive problems.

- **Domestic Land Use.** Domestic land use patterns magnified the watershed problems through the displacement of agricultural lands with houses and streets. Residential sprawl and rural build-up had been occurring without adequate land use planning, floodplain zoning, or other land use regulations needed to control flood problems.

Identified Flood Control Alternatives

The two alternatives identified in this report are described below. [Further refinement of these recommendations was made in the subsequent *Final Watershed Plan for the East Wenatchee Watershed Project* (SCS 1983), described in the next section.]

Alternative 1 (Structural Measures)

Runoff and sediment emanating from Canyon A and adjacent areas would be controlled by the following flood control features:

- **Flood Control Reservoirs.** Two reservoirs to detain floodwater and catch sediments would be constructed: a 35-foot high earth-fill dam in the middle portion of Canyon A above 10th Street and Stark Avenue, and a 40-foot high earth-fill dam located in the lower portion of Canyon A just above Lyle Avenue. The reservoirs would be designed to detain the 100-year flood with a maximum discharge of 10 cubic feet per second (cfs).

- **Upland Terraces and Diversions.** Approximately 2 miles of terraces and diversions on upland dry cropland areas would be constructed in the subdrainages immediately above the urban areas to divert runoff to the detention reservoirs.

- **Land Treatment.** Various land treatment options (e.g., contouring, terracing, and revegetation) would be applied to croplands above the upland terraces and diversions to reduce runoff and sediment loading from these areas.

- **Improved Floodways.** Discharges from the reservoirs would flow down improved floodways through the cropland and urban areas to the Columbia River. The flow pathway would follow the natural drainage of Canyon A, which passes through densely developed residential areas. Floodway improvements would include culvert and road crossing upgrades, shaping and revegetation of the waterway, and pipeline installation.

A benefit-cost ratio of 2.38 was calculated for this alternative, based on annual costs of $42,000 (amortized over 100 years at 6.875 percent, equivalent to a capital cost of about $600,000) and annual flood reduction benefits of $100,000. (Note: these costs appear to be underestimated when compared to cost estimates for comparable alternatives in the *Final Watershed Plan*.)

Alternative 2 (Nonstructural Measures)

This alternative was proposed in conceptual terms but not analyzed in detail. (It was presented as a "potential solution.") Therefore, no costs or benefits were calculated. This alternative would include the following:

- Land treatment on the cropland and rangeland

- Establishment of vegetated waterways in greenbelts through cropland and urban areas

- Preparation of a flood hazard study that would lead to building and urban land use regulations and community eligibility for federally subsidized flood insurance.

SCS East Wenatchee Watershed Project - 1983

The 1974 reconnaissance report was a precursor to a much more extensive analysis of Canyon A flooding. The 1983 investigation was conducted by the Spokane office of the SCS and is summarized in *East Wenatchee Watershed, Douglas County Washington, Final Watershed Plan* (SCS 1983). Local sponsors included the South Douglas Conservation District, Douglas County, City of East Wenatchee, and East Wenatchee Flood Control Zone District. The plan was prepared under the authority of the Watershed Protection and Flood Prevention Act (PL566, as amended).

This project began shortly after the 1974 report with a request for planning assistance (by the SCS) through PL566. A draft field examination report was presented in 1976, which found no feasible alternatives that would eliminate all significant flood damage in the watershed. A citizen advisory committee (described below) was formed in 1978 to explore public acceptance to a partial solution to the flood problems. Two alternatives were selected and proposed in a final field examination report in 1979. Following this, a recommended plan was selected by the project sponsors. A Technical Review Plan was prepared in 1982 and the Draft Watershed Plan was prepared in 1983.

The Final Watershed Plan, approved and published in 1983 (SCS 1983), documents a proposed flood control plan for Canyon A drainages, describes expected impacts, and provides the basis for authorizing federal assistance for implementation. A large portion of the estimated $3.3 million project cost was to have been funded by PL566 funds, with the remainder provided by the sponsors. The initial phase of the project was awarded $815,600 by the federal government in April 1983.

Local funding in the form of a bond issue by the East Wenatchee Flood Control Zone District, for up to $1.3 million, was presented to East Wenatchee area voters in 1983. The bond issue was defeated twice, in successive elections, the first time due to inadequate voter turnout and the second time due to inadequate approval margin. (Poor economic conditions in Douglas County, as reflected by an 18.7 percent unemployment rate in 1983, may have contributed to the defeat of the bond issues.) Douglas County officials continued to explore funding options in the 1980s, such as a real estate excise tax (Wenatchee World 22 July 1987), in order to secure matching funds before the federal funds were withdrawn. During this time, the SCS continued with final design studies for the first phase of the proposed project. Because no local matching funds could be raised by the sponsors, the project was not built.

East Wenatchee Flood Control Zone District and Citizen Advisory Committee

To plan and implement the East Wenatchee Watershed Project, a Flood Control Zone District was formed in July 1980. This District included all urban areas of East Wenatchee, from Glendale Street on the north to Grant Road and South Kentucky Avenue to the south, and a portion of the agricultural lands to the east. Taxpayers within the district would have been the source of local funding for the project.

A citizen advisory committee was formed to guide development of the project and to conduct public hearings and meetings on the project. Committee members, who were mainly citizens within the Flood Control Zone District, are listed in Table 3-2.

TABLE 3-2.
MEMBERS OF CITIZEN ADVISORY COMMITTEE FOR EAST WENATCHEE WATERSHED PROJECT

Name	Occupation
Al Berry	Civil Engineer, Horton Dennis & Associates
John Powers	Wheat Farmer
Ike Munson	Owner, Munson Engineers
Carroll Reid	Machinist, Van Doren Sales
Dick McGraw	Owner, Signs & Such
Bob Lindell	Orchardist and Planning Commission Member
Bob Dahmer	Manager, Forsgren-Perkins Engineers
Glenn Ludeman	Wheat Farmer and Chairman of South Douglas Conservation District
Perrin Cornell	President, Eastern Washington Savings & Load
Bobbie Clark	Owner, Clark's Jewelry
Chip Small	Attorney, Jeffers, Danielson, etc.
Herber Kennedy	Manager, Wenatchee Valley Mall

Description of Study Area

The East Wenatchee Watershed study encompassed the Canyon A watershed (called the North Kentucky Watershed in the 1974 report) from the headwaters on Badger Mountain to the Columbia River, an area of 5,860 acres (9.2 square miles). Drainages evaluated for flood control include the upper 3,850-acre (6.0 square mile) portion of Canyon A where the canyon emerges from the foothills and enters the urban area at Lyle Avenue, and 14 small subdrainages above and north of North Kentucky Avenue and 10th Avenue. (Most of these subdrainages eventually join the main Canyon A drainage corridor near the Columbia River, but must pass through the urban area in the process.) Thus, the study included control of runoff emanating from dry cropland, rangeland, and other nonurban areas immediately east of the East Wenatchee urbanized area, as well as safely conveying the runoff water through the urban area to the Columbia River.

Urban storm drainage was not addressed in this study, although it was recognized that urban runoff contributed significantly to the flooding problems. (Funding through PL566 could not be used for this purpose.) However, when the SCS began the design phase of the project, the flow capacity of the proposed pipeline was increased to accommodate storm

drainage inflows calculated by CH2M Hill in an earlier storm drainage reconnaissance report (CH2M Hill 1977, described below). Neither the pipeline nor the drainage system was built.

Benefits of flood control were based on reducing flood damages in the urban area downstream of the Badger Mountain foothill drainages and along lower Canyon A. This area is approximately bounded by 15th Street on the north, Grant Road on the south, and the Columbia River on the west.

Assumptions

The analysis of watershed conditions in the Final Watershed Plan was based on population and urban growth projected for the year 2032. Specific changes over 1982 conditions are as follows:

- **Land Use.** The urban area will increase from 1,740 acres to 3,145 acres, for a total of 5,370 homes in the watershed (an increase of 80 percent from 1982). Changes by land use in the 5,860 acre watershed are based on the 1976 Comprehensive Plan.

- **Hydrology and Design Storm.** Runoff from Canyon A was based on a 6-hour storm distribution patterned after the June 1972 event having 1-, 2-, 3-, 6-, and 24-hour precipitation amounts of 0.68, 1.05, 1.34, 1.65, and 2.38 inches, respectively. The resulting 2-, 10-, and 100-year flows in Canyon A at Lyle Avenue for 1982 land use conditions were estimated to be 18, 87, and 381 cfs, respectively. The future conditions 100-year flood was estimated at 485 cfs.

- **100-year Floodplain Area.** The total area flooded in a 100-year flood will increase from 641 acres under 1982 land use conditions to 739 acres under future (2032) land use.

Initially Identified Alternatives

During initial studies, the SCS identified and evaluated a large number of structural options. These options are summarized in Table 3-3. Preliminary costs and flood damage benefits were also calculated. Following public meetings, the SCS selected two of the options (IV.A.2 and I.A) and added several others (primarily nonstructural) for further analysis and modification in the Final Watershed Plan.

The options contained in Table 3-3 were made up of various combinations of dam, diversion, and outlet pipeline configurations. A single dam location was considered: below 8th Street near Nile Avenue. Diversion options included a partial diversion, which would intercept water flowing down gullies only in the immediate vicinity of 10th Street and North Kentucky Avenue area and east to Lyle Avenue, and a full diversion, which would intercept all gullies between 15th Street and Lyle Avenue. Outlet pipelines, which would carry the water from the dam and diversions to the Columbia River, included routes down 10th Street, 3rd Street, between 3rd Street and Grant Road (down the natural main channel), and below Eastmont Avenue only (lower outlet).

TABLE 3-3.
CANYON A ALTERNATIVES INITIALLY IDENTIFIED BY SCS

Alt.	Diversion	Outlet Pipeline	Cost (1982)	Maximum Benefit
Alternatives with Dam[a]				
I.A.[b]	Full	Along main channel	$2,821,000	$3,610,000
III.A.	Full	Lower outlet only	2,069,000	3,610,000
I.B.	Partial	Along main Channel	2,562,000	2,292,000
III.B.	Partial	Lower outlet only	1,758,000	2,292,000
V.	None	Along main channel	1,454,000	539,000
VI.	None	Lower outlet only	1,062,000	539,000
Alternatives without Dam[a]				
II.A.[b]	Full	Along main channel	$3,548,000	$3,610,000
IV.A.1.	Full	Along 10th Street	1,590,000	3,126,000
IV.A.2.	Full	Along 3rd Street	2,006,000	3,126,000
II.B.	Partial	Along main channel	3,047,000	2,292,000
IV.B.1.	Partial	Along 10th Street	1,173,000	1,888,000
IV.B.2.	Partial	Along 3rd Street	1,416,000	1,888,000

a. Alternatives are explained in Table 3-4.

b. Selected for further study in Final Watershed Plan, Table 3-4 (i.e., Alternative 4 and Recommended Plan, respectively).

Table 3-3 indicates that structural solutions for Canyon A would cost between $1.0 and $3.5 million (1982 cost basis). Including a dam and detention reservoir to convey the flood flows would be more costly than providing a pipeline along 10th Street. An outlet pipeline constructed along 10th Street would be more cost effective than one constructed along 3rd Street or along the main channel. However, the cost of a pipeline conveyance along the main channel to control Canyon A flows is much greater than the flood control benefit.

Thus, as described below, the recommended alternative did not include a dam or pipeline for main channel flows. (This information, provided by the SCS in the form of a data notebook, does not provide documentation of cost and benefit calculations. The accuracy of these numbers cannot be verified.)

Recommended Flood Control Alternative

The five alternatives presented in the Final Watershed Plan are summarized in Table 3-4, which includes project elements, costs, and flood control benefits for each alternative.

The recommended plan (Alternative 1, or the National Economic Development Alternative) is illustrated in Figure 3-1. This plan consisted of the following elements:

- **Diversions**. Upper and lower channels and diversions located above 10th and North Kentucky Avenue to intercept runoff and sediments from 375 acres of dry cropland areas. The two trapezoidal channels would have a total length of 11,040 feet and would be sized to detain the 100-year storm along with long-term sediment deposition. Total 100-year outflow from the eight diversion outlet structures is 18 cfs.

- **Outlet Pipeline**. A reinforced concrete pipeline with a total length of 13,975 feet would begin at 10th Street and Kansas Avenue, run down Kansas Avenue to 3rd Street, down 3rd Street to Eastmont Avenue, and then to the Columbia River. The pipeline above Eastmont Avenue was designed for the 100-year diversion outflow of 18 cfs, and below Eastmont would be designed for 435 cfs (to include the Canyon A Interceptor). Pipeline diameter ranges from 12 inches at the upper end to 54 inches in the vicinity of Eastmont Avenue.

- **Canyon A Interceptor**. A second pipe would intercept Canyon A flows (draining 6 square miles) at Eastmont Avenue and then join the outlet pipeline about 500 feet away. This pipe was designed for a 100-year Canyon A discharge of 420 cfs.

- **Flood-proofing**. Eight homes would be flood-proofed, which would include raising foundations, erecting barriers, removing ground level windows, and installing waterproof doors.

- **Land Treatment**. Land treatment measures, such as conservation cropping systems, stubble mulch, grassed waterways, stripcropping, and terraces, would be required prior to construction of the diversions. These measures would provide protection from sheet, rill, concentrated flow and gully erosion on 375 acres contributing runoff to the diversions.

As shown in Table 3-4, Alternative 1 would result in a 70 percent reduction in flood damages (from $406,000 to $123,000 per year) in the urban area below Canyon A. Assuming a total cost of the proposed project of $1,838,000 (1982 costs, as originally reported), the annual cost would be $175,000, based on a 50-year amortization at 7.875 percent. However, a subsequent construction cost estimate placed the total cost at $3,267,000 (1987 costs).

TABLE 3-4.
SUMMARY OF EAST WENATCHEE WATERSHED PLAN ALTERNATIVES

	No Action	Recommended Plan	Alternative 2 - Change in Land Use	Alternative 3 - Nonstructural	Alternative 4 - Diversions and Reservoir
Project Features	None	• Diversions above Kentucky and 10th • Pipeline from diversions to Columbia River • Interception of Canyon A flows • Flood-proofing • Land treatment	• Land acquisition (375 acres) and treatment • Flood-proofing	• Flood-proofing • Floodplain ordinances	• Alternative 1 plus detention reservoir in Canyon A
Total Cost (1982 basis)	0	$1,838,000[a]	$2,128,000	$246,000	$4,143,000
Flood Reduction Benefits					
• Acres flooded	739	543	543	739	464
• Annual flood damages[b]	$406,000	$123,000	$158,000	$346,000	$92,000
• Properties with yard and structural damage	515	219	291	397	258
• Properties with yard damage only	1180	848	848	1180	801
• Businesses flooded	32	7	32	27	1

a. 1987 estimate is $3,267,000. When urban stormwater capacity is added to outlet pipeline, cost increases to $6,556,000.
b. Based on expected damages under future land use conditions during 100-year storm.

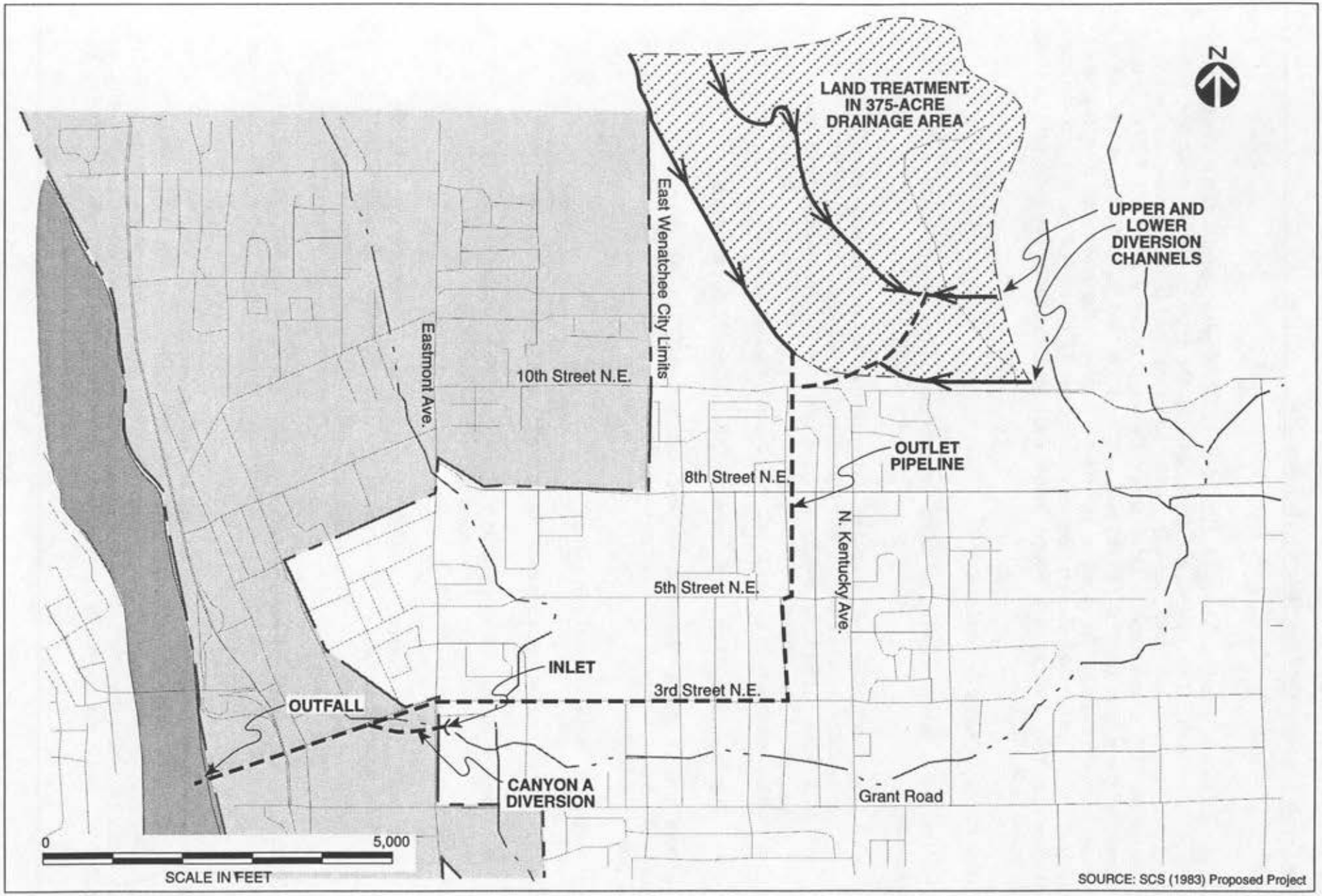

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Figure 3-1.
SCS CANYON A
DRAINAGE PROPOSAL

Design of this alternative assumed that the outlet pipeline could carry stormwater discharges as well. This option was included into the pipeline design after the Final Watershed Plan was published. The stormwater flows assumed in the pipeline design were based on the 1977 *Reconnaissance Level Storm Drainage Study* (CH2M Hill 1977). When stormwater flows from the "5th Street Northeast" and the "3rd Street Northeast" drainage systems were diverted to the pipeline at various locations, the maximum pipe diameter increased to 72 inches, and design flow increased from 18 cfs to 648 cfs above Eastmont Avenue and from 435 cfs to 1,068 cfs below Eastmont Avenue. The total project cost increased to $6,556,000.

Alternative 2 - Change in Land Use

This alternative, which emphasized environmental quality and enhancement, included the following:

- **Land Acquisition and Treatment.** Acquisition and change in land use of 270 acres of dry cropland lying above 10th Street and North Kentucky Avenue. A system of terraces would be installed and the cropland would be converted to grassland to provide permanent cover. Wildlife enhancements such as ponds and vegetation would be included.

- **Flood-proofing.** Flood-proofing of eight homes would be performed.

The total project cost for Alternative 2 was estimated at $2,128,000, or an annual cost of $183,000. Average annual flood damages would be reduced from $406,000 to $157,000, a 61 percent reduction.

Alternative 3 - Nonstructural Alternative

This alternative, comprising only nonstructural measures, included the following:

- **Flood-proofing.** Flood-proofing 118 residences and 5 businesses, or 7 and 16 percent, respectively, of the total properties that would experience flood damage, would be feasible.

- **Floodplain Ordinances.** Local floodplain ordinances would be strengthened to ensure that no new construction would be subject to significant flood damage.

The total project cost for Alternative 3 was estimated at $246,000, or an annual cost of $23,000. Average annual flood damages would be reduced from $406,000 to $346,000, a 15 percent reduction. Flood-proofing was not found to be feasible for the 1,180 residences that suffer only yard damage during the 100-year flood.

Alternative 4 - Flood Diversions and Flood Retarding Structure

This alternative, shown in Figure 3-2, is similar to the recommended plan, in that it includes the flood diversion structures above 10th Street and Kentucky Avenue and an outlet pipeline to the Columbia River. It would also include facilities to control flooding in

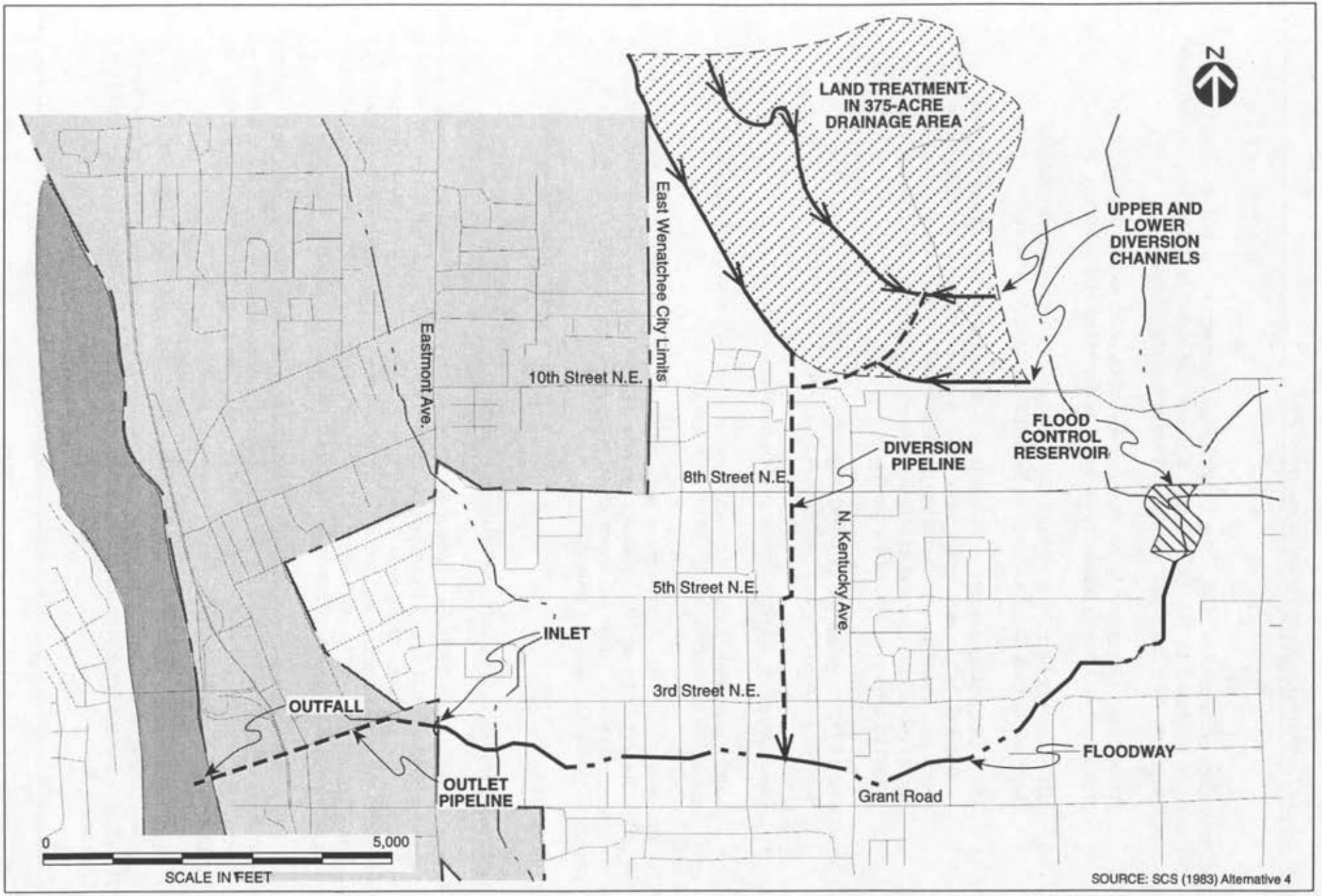

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Figure 3-2.
SCS CANYON A
DRAINAGE ALTERNATIVE

the main Canyon A channel and along Grant Road. A reservoir would be constructed in Canyon A, as proposed in the 1974 North Kentucky Watershed plan, to provide flood detention capacity. Specific elements included the following:

- **Diversions**. Upper and lower channels and diversions would be built above 10th Street and North Kentucky Avenue, as described in Alternative 1.
- **Diversion Pipeline**. A reinforced concrete pipeline would be constructed to carry water from the diversions to the main Canyon A channel.
- **Flood Control Reservoir**. A 38-foot high dam would be built in the Canyon A channel below 8th Street near Nile Avenue, creating a 24 acre-foot reservoir. Flood flows emanating from Canyon A would be detained and slowly released. A section of channel between Kentucky and Lyle Avenues would be improved to create a floodway.
- **Outlet Pipeline**. A pipe would intercept Canyon A flows at Eastmont Avenue for conveyance to the Columbia River.
- **Flood-proofing**. Eight homes would be flood-proofed.
- **Land Treatment**. Land treatment measures would be applied to 375 acres above the diversions, as described in Alternative 1.

The total project cost for Alternative 4 was estimated at $4,143,000, or an annual cost of $381,000. Average annual flood damages would be reduced from $406,000 to $91,000, a 76 percent reduction. However, since costs exceeded benefits, this alternative was not considered viable and was not selected.

CANYON B

Landslide and Debris Flooding Evaluation - 1989

Following the March 1989 flood event in Canyon B, Douglas County commissioned a consulting geotechnical firm to conduct an engineering and hydrologic study of flooding and landsliding problems in Canyon B (Shannon & Wilson 1989). This interim report was submitted to allow planning and construction of a portion of the mitigative measures that Douglas County wished to implement. The report deals only with control of sediment; impacts from flooding were not specifically evaluated.

This report summarizes the geologic conditions that were responsible for, or that contributed to, landsliding and debris flooding during the 1989 flood. During the flood, approximately 5,000 cubic yards of material were transported from the canyon to the Glendale neighborhood and the Sunset Highway.

A total of 19 recently active or potentially active slide areas were identified and mapped in the lower 3,800 feet of Canyon B (beginning at the 42-inch culvert at the head of 31st Street). The slides included translational slides, skin slides (shallow translational slides), rockfalls, and sand gullies.

Recommended Actions

Recommendations for the reduction and control of the amount of debris entering the stream channel during flood events include the following:

- **Keyed Buttress and Toe Support for Slide Areas 7 and 8.** A 200-foot long buttress, consisting of granular fill material and machine-placed heavy riprap, would be placed at the toes of these slide areas to provide support and reduce the potential for failure.

- **Channel Realignment.** The channel between Stations 11+00 and 14+00 was eroding the base of a slide zone. Realigning the channel to the center of the canyon floor would prevent this erosion.

- **Drainage, Keyed Buttress, and Toe Support for Slide Area 11.** French drains along the headscarp and sides of this slide, combined with a toe buttress, were considered the most cost-effective actions for stabilizing this slide.

- **French Drains and Surface Drains for Slide Area 12.** This large slide has the potential for forming a landslide dam that could block the stream, potentially resulting in a large flood and debris flow. A French drain at the top and sides to dewater the shallow soils would reduce the potential for failure.

- **Debris Retention Basin.** A 10,000 cubic yard basin would be constructed at the base of Canyon B, just above the head of 31st Street. The basin would trap coarse sediments presently stored in the canyon before they could be transported by floodwaters to the alluvial fan area below.

- **Periodic Monitoring.** The channel and slopes of Canyon B would be periodically monitored to identify potentially unstable conditions.

Investigation of Flooding and Sedimentation Hazards - 1990

After the 1989 interim report was produced, the analysis of flood and erosion hazards in Canyon B continued (Northwest Hydraulic Consultants 1990). The scope of the project expanded to include analysis of debris flow volumes, evaluation of floods up to the Probable Maximum Flood (PMF), and development and comparison of various flood control schemes. Proposed alternatives were evaluated in terms of cost, elimination of flood damage, and risk to life.

Assumptions

Estimates of peak flows and sediment volumes that were developed by Northwest Hydraulic Consultants for Canyon B are summarized in Table 3-5. The flood flow frequency estimates are based on regional regression equations developed by the U.S. Geological Survey, the PMF estimates were based on Bureau of Reclamation procedures, and the debris flow sediment volumes were based on field reconnaissance. Estimates of peak debris flood flow rates are higher than the annual maximum peak flows because the former include an allowance for "bulking" associated with the propagation of water/sediment/debris waves.

TABLE 3-5
PREVIOUS ESTIMATES OF PEAK FLOWS AND SEDIMENT VOLUMES FOR CANYON B.

Recurrence Interval	Flow Rate (cfs)	Sediment Volume (cu yds)
Annual Peak Flows		
10-Year Event	65	—
25-Year Event	121	—
50-Year Event	186	—
100-Year Event	270	—
Probable Maximum Flood	3,000-4,000	—
Debris Flood Peak Flows		
10-Year Event	150	1,000
50-Year Event	350	15,000
100-Year Event	500	25,000
1,000-Year Event	2,500	40,000
Probable Maximum Flood	4,000	50,000

Source: Northwest Hydraulic Consultants (1990)

The March 1989 flood event was considered to be near a 10-year event. Of the 5,000 cubic yards of sediment that was removed from Glendale Avenue, approximately 1,000 cubic yards emanated from the canyon itself and the other 4,000 cubic yards was scoured from the channel between the alluvial fan apex and the upper end of Glendale Avenue. The peak flow through the culvert at the fan apex was roughly estimated to be between 100 and 150 cfs.

Flood Control Alternatives

The schemes identified by Northwest Hydraulic Consultants were developed primarily to prevent or control sediment deposition; reduction of peak flows would be incidental. Alternatives were based on the objective of providing cost-effective reduction of risk to life and property damage from debris flows on the alluvial fan below Canyon B; they did not address control of floodwaters within the Glendale Neighborhood, threats to Sunset Highway, or control of floodwaters below Sunset Highway.

Proposed alternatives described below are summarized in Table 3-6. The elements of the storage schemes are shown in Figure 3-3, and elements of the diversion schemes are shown in Figure 3-4.

- **Storage Scheme 1.** A 10,000 cubic yard detention basin would be constructed at the canyon outlet immediately above the head of 31th Street. A low rock or concrete sill at the basin outlet would control local erosion. Storage capacity would be sufficient for sediment produced by a 40-year storm event. This alternative is identical to that proposed by Shannon & Wilson (1989).

- **Storage Scheme 2.** This scheme is similar to Storage Scheme 1, except that a 3-foot high "check dam" would be constructed to increase storage capacity to 25,000 cubic yards, which corresponds to the 100-year sediment volume. The channel would be armored below the dam to control erosion.

- **Storage Scheme 2a.** This scheme includes the features of Storage Scheme 2 and includes a 200-foot long berm along the left bank of the channel downstream from the dam. Purchase and removal of a single residence would remove the residents at greatest risk, and the berm would aid in controlling peak floods along the channel.

- **Storage Scheme 3.** This concept was developed to determine the facilities required to control the PMF sediment volume of 50,000 cubic yards. A 10-foot high dam would be needed to provide this volume.

- **Diversion Scheme 1.** The diversion schemes were developed as an alternative to storage. This scheme includes a 400-foot long armored dike that diverts floodwater and sediment to an open nine-acre area on the southwest flank of the alluvial fan (south of 31st Street and above Sunset Highway). Floodwaters would spread out in this area, depositing sediments before crossing the highway. However, no provision was made for controlling floodwaters leaving the deposition area.

- **Diversion Scheme 2.** This is similar to Diversion Scheme 1, except that the length of dikes would be increased to 900 feet to fully surround the nine-acre deposition area and an outlet structure would be provided at the base to direct outflows to an existing drainage depression on the alluvial fan.

Cost estimates in Table 3-6 include construction cost and property acquisition. Annual damage estimates include damage to dwellings and costs associated with sediment removal during cleanup. Annual damage savings (relative to no action) were converted to present-worth savings in order to compare flood control benefits to construction costs. Storage Schemes 1, 2, and 2a have benefit-cost ratios greater than 1.0, whereas Storage Scheme 3 and Diversion Schemes 1 and 2 have ratios less than 1.0. A project with a benefit-cost ratio of less than 1.0 cannot be justified on an economic basis alone, although other factors such as risk of life should be considered.

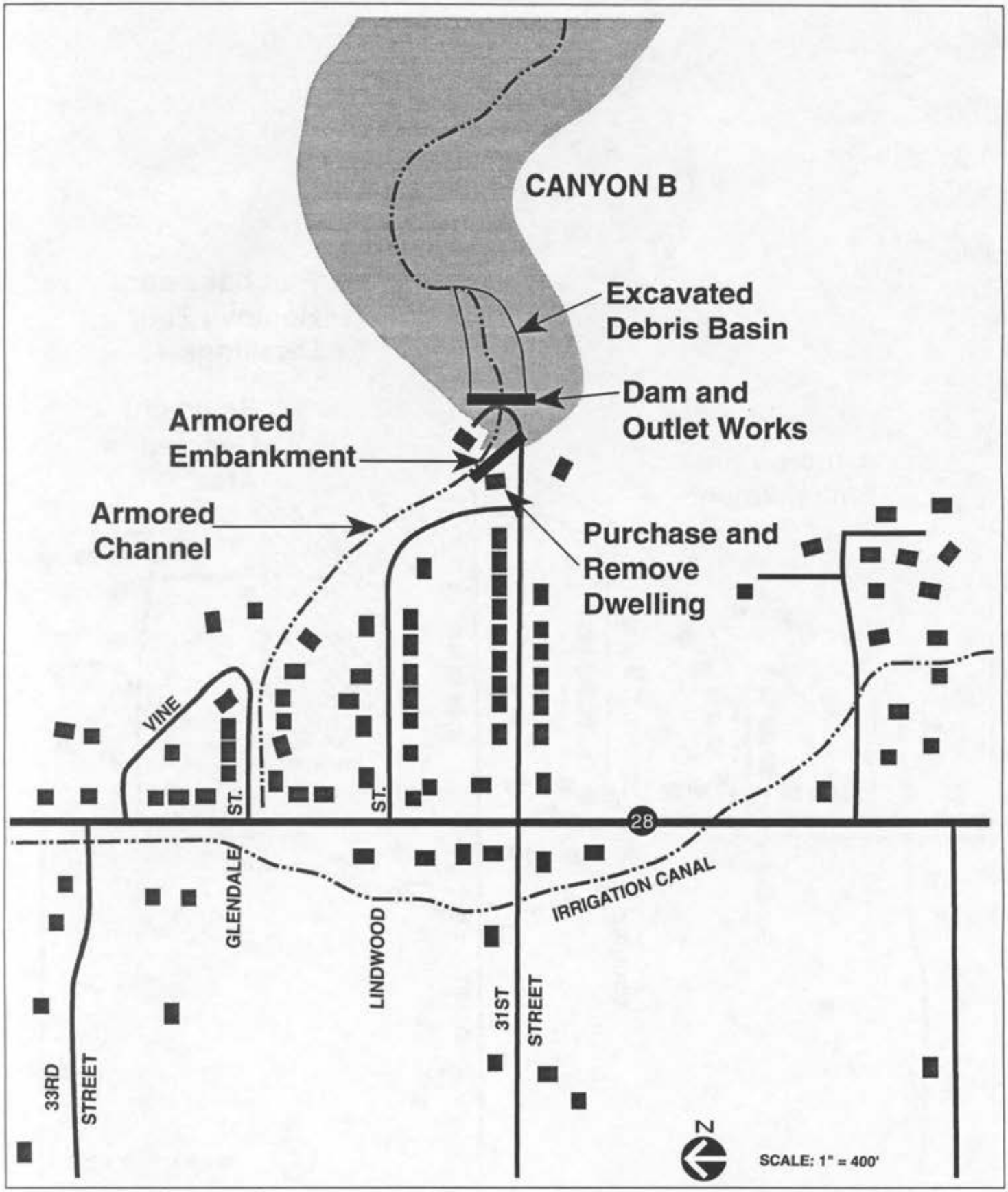
TABLE 3-6.
SUMMARY OF CANYON B ALTERNATIVES FROM 1990 INVESTIGATION

	No Action	Storage Scheme 1	Storage Scheme 2	Storage Scheme 2a	Storage Scheme 3	Diversion Scheme 1	Diversion Scheme 2
Project Features	None	• 10,000 cu yd debris basin • Rock sill at basin outlet	• 25,000 cu yd debris basin • 3 ft high concrete dam • Excavate outlet channel	• 25,000 cu yd debris basin • 3 ft high concrete dam • Remove single dwelling • 200 ft berm below dam • Excavate outlet channel	• 50,000 cu yd debris basin • 10 ft high concrete dam • Remove single dwelling • 200 ft berm below dam • Excavate outlet channel	• Remove 4 dwellings • Purchase 9 ac for sediment deposition area • 400 ft diversion dike	• Remove 4 dwellings • Purchase 9 ac for sediment deposition area • 900 ft diversion dike • Controlled outlet from deposition area
Costs and Benefits							
Total Cost (1990 basis)	$0	$35,000	$150,000	$250,000	$1,000,000	$750,000	$925,000
Annual Damages	$33,790	$18,677	$11,275	$10,325	$9,300	negligible	negligible
Present Value Savings[a]	$0	$188,900	$281,438	$293,312	$306,125	$422,375	$422,375
Benefit-Cost Ratio	---	5.4	1.9	1.2	0.31	0.56	0.46
Risk of Death							
Annual Probability	0.0093	0.00225	0.0007	0.00014	negligible	negligible	negligible
Risk in 100 years[b]	61%	20%	6.8%	1.4%	negligible	negligible	negligible

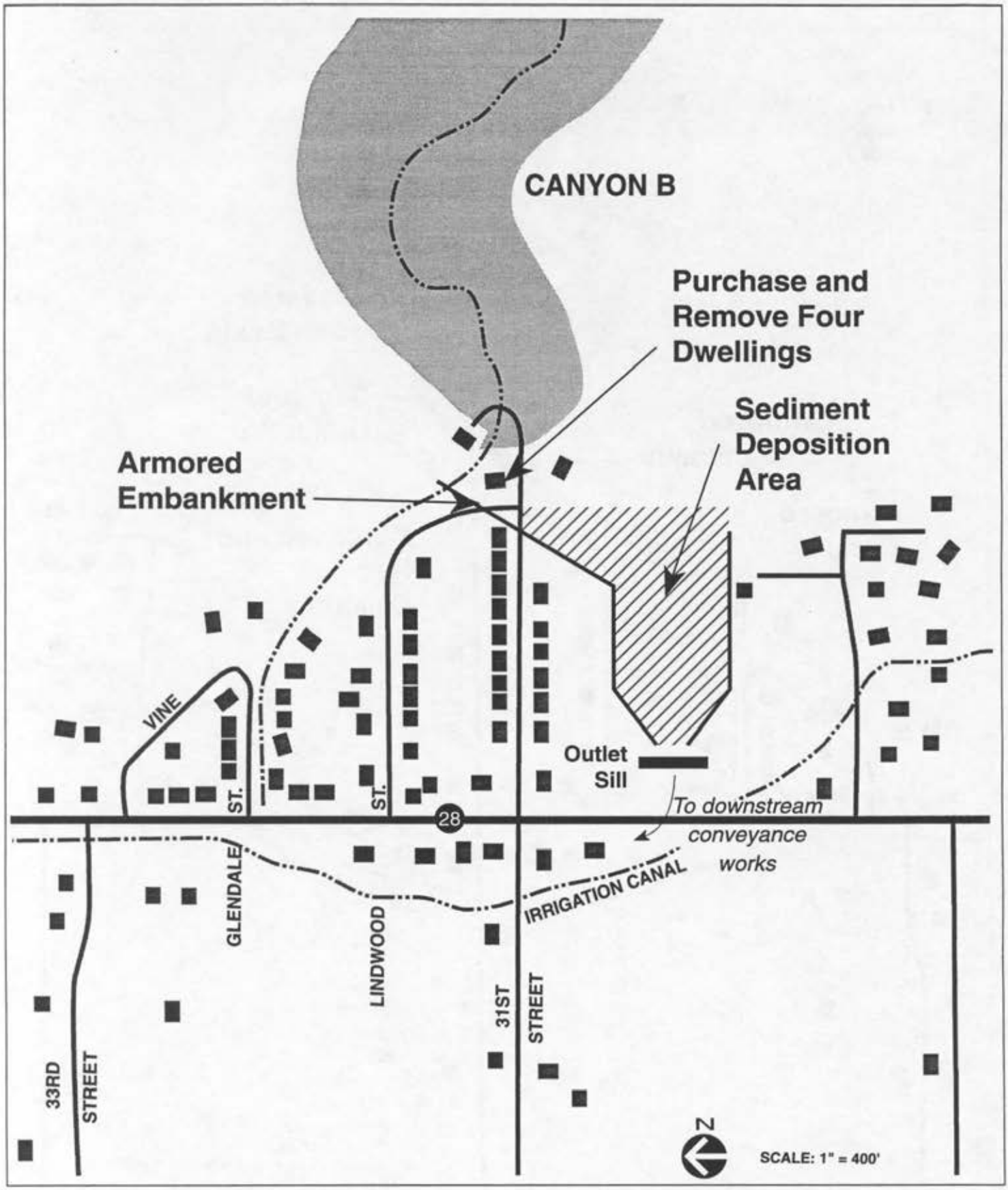
Source: Northwest Hydraulic Consultants (1990).

a. Based on discount rate of 8 percent over 100 years.

b. Probability of one death occurring in 100 years. A 1 in 10,000 (or 10^{-4}) risk is equivalent to 1 percent in 100 years.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 3-3. PREVIOUSLY PROPOSED SEDIMENT/DEBRIS STORAGE SCHEMES FOR CANYON B



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 3-4. PREVIOUSLY PROPOSED SEDIMENT/DEBRIS DIVERSION SCHEMES FOR CANYON B

The risk of life analysis in Northwest Hydraulic Consultants' report assumes that the maximum acceptable risk level for flood protection should be less than voluntary individual risks (such as air or automobile travel) and that they should approach risk levels for involuntary individual risks (such as fire or drowning). The risk level is expressed as the annual probability of death of a "Particular Individual Resident" (PDI):

$$PDI = P_h P_e P_d$$

Where P_h = Probability of occurrence of flood event
P_e = Probability of exposure to hazard if event occurs
P_d = Probability of death if exposed to hazard.

The probability of occurrence of a flood event is based on flood frequency analysis, the probability of exposure to hazard is based on whether the resident is home at the time of the event (assumed to be 50 percent chance in this study), and the probability of death if exposed to hazard is a function of the severity of the flood event (at the resident's location) and the degree of warning provided to the resident. These factors are subjective and values associated with them are based on engineering judgment.

Based on analysis of statistics, Morgan (1989) proposed that the threshold between acceptable and unacceptable risks in North America is about 1 in 10,000 on an annual basis. This annual risk value is equivalent to a probability of 1 percent that at least one death will occur in a 100-year period. Thus, in Table 3-6, No Action and Storage Schemes 1 and 2 do not provide adequate protection based on this criterion, Storage Scheme 3 and Diversion Schemes 1 and 2 provide protection that do meet this criterion, and Storage Scheme 2a is on the borderline.

Based on acceptable benefit-cost ratio and probability-of-death, Northwest Hydraulic Consultants recommended Storage Scheme 2a.

Canyon B Flood Control Project

Several actions recommended in the 1989 report were implemented by the County in 1990. The project included construction of the following features:

- French drains and drainage diversion pipes within Canyon B to stabilize active slide areas, including:
  - Two drain systems, consisting of a berm, grated inlet, and 12-inch flexible drain pipe, to intercept small drainage channels. One channel is located below the Fancher Field area and the other is on the north side of the canyon above a large unstable slide area.
  - A french drain system that intercepts shallow groundwater above the large unstable slide area.
  - Excavation of slide deposition material within the stream channel.

- A 10,000 cubic yard debris basin at the mouth of the canyon, to detain and settle out coarse sediments. A 48-inch CMP culvert through a low berm forms the outlet of the basin. The basin is designed to trap sediments only. There is no designed detention or storage capacity for water.

- A shotcrete-lined trapezoidal channel leading from the basin, alongside Glendale Street, to just above Highway 28. Average dimensions of the channel include: a 5-foot bottom width, a 3-foot shotcreted depth, an additional 1 foot of freeboard (dirt), and a 1:1 side slope. The average slope is 1.4 percent.

The system is designed for a 25-year flood. The reconstruction of Glendale Street is unusual in that the street was constructed with a sag (rather than with a crown) to allow the road to act as a floodway when the capacity of the canal is exceeded, thereby reducing the threat of flooding to adjacent property.

The original design called for a 48-inch culvert to convey flows under the highway and irrigation canal to the orchard below. However, a construction easement for the orchard property could not be obtained from the owner and the project stopped just above the highway. The County plans to eventually extend the project to the Columbia River when the necessary easements are secured.

URBAN STORM DRAINAGE

Comprehensive Storm Drainage Plan - 1973

This storm drainage report, prepared by Futrell Consulting Engineers of Wenatchee, investigated the feasibility of a storm drainage system within the urban area and a flood control and regulating system to reduce the rate of runoff entering the urban area from above (Futrell 1973). The report updated the 1969 *Comprehensive Storm Drainage Plan for East Wenatchee Urbanizing Area* (Munson-Nash-Futrell 1969). Events between 1969 and 1973 that prompted the update included continued urbanization and increased awareness of potential flooding problems brought about by the June 1972 flood.

Assumptions

Runoff from the 1,570 acre (2.5 square mile) upper drainage area was based on a 50-year design storm. A peak flow of 367 cfs was calculated using the Rational Method. Design of the storm drainage system was based on a 10-year design storm. Precipitation depths and durations were obtained from the Washington Department of Transportation Hydraulics Manual (WSDOT 1972). Hydrology and hydraulics of the closed drainage system were analyzed using a computer program for storm sewers developed by the Washington State Department of Highways, which used the Rational Method for calculating runoff.

Proposed Facilities

The Comprehensive Storm Drainage Plan combined flood control and regulating structures with a storm drainage system to control flooding in the East Wenatchee urban area.

Flood Control and Regulating System

The flood control and regulating system would affect the area between 15th Street on the north and Grant Road on the south, and east of Kentucky Avenue. Features include the following:

- **Diversion Channel.** An open channel would follow the contour of the hill to the northeast of 10th Street and Kentucky Avenue to intercept flow from drainages and ravines.
- **Regulating Reservoir.** The diversion channel would direct flow to a regulating reservoir created by a 50-foot high earth-filled dam near Mary Avenue and 3rd Street. The reservoir was sized for a 50-year storm. Maximum discharge from the reservoir would be 100 cfs.
- **Channel and Pipe Drainage.** Regulated discharges from the reservoir would flow through a series of channels and pipes generally paralleling Grant Road on the north and running to the Columbia River. This trunk system would also intercept storm drainage flows.

Costs for the diversion channel and regulating system were not given. The cost of the trunk line along Grant Avenue was given as $430,000 (1973 cost).

Storm Drainage System

Storm drain trunk lines were designed for the following areas: Grant Avenue, Lyle Avenue North and South, Kentucky Avenue North and South, James Avenue North and South, Georgia Avenue North and South, Main Street, Rock Island Road, 9th Street, 15th Street, and Rimrock Road. Costs were estimated only for the Grant Road collection system ($653,000).

Reconnaissance Level Storm Drainage Plan - 1977

The purpose of this study was to design a "representative" storm drainage system for the entire East Wenatchee urban area and to develop order-of-magnitude costs for such a system (CH2M Hill 1977). This study only considered runoff from the developed urban areas, not runoff that originates from the agricultural land above the urban area.

Assumptions

The urban storm drainage system was analyzed using CH2M Hill's STORM computer model. This model uses the Rational Method to determine runoff amounts, hydraulic equations to estimate pipe sizes, and unit cost curves to calculate costs of system components. System components and costs were developed for the 10-year, 25-year, and 100-year design storms. Separate analyses were performed for drainage systems that can serve current (1977) development only, and for a system that can serve projected future development.

Proposed Facilities

Figure 3-5 shows the primary drainage system components proposed by CH2M Hill. The total area covered by the study was 2,360 acres. (Not all collection system lines are shown on this figure.) Preliminary designs of storm drainage systems were developed for the following areas: 13th Street, 9th Street, 5th Street, 3rd Street, 1st Street, Iowa Avenue, and Kentucky Avenue.

Costs for each of the seven systems are summarized in Table 3-7. For a system that could serve future development under a 100-year design storm, total costs were estimated at $22,878,000 (1977 cost). Reducing the design storm to a 10-year event reduced costs to $16,680,000.

TABLE 3-7.
SUMMARY OF COSTS FOR 1977 PROPOSED
STORM DRAINAGE SYSTEM

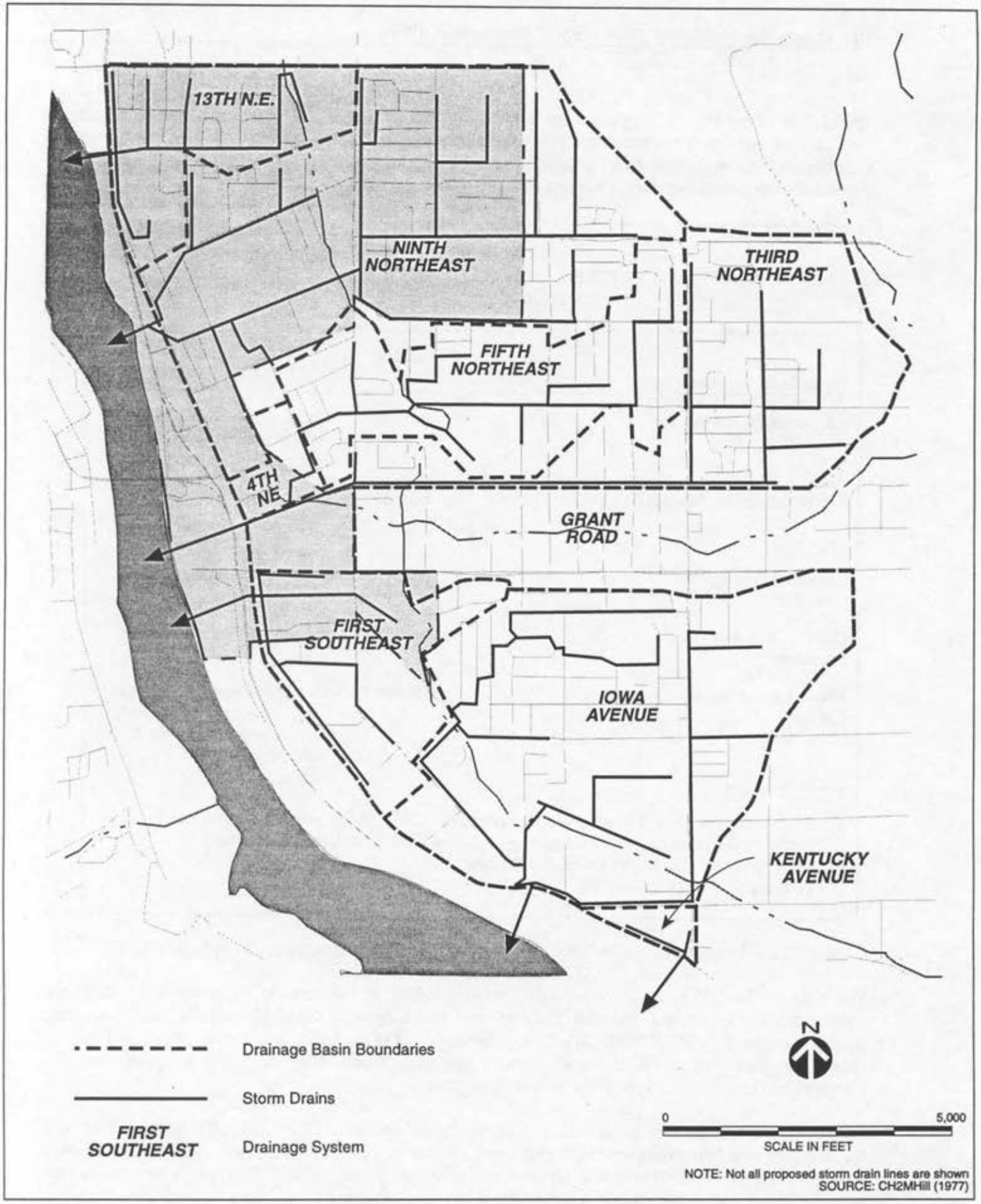
Subbasin	Cost at Full Development	Cost at Current Development
100-Year Design Storm		
13th Street Northeast	$1,639,000	$1,224,000
9th Street Northeast	5,779,000	4,253,000
5th Street Northeast	3,434,000	3,434,000
3rd Street Northeast	4,445,000	3,950,000
1st Street Southeast	1,474,000	1,362,000
Iowa Street	6,032,000	4,877,000
Kentucky Avenue	75,000	0
Total	$22,878,000	$19,100,000
25-Year Design Storm, Total	$18,495,000	—[a]
10-Year Design Storm, Total	$16,680,000	—[a]

Source: CH2M Hill (1977). 1977 costs basis.

a. Not estimated.

Douglas County Six-Year Transportation Improvement Program - 1992

The Douglas County Six-Year Transportation Improvement Program identifies and prioritizes the street and arterial projects that the County will attempt to fund and construct during the period 1993-1998. Many of these projects include additions or extensions of storm drainage systems, and two include acquisition of drainage corridors for Canyon A and Canyon B. Six-year transportation plans are required by State law and are submitted to the State Secretary of Transportation and the State Transportation Improvement Board. The County adopted the current program in June 1992.



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 3-5. PROPOSED STORM DRAINAGE SYSTEM

Table 3-8 identifies transportation improvement projects that include storm drainage facilities or road improvements along the Canyon A drainage corridor. This information will be used in the analysis of alternatives for storm drainage and Canyon A to ensure that proposals are consistent with current County planning efforts.

TABLE 3-8.
DOUGLAS COUNTY SIX-YEAR TRANSPORTATION IMPROVEMENT PROGRAM ELEMENTS

Project and Location[a]	Priority[b]	Funding Status[c]	Description
4th Street SE Extension	3	Funded	Construct new road alignment with storm drainage from Highway 28 to Pace Drive.
Badger Mountain Road RID	13	Funded	Reconstruct road with improved drainage from 19th Street to Fancher Heights
Canyon B Stormwater Corridor	16	Proposed	Purchase easements and construct drainage corridor.
Canyon A Stormwater Corridor	17	Proposed	Purchase required right of way.
Kentucky Avenue Extension Corridor	20	Proposed	Purchase required right of way. This proposed street crosses several Canyon A subdrainages.

a. 1993-1997 Six-Year Transportation Program. Only those projects that include storm drainage facilities or impact Canyon A, Canyon B, or Sand Canyon are listed
b. Priority out of 20 projects submitted to State.
c. Funding status as of June 1992.

City of East Wenatchee Six-Year Transportation Improvement Program - 1992

The City of East Wenatchee Six-Year Transportation Improvement Program identifies and prioritizes the street and arterial projects that the City will attempt to fund and construct during the period 1993-1998. Many of these projects include additions or extensions of storm drainage systems, or will impact regional flood control facilities proposed for Canyon A. The City adopted the current program in July 1992.

Table 3-9 identifies transportation improvement projects that include storm drainage facilities or road improvements along the Canyon A drainage corridor. This information will be used in the analysis of alternatives for storm drainage and Canyon A to ensure that proposals are consistent with current City planning efforts.

TABLE 3-9.
CITY OF EAST WENATCHEE SIX-YEAR TRANSPORTATION IMPROVEMENT PROGRAM ELEMENTS

Project and Location[a]	Priority[b]	Funding Status[c]	Description
11th Street - Baker Avenue to Eastmont Avenue	3	Funded	Extend existing storm drain from 11th Street and tie into Baker Avenue system.
Valley Mall Parkway - 4th Street to Grant Road	6	Funding unknown	Widen street, add curb/gutter/sidewalks, and improve storm drains. This street crosses the Canyon A corridor.
Third Street - Valley Mall Parkway to Eastmont Avenue	8	Funding unknown	Widen street, add curb/gutter/sidewalks, and install storm drains that tie into Valley Mall Parkway system. This street crosses the Canyon A corridor.
Ninth Street - Baker Avenue to Eastmont Avenue	9	Funding unknown	Grading, paving, and drainage facilities.
8th and 9th Street Corridor	10	Funding unknown	Widen street, add curb/gutter/sidewalks, and install storm drains.
Baker Avenue Extension - 5th Street to 3rd Street	13	Funding unknown	Construct new street, add curb/gutter/sidewalks, and install storm drains that tie into existing Baker Avenue system.
13th Street - Baker Avenue to Devon Avenue	14	Funding unknown	Widen street, pave, and add curb/gutter/sidewalks.
Baker Avenue - 3rd Street to 9th Street	16	Funding unknown	Construct new street, add curb/gutter/sidewalks, and install storm drains that tie into existing Baker Avenue system.

a. 1993-1998 Six-Year Transportation Program. Only those projects that include storm drainage facilities or impact Canyon A are listed
b. Priority out of 17 projects submitted to State.
c. Funding status as of July 1992.

THE PALISADES AREA OF MOSES COULEE

Although Douglas Creek near Palisades has experienced long-term flooding and erosion problems, no studies have been performed specifically to address them. In 1982 and 1989, Douglas County requested assistance from the Corps of Engineers to study the problems, but the project area did not qualify for emergency funding. The Corps and other agencies have been involved in various site reconnaissances following floods (see Hazard Mitigation Survey Report - 1989, below) and Moses Coulee was included in the Flood Insurance Study (see Flood Insurance Study for Douglas County - 1991, below).

Repairs after 1989 Flood

The March 1989 flood caused considerable damage to the Palisades Road between mile posts 1.98 and 14.3. Most of the damage occurred just above the community, between miles 12.0 and 13.3, where Douglas Creek caused extensive erosion of the shoulder up to the roadway's edge. To obtain grant money to repair the damages, the County came up with three repair alternatives and presented them to a public meeting held in Palisades on April 4, 1990. The alternatives included the following:

- Armor the channel bank; restore the shoulder and pavement (cost: $300,000)
- Relocate the road 30 feet to move it away from the creek and raise the roadbed in certain areas (cost: $356,000)
- Realign the roadway to the other side of the valley over a 2.4 mile stretch (cost: up to $900,000)

Most of the citizens at the meeting preferred the first alternative. Raising the roadbed caused concern about additional flood impacts, and the realigned road was perceived as too expensive. The County proceeded with restoration of the existing roadway alignment. The cost of repairs was covered mostly by state and federal emergency grant funds.

JAMESON LAKE

Although the level of Jameson Lake has been steadily rising for at least 65 years, it was not until the early 1980s that local residents became concerned. The road near Jack's Resort has required raising twice before 1989 due to flooding. In 1989, a dramatic runoff event caused substantial rise in the lake level. During this flood the access to the south end of the lake was washed out and roads and other facilities along the lake were damaged. A temporary detour was constructed in late 1989. Permanent repair, completed in 1990, consisted of an elevated roadbed, a culvert outlet leading to an old irrigation ditch, and two stream fords near State Route 2.

During this time County and state officials became aware of the flooding situation. J.W. Wittig, a long-time resident of Jameson Lake, provided historical documentation of the lake level. Although most were in agreement that a normal lake level should be set at an elevation of no more than 10 feet below the existing outlet elevation to provide adequate storage capacity for winter runoff events and protect lake side facilities, no agreement was formalized and no studies were made to determine the feasibility or cost of constructing a low level outlet.

FLOOD INSURANCE AND DISASTER REPORTS

Flood Insurance Study for Douglas County - 1981

The Douglas County Flood Insurance Study (FIS) was originally published in 1978 by the Federal Emergency Management Agency (FEMA) and was updated in 1981. Preparation of the study was coordinated between the private contractor, FEMA, Douglas County, COE, DNR, SCS, WSDOT, USGS, and Ecology. The Douglas County FIS covers all unincorporated areas of the County. Excluded are the incorporated towns of East Wenatchee, Bridgeport, Mansfield, Rock Island, and Waterville. Separate studies were prepared for East Wenatchee and Bridgeport.

The National Flood Insurance Program (NFIP) is a Federal program established in 1968 and administered through FEMA that allows property owners to purchase federally backed flood insurance. In return for insurance protection, participating communities are required to implement floodplain management measures to reduce flood risks in new developments. The purpose of a Flood Insurance Study (FIS) is to develop flood risk data and mapping for flood insurance rating and floodplain management purposes.

Currently, Douglas County and the cities of East Wenatchee and Bridgeport participate in the NFIP. Table 3-10 summarizes coverages, insurance premiums, and claims for the period 1978-1993. The number of policies does not indicate the actual number of structures at risk of flood damage.

TABLE 3-10.
NATIONAL FLOOD INSURANCE PROGRAM COVERAGES,
PREMIUMS, AND CLAIMS IN DOUGLAS COUNTY

Community	Date of Coverage	Policies	Annual Premium	Total Coverage	Total Claims	Dollars Paid Since 1978
Douglas County (unincorporated)	July 1978	29	$9,610	$1,852,000	2	$18,177
East Wenatchee	July 1985	2	789	124,000	0	0
Bridgeport	June 1985	1	281	147,000	0	0

Data for 1978-1993. Includes direct and write-your-own coverages.
Source: FEMA. WYO and Direct Data by Community with County and State as of April 30, 1994.

Hydrology

The 100-year flows for the East Wenatchee area canyons were estimated from a logarithmic regression relationship between peak flow and drainage area using regional stream gauge data. For Douglas Creek at Douglas, published regression equations (USGS 1975) were used to develop the flow estimates. For Douglas Creek at Palisades, the COE used Columbia

Basin stream data and graphical regression analysis between flow and drainage area to develop 100-year flood flows. The calculated discharges are summarized in Table 3-11.

TABLE 3-11.
FLOOD INSURANCE STUDY
100-YEAR FLOOD DISCHARGES
FOR DOUGLAS COUNTY LOCATIONS

Drainage	Basin Area (sq. mi.)	100-Year Discharge (cfs)
Sand Canyon	4.16	946
Canyon A	4.94	1,040
Canyon B	2.58	700
Douglas Creek at Douglas	70	3,300
Douglas Creek at Palisades	835	17,700

Source: FEMA 1981

Floodplain Hydraulic Modeling

Flood elevations in Moses Coulee in the Palisades area, Douglas Creek at Douglas, and Kummer Draw were determined using the HEC-2 hydraulic program. A previous unpublished study by the Corps of Engineers (unpublished and unavailable) was incorporated into the FIS and expanded slightly to cover a larger area. Surveyed cross-sections and the 100-year flow estimates were used to determine water surface elevations. In the Palisades area, a total of 69 cross-sections extending over approximately 20 miles were used in the analysis, beginning a few miles upstream of the Columbia River and ending a few miles upstream of Palisades. Delineation of the 100-year floodplain was interpolated from 1:24,000-scale maps with contour intervals of 20 feet. Flood profiles for the 100-year flood in this reach are published in the FIS. The locations of the surveyed cross-sections are shown on the flood boundary and floodway maps (see below).

The remaining areas of Douglas County, including East Wenatchee, were modeled using unspecified approximate methods to develop flood elevations. Flood channel cross-sections were not used in these analyses.

Flood Insurance Rate Maps

Analyses described in the Flood Insurance Study (FIS) are used by FEMA to prepare Flood Insurance Rate Maps (FIRM) that identify "special flood hazard areas" within Douglas County. Special flood hazard areas are areas subject to inundation by the 100-year flood. Different types of flood hazard areas, or zones, are identified on the FIRMs based on the location of the 100-year floodplain and the type of analysis used in the FIS to determined the

predicted water elevations during the 100-year flood. Flood hazard zones are also used to determine insurance rates.

FIRMs cover all of Douglas County, with the exception of the incorporated areas. Although an FIS was not prepared for East Wenatchee, a FIRM was prepared subsequent to the Douglas County study (FEMA 1985).

Flood hazard zones within Douglas County are summarized in Table 3-12.

TABLE 3-12.
FLOOD INSURANCE FLOOD HAZARD ZONES
IN DOUGLAS COUNTY

Location	Zone	Coverage
East Wenatchee	A	Shoreline areas of the Columbia River subject to inundation due to flood reservoir operation at Rock Island Dam.
	AO	Canyon A: a 200- to 300-foot corridor along the Canyon A drainage pathway, beginning in the tributaries below 10th Street and extending to the Wenatchee Valley Mall.
		Sand Canyon: a 100- to 200-foot corridor along the Sand Canyon drainage pathway, beginning 1/2 mile above Eastmont Avenue and extending to the Columbia River
		Canyon B: a 100- to 200-foot corridor along the Canyon B drainage pathway, beginning 3/4 mile above SR 28 and extending to the Columbia River and the alluvial fan from Vine Street to 30th Street.
	B	All areas west of Badger Mountain not included in Zone AO or Zone B.
Moses Coulee	A1-A30	The Moses Coulee valley of Douglas Creek, extending in width from a few hundred feet to a few thousand feet. Alluvial fans emanating from tributary of Moses Coulee are excluded from this zone
	A	Alluvial fans emanating from tributaries of Moses Coulee
		Douglas Creek from the Columbia River and extending upstream for approximately 2 miles.
	C	All areas beyond the Moses Coulee floodplain as defined above.

Source: FEMA (1981). Excludes City of Bridgeport.

Flood hazard zones are defined as follows:

- Zone A. Areas of the 100-year flood where base (100-year) flood elevations and flood hazard factors were not determined. Mandatory flood insurance purchase requirements apply in this zone.

- Zones A6, A7, A8, A11, A14, and A17. Areas of the 100-year flood under various depths of flooding, with base flood elevations and flood hazard factors determined. Mandatory flood insurance purchase requirements apply in this zone.

- Zone AO. Areas of 100-year shallow flooding with depths from 1 to 3 feet, and the product of flood depth (feet) and velocity (feet per second) less than 15. Mandatory flood insurance purchase requirements apply in this zone.

- Zone B. Areas between the limits of the 100-year flood and the 500-year flood, or areas of the 100-year shallow flooding with depth less than 1 foot. Flood insurance is available but not mandatory in this zone.

- Zone C. Areas of minimal flooding. Flood insurance is available but not mandatory in this zone.

Flood Boundary and Floodway Maps

Flood boundary and floodway maps, like FIRMs, show 100-year flood boundaries. They also show the floodway. A floodway includes the channel of the stream and the adjacent floodplain that must be reserved in an unobstructed condition in order to discharge the 100-year flood without increasing flood levels by more than one foot (or by less than one foot if specified in local ordinances). FEMA requires the community to designate the floodway to avoid the possibility of significantly increasing upstream flood elevations. To maintain insurance coverage, a community must prohibit development within the designated floodway that would cause any additional rise in the 100-year flood elevation.

In Douglas County, floodway boundaries and elevations were calculated only for the 20-mile reach of Douglas Creek from near the Columbia River to above Palisades. No floodways were calculated for alluvial fan and shallow flooding areas, which include the East Wenatchee area.

Hazard Mitigation Survey Report - 1989

As a result of flooding and other storm-related problems stemming from the March 10-11, 1989 storm, Douglas County and three other Eastern Washington counties were declared National Disaster Areas under Public Law 93-288 on April 14, 1989. Section 409 of Public Law 93-288 requires that a Hazard Mitigation Survey Report be prepared following the declaration to identify ways to reduce future losses in a similar event. A Hazard Mitigation Survey Team was formed by the Washington State Division of Emergency Management (DEM) to prepare the report and was composed of officials from Federal (FEMA and SCS), State (DEM, DNR, WSDOT, Ecology, and Wildlife), and local (Douglas County, City of East Wenatchee, City of Bridgeport, and Wenatchee Reclamation District) jurisdictions (DEM 1989).

The Hazard Mitigation Survey Report provides an overview of the 1989 storm, a summary of damages, and a series of specific mitigation recommendations. Potential funding sources for each recommendation are also identified. These recommendations identify specific flood control and management actions that are designed to prevent or minimize future flood damage. However, the recommendations focus only on problems experienced during the 1989 flood. The recommendations are to be used by local governments during the period immediately following the flood to guide flood damage repairs and in the future to identify long-term flood management objectives.

The following recommendations were formulated by the Survey Team:

- Control debris flow and related drainage though the Canyon B/Glendale area.
- Identify drainage corridors within the urbanized City and County areas.
- Prepare a Comprehensive Flood Plain Management Plan for the City of Bridgeport.
- Restore the Foster Creek Bridge and County roads in the Foster Creek area.
- Elevate and relocate portions of the road in the Palisades area.
- Relocate a portion of the Jameson Lake Road.
- Conduct flood preparedness and warning training.
- Develop design guidelines for subdivision regulation.

Specific problems and recommendations for areas in East Wenatchee, Moses Coulee, and the Palisades are described below. Many of these recommendations apply directly to other areas in East Wenatchee that experienced severe flooding in the past (such as Sand Canyon and Canyon A) but did not experience major flooding during the 1989 storm.

Control Debris Flow and Related Drainage through the Canyon B/Glendale Area

Floodwaters and debris flows from Canyon B flood an alluvial fan where a residential neighborhood of approximately 35 homes is located. Drainage from the canyon continues downslope, where it damages culverts and drainage systems, plugs the Wenatchee Reclamation District canal, and floods and damages SR 28 (Sunset Highway). Major erosion and sedimentation has resulted from storms with a return frequency of 2 to 4 years. Conventional drainage pipe systems are incapable of handling mass wasting and high velocity transport of eroded sediments. The following recommendations were identified for various locations of the Canyon B drainage area:

- Improve drainage within the developed areas of the alluvial fan, taking into consideration the problems that sedimentation causes in drainage systems.

- Develop a debris and water management plan for upper Canyon B and the alluvial fan toe (the area immediately below the Glendale development). For the upper canyon, the plan should address sediment management, including erosion control, slope stabilization, check dams, and debris basins. In the fan toe, measures to protect SR 28 and the irrigation canal should be identified. (Note: some of these measures were implemented in 1990 by Douglas County as described under Canyon B, Investigation of Flooding and Sedimentation Hazards - 1990.)

- Drainage from Canyon B currently flows along a marginally defined swale through orchards that lead to the Columbia River. These orchards are under pressure for development. The floodplain for this swale should be defined, mapped on revised FEMA maps, and protected as a floodway by the Flood Damage Prevention Ordinance.

Identify Drainage Corridors within the Urbanized City and County Areas

Localized flooding occurs throughout the urbanized City and Douglas County areas, causing damage to roads and private property. Damage is typically caused by debris flow and erosion of street shoulders. The following recommendations were identified:

- Numerous site-specific measures should be implemented, such as installation of roadside ditches, culverts, catchbasins, and drainage pipelines, and armoring of drainage ditches on slopes greater than 3 percent and around culvert discharge ends.

- A Comprehensive Stormwater Management Plan for the East Wenatchee area of Douglas County should be adopted and implemented. Several previous studies were prepared to address this issue and the County should identify the most appropriate and effective portions of these plans.

Elevate and Relocate Portions of the Road in the Palisades Area

The Moses Coulee Road through the Palisades area is in the floodway and was overtopped and severely damaged in several locations during the March 1989 flood. Approximately 1-1/2 to 2 miles of the road are directly adjacent to Douglas Creek, and another 10 miles were affected. Twenty-eight families were isolated for a week as a result of the flood damage. Recommendations for the road include:

- Elevate the roadway in several areas.

- Relocate portions of the road away from Douglas Creek.

- Review and construct cross drainage, flaps, etc.

- Revise the FEMA floodway map to reflect the road changes.

Reconstruction of the Palisades Road to repair damages from the 1989 flood was included in the County's six-year road plan that was approved by county commissioners in 1990

(Wenatchee World June 27, 1990). Restoration of the roadway to its original condition was completed in 1991.

Relocate a Portion of the Jameson Lake Road

Continual rise in the Jameson Lake water level is caused by subterranean flow, stormwater drainage, and the lack of a lake outlet. This has resulted in water covering and undermining the Jameson Lake Road and the Washington Department of Wildlife road closest to the lake. This lake is a popular fishing and recreation location. Flooding caused a 25-30 percent drop in fisherman attendance during the 1989 opening day weekend. This drop had a drastic economic impact on Douglas County. The Department of Wildlife estimated that over $630,000 in revenue was lost to the County. Installation of a lake outlet was discussed as a possible solution, but was not considered feasible because it might aggravate flooding downstream in the Douglas Creek drainage. The following recommendation was identified:

- Relocate the Jameson Lake Road to a higher area beginning approximately 1-1/2 miles from the lake.

Reconstruction of the Jameson Lake Road to repair damages from the 1989 flood was included in the County's six-year road plan that was approved by county commissioners in 1990 (Wenatchee World June 27, 1990). Construction was completed in 1991.

Conduct Flood Preparedness and Warning Training

The Survey Team recognized that many rural communities are unfamiliar with the concepts and techniques of flood preparedness and warning. Basic training and assistance related to warning and preparedness and the specific techniques of organizing and conducting floodfights would be most helpful. The following recommendation was identified:

- Conduct a 1-1/2 day workshop/training related to flood warning, preparedness, and floodfight techniques. A private consultant to the COE was available to conduct a 6-hour workshop on flood warning and preparedness for rural, Eastern Washington communities, and the COE would conduct a 4-6 hour session on sandbagging techniques and the organization and implementation a floodfight.

Develop Design Guidelines for Subdivision Regulation

Douglas County in 1989 did not have subdivision guidelines that address flood-proofing to a 50-year or greater event. The Survey Team recommended that the existing subdivision regulations be amended to address flood proofing of all new subdivisions to mitigate damages. The change to the regulations will add disaster flooding as a design consideration to all areas. The recommended alternatives include, but are not limited to, the following:

- Flood-proofing
- Home orientation

- **Street alignment for street access**
- **Floodway open spaces**
- **Streets for overflow corridors**
- **Overflow routes from on-site retention areas.**

CHAPTER 4.
FLOODING HISTORY AND PROBLEM AREAS

Floods in Douglas County result mostly from extreme events of short duration, or flash floods. Two distinct climatological patterns can cause flash floods: summer thunderstorms and rain-on-snow. Thunderstorms occur primarily during the summer months and can have very high rainfall intensities over relatively small areas. Rain-on-snow occurs in late winter or spring and usually has smaller amounts of precipitation. However, they are normally associated with frozen ground, which limits infiltration into the soil and therefore causes more runoff for a given amount of precipitation or snowmelt. Floods can also be caused from rainfall over long periods, as occurs during frontal storms, or from snowmelt alone when warm temperatures abruptly follow a cold and snowy period, but these are less common.

The magnitude of a flood is affected by drainage basin size. Runoff response varies by basin size because of the relationship between storm duration and the time it takes for runoff to reach the basin outlet (i.e., the time of concentration). In general, very short but intense storms can generate large amounts of runoff (relative to basin size) in a small basin, in comparison to a large basin. A previous review by FEMA of stream flooding patterns in the Columbia Plateau characterized the relationship between drainage basin and storm type as follows (Weber, J., 1978, personal communication):

- For small drainage basins (less than 25 square miles), the highest peak flows occur primarily from thunderstorms.
- For intermediate drainage basins (between 25 and 400 square miles), the highest peak flows occur primarily from regionalized frontal rainstorms.
- For large drainage basins (greater than 400 square miles), the highest peak flows occur primarily from regionalized frontal rainstorms combined with snowmelt.

Flooding problems in the East Wenatchee area are compounded by soil erosion and sedimentation. Soils in the area are composed primarily of fine sand that is easily eroded, particularly on the steep, barren slopes that are common in the East Wenatchee area. In undisturbed areas, erosion problems are relatively rare because little water runs off the highly permeable soils. The natural vegetative cover helps strengthen the soil surface and prevents erosion. However, streets and other impermeable surfaces can easily produce large volumes of runoff that rapidly erode bare soil along road margins (few roads in the East Wenatchee area have curbs and gutters). In addition, large amounts of runoff and sediment can be produced from the bare soils in agricultural areas immediately above East Wenatchee, causing severe damage from drainage into the urban area.

HISTORICAL PRECIPITATION

Precipitation records for the Wenatchee area show that the greatest 24-hour precipitation events occur during the summer months of June and August, even though the winter

months have the highest accumulations of total precipitation (Table 4-1) and the greatest frequency of storm events (Table 4-2). Thus, infrequent summer thunderstorms have the potential to generate much higher rainfall intensities and runoff than do winter frontal-type storms. Runoff caused by snowmelt varies with a combination of climatological conditions, so the magnitude and frequency of these events cannot be predicted.

24-Hour Storms

Table 4-1 lists the highest recorded 24-hour precipitation depths for each of three precipitation gages in the greater Wenatchee area. These three gages, which cover various periods of record between 1930 and 1990, give a wide spatial coverage of the region. These data show that precipitation amounts from the same storm can vary widely between the gage locations.

The greatest 24-hour precipitation amounts occurred during rainfall events in August and June but not in July, probably because climatic conditions favoring thunderstorm development do not occur in July.

Precipitation depths for storms at Pangborn Field were considerably lower than at the two Wenatchee stations, indicating that portions of the East Wenatchee area (i.e., the Canyon A area) probably receive less rainfall than the immediate Wenatchee urban area. For example, the August 1975 storm rained 2.72 inches on Wenatchee, but only 1.51 inches on Pangborn Field. However, 24-hour precipitation records may not accurately record storms if the observation time occurs in the middle of the storm. Observations are taken at 8 AM at the Wenatchee station and at midnight at Pangborn Field. The 8 AM observations at Wenatchee probably recorded most or all of the duration of thunderstorms because these events typically occur late in the day or at night, whereas the midnight observations may truncate these storms. (Newspaper accounts often describe storm events that occurred during the late night.) Therefore, precipitation estimates at Pangborn Field may be artificially low because of data collection methods.

Storm Events of Less Than 24 Hours

Although 24-hour precipitation depths can indicate the frequency of major historic storm events, much shorter storms with total precipitation depths of less than one inch can also cause severe flooding. Many of the watersheds in the Badger Mountain foothills above East Wenatchee are particularly vulnerable to these short intense storms because these small basins can create a very rapid runoff. In these situations, the maximum rainfall intensity in a one- to two-hour period over a relatively small area will determine the magnitude of the runoff. Thus, many historic flooding events do not rank as major 24-hour precipitation events in Table 4-1.

Table 4-2 summarizes maximum precipitation at the Wenatchee Experimental Station for storms with durations of between 1 and 24 hours. The data were obtained from hourly precipitation records for a period ending in 1990. These data show that rainfall in Wenatchee is characterized by intense, short storms that deposit a majority of their rainfall

TABLE 4-1.
MAXIMUM HISTORICAL 24-HOUR PRECIPITATION DEPTHS

Pangborn Field (1960-1990)		Wenatchee (1930-1990)		Wenatchee Experimental Station (1948-1990)	
Date	Depth (inches)	Date	Depth (inches)	Date	Depth (inches)
18-Aug-75	1.51	18-Aug-75	2.72	18-Aug-75	2.06
18-Apr-67	1.43	10-Jun-72	2.04	10-Jun-72	1.87
22-Sep-84	1.36	7-Jun-36	1.79	25-Aug-56	1.78
24-Nov-65	1.32	26-Aug-56	1.73	10-Dec-87	1.77
10-Nov-83	1.27	23-Aug-65	1.69	9-Dec-71	1.54
9-Jun-72	1.26	3-Jun-36	1.50	21-Aug-90	1.49
13-Sep-80	1.13	11-Aug-52	1.43	23-Aug-65	1.46
1-Feb-60	1.12	10-Dec-87	1.38	23-Sep-84	1.42
9-Dec-87	1.12	24-Nov-83	1.30	27-Oct-56	1.40
		21-Jun-84	1.23	3-Feb-63	1.40
		23-Sep-34	1.17	16-Jan-56	1.31
		16-Jun-48	1.12	15-Jan-74	1.30
		3-Feb-63	1.10	10-Aug-52	1.29
		10-Nov-83	1.10	5-May-57	1.28
		24-Jan-46	1.09	26-Sep-48	1.27
		2-Feb-60	1.08	21-Jun-84	1.27
		9-Dec-33	1.06	9-Jan-90	1.27
		9-Dec-71	1.06	30-Aug-51	1.26
		15-Jan-74	1.05	24-Nov-83	1.25
		20-May-48	1.04	24-Nov-65	1.17
		25-Oct-34	1.03	22-Nov-61	1.14
		15-Jan-56	1.00	10-Nov-83	1.13
				22-Dec-64	1.09
				3-Dec-80	1.09
				19-May-81	1.08
				11-May-51	1.07
				18-Sep-86	1.07
				11-Dec-55	1.03
				20-Dec-48	1.00
				11-Jan-72	1.00

Data Source: EarthInfo (1992). Values of 1 inch or greater only are listed. Pangborn Field observations are taken at midnight, Wenatchee observations are taken at 8 a.m., and Wenatchee Experimental Station values were determined for individual storms using hourly rainfall data.

in a one- to two-hour period. The greatest one-hour precipitation at the Wenatchee Experimental Station of 1.25 inches, occurring in August 1952, is more than half the greatest 24-hour precipitation of 2.06 inches, occurring in August 1975. The June 1972 storm ranked second in many of these categories.

TABLE 4-2.
MAXIMUM RECORDED 1- TO 24-HOUR PRECIPITATION DEPTHS

Duration	Depth (inches)	Date
1-hour	1.25	Aug 10, 1952
2-hour	1.38	Aug 25, 1956
3-hour	1.57	Aug 25, 1956
6-hour	1.77	Aug 25, 1956
12-hour	2.02	Aug 18, 1975
24-hour	2.06	Aug 18, 1975

Source: Wenatchee Experimental Station (1948-1990).

Rain-On-Snow Events

Mid-winter storms have occasionally resulted in near-record precipitation depths, but precipitation intensities are normally low. Most of the winter precipitation events in Table 4-1 did not result in any appreciable runoff.

Because precipitation falls mainly as snow during the winter, runoff does not begin until temperatures rise. The resulting runoff magnitudes are typically low or moderate. As demonstrated by the March 1989 flood, large runoff volumes can result when rain-on-snow, warm Chinook winds, and frozen ground all occur during a single event. The amount of precipitation that fell during the 1989 flooding event (as recorded at the three weather stations) was relatively minor.

MAJOR HISTORICAL FLOODS

Major floods in Douglas County over the last 30 years are summarized in Table 4-3. Historical news photographs of damage caused by flooding are shown in Figure 4-1. Information in Table 4-3 was compiled from newspaper accounts of floods (Wenatchee World 1957, 1972, 1973, 1975, 1976, 1989) and other documents and reports (Lee Johnson 1974, SCS 1974, SCS 1983, DEM 1989, and Northwest Hydraulic Consultants 1990). The news photos were provided by the Wenatchee World. These floods are representative of the particularly damaging floods that occur at a frequency of about every 10 years in the East Wenatchee and Moses Coulee/Palisades area. Localized flooding below some drainage areas in East Wenatchee may be as frequent as every 2 to 4 years (DEM 1989).

TABLE 4-3.
SUMMARY OF MAJOR FLOODS IN EAST WENATCHEE AREA
AND DOUGLAS COUNTY

Date	Location	Comments
1911-1948	Douglas Creek, Moses Coulee/Palisades	Significant floods. Corps of Engineers recorded 14 damaging floods in Moses Coulee between 1911 and 1948. The 1938 and 1948 floods were particularly severe.
March 18, 1957	Upper Douglas Creek and Moses Coulee	Significant snowmelt flood, the largest prior to the 1989.
May 5, 1957	East Wenatchee area	Significant flooding damaging 19th Street below Sand Canyon and in other unspecified areas below Badger Mountain canyons.
January 1960	Palisades area of Moses Coulee	Large flood.
June 9, 1972	East Wenatchee area	Thunderstorm caused extensive damage throughout urban area, including Kentucky Avenue, Grant Road (Canyon A), 5th Avenue, Sunset Avenue north of City (Canyon B), and Baker Street (Sand Canyon).
February 27, 1973	Moses Coulee/Palisades	Melting snow on frozen ground caused significant flooding, closing roads and flooding basements.
August 18, 1975	East Wenatchee area	Thunderstorm caused flooding along Kentucky Avenue and other areas below Badger Mountain, and mud slides over Sunset Highway near 15th Street.
August 6, 1976	East Wenatchee area	Thunderstorm caused flooding and damage from debris in Kentucky Avenue area and in older sections of Main Street (Valley Mall Pkwy).
July 18, 1987	East Wenatchee area	Thunderstorm caused flash flood and mudslides in Glendale neighborhood, flooded Sunset Highway, and caused localized urban flooding.
March 10-11, 1989	East Wenatchee area and Douglas County	Rain and melting snow on frozen ground caused damage throughout County, including East Wenatchee (most urban areas), Moses Coulee/Palisades, Jameson Lake, and many County roads. County declared Presidential Major Disaster Area.
August 6, 1991	East Wenatchee	Thunderstorm caused minor flooding, including Kentucky between 8th and 10th Avenue.
May 31, 1993	East Wenatchee	An intense thunderstorm caused flooding in the area between 8th Street and Canyon B.

JUNE 9, 1972—Deposition of sediment at 1430 8th Street residence. *(photo courtesy of The Wenatchee World)*

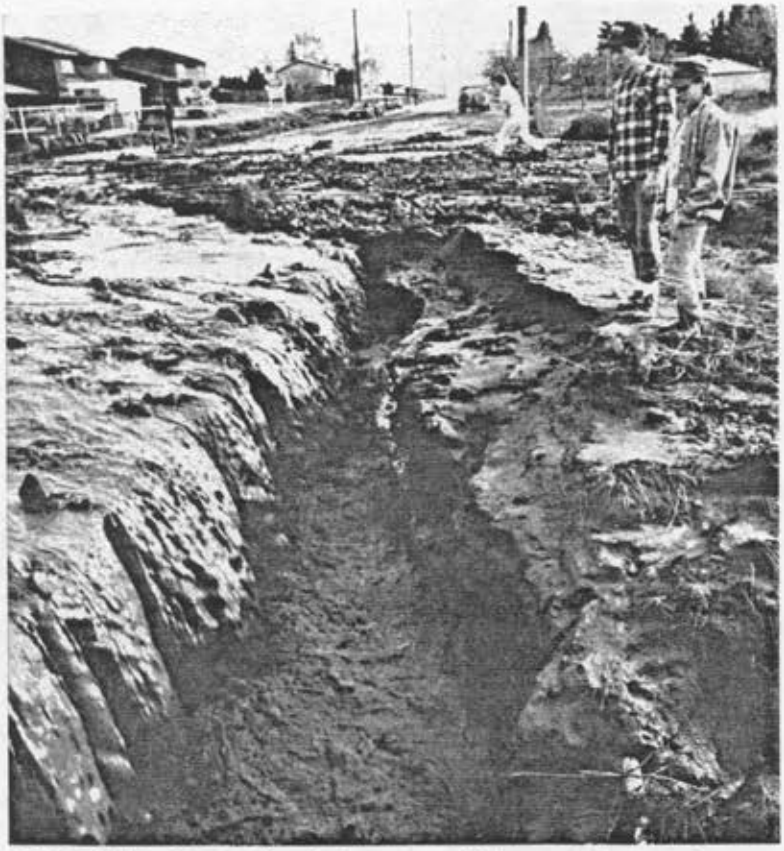
JUNE 9, 1972—Erosion along Lyle Avenue, north of 5th Street. *(photo courtesy of The Wenatchee World)*

KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-1a. DAMAGE FROM JUNE 1972 FLOOD

JUNE 9, 1972—Floodwaters that overtopped roadway at Baker Avenue and Sand Canyon cause erosion of fill. Note highly erodible fill material. *(photo courtesy of The Wenatchee World)*

AUGUST 6, 1976—Floodwaters in East Wenatchee City Park and City Hall. *(photo courtesy of The Wenatchee World)*

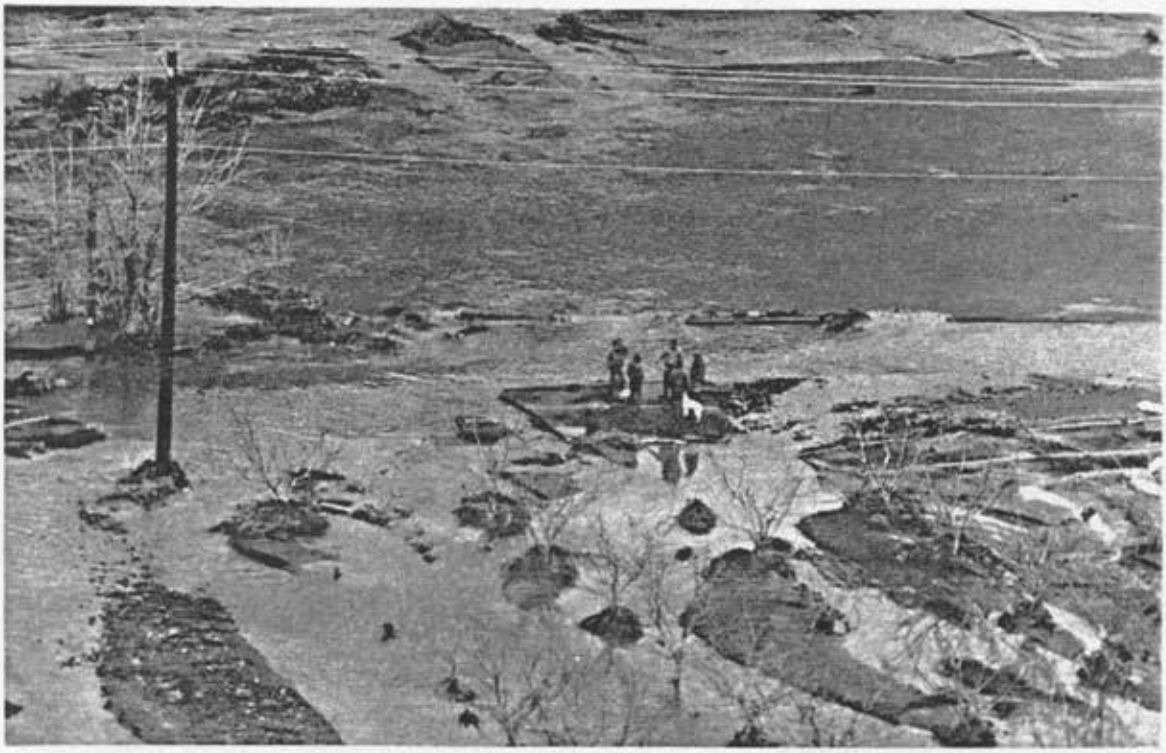
KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-1b. DAMAGE FROM 1972 AND 1976 FLOODS



MARCH 12, 1989—Flood damage to Highway 28 below Canyon B. *(photo courtesy of The Wenatchee World)*

MARCH 12, 1989—Resident at 15th Street and N. Fairmont helps control floodwaters. *(photo courtesy of The Wenatchee World)*

KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-1c. DAMAGE FROM MARCH 1989 FLOOD



MARCH 12, 1989—Douglas Creek flooding and road damage in Moses Coulee. *(photo courtesy of The Wenatchee World)*

AUGUST 6, 1991—Flood clean-up effort at 778 N. Kentucky. *(photo courtesy of The Wenatchee World)*

KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-1d. DAMAGE FROM 1989 AND 1991 FLOODS

Estimates of storm damage costs are summarized in Table 4-4. Only documented costs (from newspaper accounts and previous flood studies) are shown. Documentation of damage from other storms could not be located, and damage to residential property is often not reported.

TABLE 4-4.
DOCUMENTED STORM DAMAGE

Flood Event	Damage Type	Total Damage	Year of Estimate and Source
1957	Residential and other	Unknown	1957
	Irrigation Ditch	$4,200	(SCS 1974)
1959	Residential and other	Unknown	1959
	Irrigation Ditch	$10,700	(SCS 1974)
1972	Residential	777,000	1982
	Commercial	73,000	(SCS 1983)
	Public	81,000	
	Utility	62,000	
	Agriculture	98,000	
	Irrigation Ditch	18,000	
	Total	$1.1 million	
1976	Residential	36,000	1982
	Commercial	3,000	(SCS 1983)
	Public	22,000	
	Utility	1,000	
	Irrigation Ditch	3,000	
	Total	$65,000	
1979	Public	2,000	1982
	Agriculture	6,000	(SCS 1983)
	Irrigation Ditch	4,000	
	Total	$12,000	
1989	Total (Douglas County)	$1,700,000	1989 (DEM 1989)

May 5, 1957 Flood

This violent storm was accompanied by heavy rains and caused flooding throughout the Wenatchee and East Wenatchee area. Documentation of this storm is limited. However, it was reported that 19th Street became a torrent as runoff descended down Sand Canyon, creating a 10-foot-deep gully in the roadway. An East Wenatchee drug store was badly damaged and dozens of other businesses suffered mud damage. The only damage estimate for the storm is $4,234 in damage to the Wenatchee Reclamation District (SCS 1974). Floods

in March and April 1959 caused an additional $10,719 in damage to the District. No estimates of other damage were made although they may have been severe.

June 9, 1972 Flood

The 1972 flood is significant in East Wenatchee's history, not only because it was particularly severe, causing over $1 million in damage, but also because it initiated study and debate over reducing future flood damage. Following this flood, the Soil Conservation Service began a detailed analysis of flooding called the East Wenatchee Watershed Project. The study culminated in 1983 with the defeat of a bond issue that would have provided local funds to match federal grants for improvements to the drainage system.

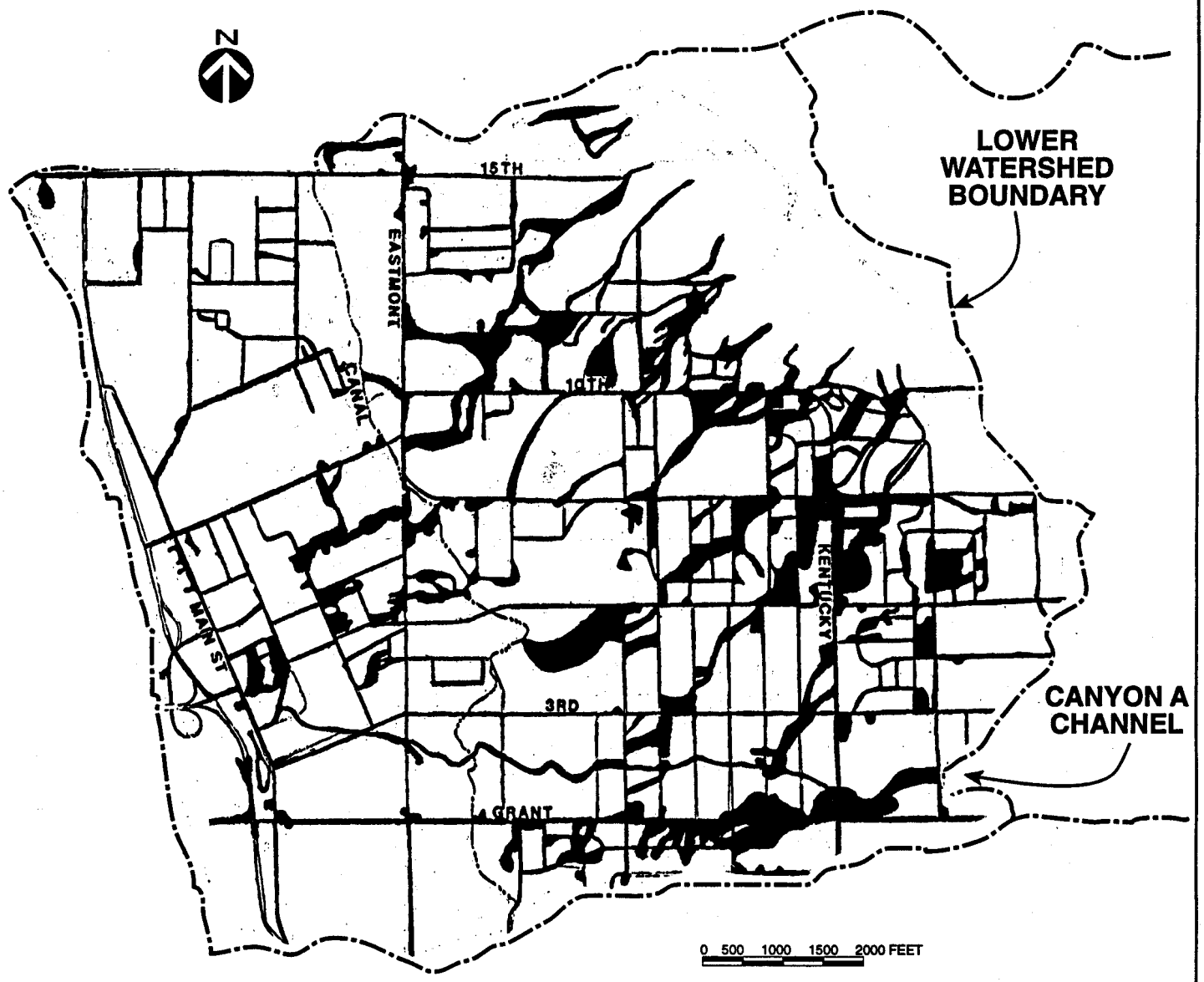
Over 350 homes suffered damage from this storm and approximately 165,000 tons of sediment was transported by surface runoff from the upper drainage areas to the lower watershed (SCS 1983), causing washouts, debris and sediment deposits, plugged culverts, and damaged roads. Damage to private property represented over 70 percent of the total storm damage. Most of this was to yards and not to structures (flood insurance covers only structural damage). Flood flows were generally less than 1 foot deep. The Wenatchee Reclamation Ditch, which bisects the urban area, collected much of the runoff and sediment.

This flood was caused by a thunderstorm (described as a cloudburst in newspaper accounts) that dumped 2.04 inches of rain during a 24-hour period (measured in Wenatchee), the second highest 24-hour precipitation in the 60-year history of the weather station. Precipitation was concentrated in the 10-hour period between 7:00 PM and 5:00 AM, when 1.57 inches of rain fell. The maximum 1-hour precipitation occurred between 8:00 and 9:00 PM and totaled 0.68 inches. The 24-hour precipitation at Pangborn Field was less, measuring 1.26 inches, but this measurement was truncated by the midnight observation time. A total of 1.68 inches was measured when the following day is included.. The rain was particularly heavy in the area bounded by Kentucky Avenue on the east, Sunset Highway on the west, Grant Road on the south, and 10th Street on the north.

A map prepared by the SCS showing areas of sediment deposition is shown in Figure 4-2. Runoff from gullies on the hillside just east of East Wenatchee, between 10th and 15th Streets, contributed greatly to urban flooding. Floodwaters from Canyon A itself also caused significant flooding along Grant Road. Floodwaters split into two separate pathways at Kentucky Avenue: one along the natural channel in the residential section between Kentucky Avenue and Eastmont Avenue, and one along Grant Road. Runoff eventually merged in the East Wenatchee city limits in the vicinity of the Wenatchee Valley Mall.

The following is a summary of damages, by locality, caused by this storm:

- East Wenatchee area, Kentucky and 10th Drainage: As with other storms, the heaviest damage was on North Kentucky from 8th Street to 10th Street, where very large volumes of water flowed through the area. Floodwaters originated in draws that drain agricultural areas located immediately above this neighborhood. Considerable damage occurred to homes and streets.



SOURCE: SCS (1993)

KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-2. URBAN AREAS BELOW CANYON A INUNDATED BY JUNE 1972 FLOOD

- East Wenatchee area, Canyon A: Grant Road became a fast-flowing floodway, with floodwater reaching 18 inches above the curbs.
- East Wenatchee area, Sand Canyon: The Baker Avenue fill washed out due to a plugged culvert, causing flooding of homes and street damage.
- East Wenatchee urban area: Floodwater flowed from the Eastmont Shopping Center down the 5th Avenue off-ramp from SR 28, closing the underpass under the Columbia River Bridge. Sunset Highway was blocked at several places between East Wenatchee and 35th Street. The business district was flooded by another flood flow in the area west of Valley Mall Parkway and south of 9th Street. The source of this water was probably urban area runoff combined with Canyon A flows.
- Crop and Orchard Lands: 2,000 acres of land were damaged, including 1,630 acres of dry cropland (500 acres of which had erosion exceeding 250 tons per acre and localized areas approaching 500 tons per acre) and 150 acres of irrigated cropland.

August 18, 1975 Flood

A steady rain that began in the morning and continued heavily through the afternoon caused flooding throughout the East Wenatchee area. A 24-hour total of 2.72 inches of rain was recorded during the storm, the highest in the 60-year history of the Wenatchee weather station, although only 1.51 inches fell at Pangborn Field, its highest ever. The maximum 1-hour precipitation, measured at the Wenatchee Experimental Station, was 0.54 inches, compared to 0.68 inches in the June 1972 flood. The following is a summary of damages caused by this storm:

- East Wenatchee area: A flash flood and mudslide covered Sunset Highway near 15th Street, resulting in 8 inches of debris accumulation. The source of water was a road leading up into the hills that was fed by several gullies (probably the small drainage areas between Sand Canyon and Canyon A).
- East Wenatchee area, Kentucky and 10th Drainage: Kentucky Avenue just north of 5th Street had 12 inches of flowing water which flooded yards and homes. Other areas were reportedly flooded, causing damage to businesses, homes, and churches.
- East Wenatchee urban area: Approaches to the East Wenatchee underpass of the Columbia River Bridge were under 4 feet of water. The source of this runoff was not reported.

August 6, 1976 Flood

Flooding during this storm was caused by a very intense thunderstorm that deposited 0.45 inches of rain over 2 hours and 1.03 inches over 24 hours. As in the June 1972 flood, the North Kentucky Avenue area and the older section of Valley Mall Parkway had the heaviest damage. The short but intense rainfall resulted in rapid runoff from small drainage basins, overwhelming the available drainage systems. The following is a summary of damages:

- East Wenatchee area, Kentucky and 10th Drainage: Kentucky Avenue between 5th and 10th Streets was covered with rocks and mud; homes and drainage systems were damaged.

- East Wenatchee area, urban areas: Runoff from the shopping center area flowed down Valley Mall Parkway and ponded in the East Wenatchee City Park. Drains plugged and sent backed-up water into businesses along the west side of the Parkway. Yards, basements, and carports were flooded elsewhere.

July 18, 1987

This evening's downpour from a thunderstorm was particularly intense, with "nearly an inch" of rain falling in about a 30-minute period in downtown Wenatchee (Wenatchee World 1987). Flash flooding occurred from the Wenatchee Valley Mall in East Wenatchee to downtown Wenatchee. In addition, the Glendale neighborhood was hit by major flooding from Canyon B, causing considerable damage.

The storm that damaged the Glendale area actually fell on the upper drainage of Canyon B, with little to no rain in Glendale. Flooding began at about 10:00 PM and lasted until 1:00 AM. Despite efforts by County crews to control flooding with sand bags and a backhoe, culverts and driveways were washed out.

The following is a summary of damages caused by this storm:

- East Wenatchee area, Canyon B: Drainage ditches along Glendale Street became plugged with sediments, causing flooding of homes and yards. Mudslides covered Sunset Highway at Glendale.

- East Wenatchee urban areas: The Wenatchee Valley Mall and other areas north of 5th Street experienced flash flooding.

March 10-14, 1989 Flood

The flood of March 1989, along with the flood of 1972, was among the most severe in recent history. As a result of damage caused by this storm, four counties in Eastern Washington—Douglas, Okanogan, Stevens, and Whitman—were declared National Disaster Areas on April 14, 1989 under Public Law 93-288 (DEM 1989). Douglas County experienced the greatest damage of the four counties, with total damage estimated at $1.7 million. This is equivalent to $70 per capita, or 29 percent of the combined City-County budget.

During February 1989, Eastern Washington experienced extremely cold weather, resulting in deep freezing of the ground. In late February and early March, snowfall occurred and the ground remained frozen. On approximately March 6, the snow turned to rain as a warming trend developed. Rain and warm temperatures (mid-40s to low 50s °F) continued, resulting in substantial melting of the snow cover. Meltwater surges occurred during the afternoon for several days. Flooding within East Wenatchee was most severe on March 10 and 11. Heavy rainfall during the night of March 10 contributed to the flooding. Despite a major effort by County crews using heavy equipment, drainage ditches along Glendale Street became filled with sediment, causing homes to flood and Sunset Highway to close. Glendale Street served as a floodway during the height of the flood.

The snowmelt runoff and freeze/thaw cycles associated with this event also created or activated a number of landslides in Canyon B (Northwest Hydraulic Consultants 1990). These landslides delivered colluvial material to the channel, which was transported downstream to the mouth of the canyon and the alluvial fan by floodwaters. Douglas County staff reported that 5,000 cubic yards of sediment was removed from Glendale Street, with debris up to 5 feet deep. Landslides in the canyon continued to occur during the months following the flood event. In 1990, the County instituted actions to control flooding and stabilization in and below Canyon B and stabilize landslides within the canyon. Four landslides in the canyon were dewatered using french drains, a debris basin was constructed at the mouth of the canyon to catch coarse debris, and the ditch along Glendale Street was reconstructed and shotcreted to prevent erosion. Drainage improvements stopped at Sunset Highway because floodway easements below the highway could not be obtained.

Damage from this storm was particularly severe in the Glendale/Canyon B area, along the Moses Coulee Road in the Palisades area, and along the Jameson Lake Road. The following is a detailed description of damages:

- Countywide: Considerable damage to roads throughout the County; urbanized areas experienced localized flooding, causing damage to roads and private property
- East Wenatchee area, Canyon B: Approximately 5,000 cubic yards of mud and debris were deposited on the streets in the Glendale neighborhood, plugging and damaging culverts and ditches, plugging the Wenatchee Reclamation District canal, and heavily damaging yards and homes. Glendale Street became a major flood route, and Sunset Highway was severely damaged by erosion and sediment deposition.
- East Wenatchee area, Canyon A: Grant Road from North Kentucky Avenue to Valley Mall Parkway turned into a muddy river, and 3 feet of water covered Valley Mall Parkway.
- East Wenatchee area, between Canyon A and Sand Canyon: NE 15th and North Fairmont Streets were flooded. Homes were damaged from runoff from small drainages immediately south of Sand Canyon. Water also ran down NE 5th Street, possibly originating from the Kentucky and 10th Drainage.
- Moses Coulee/Palisades: The valley became completely flooded, severely damaging roads and flooding homes.
- Jameson Lake: Storm runoff caused flooding of the Jameson Lake road and extensive damage.
- Bridgeport: Runoff of sediment and debris damaged roads, culverts, ditches, and property. Homes were threatened and the sewage treatment plant was flooded and damaged.

August 6, 1991

A thunderstorm that dropped 0.54 inch in less than 15 minutes caused minor flooding in East Wenatchee. Douglas County reported that damage was minor, limited to clogged catchbasins and culverts. Residential areas below the Kentucky and 10th Drainage again experienced flooding.

May 31, 1993 Flood

A particularly intense thunderstorm that lasted for about 90 minutes hit East Wenatchee in the area between 8th Street NE and Canyon B. Douglas County observers indicated that up to 2 inches of rain fell in some areas during the storm (Peterson, T., 2 June 1993, personnel communication). Whereas substantial runoff occurred from the agricultural land above 10th Street and Kentucky, very little floodwater flowed down the main Canyon A channel into the City of East Wenatchee, indicating that the storm was centered in the foothills immediately above East Wenatchee. Significant amounts of stormwater also flowed down Sand Canyon and Canyon B. The sediment detention basin in Canyon B trapped as much approximately 1,000 cubic yards of material, and the recently constructed flood channel along Glendale safely passed the floodwaters to Highway 28.

This event was typical of the thunderstorm-caused floods that occur in the East Wenatchee area every few years. Although the heavy rainfall was localized, it occurred in the area where runoff has frequently caused extensive damage to the residential areas around East Wenatchee. Thus, with the exception of the main Canyon A channel, which had minimal flooding, areas flooded are frequent problem areas

The following is an overview of damages caused by this storm (information was obtained during a site visit and from discussion with County personnel):

- East Wenatchee area, between Canyon A and Sand Canyon: Runoff from agricultural areas above 10th Street and Kentucky Avenue flowed down 10th Street, causing damage to homes and extensive roadside erosion. Runoff also affected Lyle Avenue above 5th Street, and the area around Kentucky Avenue and 8th Street.

- East Wenatchee area, Sand Canyon: Runoff caused extensive erosion along the Badger Mountain Road, from the Fancher Heights Road to Valley View Blvd. At the turn below Daniels Drive, large amounts of water and sediment veered off the road and ran through the Valley View area, damaging several houses. Runoff also flowed down 23rd and 21st Streets, originating partly from the Badger Mountain Road and partly from the slope below Fancher Heights. In Fancher Heights, a catch basin at the base of a cul-de-sac failed, causing extensive damage to a house under construction.

- East Wenatchee area, Canyon B: The debris basin trapped a large amount of sediment, and the flood channel safely conveyed floodwaters along Glendale Street. However, floodwater ended up on SR 28, causing flooding and sedimentation problems. A large amount of runoff also ran down 35th Street, north of Canyon B.

- East Wenatchee area, urban area: In general, runoff caused minor flooding and erosion problems in areas below those described above. Runoff eventually traveled downslope to the irrigation canal, where it caused damage at three locations (at 5th, 10th, and 35th Streets). Minor flooding occurred at the Wenatchee Valley Mall, caused by runoff leaving lower Canyon A at 3rd and 4th Streets.

RISE OF JAMESON LAKE

The rise of Jameson Lake has resulted in a unique flooding problem. J.W. Wittig, a lake area resident since 1925, has monitored the lake level rise to its maximum level, at the elevation of outlet, during the 1989 runoff event. Stumps observed in the lake during low water levels in the 1930s indicate that the lake level was rising before 1925. Mr. Wittig's losses have included the inundation of over 100 acres of farmland, the loss of farm buildings, and damage to an access road. The resorts at both ends of the lake also have lost considerable amounts of property and their buildings have required relocation from time to time (Wittig, J.W., 23 February 1994, personal communication).

The 1989 flood caused over $150,000 in damage to roads in the Jameson Lake area. The County's Jameson Lake Road and the Washington State Department of Wildlife road closest to the lake experienced extensive damage, preventing access to the south end of the lake. Closure of this access just prior to opening day of fishing season resulted in a significant loss of revenue to the local economy (estimated shortly after the flood at $630,000 by the Washington Department of Wildlife) (DEM 1989). These roads may be damaged again if another substantial runoff event occurs. More important, such an event may cause a major overflow to lower Moses Coulee, possibly exacerbating flood problems at Palisades.

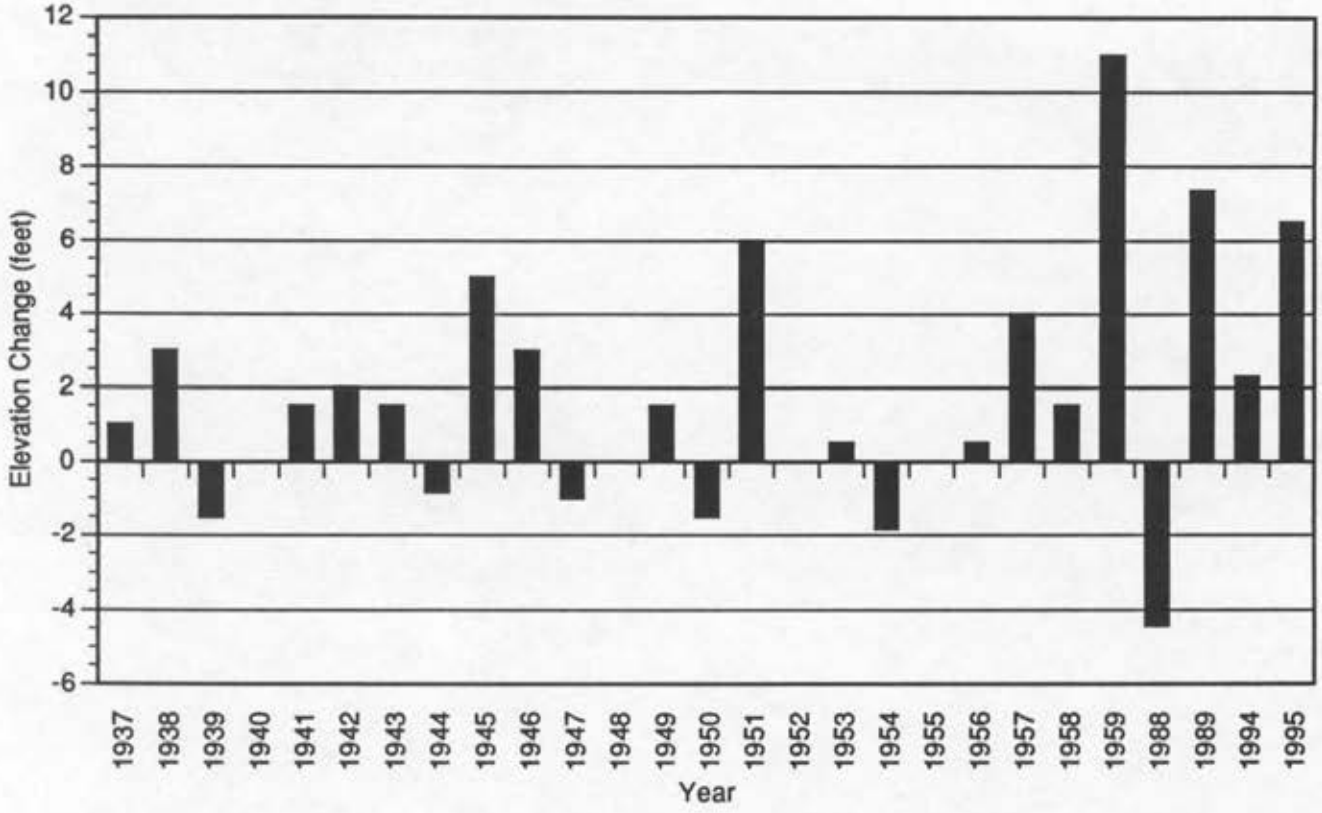
Data provided by Mr. Wittig on historical lake elevations are shown in Figure 4-3. The figure illustrates the cumulative rise of the lake since 1925 and the yearly changes. (Gaps in the data record occurred when Mr. Wittig moved away from the lake.) Since 1935, when the lake was at its lowest recorded elevation, the lake has risen nearly 45 feet. Even though there were no runoff events from 1989 to January 1995, the lake level did not drop significantly and was approximately 20 inches below the outlet elevation. Significant runoff occurred in January 1995 and caused the lake to overflow for several weeks. The water level was 5 feet higher on February 1, 1995 than in 1989 and was still rising.

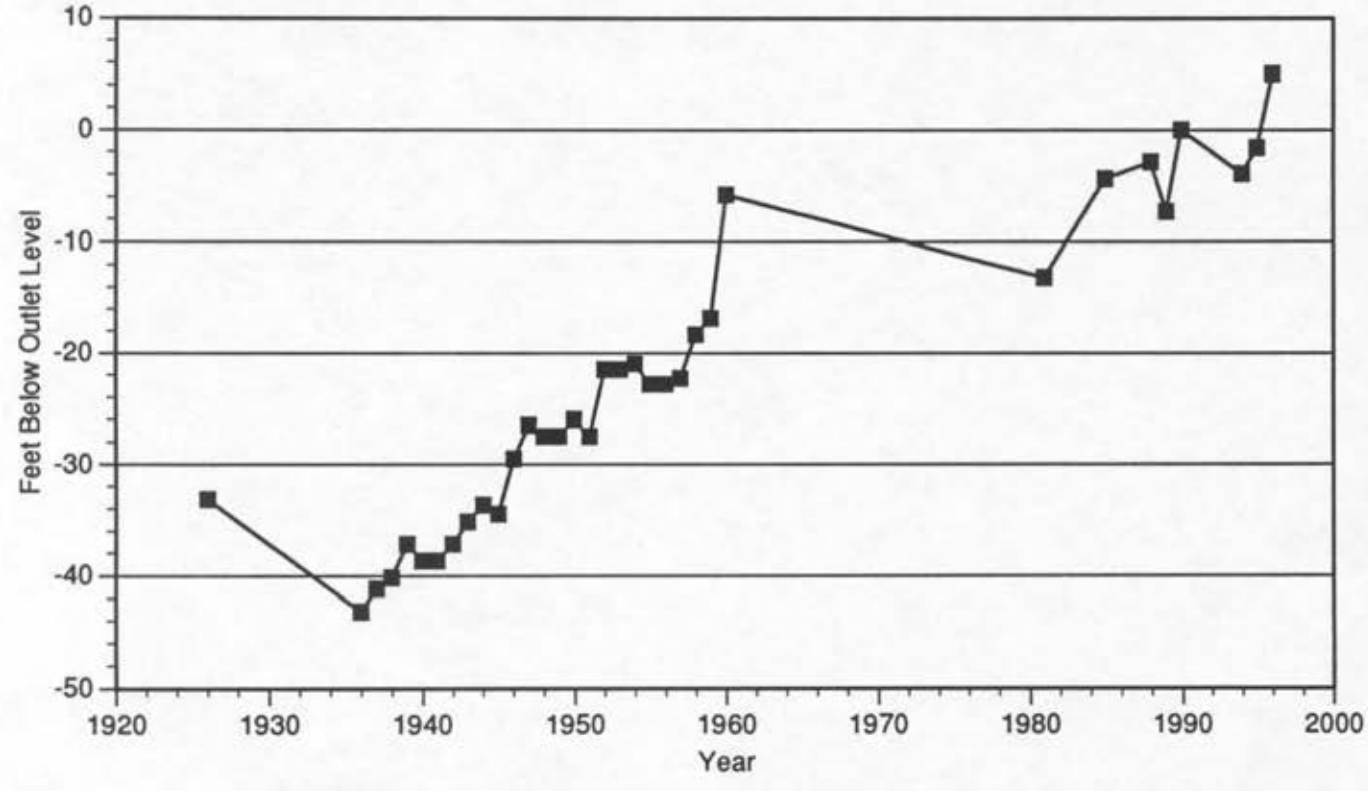
Although the rise has been fairly gradual since 1935, several years experienced very rapid rises in the lake level. The greatest annual increase occurred in 1959, when a series of three runoff events caused the lake level to rise by 11 feet. In 1989, the lake level rose by 88 inches over four days, reaching the outlet elevation but not causing significant outflow from the lake. Probably the fastest rise occurred in 1957, when the lake rose 4 feet overnight.

If the lake falls to its 1994 level, a runoff event similar to the 1989 event would cause an overflow to Moses Coulee. The 88-inch lake rise during the 1989 event corresponded to approximately 3,500 acre-feet of inflow. That much inflow to the lake at its current level would result in 2,700 acre-feet of overflow to Moses Coulee—enough water to inundate a half-mile path 8 miles long to a depth of 1 foot.

January 1995 Floods

Heavy rains in the eastern third of the County and snowmelt from the central and western County contributed to flooding in Moses Coulee. The road was temporarily impassable and suffered damage in several locations. North of Palisades at least one property owner also suffered some damage as the creek flowed across the road and through his property. Jameson Lake rose over 44 inches and Wittig's trout pond was lost.





KCM *1917 First Avenue* *Seattle, WA 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-3. HISTORICAL JAMESON LAKE LEVELS

CHAPTER 5.
REGULATORY OVERVIEW

The goals and objectives of a Comprehensive Flood Hazard Management Plan can be achieved through engineered projects targeting specific problems; wide-ranging regulatory programs in the areas of land use, shoreline management, resource management, and floodplain management; or a combination of both approaches. A regulatory framework that will support and help implement the plan's recommendations is a critical component of effective surface water management. The need for engineered projects to prevent or mitigate flood hazards may often be eliminated if complementary and forward-looking regulatory programs are initiated before extensive development occurs. Understanding existing regulations can result in the development of projects which can be constructed instead of wasting time and money on projects that will never be permitted.

The purpose of this chapter is to provide an overview of existing and pending state, federal, and local regulatory requirements that relate to flood control, surface water management, water quality, and wetlands protection. A summary of federal, state, and local surface water management laws, regulations, and policies is presented below (detailed discussion of each is provided in Appendix A). This is followed by a discussion of permitting requirements associated with construction of flood control facilities. Finally, regulations that could be implemented by the City to strengthen its management of stormwater and to respond to pending federal and state regulations are presented.

SUMMARY OF FEDERAL, STATE, AND LOCAL REGULATIONS

Many laws that directly or indirectly address flood hazard management have been enacted at the federal, state, and local levels. Table 5-1 lists these laws in the categories of flood hazard management, stormwater management, sensitive areas and other. Information on each law cited in this table is summarized in Table 5-2. Extensive descriptions are provided in Appendix A.

Most federal laws are implemented at the state and local levels. For example, the Clean Water Act regulates stormwater discharge, but the EPA has delegated the responsibility to administer the program to the State of Washington. The National Flood Insurance Program, which offers affordable flood insurance to private property owners, is a national program administered by FEMA, but it requires adoption of minimum floodplain regulations by cities and counties.

With the exception of FEMA and the National Flood Insurance Program, the most relevant laws involving flood hazard management originate at the state level. Most of these originate with state law that allows local governments to adopt regulations that promote the public health, safety and general welfare of that citizenry. Environmental laws that affect flood hazard management through habitat, shoreline and other critical-area protection measures also originate at the state level, but enforcement is increasingly becoming the responsibility of local governments. Growth management legislation has

TABLE 5-1.
SUMMARY OF SURFACE WATER MANAGEMENT REGULATIONS AND POLICIES IN DOUGLAS COUNTY

Category	Federal	State	Douglas County	City of East Wenatchee
Flood Hazard Management				
Land Use Restrictions	• National Flood Insurance Act/Flood Disaster Protection Act	• Floodplain Management Program	• Flood Damage Prevention Ordinance (participation in NFIP)	• Flood Hazard Ordinance (participation in NFIP) • Zoning Ordinance
Facilities and Building Standards	—	• Hydraulic Code (HPA)	• Flood Damage Prevention Ordinance • Subdivision Ordinance	• Flood Hazard Ordinance • Subdivision Ordinance
Planning and Policy	—	• Growth Management Act • Flood Control by Counties	• Comprehensive Plan • Regional Policy Plan • Resource Lands & Critical Areas Policy Plan	• Comprehensive Plan
Stormwater Management				
Facilities	—	• Hydraulic Code (HPA)	• Subdivision Ordinance (conditional requirements)	• Subdivision Ordinance (conditional requirements)
Water Quality	• Clean Water Act, Sections 401 and 402	• Water Pollution Control Act (Water Quality Certification or Modification) • State program for National Pollution Discharge Elimination System (NPDES) (when implemented for cities with less than 100,000 population)	—	—
Planning and Policy	—	• Growth Management Act • Flood Control by Counties	• Comprehensive Plan • Regional Policy Plan • Resource Lands & Critical Areas Policy Plan	• Comprehensive Plan • Resource Lands and Critical Areas Policy Plan

TABLE 5-1. (Continued)
SUMMARY OF SURFACE WATER MANAGEMENT REGULATIONS AND POLICIES IN DOUGLAS COUNTY

Category	Federal	State	Douglas County	City of East Wenatchee
Sensitive Areas and Other				
Stream Corridors	• Clean Water Act, Section 404 • River and Harbor Act	• Shoreline Management Act • Hydraulic Code (HPA)	• Resource Lands and Critical Areas Policy Plan • Development Standards Ordinance	• Interim Critical Areas Ordiance • Resource Lands and Critical Areas Policy Plan
Wetlands	• Clean Water Act, Section 404 (dredge and fill) • Executive Order 11990 • River and Harbor Act	• Shoreline Management Act • Executive Order 90-04	• Resource Lands and Critical Areas Policy Plan	• Interim Sensitive Areas Ordinance • Resource Lands and Critical Areas Policy Plan
Fisheries and Wildlife Habitat	—	• Hydraulic Code	—	—
General Environmental	• National Environmental Policy Act	• State Environmental Policy Act	—	—
Navigation	• River and Harbor Act	—	—	—

TABLE 5-2.
OVERVIEW OF MAJOR FEDERAL, STATE, AND LOCAL SURFACE WATER MANAGEMENT REGULATIONS

Name	Implementing Agency	Purpose	Jurisdiction	Required Approval, Permit, or Plan	Applicability to Flood Hazard Management
FEDERAL					
Clean Water Act, Section 401	State agencies empowered by EPA (i.e., Department of Ecology)	Ensures that federally permitted activities comply with the Clean Water Act, state water quality laws, discharge limitations, and any other appropriate state regulations	Waters of the U.S.	Water Quality Certification and/or Modification	• Structural measures impacting surface water will require Water Quality Certification and/or Modification
Clean Water Act, Section 402	State agencies empowered by EPA (i.e., Department of Ecology)	Establishes permit application requirements for stormwater discharges under National Pollution Discharge Elimination System Program (NPDES)	All stormwater discharges associated with industrial activity and from municipal separate storm sewer systems	Stormwater Discharge Permits	• NPDES stormwater permit is required for jurisdictions with over 100,000 population
Clean Water Act, Section 404	U.S. Army Corps of Engineers	Regulates the discharge of dredged or fill material in rivers, streams, and wetlands	Waters of the U.S., including wetlands	Individual or Nationwide Permits	• Dredging or filling in wetlands or the Columbia River will require permit
National Flood Insurance Act	Federal Emergency Management Agency	Offers affordable flood insurance to communities that adopt approved floodplain management regulations	Floodplains of the U.S.	Flood Insurance Study and approval letter from FEMA	• Participation in NFIP requires minimum floodplain management regulations

TABLE 5-2 (Continued).
OVERVIEW OF MAJOR FEDERAL, STATE, AND LOCAL SURFACE WATER MANAGEMENT REGULATIONS

Name	Implementing Agency	Purpose	Jurisdiction	Required Approval, Permit, or Plan	Applicability to Flood Hazard Management
FEDERAL (cont)					
Flood Disaster Protection Act	Federal Emergency Management Agency	Provides incentive to communities to join the NFIP by increasing available amounts of flood insurance and providing penalties for communities and individuals that do not join the NFIP and are subsequently flooded	Floodplains of the U.S.	Approval by FEMA	• Requires purchase of flood insurance as a condition of funding by federally backed lending institutions for purchase of property in floodplains
National Environmental Policy Act	Varies (usually the federal agency issuing the permit)	Requires full disclosure of potential impacts associated with proposed actions and mitigative measures	All federal actions	Environmental Assessment and Environmental Impact Statement	• Regulates proposed actions within city that may result in significant adverse environmental impacts
River and Harbor Act, Section 10	U.S. Army Corps of Engineers	Preserve the navigability of the nation's waterways	Navigable waters of the U.S.	Section 10 permit	• Regulates activities within the Ordinary High Water Mark (OHWM) of the Columbia River
Executive Order 11990	Federal Agencies	Protection of wetlands and evaluation of impacts of proposed actions on wetlands	Federal projects, federally funded activities, or other activities licensed or regulated by federal agencies	None	• Enhances existing wetland protection regulations
Executive Order 11988	Federal Agencies	Protects floodplain from development by federal agencies	Federal projects	None	• Enhances existing floodplain management reulations.

TABLE 5-2 (Continued).
OVERVIEW OF MAJOR FEDERAL, STATE, AND LOCAL SURFACE WATER MANAGEMENT REGULATIONS

Name	Implementing Agency	Purpose	Jurisdiction	Required Approval, Permit, or Plan	Applicability to Flood Hazard Management
STATE					
State Environmental Policy Act	Varies (usually the local agency issuing the permit); circulation to state and federal agencies for review	Requires full disclosure of the likely significant adverse impacts associated with a proposed action and identification of mitigative measures	All proposed actions that require permits	Environmental Assessment or Environmental Impact Statement	• Requires environmental review of any project with potential adverse environmental impacts
Shoreline Management Act	Department of Ecology; local jurisdictions	Manages uses of the shorelines of the state for protection of public interests and natural environment	All shorelines of the state (including all marine waters, lakes, reservoirs, streams and rivers >20 cfs mean annual flow, and associated wetlands)	State or state-approved local shoreline permit	• Applies to activities within the Columbia River, the adjacent lands within 200 ft. of the OHWM, the 100-yr floodplain, and all associated wetlands
Senate Bill 5411 (ESSB 5411)/Flood Control by Counties (RCW 86.12)	Counties	RCW 86.12 authorized county governments the power to levy taxes, exercise eminent domain and take action to control and prevent flood damage. ESSB 5411 provides a greatly expanded role for counties in the formulation and adoption of drainage basin plans to address flooding and land use regulations	All drainage basins located wholly or partially within the County	Comprehensive Flood Hazard Management Plan	• Allows for development of CFHMPs

TABLE 5-2 (Continued).
OVERVIEW OF MAJOR FEDERAL, STATE, AND LOCAL SURFACE WATER MANAGEMENT REGULATIONS

Name	Implementing Agency	Purpose	Jurisdiction	Required Approval, Permit, or Plan	Applicability to Flood Hazard Management
STATE (cont)					
Floodplain Management Program (RCW 86.16)	Department of Ecology	To reduce flood damages and protect human health and safety. Department oversees local implementation of floodplain regulations required for participation in the NFIP.	All floodplains within the state	State approval of floodplain management programs and regulations	• Provides eligibility for national flood insurance and for state matching funds to construct flood control facilities
State Participation in Flood Control Maintenance	Department of Ecology	Assist local jurisdictions in comprehensive planning and flood control maintenance efforts	All flood hazard management activities of local jurisdictions as approved by Ecology	FCAAP grant application, approved CFHMP for maintenance grants	• FCAAP funds available for preparation of CFHMPs, flood control maintenance projects, and emergency flood control projects
Water Pollution Control Act	Department of Ecology	Empowers the state to develop, maintain, and administer the federal statutes and programs required by the federal Clean Water Act	All receiving waters of the state	Water Quality Certification/ Modification	• Regulates activities that violate state water quality standards per the Clean Water Act
Hydraulic Code	Department of Fishand Wildlife	Protects fish, fish habitat, and wildlife habitat from damage by construction and other activities	All marine and fresh waters of the state and drainage corridors	Hydraulic Project Approval (HPA)	• HPA is required for all activities within the OHWM of streams and along natural drainage corridors
Growth Management Act (HB 2929)	Department of Community Development	Requires comprehensive plans to include surface water considerations and facilities (quantity and quality)	Twelve "growth counties" and their cities	Comprehensive Plan	• Requires adoption of development regulations and comprehensive plans

TABLE 5-2 (Continued).
OVERVIEW OF MAJOR FEDERAL, STATE, AND LOCAL SURFACE WATER MANAGEMENT REGULATIONS

Name	Implementing Agency	Purpose	Jurisdiction	Required Approval, Permit, or Plan	Applicability to Flood Hazard Management
STATE (cont)					
Executive Order 90-04, Protection of Wetlands/Model Wetlands Protection Ordinance	Department of Ecology	Provides guidance to local governments to achieve no net loss of wetland functions and values	State wetlands buffers	None	• Provides voluntary technical assistance to the local jurisdiction to regulate activities that affect wetlands
DOUGLAS COUNTY					
1988 Comprehensive Plan and Subarea Plans	Douglas County Planning Commission	Guide orderly future growth and development of county land use, circulation, and other elements of interest to the community	Greater East Wenatchee area	None	• Promotes preservation of natural drainage corridors, cost-effective measures to control flooding, and inclusion of stormwater facilities in new developments
Zoning Ordinance (Title 18, County Code)	Douglas County Planning and Building Department	Implement the growth management policies of the Comprehensive Plan by prescribing use and density requirements for land development	Douglas County unincorporated areas	Building permit	• County currently has no zoning district for areas of special flood hazard
Shoreline Management (Chapter 19.08, County Code)	Douglas County Planning and Building Department	Restricts development along shorelines	Shorelines of the State within Douglas County unincorporated areas	County approval	• Flood control facilities along Columbia River would have to comply with shoreline management regulations
Flood Damage Prevention (Chapter 15.48, County Code)	Douglas County Planning and Building Department	Restrict development and require special standards for development in Areas of Special Flood Hazard identified in Flood Insurance Study	Douglas County areas identified in Flood Insurance Rate Maps	County approval	• Restricts inappropriate land use in flood hazard areas • Prohibits channel alterations that increase flood hazard in other areas

TABLE 5-2 (Continued).
OVERVIEW OF MAJOR FEDERAL, STATE, AND LOCAL SURFACE WATER MANAGEMENT REGULATIONS

Name	Implementing Agency	Purpose	Jurisdiction	Required Approval, Permit, or Plan	Applicability to Flood Hazard Management
DOUGLAS COUNTY (cont)					
Subdivision Ordinance	Douglas County Planning and Building Department	Establishes procedures and conditions for subdividing land	Douglas County unincorporated areas	Subdivision application and drawings	• Detention of storm drainage is a conditional requirement of permit approval
State Environmental Policy Act Implementation (Chapter 19.04, County Code))	Douglas County Planning and Building Department	Enacts provisions of SEPA at local level	Douglas County unincorporated areas	Environmental Checklist, Environmental Impact Statement	• SEPA review may be required for significant flood control projects
EAST WENATCHEE					
1991 Comprehensive Plan	City of East Wenatchee	Guide orderly future growth and development of City land use, circulation, and other elements of interest to the community	East Wenatchee	None	• Identifies the need to implement drainage improvements in the East Wenatchee watershed (Canyon A)
Zoning Ordinance (Title 17, City Code)	City of East Wenatchee	Implement the growth management policies of the Comprehensive Plan by prescribing use and density requirements for land development	East Wenatchee	City approval.	• Flood hazard zoning district overlay requires review of development proposals to ensure that buildings, utilities and other facilities are protected from flood hazards
Flood Hazard Ordinance (Ordinances 280 and 388)	City of East Wenatchee	Restrict development and require special standards for development in Areas of Special Flood Hazard identified in Flood Insurance Study	East Wenatchee areas identified in Flood Insurance Rate Map	City Approval	• Restricts inappropriate land use in flood hazard areas • Prohibits channel alterations that cause increased flood hazard in other areas

originated at the state level, but regulatory implementation largely falls on local jurisdictions guided by comprehensive planning.

PRINCIPAL REGULATORY TOOLS FOR FLOOD HAZARD MANAGEMENT IN DOUGLAS COUNTY

Regulations that pertain directly to flood hazard and stormwater management include the following:

- **National Flood Insurance Program (NFIP) (Federal)** - Establishes flood boundaries and floodways for the 100-year flood within the County and provides federally-subsidized insurance to all property owners in exchange for the County's adoption of a local flood hazard ordinance.

- **Flood Damage Prevention Ordinance (City and County)** - Satisfies FEMA requirements for participation in NFIP by setting minimum standards and regulations for development in Flood Hazard Areas. Floodplain boundaries are defined in the Flood Insurance Study for Douglas County (FEMA 1981).

- **Subdivision Ordinance (City and County)** - Prescribes standards for developments, although limited to stormwater facilities in subdivisions. Requirements for storm drainage facilities are not explicitly mentioned in the ordinance, but are usually included as a conditional requirement in the building permit.

- **Zoning Ordinance (City and County)** - Establishes appropriate land uses for areas of the City and County. The City maintains a special flood hazard zoning district overlay that prescribes additional requirements for areas subject to flooding, as identified by detailed hydrological studies. This zoning requires that development proposals be reviewed to ensure that buildings, utilities, and other facilities are located and constructed to minimize damage from flooding. The County does not have a flood hazard zoning district.

The Greater East Wenatchee Comprehensive Plan (Douglas County 1988) establishes policy guidance for use by the County Commissioners in their decisions regarding future growth in the County. New ordinances and regulations will probably be needed to implement certain of its objectives. However, the flood and stormwater control objectives in the Comprehensive Plan are general in nature and typically refer to the need for studies, such as this Plan, to determine which regulatory and physical measures should be implemented.

PERMITTING REQUIREMENTS

Many of the regulatory programs summarized in Tables 5-1 and 5-2 and described in Appendix A contain permit requirements. This section clarifies which permits are required for specific types of projects and discusses the typical timing of the permit process.

A project may require one or more permits, depending on its nature and location. Table 5-3 relates the type of project to the required permits and approvals. At least five different permits are typically required for in-stream, shoreline, floodplain, and river engineering projects. The table also indicates that SEPA review is generally required for all of the listed types of projects. SEPA review may consist of completing a checklist or an environmental impact statement (EIS) if significant impacts are expected to result from the project.

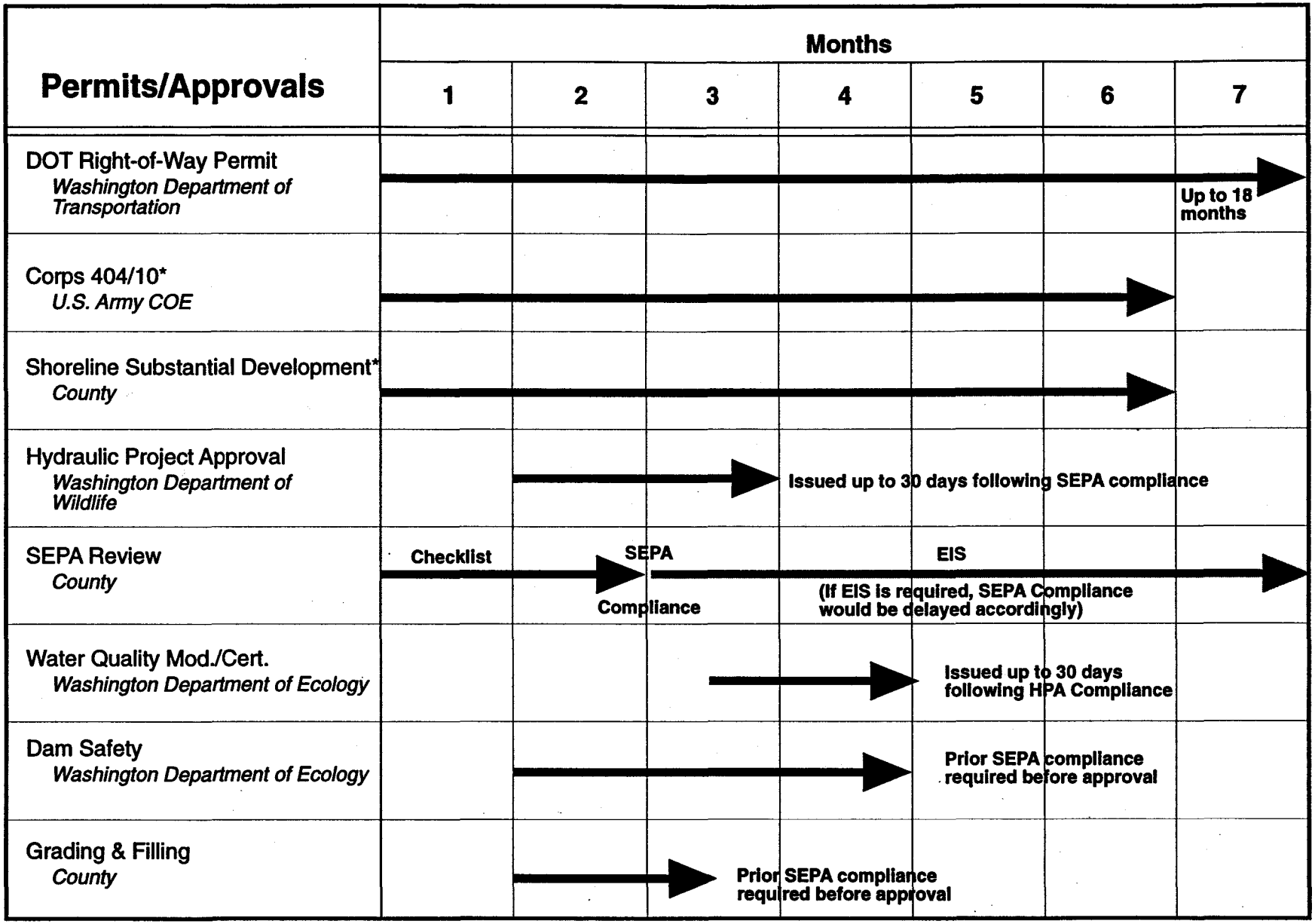
Many permit requirements depend on the location of the proposed project in relation to the river, shoreline jurisdiction, and floodplain boundary. Only work in and adjacent to the Columbia River would require a Corps of Engineers 404 permit.

The timing and coordination of permitting requirements and procedures must be understood to obtain permits contingent upon acquisition of previous permits. Figure 5-1 illustrates permit timing relationships. The Department of Transportation right-of-way permit process, required whenever work is proposed within a state right-of-way, is listed first because it can have the longest processing time. The COE and Shorelines permit processes require procurement of most other required permits and approvals before issuance. SEPA compliance may be accomplished at the checklist level. However, if an EIS is found to be necessary, this can substantially delay procurement of all permits contingent on completion of the SEPA process.

The Hydraulic Project Approval (HPA) can be submitted prior to SEPA compliance, but it will not be issued until SEPA review has been completed. The Water Quality Modification/Certification will not be issued by Ecology until the HPA has been issued. The Grading and Filling permit requires SEPA compliance prior to issuance. Individual processing times may require up to two months for these permits.

TABLE 5-3.
PERMIT REQUIREMENTS FOR FLOOD CONTROL WORK

	Project Location				Type of Work		
	In-Stream Work	Shorelines Work	Floodplain Work	Outside Floodplain	Structural Flood Control	Nonstructural Using Existing Regulation	Nonstructural Using Modified Regulations
DOT ROW Permit (for work in State Right-of-Way) *Washington Department of Transportation*		X		X	X		
COE 404/10 *U.S. Army Corps of Engineers*	X	X	X		X		
Shoreline Substantial Development *Douglas County*	X	X	X		X		
Hydraulic Project Approval (HPA) *Washington Department of Wildlife*	X	X	X		X		
SEPA Review *Douglas County*	X	X	X	X	X	X	X
Water Quality Modification/Certification *Washington Department of Ecology*	X	X	X		X		
Dam Safety *Washington Department of Ecology*	X				X		
Grading and Filling *Douglas County*		X	X	X	X		
COE 401 (Water Quality Certification) *Washington Department of Ecology*	X	X	X		X		



*These are "umbrella" permit processes that require procurement of all other permits before they can be issued.

KCM
1917 First Avenue
Seattle, Washington 98101

Douglas County
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 5-1.
TYPICAL PERMIT TIMING REQUIREMENTS

CHAPTER 6.
COMPUTER MODELING ANALYSIS

Computer modeling of Canyon A, Canyon B, Sand Canyon, and the East Wenatchee urban area was conducted using the COE HEC-1 and HEC-2 hydrologic and hydraulic computer models. The HEC-1 model simulates runoff resulting from specified precipitation events. The HEC-2 model simulates the hydraulics of flood flows. In addition to providing data to map floodplains, these models can determine the adequacy of existing hydraulic structures, such as culverts and storm drains, in conveying current and projected future flows.

The following procedure was used for this analysis:

- Basin and subbasin boundaries, land use characteristics, and other physical parameters were determined from maps and aerial photographs.
- Precipitation magnitudes and storm distribution were determined based on analysis of historic precipitation data.
- Stormwater runoff resulting from the design storm was calculated using the hydrologic analysis program HEC-1.
- Floodplain and floodway elevations were determined using the hydraulic analysis program HEC-2.
- Floodplain and floodway boundaries were drawn on maps, where appropriate.
- Flood problem areas were determined from an analysis of the modeling results.

The analysis and identification of flood problem areas was conducted for existing and future land use conditions. Change in land use from rural or agricultural to urban development directly affects runoff rates by increasing the area of impervious surfaces, decreasing soil infiltration capacities, and altering other runoff processes. This typically results in increased runoff volumes and peak flows. Current land use was determined from examination of recent aerial photographs, and future land use was defined as maximum development under 1993 zoning with no mitigation.

The modeling analysis produced estimates of 100-year flows in Canyon A, Canyon B, and Sand Canyon based on a summer thunderstorm. Winter snowmelt was not modeled because almost all significant flood events in the East Wenatchee area have been caused by thunderstorms. Winter snowmelt is generally more widespread, occurs over a longer period of time and produces smaller runoff peaks. Snowmelt events are a major cause of flooding on Moses Coulee, however. The floodplain along each drainage corridor generally was found to range from 50 feet to 200 feet in width and to be contained within the natural drainage. The primary exception includes a major split in the Canyon A floodplain at Kentucky Avenue. At Kentucky Avenue, the floodwaters flow down Grant Road, in addition to the nearby natural channel, to culverts with inadequate capacities. When

culverts with inadequate capacity are encountered, the floodwater typically overtops the roadway and the width of the floodplain increases.

The analysis of the East Wenatchee urban area produced flow estimates for runoff that enters the urban area from adjacent agricultural land, and for combined agricultural and urban runoff along the principal drainage pathways within the urban area.

Detailed hydrologic and hydraulic analyses of the Palisades area of Moses Coulee were not performed for this study. Previous studies and other available information were used to determine hydrologic characteristics. Estimates of the 100-year flood flow from the Flood Insurance Study were judged to be adequate, as were the existing 100-year floodplain maps. They are summarized in Table 3-11.

Analysis of flooding problems in the Jameson Lake area did not require detailed hydrologic or hydraulic modeling. Data from the 1989 runoff event were used to determine runoff potential. That analysis is described at the end of this chapter. Analysis of floodplain hydraulics for the Jameson Lake area was not a component of this study because the area's flooding centers on the more general issue of how to solve the problem of rising lake level.

Details of analysis procedures, assumptions, and results are presented below. Additional documentation and technical data are contained in Appendix D (floodplain maps) and in separate reports delivered to Douglas County.

ANALYSIS METHODOLOGY

Data Sources

The following data were obtained to aid the flood hazard analysis:

- Watershed delineation was determined from 1 inch = 2,000 feet, 20-foot contour USGS topographic maps (Wenatchee and Rock Island quadrangles). For areas in the East Wenatchee vicinity, 1 inch = 200 feet, 5-foot contour topographic maps (Washington State Highway Commission 1965) were used to define runoff patterns and stream cross-sections.

- Daily and hourly precipitation data for three Wenatchee-area weather stations were obtained from a CD-ROM data base for use in the precipitation frequency analysis (EarthInfo 1992).

- Color and black and white aerial photographs were obtained from the Washington State Department of Natural Resources (DNR 1986) and Aeromap U.S., Inc. (Aeromap 1993) to identify current land use.

- Soil data were obtained from the Douglas County soil survey, prepared by SCS (SCS 1981).

- Observations on watershed conditions, drainage pathways, and culvert data were obtained during field investigations. Channels and culverts were measured during this study to supplement data that were previously gathered by SCS (SCS 1993).

- The Spokane Office of SCS provided unpublished data from the 1983 East Wenatchee Watershed Project in the form of calculation notebooks and maps (SCS 1993).

- SCS personnel from the Waterville office were consulted on soil and agricultural issues. Douglas County and City of East Wenatchee personnel provided information on existing drainage facilities, complaints, and known problems.

- Numerous other reports, described in Chapter 3, contained miscellaneous data and information.

Watershed Delineation and Characteristics

Watershed boundaries were based on 1" = 2,000' USGS topographic maps for the upper basin areas, and 1" = 200' topographic maps for the lower (East Wenatchee) basin areas. Subwatershed units were defined for each watershed. Partitioning the watershed increases the accuracy of the rainfall-runoff modeling because the non-linear effects of land use, land morphology (shape), stream channel morphology, and other parameters are defined in greater detail. The network modeling capability of HEC-1 is used to link the subwatersheds into an array of runoff areas, junction nodes, and channel reaches.

Land use, soil, and other physical parameters for each subwatershed were derived from overlays of contour maps, aerial photographs, and soil maps. Various analytical procedures, such as area-weighting to calculate subwatershed curve numbers and sum-of-contours to calculate average watershed slope, were used to generate the data used in the model.

Precipitation and Design Storm

Design 24-Hour Precipitation Depths

Historical precipitation data from the Wenatchee Experimental Station were used to determine the 24-hour precipitation depths for the hydrologic modeling in this CFHMP. These data along with those from the Wenatchee area's other two weather stations—Wenatchee FAA (Pangborn Field) and Wenatchee—are summarized in Table 6-1.

Data from the latter two stations were not used for the design event because they were only taken daily, not hourly like the data for the Wenatchee Experimental Station. Also, as discussed in Chapter 4, the Pangborn records of 24-hour rainfall may be affected by the fact that the station takes its observations at midnight, which falls in the middle of many of the storm events. Although this might cause recorded depths at Pangborn Field to be consistently lower than those from the other two stations, local residents have stated that storms coming from the west rapidly dissipate as they move toward East Wenatchee, resulting in generally drier conditions.

TABLE 6-1.
PRECIPITATION DEPTH-DURATION-FREQUENCY DATA

Source/Location	Max. Historical Depth	Recurrence Interval Depth[a] 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
RECORDED PRECIPITATION							
Wenatchee (1930-1990)							
- 24-hour	2.72	0.98	1.3	1.6	1.8	2.1	2.3
Wenatchee FAA (Pangborn Field) (1960-1990)							
- 24-hour	1.51	0.89	1.2	1.3	1.5	1.7	1.8
Wenatchee Experimental Station (1948-1990)							
- 1-hour	1.25	0.32	0.52	0.65	.80	0.94	1.1
- 2-hour	1.38	0.48	0.73	0.89	1.1	1.2	1.4
- 3-hour	1.57	0.58	0.85	1.0	1.2	1.4	1.6
- 6-hour	1.77	0.79	1.1	1.3	1.5	1.7	1.9
- 12-hour	2.02	1.0	1.3	1.6	1.8	2.0	2.2
- 24-hour	2.06	1.2	1.5	1.7	2.0	2.2	2.4
DEPTH-DURATION-FREQUENCY ESTIMATES							
NOAA Atlas 2[b]							
- 0.5-hour	---	0.24	0.37	0.45	.54	0.63	0.73
- 1-hour	---	0.31	0.47	0.57	.68	0.81	0.92
- 2-hour	---	0.42	0.59	0.72	.84	0.97	1.1
- 6-hour	---	0.75	0.95	1.1	1.2	1.4	1.6
- 12-hour	---	0.98	1.2	1.4	1.6	1.8	2.1
- 24-hour	---	1.2	1.5	1.7	1.9	2.2	2.5
Washington DOT[c]							
- 0.5-hour	---	0.35	0.44	0.55	.65	0.78	0.93
- 1-hour	---	0.40	0.55	0.70	.80	0.96	1.2

a. Frequency estimates derived from daily or hourly precipitation values using Extreme-Value (Type I) distribution analysis. Data source: EarthInfo (1992). All values are in inches.

b. Miller et al. 1973

c. Washington State Department of Transportation Hydraulic Manual (WSDOT 1972)

Other common sources of precipitation data also were determined to be inappropriate for this study, such as the National Oceanic and Atmospheric Administration's (NOAA) Atlas 2 (Miller et al. 1973) and the Washington State Department of Transportation's hydraulic manual (WSDOT 1972). Both of these sources omit rainfall events from the last two decades because they are based on data collected before 1970. Moreover, the NOAA charts underestimate precipitation from storms shorter than 6 hours and the WSDOT charts offer no data for storms longer than 90 minutes. Summaries of the precipitation estimates from these sources are included in Table 6-1 for comparison to the historical data.

Precipitation Distribution

The distribution of rainfall during a 24-hour storm is equally important to total precipitation depth because peak runoff from small watersheds is largely determined by the maximum one- to two-hour precipitation intensity. A recorded storm event or standardized 24-hour distributions developed by the SCS can be used to define the storm distribution.

In the East Wenatchee Watershed Plan, the SCS used the rainfall distribution from the June 1972 storm in its rainfall-runoff analysis of Canyon A. The SCS used the TR-20 program, which is computationally similar to the methods used in the HEC-1 analysis in this study. Rainfall depths in the 1972 storm for one- to three-hour durations were considerably lower than the depths determined by the frequency analysis. For example, the maximum one-hour depth in the 1972 storm was 0.68 inches, compared to the 100-year/one-hour depth of 1.1 inches.

This study used the SCS Type II storm distribution for climates dominated by thunderstorms, which closely matched the observed data for short-duration storms. The one-, two-, and three-hour, 100-year rainfall totals in the Type II distribution are 1.1, 1.3, and 1.4 inches, respectively, compared to 1.1, 1.4, and 1.6 inches that were calculated from the frequency analysis of historical rainfall data.

Hydrologic (Rainfall-Runoff) Modeling Methods

The COE HEC-1 Flood Hydrograph Package (COE 1988) was used to predict streamflows in Canyon A, Canyon B, Sand Canyon, and the East Wenatchee urban area caused by the 10-, 25-, 50-, and 100-year recurrence interval storm events. Flow estimates were derived from rainfall frequency data generated from long-term precipitation records. This modeling method is the best to use in the absence of flow-rate records.

Precipitation runoff is modeled in HEC-1 by the SCS curve-number method. The curve number is an empirical factor, based on experimentation and experience, which quantifies the infiltration and runoff characteristics of land surfaces based on soil type, land use, and antecedent moisture conditions. This method required measurement of such physical parameters as basin area, average basin slope, stream channel length and slope, soil groups, and land use.

Comparison to actual runoff events was not used to calibrate the resulting HEC-1 models because historical streamflows for these basins have never been measured and recorded. Due to the very infrequent occurrence of these events and the large effort and expense involved in establishing monitoring equipment to measure runoff events, no effort was made to collect runoff data during the study period. The HEC-1 model does provide acceptable results to be used for floodplain delineation and the design of flood control structures.

Assumptions

The following are the principal assumptions used in the HEC-1 modeling:

- Rainfall depth-duration-frequency relationships were derived from precipitation recorded at the Wenatchee Experimental Station. The resulting 1- to 24-hour precipitation depths for storms of 2- to 100-year frequency were not adjusted to the possibly drier East Wenatchee area because of problems encountered in comparing Wenatchee Experimental Station data with the Pangborn Field data.

- A 24-hour storm based on the SCS Type II rainfall distribution was used to model runoff because the precipitation depth-duration-frequency values derived from the Wenatchee Experimental Station matched this distribution well.

- It was assumed that precipitation falls evenly over the entire watershed.

- Runoff was selected to reflect summer growth conditions. Soil hydrologic conditions and cover were assumed to be good.

- Drainage facilities were assumed to be clean and free of debris and sediment.

- Aerial photographs and USGS topographic maps were used to define the runoff model network. Runoff patterns could be readily determined in all areas except one: the alluvial fan in Canyon A near 10th Street and Stark Avenue. It was assumed that flow emanating from upper Canyon A divides equally between lower Canyon A (i.e., across Nile Avenue) and an adjacent drainage that flows toward Rock Island.

Curve Numbers and Soil-Cover Classification

A curve number is a measure of runoff potential for a given soil-cover complex. Curve numbers that reflect typical summer growth conditions were obtained from standard SCS references (SCS 1972, 1982, and 1986).

In the hydrologic classification of soils, A soils are the most pervious and D soils are the least pervious. Creation of impervious surfaces, such as roadways and urban developments, in areas dominated by A and B hydrologic soils will have a very significant impact on stormwater runoff because a relatively small area of impervious surface can generate the same amount of runoff as a much larger area of undisturbed land. Concentration of runoff by impervious surfaces can also result in significantly increased soil erosion because road margins generally lack vegetative cover, and soils in the East Wenatchee area are very erodible.

Soil hydrologic groups are shown in Figure 2-3. Soils in the upper watershed consists of mostly B hydrologic soils groups. A large extent of A hydrologic group soils are present around the City of East Wenatchee. These sandy soils exhibit very good infiltration characteristics but have poor resistance to erosion. The remaining urban area consists mostly of B hydrologic group soils, which have good infiltration characteristics.

Curve numbers are assigned on a scale of 0 to 100, with higher numbers representing soils that have more runoff. Curve numbers were generally assigned as follows:

- Fallow dry cropland—A curve number of 84 was used, based on predominant soil groups (75 percent B and 25 percent C hydrologic soil groups) and good crop residue cover.

- Rangeland—A curve number of 71 was used, based on predominant soil groups (90 percent B and 10 percent D hydrologic soil groups) under fair hydrologic condition (i.e., 50 to 75 percent of the area covered with grass).

- Orchard land—Curve numbers varied between 37 for mostly A hydrologic group soils and 58 for B hydrologic group soils. Because they are covered by grass, orchards have a good hydrologic condition (i.e., more than 75 percent grass cover).

- Residential land—Curve numbers for residential land under current conditions varied from 51 for low-density (1-acre) development in A hydrologic group soils to 72 for higher-density (1/3-acre lots) development in B hydrologic group soils. Under future conditions, the curve numbers for maximum development (R-2 and R-M zoning) were 77 and 85 for A and B hydrologic group soils, respectively.

- Open urban land—Curve numbers varied from 40 for mostly A hydrologic group soils to 48 for mixed A and B hydrologic group soils. Good hydrologic conditions (greater than 75 percent grass cover) were assumed.

- Commercial land—Commercial areas were assigned curve numbers of up to 91.

Rain-on-Snow Events

Historical records show several flooding events that were caused by late winter rain-on-snow events. This presents a complex modeling scenario because snowmelt is a function of many climatic parameters (temperature, humidity, wind, solar radiation, etc.) and soil conditions. Although many of the climatological parameters were not available for historical events, estimates were derived from climatological atlases and regional weather stations.

The rain-on-snow analysis focused on simulation of the March 11, 1989 runoff event for Canyon B. This event resulted in large amounts of flood damage in the East Wenatchee area and therefore is typical of severe rain-on-snow events. Only Canyon B was modeled for rain-on-snow events because of the substantial effort associated with setting up modeling parameters. Conclusions about rain-on-snow characteristics that result from modeling Canyon B apply to the other two canyons as well.

Since no data on actual rainfall, snow depth, and frozen soil conditions in the basin are available, it is impossible to verify the rain-on-snow model. Therefore the results of the analysis are largely qualitative.

Hydraulic (Floodplain) Modeling Methods

Flood elevations in Canyon A, Canyon B, Sand Canyon, and the East Wenatchee urban areas were estimated using the COE HEC-2 Water Surface Profiles computer program, Version 4.6.2 (COE 1991). HEC-2, the most commonly used program for floodplain analysis, is a steady-state flow model that calculates water velocities and elevations in natural and manmade channels. Basic input data to this program include channel cross-sectional profiles at regular intervals along the channel reach, hydraulic parameters for channel reaches between cross-sections, and dimensional and hydraulic parameters for bridges, culverts, and other obstructions within the floodplain. HEC-2's Standard Step Method uses the one-dimensional energy equation with energy loss due to friction estimated by Manning's Equation.

Like the HEC-1 models, the HEC-2 models created for this study could not be calibrated against actual high water marks because historical flood data are not available and no new data could be collected during the study period.

Input Data

Channel cross-sections were obtained from three sources: previous SCS surveying along Canyon A; new channel and culvert surveying conducted for this study; and 1" = 200', 5-foot contour topographic mapping prepared by the Washington State Highway Commission in 1965. The resolution of the 5-foot contour maps was determined to be sufficient for floodplain mapping in most locations in the East Wenatchee area because stream gradients are high and most streams are contained in narrow canyons. Surveyed cross-sections and culvert data were obtained at all road/culvert crossings and at other critical locations where obstructions were believed to greatly influence the extent of flooding. Culvert data were also used to calculate conveyance capacity of existing facilities.

Floodplain Delineation

100-year Floodplain Delineation

The 100-year floodplain is typically defined as the total area subject to inundation by the 100-year, or base flood. The 100-year flood is the flood having a 1 percent chance of being equaled or exceeded in any given year. Flood hazard regulations are normally based on the 100-year floodplain.

To map the 100-year floodplain boundaries, flood elevations calculated by HEC-2 are used to determine the width of the floodplain at each modeled stream cross-section on the topographic map. Floodplain boundaries in areas between the stream cross-sections are determined by interpolation of flood elevations and map contours.

ANALYSIS RESULTS FOR CANYON A

The Canyon A watershed encompasses 4,250 acres (6.6 square miles), extending from the crest of Badger Mountain to Eastmont Avenue. Figure 6-1 shows the primary watershed boundary and the subwatershed units above Lyle Avenue.

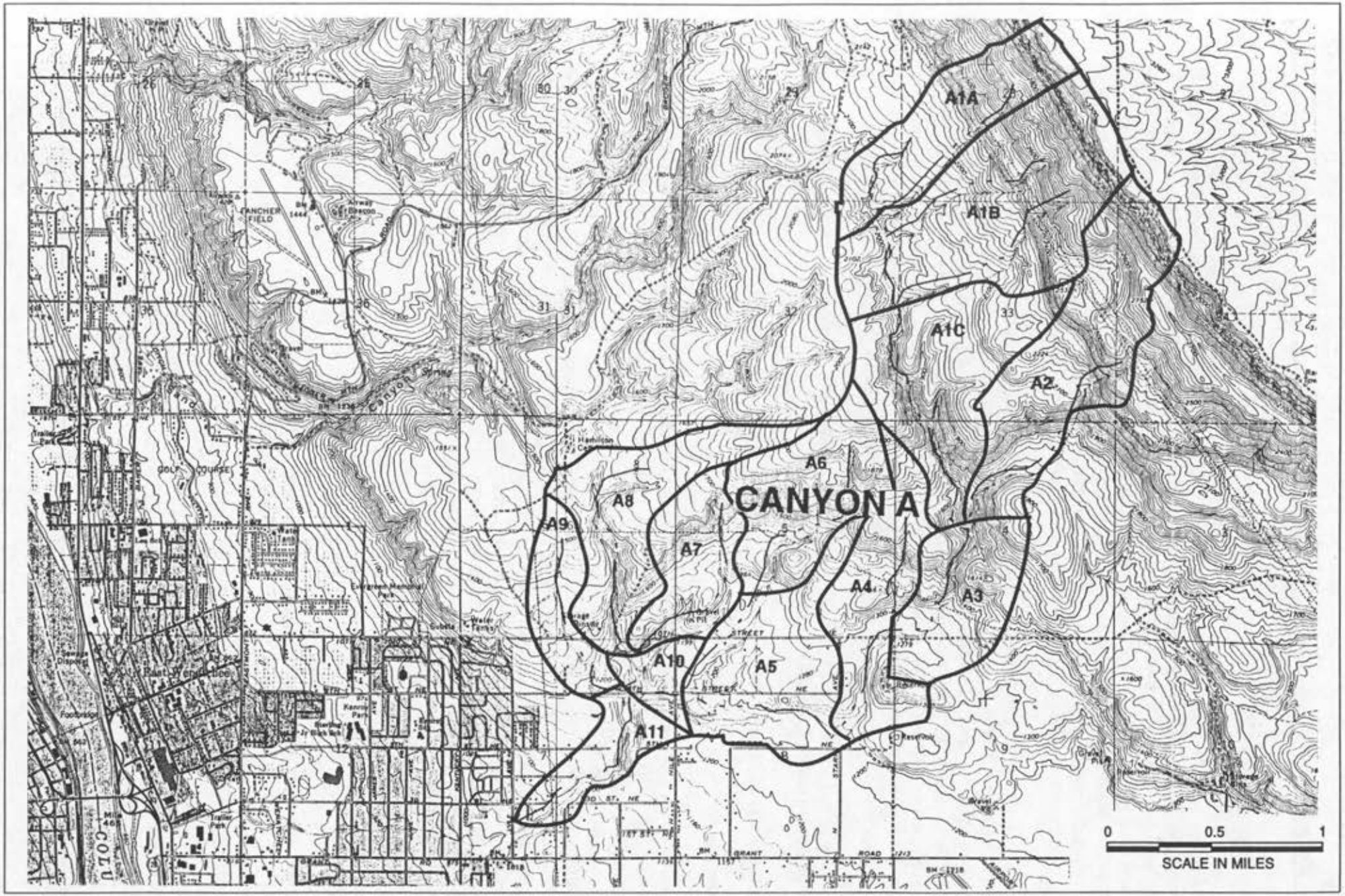


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Figure 6-1.
CANYON A
SUBWATERSHED UNITS

Based on topography and land use, the watershed can be generalized into upper, middle, and lower basins. The upper Canyon A basin (1,940 acres) extends from Badger Mountain to about 5th Street and Stark Avenue, and consists entirely of dry cropland and rangeland. The middle Canyon A basin (1,310 acres) includes the lower foothills above 10th Street down to Lyle Avenue, and consists of a mixture of dry cropland, rangeland, orchards, and suburban residential areas. The lower Canyon A basin (1,000 acres) includes orchard and developed areas along the stream channel between Lyle and Eastmont Avenues, plus the dry cropland area above the 10th Street and North Kentucky Avenue residential area.

Because an alluvial fan separates the upper and middle Canyon A basins, water flowing from the upper basin is assumed to split at this location. Part continues to the middle Canyon A basin and the remainder flows east, out of Canyon A, in a separate drainage towards Rock Island. For modeling purposes it was assumed that the flow splits equally, so that 50 percent of the upper Canyon A flow is removed at this point as a diversion loss. Further analysis of this alluvial fan may be necessary to better quantify the flow patterns, particularly if a proposed development in the drainage east of the fan proceeds.

Because it passes through the East Wenatchee urban area, the lower Canyon A basin was modeled as part of the urban-area storm drainage.

Current Conditions

Land Use

Land uses include cropland, rangeland, orchard, residential, and open urban areas, based on analysis of 1986 aerial photography (DNR 1986). The cropland is used for winter wheat production under a two-year rotation. Soil is tilled and winter wheat is planted in the fall when rains increase the soil moisture. After lying dormant during the winter, the wheat resumes growth in the spring and is harvested in July and August. After harvest, the cropland lies fallow for 12 months to replenish soil moisture levels. During the fallow period the soil remains partially to totally bare, and cover ranges from closely cropped wheat stalks and residue (stubble mulch) to none at all. During the June 1972 flood, soils in the wheat areas above East Wenatchee were fallow, resulting in extensive erosion of croplands and sedimentation in urban areas receiving the runoff. In recent years, some crop areas were allowed to revegetate naturally under the USDA Conservation Reserve Program, which pays farmers $50 per acre to keep land out of production. However, only areas exhibiting high erosion potential are eligible, and the future status of this program is unknown. Most of the cropland immediately above East Wenatchee was in production in 1993.

Rangeland areas consist of undisturbed, sparsely vegetated soils of moderate to high slope. The slope makes these areas unsuitable for dryland crops. These lands are generally not used for livestock grazing and therefore are largely undisturbed. Because they normally occupy small, unvegetated gullies, stream corridors are typically classified as rangeland.

Orchards occupy the terraces between the Badger Mountain foothills and the Columbia River and contain mostly irrigated apple and cherry trees. The fine sandy loam has good hydrologic conditions and a healthy grass cover. Orchard lands in the East Wenatchee area

are under increasing pressure for residential development because of the appeal of the gently sloping land, sunny aspect, and scenic westerly views.

Existing Drainage Facilities

An inventory of Canyon A culverts is detailed in Table 6-2. Data were obtained from surveys conducted by SCS and during this study. The capacities of these culverts were calculated using standard hydraulic methods.

Drainage facilities in Canyon A are limited to road culverts along the stream channel. A road drainage system along Grant Road is separate from Canyon A and does not affect flows in Canyon A. (However, flood flows in Canyon A have historically split at Kentucky Avenue, with a large portion flowing down Grant Road.)

Future Conditions

Assuming maximum buildout allowed under current zoning, existing orchard land and low-density residential land within the Urban Growth Boundary were modeled as residential or commercial land. Outside the Urban Growth Boundary, orchard and rangeland areas currently zoned residential were assumed to develop into low-density residential (Suburban Residential and Suburban Agriculture).

Hydrologic Analysis

A schematic of the HEC-1 model, showing runoff areas, junction nodes, storage locations, and routing reaches is shown in Figure 6-2. Watershed parameters for the HEC-1 rainfall-runoff model of Canyon A and HEC-1 input and output files are are available from Douglas County.

Modeling results from HEC-1 are tabulated for Canyon A in Table 6-3. This table lists streamflows at selected locations for the 10-year, 25-year, 50-year, and 100-year storm events. Figure 6-3 shows current and future 100-year flows at selected watershed locations.

Comparison to Previous SCS Study

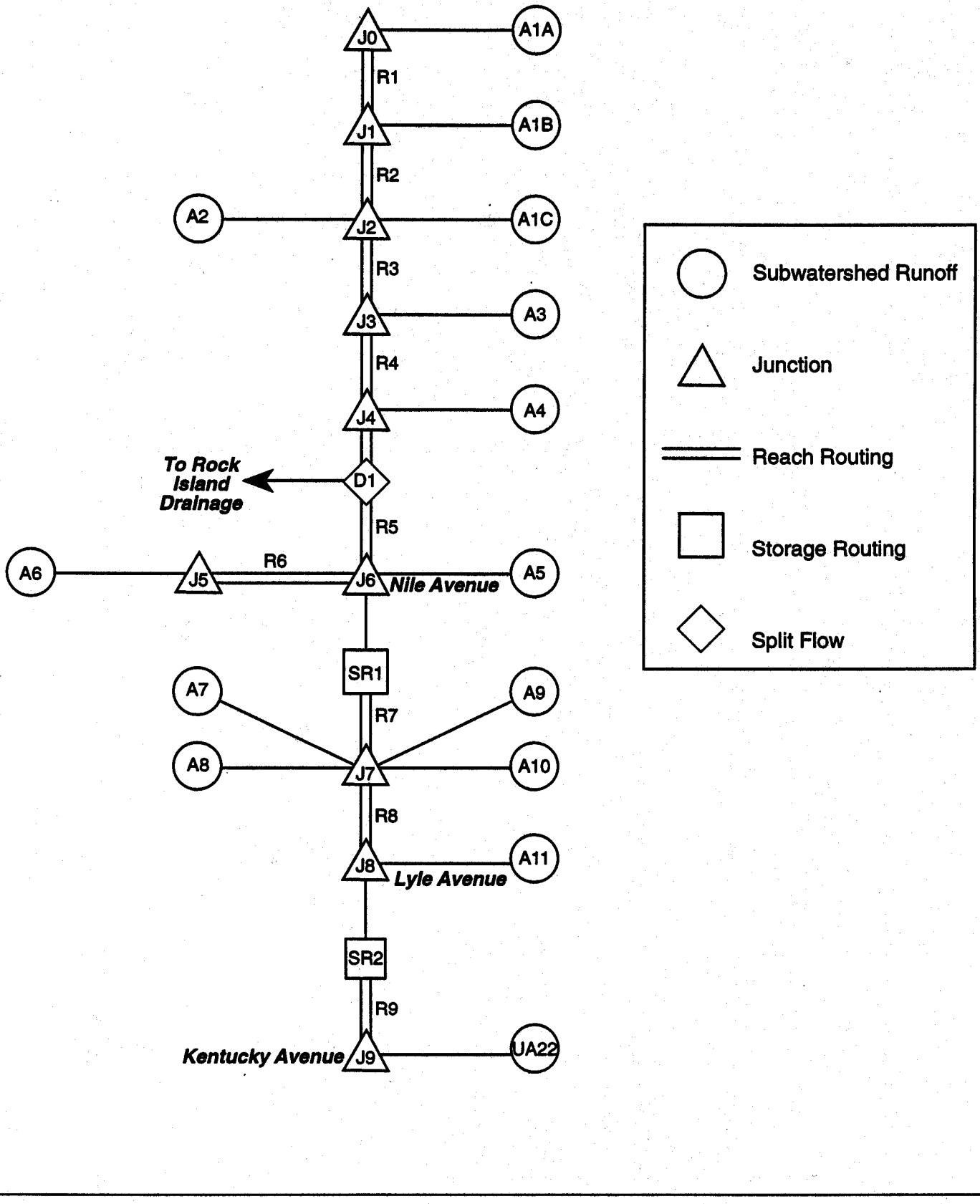
The predicted 100-year flows at Lyle Avenue for future and current conditions are 243 cubic feet per second (cfs) and 271 cfs, respectively. In the 1983 East Wenatchee Watershed Project, the SCS calculated flows of 381 cfs and 485 cfs, respectively, for this same location (SCS 1993). Factors contributing to the difference between the SCS study and this study probably include the following:

- The modeling detail of the upper Canyon A watershed was much lower in the SCS study (four subbasins vs. 13 in this study).

TABLE 6-2.
CULVERT DATA FOR CANYON A, CANYON B, AND SAND CANYON

Location	Culvert Type[a]	Diameter (inches)	Length (feet)	Invert Elevations Inlet (feet)	Invert Elevations Outlet (feet)	Road Elevation (feet)	Upstream Storage (ac-ft)	Capacity (cfs)	Design Capacity 10-year	Design Capacity 25-year
CANYON A										
Eastmont Avenue	CMP	72	60.0	799.5	797.3	805.0	0	115	115	156
Georgia Avenue	CMP arch	36x58	86.0	855.8	853.8	860.7	0	100		
Hanford Avenue	CMP arch	36x58	50.5	886.7	885.9	890.4	0	70		
Iowa Avenue	CMP arch	36x58	50.5	895.1	894.2	898.3	0	75		
James Avenue	CMP arch	36x58	50.3	906.7	905.5	911.5	0	90		
Joseph Avenue	CMP arch	36x58	50.4	919.0	917.3	923.1	0	90		
June Avenue	CMP arch	36x58	50.6	929.8	927.8	934.3	0	85		
Kansas Avenue	CMP arch	36x58	50.5	942.0	941.3	946.3	0	80		
Keller Avenue	CMP arch	36x58	50.3	956.0	954.3	960.0	0	80		
Kentucky Avenue	CMP arch	36x58	60.5	970.19	972.01	977.6	0	90	101	136
	Conc pipe	24	59.0	970.73	971.89					
Lyle Avenue	CMP arch	44x72	48.5	1004.3	1003.7	1014.0	4.0	150	111	172
Nile Avenue near 8th Street	Conc pipe	18	66.5	1146.5	1145.5	1157.7	36.3	70		
	CMCP	24	66.5	1148.0	1146.9					
8th St. 600 ft east of Nile	CMCP	24	70.6	1160.36	1159.56	1169.0	0	30		
8th St. 800 ft west of Nile	CMP arch	36x58	35.3	1137.0	1135.23	1140.3	0	70		
85h St. 2,000 ft west of Nile	CMCP	36	U[b]	1170.57	U	1173.4	0	U		
10th St. at Nile	CMCP	24	50.4	1197.87	1199.12	1200.8	0	6		
10th St. 1,500 ft west of Nile	CMCP	48	94.2	1199.73	1194.34	1205.0	0	95		
10th St. 2,600 ft west of Nile	CMCP	18	U	1294.53	U	1299.3	0	U		
10th St. at Lyle	CMCP	18	U	U	U	U	0	U		
CANYON B										
Cascade Avenue	CMP arch	38x56	66.3	784.95	782.05	790.5	0	110		
Debris Detention Basin	CMCP	72	59.8	957.34	953.51	965.9	4.0	330		
SAND CANYON										
Sunset Avenue (SR 28)	RC Box	60x60	62.8	682.27	681.07	692.0	1.2	320	285	536
19th Street	CMCP	90	97.7	726.3	723.0	737.0[c]	0	500	287	522
Baker Avenue	CMCP	48	121.4	779.09	773.77	799.09	6.1	265	293	539
Eastmont Avenue	CMCP	54	393.0	930.50	918.03	952.5	6.1	290	350	530

a. CMP arch - Corrugated metal arch pipe
Conc pipe - Concrete circular pipe
CMCP - Corrugated metal circular pipe
RC Box - Reinforced concrete box culvert
b. U - undetermined because of buried culvert end.
c. Top of dike elevation.



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-2. CANYON A RUNOFF MODELING SCHEMATIC

TABLE 6-3.
CANYON A, CANYON B, AND SAND CANYON PEAK FLOWS

Watershed and Location	Node[a]	10-Year		25-Year		50-Year		100-Year	
		Current	Future	Current	Future	Current	Future	Current	Future
Canyon A									
Nile Avenue	J6	109	113	180	186	244	251	306	314
Below Nile Avenue	SR1	42	43	53	53	59	60	66	68
Below 8th Street	J7	98	110	155	170	203	219	248	268
Lyle Avenue	J8	95	111	151	173	199	225	245	273
Kentucky Avenue	J9	85	102	120	137	172	217	233	274
Eastmont Avenue[b]	J15	90	111	129	151	181	231	245	296
Valley Mall Parkway[b]	J19	94	122	134	165	188	248	254	319
Canyon B									
Canyon Mouth	J8	198	199	309	310	405	405	493	496
SR 28	J9	192	192	294	295	406	406	496	500
Sand Canyon									
Canyon Mouth	J6	350	350	530	530	682	682	827	827
Eastmont Avenue	SR1	284	285	532	536	685	688	830	833
Baker Avenue	SR2	286	293	529	539	687	705	844	856
19th Street	J10	277	287	504	522	675	698	837	856
SR 28	SR3	265	273	504	522	675	698	837	856
Columbia River discharge	R10	263	272	481	510	658	688	826	845

a. See Figures 6-2, 6-6, and 6-9 for schematics of watershed models. The assumed drainage patterns may change during different storm intensities as capacities of ditches and culverts are exceeded and stormwater flows are forced to follow natural drainages. Flows do not include effect of runoff interception or detention by future storm drain systems. Future conditions assume maximum buildout under current zoning.

b. Flow at Eastmont Avenue and Valley Mall Parkway includes portion that currently leaves channel at Kentucky Avenue and runs down Grant Road.

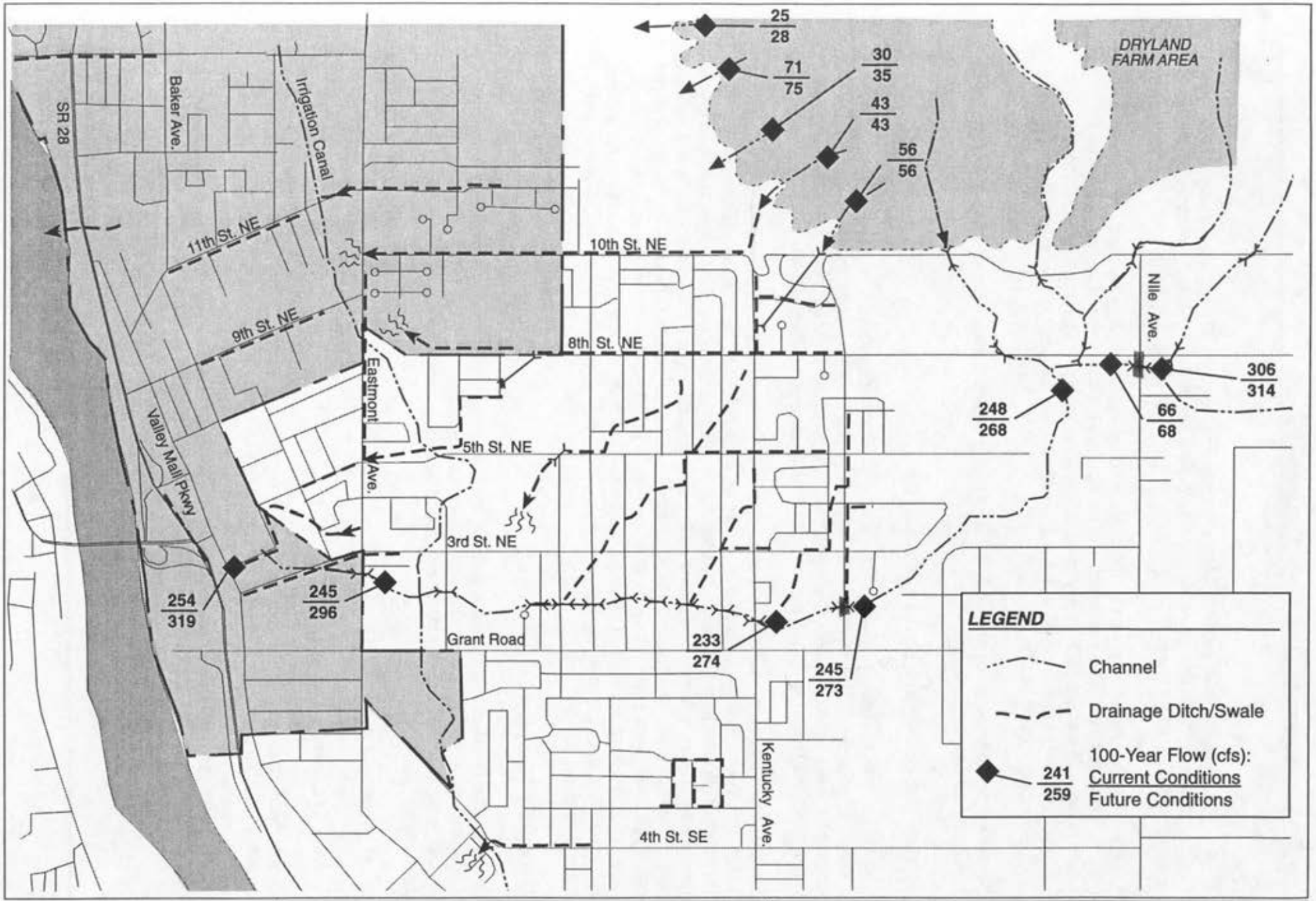


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Figure 6-3.
CURRENT AND FUTURE
100-YEAR FLOWS IN CANYON A

- Diversion of 50 percent of the upper and middle basin flows away from Canyon A at the alluvial fan above 10th Street and Stark Avenue was not considered by the SCS.

- Higher runoff curve numbers were used by the SCS, resulting in higher runoff rates. The composite curve number for the upper Canyon watershed was 81 in the SCS study and 76 in this study. The higher SCS values resulted from use of a 6-hour precipitation hyetograph compared to 24 hours in this study.

Because documentation of the SCS TR-20 models was limited, further analysis of the SCS results could not be performed.

Stream and Floodplain Hydraulic Analysis

The HEC-2 model reach extends from Eastmont Avenue upstream to 10th Street and Perry Avenue (Figure 6-4). The lower end is defined by the East Wenatchee city limits, where the channel ceases to exist, and the upper end is defined by the change in zoning from Suburban Residential to Rural Agriculture (see zoning map, Figure 2-4).

Stream cross-sections and culvert data for the Canyon A reach between Eastmont and Kentucky Avenues were largely derived from data collected by the SCS as part of the East Wenatchee Watershed Project. Additional surveying was conducted in the vicinity of Kentucky Avenue, where flood flows split into two pathways. This flow split was modeled using the Split Flow option in HEC-2 and weir flow relationships were derived from surveyed road data (split flow in this area is controlled by the elevations of Kentucky Avenue and Grant Roads). The remaining cross-sections in Canyon A were derived from the 1"=200', 5-foot contour topographic maps. Modeling results from HEC-2 are available from Douglas County.

Floodplain Mapping

Based on the flood elevations determined by the modeling, 100-year floodplain boundaries in Canyon A were delineated and are shown in Appendix D. The drawings were prepared by scanning recent (1993) aerial photographs and overlaying the floodplain boundaries on the image.

Predicted Flood Problem Areas

Existing Conveyance Facilities

Comparison of predicted flood flow rates along Canyon A (Table 6-3) with culvert design capacities (Table 6-2) indicates that most culverts in Canyon A have capacities for less than the 10-year flood. A 25-year design criterion would be acceptable for road culverts in non-critical locations, but the actual capacities of some culverts are less than those indicated in Table 6-2 because of sediment accumulation within the culvert. Flows predicted for

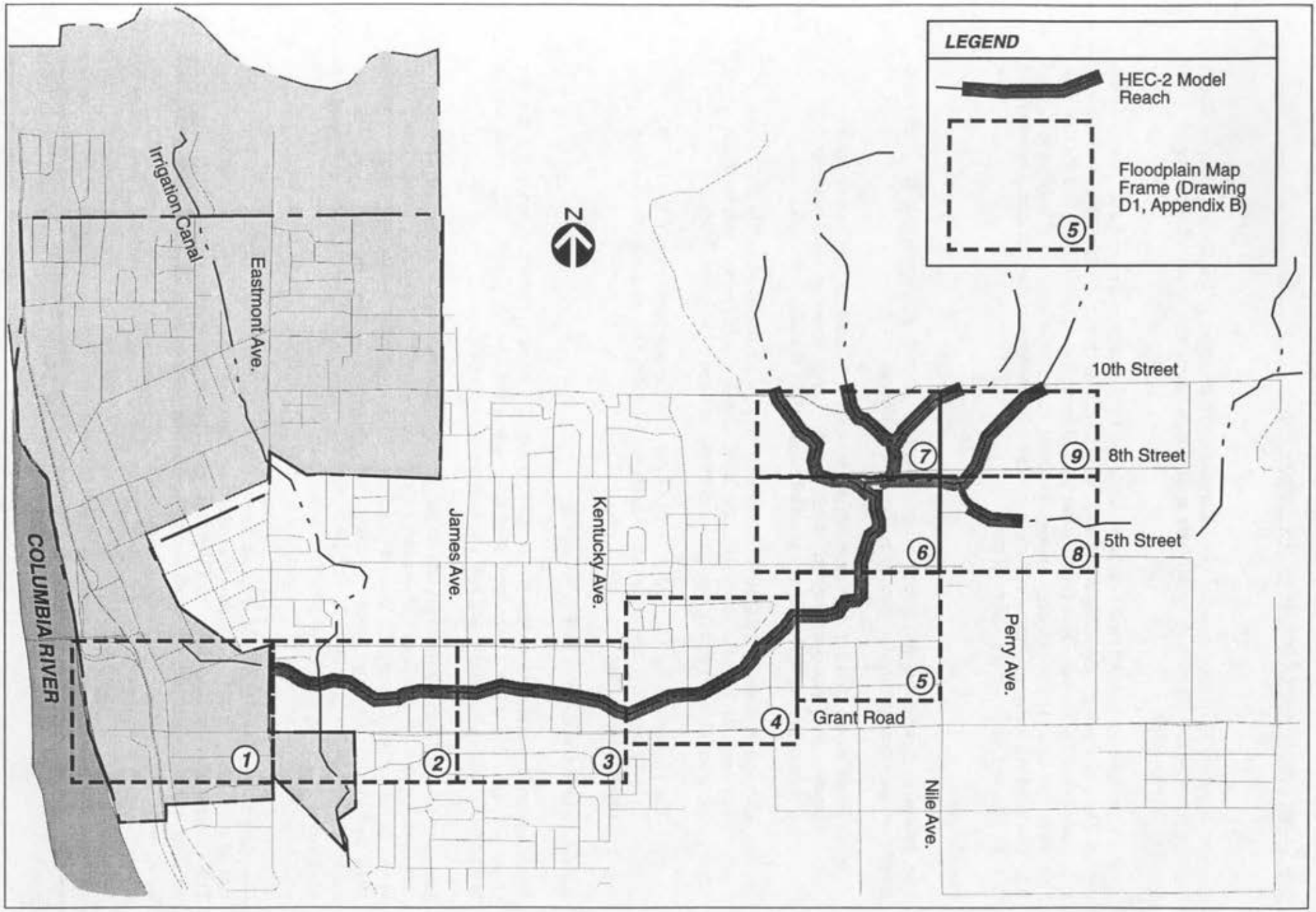

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Figure 6-4.
CANYON A FLOODPLAIN
STUDY REACH

Canyon A below Kentucky Avenue probably were not attained in the 1972 and 1989 floods because most of the Canyon A floodwater splits away from the main channel onto Grant Road at this location.

At the Nile Avenue culvert, the relatively high road fill causes water to pond nearly to the top of the fill during the 100-year flood, effectively creating a detention reservoir of approximately 31 acre-feet. This reduces the peak flow at this location from 230 cfs to 66 cfs. The culvert at Lyle Avenue is large enough to cause only minor detention behind this road fill. The road fill at Lyle Avenue currently creates a 4 acre-foot basin that could be enlarged to 15 to 20 acre-feet by raising the road bed.

Floodplain

The 100-year floodplain for existing conditions is shown in Appendix D. Principal floodplain problems along Canyon A include the following:

- Flood flows diverge at Kentucky Avenue, and a most of the water runs down Grant Road to the Columbia River. Large areas of residential and commercial development are therefore located in the 100-year floodplain.
- Canyon A ends just below Eastmont Avenue, and floodwaters flow down 3rd and 4th Streets to the Valley Mall Parkway. Limited storm drain facilities along the Parkway are inadequate to handle the large flows.
- The culverts along Canyon A below Lyle Avenue can handle only the 10- to 25-year flood. Floodwaters therefore overtop the roadways, causing localized flooding.

ANALYSIS RESULTS FOR CANYON B

The Canyon B watershed encompasses 1,700 acres (2.7 square miles), extending from the crest of Badger Mountain to the mouth of the canyon at Glendale Street. Figure 6-5 shows the primary watershed boundary and the subwatershed units.

The lower watershed boundary ends at SR 28. Runoff from areas below SR 28 was not included because very little additional area contributes runoff to Canyon B below this point. Flood flows currently cross SR 28 and reach the irrigation canal, usually filling the canal with sediment. During major events, flood flows continue through orchards and eventually reach the Columbia River. Because the entire area below Canyon B is located on an alluvial fan, several flow paths radiate from the mouth of the canyon toward the Columbia River. The current Canyon B stream channel follows one of these pathways.

Glendale Street below Canyon B used to experience frequent flooding because the entire runoff from Canyon B flowed down a relatively small ditch along the street right-of-way. The volume of water flowing from Canyon B historically exceeded the capacity of this ditch until its improvement in 1990, with excess floodwater filling the street as a muddy, debris-filled torrent. Much of the runoff eventually flows into the Wenatchee Reclamation District ditch a short distance below the highway (see Chapter 4 for additional discussion of flooding).

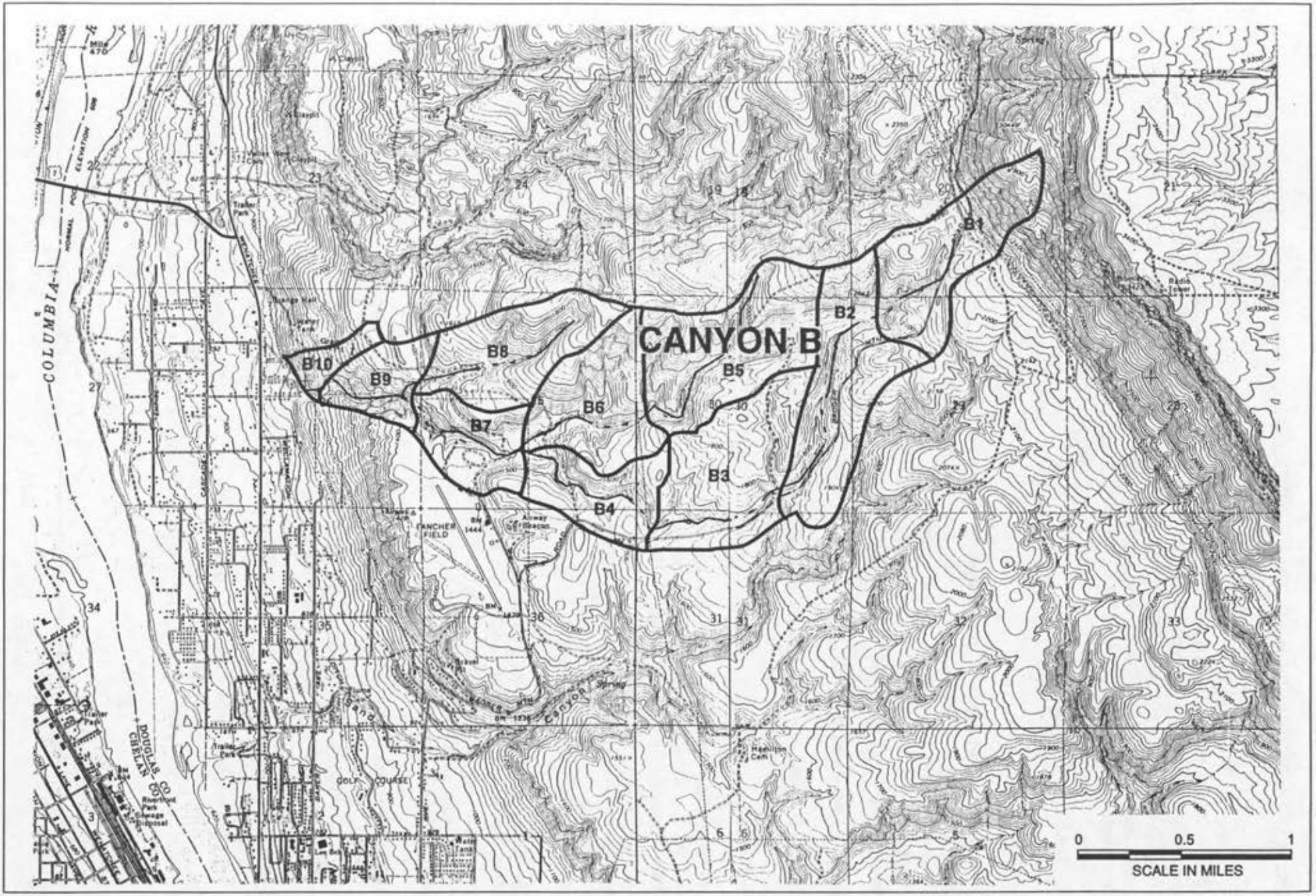

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Figure 6-5.
CANYON B
SUBWATERSHED UNITS

Recently, the County constructed a debris basin at the apex of the alluvial fan and a concrete lined channel running from the debris basin to SR 28. During the May 31, 1993 flood event, the largest since the facilities were constructed, the basin and channel performed as designed. As much as 1,000 cubic yards of sediment was trapped in the basin and flood flows were safely conveyed to SR 28 with no flooding or sedimentation problems.

Current Conditions

Land Use

Land uses in Canyon B include cropland, rangeland, orchard, residential, and open urban areas, based on analysis of 1986 aerial photography (DNR 1986). Canyon B above Glendale Avenue is almost exclusively dry cropland and rangeland. Land use changes abruptly to residential at the mouth of Canyon B. Below SR 28, orchard land is most common, although areas of low-density residential development are becoming common.

Existing Drainage Facilities

Canyon B facilities are inventoried in Table 6-2. Data on culverts, the debris basin, and the concrete channel were obtained from surveys conducted during this study and from design drawings.

Drainage facilities in Canyon B include road culverts at each of the road crossings, a debris basin at the mouth of the canyon, and a 1,500-foot long trapezoidal, concrete-lined channel along Glendale Street ending at SR 28. The debris basin and concrete-lined channel were constructed in 1990 to reduce flood and erosion/sedimentation problems in the Glendale neighborhood. The debris basin was intended to capture coarse sediments, such as gravel and cobbles, that are carried out of the canyon during large flood events. Its very large outlet (72-inch diameter pipe) does not detain floodwaters and reduce peak flows.

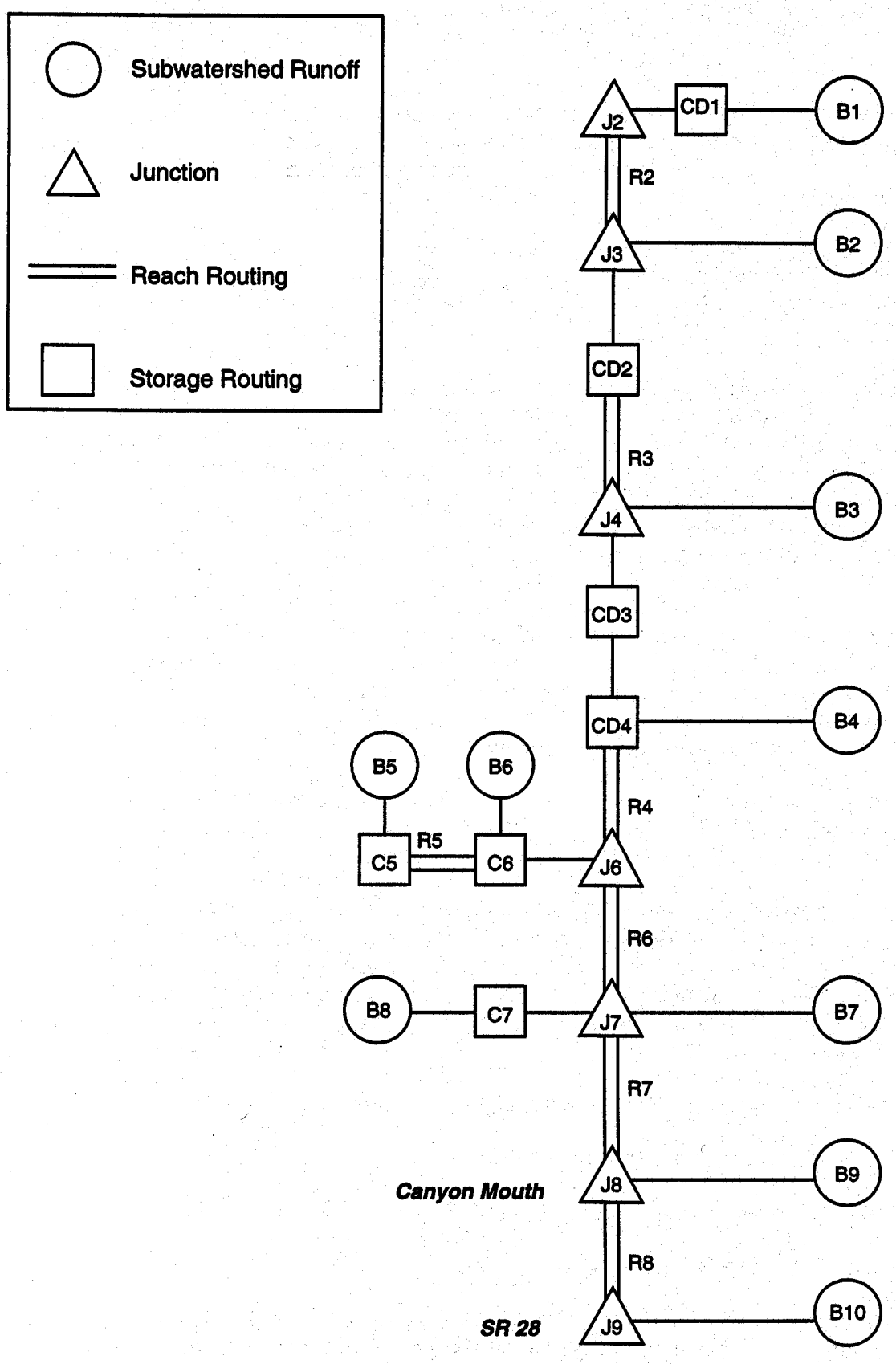
The concrete channel runs along the north edge of the alluvial fan and then turns west to follow the south shoulder of Glendale Street to SR 28. This trapezoidal channel has a shot-crete liner to reduce channel erosion (approximately 4,000 cubic yards of material were eroded from this area during the March 1989 flood). This channel was designed for an approximate 25-year event.

Future Conditions

Future conditions were modeled by changing the land use to reflect potential maximum buildout allowed under current zoning.

Hydrologic Analysis

A schematic of the HEC-1 model, showing runoff areas, junction nodes, storage locations, and routing reaches is shown in Figure 6-6. Watershed parameters for the HEC-1 rainfall-runoff model of Canyon B and HEC-1 input and output files are on file at Douglas County.



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-6. CANYON B RUNOFF MODELING SCHEMATIC

Modeling results from HEC-1 are tabulated for Canyon B in Table 6-3. This table lists streamflows at selected locations for the 10-year, 25-year, 50-year, and 100-year storm events.

Rain-on-Snow Analysis

A rain-on-snow analysis was conducted for the Canyon B watershed using data from the March 11-12, 1989 event, which was the largest snowmelt event in recent history. Runoff from the 1989 rain-on-snow event was compared to runoff from the 100-year rain-only event.

The analysis was performed to determine whether runoff from a rain-on-snow event warrants consideration in the design of drainage facilities and delineation of floodplains. Similar results from the 1989 rain-on-snow event and the 100-year rain-only event would indicate that rain-on-snow runoff is significant and that analysis is required for the 100-year rain-on-snow event (a much greater effort than simulating the 1989 event). If results for the rain-on-snow event were found to be small relative to the rain-only event, a runoff analyses based on rainfall data alone would be adequate to cover any possible rain-on-snow scenario.

Rain-on-snow runoff rates were computed using the Corps of Engineers' standard snowmelt equations (COE 1960). In a subsequent study, these equations were simplified to develop equations that are more applicable to any environment (Hendrick and Filgate, 1971) Two snowmelt equations are typically used: one for snowmelt during rain-free periods, and one for snowmelt during rainstorms.

The two snowmelt equations were used together to estimate the rate of snowmelt for the 48-hour period of March 11-12, 1989. Hourly observations of precipitation, wind speed, air temperature, dew point, and cloud cover were obtained for Pangborn Field (NCDC 1993).

The modeling consisted of estimating hourly snowmelt during the two-day event, combining it with precipitation during this period (0.23 inches over five hours during the night of March 11), then using the HEC-1 model to determine combined precipitation runoff in Canyon B. To be conservative it was assumed that all subbasins had the same maximum snowmelt. Frozen and unfrozen soil conditions were evaluated to check the effect of soil condition.

The analysis determined the following flows at the base of the canyon at Glendale Avenue:

- 1989 simulation assuming unfrozen soil: 150 cfs
- 1989 simulation assuming frozen soil: 183 cfs
- 100-year flow based on rainfall statistics: 500 cfs

This analysis indicates that a major rain-on-snow melt event such as the 1989 event is approximately one-third the magnitude of a 100-year summer thunderstorm event, equivalent to about the 10-year storm. It is unlikely that climatic conditions could change enough to cause much more runoff or that winter rainfall can approach summer levels.

Therefore, it was determined that rain-on-snow runoff events do not present a greater runoff threat than summer thunderstorm events.

Stream and Floodplain Hydraulic Analysis

Figure 6-7 shows the extent of the HEC-2 modeling reach in Canyon B. The model extends from the Columbia River upstream to the debris basin at the mouth of Canyon B. Above this point zoning changes from Suburban Residential to Rural Agriculture (see zoning map, Figure 2-4).

Stream cross-sections and culverts in the vicinity of road crossings were surveyed during this study. Cross-sections were also surveyed along the constructed concrete channel and adjacent roadway along Glendale Street. The remaining cross-sections in Canyon B were obtained from the 1"=200', 5-foot contour topographic maps. Modeling results from HEC-2 are available from Douglas County.

Floodplain Mapping

Based on the flood elevations determined by the modeling, 100-year floodplain boundaries in Canyon B were delineated (Appendix D). The drawings were prepared by scanning recent (1993) aerial photographs and overlaying the floodplain boundaries on the image.

Predicted Flood Problem Areas

Existing Conveyance Facilities

Comparison of predicted flood flow rates along Canyon B (Table 6-3) with culvert and flood channel capacities (Table 6-2) indicates that the debris basin outlet and channel are sized for about the 25-year flood. The debris basin is also sized for the amount of sediment that would accompany the 25-year flood. Floods greater than the 25-year event would overtop the debris basin and cause extensive flooding and debris deposition throughout the alluvial fan.

Floodplain

The 100-year floodplain for existing conditions is shown on Figure D-2. Principal floodplain problems along Canyon B include the following:

- Because the Canyon B flood channel is adequate for only about the 25-year flood, large areas of the alluvial fan would be flooded during larger floods.
- Floodwaters pass over SR 28 and the irrigation canal due to lack of conveyance structures.

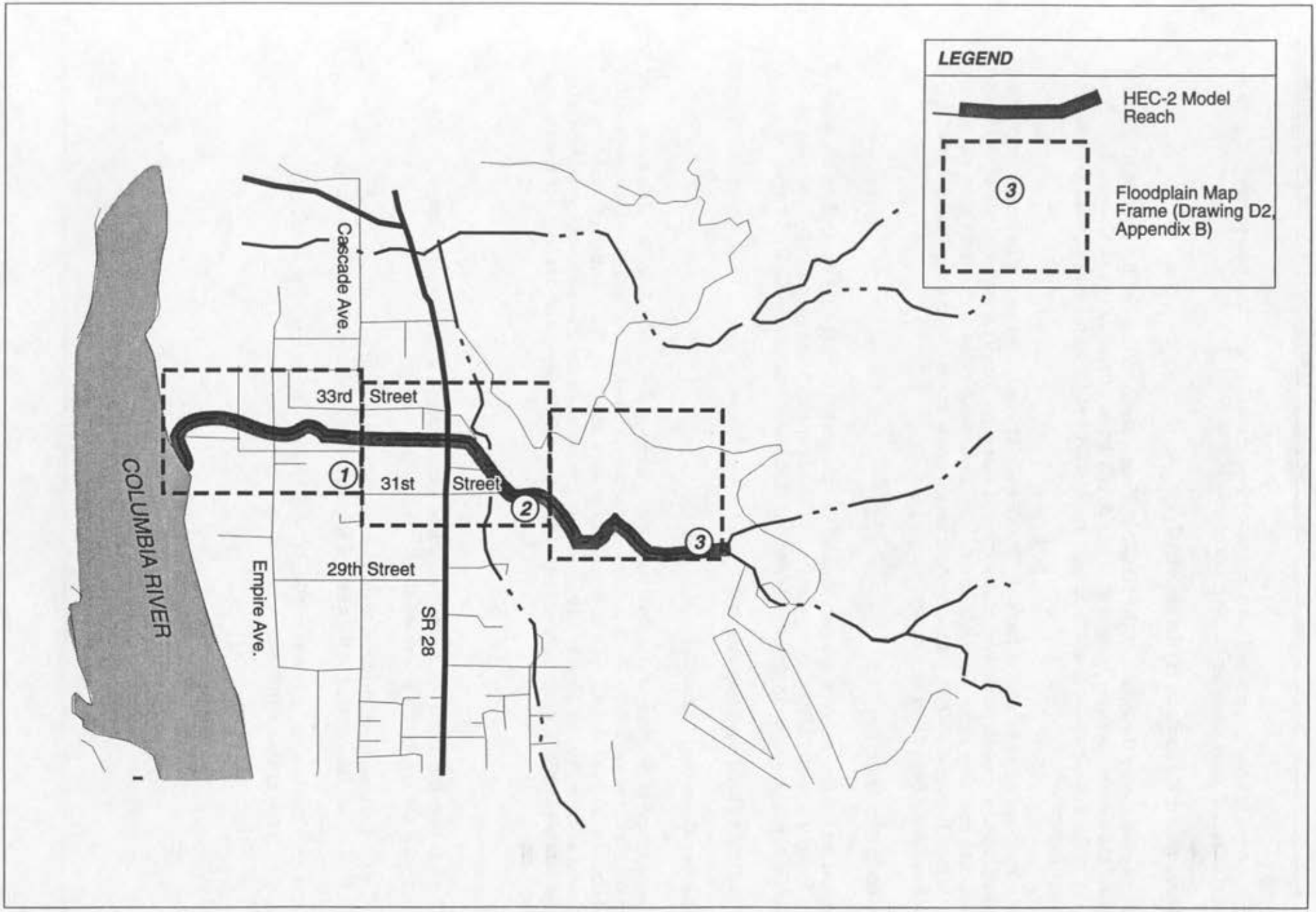


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Figure 6-7.
CANYON B FLOODPLAIN
STUDY REACH

- The 100-year floodplain meanders along a poorly defined pathway through orchards between SR 28 and the Columbia River. A few houses are at risk in the existing floodplain.

ANALYSIS RESULTS FOR SAND CANYON

The Sand Canyon watershed encompasses 2,920 acres (4.6 square miles), extending from just below the crest of Badger Mountain to the Columbia River. Figure 6-8 shows the watershed boundary and the subwatershed units.

Unlike Canyon A and Canyon B, Sand Canyon runoff is confined within a gully through the East Wenatchee area to the Columbia River. The gully is large enough to contain most flood flows, however it does open up near the mobile home park below SR 28 and a residence at 19th Street has been flooded.

Current Conditions

Land Use

Land uses in Sand Canyon include cropland, rangeland, orchard, residential, and open urban areas based on analysis of 1986 aerial photography (DNR 1986). Sand Canyon above Vista View Avenue is entirely cropland and rangeland. Land use becomes orchards as the canyon narrows into a large gully. Land use within the lower Sand Canyon watershed is dominated by the Wenatchee Country Club, fragmented orchard areas, low-density residential development and condominiums east of Baker Avenue on the south side of Sand Canyon.

Existing Drainage Facilities

Drainage facilities in Sand Canyon are limited to road culverts at four road crossings. Due to storage area behind the road fills, several of these crossings act as detention ponds. Culvert data, summarized in Table 6-2, were obtained from surveys conducted during this study.

Future Conditions

Future conditions were modeled by changing the land use to reflect potential maximum buildout allowed under 1993 zoning.

Hydrologic Analysis

A schematic of the HEC-1 model, showing runoff areas, junction nodes, storage locations, and routing reaches is shown in Figure 6-9. Watershed parameters for the HEC-1 rainfall-runoff model of Sand Canyon and HEC-1 input and output files are on file at Douglas County.

Modeling results from HEC-1 for Sand Canyon were summarized in Table 6-3. This table lists streamflows at selected locations for the 5-year, 10-year, 50-year, and 100-year storm events.

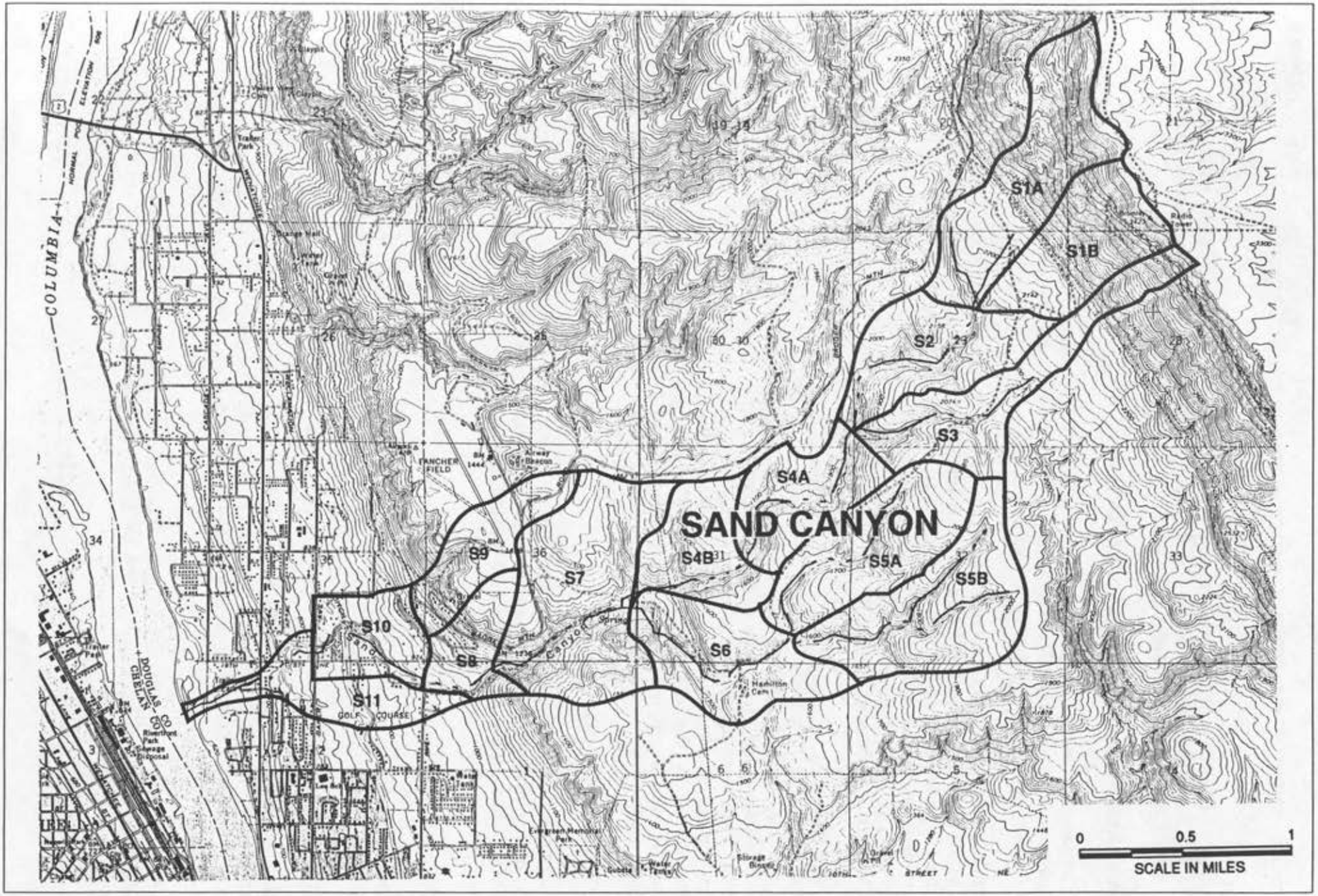

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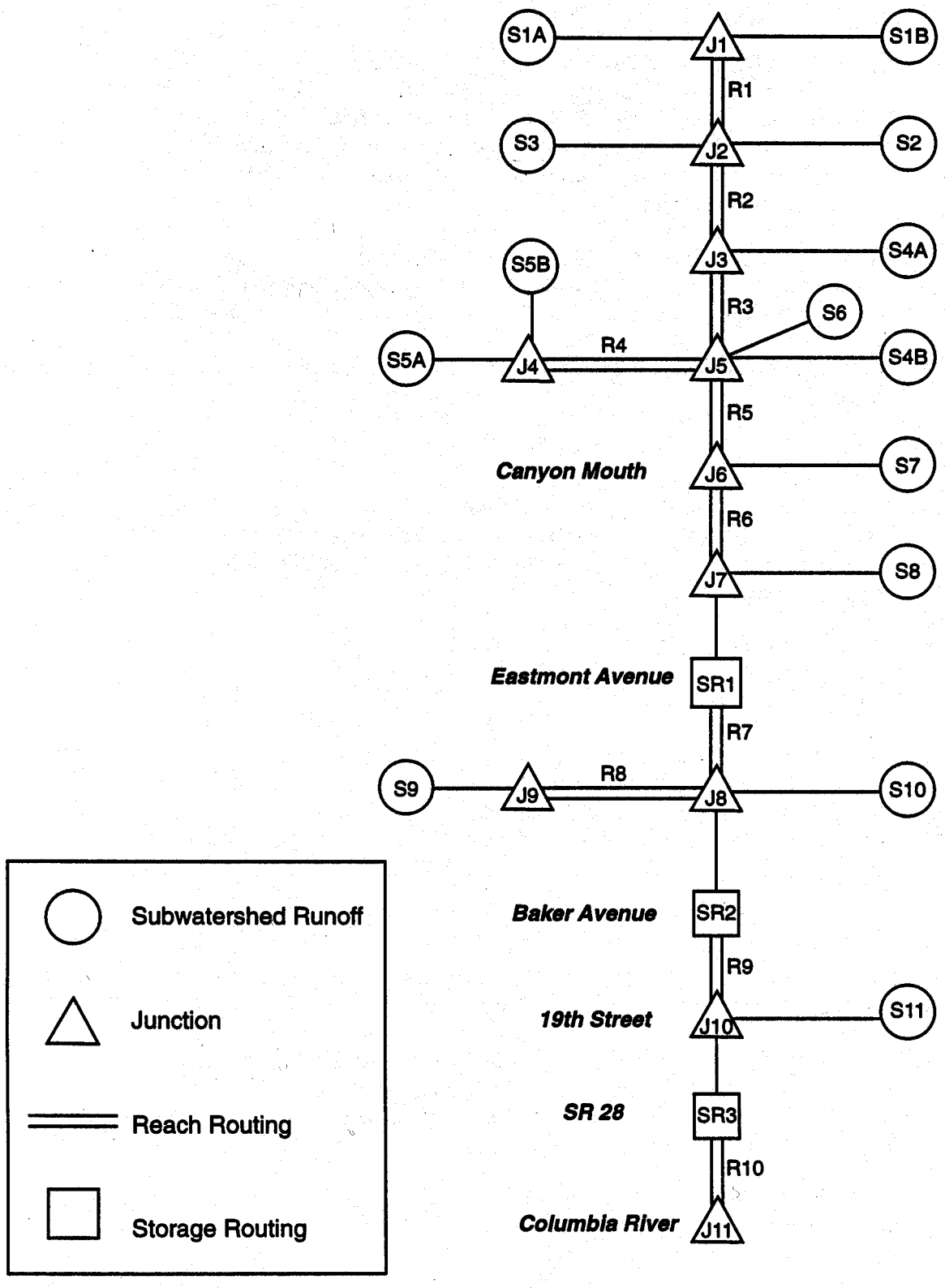
Figure 6-8.
SAND CANYON
SUBWATERSHED UNITS



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-9. SAND CANYON RUNOFF MODELING SCHEMATIC

Stream and Floodplain Hydraulic Analysis

Figure 6-10 shows the extent of the HEC-2 modeling reach in Sand Canyon. The model extends from the Columbia River upstream a short distance into Sand Canyon. The upper end of this reach is defined by the change in zoning from Suburban Residential to Rural Agriculture (see zoning map, Figure 2-4).

Stream cross-sections and culvert data in the vicinity of road crossings were surveyed during this study. The remaining cross-sections between the road crossing and up into Sand Canyon were derived from the 1"=200', 5-foot contour topographic maps.

Modeling results from HEC-2 are available from Douglas County Department of Land and Transportation Services.

Floodplain Mapping

Based on the flood elevations determined by the modeling, 100-year floodplain boundaries in Sand Canyon were delineated and are shown in Appendix D. The drawings were prepared by scanning recent (1993) aerial photographs and overlaying the floodplain boundaries on the image.

Predicted Flood Problem Areas

Existing Conveyance Facilities

Comparison of predicted flood flow rates along Sand Canyon (Table 6-3) with culvert capacities (Table 6-2) indicates that three of four existing culverts are adequate for only the 10-year flood event (the culvert at 19th Street NE can pass the 25-year flood). Floods greater than the culvert's design capacity would overtop the roadway and potentially cause failure of the road fill.

Floodplain

The 100-year floodplain for existing conditions is shown on Drawing D3 in Appendix D. Principal floodplain problems along Sand Canyon include the following:

- The short levee above 19th Street was constructed to keep floodwaters from leaving the otherwise well-defined Sand Canyon channel. However, it is not high enough to fully contain the 100-year flood. It is currently adequate for about a 50-year flood.

- Below SR 28, the channel is located near a trailer park, and mobile homes may be located within the floodplain.

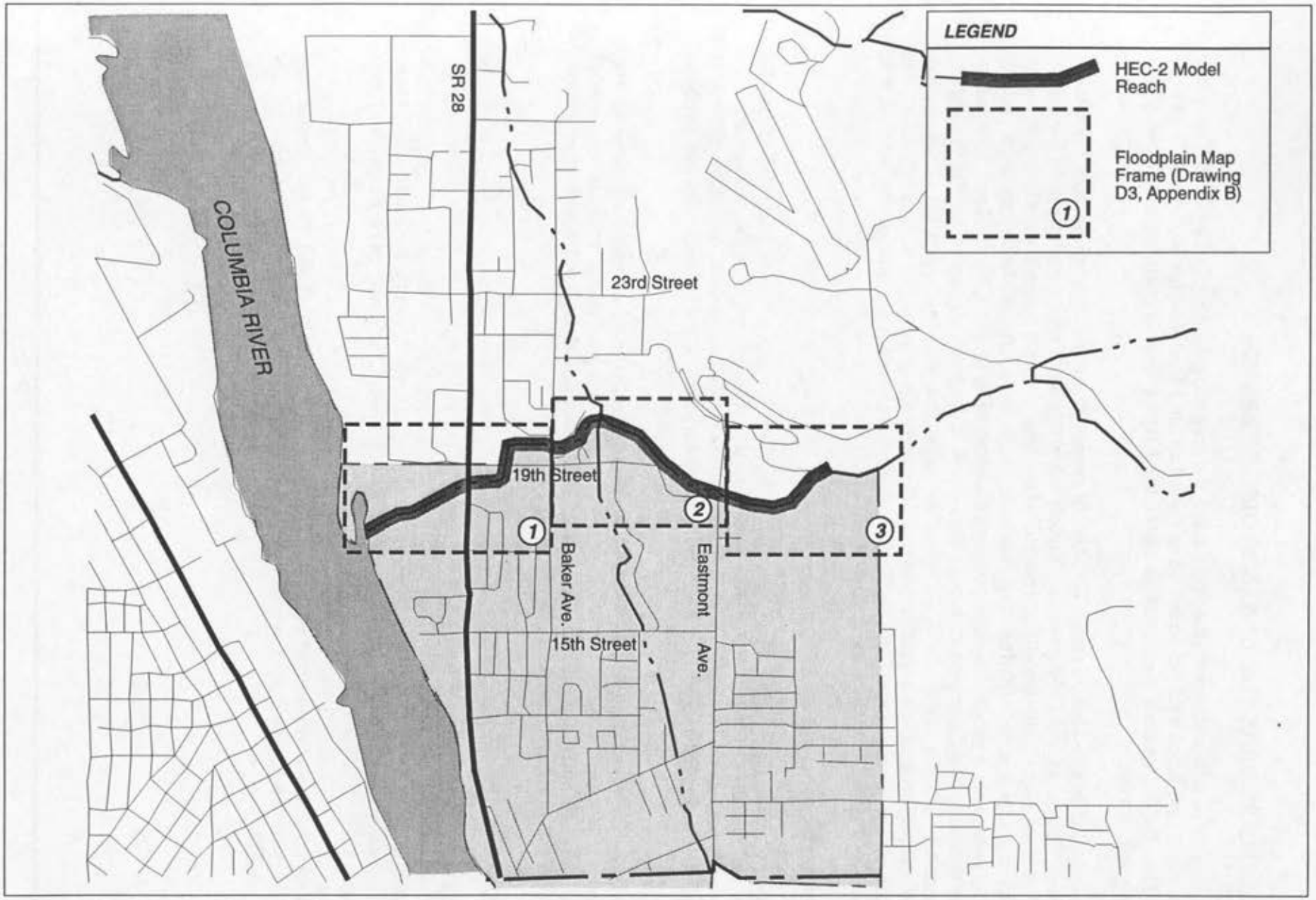


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Figure 6-10.
SAND CANYON FLOODPLAIN STUDY REACH

ANALYSIS RESULTS FOR URBAN STORM DRAINAGE

The analysis of urban storm drainage included the area roughly bounded by Sand Canyon to the north, Grant Road and 4th Street SE to the south, and Lyle Avenue to the east (Figure 6-11). This 2,450-acre area encompasses all of the City of East Wenatchee and most of the County urban area.

Also included in this study area is 375 acres of cropland immediately above East Wenatchee between 15th Street and Lyle Avenue. Runoff from this land flows directly into the urban area, causing significant flooding, and therefore has a direct impact on storm drainage within the urban area. During large storms, much of the runoff from this area follows streets, swales, and other drainage pathways westward into the City of East Wenatchee, rather than into the Canyon A channel. This runoff is largely intercepted by the Wenatchee Reclamation District canal, although when the canal fills with sediment (as it has during major runoff events) it overflows and runoff continues toward the Columbia River. A portion of the urban runoff above Eastmont Avenue eventually makes its way to the Canyon A channel and the City of East Wenatchee.

Modeling Objective

Drainage facilities within the East Wenatchee area are limited and not designed to handle stormwater flows during major floods. To determine the potential magnitudes of stormwater flows under current and future land use conditions, a HEC-1 hydrologic model was developed. The model study determined stormwater flows to help identify problem areas and provide data necessary to solve the drainage problems.

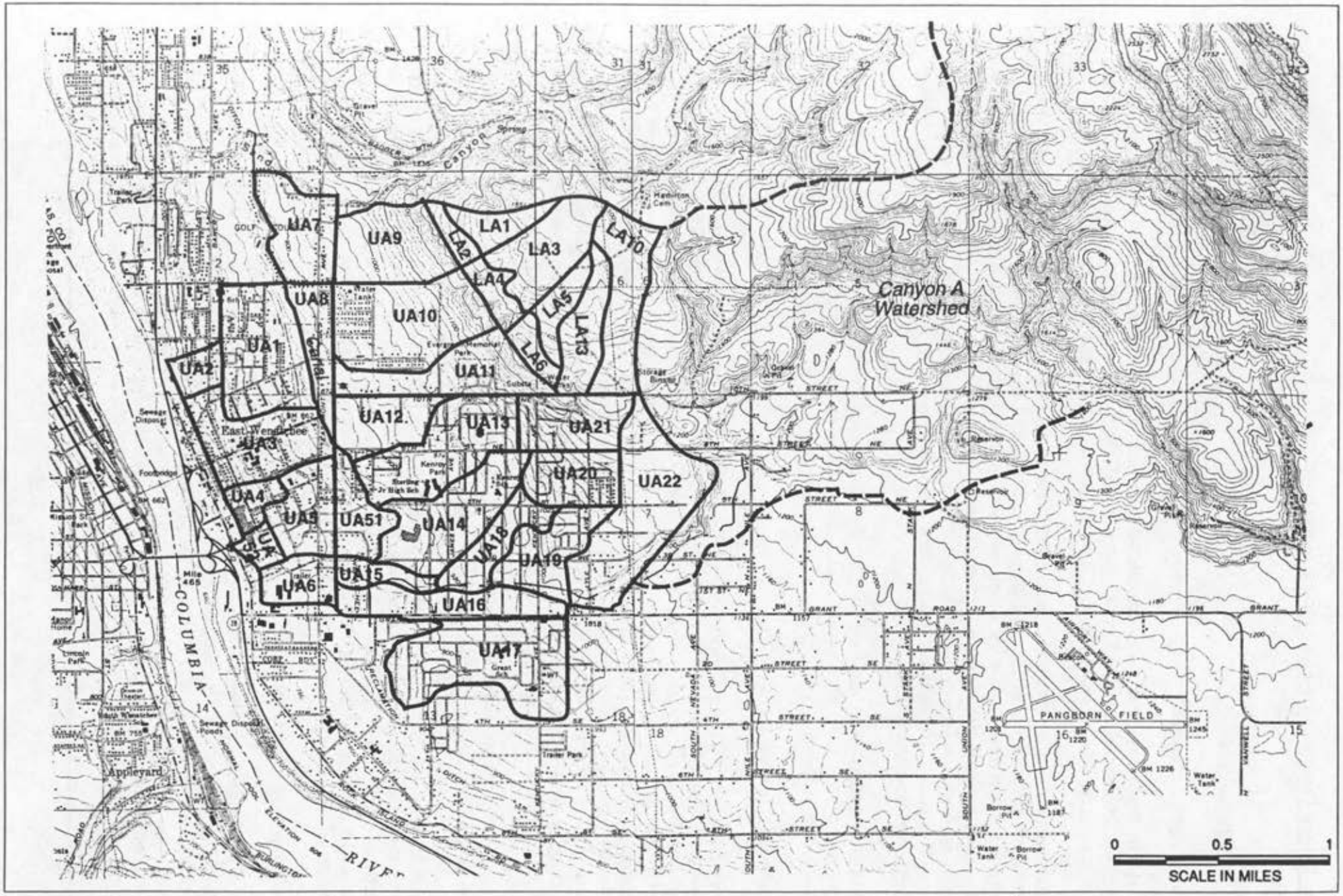
Because HEC-1 is not designed to incorporate specific drainage structures, such as pipes and manholes, a more detailed and focused modeling analysis using a computer model specifically designed for stormwater system analysis should be performed after design concepts for stormwater control are proposed.

Current Conditions

Land Use

Residential density in the East Wenatchee area ranges from 1/5-acre to 2-acre lots. Many open areas are also present, including parks, cemeteries, schools, play fields, and golf courses.

Existing land use was determined from 1986 aerial photography (DNR 1986). Residential density was determined by counting the number of dwellings in a typical area of the watershed.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-11. URBAN RUNOFF MODELING SUBBASIN UNITS

Existing Drainage Facilities

Storm Drain Inventory

A storm drain inventory was conducted to identify and characterize all storm drainage facilities within the City of East Wenatchee and the surrounding urban area. The survey was conducted in cooperation with City and County maintenance staffs.

Facilities included culverts, maintained ditches, catch basins, storm drain pipes, manholes, detention facilities, retention/infiltration facilities, and outfalls. Information was collected over a several-day period by inspecting all known and observed drainage facilities. If available, as-built drawings of street projects and developments were reviewed. Data recorded from the survey included facility locations, pipe diameters, culvert lengths, and type of material. If available, design data such as invert elevations and detention facility sizes were obtained from as-builts.

Data were recorded in the field on 1" = 200' maps and entered into an existing AutoCAD drawing of the East Wenatchee area. The resulting storm drain inventory maps are included as Appendix C.

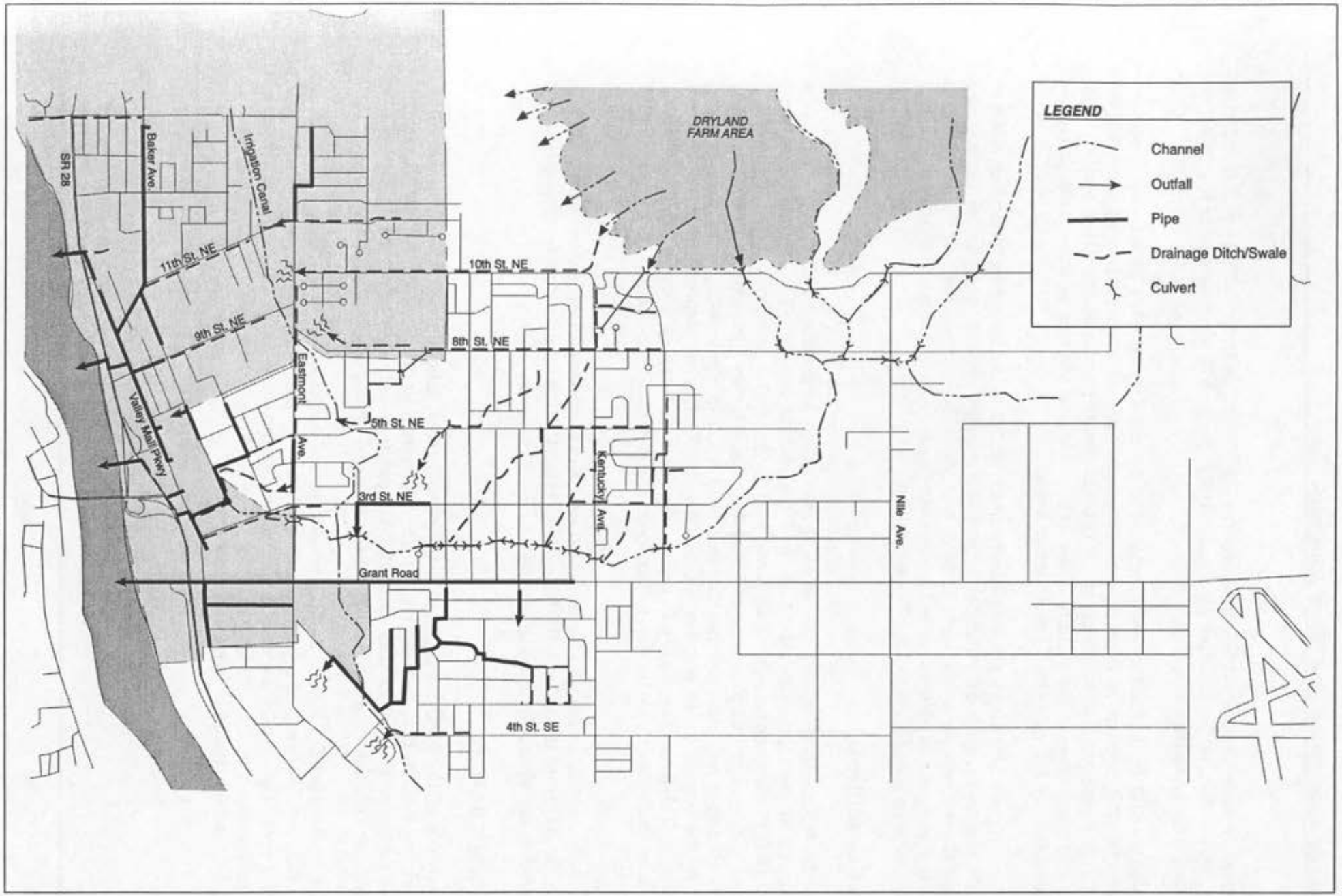
Conveyance Facilities

A generalized map of storm drainage systems and facilities in the East Wenatchee area is shown in Figure 6-12. Above Eastmont Avenue, nearly all storm drainage is conveyed by open ditches and culverts parallel to roadways. During large rainfall events, however, the capacity of the ditches and culverts is sometimes exceeded (or they become plugged with sediment) and stormwater runs diagonally through the neighborhoods, following natural drainage pathways. Most ditches terminate in orchards or fields above the irrigation canal. During large rainfall events, water flows into the canal. With the exception of the Canyon A channel and the Grant Road storm drain, no facilities convey stormwater across the irrigation canal. (See observed flood problem areas discussion in Chapter 4.)

Below Eastmont Avenue and along Grant Road, three separate storm drain systems exist. The Grant Road system begins at Keller Avenue and extends to an outfall on the Columbia River. This system collects drainage from Grant Road, Simon Avenue, and a portion of Rock Island Road. The Baker Avenue system collects drainage from a large portion of the City, including part of the Wenatchee Valley Mall. Its outfall to the Columbia River is north of 9th Street. The Valley Mall Parkway system collects drainage from portions of Colorado Avenue, 5th Street, 4th Street, and the Parkway. This system drains to the State Highway ditch and then to an outfall north of the bridge.

Retention and Infiltration Systems

As of 1988, the City and the County require on-site retention and infiltration in all new developments for the 25-year rain event. The requirement is a condition for development permits, not a part of the subdivision ordinance. In addition to their use in several residential developments, large retention/infiltration systems have been constructed in three commercial developments (Bimart, Safeway, and Top Foods, all along Grant Road) to collect parking lot runoff. However, retention and infiltration systems can be controversial.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-12. EXISTING STORM DRAINAGE FACILITIES AND PATHWAYS IN EAST WENATCHEE AREA

Concerns include siltation of the infiltration beds during major runoff events (rendering some system designs inoperable), responsibility for long-term maintenance of the facilities, and effects on groundwater quality.

A retention and infiltration system constructed by the City at 11th Street and Eastmont Avenue in 1992 consists of three 36-inch diameter, 130-foot long, perforated pipes buried along 11th Street just below Eastmont. It collects runoff from a storm drain serving 12th Street and other areas in the vicinity. The 2,750 cubic foot volume of this retention facility is adequate only for very small precipitation events.

Because they are small and not extensively used, and because modeling objectives did not include the evaluation of potential future stormwater system designs, retention and infiltration systems were not incorporated into the HEC-1 modeling. If the practice of requiring stormwater detention/infiltration continues, future analyses of storm drainage system designs should account for these facilities.

Future Conditions

To model future development conditions, it was generally assumed that all areas would be developed to the maximum extent allowed under 1993 zoning. The dryland crop areas above East Wenatchee between 15th Street and Lyle Avenue present a different situation because the majority of this area is zoned for single-family development. Based on the HEC-1 modeling assumptions, this change would result in a reduction of stormwater runoff because the runoff curve number would drop to 75 (for residential) from 86 (for dry cropland). This land use change is unlikely in the near term, so current land use in this area was maintained to model future conditions because it reflects a greater runoff potential.

The future conditions analysis assumed no new storm drainage systems to convey, detain, retain, or infiltrate urban runoff. Therefore, HEC-1 modeling for future conditions was intended to simulate a worst-case scenario.

Hydrologic Analysis

A schematic of the HEC-1 model, showing runoff areas, junction nodes, storage locations, and routing reaches is shown in Figure 6-13. Watershed parameters for the HEC-1 rainfall-runoff model of the urban area and HEC-1 input and output files are contained in files available at Douglas County Department of Land and Transportation Services.

Modeling results from HEC-1 for the urban area are summarized in Table 6-4. This table lists predicted flow rates at selected locations for the 10-year, 25-year, 50-year, and 100-year storm events. Figure 6-14 illustrates the predicted current and future 25-year storm flows at various locations in the urban area. The 25-year flows are shown because this event is typically used for design of stormwater systems.

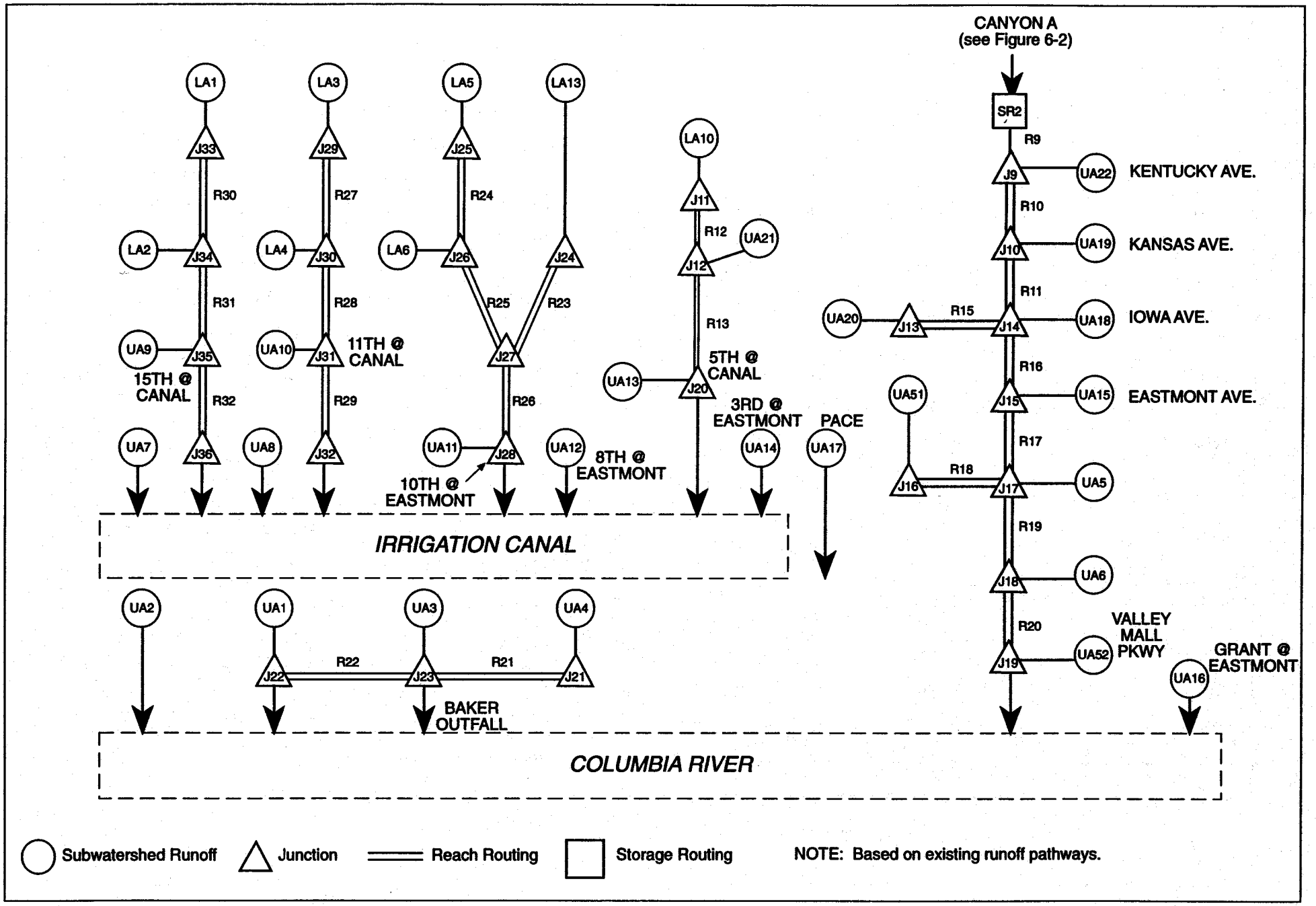


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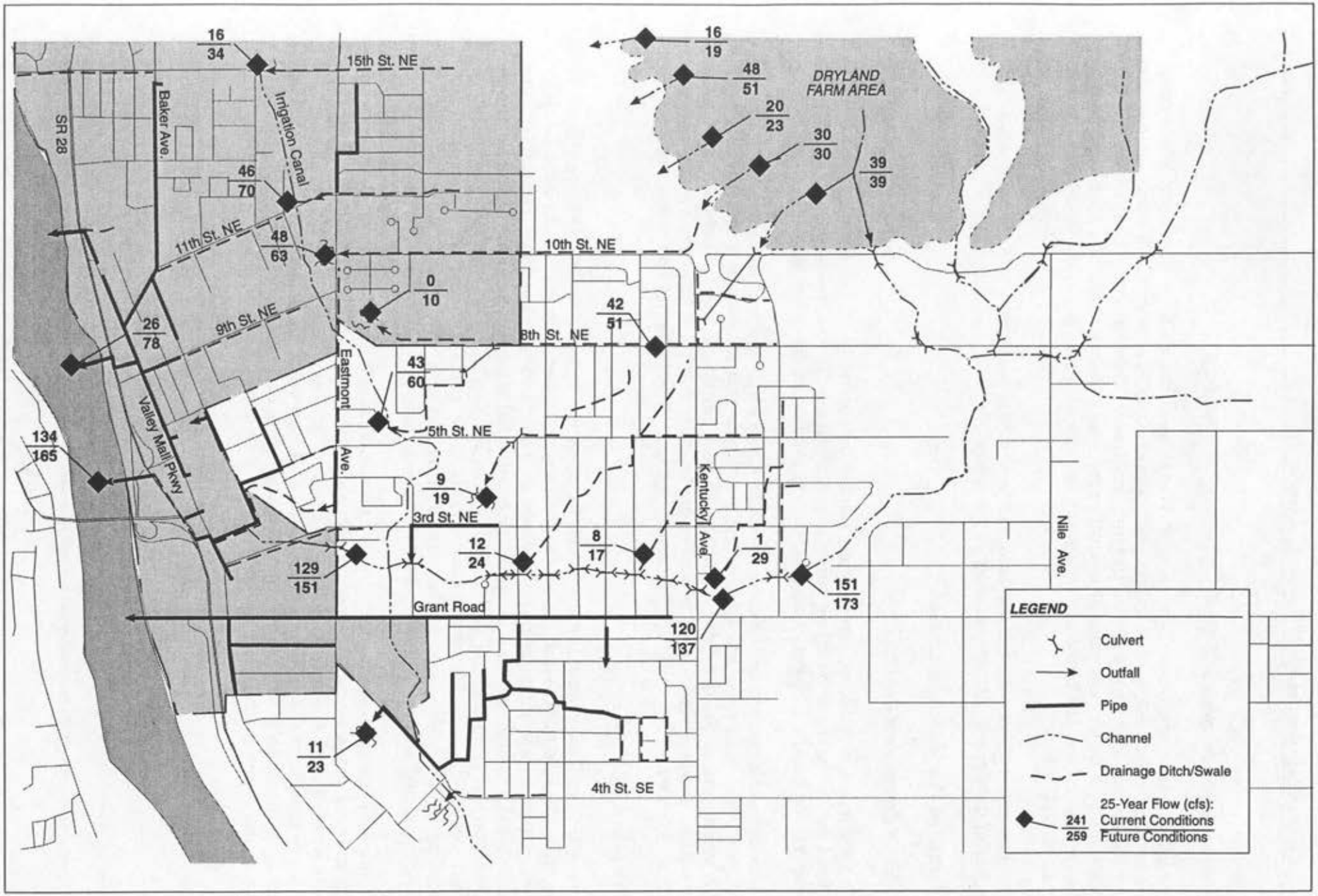
Figure 6-13.
URBAN RUNOFF MODELING
SCHEMATIC

TABLE 6-4.
URBAN STORMWATER RUNOFF PEAK FLOWS (cfs)

Location	Node[a]	10-Year		25-Year		50-Year		100-Year	
		Current	Future	Current	Future	Current	Future	Current	Future
Runoff from croplands	J34	11	13	16	19	21	23	25	28
above East Wenatchee	J30	33	36	48	51	60	64	71	75
between 15th Street and	J26	14	16	20	23	25	29	30	35
Lyle Avenue	LA13	22	21	30	30	37	37	43	43
	LA10	28	28	39	39	48	48	56	56
Kentucky Ave at Canyon A	UA22	0	17	1	29	1	40	3	51
Kansas Ave at Canyon A	UA19	3	9	8	17	12	23	16	29
Iowa Ave at Canyon A	UA18+R15	5	12	12	24	18	33	25	42
15th Street at canal	R32	11	21	16	34	20	46	25	57
11th Street at canal	R29	32	44	46	70	57	92	69	113
10th Street at Eastmont	J28	34	42	48	63	60	80	72	96
8th Street at Keller	J12	28	35	42	51	53	65	64	77
8th Street at Eastmont	UA12	0	5	0	10	0	15	1	21
5th Street at canal	J20	29	39	43	60	55	78	68	95
3rd Street at Eastmont	UA14	4	11	9	19	13	26	18	33
Grant Road at Eastmont	UA16	0	2	1	3	2	5	3	7
Pace Drive at Ridgemont	UA17	5	13	11	23	16	31	21	39
Baker Avenue outfall	J23	16	56	26	78	35	95	44	112

a. See Figure 6-13 for schematics of watershed models. The assumed drainage patterns may change during different storm intensities as capacities of existing ditches and culverts are exceeded and stormwater flows are forced to follow natural drainages. Flows do not include effects of runoff interception or detention by future storm drain systems. Future conditions assume maximum buildout under current zoning.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-14. CURRENT AND FUTURE 25-YEAR STORMWATER FLOWS IN EAST WENATCHEE AREA

Comparison to Previous SCS Study

For the dryland crop areas above East Wenatchee, the SCS in the East Wenatchee Watershed Project estimated a substantially lower runoff value than this study—114 cubic feet per second (cfs) versus 288 cfs (future conditions). This difference is attributed to the SCS's use of a lower peak-rainfall intensity that was patterned after the June 1972 storm. Because the urban-area basins are very small, the rate of runoff is largely determined by the peak-rainfall intensity.

The maximum 30-minute rainfall assumed in the SCS study was 0.45 inches, versus 0.75 inches in the Type II distribution used in this study.

Identified Flood Problem Areas

Existing Conveyance Facilities

Under current conditions, the existing ditches and culverts in the County urban areas would be incapable of handling runoff, from storms with less than a 10-year recurrence interval. To handle a 25-year storm, significant improvements to the system are required.

There is no information on the capacity of the City's existing storm drainage system, so its adequacy was not evaluated. However, it is probable that the system is underdesigned for the magnitude of flows predicted for the 25-year storm. If the assumptions on future conditions become true, and no measures are taken to control stormwater runoff, all areas of the County and City will experience large increases in runoff rates and storm damage.

Floodplain

Areas around East Wenatchee that could be impacted by a 100-year flood are shown in Figure 6-15. This map, which covers the urban area between Canyon A and Sand Canyon, was prepared from a similar map contained in the East Wenatchee Final Watershed Plan (SCS 1983). Similar but less extensive flooding conditions would occur in the suburban areas north of Sand Canyon, such as below Fancher Heights. This map is based on future land use conditions. Historical flood events have not approached the magnitude of flooding shown. However, as demonstrated by the June 1972 event (a 50-year storm), flooding would be severe even under current conditions.

Figure 6-15 illustrates the significance of agricultural runoff that flows into the urban area. Agricultural runoff emanating from several gullies along the base of the foothills combines with urban runoff as it follows streets and natural drainage depressions through the urban area, eventually reaching the Columbia River. Large amounts of sediment, carried from the agricultural areas and eroded from street margins, accompany the runoff but most of it settles out before reaching the river.

LEGEND

- Areas Flooded by 100-Year Storm
- Agricultural Land Runoff

SCALE: 4" = 1 mile (approx.)
SOURCE: SCS 1983
Base map from 1993 aerial photos (Aeromap 1993)

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Figure 6-15.
URBAN FLOODING POTENTIAL DURING 100-YEAR STORM

JAMESON LAKE ANALYSIS

Potential for Additional Flooding

Given Jameson Lake's current high level, a significant runoff event like that of 1989 will cause the lake to rise considerably higher than the outflow elevation, damaging roads that are not much higher than the outlet. Initially, outflow from the lake would be through two 24-inch culverts. Eventually flow will flood the road over the culverts and continue as overland flow. The rate of inflow would be much greater than the rate of outflow, resulting in a temporary but substantial increase in lake level above the outlet elevation.

To determine how high the lake can rise, KCM simulated the effects of the 1989 storm. The analysis assumed a lake elevation before the storm equal to the outlet elevation. This condition will occur if the lake continues its slow rise. The 3,500 acre-feet of water that entered the lake over four days in 1989 corresponds to an average inflow of 440 cfs. The rate of outflow through the culverts would be about 30 cfs. The outflow rate would not equal or exceed the inflow rate until the lake level rises a foot or two above the road elevation. At this point the lake level would stabilize until the inflow subsides. The analysis indicated that the lake would rise to four or five feet above the outlet elevation, or several feet above the road, during an event similar to the 1989 event. This would cause much more damage than occurred in 1989.

Long-time lake resident J.W. Wittig's historical data were used to estimate the amount of runoff entering the lake from a 100-year event (the 1989 event was a 35-year event). The 100-year runoff volume was calculated to be approximately 7,000 acre-feet of water using probability analysis of past lake level rise.

Lake Storage Needed to Contain Runoff

If adequate storage were available, the lake could capture all the runoff from a significant storm and release it at a low rate to prevent downstream impacts. Drainage of accumulated runoff to Moses Coulee could occur at any time after the runoff season via an outlet valve and pipe. A steady outflow during the spring would be of great benefit to wildlife in wetlands that could be created in Moses Coulee below the lake.

At 30 cfs it would take two months to drain the amount of water that flowed to the lake during the four-day 1989 event. If several back-to-back runoff events occurred, as happened in 1959, there would not be enough time to drain the runoff from one event before the next event occurred. Therefore, storage equal to the total annual runoff would be required to assure that all runoff can be contained. A lake level 8 feet below the current outlet elevation would be needed to provide storage for 3,500 acre-feet of runoff, the amount from the 1989 event. To contain runoff from a 100-year storm—7,000 acre-feet—the lake level would have to be 15.5 feet below the current outlet elevation.

CHAPTER 7.
FLOOD PROBLEMS

This chapter summarizes the historical flood problems identified in Chapter 4 and the flood problems predicted by computer modeling as described in Chapter 6. The summary also includes flood problems identified during interviews with County and City maintenance personnel, from information gathered at public meetings during June and July of 1993, and from on-site inspection of existing drainage facilities.

EAST WENATCHEE FLOOD PROBLEMS

Table 7-1 summarizes all identified flood problems in the East Wenatchee area. Locations of the problems are shown in Figures 7-1 and 7-2. Each flood problem is listed as one of the following types:

- Local drainage or floodplain.—Flooding caused by a localized stormwater drainage problem or by activities within the floodplain. Fixing the problem does not necessarily affect downstream flooding.

- Regional drainage or floodplain.—Flooding, generally over a widespread area, caused primarily by a single, dominant drainage or floodplain problem. Fixing the problem helps eliminate or reduce many related flood problems.

- Maintenance or regulatory problem.—Flooding caused by lack of maintenance to prevent plugging of culverts and ditches, by inadequate regulations to control runoff from new developments, or by inadequate building permit review and inspection that allows improperly designed and constructed drainage systems.

Principal Causes of Flooding In East Wenatchee

The principal causes of flooding within the four study areas—Canyon A, Canyon B, Sand Canyon, and Urban Storm Drainage—are highlighted below; most of the flood problem areas can be attributed to a few fundamental causes:

- **Runoff from agricultural lands into urban areas.** Stormwater from approximately 375 acres of dryland wheat farms discharges directly into the urban area of East Wenatchee at several locations. Existing drainage systems, consisting of roadside ditches and culverts, are too small to handle the flows and volumes of sediment.

- **Inadequate urban stormwater drainage system.** The East Wenatchee urban area does not have an integrated system to intercept, convey, and dispose of stormwater. Most ditch systems above Eastmont Avenue currently drain to open fields or the irrigation canal. Below Eastmont, the existing system is undersized and cannot be expanded to serve other flood-prone areas. Continued flooding and future development will require new systems to handle the stormwater.

TABLE 7-1.
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]		
		Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
CANYON A				
1. Canyon A	Uncontrolled runoff from large drainage area above East Wenatchee flows through urban area.			Runoff from upper basin enters urban area
2. Canyon A at 5th Street and Stark Avenue (alluvial fan)	Runoff from upper canyon divides: part going to East Wenatchee and contributing to urban flooding and part going to Rock Island where future development is proposed.			Runoff from upper basin enters urban area
3. Canyon A at Lyle Avenue	Floodwaters overtop the roadway during major storms. Culverts currently plugged with sediment.	Plugged drainage culverts and ditches	Culverts too small for 100-year flood	Runoff from upper basin enters urban area
4. Canyon A at Kentucky Avenue	During major storms most Canyon A floodwater flows down Grant Road, severely flooding many homes and businesses.		Urban encroachment and lack of suitable drainage channel	Runoff from upper basin enters urban area
5. Canyon A between Kentucky and Hanford Avenues	Homes were constructed in the floodway and encroach on the channel. These homes risk severe flood damage, particularly if floodwaters are prevented from flowing down Grant Avenue.		Urban encroachment and lack of suitable drainage channel	Runoff from upper basin enters urban area
6. Canyon A in Eastmont County Park	Canyon runs through residential properties on Green Place.		Urban encroachment and lack of suitable drainage channel	Runoff from upper basin enters urban area
7. Canyon A at Third Avenue	The channel disappears at 3rd Avenue. Floodwater flows down 3rd or 4th Avenue to Valley Mall Parkway.		Absence of drainage channel through East Wenatchee	Runoff from upper basin enters urban area
8. Canyon A at Valley Mall Parkway	Floodwater is drained by a few street catch basins that lead to undersized culverts and ditches along SR 28, resulting in flooding of the Parkway and risk of flood damage to businesses.		Absence of drainage channel through East Wenatchee	Runoff from upper basin enters urban area

TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]		
		Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
CANYON B				
9. Canyon B	Uncontrolled runoff from large drainage area flows through residential and orchard areas.			Runoff from upper basin enters urban area
10. Canyon B above Glendale Street	Erosion and landsliding can result in large volumes of sediment, and possibly debris flows.		Unstable soils and debris flow potential in upper canyon.	Runoff from upper basin enters urban area
11. Canyon B flood channel and alluvial fan	Recently constructed flood channel is only adequate for the 25-year flood. The 100-year floodplain covers most of the alluvial fan.		Undersized drainage channel limited to 25-year capacity.	Runoff from upper basin enters urban area
12. Canyon B at SR 28 and Irrigation Canal	Flood channel along Glendale Street ends at the highway. No facilities exist to transport floodwaters across highway and irrigation canal.		Lack of highway/canal crossing	Runoff from upper basin enters urban area
13. Canyon B from SR 28 to the Columbia River	Flood pathway is not readily apparent and a floodway has not been designated in this area. A few homes are at risk and there are no restrictions against future development.		Undefined floodway/flow path in orchard area	Runoff from upper basin enters urban area
14. 32nd and Fir Avenue	Localized drainage problem where Canyon B crosses Fir Street, Empire and Cascade Avenues.		Culverts too small for 100-year flood. Current capacities range between 10- and 25-year flood.	Runoff from upper basin enters urban area
SAND CANYON				
15. Sand Canyon	Uncontrolled runoff from large drainage area flows through urban area.			Runoff from upper basin enters urban area
16. Sand Canyon between Eastmont Avenue and SR 28	Undersized culverts convey less than the 25-year flood. Higher floods could cause significant damage.		Culverts too small for 100-year flood	Runoff from upper basin enters urban area

TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]: Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
SAND CANYON				
17. Sand Canyon at 19th Street	Short levee embankment above 19th Street protects adjacent property to about the 50-year flood level. Higher floods could cause significant damage.		Undersized drainage channel and urban encroachment	Runoff from upper basin enters urban area
18. Sand Canyon at Mobile home park below Highway 28	Channel is poorly defined in this area.		Undersized drainage channel and urban encroachment	Runoff from upper basin enters urban area
19. Sand Canyon at Highway 28	Flow through culvert is controlled by weir that diverts water to irrigation ditch. Requires specific action to allow flood flow to pass downstream.		Culverts too small for 100-year flood	Runoff from upper basin enters urban area
URBAN AREA - NORTH OF 19th STREET NE				
20. Fancher Heights subdivision	Severe flooding and erosion occurred during May 31, 1993 storm on 23rd Street when dry well at base of Monument Place failed and runoff flowed down hillside.	Review adequacy of design criteria for runoff control in new developments	Drainage facilities are too small to prevent flooding during major rainfall events	New development caused increased runoff and downstream flooding
21. Badger Mountain Road	Poor drainage causes roadside erosion above and below Fancher Heights. Unsuitable sandy soil was used to backfill ditches.	Review adequacy of existing maintenance practices		Uncontrolled drainage into urban area
22. Ski View Drive, Vista View Drive, Valley View Blvd., 21st Street, and Devon Avenue	Stormwater and sediment from Badger Mountain Road flows over roads and onto residential properties.		Drainage facilities are too small to prevent flooding during major rainfall events	Uncontrolled drainage into urban area

TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]: Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
URBAN AREA - NORTH OF 19th STREET NE				
23. Autumn Drive	Runoff from Autumn Drive, Autumn Place, Baker Avenue, and 21st Street collects at one drain. Drainage system required by building permit for Autumn Place development was never built.	Review adequacy of procedures for design review, inspection, and enforcement of building permits.	Drainage facilities are too small to prevent flooding during major rainfall events	
URBAN AREA - 19TH STREET NE TO GRANT ROAD (ABOVE CANAL)				
24. 10th Street and Lyle Avenue	Runoff from croplands flows into residential area. Existing culvert diverts water to 8th and Kentucky.			Uncontrolled stormwater runoff from area enters urban area
25. Lyle Avenue between 5th and Glen Streets	Runoff from croplands flows into residential area.			Uncontrolled stormwater runoff from area enters urban area
26. 10th Street below Kentucky Avenue	Runoff from cropland runs down 10th Street, causing erosion and flooding. Previous ditch repair failed to control ditch erosion.	Review adequacy of existing maintenance practices.	Drainage facilities are too small to prevent flooding during major rainfall events	Uncontrolled stormwater runoff from area enters urban area
27. Residential area bounded by Lyle and James Avenues and 5th and 10th Streets	Runoff from croplands impacts numerous homes in this area. Ditches along Keller and Jennifer Avenues are too small to carry runoff to 8th Street.	Plugged culverts and ditches	Drainage facilities are too small to prevent flooding during major rainfall events	Uncontrolled stormwater runoff from area enters urban area
28. 8th Street at Kentucky Avenue	Runoff from above 8th and Kentucky flows into under sized culverts and ditch along 8th Street,	Plugged culverts and ditches	Drainage facilities are too small to prevent flooding during major rainfall events	Uncontrolled stormwater runoff from area enters urban area

TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]: Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
URBAN AREA - 19TH STREET NE TO GRANT ROAD (ABOVE CANAL)				
29. 8th Street to Ella Street, Grover Place, and Garten Court	Stormwater from 8th and Kentucky flows down 8th Street in undersized ditch and empties into irrigation canal at 5th Street. Houses are flooded along Ella and Grover.	Plugged culverts and ditches	Drainage facilities are too small to prevent flooding during major rainfall events; no designated facility or outfall to receive runoff; no facilities to convey stormwater across canal	Uncontrolled stormwater runoff from area enters urban area
30. 10th Street at Eastmont Avenue	Drainage at 10th Street and Eastmont empties into orchard below Eastmont, where it infiltrates or flows into irrigation canal. This orchard may eventually be developed.		No designated facility or outfall to receive runoff; no facilities to convey stormwater across canal	Uncontrolled stormwater runoff from area enters urban area
31. 11th Street at Eastmont Avenue	Stormwater from croplands and subdivisions reaches 11th and Eastmont, and then flows down 11th into canal and City.		No designated facility or outfall to receive runoff; no facilities to convey stormwater across canal	Uncontrolled stormwater runoff from area enters urban area
32. Manhattan Square development	Development blocked natural drainage pathway. Pipe diameter decreases from 21" to 14".	Review adequacy of procedures for design review, inspection, and enforcement of building permits.		
33. Reclamation District canal	Stormwater and sedimentation causes major damage to canal at 5th, Glendale, and 35th Streets, and minor damage at most other road crossings		No facilities to convey stormwater across canal	Uncontrolled stormwater runoff from area enters urban area

TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]: Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
URBAN AREA - 19TH STREET NE TO GRANT ROAD (ABOVE CANAL)				
34. NE Mary at 1st, Astor between 15th and 17th, Gormley Street at Grover Avenue	Localized drainage problem areas.		Drainage facilities are too small to prevent flooding during major rainfall events	
URBAN AREA - 19TH STREET NE TO GRANT ROAD (BELOW CANAL)				
35. Eastmont Avenue between 3rd and 4th Streets	Stormwater from ditch along Eastmont between 5th to 10th Streets empties into a pasture below Eastmont. This water continues to 5th and Baker and then to Valley Mall Parkway.		Drainage facilities are too small to prevent flooding during major rainfall events; no designated facility or outfall to receive runoff.	
36. 3rd, 5th, 9th, 11th, 13th, 15th and 19th Streets below Eastmont Avenue	Roadside erosion and flooding.		Drainage facilities are too small to prevent flooding during major rainfall events	
37. Baker Avenue and Valley Mall Parkway storm drain systems	Valley Mall Parkway system cannot handle combined local urban runoff and Canyon A flows. Capacity of systems are unknown.		Drainage facilities are too small to prevent flooding during major rainfall events	Uncontrolled runoff from agricultural area entering urban system
URBAN AREA - SOUTH OF GRANT ROAD				
38. South Iowa at 4th Street	Drainage from residential area creates flooding problems where ditch ends.		Drainage facilities are too small to prevent flooding during major rainfall events	

TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]		
		Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
URBAN AREA - SOUTH OF GRANT ROAD				
39. 2nd, 3rd, and 4th Street S.E. at Karry Avenue	Residential area has poor drainage.		Drainage facilities are too small to prevent flooding during major rainfall events	
40. S. Iowa at S. 1st Street and Tedford Street	Existing storm drains are ineffective, causing local flooding.		Drainage facilities are too small to prevent flooding during major rainfall events	
41. Keller Street at Kent Place	Low point collects runoff from several streets, but no drain exists to carry water away.		Drainage facilities are too small to prevent flooding during major rainfall events	
42. Jarvis at 2nd, Houston at 2nd, Lyle at SE 6th	Localized drainage problem areas.		Drainage facilities are too small to prevent flooding during major rainfall events	
43. Rock Island Road near SE 8th Street	Runoff flows over Rock Island Road.		Drainage facilities are too small to prevent flooding during major rainfall events	
44. Runoff from Fancher Field into Canyon B	Runoff from the air field and gun club drains via a ditch to Canyon B. Surge of water from ditch may have contributed to 1989 flooding.		Drainage facilities are too small to prevent flooding during major rainfall events	
45. Gormley Street at Grover Avenue	Streets have inadequate drainage facilities, plus runoff from agricultural areas enters residential streets.		Drainage facilities are too small to prevent flooding during major rainfall events	Uncontrolled stormwater runoff from agricultural area enters urban area

TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]: Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
URBAN AREA - SOUTH OF GRANT ROAD				
46. Ski View Drive, Vista View Place	Stormwater from Ski View and Vista View discharges from large culvert into poorly designed and undersized half-pipe. Overflow floods house below.	Review adequacy of procedures for design, review and enforcement of drainage standards	Drainage facilities are too small to prevent flooding during major rainfall events	
47. Fire station lot above Eastmont Avenue between 4th and 3rd Streets.	Stormwater from residential streets above fire station drains into parking lot. Conveyance of this water through property was not considered in fire station design.	Review adequacy of procedures for design, review and enforcement of drainage standards	Drainage facilities are too small to prevent flooding during major rainfall events	
48. S. Mary at Alice Place	Runoff from S. Mary and Alice Place causes local flooding.		Drainage facilities are too small to prevent flooding during major rainfall events	
PALISADES AREA OF MOSES COULEE				
49. Moses Coulee	Runoff from snowmelt and rainfall causes flooding of Moses Coulee valley bottom.			Farmland, homes, and county roads can all be under water
50. Between Douglas Creek and Palisades	Channel capacity of Douglas Creek is insufficient.			Channel not sufficient for annual flood events
51. Palisades Road	Palisades Road is damaged during flood events, preventing emergency access.			Roadway located in low portion of valley and, in many places, next to the creek
52. Base of Douglas Canyon	Sediment is deposited at base of Douglas Creek Canyon and farmlands are lost.		Increased runoff causes large amounts of sediment from upper Douglas Creek	

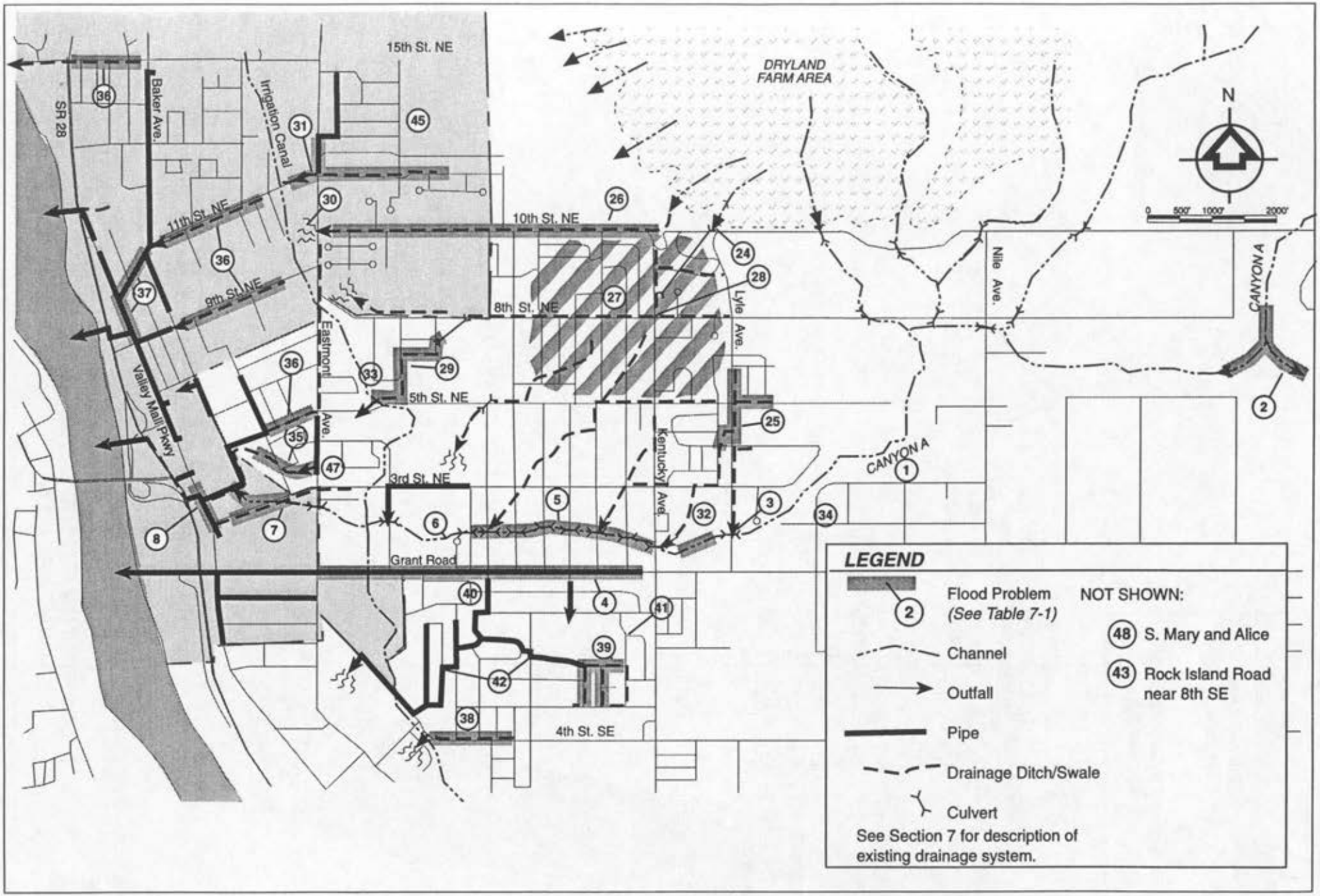
TABLE 7-1 (Continued).
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA

Location	Individual Problem Description[a]	Category of Flood Problems[b]: Maintenance or Regulatory Problem	Local Drainage or Floodplain Problem	Regional Drainage or Floodplain Problem
PALISADES AREA OF MOSES COULEE (Continued)				
53. Community of Palisades	The area lacks a documented flood warming system for evacuation when necessary.			No formal warning system is in place.
JAMESON LAKE				
54. Jameson Lake Area	Roads and farms risk flood damage because rising of lake level was not anticipated when structures were built.			Damage to structures is possible when lake rises during flood events.
55. Outlet of Jameson Lake	A major runoff event causes significant overflow to Moses Coulee.			A large overflow from Jameson Lake aggravates downstream flooding problems

a. As compiled from engineering studies, newspaper accounts, drainage complaints, City and County personnel, and other sources.

b. Solutions to flooding are categorized as follows:

Maintenance or regulatory problem—flooding is caused by lack of maintenance on culverts and ditches, by inadequate regulations for new developments, or by inadequate building permit review and inspection of drainage systems.
Local drainage—flooding is caused by a localized problem. Fixing the problem does not affect severity of downstream flooding.
Regional drainage—flooding at many locations is caused primarily by a single, dominant drainage problem. Fixing the problem will help eliminate or reduce the severity of many related flood problems.



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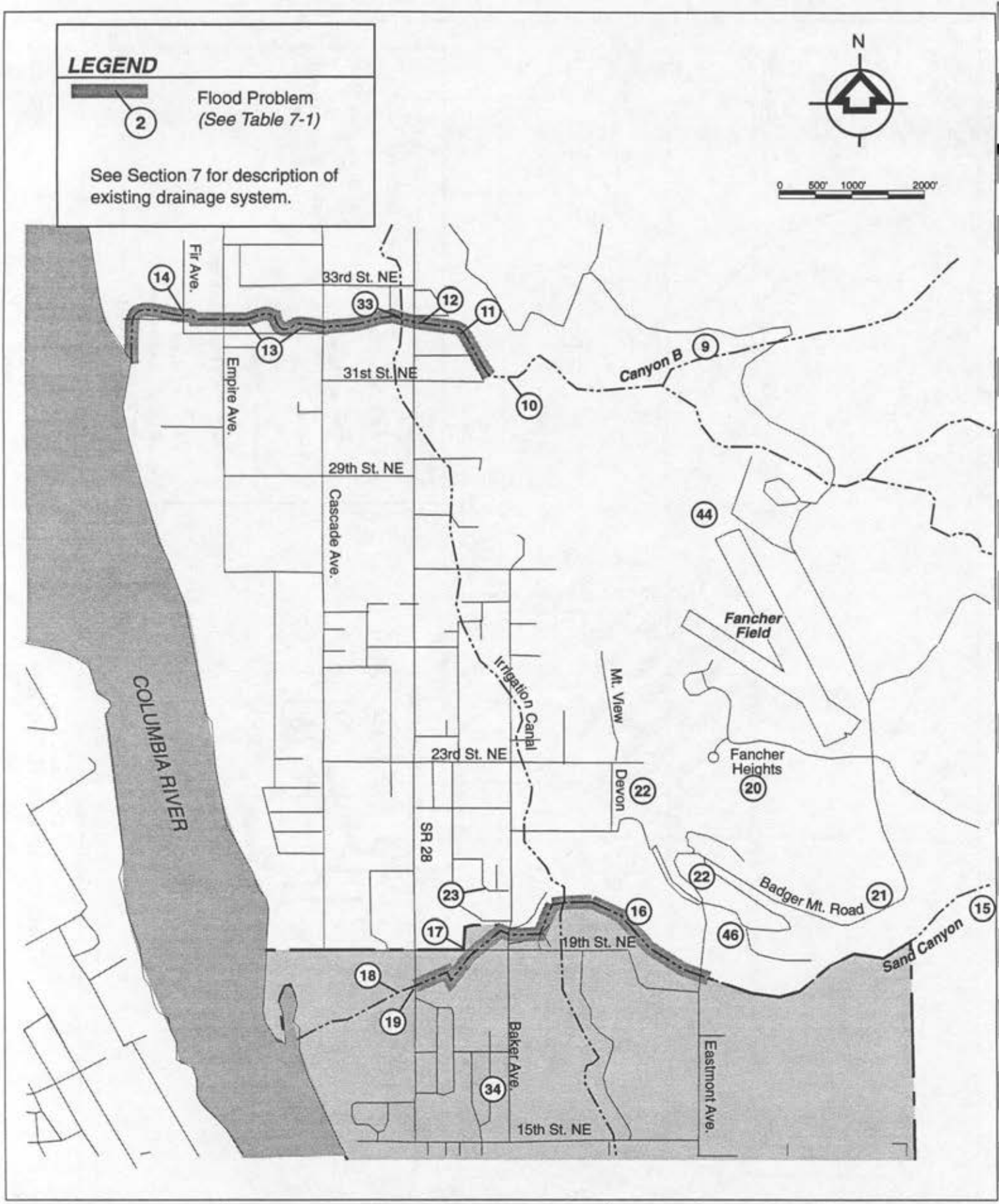
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 7-1.
FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA
(south of 15th Street NE)



KCM 1917 First Avenue Seattle, Washington 98101	COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 7-2. FLOOD PROBLEM AREAS IN EAST WENATCHEE AREA (north of 15th Street NE)

- **Lack of Canyon A drainage corridor in commercial areas below Eastmont Avenue.** Development in the commercial core of East Wenatchee has occurred without provision for a drainage corridor for Canyon A. Floodwaters now discharge from Canyon A onto City streets. Existing drainage systems are too small for moderate to large events.

- **Increased runoff from new development.** Citizens have complained that new developments, including Fancher Heights and Manhattan Square, have resulted in new or increased runoff. Flooding is attributed by citizens to undersized facilities that were built to inadequate County standards, poorly built drainage facilities that should not have passed County inspection, and, in certain cases, required facilities that were never built.

- **Lack of preventive maintenance of existing drainage system.** Citizens have also complained that the County has failed to properly maintain culverts and ditches, causing them to perform poorly or fail during rainstorms. Some feel that many local flooding problems would not have occurred if culverts and ditches were cleaned out and certain undersized culverts replaced. The process by which citizen complaints are followed up by the County has been criticized as being slow or unresponsive, with the resulting remedies inadequate.

- **Increasing development within the natural drainage corridors of Canyon A and Canyon B.** The natural Canyon A channel between Lyle and Eastmont Avenues is gradually shrinking from encroaching development, decreasing its capacity and causing floodwaters to split off onto Grant Road. Development on the Canyon B alluvial fan also occurred without consideration of flood hazard, leaving an inadequate channel for flood flows.

- **Highly erodible soils.** Soils in the East Wenatchee area are composed primarily of fine sand that is highly erodible. Even the smallest rainfall events can cause drainage problems because ditches erode easily and culverts become plugged. Compounding this problem is the steep terrain in the area. Runoff in the ditches along roads that run down the hill slopes develops high velocities, and even ditches that have been lined with riprap have been scoured out. Sediment settles out where the slope gradient flattens out.

Canyon A

Flooding problems in Canyon A are caused by several factors, including watershed and climate conditions that produce rare but significant floods; encroachment of residential areas; and a lack of conveyance channel or other means for drainage below Eastmont Avenue.

Fallow wheat fields in the upper Canyon A watershed contribute to severe runoff and erosion. Fallow fields can be mostly bare, and the hard, dry surface provides a high runoff potential. Soil erosion can also be high, as demonstrated in the 1972 flood, because the

sandy loam soils are easily erodible. Large quantities of sediment are deposited in the urban residential areas of East Wenatchee because the crop areas are nearby and there are no intermediate areas of deposition (such as an alluvial fan). The local climate is such that significant runoff occurs rarely—major floods occurred only twice in the last two decades (in 1972 and 1989).

Urban encroachment on the Canyon A channel below Lyle Avenue is causing the channel to gradually disappear. In the residential area between Lyle and Eastmont Avenues, the reduction in channel size and redirection of flood flows caused by development has forced floodwaters onto Grant Road. Under these conditions Grant Road becomes a torrent strong enough to move cars. Many homes and businesses are severely flooded.

Canyon A ends a short distance below Eastmont Avenue. Floodwaters have no place to go except onto streets and through yards. In fact, the downstream end of Canyon A is a parking lot at Valley Mall. Existing drainage facilities are adequate only for light rainfall events and not for regional floods from Canyon A.

Canyon B

Similar to Canyon A, the Canyon B watershed has severe runoff and erosion potential, as evidenced by the large alluvial fan at the canyon's mouth. Although alluvial fans indicate flood hazards, long periods can pass between periods of fan growth. Public awareness of the hazard often diminishes during these intervals so that development on alluvial fans is not uncommon.

In Canyon B, most of the alluvial fan has been developed during the last 20 years without consideration of these hazards. Review of flooding history reveals many floods below Canyon B and considerable flooding and sedimentation along Glendale Street. These events occasionally block SR 28 and fill the irrigation canal with sediment. To help mitigate the flooding and erosion hazards along Glendale Street, the County recently constructed a concrete-lined flood channel parallel to Glendale. However, this project ended at SR 28.

Below SR 28, Canyon B consists of gentle swales through orchards and occasional small gulches between terraces. Flooding in this area is not reported to be a significant problem, except for deposit of sediments in the orchard immediately below SR 28. There is no recognized floodway between SR 28 and the Columbia River, and although this area is still mostly orchard and undeveloped land, residential development is allowed under current zoning and flood hazard regulations.

Sand Canyon

The Sand Canyon watershed is similar to Canyons A and B in that it drains dryland wheat farms that have severe runoff and erosion potential. However, because Sand Canyon is generally well-defined all the way to the Columbia River, flooding in the urban area has not been a significant problem.

A few potential flood hazards do exist, however. Baker Avenue road crossing washed out during the 1972 flood. Therefore, the adequacy of the existing culverts to handle large floods is in question. Also, flooding problems have been reported at a residence on

19th Street and the drainage corridor near the mobile home park below Highway 28 is poorly defined.

Urban Storm Drainage

With the exception of a few main roads in the City of East Wenatchee and Grant Road in unincorporated Douglas County, the East Wenatchee area does not have a constructed storm drainage system. Instead, runoff is conveyed through by an irregular network of roadside ditches and road culverts. As illustrated in Figures 7-1 and 7-2, and explained in Chapter 6, these drainage systems follow major roadways, occasionally jog through fields and neighborhoods following natural drainage swales, and typically terminate in open fields or the irrigation canal rather than at stream channels. Thus, storm drainage has no place to go, and the nearest convenient stream channels for storm drain discharge—Canyon A or the Columbia River—are generally far away.

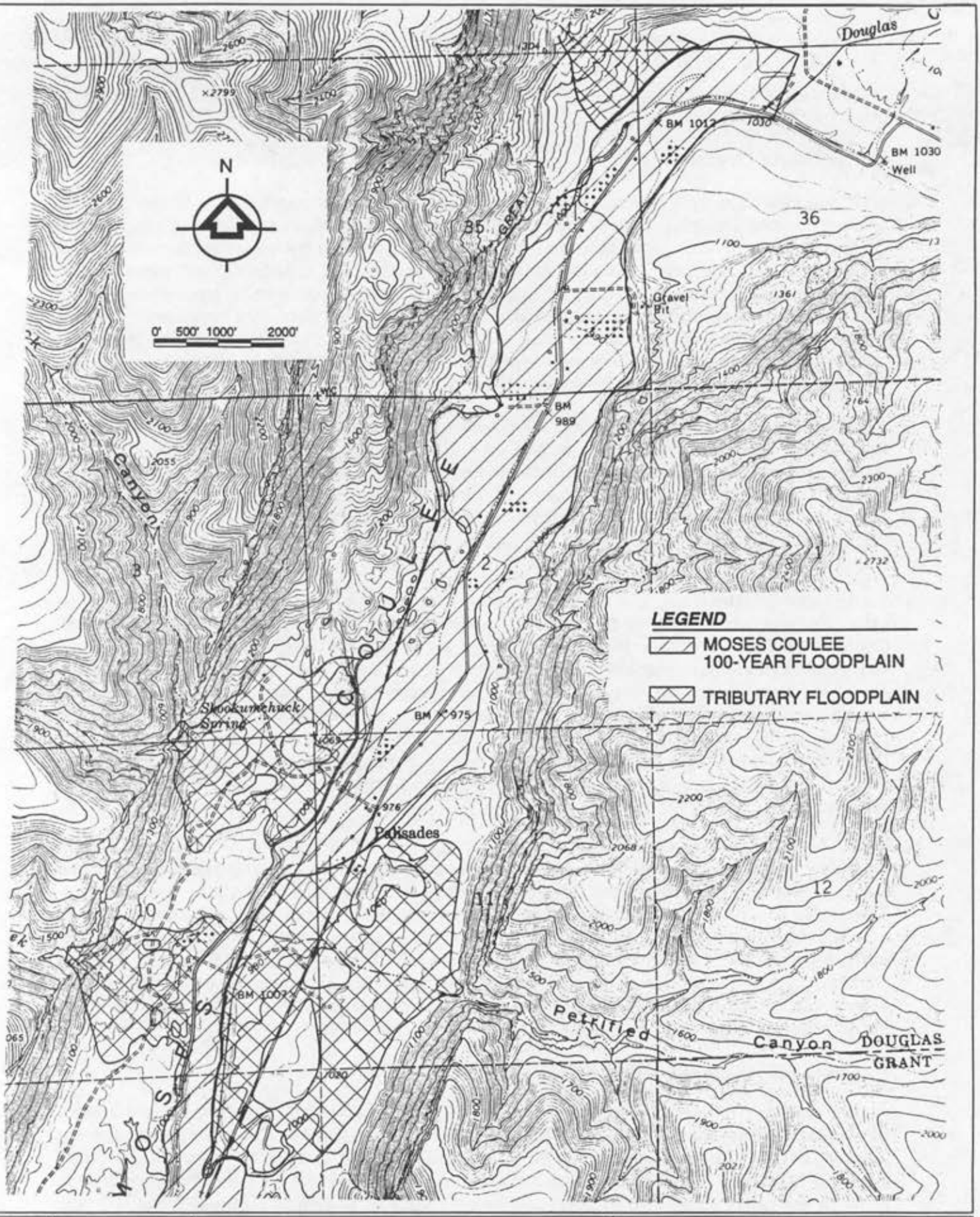
Flooding from urban storm drainage affects numerous residential areas and causes damage to roadside ditches and shoulders in the area above Eastmont Avenue. Below Eastmont Avenue in East Wenatchee, many roads leading down the hill collect local runoff, causing localized flooding and accumulation of water at the bottom along Valley Mall Parkway. When this flow combines with runoff from Canyon A, the Parkway becomes flooded. The existing drainage system, which drains both the Parkway and Baker Avenue through a single 18-inch outfall to the Columbia River, is much too small to convey these flows.

During small rainstorms, the existing systems can contain runoff in the East Wenatchee area. However, maintenance crews must work constantly to keep culverts open and ditches clean to prevent extensive flooding. Several systems, including lower 10th Street and Eastmont Avenue between 3rd and 8th, discharge to open fields where runoff infiltrates. However, these areas may eventually be developed into residential areas, requiring that stormwater be handled differently. Drainage down 8th Street is probably the greatest problem in the area above Eastmont Avenue because this stormwater can only drain into the irrigation canal. The reclamation district, which owns the canal, disapproves of this and regularly bills the County for cleanup and repair costs caused by stormwater and associated sedimentation.

Many of the flooding and erosion problems associated with Canyon A become urban drainage problems. Figure 7-1 illustrates how drainage from dryland farm areas above Canyon A enters the urban area along the hillside between 15th Street and Lyle Avenue. Therefore, the problem of urban storm drainage in East Wenatchee is not limited to management of runoff from streets and yards, but includes runoff from adjacent agricultural lands. Not only does this greatly increase the magnitude of flow that must be controlled, but it also adds the problem of sedimentation that accompanies agricultural runoff. This complicates the design of any potential drainage system because sediment can quickly clog culverts and underground pipes.

PALISADES AREA OF MOSES COULEE

Severe flooding of lower Moses Coulee every 10 to 15 years and smaller, more frequent floods have severe impacts on the community of Palisades and the Palisades Road. Severe flooding can isolate the town and most of Moses Coulee for a week or more because road access is blocked by floodwaters that are slow to recede. Floods commonly block access through the valley every two to five years on average. As shown in Figure 7-3, the 100-year



KCM 1917 First Avenue Seattle, Washington 98101	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 7-3. 100-YEAR FLOODPLAIN IN MOSES COULEE (PALISADES AREA)

floodplain in Moses Coulee as shown by FEMA extends over the entire valley bottom. Extensive road damage from the flooding is because the road in the Palisades area is near the stream channel. Damages have included severe erosion of the shoulder, pavement damage, and other local drainage problems along the 14-mile roadway.

The principal causes of flooding in Moses Coulee and the associated problems are as follows:

- **Runoff from rare snowmelt events causing extensive flooding of the Moses Coulee valley bottom.** When snowmelt occurs in combination with frozen ground conditions, large volumes of runoff are produced. However, these floods are rare, occurring only every 10 to 20 years (in 1939, 1948, 1960, 1973, and 1989). Dryland wheat farming in upper Douglas Creek and other upland areas contribute to this problem because bare ground increases the amount of runoff. When floodwaters reach the flat bottom of Moses Coulee they can spread from wall to wall and take longer than a week to recede because of slow drainage out of the coulee. Although a few homes are particularly vulnerable to flood-related damage, most end up with wet basements or become isolated by floodwaters.

- **Insufficient channel capacity in Palisades area to carry runoff.** Between Palisades and Douglas Creek the channel is too small to convey runoff from even small flood events causing flooding and erosion. Over the years, lack of ditch maintenance to remove accumulated sediment and debris may have contributed to a greatly diminished channel capacity. Several homes along the channel would be in the way if the channel were widened.

- **Damage to Palisades Road during flood events.** Flooding damages the Palisades Road at several locations. Above Palisades, the road is adjacent to Douglas Creek and lacks adequate bank protection. Although damage surveys following previous floods indicated the need to relocate this road away from the creek, the roadway was always restored to its previous condition. This was due to concerns of local property owners. Damage also occurs at many other locations due to inadequate cross-drainage.

- **Sediment deposition at base of Douglas Creek canyon (above Palisades).** Large amounts of sediment from upper Douglas Creek have been deposited over a broad area at the base of Douglas Creek where it meets Rattlesnake Creek. Farmlands that once occupied this area have been lost.

- **Lack of a documented flood warning system.** Over the years an ad hoc system of flood warning has been developed by the residents of the valley. This system should be documented and institutionalized to guarantee that the system is continued and effective for many more years. A system of rain gauges and flood gauges would also help in predicting the magnitude and timing of floods. This will allow appropriate warning when evacuation is necessary.

JAMESON LAKE

Because Jameson Lake has no outlet, evaporation and infiltration are the only means by which water can leave the lake. In recent years, the lake level has been steadily rising, most likely due to increased groundwater and surface water flows to the lake. Although the lake has experienced this rise since the early 1900s, in the last 10 years it has risen to the point where flood damages have been particularly severe and the threat of overflow to Moses Coulee is imminent. The following effects of dryland wheat farming, which covers most of the Jameson Lake watershed, may be partially responsible for the rise:

- Dryland wheat farming requires that farmland lies fallow for a year to allow rains to increase the moisture level within the root zone. A considerable amount of deep percolation also occurs, potentially increasing the recharge of groundwater that flows to Jameson Lake via a shallow aquifer. Under natural vegetation conditions, evapotranspiration (evaporation and the use of water by plants) would limit this recharge.

- Increased surface water runoff results when agricultural areas are cleared of vegetation and only bare soil remains. Runoff is greater from bare soil than from naturally vegetated soils for several reasons:
  - There are no leaves to intercept and retain rainfall
  - Fine soil on the surface reduces rainfall infiltration
  - Plowed furrows allow runoff to collect and transport runoff more quickly.

These two supplies of water to Jameson Lake can cause significant increases in lake level. Groundwater can cause a steady, long-term rise and surface water can cause occasional abrupt rises. The 3,500 acre-feet of inflow during the 1989 event translates to roughly 0.5 inches of runoff from Jameson Lake's watershed.

Long-term climatic changes may also be responsible for the increased lake levels. However, these effects are difficult to separate from the effects of changing agricultural land use over the last century.

The following are the most significant flood hazards associated with Jameson Lake's rising level:

- **Roads and farms risk flood damage because high lake levels were not anticipated when these facilities were built.** If the lake rises further, additional damage will occur. The outlet may not be large enough to drain water quickly enough to prevent a significant increase in lake level. Predictions based on 1989 flood data indicate that the lake could rise four to five feet above the outflow elevation (which was the maximum flood elevation in 1989) if a similar event occurs again.

- **The next major runoff event will probably cause significant overflow to Moses Coulee.** A rapid rise in the Jameson Lake level will probably cause a large amount of water to drain to Moses Coulee over a short period of time, causing downstream damage and potentially aggravate flooding problems in the Palisades area.

CHAPTER 8.
FLOOD HAZARD MANAGEMENT OPTIONS

Comprehensive flood hazard management emphasizes the use of diverse approaches to solve flooding problems. These approaches involve engineering, environmental protection, and planning measures. Stormwater and flood damage control measures can be classified as either structural or nonstructural. Structural measures involve engineered facilities within the drainage area or along the receiving stream channel. Nonstructural alternatives include land use regulations and other measures such as steps to reduce runoff, preserve wetlands and streams, or acquire land.

Potential structural and nonstructural measures described below relate primarily to urban stormwater control. Only options judged to be applicable to Douglas County's particular flood problems are described. For example, constructed wetlands and wet detention ponds were not considered because they could not be sustained in the arid climate. Consideration has been given to options that improve water quality in addition to reducing flood hazards.

STRUCTURAL ALTERNATIVES

Structural alternatives for stormwater control are common in storm drainage systems. Some, such as catchbasins and on-site detention ponds, control local runoff. Others, such as conveyance systems and regional detention basins, perform more regional functions. With the growing use of water quality best management practices (BMPs), many structural facilities have been adapted to control pollution (e.g., detention facilities that provide water treatment).

Conveyance Systems

Conveyance systems include all portions of the surface water system, either manmade (e.g., pipes and ditches) or natural (e.g., stream channels), that transport storm and surface water runoff. A properly designed pipe system maximizes hydraulic efficiency by utilizing proper materials, pipe slope and pipe sizes. Channel sections are sized to provide adequate capacity for design flows while minimizing erosion and allowing for aesthetics, habitat preservation, and enhancement of water quality. Discharge from conveyance systems should occur at the natural drainage points as determined by topography and drainage patterns.

The elements of conveyance systems can be grouped into five categories:

- **Pipe systems**—These are networks of inlets, catchbasins, pipes and manholes designed to convey stormwater. Pipe systems are designed for open, gravity flow except where pump stations are needed to drain low-lying areas or to transport runoff across basin divides. Pipe systems may be the only option in urbanized areas where natural drainage corridors have been built over or where street designs and development patterns preclude the use of open channels. Underground pipe systems may experience problems in areas where levels of soil erosion and sedimentation are high.

- **Culverts and bridges**—Culverts are relatively short segments of pipe placed under road embankments; bridges are structures that pass over channels that are too large for a culvert or are required for other design or aesthetic criteria.

- **Outfalls**—An outfall is the downstream terminus of a piped conveyance system. Outfalls should discharge to natural drainages or rivers to avoid creating new flooding problems in downstream areas. An outfall may need to include an energy dissipator to prevent erosion in the immediate vicinity.

- **Open channels**—Open channels can be natural, such as streams, creeks, and swales, or constructed, such as ditches or channels. Ditches and channels may be pavement-lined, rock-lined, vegetation-lined, or *bioengineered*—a combination of designing soil and vegetation properties to stabilize eroded, damaged, or new channels. A primary concern with roadside ditches in East Wenatchee is the combination of steep gradients and highly erodible soil, causing maintenance problems and recurring loss of function during major runoff events.

- **Floodplains and floodways**—These are natural conveyances similar to open channels except that development within them is regulated to preserve their flood conveyance value. Stream channel improvements can increase the conveyance capacity of floodways and floodplains if urban encroachment has restricted the size of the floodplain. Alternatively, the floodplain can be restored by removing obstacles such as houses and improving bridge constrictions.

Open, vegetated channels are the preferred method of conveyance when considerations of both water quantity and water quality are important. Vegetation helps keep the channel from eroding and can provide some water quality treatment. In rural or undeveloped areas, the natural drainage system usually conveys drainage adequately. Constructed improvements are gradually added as development encroaches. In urban situations, pipes are often the only alternative due to the presence of street barriers, previously developed property, or lack of space.

Infiltration Facilities

Infiltration facilities enhance drainage of stormwater runoff directly into the soil. An infiltration facility is classified as a *retention facility* because it permanently stores water to allow infiltration, rather than temporarily detaining it (as in a *detention facility*) before releasing it downstream.

Infiltration reduces the amount of water entering conveyance systems, thereby reducing peak flows and required conveyance capacities. It can also provide treatment of runoff and recharge groundwater. Infiltration facilities require careful design, construction, and maintenance. They are not practical in all cases because of the many potential design problems, such as soil with too little or too much permeability, shallow depth to groundwater, and proximity to existing wells or drainfields. When conditions are favorable, infiltration is a preferred runoff control practice.

The following are common infiltration facilities:

- **Infiltration basins**—These are water impoundments made by constructing a dam or embankment, or by excavating a pit in or down to permeable soils. The infiltration basin temporarily stores water during a runoff event, after which all water percolates into the ground. These basins may require large areas and continual maintenance to perform properly.

- **Infiltration trenches**—An infiltration trench is a shallow excavated trench (2 to 10 feet deep) that is backfilled with coarse gravel. Because they are relatively small, these facilities are generally used only for small drainage areas where runoff treatment is the primary concern. An advantage of their small size is that they can be retrofitted into existing developed sites.

- **Dry wells**—A dry well is like an infiltration trench but it is smaller and is typically connected to only a single catchbasin. Dry wells are commonly used in new developments to prevent off-site discharge of stormwater runoff. When compared to normal catchbasin and pipe systems, their capacity is very small and therefore they are easily overwhelmed.

- **Roof downspout systems**—A roof downspout system is a small-sized dry well or sump intended only for use in controlling runoff from roof downspout drains. These systems are effective for groundwater recharge because runoff from roofs rarely has high levels of pollutants.

- **Modular and porous pavement**—These pavements allow rainfall to infiltrate through otherwise impervious surfaces, decreasing runoff flow rates. Modular and concrete grid pavements consist of strong structural materials with regularly interspersed void areas that are filled with pervious materials, such as sod, gravel, or sand. These pavements are expensive and are suited for low-volume traffic areas, driveways, and parking lots. Porous pavement includes porous asphalt pavement and pervious concrete pavement, which allow rainfall to flow directly through the pavement material.

Detention Facilities

Detention facilities reduce peak runoff rates by temporarily storing stormwater runoff. These facilities catch and detain runoff from upstream conveyances and open areas, releasing it at a lower, pre-determined rate. The amount of storage in the detention pond and the design of the outlet structure determine how much peak flow rates can be reduced. Detention facilities are particularly effective for flash runoff events (i.e., short duration with a high peak) because relatively little volume is needed to significantly reduce the peak rate of flow.

Detention facilities can also provide water quality treatment if permanent water storage and wetland vegetation are incorporated into a wet pond design. In East Wenatchee, the arid climate and infrequent occurrence of runoff make wet ponds impractical unless irrigation is provided. Without irrigation the vegetation in detention ponds will die.

Detention facilities are categorized as follows:

- **Regional detention ponds**—Detention ponds are open, above-ground basins designed to contain runoff from a particular storm (such as a 10-year, 24-hour storm) and gradually release it after the peak of the storm has passed. They can be entirely constructed, or they can be modified from existing topographic depressions. The many design options for detention ponds allow different levels of treatment and flow control. Regional detention ponds are large (greater than 1 acre-foot in volume) and are located at convenient sites within large drainage basins. State dam safety rules will apply to all facilities with 10 feet or more of depth or 10 acre-feet or more of storage volume.

- **On-site detention ponds**—On-site detention basins are designed to serve small developments or subdivisions. Local storm drainage ordinances often require them to limit runoff to pre-development conditions.

- **Tanks and vaults**—Tanks and vaults are underground facilities for the storage of surface water. Tanks are typically large diameter pipes, and vaults are square, reinforced concrete vessels. They both serve the same purpose as detention ponds, except they can be located in areas where ponds are not feasible (such as under streets and parking lots).

Detention ponds are very common in urban storm drainage systems because they can be easily integrated into both existing and new stormwater systems. Detention ponds are particularly attractive in terms of cost, effectiveness, and reliability criteria, and much experience has been gained on their use. Many local governments require on-site detention ponds in new developments, so they often are built with private funds. Regional detention ponds usually require public funds because they are part of the public drainage system.

Debris Basins

A debris basin is similar to a detention pond except that it is designed to catch debris and large sediment loads that accompany a runoff event. Debris basins generally consist of a gradually sloping basin within a drainage corridor with a wall or embankment at the downstream end. The outlet is designed to let all water pass through unimpeded, so the basin provides no water detention. Instead, the gradually sloping basin bottom allows course-grained sediments to settle out as the water-sediment mixture passes through the basin. Fine-grained sediments pass through the basin, but these generally keep traveling with the flood flow through downstream areas.

Levees

Levees are embankments constructed parallel to stream and river courses to contain or divert floodwaters. Because they are subject to the erosive forces of high velocity water, levees must be designed using appropriate soil types, vegetative cover, and, occasionally, riprap armor. Levees constructed solely of concrete are called floodwalls. Levees are very effective in controlling flooding. However, they can deflect or back up floodwaters to previously unflooded areas, or harm environmentally sensitive areas by altering floodplain

habitat. In Douglas County, negative impacts would probably be limited to off-site flooding because of the lack of sensitive floodplain areas.

NONSTRUCTURAL ALTERNATIVES

The most effective stormwater quality and quantity control mechanism is regulation of where, when and how development can occur. Once urban runoff is generated, management options are limited. Nonstructural alternatives are broadly classified as land use/development-related regulations, programs involving acquisition of flood-prone properties, resource management regulations, environmental protection measures, and floodproofing programs. Nonstructural alternatives do not use engineered facilities to control floodwaters; instead they prevent or minimize the impacts of flooding by controlling land use practices that increase runoff over natural conditions and by managing flood-prone areas so that land uses are compatible with flooding or not unacceptably affected by it.

Regulatory Measures

Regulatory measures to prevent or minimize flood damages caused by stormwater runoff or river flooding can be categorized into four main groups: zoning and land use regulations that control development to limit damage in flood-prone areas and control the generation of urban runoff; development standards that require developers to install facilities to control runoff at its source; resource management regulations that regulate natural resource development activities; and environmental and sensitive area protection that preserves environmentally important areas.

Zoning and Land Use Regulations

Zoning and land use regulations control land development by limiting the types of development within identified areas to acceptable uses. In river floodplains as well as floodplains associated with ephemeral streams, the intent is to prevent damage by avoiding the construction of structures that are likely to be damaged or severely affected by flooding. Local flood damage prevention ordinances are the primary means of controlling development in identified floodplains and alluvial fans. In areas outside identified floodplains, local zoning is effective in controlling the generation of urban runoff by limiting the density of new development.

Controlling urban runoff is an important objective not only in urban areas experiencing rapid growth, but also in areas where existing development occurred without adequate consideration of stormwater management. Zoning and land use regulations are normally implemented as part of a comprehensive plan for the area. Other regulatory measures, such as a critical areas ordinance and shoreline master plans, can also be implemented to control development.

Following are typical zoning and land use regulations:

- **Flood damage prevention ordinances**—State law (Chapter 35 RCW) authorizes cities and counties to adopt ordinances and take actions to protect lives and properties from flood damage. Flood hazard ordinances adopted by counties and cities outline requirements for drainage facilities

and floodplain activities, and are a requirement of the National Flood Insurance Program. Local codes acceptable to the NFIP must be enacted and enforced to maintain eligibility for flood insurance. Elements of these codes include requirements for locating critical facilities outside the 100-year floodplain, design requirements for structures within the floodplain, prohibitions on floodway encroachment, and penalties for violations.

- **Zoning code revisions**—The zoning code is the primary local regulation used to identify which areas of a city or county can be developed for specific land uses. Although entirely legal and appropriate in many situations, zoning code revisions often mean reducing the amount and intensity of existing land uses through "downzoning," an action that is usually opposed by landowners.

Development Standards

Development standards are specific requirements imposed by local codes for drainage facilities, runoff detention, erosion and sedimentation control, and other controls that can be implemented on developed sites. These standards are useful for controlling stormwater runoff in all areas of a jurisdiction, including those inside and outside the floodplain.

Currently, development standards for stormwater control are contained in the Douglas County Subdivision Ordinance. This ordinance can be revised to codify stricter standards for stormwater runoff control.

Resource Management Regulations

Because management of natural resources directly affects land use, such activity is integrally tied to flood hazard management. For the East Wenatchee area, resource management regulations could include regulation of agricultural practices in the drainages above the urban area. Runoff from these drainages is increased by agricultural activities because the loss of vegetative cover results in less rainfall being intercepted and soil being less permeable. Loss of vegetative cover also dramatically increases soil erosion.

Except in extreme circumstances, resource management programs for soil and farmland conservation are based on voluntary compliance. Programs that have been used to help farmers and local governments solve flooding and erosion problems include the Conservation Reserve Program (CRP), the Agricultural Conservation Program (ACP), and Public Law 83-566 (PL566), the Watershed Protection and Flood Prevention Act. These programs were summarized in Chapter 1. CRP and ACP funds are very limited.

Environmental and Sensitive Area Protection

Many features of the natural landscape, such as wetlands, forests, and floodplains, act as nonstructural flood control facilities by virtue of their abilities to retain rainfall and store floodwaters. Thus, environmental and sensitive area protection measures often attain flood hazard management objectives as well as their environmental protection objectives.

Sensitive (or critical) areas ordinances carry out the goals of local comprehensive land use plans for sensitive areas. They identify and manage environmentally sensitive areas to

prevent destruction of resources necessary to the health, safety and welfare of the public, and to reduce losses of property and human life. Sensitive areas include steep slopes, landslide hazard areas, erosion hazard areas, geologic hazard areas, arable lands, critical watersheds, streams, wetlands, groundwater recharge areas, and critical wildlife habitats. Related objectives include protecting and restoring sensitive areas and preventing adverse impacts on water quality, wetlands, and streams. The ordinances apply to most activities in sensitive areas, including development, clearing, surface mining, blasting, and filling and grading.

Other environmental protection measures include wildlife refuges, forest reserves, public parks, farmland preservation, and other open space preservation measures.

Land Acquisition and Relocation of Structures

The acquisition of floodplain and wetland areas is the most effective tool for preventing the loss of life and economic damage that result from flooding, as well as the loss of riparian habitat, increased erosion, and reduced water quality. Acquisition permanently prevents the development of these lands and preserves them in their natural state for use as parks, floodwater storage areas, or flow conveyance areas during times of large flood events.

Maintenance of these lands in their natural state ensures that riparian habitat is not reduced and water quality is not degraded by development. In urban areas, streams can also serve as greenbelts and provide aesthetic enhancement for the community. The major drawback of acquiring floodplain lands is the initial expense. In many instances, however, it is much less expensive over the long term to acquire these areas than to provide structural solutions to problems that development later creates. Structures at risk from flooding can be relocated to safer areas on the same property, thereby eliminating the need to purchase the property.

Public Awareness

Public education can be critical to public safety and environmental protection and help minimize flood damages to people, property and resources. Public awareness can be increased through educational programs developed and presented by government agencies, citizens groups, or both.

A surface water education program for residents and government staff will improve public knowledge of flood hazard management issues. The following activities and materials could be developed as part of the education program:

- Periodic educational walks to observe and inventory the condition and function of flood corridors and drainage pathways in the County and City
- Newspaper articles addressing a series of stormwater and flood hazard management topics
- Educational brochures targeted at homeowners, schoolchildren, business and industry describing what to do in a flood, how to floodproof homes or businesses, materials to have on hand in case of a flood, or how to implement BMPs

- Public involvement activities to maintain flood hazard management and stormwater facilities
- Brochures and pamphlets published by FEMA and Ecology.

Floodproofing

Effective floodproofing reduces or eliminates damage to property exposed to floodwaters. Floodproofing consists of modifying structures, their sites, and/or building contents to keep water out or to reduce the effects of water entry into the structure. Such modifications can be made when buildings are under construction or during repair, remodeling, or expansions of existing structures. Floodproofing may be permanently in place, which is preferred, or it may require some action at the time of the flood (i.e., sandbagging). Because floodproofing can be applied directly to specific buildings at risk and can be done by individuals, it can be very inexpensive. Floodproofing needs little community involvement to be successful, but the probability of success is greatly increased if a public agency provides technical assistance and guidance. Floodproofing is typically targeted at areas within river floodplains, not areas subject to stormwater runoff.

Flood Insurance

The National Flood Insurance Program allows property owners to purchase federally subsidized flood insurance in communities that participate in the program, which includes both East Wenatchee and Douglas County. Flood insurance will pay for structural damage caused by flooding, but not for yard damage. Therefore, only a portion of residential area damage is covered and damage to public facilities such as roads is not covered.

To obtain a federally backed mortgage policy, which includes nearly all such policies, homeowners who live in areas of special flood hazard must have flood insurance. In Douglas County this includes the 100-year floodplains of Canyon A, Canyon B, Sand Canyon, and Moses Coulee. Only a minority of homeowners obtain flood insurance, primarily due to the relatively high cost ($250-$300 per year). Flood insurance can be obtained by residents within less flood-prone zones, but is not mandatory.

Flood Warning System

A flood warning system alerts residents of imminent flooding so they can evacuate or make preparations to fight the flood. Flood warning systems are best used when there is time to take action. The National Weather Service often broadcasts flash flood warnings for relatively large geographical areas when weather conditions are likely to result in rainfall with damaging runoff. However, it is generally impossible to predict exactly where the storm will hit. A flood warning system can be set up at site-specific locations, such as in a drainage corridor upstream of an urban area. This type of system can alert residents if an actual flood wave is approaching, which is particularly valuable at night when other warning signs are not visible.

Operation and Maintenance

Operation and maintenance are critical for any storm drainage system. They prevent pollutants and sediments captured by stormwater facilities from being released to receiving

waters during storm events. To ensure proper operation and maintenance of private facilities, an ordinance providing enforcement is required.

Development of an operation and maintenance program should include the following (Ecology 1992):

- Developing goals and objectives for the program, including a definition of the level of service to be provided
- Review and evaluation of existing statutes, ordinances, and policies
- Identification of parties responsible for maintenance and operation
- Definition of the frequency of planning, inspection, and maintenance
- Determining staffing and resource needs
- Developing a record-keeping system.

A lack of County resources for maintenance of its drainage system over many years has left the system functioning poorly, primarily due to the accumulation of sediment in culverts and ditches. The lack of a detailed storm drain inventory that can be used to identify system components for routine maintenance has also inhibited upkeep of the system. Implementing an operation and maintenance program will ensure that the system functions as intended, so that it does not fall into disrepair and require early replacement.

CONSIDERATIONS FOR EVALUATING OPTIONS

Analysis of flood hazard management measures must take into consideration the measures' direct benefits as well as such factors as public expectations on cost and performance and potential adverse environmental impacts.

Applicability to Douglas County

The applicability of each of the structural and nonstructural stormwater control measures identified above is summarized in Table 8-1. Each measure is rated on its appropriateness for specific current and future conditions in Douglas County. Comments explain the evaluations. Table 8-1 will be used in the development and evaluation of alternatives.

Potential Environmental Impacts

Flood hazard management measures that involve structural modification in floodplains have historically had unavoidable environmental and human impacts. Environmental impacts generally resulted from changes forced upon natural processes and ecosystems by structural alterations; human impacts resulted from changes in land uses and values. Depending on the size, design, and primary purpose of proposed facility, adverse impacts can be significant. Floodplain projects typically require considerable analysis of such impacts and consideration of whether the primary project benefits are justified in light of them.

Environmental impacts of stormwater facilities are fundamentally different from those associated with flood hazard management for several reasons. First, the urban setting,

TABLE 8-1.
SUITABILITY OF FLOOD AND STORMWATER CONTROL MEASURES

Control Measure	Suitable for Existing System?	Suitable for New Development?	Comments
STRUCTURAL CONTROLS			
Conveyance systems:			
Pipes	Yes	Yes	All are integral components in urban stormwater systems for both existing and new developments
Culverts	Yes	Yes	
Ditches	Yes	Yes	
Channels	Yes	Yes	
Outfalls	Yes	Yes	
Floodplain conveyance:			
Floodways	Maybe	Yes	Depends on condition of floodplain. Existing floodplains should be preserved.
Levees	Maybe	Maybe	
Infiltration facilities:			
Basins/trenches	Maybe	Yes	Can supplement or replace detention on a small scale; requires broad implementation plan
Roof downspouts	Yes	Yes	
Porous pavement	No	Maybe	
Roadside detention	Maybe	Yes	
Detention facilities:			
Detention ponds	Yes	Yes	Effective in all situations if land is available; can be retrofitted for growth
Tanks and vaults	Yes	Yes	
Other:			
Wet ponds	No	No	Not practical in Douglas County due to arid climate
Constructed wetlands	No	No	
Biofilters	No	No	
NONSTRUCTURAL CONTROLS			
Regulatory measures:			
Zoning and land use	No	Yes	Effective for controlling future growth or redevelopment which causes increases in urban runoff; cannot solve problems with existing system
Development standards	Yes	Yes	
Regulatory measures:			
Resource management	No	Yes	Effective for controlling impacts of future changes in land use
Regulatory measures:			
Environmental and sensitive area protection	No	Yes	Cannot solve problems with existing system

TABLE 8-1 (Continued).
SUITABILITY OF FLOOD AND STORMWATER CONTROL MEASURES

Control Measure	Suitable for Existing System?	Suitable for New Development?	Comments
NONSTRUCTURAL CONTROLS (Continued)			
Public acquisition of flood prone areas	Yes	Yes	Effective where it is cost effective and may serve other land use objectives (e.g. wetlands protection or open space)
Public awareness	Yes	Yes	Has value in protection of water quality and building support for a stormwater program
Floodproofing	Yes	Yes	Has high value when only a few sites require action
Flood insurance	Yes	Yes	Required in all floodplain areas, but few actually obtain it due to high cost
Flood warning system	Yes	Yes	Would be effective along Canyon areas and in Palisades
Operation and maintenance	Yes	Yes	Maximizes benefit of any system

where stormwater facilities are normally located, typically lacks or is not capable of supporting extensive environmental resources. For example, fish habitat is not normally relevant in artificial conveyance systems. Second, the stormwater system may already exist but require modification to provide better performance or accommodate future growth. Thus, the proposed action can be viewed as strictly beneficial relative to existing conditions. Finally, stormwater control facilities not only protect lives and property, but also can (and are increasingly required to) provide water quality protection, habitat enhancement, and other environmental amenities.

Since stormwater management facilities usually enhance the environment directly or indirectly, the assessment of environmental impacts focuses on distinguishing which measures provide more benefit than others. However, adverse impacts are noted in a few cases. Table 8-2 shows the potential environmental and human amenities and impacts associated with each stormwater control measure previously discussed.

TABLE 8-2.
ENVIRONMENTAL IMPACTS AND BENEFITS ASSOCIATED WITH FLOOD HAZARD MANAGEMENT MEASURES

Facility	Fish Resources	Wildlife Resources	Scenic/Aesthetic/Historic	Water Quality	Hydrology	Recreation
Conveyance systems						
Pipes	none	none	6	7	12, 16	none
Culverts	1	none	6	7	none	none
Bridges	none	none	6	none	none	none
River outfalls	none	none	none	8	none	none
Open channels	none	3	4, 6	11	none	none
Ditches	none	none	6, 9	none	none	none
Floodplains and floodways	none	3	4, 6	11	none	13
Infiltration facilities						
Infiltration basins	none	none	4, 6	15	14, 16	13
Trenches and dry wells	none	none	6	15	14, 16	none
Roof downspout systems	none	none	6	15	14, 16	none
Porous pavements	none	none	6	15	14, 16	none
Roadside infiltration	none	none	6	15	14, 16	none
Detention facilities						
Detention ponds	none	3	4, 6	8	16	13
Tanks and vaults	none	none	6	a	16	none
Debris basins	none	3	4	5	none	none
Levees	none	10	6	a	17	none

NOTES:
1. If fish are present in stream, long-term impacts may include blockage of fish passage if not properly designed.
2. Bridges, as compared to culverts, allow wildlife to better utilize drainage corridors for travel.
3. Vegetated channels, natural floodplains, and detention ponds provide good opportunities for creating terrestrial wildlife habitat. Buffer areas providing diverse biological communities can be enhanced through planting of trees, shrubs, and grasses. Habitat can be improved in channels that are currently degraded.
4. Detention ponds, floodplains, vegetated channels, and infiltration areas enhance the scenic quality of the affected area by adding open space, natural vegetation, and landscaped grounds. They have high aesthetic value in urban settings and may increase property values.
5. Debris basins retain coarse sediments but not fine sediments.
6. Stormwater runoff facilities will help preserve historical resources by limiting flood damage.
7. Piped conveyance systems alone do not provide the water quality enhancement benefits that of other facilities, such as channels and detention ponds.
8. River outfalls can convey urban pollutants and sediments directly to a river if source areas are not controlled.
9. Concrete lined open ditches can be unaesthetic in urban areas.
10. Levees reduce wildlife habitat by reducing the size of natural vegetation areas.
11. Vegetated ditches and channels enhance water quality by limiting erosion and sedimentation and by providing limited pollutant removal capability.
12. Flow characteristics would be more efficient, resulting in more rapid runoff. Analyses and design should ensure that downstream areas are not adversely affected by increased flow rates.
13. Passive recreational opportunities (walking, bird watching, picnic areas) can be included in facility design.
14. Infiltration facilities enhance groundwater recharge, providing low flow maintenance.
15. Infiltration systems have high pollutant removal efficiencies.
16. Use of infiltration and detention facilities may reduce the required size of downstream conveyance systems. Detention facilities reduce downstream peak flows and protect habitat.
17. Use of levees to control floodwaters may result in increased flood impacts in other areas due to diverted or backed-up floodwaters.

CHAPTER 9.
FUNDING OPTIONS

Adequate financing is a major obstacle to implementation of surface water management programs in Douglas County. Traditional County sources of financing have not been sufficient to provide basin-wide planning, major stormwater and floodwater drainage improvements, adequate maintenance of existing systems, and administration of regulations that control private sector activities impacting the systems. The County must find the mix of financing options best suited to meet its immediate short-term needs under existing legislation and local authority.

This chapter briefly describes the available funding options. Based on funding and financing options available to the County, a recommendation is made for implementation of comprehensive flood control and surface water management programs.

FUNDING SOURCES

Potential funding sources are divided into two categories: financing and revenue options the County can implement through administrative actions; and external sources such as state and federal grants and loans. Table 9-1 summarizes these options.

TABLE 9-1.
SUMMARY OF FUNDING OPTIONS

County Administrative Options	External Funding Sources
Developer Contributions - Drainage Development Fees - Construction in Lieu of Fees	Public Works Trust Fund
Drainage Districts	Soil Conservation Service—PL 83-566
River Improvement Fund	Corps of Engineers—Section 205
Local Improvement Districts	FEMA Hazard Mitigation Grant Funds
Surface Water Utility	FEMA Property Acquisition—Section 1362
County Revenues - Current Expense Fund - Road Fund - Real Estate Excise Tax - Debt Financing (bonds)	Road Emergency Relief (ER) Funds
Flood Control Zone Districts	Soil Conservation Service RC&D Program

County Administrative Options

The State Legislature has authorized counties to use a variety of financing concepts for surface water management. From a practical standpoint, however, financing surface water management must reflect the unique needs and attitudes of Douglas County. The funding

alternatives identified in this section need to be evaluated for consistency with existing public policies. The public will better understand surface water management issues and the rationale underlying the funding recommendation if the alternatives are clearly in tune with existing local policies on land use, economic development, and environmental protection. Such existing policies should not, however, foreclose opportunities to introduce new financing concepts or adjust existing policies.

Developer Contributions

Developing land increases the amount and rate of flow of surface water runoff and the need for drainage facilities to handle it. Thus, development creates the need for additional drainage facilities. Developer contributions are a means of recovering a share of the cost of drainage facilities constructed downstream to handle the increased runoff.

Regional drainage facilities may be constructed to handle the runoff from private property within a drainage basin. A comprehensive plan identifies the regional drainage improvements needed to accommodate a projected level of development—usually the maximum development allowable under the comprehensive land use plan or current zoning for the properties within the basin.

The comprehensive plan or development standards may assume that property owners are responsible for limiting runoff from their property to a specified rate or level of flow. If regional facilities are needed, the plan identifies the type and cost of such facilities.

Developers' contributions are frequently used to help fund regional drainage capital improvements but provide no mechanism to operate and maintain improvements or other elements of a comprehensive surface water program. Developer contributions most commonly involve drainage development fees and/or construction in lieu of fees.

Drainage Development Fees

Drainage development fees are collected from a developer at the time the runoff from the property is increased (when the property is developed). The cost of drainage improvements can be allocated among undeveloped properties in the basin based on the total area of land in each zoning classification and the estimated contribution to runoff potentially generated by all land at full development. This determines the share of the capital system costs that should be paid by each land use classification. That value is divided by the undeveloped area in each classification to determine the fee per square foot for developing properties in that classification.

The development fees are collected as each parcel is developed. This method works well in drainage basins with undeveloped property that will need downstream improvements off-site as the land is developed.

The following are the key advantages of drainage development fees:

- An equitable fee for each parcel can be calculated that is determined by the size of the parcel and applicable zoning. This calculation is easy for developers to understand and for the County to administer.

- Fees are based on the estimated cost of constructing off-site improvements.
- New drainage improvements can be scheduled by the County as they are needed. The need is determined by the level of development in each basin.
- Fees are assessed equitably because those collected from property in any drainage basin are used to pay for improvements in that basin only.

The key disadvantages of drainage development fees are as follows:

- The County incurs a liability to provide needed improvements upon receiving the fees.
- Basin plans with capital-cost estimates must be in place before the fee can be calculated.
- Significant changes in zoning, particularly down-zoning, may result in inadequate revenue to fund the facilities.
- Significant increases in construction costs over estimates used in the basin plan may result in insufficient revenue recovery.
- Patterns of development may require construction of more improvements than money is available for.
- Flexibility is limited because funds must be used for improvements in the basin from which they were collected. This requires an accurate accounting record.
- New developers may perceive an unfair burden if most land in the basin is already developed and development fees have not been charged historically.
- Fees pay for capital improvements only.

Construction in Lieu of Fees

This method assumes that the developer will construct or contribute directly to the construction of needed regional improvements in return for the ability to develop the land. This method tends to be used in developed areas with drainage facilities already in place that cannot accommodate increased runoff created by the additional development, or in areas that are developing where facilities are needed before development can take place.

The maintenance responsibility for drainage facilities constructed by developers needs to be defined. If the County is granted ownership or control of the facilities, the County will be able to ensure that the facilities are maintained to an acceptable level.

Key advantages of construction in lieu of fees are as follows:

- Facilities are constructed before the new development occurs.
- The County does not have to administer design and construction.

- The development creating the need for the new improvements will pay for the cost of the improvements.
- The new facilities will often benefit the County and other properties in addition to the new development.
- The County does not have to fund the costs of improvements or may fund only a portion of the costs.
- The County and the developer do not have to wait for the needed improvements to be scheduled into the annual budgeting cycle before the land can be developed.

Key disadvantages of construction in lieu of fees are as follows:

- New development may pay more than its equitable share of the cost of the system. This can be recovered by the initial developer through a "reimbursement agreement" using future development fees.
- Private developers may be financing facilities that serve public needs.
- This method deals only with capital improvements, not with ongoing operating and maintenance (O&M) costs.

Drainage Districts

Creating a drainage district is a method of financing drainage capital improvements and ongoing maintenance and operations. The processes of creating a drainage district and setting assessments are specified in the RCW 85.06, Drainage District, and RCW 85.38, Special District Creation and Operation. These laws apply specifically to counties and provide a method of financing and operating facilities to serve specific areas of land. A city may operate as a drainage district, however the creation and assessment process is specifically tied to the county legislative authority within which the drainage district is located.

Creation of a drainage district involves a vote by landowners and election of a board of commissioners. Election of the board reduces the active involvement of the County in the operation and management of the district.

State law also specifies the method of assessing property within a district. Assessment zones must be defined to reflect the relative benefit or use each property will receive from district operations and facilities. The assessment zones determine the dollar value of benefit per acre.

An annual budget must be adopted each year and must demonstrate that the assessments are sufficient to cover annual expenses. The cost of improvements is not included in the special assessment until the year after the improvements are constructed.

Key advantages of drainage districts are as follows:

- They provide funding for both O&M and capital improvements.

- Assessments are billed on property tax statements and collected with property taxes.
- Costs are equitably allocated to all property owners in the district based on benefit or use received on a district-wide basis.

Key disadvantages of drainage districts are as follows:

- Involvement of the County in the management and operations of the district is limited. The County has a legislative role in creation, and a separately elected board of commissioners manages the District.
- Property owners must approve the creation of district by vote.
- Funds for capital improvements cannot be collected until after the improvements are completed.
- District creation and benefit-assessment processes defined by statute are very complicated.
- The County's flexibility in working with developers is limited.
- Assessments may be limited by the property tax lid.

Flood Control Zone Districts

Flood control zone districts, which are authorized by RCW 86.15, may be established by either a petition signed by 25 percent of the voters in the proposed district, or by action of the County Commissioners. A flood control zone district is governed by a board of supervisors who are the County Commissioners. Prior to establishment of a flood control zone district, incorporated areas within the proposed District must be given the opportunity to be excluded. These districts have the authority to use several different funding mechanisms including a regular levy, an excess levy, a service charge, local improvement districts (LIDs), and bonds.

- A regular levy requires authorization by the supervisors. The maximum amount that can be levied is 50 cents per $1,000 of assessed valuation.
- An excess levy is a property tax requiring annual voter approval. It does not fall under the constitutional and statutory limitations of regular levies. An excess levy is based on property value, and would not affect existing County revenues. The levy, if approved annually by voters, can generate substantial revenue for overall stormwater management or flood control drainage. However, considerable cost is involved making voters familiar with the issues on an annual basis, and there is no certainty of funds from year to year.
- A service charge similar to that of a storm drainage utility is allowed under a flood control zone district.

River Improvement Fund

The River Improvement Fund was created under the taxing authority established by RCW 86.12 and has been a good source of financing flood control maintenance. Originally, the purpose of the fund was to finance drainage activities related to flood control, but it can and is being used to fund other activities related to flood or stormwater control as specified in RCW 86.12.020.

The River Improvement Fund is generated from a Countywide levy of up to $0.25 per $1,000 assessed value (AV). The levy rate has to be consistent throughout the County, but the revenue appropriation can vary among basins. The funds can be used to share costs of surface water management activities with local governments and match the state FCAAP program. The revenue for the River Improvement Fund comes from the Countywide property tax subject to statutory limitations on rate and amount. The levy is subject to the following limitations:

- It may not exceed $0.25 per $1,000 AV.
- Increases in the levy may not force the overall county assessment to exceed statuary limits.

For this fund, there is little relationship between the need for drainage or surface water management and the amount of property tax paid by individuals and businesses. Also, many tax-exempt properties such as schools, churches and publicly owned property contribute runoff.

Local Improvement Districts

Local improvement districts (LIDs) allow the County to issue bonds for the cost of improvements and to recover the cost through assessments based on "specially benefiting" property. Special benefit is defined by the increased property value that results from the improvements.

For water and sewer improvements, properties are considered specially benefiting when they are physically connected or have the ability to physically connect to the sewer or water system. For drainage improvements, it is often difficult to demonstrate special benefit because there is generally no physical connection and property value often is not directly affected by the existence of a drainage system, except where flooding is frequent. Moreover, property at the top of a hill does not specially benefit from drainage improvements, but it does contribute to the surface water problems. Property at the bottom of the hill sees a more positive effect from the drainage improvements, even though it contributes only a portion of the runoff.

LIDs have been used to finance water supply, sanitary sewers and storm drains when all three utilities are needed in an area. An LID might be appropriate for construction of a facility to serve several properties where the runoff contribution and benefit are similar.

Surface Water Utility

The underlying concept of a surface water utility is that all properties contribute surface water runoff to the drainage system and therefore should pay an equitable share of the system's O&M and capital costs.

RCW 36.89 gives the County authority to generate revenues by charging those who contribute to an increase in surface water runoff or who benefit from any stormwater control facility the County provides. Schools, churches, and other tax-exempt properties as well as public entities and public property are subject to the same rates and charges as private properties.

The formation of a surface water utility would give the County a continuous and reliable funding source to pay for both capital improvements and ongoing maintenance and operating costs. The County would have direct control over rates and charges rather than being limited to the prescribed methods set forth by statute for a drainage district.

A reliable source of funding is a key element in developing and continuing a successful, well-managed surface water drainage system. The existence of a utility charge would provide Douglas County with the opportunity to plan and carry out its comprehensive flood hazard management plan. The County can create a County-wide utility that is implemented on a basin-by-basin approach using variable rates. The fees can be included with property tax statements. A new billing system is not needed to collect the fee.

The primary disadvantage to establishing a drainage utility is the public perception that a new charge is being imposed for a service already being provided.

County Revenues

A number of County funding sources can be used in a discretionary manner to finance storm drainage and flood control. They include the current expense fund, the road fund, the real estate excise tax, and debt financing.

Current Expense Fund

The Current Expense Fund provides the general revenue used for County operations and services. It is derived from sources including property and sales taxes, fees, licenses, fines, investment interest, and contributions for services from other governments. Taxes are the most significant source of revenue for the Current Expense Fund. Of the amount contributed by taxes, property taxes provide the largest percentage of revenue. Taxes are levied upon all taxable real and personal property. Not all of the levy goes into the Current Expense Fund. Dedicated levy amounts are deposited in other funds such as the River Improvement Fund discussed previously.

The property tax is based on the assessed value of property and the levy rate per $1,000 AV. The County Commission sets the levy rate, which is subject to two statutory restrictions. RCW 84.52.043 sets the maximum levy rate for the All-County levy at $1.80 per $1,000 AV. In addition, RCW 84.55.010 restricts the amount of taxes levied to 106 percent of the highest of the three prior years' levy amounts plus an additional amount derived from taxing the

assessed valuation of new construction. The latter restriction, called the 106 percent lid, has historically held the maximum levy rate below the $1.80 per $1,000 AV level.

State law also provides full or partial exemptions to certain types of property and classes of ownership. Some non-profit organizations such as churches and government are totally exempt from property taxes while partial exemptions are given to low-income/senior and handicapped citizens. Also, farm, open space and timber land is generally valued at less than fair market value.

Road Fund

The Road Fund is generated by sources including a County road levy, gasoline sales tax, and federal and state grants. A portion of the Road Fund is used to pay for drainage activities associated with County Roads. The County road levy is limited to a maximum rate of $2.25 per $1,000 AV and restricted by the 106 percent lid.

Road funds cannot be used for non-road-related activities without jeopardizing the County's eligibility for state financial programs including the Rural Arterial Program (RAP).

Real Estate Excise Tax

RCW 82.46 allows counties and cities to levy an excise tax equivalent to 0.25 percent of the sale of real property. These funds are used explicitly for capital facilities on the premise that revenues generated through property sales reduce the burden on the general public of the problems created by growth and development.

Debt Financing

Debt financing is often used to fund drainage-related capital projects. The sale of bonds is an option but the debt service on bonds represents an ongoing funding requirement. Options for debt financing include the following:

- *General Obligation (GO) Bonds* are bonds for which the full faith and credit of the issuing government are pledged. The bonds are secured by an unconditional pledge of the issuing government to levy unlimited taxes to retire the bonds. GO bonds may require voter approval and may create a need to raise taxes. Interest rates are generally the lowest available.

- *Revenue Bonds* are bonds whose principal and interest are payable exclusively from earnings of an Enterprise Fund (such as a surface water utility) and therefore are more equitable than GO bonds. There are generally higher interest rates and a reserve is required. Bonds usually contain restricted operations and the market is not as broad as for GO bonds. Usually there is no need for voter approval and often limits are not subject to debt ceiling.

- *Bond Anticipation Notes* are short-term interest-bearing notes issued in anticipation of bonds to be issued at a later date. Anticipated notes increase issuer's risk and assume that long-term rates will fall.

- *Revenue Anticipation Notes* are short-term interest-bearing notes issued in anticipation of revenue to be received at a later date.

- *Grant Anticipation Notes* are short-term interest-bearing notes issued in anticipation of grants to be received later.

- *Tax Anticipation Notes* are interest-bearing notes issued in anticipation of taxes to be received later.

- *Industrial Development Bonds (IDB)* are bonds issued for private and quasi-public endeavors. They are secured by revenues of the bond-financed property. IDBs are used by governments to provide lower-cost financing to promote industrial and commercial development. The public purpose of some IDB issuances raises questions; IDB may crowd out other demands on municipal market. These bonds are restricted by the "1982 Tax Equity and Fiscal Responsibility Act."

- *Industrial Revenue Bonds* are bonds issued by the County, the proceeds of which are used to construct facilities in conjunction with a private business enterprise. Lease payments made by the business enterprise to the government are used to service the bonds. These bonds are usually in the form of GO or Revenue bonds. They provide low-cost financing and higher marketability due to yield.

External Funding Sources

Table 9-2 lists potential funding sources from state and federal grant and loan programs that should be explored for financing flood hazard management projects in Douglas County. Since the comprehensive plan specifies projects that are non-emergency in nature, the funding sources presented are available primarily for identified capital improvements. Several promising funding sources could provide near-term financial assistance, primarily for construction of flood control facilities. Other funding sources would become available if a federal disaster were declared, making additional funds available for repair, replacement, or mitigation. The primary disadvantage of mitigation funding sources is that funds would not become available, so facilities could not be constructed, until after the next major flood.

Flood Control Assistance Account Program (FCAAP)—Department of Ecology

The FCAAP program was established by the State Legislature in 1984 to assist local jurisdictions in comprehensive planning and maintenance efforts to reduce flood damages. To be eligible, a community must receive Ecology's approval of its floodplain management activities. Additionally, Douglas County would have to meet the requirements of the National Flood Insurance Program (NFIP). Every two years, $500,000 in non-emergency grant funds are available within any one county, but only $4 million is available statewide. The application period is during the winter with a deadline in the spring. Ecology evaluates and releases a priority list for funding in July. Non-emergency grants may be effective for work six months after funding and negotiations are complete.

TABLE 9-2.
EXTERNAL GRANT AND LOAN FUNDING SOURCES

Program and Agency	Description	Grant or Loan	Percentage Fundable	Requirements	Funding Amounts	Contact
Flood Control Assistance Account Program (FCAAP) - Department of Ecology	Floodplain management program for comprehensive flood hazard management, and maintenance of flood control facilities.	Grant	Planning: 75%; non-emergency maintenance: 50%; emergency maintenance: 80%.	Ecology-approved CFHMP completed or in progress; participation in National Flood Insurance Program.	Maximum per county per biennium: $500,000 for planning and non-emergency projects; $150,000 for emergency projects.	Tim D'Acci, Department of Ecology Shorelands and Coastal Zone Management Program, P.O. Box 47600, Olympia, WA 98504-7600 (206) 407-6796
Public Works Trust Fund - Department of Community Development	A low-interest revolving loan fund to help local governments finance critical public works needs. Eligible projects include repair, replacement or improvement of bridges, roads, domestic water, local ferries, sanitary sewer and storm sewer.	Loan	100% local.	Must be a local government with a long-term plan for financing public works needs. Must also impose a 1/4% real estate excise tax for capital purposes.	$48 million available for state in recent years, but decreased significantly in current budget.	Isaac Huang or Jeanette Johnson, Department of Community Development, P.O. Box 48300, Olympia, WA 98504-8300 (206) 586-0663
Watershed Protection and Flood Prevention Act (PL566) - Soil Conservation Service	Provides technical and financial assistance to local governments in planning and construction of improvement in small watersheds. Projects include flooding, erosion and sediment, conservation, development, utilization, and disposal of water.	Grant	Up to 100% of construction cost. Local sponsor pays for land acquisition and urban stormwater elements.	Several criteria, including favorable benefit-cost ratio, willingness of local sponsor to carry out project, and no critical environmental issues.	$62 million available in U.S. in 1993.	Lynn Brown, State Conservationist, U.S.D.A. Soil Conservation Service, Spokane, WA. (509) 353-2341
Small Flood Control Projects (Section 205) - Corps of Engineers	Program to reduce flood damages through projects not specifically funded by Congress.	Grant	100% of reconnaissance studies; 50% of feasibility study and construction cost.	Project adopted for construction only after engineering feasibility, environmental acceptability, and economic justification is shown.	Federal cost limit is $4 million per project.	Frank Urabeck, U.S. Army Corps of Engineers Seattle District. (206) 764-3708

TABLE 9-2 (Continued).
EXTERNAL GRANT AND LOAN FUNDING SOURCES

Program and Agency	Description	Grant or Loan	Percentage Fundable	Requirements	Funding Amounts	Contact
Hazard Mitigation Grant Funds (Section 404) - Federal Emergency Management Agency and Washington Department of Community Development	Provides funds for projects that mitigate problems to avoid future recurrence of the same problem (i.e., acquisition of flood-prone areas instead of repair of damaged buildings).	Grant	75% federal plus additional state match.	Requires Federal Disaster Area declaration and approved flood hazard management plan that identifies mitigation measures.	—	Robert Freitag, Federal Emergency Management Agency, Region X, Federal Regional Center, Bothell, WA 98021-9796 (206) 487-4701
Flooded Property Acquisition Program (1362) - Federal Emergency Management Agency	Provides option to purchase flood-damaged property from owners who incur repeated flood damages.	Grant	100% federal.	Requires flood insurance coverage of structures involved. Structure must be damaged by over 50% of value.	—	Robert Freitag, Federal Emergency Management Agency, Region X, Federal Regional Center, Bothell, WA 98021-9796 (206) 487-4701
Resource Conservation and Development Program - Soil Conservation Service	Provides project grants, advisory services, and counseling for installation of approved measures specified in RC&D area plans. Technical and financial assistance is available for water management.	Grant	Assistance with identifying grant sources.	Proposals for measures are judged on relevance to the RC&D area plan's goals and objectives. RC&D was established in 1992 and its program is under development.	—	Blaine Delaney, North Central Washington Resource Conservation and Development Council 133 East Johnson Ave, P.O. Box 666, Chelan, WA 98816 (509) 682-8284
Emergency Relief (ER) Funds - State Department of Transportation and Federal Highway Administration Title 23	Provides technical assistance and construction funds from State and Federal sources for temporary and permanent restoration of flood-damaged roadways.	Grant	100% federal and state funding for restoration within 90 days. 83% funding after 90 days.	Projects must be for temporary or permanent restoration of damages caused by declared Federal Disasters.	Dependent on road damage.	Stan Delzen, North Central Region State Aid Engineer. Washington Department of Transportation, P.O. Box 98, Wenatchee, WA 98807

Public Works Trust Fund—Department of Community Development

This State fund offers low interest loans for rehabilitation and repair of public works infrastructure, including stormwater facilities. Local governments such as counties, cities and special purpose districts are eligible for these loans. Loans are paid back using revenue from sources such as local utility and sales taxes on local water, sewer, and garbage collection, and from a 1/4 percent real estate excise tax. Applications are accepted annually between April and July.

Watershed Protection and Flood Prevention Act (PL 83-566)—Soil Conservation Service

The Small Watershed Program of PL-566 provides federal funding for watershed protection, flood prevention, and agricultural water management. Funds from PL-566 can be used to prepare studies and construct flood control projects, both structural and non-structural. In addition, PL-566 was modified in 1990 to authorize cost-share assistance to project sponsors for acquisition of wetland and floodplain easements to maintain or enhance their capabilities to retain excess floodwaters, improve water quality and quantity, and provide habitat for fish and wildlife.

PL-566 is a cost-sharing program that requires matching funds from a local sponsor. The East Wenatchee Watershed Project was conducted by the SCS under authority and funding of PL-566, and would have paid for 75 percent (over $3.5 million) of the construction cost. Although the funds allocated for this project were recently reprioritized for other SCS projects, they can probably be made available again if the County commits the local matching share. The total amount available throughout the country was $62 million in 1993.

This program has been recently modified as a result of the 1993 flooding on the Mississippi River. The types of eligible projects have been expanded and for some projects the federal cost shared.

Small Flood Control Projects (Section 205)—Corps of Engineers

This program funds flood control facilities that are not specifically authorized by Congress (through the Civil Works Projects program). The Corps of Engineers designs and constructs the project. The Corps pays up to $40,000 for reconnaissance studies, and 50 percent of feasibility study and project construction costs. A local sponsor must provide all lands, easements, and rights-of-way necessary for construction of the project. The federal cost limit is $4 million per project.

Hazard Mitigation Grant Funds (PL 93-288, Section 404)—FEMA and DCD/DEM

Section 404 of PL 93-288, the Robert T. Stafford Disaster Relief and Emergency Assistance Act (or the Disaster Relief Act), as amended by PL 100-707 and PL 103-181, the Hazard Mitigation and Relocation Assistance Act of 1993, provides funding for hazard mitigation projects, property acquisition, and relocation assistance. Funds from the Section 404 program would become available only after a presidential federal disaster is declared and if the mitigation measures had been previously proposed in an approved plan. After such a declaration, mitigation monies may be made available to cities, counties and other local entities for

projects that will reduce future damages and protect lives. The federal government can contribute up to 75 percent of the cost of hazard mitigation measures. However, the total amount of mitigation funding under any disaster declaration cannot exceed 15 percent of the total grant funds provided for the disaster. The state can provide additional matching funds.

Several criteria must be met before a project is eligible for funding. These include protecting lives and property, reducing flood damage vulnerability, implementing comprehensive programs and standards to reduce future flood damage, and others. Historically, there have been many more requests for hazard mitigation monies than dollars available, so projects are carefully evaluated and ranked. The Department of Community Development Division of Emergency Management (DCD/DEM) administers this program for FEMA by reviewing applications to ensure compliance with state and federal criteria. Applications are then sent to FEMA for approval.

Another program in the Disaster Relief Act, Section 406, provides disaster relief funds for damaged public and private non-profit facilities. These funds are used mostly for rebuilding of destroyed or damaged facilities. However, if a community or private non-profit agency decides not to rebuild the facility, 90 percent of the federal share for reconstruction is made available for other activities, which include hazard mitigation measures.

This act has recently been revised by Congress to allow for cost sharing of mitigation activities before a disaster occurs.

Flooded Property Acquisition Program (Section 1362)—Federal Emergency Management Agency

This program provides for the purchase of flood-damaged property. Eligible owners of damaged property may elect to sell the land and building to FEMA, which subsequently transfers the property to the community. The structure must have a National Flood Insurance policy in force at the time of the flood. Also, damage to the structure must meet one of the following three criteria:

- It has occurred at least three times over a 5-year period, with an average damage of 25 percent or more of the value of the structure.
- It was a result of a single flood with damage of 50 percent or more to the structure.
- It resulted from a single flood that left the structure irreparable due to local ordinance limitations or significantly increased building costs.

Raw land is not eligible for this program. This program does not require a Federal Disaster declaration.

Emergency Relief (ER) Funds—State DOT and FHWA Title 23

The State Department of Transportation serves as the clearinghouse for emergency road repair grants for damages associated with declared federal disaster areas. These grants can

provide technical assistance and construction monies to the County from State (Rural Arterial Program) and federal (Federal Highway Administration) sources for temporary and permanent restoration of flood-damaged roadways. Title 23 Emergency Relief monies are a major source of these funds. Permanent repairs can often incorporate designs that help prevent future damage. The local jurisdiction can also contribute additional funds, beyond that allocated for the emergency relief permanent restoration, to incorporate additional mitigation features in the project. The Trans-Aid Division of the Washington State Department of Transportation passes through Federal Highway Administration (FHWA) regular road monies and Title 23 Emergency Relief monies.

Resource Conservation and Development (RC&D) Program (PL 74-46)—Soil Conservation Service

The North Central Washington (NCW) RC&D Council was established in 1992 to improve the environment, economy, and standard of living in Chelan, Douglas and Okanogan Counties. Although funded by the U.S. Department of Agriculture through the Soil Conservation Service, the NCW RC&D is locally organized, sponsored, and directed. Its primary purpose is to help sponsoring groups seek funds and services from federal, state, and local sources. In particular, the RC&D has secured funding to establish a grants library in Okanogan County and therefore is a source of information on funding. Other RC&D projects relate to forestry, natural resources education, tourism, agriculture, legislation, and economic development. Both Douglas County and the City of East Wenatchee are sponsors of the NCW RC&D area.

FUNDING SOURCE EVALUATION CRITERIA

The County should seek to fund all elements of a surface water management program at an adequate and uniform level. Some options may only address the funding of capital improvements, while others may address the funding of all elements of a program but provide inadequate revenues. The use of one method, such as a surface water utility with a service charge, would not preclude other methods, such as local improvement districts or developer contributions to fund particular improvements. A mix of funding options may provide the greatest flexibility.

When developing funding for public programs, it is appropriate to identify criteria to be used in evaluating potential sources. Criteria listed below should help the County determine the most suitable funding sources for surface water management:

- Equity —Does the funding source equitably collect revenue from those who contribute to drainage problems and those who will benefit from improvements?
- Stability—Are revenues from this source reliable and predictable? Can the County plan on them over the long run?
- Control—Can the County control the revenue source, increasing it or decreasing it as required to fund programs?
- Adequacy—Does this source generate sufficient revenue to fund the desired program?

- Relatedness—Is this source of funding related to the problem that the revenue will be used to address?
- Ease of Implementation—Can this revenue source be activated quickly enough to fund the County's program?
- Restrictions—What are the restrictions on using this funding source? Will it fund capital operations? Work on private property? What other restrictions are there?
- Acceptability—Is this source likely to be acceptable to the citizens of Douglas County and its elected officials?
- Legality—What are the legal restrictions and requirements for implementing or using this source?

These criteria should be used to evaluate each potential funding source and thereby develop the overall funding program. Table 9-3 lists the funding sources and offers a preliminary evaluation of each against the criteria listed.

Table 9-3 shows that utility charges meet most of the funding source criteria. Establishing a utility, however, can be difficult, and assuring that revenues are adequate to fund capital, maintenance, and operations will depend upon the level of initial charges set and the willingness of the County to adjust charges as necessary.

Surface water runoff does not follow jurisdictional or political boundaries but flows within natural drainage basins or subbasins. Funding arrangements should recognize the cross-jurisdictional nature of drainage basins.

Programs to be Funded

When determining the adequacy of a funding source, it is important to consider the types of programs and projects that will be funded. Few funding sources can by themselves meet all the financial needs of a surface water management program. Therefore, the selected funding mix should be adequate to fund each program element. Basic program elements to be funded include the following:

- Operations and maintenance (O&M)
- Capital improvements
- Management of the surface water management program to meet County standards for design, maintenance, and construction
- Billing, collection and administering revenue generation.

Table 9-4 summarizes how each of the seven County funding options described above meet these funding use requirements

TABLE 9-3.
FUNDING MATRIX

Criteria	County Administrative Options						State/Federal Grants and Loans[b]			
	General Government Taxes	Developer Contributions	Improvement in lieu of Contribution	Utility Charges	Local Improvement Districts	Flood Control District	Public Works Trust Fund & local bonds	SCS PL566, COE 205 or other Federal	State FCAAP	FEMA mitigation or FHWA aid
Equity	NO	MAYBE	MAYBE	YES, based on contribution	YES based on benefit, not on contribution	YES based on either benefit or contribution	NO	Externally funded	NO	YES
Stability	Compete w/other functions	Depends on new development	Depends on new development	YES	NO	YES	NO	NO	NO	NO
Control	Limited ability to increase	Only with new development	YES	YES	NO	YES	NO	NO	NO	NO
Adequacy	NO	NO	NO	MAYBE	NO	MAYBE	NO	MAYBE	NO	NO
Relatedness	Sources not related to drainage problems	YES	YES	YES	YES	YES	Sources not related to drainage problem	YES	Sources not related to drainage problem	YES
Ease of Implementation	In place	In place	In place	Somewhat difficult	Difficult	Somewhat difficult	Difficult	Difficult	Difficult	Not predictable
Restrictions	Must fund public purpose items	On-site capital only	On-site capital only	Funds public system O&M and capital	Capital only	Funds both capital and O&M	Local match and funding limits per category	Local match required	Required flood plan approved & participation in NFIP, limited funds for non-emergency	Federal Disaster declaration required for fund availability
Acceptability	High	Medium	Medium	Medium	Low	Medium-Low	Medium	High	High	High
Legality	OK	May be issues[a]	May be issues[a]	OK	OK	OK	OK	OK	OK	OK

a. Developers can be required to develop mitigation measures directly related to their projects or to contribute to projects off site directly required because of their development. Such contributions need to be in conjunction with plans that identify drainage facilities.

b. Many state funding programs could be tapped for specific types of improvements, emergencies or programs. The most likely are shown above.

TABLE 9-4.
ADEQUACY OF COUNTY FUNDING SOURCES FOR VARIOUS USES

Option	O&M	Capital Improvements	Management Programs	Billing and Administration
Developer Contributions		X		
Drainage District	X	X		X
River Improvement Fund	X	X		X
Local Improvement District		X		X
Surface Water Utility	X	X	X	X
County Revenues	X	X	X	X
Flood Control Zone District	X	X	X	X

Procedure for Evaluating Funding Options

The County should review the evaluation criteria and rate the funding options. Some criteria may be weighted to recognize their greater importance. The evaluation could be performed considering funding options for operation and maintenance separately from funding options for capital improvements. Sample forms for this evaluation process are shown in Figures 9-1 and 9-2. The evaluation process should be conducted in a workshop involving both staff and elected officials. This detailed evaluation should be performed before proceeding with the funding program recommended in this section.

CONCLUSIONS

Based on initial evaluation of the funding options, a surface water utility for the East Wenatchee area appears to be the best primary approach to generate revenue for Douglas County surface water management programs. A utility will allow the County to implement the service charge only in basins where services are provided and to apply variable rates among the basins. A utility will also allow tax-exempt property to be included.

Forming a Surface Water Utility

A surface water utility may be established according to RCW 36.89, which states in part:

> Counties are authorized to establish, acquire, develop, construct, and improve ... stormwater facilities...within and without the cities and towns of the county and for such purposes have the power to acquire lands, buildings and other facilities by gift, grant, purchase, condemnation, lease, devise, and bequest, to construct, improve, or maintain buildings, structures and facilities for such purpose... (RCW 36.89.030)

Evaluation of Funding Methods (Operations and Maintenance) Weighted Score

Evaluation Criterion	Weight [a]	Funding Sources						
		Flood Control Zone Districts	River Improvement Fund	Other Districts	Current Expense Fund	Road Fund	Real Estate Excess Tax	Surface Water Management Utility
Ease of Implementation	1	3	5	2	5	5	4	3
Responsiveness	2	8	8	8	6	8	2	10
Ease of Administration	1	3	3	3	5	5	3	4
Compatible & Consistent with Existing Policies and Systems	1	4	5	3	3	1	3	5
Legal Framework	1	5	5	5	5	4	5	5
Revenue Capacity	2	10	6	8	2	2	4	10
Perceived Equality	2	10	10	10	6	4	2	10
Public Acceptance	3	9	9	6	9	6	9	9
TOTAL		**52**	**38**	**45**	**41**	**35**	**32**	**56**
OVERALL RATING [b]		**2**	**5**	**3**	**4**	**6**	**7**	**1**
Scoring System: 10 = high, 5 = medium, 1 = low.								

a. Weighting: 3 is most important; 1 is the least
b. Ratings: 1 is the highest; 7 is the lowest

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 9-1.
SAMPLE EVALUATION FORM—
OPERATIONS AND MAINTENANCE

Evaluation of Funding Methods
(Capital Improvements)
Weighted Score

Evaluation Criterion	Weight [a]	Funding Sources							
		G.O. Bonds	Revenue Bonds	Industrial Bonds	FCAAP	Public Works Trust Fund	Centennial Clean Water Fund	Loans	Surface Water Management Utility
Ease of Implementation	1	3	3	1	5	4	5	2	3
Responsiveness	2	8	10	4	5	4	10	2	3
Ease of Administration	1	5	5	2	4	5	5	2	4
Compatible & Consistent with Existing Policies and Systems	1	5	5	5	5	5	5	3	5
Legal Framework	1	5	5	5	5	5	5	5	5
Revenue Capacity	2	6	4	4	6	6	6	2	2
Perceived Equality	2	6	10	10	10	10	10	10	10
Public Acceptance	3	6	9	12	15	15	15	9	9
TOTAL		44	51	43	55	54	61	35	48
OVERALL RATING [b]		6	4	7	2	3	1	8	5
Scoring System: 15 = high, 1= low									

a. Weighting: 3 is most important; 1 is the least
b. Ratings: 1 is the highest; 7 is the lowest

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 9-2.
SAMPLE EVALUATION FORM—
CAPITAL IMPROVEMENTS

> The words "storm water control facilities"...means any facility, improvement, development, property or interest therein, made, constructed or acquired for the purpose of controlling, or protecting life or property from, any storm, waste, flood or surplus waters wherever located within the county... (RCW 36.89.010)

Cities and counties in Washington have established separate utilities or expanded the authority of existing sewer utilities to cover surface water. A utility provides a mechanism for consistent and predictable financial support for construction and operation of facilities and for administration of the surface water management program. Forming a utility also provides broad visibility for surface water issues, making elected officials and the public more aware of the regulatory and facility requirements placed upon jurisdictions. For this reason, it is recommended that public information and opportunities for public involvement be provided throughout the utility development process.

The following are the minimum requirements for establishing a utility and imposing fees and charges:

- Adoption of a comprehensive surface water plan
- Identification of planned expenditures
- Adoption of a system of fees and charges
- Classification of rate payers
- Establishing a system for billing rates, fees, and charges.

Adopt Comprehensive Plan

The adoption of a comprehensive surface water plan can be accomplished through the following steps:

- Prepare a comprehensive surface water plan for the County. The plan should include a statement of purpose, identification of County policies relating to surface water, the physical boundaries of the utility, a description of drainage basins covered by the utility including those portions of basins that are beyond the corporate limits of the County, identification of improvements planned, cost estimates, and a financing plan.
- Prepare an agreement with East Wenatchee as per RCW 36.89.050 for portions of basins that are in the City. The agreement should identify jurisdictional responsibility for construction and maintenance of facilities located in the City.
- Determine whether the surface water utility will be formed within the existing framework of the County or as a separate utility.
- Adopt the comprehensive plan.

Establish Utility

Once the comprehensive surface water plan has been adopted, the utility is established as follows:

- Adopt an ordinance establishing a surface water utility. The ordinance must refer to the comprehensive surface water plan and express the intent to establish and collect fair and equitable rates, fees, and charges.

- Develop an annual budget and a 6- to 10-year capital improvement program. This will set the revenue requirements for the utility. These will be the basis for determining the level of rates, fees and charges necessary to support the utility.

Set Rate Structure, Rates and the Method for Billing and Collecting Charges

The following steps establish rates and billing/collecting methods:

- The County may establish rates, fees and charges after the utility is adopted. Rates, fees and charges should be set to recover the full costs of operating the utility. Costs might include maintenance and operations of storm drains, capital construction of facilities, and regulations. A variety of mechanisms might be used to finance these.

- Determine the method of billing and collecting drainage fees and charges. The County may need to set up a new billing function, contract with another agency (e.g., the water district), expand the information in an existing County billing system (property tax statements), or otherwise modify current practices. The time required to do this is often as long as or longer than the time required to prepare and adopt the appropriate ordinances. Personnel should be trained in customer service (be knowledgeable about the program and able to answer specific account-related inquiries) before new bills are sent out.

- Develop account information to be used to establish rates or fees. The generally accepted methods of determining a surface water service charge or rate are as follows:

  - *Amount of Impervious Surface*. Rates under this approach are set in direct proportion to the measured, estimated, or assumed extent of impervious area for each parcel of land. Impervious surface is land occupied by buildings, pavement, or other impermeable surfaces.

  - *Density of Development*. Under this approach, rates are determined by a runoff coefficient that is appropriate for the type of land and the nature of improvements on it.

  - *Flat Fee*. This approach utilizes a constant or uniform fee for each property within pre-existing classes or can be applied community-wide.

- Conduct an analysis of the ability of the preferred rate structure to meet the utility's revenue requirements. With this information, recommendations for rates, fees and charges should be made to the County Commissioners. Rates, fees and charges can be adopted by resolution, however, and ordinance is the preferred means.

A service charge for surface water management may be established based on the premise that those who contribute runoff to the system should pay in relation to the amount of runoff. Typically, an equivalent service unit (ESU) is established, defined as the average amount of impervious surface on a single-family residential lot. The ESU is the basis for rates, as in the following example:

Property: Convenience store with 11,800 square feet of impervious surface

ESU: 2,950 square feet (average amount of impervious surface on a single-family residential property)

Rate/ESU (example): $3.50

Calculation: $\frac{\text{11,800 square feet of impervious surface}}{\text{2,950 square feet}} = 4 \text{ ESUs}$

Monthly Service Charge (example): 4 ESUs x $3.50 = $14.00 per month

The charge is based on contribution to drainage problems or benefits from their remediation. Public entities such as schools, churches, and state agencies, while exempted from property tax levies, may pay a service charge for their contribution to drainage problems. Adoption of a service charge would not negatively impact other County revenues. The surface water drainage concept is currently used in Clark, Snohomish, Kitsap, King, Pierce and Thurston County. Several court cases have upheld counties' authority to create a surface water utility (see Teter vs. Clark County, State Supreme Court decision, August 8, 1985).

Conduct Public Hearings

Public hearings should be held at several critical points in the process of forming the utility to inform citizens of the planned program, costs, benefits, and rates and to get input from the public. Key times for holding public hearings are prior to adoption of the comprehensive surface water plan, prior to the adoption of an ordinance establishing the utility, and prior to adoption of utility rates, fees, and charges. These hearings may be held in conjunction with County budget hearings.

Supplementary Revenue Sources

Surface water utility revenue from service charges may be supplemented by other funding mechanisms as needed. System development charges, permitting fees, inspection fees, and other charges might be used to charge new development for capital costs the County might incur to support the new development or the costs of the regulatory functions necessary to

assure that construction is completed in compliance with regulations. State and federal grants may be used to complement the budget for capital facilities or land acquisition.

Suggested Utility Policies

The following potential County policies would support and/or suggest the need for a surface water utility:

- Drainage will be monitored and controlled to avoid long-term problems caused by runoff such as flooding, soil erosion, and sedimentation in natural drainage ways, and impacts on downstream water quality and development.
- A fair and equitable system of charges will be implemented.
- Given that the volume and flow rate of runoff increases as property is developed with hard surfaces, such as rooftops, parking lots, driveways, patios, the variations in runoff from different types of property will be recognized in the County's rate structure.
- Individual property owners are responsible for the control of runoff from their own property; the County will recognize this responsibility in its regulatory efforts.
- The system of capital drainage facilities will be designed to support existing and planned residential, commercial, agricultural, and industrial development as well as the naturally occurring surface water issues.
- The system of capital drainage facilities will be designed to handle the runoff created by the highest level of development allowable under the current zoning at the time of design.
- All new development will pay its fair share of the capital facilities required in the drainage basin to support such new development.
- The County will recognize the contribution of existing development to runoff problems and will equitably spread the costs of solving these problems.

RECOMMENDED ACTION PLAN

The following is a summary of the actions the County should take to fund the stormwater management program.

- Conduct a workshop to evaluate the funding options against the respective criteria.
- Adopt a funding policy that outlines the methods to be used to finance stormwater needs in the County.

- Prepare a public involvement program to inform the public of the funding approach and to build support for adoption of the utility or other method selected.
- Prepare a cost-of-services study and projected capital and O&M budgets.
- Adopt a resolution of intent setting forth officially the funding approach.
- Conduct a public involvement program.
- Adopt the ordinance that establishes the funding method and establishes the budget accounts as well as the method of charges.
- Develop the billing data base and the method of billing and collecting revenue.
- Prepare and adopt the rate or service charge ordinance.
- Impose the service charge through a regular billing sequence and respond to questions/issues related to the service charge or other fees/assessments.

CHAPTER 10.
ANALYSIS OF FLOOD HAZARD MANAGEMENT ALTERNATIVES

Potential flood hazard management solutions were developed for each of the problems identified in this study. The potential solutions include constructed projects, new policy decisions, land use modifications, additional development standards, and options for retrofitting existing structures. These solutions were analyzed to determine their impacts, costs, and benefits to the public. The solutions that best meet the goals and objectives of the study were then selected for recommendation. Both the potential course of action and the decision-making process are described in this chapter.

DEVELOPMENT OF SOLUTIONS

Two categories of potential actions were developed to address flooding problems. One refers to nonstructural actions that were developed to help prevent the creation of additional problems as the study area continues to urbanize. The other provides solutions to existing problems and are primarily structural solutions.

Four types of solutions were developed for existing problem sites and for use in preventing the creation of additional problems in the future. Potential solutions developed to address future problems, being nonstructural, include regulatory options, development standards, and land use controls. The solutions to existing problems, being primarily structural in nature, require a capital expenditure. Therefore these solutions are potential capital projects. Project description sheets in Appendix B contain detailed descriptions, design criteria and requirements, identified issues, and total costs for the individual capital projects. Each project is identified by a project code, such as *CA-11a*, to allow cross-referencing with the alternatives.

NONSTRUCTURAL SOLUTIONS

The nonstructural solutions developed to address potential future problems do not require a major expenditure of funds or the implementation of a capital project. These solutions address either regulations, development standards or land use policies. Several potential solutions were developed for each category for consideration by the advisory committee.

The solutions were presented to the advisory committee at their March 23, 1994 meeting. The ramifications and impacts of each potential solution were discussed by the members before they voted on each set of solutions. The committee voted first on whether or not each solution was acceptable. They then expressed their opinion on the importantance of its implementation by ranking each solution on a scale of one to ten with ten being the most important.

Regulatory Options

Many nonstructural options under the general category of regulations offer great potential for managing flood hazards and reducing future risk. These alternatives address mostly future activities, such as new development or redevelopment. Consequently, they offer only limited benefits in urban areas.

Regulations refer to general restrictions on land use and development that are dictated and enforced by local ordinances. An example is the floodplain regulations in the Flood Damage Prevention ordinance, Chapter 15.48 of the County Code. These regulations strictly regulate what types of development are allowed and the standards for construction within a designated 100-year floodplain. Violations of City and County ordinances can result in criminal penalties, imprisonment, and other enforcement action.

Potential regulatory changes that provide improved flood hazard management are listed in Table 10-1. Most options in Table 10-1 focus on the existing Flood Hazard Prevention Ordinance. Suggested changes include new or additional restrictions for development in the floodplain, along drainage corridors, and on alluvial fans. These options were discussed and voted on at the March 23, 1994 committee meeting. The results of voting by the committee are shown in Table 10-2.

TABLE 10-1.
REGULATORY OPTIONS

Proposal	Current Standard or Policy	Purpose
Prohibit new development in FEMA AO and numbered A zones.	No restrictions within FEMA floodplain (development is restricted in floodways, but no restrictions in County). AO zones include Canyon A, Canyon B and Sand Canyon flood corridors. Numbered A zones include most of Moses Coulee.	Prevents inappropriate development in floodplain, thereby avoiding flood hazards
Require lowest floor to be two feet above base flood for all new and substantial improvements.	Zero feet for AO zones and 1 foot for numbered A zones. Substantial improvements are those exceeding 50% of value of structure.	Minimizes flood damage of homes located in floodplains
Prohibit critical facilities in floodplain (i.e., fire stations, medical facilities, etc.).	No restrictions	Avoids disruption of emergency services during flood events
Prohibit fill or obstructions within natural drainage pathways.	No restrictions, except for designated floodplains	Prevents development from creating new drainage problems
FEMA base (100-year) flood boundaries should be shown on better maps and should be allowed in administration of the flood hazard ordinance.	Ordinance references FEMA maps only	Permits ease in interpretation of floodplain boundaries. Use of non-FIS data would be allowed only if base flood data were not in FIS report.

TABLE 10-1 (Continued).
REGULATORY OPTIONS

Proposal	Current Standard or Policy	Purpose
Floodproofing designs shall be certified and inspected prior to permit approval.	No established procedures for certification, other than general permit review	Ensures floodproofing requirements are being met
All new lots should show floodplain limits.	Current practice, but not required	Informs buyers, landowners, and permit reviewers of flood hazards
Identify alluvial fan and geologic hazard areas that are prone to debris flows and land slides and establish appropriate development restrictions.	Not available	Identifies hazards areas other than floodplains. Will be required for GMA.
Consider combining floodplain and shoreline ordinances.	Separate ordinances	Improves efficiency of administration
Establish minimum setbacks from all streams and principal drainages.	No requirements	Prevents development from encroaching on drainage pathways
Prohibit development on alluvial fans without prior control of drainage.	No requirements	Recognizes hazard of alluvial fan flooding, when floodproofing is not sufficient.
Incorporate floodplain ordinance into building code.	Not incorporated	Provides additional enforcement power for floodplain restrictions
Show floodplain and shoreline boundaries on zoning maps.	Not shown	Identifies regulated floodplain and shoreline areas

Development Standards

Development standards refer to specific stormwater requirements for buildings, subdivisions, and related development to prevent new development or redevelopment of property from having an impact on downstream property owners. These requirements are typically specified in the subdivision ordinance or a stormwater ordinance. Probably the most important development standard is the rainfall intensity (or design storm) that a storm drainage system must be designed for. Currently, this and other standards are not specified in any ordinance.

TABLE 10-2.
CITIZEN ADVISORY COMMITTEE, MARCH 23, 1994
VOTING RESULTS-REGULATORY OPTIONS

Proposal	Acceptable? Yes	Acceptable? No	Number of Votes (Rank) 10	8-9	5-7	1-4
1. Prohibit new *or inappropriate* development in FEMA AO and Numbered A zones.	12	0	7	2	1	2
2. Require lowest floor to be 2 feet above base flood for all new and substantial improvements.	12	0	4	5	3	0
3. Prohibit critical facilities in floodplain (i.e., fire stations, medical facilities, etc.)	11	1	9	1	1	0
4. Prohibit fill or obstructions within natural drainage pathways	11	1	7	2	1	0
5. FEMA base (100-year) flood boundaries should be shown on better maps and should be allowed in administration of the flood hazard ordinance.	12	0	2	5	2	2
6. Floodproofing designs shall be certified and inspected prior to permit approval.	11	1	5	1	4	1
7. All new lots should show floodplain limits.	12	0	4	6	2	0
8. Identify alluvial fan and geologic hazard areas that are prone to debris flows and land slides and establish appropriate development restructions	12	0	5	4	3	0
9. Consider combining floodplain and shoreline ordinances.	7	3	0	1	3	3
10. Establish minimum setbacks from all streams and principal drainages.	11	0	2	5	2	2
11. Prohibit development on *high risk* alluvial fans without prior control of drainage.	12	0	4	6	2	0
12. Incorporate floodplain ordinance into building code.	11	0	6	2	2	1
13. Show floodplain and shoreline boundaries on zoning maps.	12	0	7	3	2	0

Potential development standard options that were discussed with the committee are listed in Table 10-3. In addition to these, a stormwater ordinance would include many additional standards that address more routine aspects of drainage design. Review of development standards for any particular project would occur during the development or building permit review process. Failure to meet a standard would result in nonissuance of the permit.

These options were discussed and voted on at the March 23, 1994 committee meeting. The results of voting by the committee are shown in Table 10-4.

Land Use Controls

Land use controls refer mostly to governmental planning policies that dictate the nature and pattern of development within a community. Many of these policies relate directly to floodplain and stormwater runoff hazards. For example, one land use control policy is preservation of orchard areas that currently receive and infiltrate stormwater runoff. Establishment of such a policy would, in effect, authorize local officials to pursue whatever steps are needed to achieve the objectives of the policy. Of course, policies by themselves are not enforceable. Instead, they are intended to guide the implementation of other projects and programs. Policies need to be implemented through the zoning code and in other ways.

Potential land use control options are listed in Table 10-5 These options cover a broad spectrum of government activities, ranging from how land located in flood hazard areas are taxed to general planning goals of the Growth Management Act. Many would require considerable effort, resources, or political will to implement. These options were discussed and voted on at the March 23, 1994 committee meeting. The results of voting by the committee are shown in Table 10-6.

CAPITAL PROJECTS

Multiple capital projects were developed as potential solutions for each of the currently known problems. In some cases several of these projects were grouped to form alternatives to address an entire drainage basin or a significant portion of it. Each project was analyzed to determine its potential level of protection, cost of implementation, feasibility, and impacts. Criteria were then developed for the advisory committee's use in selecting between alternatives and between projects to solve individual problems. Options for the design criteria for these projects were also discussed by the committee. Table 10-7 shows advantages and disadvantages of each potential design standard criteria. This table supplied guidelines for determining the level of service provided by future drainage facilities within the county.

The potential capital solutions for problems within the study area are described by drainage basin. First the potential solutions for Canyon A are described, then Canyon B, Sand Canyon, the general urban area, Moses Coulee and Jameson Lake.

TABLE 10-3.
DEVELOPMENT STANDARD OPTIONS

Proposal	Current Standard or Policy	Purpose
Establish stormwater ordinance.	Standards are currently enforced through conditions on building permits, but not written into any ordinance	Establishes clear standards, authority, and enforcement
No additional runoff due to development unless provisions are made to convey water safely to river.	Standard not written into any ordinance	Prevents development from creating new drainage problems.
Set runoff criteria for drainage control at new developments based on actual experience, such as 2 inches in 90 minutes during May 1993 storm.	Current requirement of 25-year storm (approx. 0.75 inch in 90 minutes) does not reflect localized, intense thunderstorms	Establishes realistic standard.
Require infiltration of all runoff from impervious surfaces.	No requirement	Detention without infiltration still generates offsite runoff that is conveyed downstream.
Establish division of responsibility between developer and City/County on providing stormwater facilities.	Not established	Establishes clear authority and responsibility (other jurisdictions require offsite mitigation or impact fees from developers to supplement public spending on improvements).
Promote roadside infiltration where possible	No requirement	Widespread use of infiltration to supplement or replace current requirements for curbs, gutters, and sidewalks.
Design stormwater facilities for maximum buildout.	No requirement	Plans for adequate capacities of stormwater facilities in floodplains
Eliminate requirement for curbs, gutters and sidewalks if roadside infiltration is provided.	Curbs, gutters and sidewalks are required in new major (>4 lot) subdivisions.	Reduces impervious area to reduce runoff, particularly if replaced with infiltration systems.
Reduce the width of paved residential streets.	36 feet plus 5 feet for each sidewalk	Reductes impervious area to reduce runoff.
Require drywells for all roof downspouts	No requirement	Eliminates one source of runoff generated by development

TABLE 10-3 (Continued).
DEVELOPMENT STANDARD OPTIONS

Proposal	Current Standard or Policy	Purpose
Require grassed swales with infiltration adjacent to roads	No requirement	Allows runoff to infiltrate, reducing stormwater flows. Improves water quality.
Establish criteria for flow capacity of drainage facilities such as culverts, ditches, and pipes (i.e., 25-year, 50-year, or 100-year).	Standard not written into any ordinance.	Establishes clear standards that reflects a predetermined level of protection.
Leave native vegetation in all drainage pathways unless irrigation is provided.	No requirement.	Reduces erosion resulting from disturbed or bare soils

TABLE 10-4.
CITIZEN ADVISORY COMMITTEE, MARCH 23, 1994
VOTING RESULTS-DEVELOPMENT STANDARD OPTIONS

Proposal	Acceptable?		Number of Votes (Rank)			
	Yes	No	10	8-9	5-7	1-4
1. Establish stormwater ordinance.	12	0	3	5	5	0
2. No additional runoff due to development unless provisions are made to convey water safety to river.	12	0	5	4	2	1
3. Set runoff criteria for drainage control at new developments based on actual experience, such as 2 inches in 90 minutes during May 1993 storm.	10	1	4	5	0	1
4. Require infiltration of all runoff from impervious surfaces.	9	3	1	7	1	0
5. Establish division of responsibility between developer and City/County on providing stormwater facilities.	11	0	4	1	7	0
6. Promote roadside infiltration where possible.	10	2	4	4	2	0
7. Design stormwater facilities for maximum buildout.	10	1	2	5	3	0
8. Eliminate requirement for curbs, gutters and sidewalks if roadside infiltration is provided.	5	6	2	2	1	0
9. Reduce the width of paved residential streets	6	5	1	2	2	1
10. Require drywells for all roof downspouts.	5	6	1	1	3	0
11. Require grassed swales with infiltration adjacent to roads.	8	4	1	3	2	2
12. Establish criteria for flow capacity of drainage facilities such as culverts, ditches, and pipes (i.e., 25-year, 50-year, or 100-year).	12	0	6	4	1	1
13. Leave native vegetation in all drainage pathways unless irrigation is provided.	11	1	3	4	1	2

TABLE 10-5.
LAND USE CONTROL OPTIONS

Proposal	Current Standard or Policy	Purpose
Promote preservation of orchards and other open areas that currently receive and infiltrate stormwater or are subject to hazardous flooding conditions	No policy or program (Achieved through down-zoning, purchase of development rights, property taxes based on nondeveloped use, etc.)	Maximizes existing beneficial uses of these areas. If developed, requires new facilities to be constructed to replace drainage functions of existing open areas.
Retain sensitive areas in natural states (drainage corridors, infiltration areas, alluvial fans, agricultural runoff areas, slide zones)	No established program (Comprehensive plan promotes preservation of natural drainage areas and floodplains)	Prevents inappropriate development in hazardous areas, thereby avoiding future problems.
Promote infilling to maximize existing developed areas and infrastructure	General objective of GMA planning	Minimizes creating impacts in new areas
Plan for combined use of future parks to include stormwater detention	No policy or program	Maximizes beneficial use of public areas
Plan for combined use of drainage corridors and floodplains to include multiple use, open space, parks, and other compatible uses	No policy or program	Maximizes beneficial use of open areas
Prioritize drainage problems—fix major problems first, those causing significant impacts to existing development, and remaining problems in the future as funds become available and growth necessitates improvements	No policy other than maximum cost-effectiveness (CFHMP can define all necessary criteria)	Maximizes beneficial use of public funds
Down-zone hazardous areas to floodplain, infiltration, etc. zones as appropriate	No policy or program	Preserves existing land use where natural hazards exist or beneficial uses are provided
Assess property taxes for hazardous land areas based on existing (undeveloped or developed) use.	No policy or program.	Reflects actual current use of land by taxes, reduces expectations of landowner, and lowers tax assessment for unbuildable property.

TABLE 10-5 (Continued).
LAND USE CONTROL OPTIONS

Proposal	Current Standard or Policy	Purpose
Require donation of hazardous areas to County when large parcels are developed	No requirements	Prevents future flood problems through regulatory mechanism to permanently acquire flood hazard areas
Allow density credits for hazardous areas left as open space	No policy or program	Prevents future flood problems through incentive to developer to preserve flood hazard areas
Leave native vegetation in all drainage ways, especially non-irrigated farmland	No requirements	Reduces erosion resulting from disturbed or bare soils
Purchase high priority sensitive areas	No policy or program	Prevents future flood problems through acquisition of flood hazard areas

TABLE 10-6
CITIZEN ADVISORY COMMITTEE, MARCH 23, 1994
VOTING RESULTS-LAND USE CONTROL OPTIONS

Proposal	Acceptable? Yes	Acceptable? No	Number of Votes (Rank) 10	8-9	5-7	1-4
1. Promote preservation of orchards and other open areas that currently receive and infiltrate stormwater or are subject to hazardous flooding conditions.	12	0	7	4	1	0
2. Retain sensitive areas in natural states (drainage corridors, infiltration areas, alluvial fans, agricultural runoff areas, slide zones).	12	0	6	4	2	0
3. Promote infilling to maximize existing developed areas and infrastructure.	9	3	2	4	2	1
4. Plan for combined use of future parks to include stormwater detention.	12	0	3	6	2	1
5. Plan for combined use of drainage corridors and floodplains to include multiple use, open space, parks, and other compatible uses.	11	0	4	5	2	0
6. Prioritize drainage problems - fix major problems first, those causing significant impacts to existing development, and remaining problems in the future	11	1	5	3	2	0
7. Down zone hazardous areas to floodplain, infiltration, etc. zones as appropriate.	10	2	2	4	3	0
8. Assess *property taxes* in hazardous areas based on existing use.	11	1	1	5	5	0
9. Require donation of hazardous areas to County when large parcels are developed.	5	7	2	2	0	1
10. Allow density credits for hazardous areas left as open space.	12	0	2	5	3	2
11. Leave native vegetation in all drainage ways, especially non-irrigated farmland	10	2	5	3	0	1
12. Purchase *high priority* sensitive areas.	9	3	3	2	3	1

TABLE 10-7.
DESIGN CRITERIA OPTIONS FOR EAST WENATCHEE FLOOD CONTROL

Issue	Advantages	Disadvantages
STORMWATER SYSTEM DESIGN		
Unlined ditches and culverts	• Minimal cost • Easy to maintain • Natural appearance • Potential water quality benefits	• Easily eroded on steep slopes • Sediment eroded from ditch can cause more damage than floodwater • Ditch may preclude other uses such as sidewalks and parking • Sometimes difficult to follow natural drainage pathways • Ditch size may be very large
Paved ditch and culverts	• Provides protection against ditch erosion • Easy to maintain	• Increased expense for paving ditch • Increases impervious area, creating additional runoff • High water velocities in ditch may be hazardous • May be unsightly • Ditch may preclude other uses such as sidewalks and parking
Curbs/gutters/sidewalks	• Required for new developments • Increases property values • Greatest protection against roadside erosion • Allows use of road ROW for sidewalks and parking.	• Increases impervious area, creating additional runoff • Expensive • Concentrates flows • Minimal water quality benefits • Requires underground conveyance system.
Underground pipes	• Most efficient in conveying storm-water • Can work on adverse street slopes and difficult topography • Aesthetically pleasing (out of sight) • Eliminates roadside erosion	• Very expensive • Clogs easily when sedimentation is a problem, requiring expensive maintenance • Requires major construction effort; best done with street reconstruction • Cannot always be connected to existing systems because of limited downstream capacity • No water quality benefits
Onsite detention	• Reduces runoff at source • Creates open space • Provides water quality benefits • Required for new construction • Possible multiple use • Potential for open space density credit	• Difficult to retrofit in existing development • Expensive • Ties up potentially developable land • Requires long-term maintenance by property owners, which can be a serious problem

TABLE 10-7 (Continued).
DESIGN CRITERIA OPTIONS FOR EAST WENATCHEE FLOOD CONTROL

Issue	Advantages	Disadvantages
Regional detention/infiltration	• Generally more cost effective than onsite detention • Easily integrated into existing systems • Reduces downstream conveyance sizes • Detention sites can be multi-use (i.e., open space, parks, play fields) • Provides water quality benefits	• Large land parcels may not be available • Requires purchase of land for detention pond • Moderately expensive
DESIGN STORM - STORMWATER		
Minimum (10-year)	• Lowest cost	• Least protection • Rarely used today as standard in municipal systems
Average (25-year)	• Moderate cost • Common in stormwater ordinances • DOT standard for culverts	• Moderate protection • Minimal factor of safety for unforeseen events
High (50- to 100-year)	• Most protection • Typically used for environmentally sensitive areas • Increasingly used in stormwater ordinances • DOT standard for bridges, highway embankments, and major structures • Provides factor of safety for unforeseen events or errors in design rainfall magnitudes (e.g., 1993 storm exceeded 100-year event in certain areas)	• Highest cost • Flood control benefits may not significantly increase (i.e., marginal costs may be greater than marginal benefits)
DESIGN STORM - FLOODPLAINS		
100-year for floodplain	• Minimum requirement of FEMA for flood insurance; less strict standard not possible • Provides greatest protection against flooding in natural drainage pathways • Land owners can purchase federally subsidized flood insurance	• Local authorities must enforce floodplain ordinance to ensure compliance • FEMA maps are often not accurate; actual floodplain may extend beyond boundary • Flood insurance covers only structural damage, not yard damage • Due to cost, relatively few residents opt to purchase flood insurance

TABLE 10-7 (Continued).
DESIGN CRITERIA OPTIONS FOR EAST WENATCHEE FLOOD CONTROL

Issue	Advantages	Disadvantages
10-year for bridges and culverts	• Least cost (few improvements are needed for existing system) • Most bridges should be able to withstand overtopping with no damage	• Least protection (current capacity of most existing bridges)
25-year for bridges and culverts	• Increased protection • DOT standard for culverts • May be achieved by modifying existing bridges • Most bridges should be able to withstand overtopping with minimal damage	• Moderately expensive • Some bridges may require reconstruction to provide this level of protection
100-year for bridges and culverts	• Greatest protection • Improves wildlife corridor • DOT standard for bridges, highway embankments, and major structures	• Very expensive • Replacement of most bridges will be required • Usually required only when road is critical transportation route or bridge failure may have catastrophic consequences

Projects versus Alternatives

Due to the possible far reaching effects of flood events, solving all the flooding problems along a particular drainage corridor typically requires implementation of many individual projects. For example, four reaches along Canyon A have different flooding problems. Several solutions were developed for each problem within these four reaches. The potential solutions were compared and the best solutions were combined into sets of solutions that addressed all of the flooding issues within the drainage corridor. These sets of solutions are the alternatives that were presented to the advisory committee.

The alternatives with their individual projects are identified below for each study area. In most cases more than one project makes up an alternative. Some alternatives also require miscellaneous actions that are not formally described by a project (i.e., maintenance). Only a few of many possible combinations of projects are presented. The alternatives represent a relatively uniform level of protection throughout the study area, or they focus on one or more particularly severe problem that is singled out as being critical.

Many alternatives were identified in areas where flooding problems are complex and costly to solve, such as along Canyon A. Fewer alternatives were identified where flooding solutions are simple.

Engineering Analysis

Development of flood hazard management alternatives requires a reconnaissance-level engineering analysis to determine overall effectiveness (or level of protection), construction

cost, and impacts of the alternatives and their individual projects. A reconnaissance-level analysis allows one to investigate many options without having to conduct a detailed analyses of each one. The overall goal of the reconnaissance-level analysis is to determine the feasibility of a solution given the existing regulatory structure, funding capabilities, and community values. Some solutions, such as piping all runoff within the community to the Columbia River, were not considered due to their high cost or their conflict with the desires of the community.

Level of Protection

Probably the most important consideration in developing a stormwater control project is determining the appropriate level of protection. Level of protection refers to how much flood control benefit the project provides. For example, protection against the 100-year flood is commonly regarded as the highest practical level of protection that any project should provide. However, a lower level of protection such as a 50-year or 25-year event may alleviate all common flooding problems and even reduce the severity of the larger floods. The obvious benefit of a lower level of protection is a potentially large immediate cost savings, thereby freeing up funds to solve other flood problems in the community. Other benefits such as reduced construction impacts will also be gained. The alternatives were initially selected to give different levels of protection, resulting in different total costs. The chosen level of protection is dictated to some degree by FEMA requirements as well as community standards. The 100-year level of protection was chosen for all existing major drainage ways, while the 25-year storm event was selected as a minimum design standard for storm drainage facilities.

Cost Estimates

Functional requirements of the drainage system were investigated by applying computer analysis tools and other information presented in Chapter 6 to the flood problems identified in Chapter 7. Other engineering and hydraulic analysis techniques were used to determine realistic arrangements and sizes of canals, pipelines, detention ponds, infiltration facilities, ditches and other facilities. After a conceptual design was formulated, quantity estimates were derived from existing maps and other site information. In general, new field investigations were not conducted.

Cost estimates for each project were based on unit cost data compiled from several sources and verified with County staff. Unit costs were obtained from recent County drainage projects, Washington Department of Transportation bid tabulation summaries, available cost guides (e.g., Means), contacts with construction contractors, and KCM data. Markups for contingencies, engineering, and other indirect costs were based on commonly accepted values. The resulting total estimated project cost are intended for project comparison and for determining overall funding requirements. Further analyses should be conducted for competing projects with similar costs or to resolve issues on project practicality or impacts.

Impacts Analysis

Some of the impacts expected with each project are shown on the summary sheets in Appendix B as "Issues." Impacts include potential environmental impacts from the project, permit issues, safety, disruption of the community or traffic during construction, downstream impacts, and aesthetics. The issues were described to the advisory committee

and considered during evaluation of the projects and alternatives. The environmental analysis is sufficient to allow the selection of alternatives, but is not sufficient to satisfy SEPA. Each construction project will be required to go through the SEPA process before construction can begin.

Selection Criteria

Selection criteria are quantifiable indicators of project benefits and impacts to be used for the selection of projects. The criteria are defined and ranked to determine which aspects of flood and stormwater control projects are most important for consideration when projects are selected and prioritized. The advantages and disadvantages of several types of design and design standards (Table 10-7) were discussed at several meetings.

The following selection criteria used for the alternatives are listed in order of decreasing importance:

- Cost effectiveness
- Level of flood control protection that the project provides
- Neighborhood disruption, both during and after construction
- Potential for County liability
- Ease of maintenance
- Aesthetics
- Water quality benefit
- Health benefits other than those associated with flooding

Therefore, providing maximum flood protection at minimum cost and disruption was the primary concern. Other indirect impacts and benefits such as aesthetics and water quality were of less importance. No numerical rating of the solutions was undertaken; they were voted on by the committee as to their suitability and preference.

Canyon A

When various projects were combined to form a basin-wide solution, an alternative was created. In Canyon A, potential solutions were combined into nine different alternatives for consideration by the advisory committee. The potential solutions to the Canyon A problems are shown in Table 10-8. These have been combined to form the alternatives shown in Table 10-9. Each alternative is formulated to provide a different level of protection or a different means of achieving the desired level of protection. Individual projects that make up each alternative are identified by the project code in parenthesis. Advantages and disadvantages of each alternative are also summarized in the table. Complete descriptions of each potential project are contained in Appendix B.

TABLE 10-8.
CANYON A POTENTIAL SOLUTIONS

Project[a]	Project Name
CA-1	Canyon A - Detention dams
	1a: 13 ac-ft dam at Lyle Avenue
	1b: 35 ac-ft dam above Lyle Avenue
CA-2	Canyon A - Change in agricultural practices
CA-3	Canyon A - Increase capacity of road culverts
	3a: 100-year capacity at Lyle Avenue only
	3b: 25-year capacity at all culverts
	3c: 100-year capacity at all culverts
CA-4	Canyon A - Reinforce road embankment at Lyle Avenue
CA-5	Canyon A - Grant Road flooding: dike at Kentucky Avenue
CA-6	Canyon A - Pipeline from Kentucky Ave to Columbia River under Grant Road
	6a: 60-inch pipeline
	6b: 48-inch pipeline (requires Project CA-1a)
CA-7	Canyon A - Channel improvements and flood easement from Lyle to Hanford
CA-8	Canyon A - Relocate homes in floodplain and establish flood easement from Lyle to Hanford
CA-9	Canyon A - Relocate channel in Eastmont Park
CA-10	Canyon A - Floodproof homes in floodplain
CA-11	Canyon A - Pipeline from Eastmont to Columbia River (100-year flow)
	11a: 60 inch pipeline
	11b: 48 inch pipeline (requires Project CA-1a)
	11c: 42 inch pipeline (requires Project CA-1b)
CA-12	Canyon A - Channel from Eastmont to Columbia River
CA-13	Canyon A - Pipeline from Kentucky Ave to Columbia River under Kentucky Ave.

a See Appendix B for description sheets detailing each project.

Alternatives for Canyon A tend to be costly. Between $4 and $6 million is needed to provide complete protection against the 100-year flood (Alternatives CA-A through CA-D) as shown in Table 10-9. If only the major problems areas are targeted for protection, such as Grant Road and East Wenatchee below Eastmont Avenue, costs can be reduced substantially but other areas may actually experience increased flooding as a result of diverting floodwaters. The no-action alternative would result in average annual damages that were roughly estimated to be more than $100,000 per year.

In general, the following important points were considered before selecting the preferred alternative:

- The primary problem areas along Canyon A are flooding of Grant Road and flooding of East Wenatchee below Eastmont Avenue. Solving these problems will require a costly pipeline that can follow one of several possible routes to the Columbia River. The pipe alternative that has the least disruption and impacts will probably be the most preferable.

- Several improvements can be made at relatively low cost, such as relocating the channel in Eastmont Park, clearing out the existing channel between Kentucky and Hanford, and modifying the road or culvert at Lyle Avenue.

- The cost of restoring the floodway between Kentucky and Hanford is high. A temporary solution such as channel maintenance may suffice until a future opportunity for permanent restoration becomes available.

- Widespread floodproofing would probably not gain much protection because flooding is dispersed throughout a wide area and cost-effective improvements would be difficult to make.

- The no-action alternative would result in continued periodic flood damages. If this alternative is selected, every flood issue will return after the next flood and the debate will begin again.

The committee members voted first on the acceptability of each alternative as a potential solution for the problems in Canyon A and then ranked their top four alternatives in order of preference. The results of the voting by the advisory committee are shown in Table 10-10. Alternative CA-A, which provides a 100-year level of protection at reasonable cost, was selected for implementation and is recommended in Chapter 11.

TABLE 10-9.
ALTERNATIVES FOR CANYON A

	Alternatives (maximum ---> minimum protection)								
	Alt. CA-A* Canyon A flood corridor with pipeline below Eastmont	Alt. CA-B Canyon A dam, flood corridor, and pipeline below Eastmont	Alt. CA-C Intercept floodwaters at Kentucky, pipe south via Kentucky	Alt. CA-D Intercept floodwaters at Kentucky, pipe west via Grant Road	Alt. CA-E Prevent flooding of Grant Road, pipeline between Eastmont and river	Alt. CA-F Prevent flooding of Grant Road, channel between Eastmont and river	Alt.CA-G Floodproofing	Alt. CA-H Protection of Grant Road and Floodproofing	Alt. CA-I No Action
Level of Protection	100-year flood and all stormwater inflows along Canyon A from Lyle to Columbia River	100-year flood and all stormwater inflows along Canyon A from Lyle to Columbia River	Prevent 100-year flood from entering urban area. Smaller pipeline to carry stormwater runoff through East Wenatchee	Prevent 100-year flood from entering urban area. Smaller pipeline to carry stormwater runoff through East Wenatchee	100-year flood below Eastmont, confinement of floodwaters to Canyon A above Eastmont.	100-year flood below Eastmont, confinement of floodwaters to Canyon A above Eastmont.	Prevent structural damage to homes and businesses	Prevent structural damage; keep floodwaters off Grant Road	Less than 10-year storm above Eastmont, no protection below Eastmont
Upper Basin *Problems:* • Uncontrolled runoff from farmland areas	(None)	• 35-AF Detention dam above Lyle (CA-1a) Cost: $1.3 million	(None)	(None)	• Program for better farmland management Cost: none	• Program for better farmland management Cost: none	• Program for better farmland management Cost: none (existing resources)	• None. Minimal impacts from flooding	• None. Minimal impacts from flooding.
Lyle-Kentucky *Problems:* • Undersized culvert at Lyle Ave. • Canyon A floods Grant Road, impacts more than 100 homes	• Culvert for 100-year flow at Lyle (CA-3a) • Dike to prevent flooding of Grant Road (CA-5) Cost: $161,000	• Dike to prevent flooding of Grant Road (CA-5) Cost: $116,000	• 72-inch pipeline and canal along Kentucky Avenue running south from Canyon A to Columbia River (CA-13) Cost: $3 million	• Reinforce road embankment at Lyle (CA-4) or enlarge culvert (CA-3a) • 60-inch pipeline along Grant Road running west from Kentucky to Columbia River (CA-6a) Cost: $4.6 million	• Reinforce road embankment at Lyle (CA-4) or enlarge culvert (CA-3a) • Dike to prevent flooding of Grant Road (CA-5) Cost: $144,000	• Reinforce road embankment at Lyle (CA-4) or enlarge culvert (CA-3a) • Dike to prevent flooding of Grant Road (CA-5) Cost: $144,000	• Floodproofing of homes and businesses along Grant Road (CA-10) Cost: $1.5 million	• Dike to prevent flooding of grant road (CA-5) Cost: $116,000	• None. Risk of overtopping of Lyle Avenue embankment and severe flooding of Grant Road remains.
Kentucky-Eastmont *Problems:* • Channel too small to carry floodwaters, impacts 10-20 homes • Channel runs through backyards in Eastmont Park, impacts several homes	• Flood channel and easement (CA-7) • 100-year culverts (CA-3c) • Relocate channel in Eastmont Park (CA-9) Cost: $2.2 million	• Flood channel and easement (CA-7) • 100-year culverts (CA-3c) • Relocate channel in Eastmont Park (CA-9) Cost: $2.0 million	• Relocate channel in Eastmont Park (CA-9) • Maintain existing corridor (existing resources) Cost: $50,000	• Relocate channel in Eastmont Park (CA-9) • Maintain existing corridor (existing resources) Cost: $50,000	• Relocate channel in Eastmont Park (CA-9) • Clean out and repair existing channel • Purchase flood corridor over time (paid by FEMA mitigation funds if Federal Disaster declared) Cost: $100,000 initially, extra funds for corridor	• Relocate channel in Eastmont Park (CA-9) • Clean out and repair existing channel • Purchase flood corridor over time (paid by FEMA mitigation funds if Federal Disaster declared) Cost: $100,000 initially, extra funds for corridor	• Floodproofing of homes along Canyon A (CA-10) Cost: $270,000	• Floodproofing of homes along Canyon A (CA-10) Cost: $270,000	• None. Risk of flooding neighborhoods between Kentucky and Hanford and along Eastmont Park remains.
Eastmont-River *Problems:* • No conveyance for Canyon A floodwaters - empties onto streets and floods commercial areas	• 60-inch pipeline from Eastmont to Columbia River (CA-6a) Cost: $1.9 million	• 42-inch pipeline from Eastmont to Columbia River (CA-6b) Cost: $1.4 million	• 30-inch pipeline below Eastmont to carry stormwater (72 cfs) (CA-6c) Cost: $700,000	• 30-inch pipeline below Eastmont to carry stormwater (72 cfs) (CA-6c) Cost: $700,000	• 60-inch pipeline from Eastmont to Columbia River (CA-6a) Cost: 1.9 million	• Open channel with culverts below Eastmont (CA-12) Cost: $1.0 million	• Floodproofing of businesses in East Wenatchee (CA-10) Cost: $0.5 million	• Floodproofing of businesses in East Wenatchee (CA-10) Cost: $0.5 million	• None. Risk of severe flooding in East Wenatchee remains.
Total Cost	**$4.3 million**	**$4.8 million**	**$3.8 million**	**$5.7 million**	**$2.1 million or more**	**$1.2 million or more**	**$2.3 million**	**$0.9 million**	**$100,000 annual (approx.)**
Advantages	• Maximum protection (solves all major problems) • Mall owner may pay for portion of pipeline below Eastmont • Eliminates onsite detention in urban area	• Maximum protection (solves all major problems) • Mall owner may pay for portion of pipeline below Eastmont • Eliminates onsite detention in urban area	• Maximum protection (solves all major problems) • Less disruption to residents along Canyon A • Less costly	• Maximum protection (solves all major problems)	• Eliminates flooding on Grant Road and in City • Part of cost can be deferred into future, with possibility of 70-90% paid by FEMA • Mall owner may pay for portion of pipeline below Eastmont	• Eliminates flooding along Grant Road and in City • Less costly than pipeline • Part of cost can be deferred into future, with possibility of 70-90% paid by FEMA	• Reduces principal threat to public safety	• Reduces principal threat to public safety	• No public expenditures on stormwater control facilities, avoiding new taxes
Disadvantages	• High cost • Disruption of relocated residents and businesses • New river outfall	• Detention dam is not cost-effective • Dam safety issues • Disruption of relocated residents	• Diversion of floodwaters at Kentucky does not eliminate need for pipeline below Eastmont • Discharge to southern drainage may cause new problems	• Diversion of floodwaters at Kentucky does not eliminate need for pipeline below Eastmont • High cost	• Increased hazard between Kentucky and Hanford, with County potentially liable for damages	• Open channel through city may not be compatible with land use • Right-of-way may not exist • Increased hazard between Kentucky and Hanford, with County potentially liable	• No significant reduction in flooding damage • Only structures can be floodproofed; will still have flooding of yards and disruption of traffic • No reduction in damage to roads, utilities, public services, and commercial areas	• No significant reduction in flooding damage • Only structures can be floodproofed. Will still have flooding of yards and disruption of traffic. • No reduction in damage to roads, utilities, public services, and commercial areas	• All flooding problems remain, incurring annual damage costs • Continued threat to public safety • Flooding potential in County and City may discourage development and negatively affect public image

*** Preferred alternative**

CANYON A

imum ---> minimum protection)

Alt. CA-E ent flooding of Grant d, pipeline between astmont and river	Alt. CA-F Prevent flooding of Grant Road, channel between Eastmont and river	Alt.CA-G Floodproofing	Alt. CA-H Protection of Grant Road and Floodproofing	Alt. CA-I No Action
ear flood below mont, confinement of lwaters to Canyon A e Eastmont.	100-year flood below Eastmont, confinement of floodwaters to Canyon A above Eastmont.	Prevent structural damage to homes and businesses	Prevent structural damage; keep floodwaters off Grant Road	Less than 10-year storm above Eastmont, no protection below Eastmont
ogram for better mland management none	• Program for better farmland management Cost: none	• Program for better farmland management Cost: none (existing resources)	• None. Minimal impacts from flooding	• None. Minimal impacts from flooding.
inforce road bankment at Lyle A-4) or enlarge lvert (CA-3a) ke to prevent flooding Grant Road (CA-5) $144,000	• Reinforce road embankment at Lyle (CA-4) or enlarge culvert (CA-3a) • Dike to prevent flooding of Grant Road (CA-5) Cost: $144,000	• Floodproofing of homes and businesses along Grant Road (CA-10) Cost: $1.5 million	• Dike to prevent flooding of grant road (CA-5) Cost: $116,000	• None. Risk of overtopping of Lyle Avenue embankment and severe flooding of Grant Road remains.
locate channel in stmont Park (CA-9) ean out and repair isting channel rchase flood corridor er time (paid by MA mitigation funds Federal Disaster clared) $100,000 initially, ra funds for corridor	• Relocate channel in Eastmont Park (CA-9) • Clean out and repair existing channel • Purchase flood corridor over time (paid by FEMA mitigation funds if Federal Disaster declared) Cost: $100,000 initially, extra funds for corridor	• Floodproofing of homes along Canyon A (CA-10) Cost: $270,000	• Floodproofing of homes along Canyon A (CA-10) Cost: $270,000	• None. Risk of flooding neighborhoods between Kentucky and Hanford and along Eastmont Park remains.
inch pipeline from stmont to Columbia ver (CA-6a) 1.9 million	• Open channel with culverts below Eastmont (CA-12) Cost: $1.0 million	• Floodproofing of businesses in East Wenatchee (CA-10) Cost: $0.5 million	• Floodproofing of businesses in East Wenatchee (CA-10) Cost: $0.5 million	• None. Risk of severe flooding in East Wenatchee remains.
million or more	**$1.2 million or more**	**$2.3 million**	**$0.9 million**	**$100,000 annual (approx.)**
minates flooding on ant Road and in City rt of cost can be ferred into future, h possibility of 70-90% d by FEMA ll owner may pay for rtion of pipeline ow Eastmont	• Eliminates flooding along Grant Road and in City • Less costly than pipeline • Part of cost can be deferred into future, with possibility of 70-90% paid by FEMA	• Reduces principal threat to public safety	• Reduces principal threat to public safety	• No public expenditures on stormwater control facilities, avoiding new taxes
reased hazard ween Kentucky and nford, with County entially liable for nages	• Open channel through city may not be compatible with land use • Right-of-way may not exist • Increased hazard between Kentucky and Hanford, with County potentially liable	• No significant reduction in flooding damage • Only structures can be floodproofed; will still have flooding of yards and disruption of traffic • No reduction in damage to roads, utilities, public services, and commercial areas	• No significant reduction in flooding damage • Only structures can be floodproofed. Will still have flooding of yards and disruption of traffic. • No reduction in damage to roads, utilities, public services, and commercial areas	• All flooding problems remain, incurring annual damage costs • Continued threat to public safety • Flooding potential in County and City may discourage development and negatively affect public image

TABLE 10-10.
CITIZEN ADVISORY COMMITTEE, MARCH 23, 1994
VOTING RESULTS — CANYON A OPTIONS

Proposal	Acceptable?		Number of Votes (Rank)			
	YES	NO	1st	2nd	3rd	4th
Alt. CA-A[a] Canyon A flood corridor with pipeline below Eastmont	8	2	3.5	1.5	0	1
Alt. CA-B Canyon A dam, flood corridor, and pipeline below Eastmont	4	6	1.5	0.5	1	2
Alt. CA-C[b] Intercept floodwaters at Kentucky, pipe south via Kentucky	7	3	4	1	0	0
Alt. CA-D[d] Intercept floodwaters at Kentucky, pipe west via Grant Road	5	5	0	1	2	1
Alt. CA-E[c] Prevent flooding of Grant Road, pipeline between Eastmont and river	6	4	2	3	0	0
Alt. CA-F Prevent flooding of Grant Road, channel between Eastmont and river	4	6	0	1	2	0
Alt. CA-G Floodproofing	1	9	0	0	0	0
Alt. CA-H Protection of Grant Road and Floodproofing	2	8	0	0	1	0
Alt. CA-I Do Nothing	2	8	0	0	0	1

a. Preferred alternative
b. Second alternative
c. Third alternative
d. Fourth alternative

Canyon B

The potential solutions to the Canyon B problems are shown in Table 10-11. These have been combined to form the six alternatives shown in Table 10-12. These alternatives have been developed to address flooding issues upstream of SR28, the Sunset Highway, and the lack of a defined drainage channel from the Sunset Highway to the Columbia River.

TABLE 10-11.
CANYON B POTENTIAL SOLUTIONS

Project[a]	Project Name
CB-1	Canyon B - Detention dam
CB-2	Canyon B - Change in agricultural practices
CB-3	Canyon B - Relocate homes in floodplain
CB-4	Canyon B - Reinforced berm to deflect floodwater and debris
CB-5	Canyon B - Increase size of debris basin to 100-year sediment capacity
CB-6	Canyon B - Drainage channel for 25-year flood
CB-7	Canyon B - Drainage channel for 100-year flood
CB-8	Canyon B - Primary and secondary channels for 100-year flood
CB-9	Canyon B - Floodproof homes in floodplain

a. See Appendix B for description sheets detailing each project.

The alternatives include potential projects in the upper basin, within the alluvial fan area, and from Sunset Highway to the Columbia River. The alternatives will provide protection from storms with a recurrence interval ranging from 25 years to 100 years. The cost of these alternatives range from approximately $700,000 for a partial solution to as much as $2,300,000 for a 100-year level of protection for the entire corridor downstream of the canyons mouth. The committee chose alternative CB-C to be recommended for implementation. This alternative will provide the highest level of protection for a 100-year flood.

Project description sheets in Appendix B contain detailed descriptions, design criteria and requirements, identified issues, and the total estimated cost for each projects implementation.

TABLE 10-12.
ALTERNATIVES FOR CANYON B

	Alternatives (maximum ---> minimum protection)					
	Alt. CB-A Detention dam with channel to river	Alt. CB-B Enlarge existing channel to 100-year capacity	Alt. CB-C* Primary and secondary channels for 100-year flow	Alt. CB-D 25-year flood channel with other improvements	Alt. CB-E Debris flow deflection structure	Alt. CB-F Floodproof homes
Level of Protection	100-year	100-year	100-year	25-year	25-year	Undetermined
Upper basin *Problems:* • Uncontrolled runoff from farmland areas	• 35-foot high detention dam with 30 ac ft storage; 100-year discharge is 300 cfs (CB-1). Cost: $1.4 million	• Enlarge existing debris basin to 100-year sediment capacity (CB-5) Cost: $291,000	• Enlarge existing debris basin to 100-year sediment capacity (CB-5) Cost: $291,000	• Upper basin improvements: - Farmland conservation practices to limit runoff (terracing, vegetated drainage pathways, detention berms) - Continued slide stabilization in canyon	• Reinforced berm to deflect floodwater and debris to undeveloped portion of alluvial fan (CB-4) Cost: $1.2 million (mostly land acquisition costs)	• Program for better farmland management to reduce runoff Cost: none (existing resources)
Alluvial fan area *Problems:* • Drainage channel sized for only 25-year flood; up to 48 homes at risk • Debris flow potential; up to 48 homes at risk	• None - channel already exists Cost: none	• Enlarge existing Glendale flood channel to 100-year capacity (CB-7) Cost: $132,000	• Use existing Glendale channel (300 cfs capacity) • Construct 200 cfs secondary channel south of 31st street to Columbia River (CB-8) Cost: $631,000	• None - channel already exists	• None - channel already exists	• Floodproof homes on alluvial fan (48 homes) and remove a few homes at greatest risk to debris flow (CB-9) Cost: $720,000
Sunset Highway to Columbia River *Problems:* • No highway or canal crossing for floodwaters • Undefined floodway between highway and Columbia River	• Culvert under roadway and 300 cfs drainage channel to river (CB-6) Cost: $699,000	• Culvert under roadway and 500 cfs drainage channel to river (CB-7) Cost: $919,000	• Culvert under SR 28 at end of Glendale channel and 300 cfs drainage channel to river (CB-6) Cost: $699,000	• Culvert under SR 28 at end of Glendale channel and 300 cfs drainage channel to river (CB-6) Cost: $699,000	• Culvert under SR 28 at end of Glendale channel and 300 cfs drainage channel to river (CB-6) Cost: $699,000	• None
Total Cost	**$2.3 million**	**$1.3 million**	**$1.6 million**	**$699,000**	**$1.9 million**	**$720,000**
Advantages	• Provides flood protection for entire alluvial fan • Effective utilization of recently constructed channel	• Provides flood protection for entire alluvial fan	• Provides flood protection for entire alluvial fan • Two channels provide better reliability than one • Project can be implemented in two phases—25-year capacity first, later upgrade to 100-year capacity—to ease funding requirements	• Conveys up to 25-year flood safely to river, solving frequent flooding problems • Can be upgraded later to 100-year capacity when funds are available	• Provides greatest protection against debris flows • Conveys up to 25-year flood safely to river, solving frequent flooding problems	• Provides protection to public health
Disadvantages	• Dam safety rules will be cumbersome • Public opposition to dam in neighborhood • Expensive	• Single channel less reliable than two channels • Very difficult to upgrade existing ditch to 100-year flood • Single channel may erode severely under 100-year flood	• Flood easements must be purchased down second drainage to river	• Entire alluvial fan still subject to 100-year flood	• Entire alluvial fan still subject to 100-year flood	• Frequent damage to canal and roadways will still occur • Provides protection of structures only; yard damage will still occur

* Preferred alternative

Sand Canyon

The potential solutions to the Sand Canyon problems are shown in Table 10-13. The problems identified in Sand Canyon were undersized culverts, the existence of one home which may flood during events larger than a 25-year event, problems along Badger Mountain Road and a trailer park which is at risk. Project description sheets in Appendix F contain detailed descriptions, design criteria and requirements, identified issues, and total estimated costs for each of the projects.

TABLE 10-13.
SAND CANYON POTENTIAL SOLUTIONS

Project[a]	Project Name
CS-1	Sand Canyon - Change in agricultural practices
CS-2	Sand Canyon - Reinforce roadway embankments
CS-3	Sand Canyon - Increase capacity of roadway culverts to 100-year flood
CS-4	Sand Canyon - Improve channel along mobile home park
CS-5	Sand Canyon - Relocate or floodproof home in the floodplain
CS-6	Sand Canyon - Drainage improvements to Badger Mountain Road

a See Appendix B for description sheets detailing each project.

The identified solutions varied only in the level of protection they would provide or the potential timing of the projects implementation. These alternatives, their costs, advantages and disadvantages are described in Table 10-14. Alternative SC-A, which provides a 100-year level of protection, was selected by the advisory committee to be recommended for implementation.

TABLE 10-14.
ALTERNATIVES FOR SAND CANYON

Location	Alternatives (maximum ---> minimum protection)		
	Alt. SC-A* Conveyance and floodplain improvements	Alt. SC-B Conveyance improvements (25-year capacity)	Alt. SC-C Make conveyance improvements if future flooding causes problems
Level of Protection	100-year floodplain, 100-yer culvert	25-year flood	100-year floodplain and 25-year culvert (future)
Undersized culverts and drainage channel in Sand Canyon *Problems:* • Three culvert crossings are sized for only 10-year flood • Small channel adjacent to mobile home park may cause flooding	• Increase culverts to 100-year capacity (CS-3) • Reduce road embankments (CS-2) • Improve channel along mobile home park (CS-4) • Relocate homes in floodplain (CS-5)	• Increase culverts to 25-year capacity (CS-3) • Improve channel along mobile home park (CS-4)	• Improvements as needed after flood damage occurs: - Increase culverts to 25-year capacity (CS-3) - Reinforce road embankments (CS-2) - Improve channel along mobile home park (CS-4) - Relocate homes in floodplain (CS-5)
Total Cost	**$545,000**	**$260,000**	**$250,000 to $500,000**
Advantages	• Maximum protection	• Provides standard level of protection for roadways	• Conveyance improvements would occur only if culverts fail during flood, deferring costs • Flood damaged homes could be purchased with FEMA relocation funds • Channel improvements can be made earlier with FEMA mitigation funds
Disadvantages	• Disruption to relocated residents • Current flooding threats not serious	• Less than 100-year protection • Current flooding threats not serious	• Does not solve current flooding threats

* Preferred alternative

Urban Area

The potential solutions to the Urban Area problems are shown in Table 10-15. These projects were developed to address the major drainage issues within the urban area that are not associated with one of the canyons. The two major issues in this area are the level of protection to be provided and the runoff from the agricultural areas above the community.

TABLE 10-15.
URBAN AREA POTENTIAL SOLUTIONS

Project[a]	Project Name
UA-1	Agricultural runoff - Channel runoff to Sand Canyon
UA-2	Agricultural runoff - Channel runoff to Canyon A
UA-3	Agricultural runoff - Pipe runoff to Columbia River
UA-4	Agricultural runoff - Change in agricultural practices
UA-5	Agricultural runoff - Floodproof homes in floodplain
UA-6	Urban storm drainage - New underground drainage system
	6a: 25-year storm design
	6b: 100-year storm design
UA-7	Urban storm drainage - Major improvements to existing system
UA-8	Urban storm drainage - Minor improvements to existing system
UA-9	Urban storm drainage - Preserve existing infiltration areas above canal
UA-10	Urban storm drainage - Retardation/infiltration ponds above canal
UA-11	Urban storm drainage - Convey runoff across irrigation canal

a. See Appendix B for description sheets detailing each project.

The runoff from the agricultural areas is uncontrolled and, particularly in the vicinity of 10th Street and Kentucky Avenue, is highly erosive with no safe pathway to the Columbia River. Several of the proposed projects have been combined to form the six alternatives that address upland agricultural runoff shown in Table 10-16. These alternatives all potentially provide a 100-year level of protection and vary in cost from $500,000 to $4,000,000. Alternative UA-D was preferred by the advisory committee because of its ease of implementation and relatively low cost.

The level of protection provided has a great impact on the cost of developing facilities and the type of facilities which need to be constructed. Three methods for providing at least a 25-year level of protection within the urban area were developed and are shown in Table 10-16b. These range from a cost of $1,000 per acre to over $11,000 per acre. The committees preference was to implement alternative UA-I. The projects required to implement alternative UA-I are included in the Capital Improvement Program shown in Chapter 11. Project description sheets in Appendix B contain detailed descriptions, design

criteria and requirements, identified issues, and total each costs for each of the potential project within the urban area.

Palisades Area of Moses Coulee

In the Palisades area of Moses Coulee the stream has flooded the entire valley at times for up to two weeks (1989) and frequently inundates the roadway (most recently in January and February 1995). This prevents access of many residents to their homes, livestock and farms. The potential solutions to the Moses Coulee/Palisades problems are shown in Table 10-17.

Alternative MC-A was not chosen due to its high cost in comparison to the number of people residing in the area. However, the committee did believe it would be prudent to document the existing warning system, to relocate or elevate frequently flooded sections of the road, to widen portions of the stream channel, and to flood proof or relocate homes currently at risk if property owners are willing. Therefore the committee combined portions of MC-A with MC-B and MC-C to form their preferred alternatives which are shown in Chapter 11. The selected projects will provide a 100-year level of protection to the Coulee's residents.

Jameson Lake

The water level of Jameson Lake has increased drastically over the past several decades. Alternatives to solve the Jameson Lake problems are shown in Table 10-18 and project description sheets are contained in Appendix B. Alternative JL-B, which provides protection from storms similar to the one that occurred in 1989, was selected by the committee as their preferred alternative. The selection was due to its capability to provide a high level of protection and and at the same time to potentially maintain the lake at a historically high level.

Summary

The potential solutions examined by KCM, Douglas County and the advisory committee covered a wide spectrum of nonstructural and structural answers to known and potential flooding problems. These solutions were all examined conceptually to determine their potential costs, disruption to the community, impacts, how well a solution achieved the goals of the plan, and other potential benefits. This information was discussed by the committee over the course of several meetings. The committee then proceeded to select the projects they preferred for implementation and the modifications to existing land uses, regulations and development standards they felt would help to reduce the future risk of damage from flood events. The recommendations in Chapter 11 represent a comprehensive approach to the management and resolution of flood problems within Douglas County and the City of East Wenatchee and the consensus of the advisory committee.

TABLE 10-16a.
ALTERNATIVES FOR URBAN AREA

	Alternative (maximum ---> minimum protection)					
	Alt. UA-A Divert agricultural runoff to Sand Canyon	Alt. UA-B Divert agricultural runoff to Canyon A	Alt. UA-C Pipe agricultural runoff to Columbia River	Alt. UA-D* Interceptor storage canals to infiltrate runoff	Alt. UA-E Divert agricultural runoff to 10th Street Infiltration Pond	Alt. UA-F Agricultural land use change
Level of Protection	100-year	100-year	100-year	100-year	100-year	Reduced runoff from farmland
Agricultural runoff entering urban area *Problems:* • Uncontrolled runoff and sediment from farmlands impacts residential areas between 15th and 5th NE	• Intercept runoff at bottom of bluff and route runoff to Sand Canyon along ditch parallel to proposed Kentucky Avenue Extension (UA-1)	• Intercept runoff in canal at top of bluff and channel runoff to Canyon A (UA-2) (Option: convey runoff via pipeline down Kentucky or Lyle)	• Intercept runoff at top and bottom of bluff and pipe runoff via Kansas Avenue and 3rd Street to Columbia River (UA-3), proposed by SCS as East Wenatchee Watershed Project.	• North of 10th Street, intercept runoff at bottom of bluff with flat storage canal. Infiltrate all runoff. If necessary, convey overflow to Sand Canyon via a controlled outlet • East of Kentucky, intercept runoff at edge of farmland along 10th Street with flat storage canal. Infiltrate all runoff. If necessary, convey overflow to Canyon A tributary via a controlled outlet or pipeline down Lyle Avenue to Canyon A	• Intercept runoff at top and bottom of bluff and channel runoff down 10th to infiltration pond in existing orchard area (UA-12)	• Purchase farmland and implement conservation practices that limit runoff (UA-4)
Total Cost	**$499,000 (in addition to $5 million road project)**	**$927,000 (plus flood easements in Canyon A)**	**$2.1 million above Eastmont; $1.9 million below Eastmont**	**approx. $1 million**	**$1.3-1.8 million**	**$300,000** (assuming land at $500 per acre)
Advantages	• Prevents runoff and high sediment loads from entering urban area • Most direct route to existing drainage leading to Columbia River • Funding may be largely covered by road grant	• Prevents runoff and high sediment loads from entering urban area	• Prevents runoff and high sediment loads from entering urban area • Can tie in to pipeline below Eastmont	• Prevents runoff and high sediment loads from entering urban area • Under normal operations stormwater will be infiltrated, resulting in no downstream impacts	• Prevents runoff and high sediment loads from entering urban area • Most direct route through urban area	• Sediment load is greatly reduced • Runoff is reduced, but is difficult to predict how much • Existing ditches may be able to handle runoff from smaller storms
Disadvantages	• Road project is unlikely within next 10 years, if ever • Increases flooding potential in Sand Canyon; will require mitigation such as purchase of flood easements or detention pond • Salmon in lower canyon may be an environmental issue if impacts are not mitigated	• Not all runoff diverted because canal is at top of bluff • Increases flooding potential in Canyon A; requiring purchase of flood easement (not included in cost, but shown in Alt. CA-A)	• High cost • New river outfall	• Overflows to Canyon A and Sand Canyon may occur if design flow is exceeded or sediment fills canal. However, both canyons will share equally in conveying floodwater to river	• Large infiltration facility at base of 10th needed; overflow may occur • No provision for conveyance to river • Steep 10th Street may need expensive pipeline instead of channel	• Runoff will still enter urban area, with extreme events still causing damage • Land cost may be higher (most is zoned residential)

*Preferred Alternative

TABLE 10-16b.
ALTERNATIVES FOR URBAN AREA (Continued)

	Alternatives (maximum —> minimum protection)		
	Alt. UA-G New underground drainage system	Alt. UA-H Major improvements to existing system	Alt. UA-I* Enhance existing system; preserve infiltration areas, designate drainage pathways
Level of Protection	25-year storm or other appropriate standard	25-year storm or other appropriate standard	25-year storm for problem area fixes only
Stormwater drainage *Problems:* • Limited and undersized drainage facilities • No receiving point for stormwater - drains onto orchards • Stormwater causes damage to irrigation canal	• Solve agricultural runoff problem • Construct underground pipe system throughout urban area to convey runoff to river (UA-6)	• Solve agricultural runoff problem • Construct system of open ditches and culverts to convey runoff to infiltration ponds above canal (UA-7)	• Solve agricultural runoff problem • Fix each localized drainage problem • Maintenance program to clean out ditches and replace undersized culverts • Designate and preserve flow pathways • Preserve infiltration areas (orchards)
Total Cost	**$26 million ($11,000 per acre)**	**$6,000 per acre**	**$1000 to $3000 per acre**
Advantages	• Maximum protection in all areas • Does not interfere with land uses	• Maximum protection along principal drainage routes	• Low cost • Interception of agricultural runoff may eliminate need for extensive improvements
Disadvantages	• Extreme high cost • High sediment load may plug system • System may not be needed if agricultural runoff is intercepted	• High cost • Ditches are unsightly and may interfere with property access • System may not be needed if agricultural runoff is intercepted	• Does not provide uniform level of protection • Minor flooding problems will always occur, but can be reponded to on an as-needed basis.

*Preferred alternative

TABLE 10-17.
ALTERNATIVES FOR PALISADES AREA OF MOSES COULEE

Location	Alternatives (maximum —> minimum protection)		
	Alt.MC-A Structural flood control improvements	Alt. MC-B Minor improvements to existing facilities	Alt. MC-C Emergency preparedness and non-structural
Level of Protection	100-year flood	Minor improvement over current	Current
Flooding isolates local residents *Problem:* • Infrequent floods (every 10-20 years) can isolate several dozen families for up to 10 days	• Structural flood control facilities, such as detention dams, levees, and channel widening to reduce flooded area Cost: >$1 million	• Emergency management plan for food and medical supplies, communications, emergency access, and temporary road repair	• Emergency management plan for food and medical supplies, communications, emergency access, and temporary road repair
Flooding of residential homes *Problem:* • Floods cause minor residential damage	• Floodproofing in areas not protected by structural facilities	• Floodproofing of structures at most risk • Improved floodplain management (i.e., prevent development in flood hazard areas)	• Limited floodproofing where cost effective, other floodproofing and/or relocation will be done with FEMA mitigation funds after next flood • Improved floodplain management
Flood damage to Palisades Road *Problem:* • Floods cause severe damage to the Palisades road due to overflow from the adjacent channel, erosion of roadbed, and poor cross-drainage	• Relocate and/or elevate road away from channel in Palisades area • Improve cross-drainage Cost: ~$1 million	• Increase channel size in Palisades area to improve conveyance • Bank protection at erosion areas, better cross drainage at problem areas • Repair flood damage when it occurs	• Repair flood damage when it occurs Cost: $50,000 annual damage
Loss of farmland due to sedimentation *Problem:* • Sediment deposition at base of Douglas Creek has resulted in loss of farmland	• Encourage better agricultural management practices in Douglas Creek watershed, using assistance from SCS	• Encourage better agricultural management practices in Douglas Creek watershed, using assistance from SCS	• Encourage better agricultural management practices in Douglas Creek watershed, using assistance from SCS
Total Cost	**Very high (>$2 million)**	**$100,000 or more**	**Minimal**
Advantages	• Reduces flood threat	• Provides flood reduction benefits during low to moderate flooding	• Minimal cost • Damages occur too infrequently to justify large expenditures
Disadvantages	• Very high cost for low population receiving benefit and very infrequent flood threat • Significant reduction in floodplain area may not be possible • Relocated road will compli-cate driveway access and may still be under water during floods	• Most significant flood problems remain the same • Community will be occasionally isolated • Damages similar to 1989 can be expected every 10-20 years	• Community will be occasionally isolated • Residents must be convinced that flooding will always be an unsolvable problem • Damages similar to 1989 can be expected every 10-20 years

TABLE 10-18.
ALTERNATIVES FOR JAMESON LAKE

Location	Alternatives (maximum —> minimum protection)		
	Alt. JL-A Construct outlet and lower lake to create storage	Alt. JL-B* Construct outlet and lower lake to create storage	Alt. JL-C Floodproofing and/or relocation of facilities
Level of Protection	100-year flood	Flood similar to 1989 (i.e., 35-year flood)	100-year flood
The level of Jameson Lake is rising, causing flood damage and new flooding threats *Problems:* • Increased ground-water inflow and runoff has caused long-term increase in lake levels • Roads, homes, farms, and recreational facilities have long suffered damage from the rising lake level • The next major runoff will probably cause severe lake-side damage and overflow to Moses Coulee that could impact downstream areas including Palisades	• Encourage better agricultural management practices in Douglas Creek watershed, using assistance from SCS • Construct outlet pipeline and establish permanent lake level at 15.5 feet below outlet elevation	• Encourage better agricultural management practices in Douglas Creek watershed, using assistance from SCS • Construct outlet pipeline and establish permanent lake level at 8 feet below outlet elevation	• Encourage better agricultural management practices in Douglas Creek watershed, using assistance from SCS • Floodproof and/or relocate houses, farm buildings, and recreational facilities along shoreline. Set maximum high water at 4 feet above outlet elevation. • Relocate South Jameson Lake Road away from shoreline
Total Cost			
Advantages	• Provides maximum protection, to both lake-side areas and Moses Coulee • Very little disruption of existing homes and facilities • Low flow outlet will benefit downstream wildlife areas	• Lower cost • Will provide protection against nearly all historical flood events, including 1989 • Very little disruption of existing homes and facilities • Low flow outlet will benefit downstream wildlife areas	• Eliminates flooding threat
Disadvantages	• High cost for relatively few benefited residents • Outlet facility will need continual operation and maintenance	• Threat of flooding above 35-year event remains, although damages from these would be greatly reduced • Outlet facility will need continual operation and maintenance	• Disrupts most homes and facilities along lake • Major threat of large flood down Moses Coulee remains

* Preferred alternative

CHAPTER 11.
RECOMMENDATIONS

Potential flood hazard management recommendations for the study area of this CFHMP are presented in this chapter. These recommendations were selected from the potential solutions presented in Chapter 10. Those potential solutions were developed to address the flood problems identified in Chapter 7 and to prevent additional problems from developing in the future. Both structural and nonstructural solutions were presented for the advisory committee's consideration. The committee decided that a combination of new regulations, design standards, land use controls, and capital projects would be the best approach to manage the hazards associated with flooding within the study area. Their votes on each alternative were discussed in Chapter 10 and the results are presented in this chapter.

REGULATORY RECOMMENDATIONS

Regulatory recommendations provide restrictions on land use and development that are dictated and enforced by local ordinances, such as the floodplain regulations in the Flood Damage Prevention Ordinance, Chapter 15.48 of the County Code. These regulations strictly control the types of development allowed within the 100-year floodplain. Violations of City and County ordinances can result in criminal penalties and imprisonment.

The following are the top six regulatory recommendations of the advisory committee. Implementation of these recommendations will provide improved flood hazard management within Douglas County and East Wenatchee. Most of these recommendations focus on the existing Flood Hazard Prevention Ordinance.

Prohibit Critical Facilities within Floodplains

Development of critical facilities, i.e., fire stations, medical facilities, schools, etc., within flood hazard areas should be prohibited. This will help prevent the disruption of emergency services during flood events.

Show FEMA Base Flood Boundaries and Shoreline Boundaries on Additional Maps

The limits of the FEMA base flood and shoreline boundaries should be shown on zoning maps and maps of new developable parcels. This would help the buyers, landowners and permit reviewers to be informed of potential flood hazards and prevent development from encroaching on drainage pathways.

Identify Alluvial Fan Hazards

Alluvial fans, geologic hazard areas, and areas that are prone to landslides need to be identified. The County should prohibit development within these areas unless prior control of the drainage corridor has been established. Developers need to be able to recognize the unique hazards within these hazardous areas and the County should control development accordingly.

Prohibit Development within Sensitive Areas

New development within the FEMA AO and FEMA A zones should be prohibited to prevent inappropriate development within the floodplain and to avoid flood hazards. The County currently has few restrictions within the FEMA floodplain. If new development is allowed to be constructed within the floodplain, the County should require that the lowest floor be 2 feet above the FEMA base (100-year) flood elevation. This would minimize flood damage of structures located within the floodplain. The placement of fill or other obstructions within natural drainage pathways should be prohibited to preserve conveyance capacity and prevent new problems from occurring.

Combine Ordinances

Consideration should be given to combining floodplain and shoreline ordinances. Other jurisdictions have combined these ordinances to help improve the efficiency of administration. The City of East Wenatchee and Douglas County should ensure that their ordinances and requirements are identical to ensure the proper long-term management of flood hazards within the East Wenatchee urban area.

DEVELOPMENT STANDARD RECOMMENDATIONS

These recommendations for additional development standards will ensure that stormwater issues for the construction of new buildings, subdivisions, and other development are addressed during the planning stage. The most important of these is defining the rainfall intensity (or design storm) that a storm drainage system must be designed to accommodate. Currently, this and other standards are not specified by Douglas County in an ordinance. These requirements are typically specified in a subdivision ordinance or a stormwater ordinance (which is not currently in place in Douglas County). Review of development standards for any project would occur during the development or building permit review process. Failure to meet a standard would result in denial of the permit.

Following are the six most important recommendations for additional development standards as approved by the advisory committee.

Define Flow Capacity Criteria

Flow capacity criteria need to be established for new drainage facilities (i.e. 25-year, 50-year, or 100-year flood events). Most drainage facilities (i.e. culverts, ditches, and pipelines) within the County are not designed for an adequate level of service (LOS) and are frequently flooded by small storm events. All new major drainage facilities are recommended to be designed to safely pass the flow predicted to be caused by the 100-year, 24-hour storm. The total precipitation used to predict the runoff should be as shown in NOAA Atlas 2 (Miller et al. 1973). A Type II SCS rainfall distribution should be used to distribute the rainfall over the storm's 24-hour duration. This level of service should be required for all new facilities in Canyon A, Canyon B, Sand Canyon, Moses Coulee, and all similar drainages.

Define New Runoff Criteria

Runoff criteria for new developments should be based on an experienced historical storm event. The County experienced one such storm event during May 1993. During this event, the County experienced 2 inches of rain within a 90-minute period. Until recently the County required the use of a 25-year storm event (approximately 0.75 inch in 90 minutes) which does not reflect the common occurrence of localized, intense thunderstorms. The County now receives a greater level of protection because they are requiring the use of a design event of 2 inches of rain within a 90-minute period with a Type II SCS distribution. The County and City should both continue to require this as a minimum design standard.

Avoid New Drainage Problems

New drainage problems need to be avoided. Developers must be required to plan for detainment or infiltration of runoff created by their development unless provisions are made to safely convey the runoff to the Columbia River. This may require that the developers include drywells for roof downspouts, include grass swales along streets in place of curbs and gutters, or create detention or infiltration ponds within the development. The County may even need to reduce the standard width of paved residential streets to decrease the impervious area.

Design for Maximum Buildout

Stormwater facilities need to be designed for maximum buildout to avoid undersizing facilities. Replacement of undersized facilities is much more expensive than properly sizing the facilities initially.

Define Authority

Clear authority and responsibility needs to be established between the City, County and developers for providing, operating and maintaining stormwater facilities. Other jurisdictions now require offsite mitigation or impact fees from developers to supplement public spending on improvements.

Establish Clear Ordinances

Drainage standards are currently enforced through conditions on building permits. There is a need for an ordinance establishing design standards that can be uniformly enforced by County officials. This may take the form of a new ordinance or could be incorporated into the building code or the subdivision ordinance.

LAND USE RECOMMENDATIONS

Land use recommendations controls the governmental planning policies that dictate the nature and pattern of development within a community. Many—such as a policy to preserve orchard areas that currently receive and infiltrate stormwater runoff—relate directly to floodplain and stormwater runoff hazards. Establishing such a policy would authorize local officials to pursue the actions needed to achieve it. However, policies by themselves are not enforceable; they are intended to guide the implementation of other projects and programs.

The following land use practices have been recommended by the advisory committee. These cover a broad spectrum of activities, ranging from reducing taxes on land in flood hazard areas to establishing general planning goals required by the Growth Management Act. Many may require considerable effort, resources, or political will to implement.

Preserve Existing Infiltration Areas

Areas that currently receive and infiltrate stormwater need to be preserved. This can be achieved through down-zoning the present land use or purchasing of development rights by the County. It may also help to base property tax assessments on current land use instead of maximum potential use. This will reduce taxes on existing infiltration areas and reduce the incentive to develop them. The results will maximize the beneficial use of these areas for infiltration. If development occurs within a particular parcel, the developer should be required to replace the drainage function of that parcel with a facility having similar or better drainage characteristics.

Prohibit Development within Sensitive Areas

To preserve the natural drainage corridors and floodplains, development within sensitive, flood-prone areas, or areas that experience extensive erosion should be prohibited. This policy will help to prevent inappropriate development in hazardous areas.

Prioritize Projects

Douglas County and the City of East Wenatchee should prioritize drainage problems within the study area on the basis of the adopted Capital Improvement Plan shown later. Solutions to major drainage problems need to maximize the use of public funds and provide the greatest benefit to the existing development. Solutions to existing problems must also provide the foundation to help prevent future flooding problems as additional funds become available and growth necessitates improvements.

Maximize Use of Public Land

When appropriate, maximize the use of public parks or other public open spaces to include drainage corridors, floodplains, infiltration ponds, and other drainage facilities.

Down-Zone Hazardous Areas

Down-zone hazardous areas or areas within the floodplain. The County should preserve the existing land use where natural hazards exist and limit the development within these areas. By down-zoning hazardous areas the expectations of development owners will more closely approximate how the property should and can be developed.

Revise Property Taxes

Property taxes for hazard areas should be based on existing use and zoning, either developed or undeveloped. This would reflect the actual value of the land and its development potential and would reduce expectations of the landowners.

Purchase Sensitive Areas

If the developer is not willing to donate or preserve flood-hazard areas, the County or City can purchase the more sensitive areas. Acquisition of highly sensitive areas will prevent future flood problems.

FUNDING RECOMMENDATION

With this study, the advisory committee recommends that the City of East Wenatchee and Douglas County establish a forum for coordination between the County and the City. They should then establish either a flood control zone district or a surface water utility to implement the capital facilities section of this plan and to remain abreast on the flooding and drainage needs of the communities.

The establishment of either a district or utility will dedicate a source of revenue to implement the recommendations of this plan. Once a dedicated source of revenue has been established bonds can be used to accelerate the completion of the Capital Improvement Plan if the community so desires. In addition, the City and County should pursue outside sources of money whenever available and tie drainage improvements in with other development activities. Officials should meet regularly to discuss the flood issues, funding options and progress of the implementation program.

CAPITAL IMPROVEMENT PROGRAM

The projects selected in Chapter 10 for implementation and the problems they address are shown in Tables 11-1 through 11-7. These major projects have been combined into the Capital Improvement Program (CIP) shown in Figure 11-1, Figure 11-2, and Table 11-8. The projects shown in the CIP are segregated by drainage basin and location within East Wenatchee. The projects are also shown in order of priority (high, medium, or low) as determined by the advisory committee.

High priority projects are believed to be life-threatening problems or where property damage frequently recurs. One other reason for a project to receive a high priority is the potential for external funding. Whenever external funds are available for the construction of any project on the Capital Improvement Plan, that project should receive the highest priority possible for construction.

A low priority project solves a problem which is not life threatening, which is not expected to occur until future development is in place, or which creates only minor levels of damage. A medium priority project addresses problems which are less severe than the high priority projects but more severe than the low priority projects.

The proposed timing of each project has been based upon its priority, cost, and the desire to maintain expenditures at a relatively constant level over the course of the 20-year life of the proposed program. The timing of individual projects can be accelerated if additional sources of revenue become available or if projects can be more economically accomplished than is currently estimated.

The schedule is based upon the belief that the community probably is not willing to spend more than $500,000-$600,000 per year on drainage improvements. Additional money can be

obtained from grants, developer contributions and from combining the drainage improvements with other projects such as road improvements. All project costs are shown in 1994 dollars and have not been increased to take inflation into account. If this amount of money is not available, implementation of the CIP could still occur, but at a slower rate than currently projected.

Conceptual plans and cost estimates for each proposed project are shown in appendix.

This Capital Improvement Program has been recommended by the advisory committee for the following reasons:

- To provide a comprehensive approach to problems throughout the community
- To reduce the existing level of liability
- To resolve the existing threats to life, health and property
- To prevent existing problems from becoming more severe
- To create a mitigation plan in case of a disaster
- To provide protection of valuable natural resources and hazardous areas.

TABLE 11-1.
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS - CANYON A

Basin Ranking	Project[a]	Description	Problems Solved[b]
1	CA-11a	60" pipeline from Eastmont to river (100-year flood capacity)	7,8
2	CA-9	Relocate channel in Eastmont Park	6
3	CA-14	Clean out sediments in all Canyon A culverts between Lyle and Hanford Avenues.	3,5
4	CA-7	Flood channel between Kentucky and Hanford	5,32
5	CA-5	Dike at Kentucky Avenue to prevent flooding of Grant Road	4
6	CA-3a	Culvert at Lyle (100-year flood capacity)	3

a. Projects are shown on Figure 11-1.

b. Problems are listed in Table 7-1 and shown on Figure 7-1.

TABLE 11-2.
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS - CANYON B

Basin Ranking	Project[a]	Description	Problems Solved[b]
1	CB-6	Culvert under SR-28 and drainage channel to river with 25-year flow capacity	12,33, 13,14
2	CB-10	Check dams in upper Canyon B to detain runoff	9
3	CB-11	Detention pond in existing ditch at Fancher Field	44
4	CB-5	Enlarge existing debris basin to 100-year sediment capacity	10
5	CB-8	Secondary channel south of 31st Street to increase system capacity to 100-year flow	11,12

a. Projects are shown on Figure 11-2.

b. Problems are listed in Table 7-1 and shown on Figure 7-1.

TABLE 11-3.
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS - SAND CANYON

Basin Ranking	Project[a]	Description	Problems Solved[b]
1	CS-2	Reinforce roadway embankments	16
2	CS-3	Increase capacity of roadway culverts to 25-year flood	16
3	CS-4	Improve channel along mobile home park	18
4	CS-5	Relocate homes in floodplain	17

a. Projects are shown on Figure 11-2.

b. Problems are listed in Table 7-1 and shown on Figure 7-1.

TABLE 11-4.
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS - URBAN AREA

Basin Ranking	Project[a]	Description	Problems Solved[b]
1	UA-15	Install additional dry wells along Fancher Heights streets	20
2	UA-9	Preserve existing infiltration areas above canal (i.e., property at 10th and Eastmont).	30,33
3	UA-13a	Intercept agricultural runoff. (Canyon A)	24,26,27,28,29,30,31,33,45
4	CS-6	Drainage improvements to Badger Mountain road as part of upcoming Local Improvement District project.	21,22
5	UA-14	Autumn Drive dry wells	23
6	UA-23	Increase size of ditch and culverts between 8th and 5th Streets, and convey across 5th Street to open ballfield or parking property	29
7	UA-19	8th & Kentucky culvert improvements	28
8	UA-17	Lyle Ave ditch to Canyon A	3,23
9	UA-16	Vista View/Ski View drainage	46
10	UA-21	S. Mary and Alice dry wells	48
11	UA-22	Grover Avenue dry wells	45
12	UA-24	An existing infiltration vault at 11th and Eastmont cannot handle large flow rates. Surcharge from this system should be diverted with an overflow weir and routed to the proposed infiltration area at base of 10th.	31
13	UA-25	Ongoing Improvements	
14	UA-18	Eastmont at 3rd/4th culverts	47
15	UA-13b	Intercept agricultural runoff. (Sand Canyon)	24

a. Projects are shown on Figures 11-1 and 11-2.

b. Problems are listed in Table 7-1 and shown on Figure 7-1.

TABLE 11-5.
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS - MOSES COULEE/PALISADES

Basin Ranking	Project	Description	Problems Addressed[a]
1	MC-4	Douglas Creek widening	49,50,51
2	MC-1	Flood warning plan	53
3	MC-2	Flood proofing	49
4	MC-3	Road and access improvements	51

a. Problems are listed in Table 7-1 and described in Chapter 7.

TABLE 11-6.
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS - JAMESON LAKE

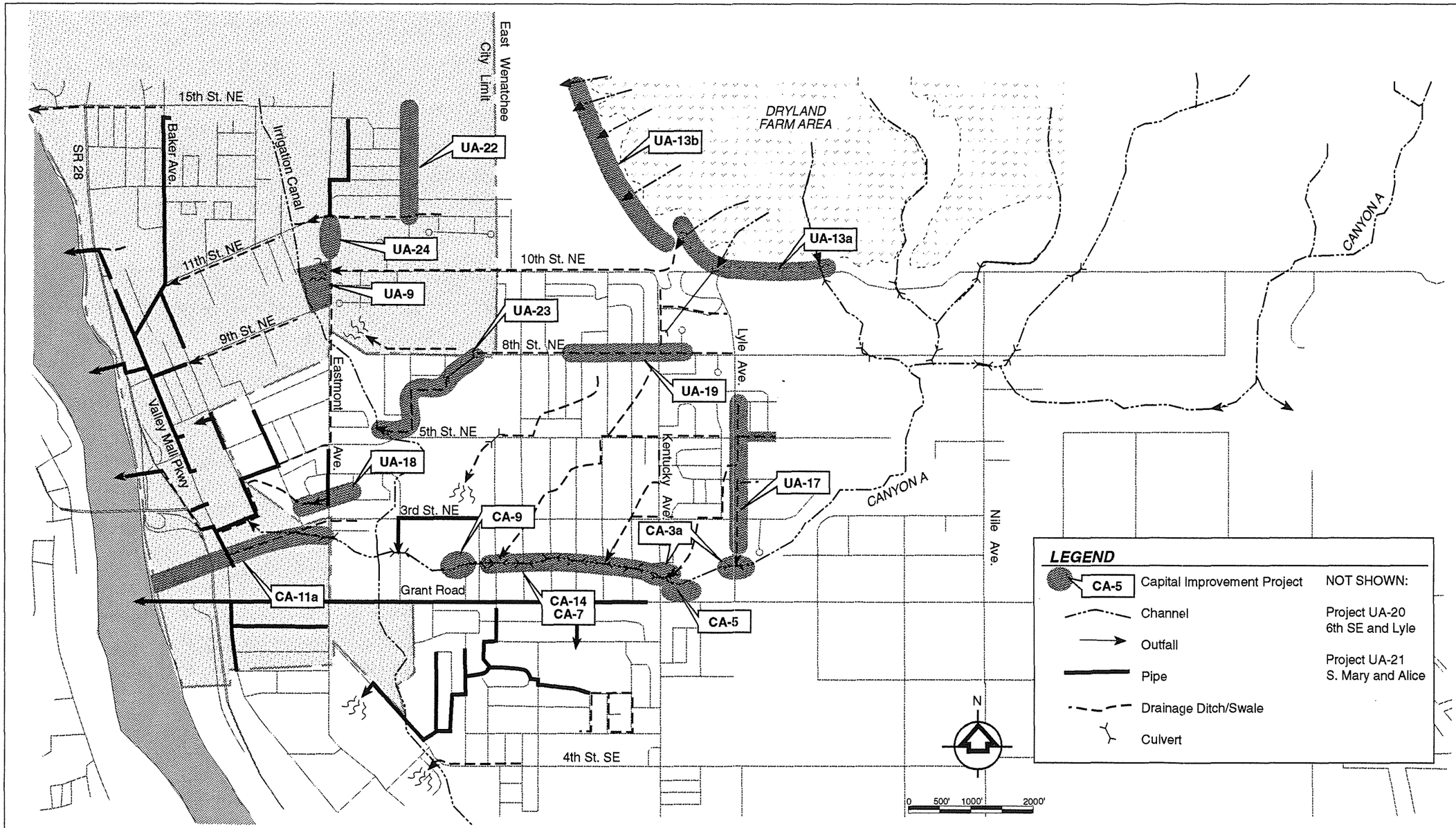
Basin Ranking	Project	Description	Problems Addressed[a]
1	JL-1	Outlet pipeline	54,55

a. Problems are listed in Table 7-1 and described in Chapter 7.

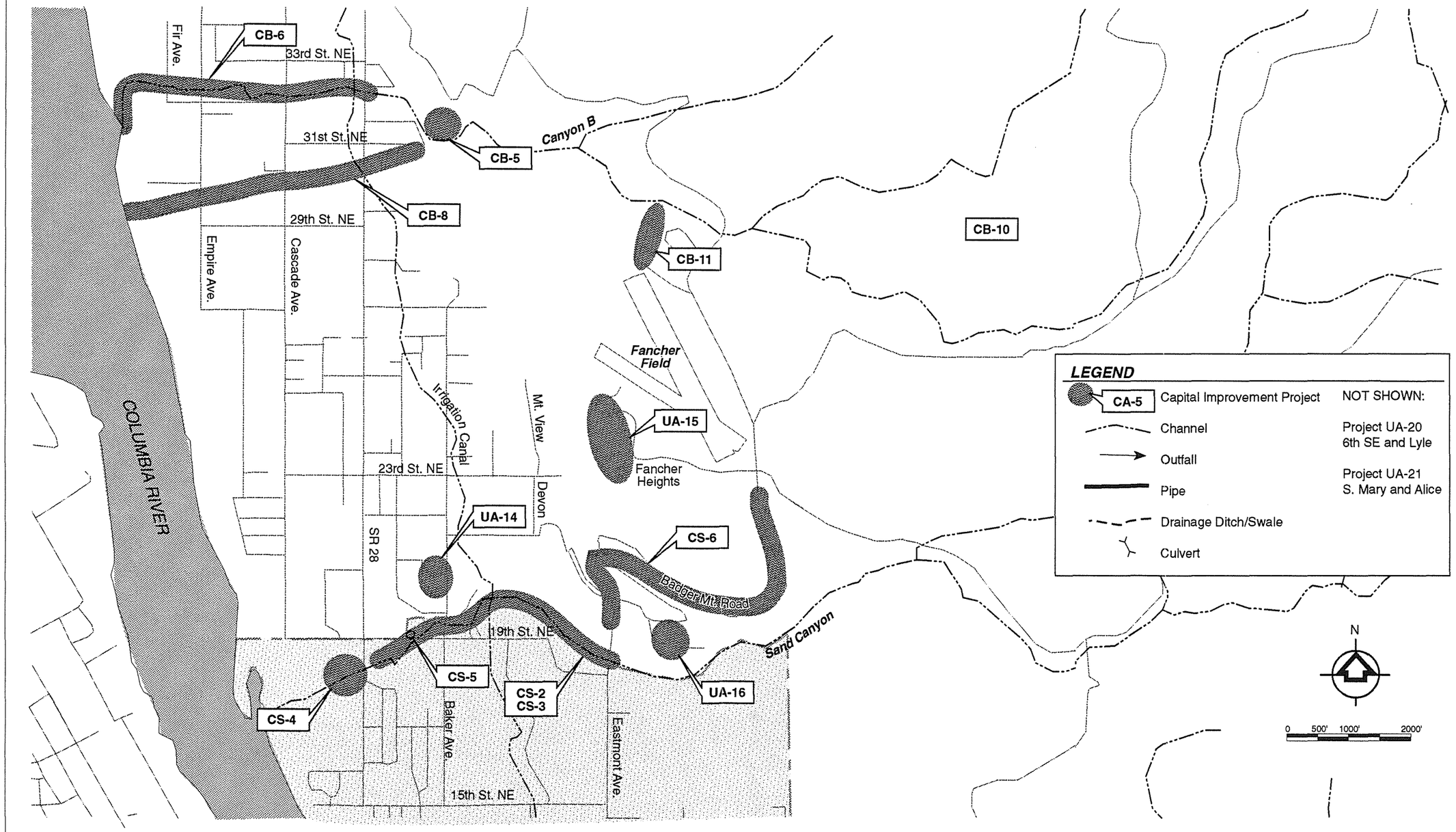
TABLE 11-7.
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS -
URBAN AREA MINOR DRAINAGE PROJECTS

Project and Description	Problems Solved[a]
CANYON A	
Remove obstructions and restore ditch (where possible under current conditions) in Canyon A between Lyle and Hanford Avenues.	4,5
CANYON B	
Monitor debris slides in Canyon B and sediment accumulation in the debris basin. Remove sediments as necessary following storm events and reseed with native vegetation.	10
SAND CANYON	
Modify operation of irrigation diversion weir in Sand Canyon at Highway 28 to ensure that weir does not interfere with flow capacity of road culvert.	19
URBAN AREA - COUNTY	
Install originally proposed infiltration trench for Autumn Place in cooperation with property owner. Dry well was placed in 1994.	23
Ensure that neighborhood ditches and culverts are adequately maintained through a regular maintenance program	26,27
Verify need to upgrade pipe in Manhattan Square (Reduces from 22 in. to 14 in.)	32
Convey stormwater across irrigation canal at S. Kentucky, 3rd, 11th, 15th, 19th, 21st, 23rd, 35th, and Baker.	33
Designate drainage pathway between Eastmont and Baker Avenue. When Baker Avenue is extended to 3rd Street install inlet to new storm drain (this drain may lead to Canyon A pipeline running down 3rd).	35
Construct drainage facilities as part of 4th Street SE Extension project.	38
Extend storm drainage system from 2nd Street. Recently completed as part of Road Improvement District. (86-2, 90-1, and 92-1.)	39
Verify storm drain connections with downstream facilities. Study of entire "Tedford" basin (i.e., between Grant Road and 4th Street SE below Kentucky Avenue) may be required.	40,41,42
URBAN AREA - CITY	
Many streets in East Wenatchee streets do not have storm drains. New storm drains can be installed and connected to existing underground systems. As the adequacy of the existing system to handle new connections is unknown, a storm drainage study of the City's system is needed before recommendations can be made.	36,37

a. Problems are listed in Table 7-1 and shown on Figures 7-1 and 7-2.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 11-1. CAPITAL IMPROVEMENT PROJECTS IN EAST WENATCHEE AREA (south of 15th Street NE)



KCM *1917 First Avenue* *Seattle, Washington 98101*	Douglas County COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 11-2. CAPITAL IMPROVEMENT PROJECTS IN EAST WENATCHEE AREA (north of 15th Street NE)

Table 11-8
CIP PROJECT PRIORITY AND SCHEDULE

Overall Ranking	Basin Ranking	Project (1)	Description	Total Cost	CIP Schedule 1994 (1)	1995 (2)	1996 (3)	1997 (4)	1998 (5)	1999 (6)	2000 (7)	2001 (8)	2002 (9)	2003 (10)	2004 (11)	2005 (12)	2006 (13)	2007 (14)	2008 (15)	2009 (16)	2010 (17)	2011 (18)	2012 (19)	2013 (20)	2014 (21)
Canyon A																									
High	1	CA-11a	Pipeline below Eastmont	$1,925,000						140	415	490	440	440											
High	2	CA-9	Relocate channel in park	$53,000				53																	
High	3	CA-14	Ditch and culvert cleaning	$18,000				18																	
Medium	4	CA-7	Flood channel	$3,020,000										200	600	550	520	650	500						
Medium	5	CA-5	Dike at Kentucky	$123,000															123						
Medium	6	CA-3a	Upgrade culverts at Lyle & Kentucky	$105,000													105								
			Subtotal	$5,244,000																					
Canyon B																									
High	1	CB-6	25-yr channel below SR28	$923,000	155	350	418																	490	295
Medium	2	CB-10	Check dams	$100,000					100																
Medium	3	CB-11	Detention at Fancher	$46,000							46														
Low	4	CB-5	Enlarge debris basin	$291,000																291					
Low	5	CB-8	Upgrade to 100-yr channel	$785,000																					
			Subtotal	$2,145,000																					
Sand Canyon																									
Medium	1	CS-2	Reinforce road fill	$35,000											35										
Low	2	CS-3	25-yr culverts	$220,000																	65	155			
Low	3	CS-4	Channel at mobile homes	$70,000																		70			
Low	4	CS-5	Relocate home	$200,000																		200			
			Subtotal	$525,000																					
Urban Area																									
High	1	UA-15	Fancher Hts. dry wells	$25,000	25																				
High	2	UA-9	Infiltration area at 10th St.	$400,000		20	280									100									
High	3	UA-13a	Intercept agricultural runoff (CA)	$946,000			25	250	250	421															
High	4	CS-6	Badger Mt. road drainage	(separate RID)		20																			
Medium	5	UA-14	Autumn Drive dry wells	$18,000				18																	
Medium	6	UA-23	8th St. drainage and infiltration	$247,000									247												
Medium	7	UA-19	8th and Kentucky culverts	$85,000				85																	
Medium	8	UA-17	Lyle Ave. ditch to Canyon A	$73,000				73																	
Medium	9	UA-16	Vista View/Ski View drainage	$108,000					108																
Medium	10	UA-21	S. Mary and Alice dry wells	$12,000				12																	
Medium	11	UA-22	Grover Ave. dry wells	$18,000				18																	
Medium	12	UA-24	Eastmont at 11th/10th pipe	$63,000													35	28							
Medium	13	UA-25	Ongoing improvements	$200,000		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Low	14	UA-18	Eastmont at 3rd/4th culverts	$78,000																55	23				
Low	15	UA-13b	Intercept agricultural runoff (CS)	$2,158,000																100	628	280	600	150	400
			Subtotal	$4,431,000																					
Moses Coulee/Palisades																									
High	1	MC-4	Roadway & Channels	$851,000		30	810	11																	
High	2	MC-1	Flood warning plan	$20,000			20																		
Medium	3	MC-2	Floodproofing	$200,000			20	40	40		80	40													
Low	4	MC-3	Road & access improvements	$500,000					20													30	150	150	150
			Subtotal	$1,571,000																					
Jameson Lake																									
Low	1	JL-1	Outlet pipeline	$269,000		20	200	49																	
			Subtotal High	$5,410,000																					
			Subtotal Medium	$4,253,000																					
			Subtotal Low	$4,302,000																					
			Total	$13,965,000	$180	$430	$1,783	$637	$528	$571	$531	$540	$697	$650	$645	$660	$670	$688	$633	$456	$726	$745	$760	$800	$855

(1) Projects within City of East Wenatchee are shown in bold

Cost ($1000)

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APPENDIX A.
FEDERAL, STATE, AND LOCAL REGULATIONS AND POLICIES

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FEDERAL, STATE, AND LOCAL REGULATIONS AND POLICIES

This appendix provides an overview of the existing federal, state, and local regulations that directly or indirectly affect stormwater and flood hazard management in Douglas County.

FEDERAL

Clean Water Act

The Clean Water Act of 1977 and the Water Quality Act of 1987 (amendments to the Federal Water Pollution Control Act) provide the backbone for the national approach to water quality policy and action. The goal of this federal law is the total elimination of pollutant discharge into the nation's navigable waters.

The provisions of Sections 401, 402, and 404 of the Clean Water Act (33 USC 1251 et seq., as amended by Public Law 92-500) are pertinent to surface water management in Douglas County. Section 401 requirements pertain to any activity that requires a federal permit and that may result in a discharge to state water. Under Section 402, National Pollution Discharge Elimination System (NPDES) regulations require all municipal stormwater discharges from medium and large municipal separate storm sewers and those associated with industrial activities to obtain federal permits. Section 404 specifically regulates discharge of dredged or fill material into "waters of the nation," including wetlands.

Section 401 - Water Quality Certification

Section 401 (40 CFR 121) ensures that activities that require a federal permit (such as Corps of Engineers Section 404 permit for filling of a wetland) comply with the Clean Water Act, state water quality laws, and other appropriate state regulations (e.g., the Hydraulic Code, Water Pollution Act). Section 401 is implemented through a certification process. In the State of Washington, the Department of Ecology (Ecology) implements Section 401 requirements [WAC 173-225; RCW 90.48; WAC 173-201-035(8)(e)]. Ecology also tracks the responses of other state reviewing agencies and is the final authority on approval, denial, or special conditions for certification.

A Water Quality Certification certifies that an activity requiring a federal permit will comply with water quality standards and discharge limitations for waters of the State of Washington (Chapter 173-201 WAC). The Certification is similar to a permit and is required under Section 401 as a prerequisite to obtaining a U.S. Army Corps of Engineers (COE) permit, a Federal Energy Regulatory Commission (FERC) license, or other federal permit. Usually, the federal permitting agency notifies Ecology of applications for federal permits. Issuance of a Certification is exempt from State Environmental Policy Act (SEPA) requirements.

Most in-stream construction activities, including flood hazard management projects such as riprap revetment and gravel bar scalping will unavoidably violate state water quality standards (particularly the turbidity standard) on a short-term basis. Such projects will require a Temporary Modification of Water Quality Standards, an order issued by Ecology to

control short-term activities that are essential to the public interest. The order may be required before Ecology issues a Water Quality Certification, and must comply with SEPA requirements.

Application to Douglas County

Because the stream channels are dry for nearly all days of the year, the potential for water quality impacts during construction are remote. Therefore, a permit is not anticipated.

Section 402 - National Pollution Discharge Elimination System

The Water Quality Act of 1987 amended Section 402 with a new subsection regulating stormwater discharges. The amendment requires a phased approach to control pollutants that are mobilized and transported by stormwater discharges. Although pollutants entering storm and surface water systems have historically been considered non-point in nature, they are now regulated as point sources under Section 402(p) and are thus subject to the permitting process of the Clean Water Act's National Pollutant Discharge Elimination System (NPDES).

The U.S. Environmental Protection Agency (EPA) established permit application requirements for stormwater discharges associated with industrial activity and discharges from municipal separate storm sewer systems on November 6, 1990 (40 CFR Parts 122, 123, and 124). Permitting authority for programs regulating industrial and municipal stormwater in Washington State was granted to Ecology by EPA.

Application to Douglas County

Douglas County is not classified as a large or medium municipality according to definitions specified in the final NPDES regulations. Therefore, Douglas County is not currently subject to the full requirements of the new NPDES stormwater regulations. However, small communities will eventually be regulated under NPDES stormwater requirements. It is difficult to predict the level of requirements that will be established by the EPA for communities such as East Wenatchee. It is likely that the first round of efforts to attain regulatory compliance will emphasize control of pollutant sources and their removal from contact with stormwater. Such controls may include a variety of structural or nonstructural measures. The regulations for small cities are likely to reflect the experience of EPA associated with NPDES permitting for larger cities.

Section 404 - Dredge and Fill Requirements

Section 404 of the Clean Water Act (USC 1394) regulates the discharge of dredged or fill material into waters of the United States, including wetlands. The COE issues or denies permits to administer the provisions of Section 404.

Under the law, discharges of dredged or fill material in wetlands may require a nationwide permit or an individual permit. Nationwide permits are issued to authorize specific categories of work, including minor road crossing fills, replacement, repair, and rehabilitation, and mooring buoys. The nationwide permit is required for smaller projects and the review process for obtaining this permit generally takes less than 20 days. The main

nationwide permit dealing with wetland fills is Nationwide Permit 26. This permit regulates filling that will cause the loss or substantial adverse modification of less than one acre of isolated waters or waters with an average annual flow of less than 5 cfs (headwaters). This includes isolated wetlands and wetlands adjacent to and above the headwaters of tributary water bodies. Fills of 1 to 10 acres of isolated wetlands or wetlands above the headwaters of tributary water bodies also require review of associated environmental impacts by the COE, the EPA, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Washington State Department of Ecology.

Individual permits are required for wetland proposals involving:

- Fill of less than 10 acres that is not authorized under Nationwide Permit 26
- Fill of more than 10 acres
- Fill of any area in wetlands below the headwaters of and adjacent to a stream
- Fill of any area in tidal waters and their adjacent wetlands.

The review process for an individual permit includes an analysis by the COE of whether the project's benefits outweigh predicted environmental impacts. Completion of an Environmental Impact Statement may be necessary for some projects. In addition, there is a 30-day period in which the proposal is available for review by federal, state, and local agencies, Native American groups, interest groups, and the general public.

Proposed activities in wetlands may be subject to other laws in addition to or in association with a Section 404 permit. For example, in the State of Washington, Ecology has the right to place conditions on or request denial of a Section 404 permit if a proposed project does not comply with state water quality laws. The COE cannot issue a Section 404 permit if the state has denied water quality certification. Furthermore, if any local agency permit associated with the project is denied, the COE will deny the 404 permit.

Application to Douglas County

Flood control and storm drainage activities in Douglas County are not anticipated to affect any wetlands, and therefore no Section 404 permit will be needed.

National Flood Insurance Act / Flood Disaster Protection Act

In 1968, the U.S. Congress initiated the National Flood Insurance Program (NFIP) (Chapter 44 CFR) under the National Flood Insurance Act to relieve the burden of disaster relief on the national treasury and on state and local tax bases. The NFIP is administered by the Federal Insurance Administration (FIA), which is part of the Federal Emergency Management Agency (FEMA). The NFIP makes affordable flood insurance available to communities that adopt approved floodplain management regulations. Communities that do not participate in the NFIP do not qualify for certain flood disaster relief.

Congress added several provisions to the NFIP under the Flood Disaster Protection Act of 1973 in order to strengthen the program. The 1973 act provided additional incentives to communities to join the NFIP by substantially increasing the amount of flood insurance coverage available and providing penalties for communities and individuals that choose not to join the NFIP and are subsequently flooded. Specific new requirements include the following:

- Any acquisition or construction undertaken in identified special flood hazard areas requires purchase of federal flood insurance if available.
- Acquisition of properties in the floodplain that are to be secured under mortgages from a federally related lender requires purchase of federal flood insurance if available.
- Communities identified by FEMA as flood-prone have one year from the time of designation to enroll in the NFIP; otherwise disaster-assistance funds and federal financial assistance for acquisition or construction of property in flood hazard areas will be denied.

The NFIP consists of an emergency program and a regular program. The emergency program is initiated when the FIA notifies a community that it has been identified as a flood-prone area. Notification is provided in the form of a Flood Hazard Boundary Map (FHBM). The FHBM is a preliminary delineation of the flood hazard areas and shows no elevations. After receiving the FHBM, a community becomes a participant by completing an application to the FIA. Upon acceptance of the application, limited amounts of flood insurance are made available to the community. The community is required to adopt minimum floodplain management regulations based on the FHBM and is encouraged to use any additional information available to establish flood elevations.

A community enters the regular NFIP program upon adoption of an ordinance approved by FEMA. A detailed technical flood insurance study that involves hydrologic and hydraulic analyses is normally performed, and is referenced in the ordinance as the basis for the regulatory program. The products of the study are the Flood Insurance Rate Map (FIRM) and the Flood Insurance Study. The Flood Insurance Study provides data on the width of the floodway and floodplain, the cross-sectional area, and the floodwater velocity at given points in the stream. The FIRM delineates areas adjacent to rivers that are subjected to flood risks and an insurance rate is determined for each area. New FIRMs also delineate flood insurance rate zones, limits of the 100-year floodway and floodplain, and, frequently, the limits to the 500-year floodplain. FIRMs and the associated insurance studies are available from the regional branch of FEMA.

The 100-year flood determines the geographic jurisdiction of NFIP-related programs. The 100-year flood is frequently called the "base flood" and is defined as the discharge that has a 1 percent chance of occurring or being exceeded in a given year. The 100-year floodplain is the area that would become inundated by water during the 100-year flood.

The floodway is an engineering concept incorporated into the NFIP floodplain management criteria. A floodway is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without

cumulatively increasing the water surface elevation more than a certain amount (1 foot for NFIP). Floodways are calculated by FEMA for the 100-year base flood for major rivers and streams as part of the flood insurance study undertaken for a community.

Since 1990, communities that have adopted programs or regulations to reduce flood-related damages have been eligible to receive reduced insurance rates under the Community Rating System (CRS). Communities must apply to FEMA to be certified for a rate reduction before policy holders within the community can receive a rate reduction. There are 21 different activities, divided into four groups, that count towards the credit. The groups are public information, mapping and regulations, flood damage reduction, and flood preparedness.

Application to Douglas County

Douglas County is currently a member of the NFIP. The FEMA community number for Douglas County is No. 530036. The current floodway and floodplain maps became effective on May 17, 1982 based on information contained in the 1981 Douglas County Flood Insurance Study. Douglas County's Flood Damage Prevention Ordinance (see below) incorporates the elements required by the NFIP for national flood insurance eligibility. Therefore, federally subsidized flood insurance is available for local residents. To continue coverage, the County must maintain participation in the NFIP and maintain minimum floodplain management regulations. FEMA requires a certification letter for any revisions to the FIRM. Activities that require certification include stream channel modifications, installation of culverts, and bridge construction. Douglas County may become eligible for CRS credits and a reduction in premium rates after adoption and implementation of this plan. In addition, purchases of property in the floodplain by individuals or groups using federal funding or federally backed funding sources (i.e., mortgages) also requires purchase of flood insurance.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 USC 4321 et seq.) established a process requiring federal agencies to consider the environmental impacts of agency-sponsored development projects and of agency decisions on permits and approvals required for privately sponsored development projects. The NEPA process requires the full disclosure of environmental impacts and their consideration, along with technical and economic considerations, prior to an agency decision.

Guidance for the implementation of NEPA is provided by the Council on Environmental Quality (CEQ). The CEQ Regulations (40 CFR 1500-1508) place significant emphasis upon the consideration of alternatives, including ways to mitigate harmful environmental effects. Generally, the NEPA process occurs concurrently with Section 404 reviews by the COE. Most federal agencies have adopted their own regulations for implementing NEPA requirements.

NEPA requires that an environmental impact statement (EIS) be prepared for any major federal action that would have significant adverse environmental impacts. The EIS must thoroughly evaluate any adverse environmental impacts of the proposed action and its

alternatives. Permits issued by a federal agency (such as Section 404 permits) are among the federal actions that may require an EIS.

To determine whether a proposal would have significant adverse environmental impacts, the agency may prepare an environmental assessment (EA). A permit applicant often provides much of the information and analysis used to prepare the EA. The EA contains sufficient evidence and analysis to determine whether an EIS is required. If an EIS is not required, a Finding of No Significant Impact (FONSI) document is prepared by the federal agency to explain why an EIS is not required. Compliance with NEPA is achieved upon completion of the FONSI or EIS.

Application to Douglas County

Proposed actions within Douglas County that will potentially result in significant adverse environmental impacts can be regulated and controlled through the NEPA process as implemented by SEPA. Adverse impacts to the County's water quality, hydrologic regime, and aquatic biota and habitat, including wetlands, must be evaluated under SEPA if a determination of significance is made for a particular proposed action. This process serves as a tool to address a wide diversity of environmental impacts from major activities such as development.

River and Harbor Act, Section 10

The River and Harbor Act was enacted in 1899 to preserve the navigability of the nation's waterways. Section 10 (33 USC 403) prohibits the unauthorized obstruction or alteration of any navigable water of the United States. The provisions apply to all structures or work below the mean high water mark of navigable tidal waters and the ordinary high water mark of navigable fresh waters. Actions in wetlands within these limits are subject to Section 10 provisions.

Provisions of Section 10 are implemented by the COE through a permit process that includes consideration of navigation, flood control, fish and wildlife management, and environmental impacts. Compliance with National Environmental Policy Act (NEPA) is required. Section 10 reviews often occur simultaneously with Section 404 permit processing.

Application to Douglas County

The Columbia River, including the reach that flows through Douglas County, is a navigable water under the Rivers and Harbors Act. Therefore, activities in the river channel wetlands within the ordinary high water mark (OHWM) of the Columbia River can be regulated through Section 10, as well as Section 404. However, because navigation will not be impacted, flood control and stormwater facilities that discharge to the Columbia River will probably not require a Section 10 permit.

Executive Order 11990 (Wetlands)

In 1977, Executive Order 11990 directed federal agencies to avoid the unnecessary alteration or destruction of wetlands. The order requires federal agencies to provide leadership and

take action to minimize the destruction, loss, or degradation of wetlands affected by any federal project or project that receives federal funding. Federal agencies must also address impacts to wetlands and mitigate unavoidable impacts. The order establishes wetland protection as the official policy of all federal agencies.

Application to Douglas County

While the order does not regulate wetlands per se, it does establish wetland protection as the official policy of all federal agencies. Many policies and regulations in the State of Washington reflect this policy (see below).

STATE REGULATIONS

Water Pollution Control Act

The Water Pollution Control Act (RCW 90.48) empowers the state to develop, maintain, and administer the statutes and programs required by the Clean Water Act. The policies set forth in the federal act are reflected in the State Water Quality Standards (WAC 173-201).

Application to Douglas County

The Water Pollution Control Act empowers Ecology to bring punitive actions for the illegal discharge of pollutants, including fines, prosecution, and incarceration. It also authorizes assistance to local jurisdictions for construction of water quality control projects.

State Environmental Policy Act

The Washington State Environmental Policy Act (SEPA) (Chapter 43.21C RCW) was passed by the legislature to ensure that environmental values are considered (in addition to technical and economic considerations) in decisions by state and local government officials. SEPA policies and goals apply to actions at all levels of government in the state except the judiciary and state Legislature. The most recent implementing rules (WAC 197-11) were adopted by Ecology in 1990. This act conforms to the provisions of NEPA as described above.

RCW 43.21C lists SEPA's four primary purposes:

- Encourage productive and enjoyable harmony between people and their environment.
- Prevent or eliminate damage to the environment and biosphere.
- Stimulate the health and welfare of people.
- Enrich the understanding of ecological systems and natural resources important to the state and the nation.

The SEPA process starts with a permit application to an agency or an agency proposal for official action. Prior to acting (issuing permits, approvals, etc.) on a non-exempt project,

agencies must assure that appropriate consideration has been given to the environment. The severity of potential environmental impacts associated with a proposed project will determine whether an EIS is required. If an EIS is not issued, a Determination of Non-significance (DNS) must be issued.

After completion of the EIS or DNS, agencies may act upon the permit application or other approval required for the project. Administrative or legal appeals and challenges concerning SEPA compliance must be linked to a specific governmental action (e.g., permit) and be brought in a timely manner.

Agencies may deny permits or other approvals under SEPA if the proposal would likely result in significant adverse environmental impacts and if mitigating measures would be insufficient to mitigate the identified impact. SEPA rules place a particular emphasis on the identification of mitigating measures that may be required under SEPA as permit conditions.

The consistency of a proposal with existing plans and policies, (e.g., local shoreline master programs, comprehensive plans, zoning codes), may be evaluated in the EIS. Completion of the SEPA process is necessary before agency decisions may be made on the Hydraulic Project Approval, Shoreline Substantial Development permit and many other local and state permits and approvals.

A variety of proposed actions are categorically exempt from the SEPA process. Most categorical exemptions use size criteria to differentiate between exempt and non-exempt actions. Exempted projects include most single-family homes, commercial buildings under 4,000 square feet, parking lots for 20 cars or less, and landfills or excavations of 100 cubic yards or less. Under SEPA provisions, cities and counties are allowed to set their own size criteria within a specified range for five categories of exemptions. Criteria cannot be more restrictive than those of SEPA unless the location of a proposed action is an environmentally sensitive area.

Application to Douglas County

SEPA requires preparation of environmental review (i.e., environmental checklist, environmental assessment, or EIS) documents for any project and adherence to its provisions and guidelines, as empowered by NEPA. As discussed earlier, SEPA can be used as a regulatory tool by local jurisdictions to control and mitigate activities that are likely to have significant adverse environmental impacts

Washington State Shoreline Management Act

The purpose of the Washington State Shoreline Management Act (SMA) (RCW 90.58) is to protect public resources such as water, fish and wildlife, and the habitat that supports them by regulating public and private development in shoreline areas. The SMA provides the legal basis for state policy and for the implementing regulatory documents adopted as Washington Administrative Code. It defines shoreline designations; provides guidance to Ecology and local jurisdictions for developing procedures, rules, and plans for shoreline activities; establishes timelines for the development of local shoreline management plans; and identifies activities generally exempt from shoreline permits.

The SMA defines shorelines as follows:

> All of the water areas of the state, including reservoirs, and their associated wetlands, together with the lands underlying them, except 1) shorelines of statewide significance; 2) shorelines on segments of streams upstream of a point where the mean annual flow is 20 cfs or less and the wetlands associated with such upstream segments; and 3) shorelines on lakes less than 20 acres in size and wetlands associated with such small lakes.

Wetlands are defined in the act as " ...those lands extending landward for 200 feet in all directions as measured on a horizontal plane from the ordinary high water mark (of a water body); floodways and contiguous floodplain areas landward 200 feet from such floodways; and all marshes, bogs, swamps, and river deltas associated with the streams, lakes, and tidal waters which are subject to the [Shoreline Management Act]."

Shorelines of Statewide Significance include the rivers (downstream of where mean annual flow is 1,000 cfs or greater), adjacent lands within 200 feet of the ordinary high water mark, areas within the floodway, contiguous floodplain areas landward 200 feet from the floodway, and all associated marshes, bogs, and swamps.

The SMA requires permits for substantial development within the Shorelines of the State. Substantial development is defined as any development for which the total cost, or fair market value, exceeds $2,500, or any development that materially interferes with normal public use of the water or Shorelines of the State. Exceptions include normal maintenance or repair of existing structures, construction of residential bulkheads, emergency construction, construction of barns or similar agricultural structure on wetlands, construction or modification of navigational aids, construction of a single-family residence on a wetland, construction of docks for pleasure boats, irrigation systems, and pre-existing agricultural drainage and diking systems. A conditional use permit can be issued to allow greater flexibility in a manner consistent with the policies of RCW 90.58.020. By authorizing a conditional use, the appropriate local government agency may attach special conditions to prevent undesirable effects of the proposed use. A variance can be granted for relief from bulk, dimensional, or performance standards set forth in the Shoreline Master Program where extraordinary or unique circumstances affect the property such that unnecessary hardships are imposed on the applicant.

The SMA describes the following shoreline use criteria (in order of preference) that Ecology should consider in developing guidelines for Shorelines of Statewide Significance and local jurisdictions should consider when developing master programs for Shorelines of Statewide Significance (RCW 90.58.020):

1. Recognize and protect state-wide interest over local interest.
2. Preserve the natural character of the shoreline.
3. Consider long-term over short-term benefit.
4. Protect the resources and ecology of the shoreline.

5. Increase public access to publicly owned areas of the shorelines.

6. Increase recreational opportunities for the public in the shoreline.

7. Provide for other considerations when appropriate, including economic development, circulation, housing, a range of land uses adjacent to shorelines, historic, cultural, and scientific considerations, and other considerations found to be appropriate or necessary.

Any permitted uses that are allowed based on the above criteria must minimize damage to the ecology and environment of the shoreline area and minimize any interference with the public's use of the water.

Application to Douglas County

Based on the definitions in the SMA, the Columbia River is considered a "Shoreline of State-wide Significance." Therefore, activities within the river itself, the adjacent lands within 200 feet of the ordinary high water mark, the 100-year floodplain, and all associated wetlands are subject to the provisions of the SMA.

The SMA is implemented for the Columbia River by the Douglas County Shoreline Management Master Program. The City of East Wenatchee has adopted a Shoreline Master Program based on the County's program.

State Statutes Addressing Flood Hazard Management

The three principal state statutes that address flood hazard management activities are titled: Flood Control by Counties (RCW 86.12), Floodplain Management (RCW 86.16), and State Participation in Flood Control Maintenance (RCW 86.26) (Ecology 1991). Portions of these three statutes were amended in 1991 by Engrossed Substitute Senate Bill 5411 (SB 5411) to strengthen and coordinate flood hazard management activities statewide. The state statute entitled State Participation in Flood Control Maintenance and the related FCAAP program are the basis for this report.

Flood Control by Counties/Senate Bill 5411

RCW 86.12, originally enacted in 1907, authorizes counties to levy taxes and exercise eminent domain to control and prevent flood damage. RCW 86.12 was substantially enlarged in 1991 by ESSB 5411, which added three new sections. The intent of the bill was to develop a "coordinated and comprehensive state policy to address the problems of flooding and the minimization of flood damage..." The bill greatly expands counties' roles in the formulation and adoption of CFHMPs. Specifically, "the county legislative authority of any county may adopt a comprehensive flood control management plan for any drainage basin that is located wholly or partially within the county..." Plan elements are mandated. While counties are given responsibility for basin plan development, plans are to be developed through a participatory process involving cities, towns, or special districts within the basin.

Application to Douglas County

Most of the provisions contained in Chapter 86.12 are reserved for county activities, since flood hazard management planning is most effectively undertaken on a watershed-wide basis.

Floodplain Management Program

Washington State's Floodplain Management Program (RCW 86.16) integrates local and state regulatory programs in a comprehensive effort to reduce flood damages and protect human health and safety. The state program requires that local flood-prone jurisdictions adopt a flood damage prevention ordinance based upon federal standards contained in the NFIP.

Application to Douglas County

Douglas County's Flood Damage Prevention Ordinance (described in the County Regulations section below) is consistent with the requirements of the NFIP, as well as the state Floodplain Management Program. Therefore, Douglas County is eligible for national flood insurance and for matching funds from the state to improve or construct flood control facilities and to develop flood control management plans. This CFHMP is funded by this program.

State Participation in Flood Control Maintenance

Through the Flood Control Assistance Account Program (FCAAP) administered by Ecology, local governments participating in the NFIP and meeting state requirements are eligible for matching funds to repair or restore existing flood control facilities, to maintain or improve channel capacity, and to develop comprehensive flood control management plans such as this document. An optional element of this program provides for local governments to use the planning process to develop a wetlands management strategy for the community's flood-prone areas.

Application to Douglas County

Completion of this CFHMP is partially funded through moneys from the state FCAAP fund. Adoption of this plan and completion of the proposed structural and nonstructural elements within will mitigate flood hazards and achieve the previously articulated goals and objectives. In addition, in order for the Douglas County to be eligible for FCAAP moneys for flood control maintenance activities, a CFHMP must have been completed and adopted by the appropriate local authority, or a CFHMP must be in the process of being prepared.

Water Pollution Control Act

The Water Pollution Control Act (Chapter 90.48 RCW) empowers the state to develop, maintain, and administer the federal statutes and programs required by the Clean Water Act. The policies set forth in the federal act are reflected in the State Water Quality Standards (WAC 173-201).

The Water Pollution Control Act empowers Ecology to bring punitive actions against water quality violators. Punitive measures for the illegal discharge of pollutants, including fines, prosecution, and incarceration, are outlined in the act

Application to Douglas County

In the absence of stormwater control measures and other best management practices, increased development can result in violation of water quality standards for temperature, turbidity, and dissolved oxygen, and impair the aesthetic quality of receiving waters. Activities within the County that may result in violations of state water quality standards can be controlled or halted through the provisions of this act. Extensive water quality monitoring to determine compliance with state water quality standards has not been performed in the County to date. As discussed above, monitoring of Douglas County's stormwater runoff may be required under the pending federal NPDES stormwater regulations.

Washington State Hydraulic Code

The Washington State Hydraulic Code (RCW 75.20.100-140) regulates activities within or affecting the state's salt and fresh waters. The purpose of the Hydraulic Code is to preserve fish and wildlife habitat in and around the waters of the state. The Hydraulic Code is administered by the Washington State Department of Fish and Wildlife. Fish Management typically has jurisdiction over projects to be constructed in salt or fresh waters of the state containing salmon, while Wildlife Management typically has jurisdiction over projects to be constructed in fresh waters of the state without salmon.

Any work that falls within the definition of a hydraulic project requires written approval, referred to as Hydraulic Project Approval (HPA), from the Department of Fish and Wildlife. Hydraulic projects are defined in the code as work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state.

Application consists of a form submitted to the Department of Fish and Wildlife accompanied by plans and specifications of the proposed hydraulic project. Any one of the following constitutes application for an HPA:

- A completed hydraulic project approval application submitted to the Department of Fish and Wildlife
- A completed forest practice application submitted to the Department of Natural Resources if the project is part of a forest practice as defined in WAC 222-16-010(19)
- A Section 10 or 401 public notice circulated by the COE or United States Coast Guard.

Verbal approval for emergency work may be granted immediately upon request to repair existing structures, move obstructions, restore banks, or protect other property that is subject to immediate danger by weather, flow, or other natural conditions. Verbal approval may also be granted immediately for driving across a stream during an emergency. "Emergency"

is defined as an immediate threat to life or public or private property, or an immediate threat of serious environmental degradation arising from weather, streamflow conditions or other natural conditions.

The Hydraulic Code specifies technical provisions for hydraulic projects. Fresh water technical provisions defined in the code rules (WAC 220-110-050 through 220-110-220) that are applicable to this plan include those for the following activities:

- Bank protection
- Bridge, pier, and piling construction
- Bridge construction—stringer type
- Channel change—temporary and permanent
- Channel realignment
- Temporary bypass culvert or flume
- Dredging
- Gravel removal
- Log and log jam removal
- Logging
- Pond construction
- Water diversions.

The technical provisions in the code do not automatically apply to each HPA. Rather, each application is reviewed individually. In addition to the technical provisions, restrictions related to the proposal or the site may be imposed.

A hydraulic project application may be denied when the Department of Fish and Wildlife rules that it is directly or indirectly harmful to fish life and adequate mitigation cannot be assured by conditioning or modifying the proposal. The code states that protection of fish life is the only grounds for denying or conditioning an application.

The code is currently being revised and the revised code may include provisions for regulating the quality and quantity of stormwater discharges to fish-bearing waters. Changes are proposed to provide greater emphasis on bioengineered bank protection or use of bioengineering elements in traditional bank stabilization projects. An example of the latter is the planting of large woody vegetation within banks to be stabilized with rock riprap, thereby providing riparian cover for fisheries.

Application to Douglas County

The County will be required to obtain an HPA for most flood and stormwater control activities including streambank protection; construction of bridges, piers, and docks; culvert installation; gravel removal; channel realignments; placement of outfalls; debris removal; pipeline crossing; and detention pond construction. HPAs are required for activities in natural drainage corridors as well as in flowing stream corridors.

Growth Management Act

In April 1990, the Washington Legislature passed the Growth Management Act (House Bill 2929). Amended by the Legislature in 1991 and 1993, the Act takes significant steps toward managing growth in the state's fastest growing counties. HB 2929 defines 13 broad goals for comprehensive plans and development regulations in counties and cities that are required to or choose to plan under Section 4 of this act. The goals that relate to surface water and environmental issues include the following:

- Reduce the inappropriate conversion of undeveloped land into sprawling, low-density development.
- Encourage the retention of open space and development of recreational opportunities; conserve fish and wildlife habitat; increase access to natural resource lands and water; and develop parks.
- Maintain and enhance natural resource-based industries, including productive timber, agricultural, and fisheries industries. Encourage the conservation of productive forests and productive agricultural lands, and discourage incompatible uses.
- Protect the environment and enhance the state's high quality of life, including air and water quality and the availability of water.

The Growth Management Act (GMA) is administered by the Washington State Department of Community Development. The department offers technical assistance and guidance to counties and jurisdictions that are required, or voluntarily choose, to plan under this Act.

Counties and their cities that are required by the GMA to develop and adopt a comprehensive plan by July 1, 1994 are defined by the following thresholds:

- Counties with a population of 50,000 or more that have experienced a population increase of at least 10 percent in the last 10 years, and cities within such counties
- Counties, regardless of population, that have experienced a population increase of more than 20 percent in the last 10 years, and cities within such counties.

Other counties may also be mandated to comply with the GMA if in the future they exceed either threshold criteria. Even though Douglas County has voluntarily opted into the GMA

process, they would have been mandated in 1991 to plan under GMA because they exceeded the threshold criteria (see Application to Douglas County, below).

Local governments are required to classify and designate "resource lands of long-term commercial significance" and "critical areas." Resource lands of long-term commercial significance include agricultural, forest, and mineral resource lands. Critical areas include wetlands, fish and wildlife habitat areas, aquifer recharge areas, frequently flooded areas, and geologically hazardous areas.

Comprehensive plans must include the following:

- Description of objectives, principles, and standards used to develop the plan.
- Land use element designating the proposed general distribution, general location and extent of uses of lands. The land use element should also provide for the protection of the quality and quantity of groundwater used for public water supplies, review drainage, flooding, and stormwater runoff patterns, and provide guidance for corrective actions to mitigate or cleanse discharges that pollute waters of the state.
- Housing element recognizing the vitality and character of established residential neighborhoods.
- Capital facilities plan consisting of an inventory of publicly owned facilities, a forecast of future needs, proposed locations and capacities of expanded or new capital facilities, and a six-year financing plan.
- Utilities element consisting of the general location and capacity of all existing and proposed utilities, including electric lines, telecommunication lines, and natural gas lines.
- Rural element permitting land uses compatible with the rural character of such lands that provide for a variety of rural densities.
- Transportation element that implements and is consistent with the land use element.

Optional elements of the plan include conservation, solar energy, and recreation.

The GMA also requires the designation of an urban growth area within which urban growth shall be encouraged and outside which growth can occur only if it is not urban in nature. Furthermore, each urban growth area is required to include greenbelt and open space areas. Open space corridors between and within urban growth areas must include designated lands used for recreation, wildlife habitat, trails, and connection of critical areas.

The Growth Management Act establishes reporting requirements for counties and cities required to develop comprehensive plans. Designations of resource lands of long-term commercial significance and critical areas were required by March 1, 1992. The

development of comprehensive plans or modification of existing plans was to have begun by March 1, 1992. County-wide planning policies, which are used to provide the framework for comprehensive plans, were to be developed by July 1, 1992. Extensions enacted by the 1993 Legislature postponed both the comprehensive plan and implementation regulations deadlines by a year to 1994 and 1995, respectively.

The Washington State Department of Community Development has established a program of technical and financial assistance and incentives to encourage the creation of comprehensive plans and development regulations throughout the state. The act encourages jurisdictions to require, by ordinance, that new growth and development pay a proportionate share of the cost of new facilities needed to serve it.

The GMA requires the adoption of regulations and procedures for the development of short plats and subdivisions, regional transportation plans, forest practices and water rights issues. The GMA also encourages economic prosperity and balanced economic growth by building to local capacity in rural areas and encouraging urban-rural links.

House Bill 1025 amended HB 2929 and established requirements that county-wide planning policies be adopted as a framework for the county and city comprehensive plans. These policies, to be adopted by the county in cooperation with its cities, were required by July 1, 1992. The following features were to be included:

- Urban Growth Areas (areas targeted for higher density development)
- Policies for promotion of contiguous and orderly development and provision of urban services to such development
- Policies for siting public capital facilities of a county-wide or state-wide nature
- Policies for county-wide transportation facilities and strategies
- Policies that consider the need for affordable housing, such as housing for all economic segments of the population and parameters for its distribution
- Policies for joint county and city planning within urban growth areas
- Policies for county-wide economic development and employment
- An analysis of fiscal impacts.

Application to Douglas County

Douglas County opted to voluntarily comply with the Growth Management Act comprehensive plan and development regulations in October 1990. However, in April 1991 the State officially mandated Douglas County to comply with the GMA because the County had experienced a 20 percent population increase over the previous 10 years.

Since the County volunteered into the GMA planning process, it has been given a longer compliance period than counties that were mandated into GMA planning. Douglas County set up a planning process and schedule that would result in the submission of the County's Comprehensive Plan by October 31, 1993. As of late May 1993, the County had not changed its submission deadline, though the State Legislature approved a year extension for all comprehensive plans. (Jerry Litt, Douglas County Planning Director, May 27, 1993 personal conversation with W. Jones, KCM, Inc.)

Douglas County is currently preparing background data collection, map preparation, and the planning elements for the Comprehensive Plan. The County has adopted a Critical Areas Ordinance and prepared a policy plan covering its resource lands and critical areas. The Flood Hazard Management Plan will be an important addition to the critical areas inventory and to the comprehensive planning process regarding future land use, transportation, environmentally sensitive areas, and capital improvements.

Other GMA planning activities related to the flood hazard management plan that are currently underway include the development of the County's land use classification element, which will be used to prepare growth and development alternatives. The transportation element of the comprehensive plan is also under development, and is to be completed in late summer. The rural element, which addresses specific county rural activities and policies, will be completed in early May 1995. Finally, the capital facilities plan, which will identify capital facility deficiencies and a schedule for financing improvements for a six-year and long-term planning horizon including flood hazard improvements, will be completed in 1995.

Executive Order 90-04, Protection of Wetlands

Washington Executive Order 90-04 directs all state agencies to "rigorously enforce their existing authorities to ensure wetlands protection" and includes the following stipulations:

- Ecology shall exercise its authority under the Shoreline Management Act and the Clean Water Act to condition, deny, or appeal permits to assure wetlands protection.
- Ecology shall develop a model wetlands protection element for local governments to consider when amending shoreline master programs under the Shoreline Management Act.
- The Puget Sound Water Quality Authority shall continue its efforts to ensure full implementation of the wetlands elements of the Puget Sound Water Quality Management Plan.
- The Department of Fish and Wildlife shall fully implement the authority granted under the Hydraulic Code to condition or deny permits to protect fish life assuring wetlands protection.

The order also directs the DNR, the Forest Practices Board, the Department of Agriculture, the Department of Community Development, and other state agencies to review and amend their rules and regulations to better protect wetlands. Ecology is directed to assist

these agencies in the review of their rules. Development of statewide policies, standards for wetlands rating systems and inventories, mitigations, buffers, restoration, and enhancement is the prime responsibility of Ecology. The executive order also creates an interagency Wetlands Review Board and requires wetlands education and outreach activities.

Model Wetlands Protection Ordinance

In response to Executive Order 90-04, Ecology developed a Model Wetlands Protection Ordinance in September 1990. The model ordinance is a voluntary technical assistance recommendation. Ordinance standards and policies are based on existing local ordinances that protect wetlands and on the expertise of Ecology staff and other professional experts. Local governments may use the model ordinance to achieve the goal of "no net loss of wetlands" within their jurisdiction. Ecology has no authority to require that local governments adopt the ordinance or any of its policies or standards.

In addition, Ecology has established a Wetland Protection Grant Program to assist local jurisdictions in implementing wetland protection regulations. Local jurisdictions that choose to adopt the model ordinance under the grant program can modify the ordinance based on public comment and site-specific needs of the community and its environmental setting. Local programs funded by the grant are expected to reflect the intent of the model ordinance to achieve a goal of no net loss of wetland functions and values.

Application to Douglas County

Because Executive Order 90-04 requests that all actions of local governments in the state be consistent with its intent and goals, the County can gain additional support from the state in the regulation of all activities in its wetlands. Ecology, in consultation with local governments, will develop a model local wetlands protection ordinance and will initiate a local grants program for the development of local wetlands protection programs. Wetlands provisions in existing state regulations, such as the Hydraulic Code and the Shoreline Management Act, are also strengthened as a result of this order.

Other Codes that Provide Authority for Surface Water Management

Several other sections in the Washington Administrative Code (WAC) provide authority for cities and municipalities to manage surface water. For example, the Sewerage Systems-Refuse Collection and Disposal Code (RCW 35.67.020) allows jurisdictions to establish storm and surface water utilities. Authority to assess charges to public and private properties is also provided in code.

Application to Douglas County

The WAC empowers Douglas County to form a stormwater utility and to charge fees for management and implementation of stormwater control measures. Because the County's stormwater drains to the Columbia River, the County is required by the WAC to review and study the effects of stormwater on receiving waters.

DOUGLAS COUNTY REGULATIONS

Comprehensive Plan

The Greater East Wenatchee Comprehensive Plan was adopted in 1988. The Comprehensive Plan is a policy document prepared by the County planning staff under the direction of citizens, members of local agencies and business, and the Douglas County Planning Commission. It serves as a guide for the County Board of Commissioners in its decisions regarding long-range development of the community. As such, it provides a guide for orderly growth and development and for the physical improvements accompanying this growth in the East Wenatchee area of Douglas County (excluding the City of East Wenatchee). The 1988 Plan replaced the previous Plan adopted in 1978.

The Plan emphasizes the following primary elements and associated goals:

- **Land Use:** Provide sufficient housing with associated services; create opportunities for commercial development that will provide a diverse and sound economic base; promote industrial development which contributes to economic diversification and stability; and provide for continued support and expansion of Pangborn Airport.

- **Circulation:** Provide circulation and transportation systems.

- **Conservation and Natural Resources:** Preserve and protect the quality of natural resources; preserve and encourage agricultural land uses as a viable permanent land use; and provide for sufficient quantities of parks, recreation, and open space.

- **Public Service:** Ensure that public facilities are adequate to accommodate changing needs; provide for efficient and cost-effective improvements of public utilities as necessary for development; ensure that improved and quality services are delivered to residents of annexed areas.

Flood Hazard and Stormwater Management

Although flood hazard and stormwater management goals are not a major emphasis of the Plan, several specific policy statements are included within the four basic elements. Pertinent policy statements and implementation recommendations include:

- Require a full range of public services to new developments when feasible, including facilities for stormwater runoff within the Urban Growth Boundary.

- Promote the preservation of natural drainage areas, including establishment of floodplain areas. This would be implemented through programs to obtain permanent easements or rights-of-way in existing drainage channels, and develop and implement land use standards to maintain natural watercourses.

- Promote the control or diversion of stormwater in a cost-effective manner by use of on-site diversions, curbs and gutters, collection systems, use of natural watercourses, or other means. Require future developments to provide adequate control of excess water to protect adjacent property from stormwater runoff.

- Recognize and respond to the need for flood control in both new development and on an area-wide basis.

- Modify all development codes to reflect policies on stormwater management, update existing comprehensive stormwater plans to be consistent with Comprehensive Plan, and require all local governments to comply with provisions of the National Flood Insurance Program.

The Plan recognizes that, until an adequate storm drainage system is installed, it is impractical to extensively upgrade urban streets with curbs and gutters because this will overtax the existing systems.

Shoreline Design Area Plan

In June 1992, a sub-area plan for the Shoreline Design Area was created. The Shoreline Design Area includes an 11-mile portion of the Columbia River shoreline between Lincoln Rock State Park to the north, Rock Island Hydro Park to the south, and Sunset Highway to the east. It includes areas within both Douglas County and the City of East Wenatchee. This sub-area plan was prepared in response to comments received during public hearings conducted for the 1988 Plan. These comments indicated that there was a need to further examine river resources and to determine long range goals and policies for this area.

The plan achieves the following five primary goals:

- Greatly improves public access to the river and shoreline

- Preserves unique and sensitive shoreline areas, wetlands, riparian zones, drainages, gullies, and upland areas

- Provides for diverse recreational opportunities

- Aids in economic diversification by providing opportunities for commercial, industrial, and recreational development throughout the area

- Recommends a transportation and circulation network for both local and regional traffic.

Zoning Ordinance

The Douglas County Zoning Ordinance is adopted as Title 18 of the Douglas County Code. This ordinance was most recently amended on February 1, 1993. The purpose of the Zoning Ordinance is to further the goals and policies of the Comprehensive Plan for the physical development of the County. The objectives of the zoning ordinance are to:

- Encourage orderly growth of the County.
- Promote compatible uses of land.
- Provide desired levels of population density and intensity of land use.
- Facilitate adequate levels of community services and utilities.
- Provide workable relationships between land uses and the transportation system.

The zoning ordinance contains the use and density requirements that guide land use in the County. A zoning map that identifies specific land use zones in the County was adopted with the code. The use determination of each zone is in accordance with the guidelines of the comprehensive plan and existing uses of the land.

Douglas County has no specific zoning districts for floodplains in the zoning ordinance. East Wenatchee has a flood hazard zoning district, which is applied as an "overlay" to standard zoning districts. An overlay specifies additional flood hazard-related restrictions to the underlying zoning district. However, this particular zoning is currently not designated to any area of the City.

Flood Damage Prevention Ordinance

Flood hazard management in Douglas County is implemented under the Flood Damage Prevention Ordinance, Chapter 15.48 of the County Code. This ordinance, enacted in 1987, complies with the federal requirements of the NFIP for flood insurance eligibility. The County is given authority to regulate flood hazards by RCW 36.32.120(7), which delegates responsibility to local governmental units to adopt regulations designed to promote the public health, safety, and general welfare of its citizenry.

Flood hazard management was originally implemented in 1984 under the Flood and Mudslide Areas Ordinance, Chapter 15.36 of the County Code. Chapter 15.48 greatly expands this ordinance by adding specific details and requirements.

To accomplish the goals of protection of health and property, minimization of costs associated with flood damage, and awareness of flood hazard areas, the Flood Damage Prevention Ordinance includes the following general methods to regulate flood hazards in the County:

- Restrict or prohibit land uses that are dangerous due to water or erosion hazards.
- Require that uses vulnerable to floods be protected against flood damage at the time of initial construction.
- Control the alteration of natural floodplains, stream channels, and natural protective barriers that help accommodate or channel floodwaters.

- Control filling, grading, dredging, and other development that may increase flood damage.

- Prevent or regulate the construction of flood barriers that will unnaturally divert floodwaters or may increase flood hazards in other areas.

This ordinance applies to all lands designated as "Areas of Special Flood Hazard" in the Douglas County Flood Insurance Study. Responsibility for development permit review is given to the County Planning Department.

General standards for flood hazard protection in special flood hazard areas include the following:

- Anchoring requirements for new developments, substantial improvements, and manufactured homes

- Use of flood-resistant construction materials and utility equipment and the use of construction methods that minimize flood damage

- Design and location requirements for water and sewage disposal systems that minimize adverse impacts due to flooding

- The requirement that subdivision proposals include designs to minimize flood damage

- Review of building permits to ensure proposed construction is reasonably safe from flooding.

The provisions for flood hazard protection in designated floodways are considerably more stringent than those presented for special flood hazard areas. (A floodway is designated in Moses Coulee, but not in Canyon A, Canyon B, or Sand Canyon in the East Wenatchee area.) The placement, construction, reconstruction, or substantial improvement of any structure is prohibited in the floodway, as is a range of other encroachments associated with development. However, exceptions to this requirement can be made if the encroachment does not result in an increase in flood levels during the occurrence of the base flood discharge. If this requirement is satisfied, the general and special standards for special flood hazard areas must still be met for construction and substantial improvements within floodways.

State Environmental Policy Act Implementation

Policies and procedures for implementation of SEPA rules in Douglas County are specified in Chapter 19.04 of the County Code. This chapter largely incorporates the State's rules by reference.

Shoreline Management

Local shoreline management plans implement the state Shoreline Management Act requirements and include restrictions on development on marine and freshwater shore-

lines of the state, including estuaries, lakes, streams greater than 20 cfs, and associated wetlands. Douglas County has adopted shoreline management regulations in Chapter 19.08 of the County Code.

Subdivision Ordinance

The Douglas County Subdivision Ordinance is contained in Chapter 7 of the Douglas County Code in Douglas County Subdivision Regulations 4.06.23. The Subdivision Ordinance establishes procedures and conditions for subdividing land into smaller parcels within unincorporated areas of Douglas County. A subdivision is defined as the division of land into five or more lots, with any lot being five acres or less. A short subdivision is the division of land into four or less lots.

Subdivision regulations may complement but not supersede the zoning ordinance. Whereas zoning regulations describe where different types of land use shall occur, subdivision regulations describe how the development shall occur to ensure its proper functioning. Most jurisdictions have measures for storm drainage under traditional subdivision regulations. Other planning tools to reduce stormwater-related impacts include the use of overlay zones (i.e., floodplains, sensitive areas), planned unit developments, and amenity densities.

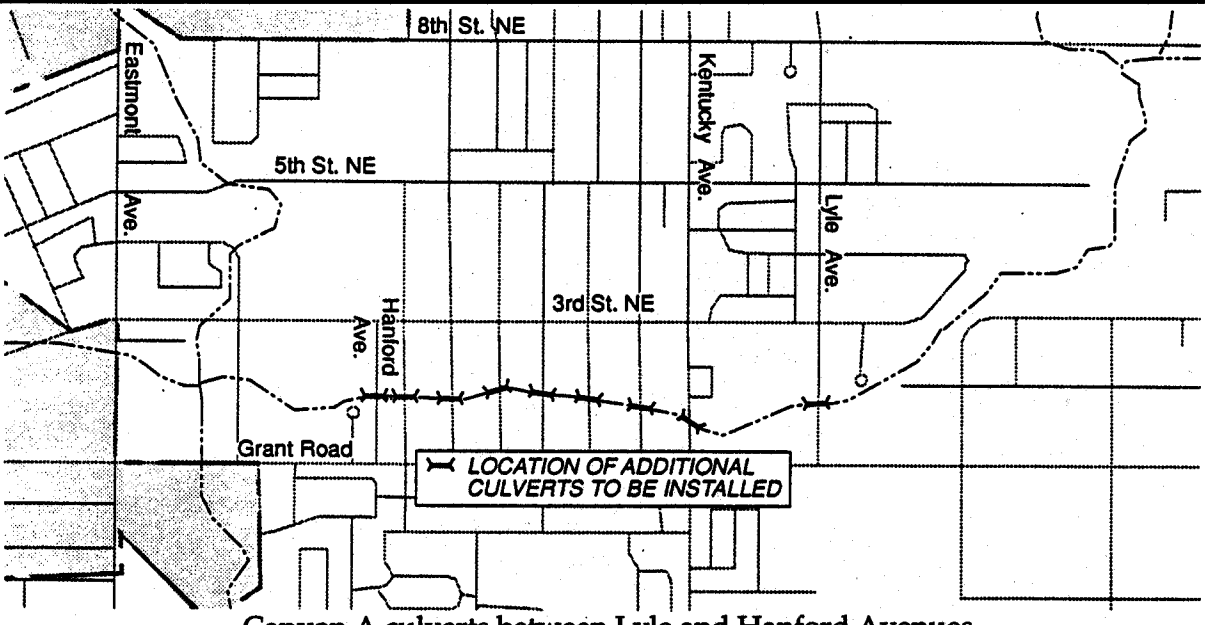
The Subdivision Ordinance is presently the primary tool for stormwater management associated with new developments. Stormwater drainage is implemented under conditional requirements specified by the County during permit review. In addition to curbs, gutters, and storm drainage facilities, the County requires that new developments not increase the rate of stormwater discharge over that which occurs under existing conditions. This typically requires on-site detention and infiltration for a 25-year design storm. This ordinance could be strengthened by codifying these specific requirements for drainage control.

APPENDIX B.
PROJECT SUMMARY SHEETS AND PRELIMINARY COST ESTIMATES

PROJECT SUMMARY SHEET

Project Title:	Canyon A - Increase capacity of road culverts
Project Description:	Replace or upgrade culverts along Canyon A corridor between Lyle and Hanford Avenues to increase flow capacity. Currently, most culverts pass less than the 10-year flood. Replacement would reduce localized flooding in residential areas.
Design Criteria:	* **Project CA-3a:** 100-year capacity at Lyle and Kentucky Avenue culverts only (roads downstream will continue to overtop) **Project CA-3b:** 25-year capacity at all culverts (> 25-year storm flows will overtop roads) **Project CA-3c:** 100-year capacity at all culverts
Design Requirements:	* **Project CA-3a:** 60-inch culvert at Lyle, two 48-inch culverts at Kentucky **Project CA-3b:** Add second 48-inch culvert at all streets from Kentucky to Hanford (8 crossings) **Project CA-3c:** Add two 48-inch culverts at all streets from Kentucky to Hanford (8 crossings) and one 60-inch culvert at Lyle Avenue.
Issues:	**Design:** Extensive channel improvements also needed (Project CA-7) **Downstream Impacts:** Larger culverts would change the storage characteristics of the Lyle Avenue embankment. Flows would increase (relative to current conditions) during more common floods (i.e., 25-year or less) but would decrease during less frequent floods.
Maintenance:	Sediment removal (most now are partially filled with sediment).
Estimated Project Cost:	* **Project CA-3a:** $105,000 **Project CA-3b:** $227,000 **Project CA-3c:** $400,000

* Recommended Project



Canyon A culverts between Lyle and Hanford Avenues

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CA-3A

CANYON A
LYLE AVENUE
UPGRADE CULVERT TO 100-YR CAPACITY

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$3,000.00	$3,000
2	EXCAVATION - STRUCTURAL/TRENCH	331	CY	$15.00	$4,965
	SOIL DISPOSAL - OFFSITE	163	CY	$1.50	$245
	GRAVEL FILL - PIPE BEDDING	50	CY	$20.00	$1,000
	COMPACTED BACKFILL - PIPE TRENCH	194	CY	$12.00	$2,328
3	71x47 INCH CMAP CULVERT	175	LF	$155.00	$27,125
	CMP FLARED END SECTION - 60 INCH	1	EA	$2,300.00	$2,300
4	PAVEMENT CUTTING	135	LF	$3.00	$405
	PAVEMENT RESTORATION	86	SY	$50.00	$4,300
5	EROSION/SEDIMENT CONTROL	1	LS	$6,250.00	$6,250
	TRAFFIC CONTROL	16	DY	$300.00	$4,800
	TRENCH SAFETY SYSTEM	95	FT	$7.00	$665
				SUBTOTAL:	$57,383

SALES TAX	7.80%		$4,476
		SUBTOTAL:	$61,858
CONTINGENCY	30%		$18,558
		CONSTRUCTION COST SUBTOTAL:	$80,416
ENGINEERING, LEGAL & ADMIN.	30%		$24,125
LAND ACQUISITION	AC		
		SUBTOTAL:	$104,541
		TOTAL ESTIMATED PROJECT COST:	**$105,000**

PROJECT SUMMARY SHEET

Project Title: Canyon A - Grant Road flooding: dike at Kentucky Avenue

Project Description: A low dike, several hundred feet long and approximately 3.5 feet high, would be constructed along the south side of Canyon A above Kentucky Avenue to prevent floodwaters from leaving the natural channel pathway and flooding Grant Road. Culverts at Kentucky Avenue would be upgraded to handle increased flows in Canyon A.

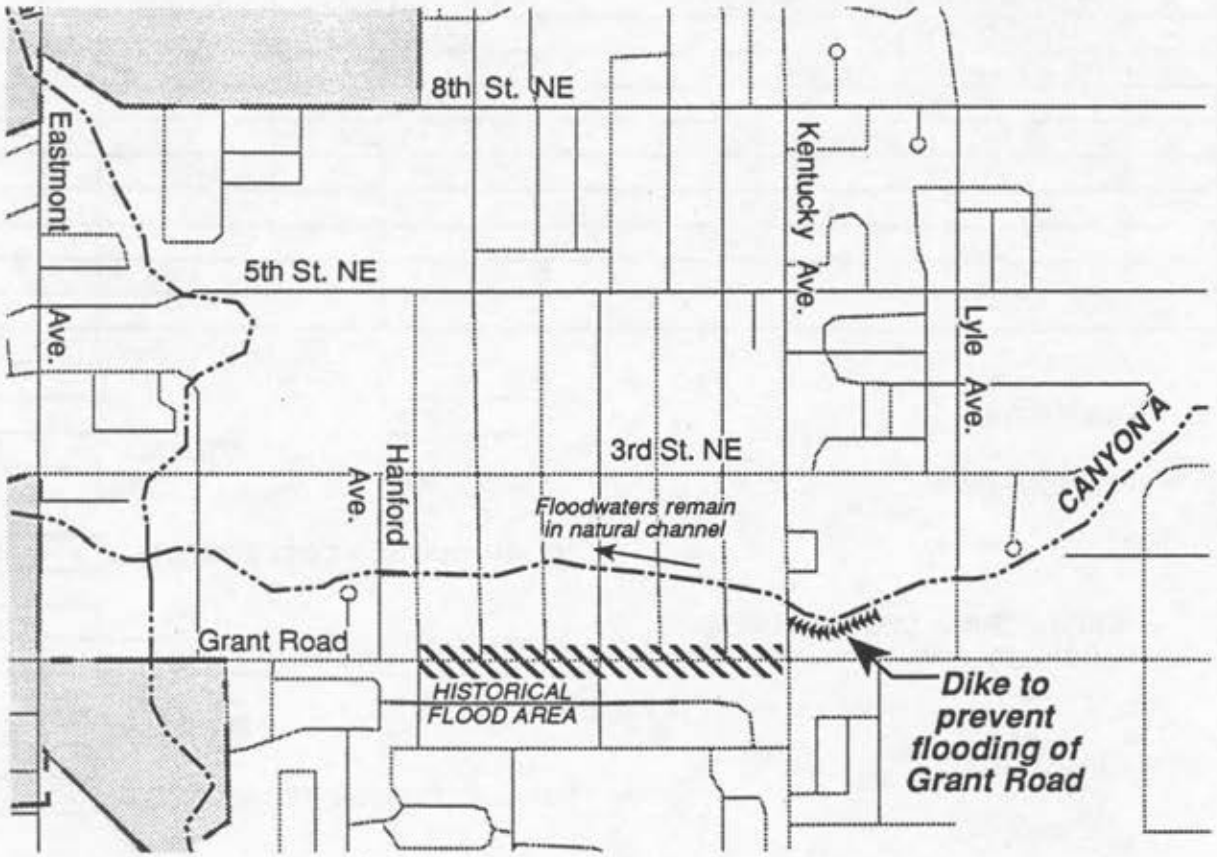
Design Criteria: 100-year flood plus 2 feet of freeboard

Design Requirements: Compacted earth (meeting geotechnical specifications for stability) with grass cover and riprap. Two additional 48-inch culverts at Kentucky Avenue.

Issues: **Downstream Impacts:** Increased flooding in Canyon A below Kentucky Avenue, caused by increased flows, should be mitigated through channel improvements or easements.

Maintenance: Routine inspections and maintenance.

Estimated Project Cost: $123,000



Location of dike at Kentucky Avenue

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CA-5

CANYON A
CHANNEL, DIKE, AND CULVERTS ABOVE KENTUCKY AVENUE
TO PREVENT FLOODING OF GRANT ROAD

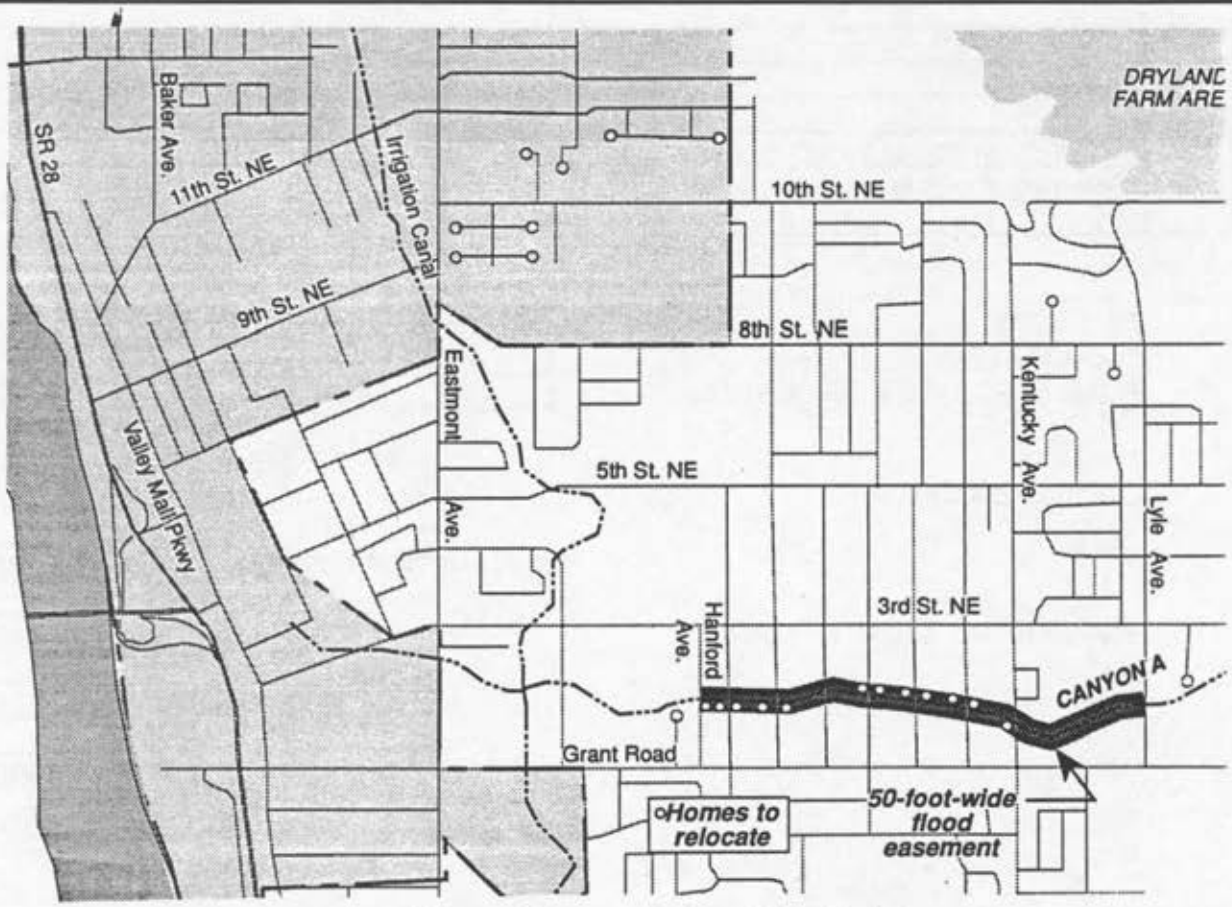
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$3,000.00	$3,000
2	EXCAVATION - STRUCTURAL/TRENCH	200	CY	$15.00	$3,000
	EXCAVATION - CHANNEL	3,050	CY	$7.50	$22,875
	SOIL DISPOSAL - OFFSITE	3,020	CY	$1.50	$4,530
	GRAVEL FILL - PIPE BEDDING	25	CY	$20.00	$500
	EMBANKMENT COMPACTION	500	CY	$2.00	$1,000
3	57x38 INCH CMAP CULVERT	120	LF	$100.00	$12,000
4	PAVEMENT CUTTING	120	LF	$3.00	$360
	PAVEMENT RESTORATION	60	SY	$50.00	$3,000
5	EROSION/SEDIMENT CONTROL	1	LS	$5,000.00	$5,000
	TRAFFIC CONTROL	30	DY	$300.00	$9,000
	TRENCH SAFETY SYSTEM	50	FT	$7.00	$350
6	RIPRAP FILL - HEAVY PLACED	100	CY	$30.00	$3,000
				SUBTOTAL:	$67,615

SALES TAX	7.80%		$5,274
		SUBTOTAL:	$72,889
CONTINGENCY	30%		$21,867
		CONSTRUCTION COST SUBTOTAL:	$94,756
ENGINEERING, LEGAL & ADMIN.	30%		$28,427
LAND ACQUISITION	AC		
		SUBTOTAL:	$123,182
		TOTAL ESTIMATED PROJECT COST:	**$123,000**

PROJECT SUMMARY SHEET

Project Title:	Canyon A - Channel improvements and flood easement from Lyle Avenue to Hanford Avenue
Project Description:	The Canyon A channel between Lyle and Hanford Avenues would be enlarged to fully contain the 100-year flow. A flood easement or right-of-way would be established to ensure permanent protection. Up to 12 homes would require relocation. Existing culverts would be used or project could be constructed in conjunction with Project CA-3c and CA-5.
Design Criteria:	Channel with 100-year flow capacity, 1 foot freeboard, and 10 foot buffer. (100-year floodplain assumes no split flow to Grant Road).
Design Requirements:	Broad trapezoidal earth channel, landscaped and revegetated. Purchase and removal of 12 homes. Secure easements or right-of-way for 5 acres of land.
Issues:	**Design:** Residents of relocated homes may experience severe disruption.
Maintenance:	Routine maintenance and repair. Channel should be sodded and irrigation may be required.

Estimated Project Cost: $3.0 million



Canyon A flood channel between Lyle and Hanford Avenues

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CA-7

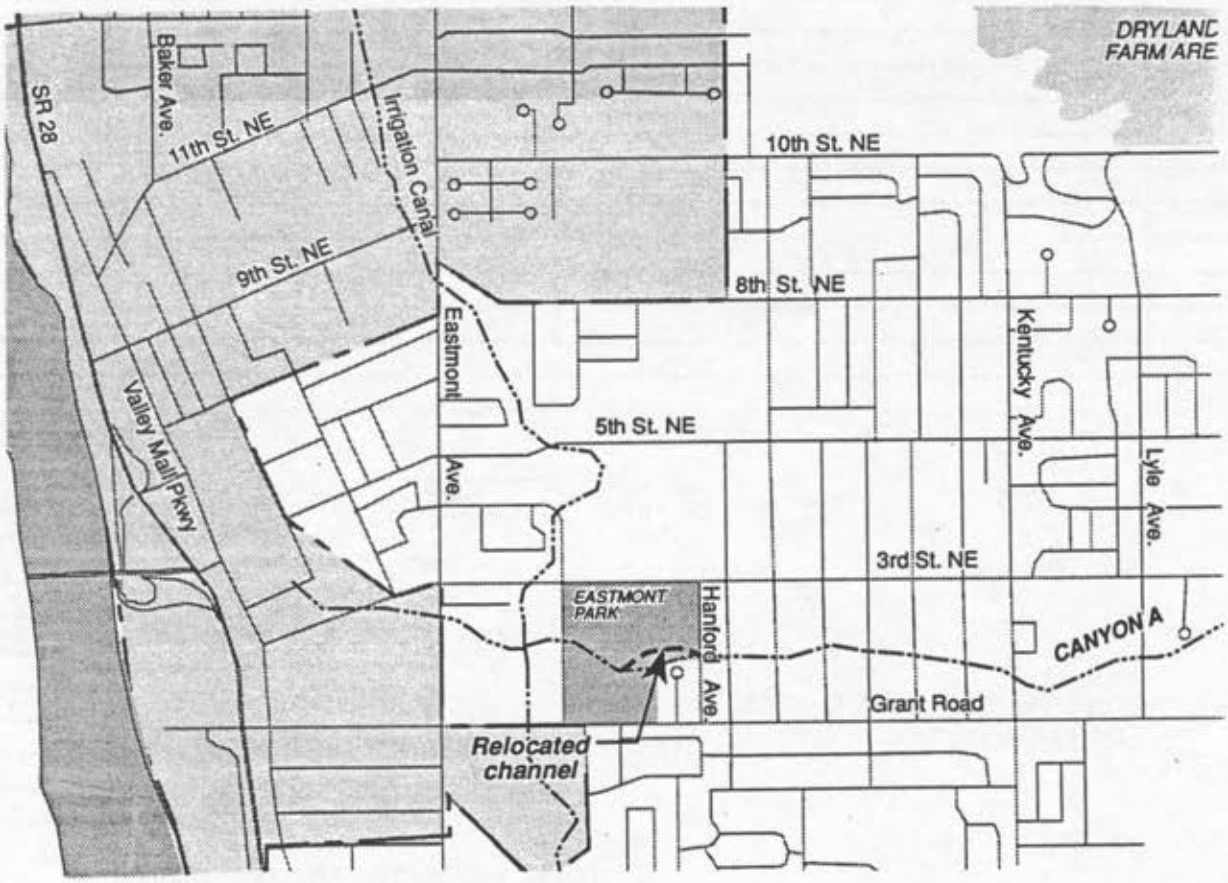
CANYON A
LYLE AVENUE TO HANFORD AVENUE
FLOOD CHANNEL AND RIGHT-OF-WAY

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$5,000.00	$5,000
2	EXCAVATION - CHANNEL	7,500	CY	$7.50	$56,250
3	URBAN SEEDING & FERTILIZATION	5	AC	$1,000.00	$5,000
4	EROSION/SEDIMENT CONTROL	1	LS	$25,000.00	$25,000
	TRAFFIC CONTROL	30	DY	$300.00	$9,000
5	IRRIGATION SYSTEM	5	AC	$2,000.00	$10,000
	(Assumes homes can be removed for salvage costs)				
	(Easement area is in addition to purchased lots)				
				SUBTOTAL:	$110,250
	SALES TAX	7.80%			$8,600
	FLOOD EASEMENT - URBAN	96,000	SF	$1.75	$168,000
	HOME PURCHASE & RELOCATION	12	EA	$125,000.00	$1,500,000
				SUBTOTAL:	$1,786,850
	CONTINGENCY	30%			$536,055
				CONSTRUCTION COST SUBTOTAL:	$2,322,904
	ENGINEERING, LEGAL & ADMIN.	30%			$696,871
				SUBTOTAL:	$3,019,776
				TOTAL ESTIMATED PROJECT COST:	**$3,020,000**

PROJECT SUMMARY SHEET

Project Title:	Canyon A - Relocate channel in Eastmont Park
Project Description:	A short section of Canyon A immediately below Hanford Avenue would be shifted to the north to eliminate flooding of several homes at the end of Green Place.
Design Criteria:	Channel with 100-year flow capacity. (100-year flow assumes no split flow to Grant Road, requiring Project CA-5).
Design Requirements:	Broad trapezoidal earth channel, reseeded to existing park grass.
Issues:	None.
Maintenance:	None.

Estimated Project Cost: $53,000



Canyon A channel relocation in Eastmont Park

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CA-9

CANYON A
RELOCATION OF CHANNEL IN EASTMONT PARK

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$1,000.00	$1,000
2	EXCAVATION - CHANNEL	2,775	CY	$7.50	$20,813
3	EROSION/SEDIMENT CONTROL	1	LS	$2,500.00	$2,500
4	URBAN SEEDING & FERTILIZATION	2.50	AC	$1,000.00	$2,500
	IRRIGATION REPAIR/REPLACEMENT	2.50	AC	$1,000.00	$2,500
				SUBTOTAL:	$29,313

SALES TAX	7.80%		$2,286
		SUBTOTAL:	$31,599
CONTINGENCY	30%		$9,480
		CONSTRUCTION COST SUBTOTAL:	$41,079
ENGINEERING, LEGAL & ADMIN.	30%		$12,324
LAND ACQUISITION	AC		
		SUBTOTAL:	$53,402
		TOTAL ESTIMATED PROJECT COST:	**$53,000**

PROJECT SUMMARY SHEET

Project Title: Canyon A - Pipeline from Eastmont Avenue to Columbia River

Project Description: A pipeline would be constructed between Eastmont Avenue and the Columbia River to carry Canyon A floodwaters. This 3200 foot long pipeline would follow 3rd Street, pass under Valley Mall Parkway, and tunnel under SR 28. Upstream detention can reduce the pipeline diameter. A portion between Third and Eastmont was completed during 1994 using 72-inch CMP.

Design Criteria:
* **Project CA-11a:** 100-year flow of 296 cfs (no upstream detention).
Project CA-11b: 100-year flow of 123 cfs (requires 13 acre-foot upstream detention - Project CA-1a).
Project CA-11c: 100-year flow of 80 cfs (requires 35 acre-foot upstream detention - Project CA-1b).

Design Requirements:
* **Project CA-11a:** 60-inch reinforced concrete pipeline
Project CA-11b: 48-inch reinforced concrete pipeline
Project CA-11c: 42-inch reinforced concrete pipeline

Issues:
Construction: Disruption of traffic along 3rd Street and Valley Mall Parkway. (Reconstruction of these roads are already proposed).
Permits: HPA

Maintenance: Periodic inspection and cleaning.

Estimated Project Cost:
*Project CA-11a: $1.9 million
Project CA-11b: $2.6 million (includes detention dam, Project CA-1a)
Project CA-11c: $2.6 million (includes detention dam, Project CA-1b)

* Recommended Project

Canyon A pipeline below Eastmont Avenue

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CA-11A

CANYON A
PIPELINE FROM EASTMONT AVE. TO COLUMBIA RIVER
60 INCH CONCRETE PIPE

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$50,000.00	$50,000
2	EXCAVATION - STRUCTURAL/TRENCH	11,600	CY	$15.00	$174,000
	TUNNEL - 60 INCH RCP/84 INCH CASING	100	LF	$490.00	$49,000
	SOIL DISPOSAL - OFFSITE	2,300	CY	$1.50	$3,450
	GRAVEL FILL - PIPE BEDDING	850	CY	$20.00	$17,000
	COMPACTED BACKFILL - PIPE TRENCH	8,400	CY	$12.00	$100,800
3	60 INCH REINFORCED CONCRETE PIPE	3,220	LF	$150.00	$483,000
	96 INCH MANHOLE	9	EA	$8,000.00	$72,000
	CULVERT INLET W/TRASH RACK	1	EA	$7,000.00	$7,000
	CONCRETE STRUCTURAL	15	CY	$500.00	$7,500
4	PAVEMENT RESTORATION	120	SY	$50.00	$6,000
	SIDEWALK/GUTTER RESTORATION (2 SIDES)	20	LF	$40.00	$800
5	EROSION/SEDIMENT CONTROL	1	LS	$10,000.00	$10,000
	TRAFFIC CONTROL	45	DY	$300.00	$13,500
	TRENCH SAFETY SYSTEM	3,220	FT	$7.00	$22,540
	RELOCATE UTILITIES	1	LS	$15,000.00	$15,000
6	OUTFALL	1	EA	$25,000.00	$25,000
	(Assumes 3rd Street will be reconstructed as separate project				
	under Six Year Transportation Improvement Program)				
				SUBTOTAL:	$1,056,590

SALES TAX	7.80%		$82,414
		SUBTOTAL:	$1,139,004
CONTINGENCY	30%		$341,701
		CONSTRUCTION COST SUBTOTAL:	$1,480,705
ENGINEERING, LEGAL & ADMIN.	30%		$444,212
LAND ACQUISITION		AC	
		SUBTOTAL:	$1,924,917
		TOTAL ESTIMATED PROJECT COST:	**$1,925,000**

PROJECT SUMMARY SHEET

Project Title: Canyon A - Culvert cleaning between Lyle and Hanford Avenues

Project Description: The culverts along Canyon A between Lyle and Hanford Avenues have not been adequately maintained. Sediment clogs many of the culverts, and the ditch is poorly defined in certain areas. Removal of sediment from the culverts and around their entrances and exits will improve conveyance capacity of this system until a permanent flood channel is built.

Design Criteria: Existing culvert capacity (approx. 10-year flow of 90 cfs)

Design Requirements: County maintenance crews will remove sediment from culverts using conventional equipment. Cleaning around the culvert ends may be limited by property access.

Issues: **Access:** There is no easement along Canyon A to allow County crews to access and maintain the ditch in private property so ditch cleaning will be limited to around culvert ends in public right-of-way. Owners must grant this access for channel maintenance to occur. The County may want to obtain permanent easements to allow future maintenance activities.

Maintenance: Periodic inspection and maintenance.

Estimated Project Cost: $18,000

Canyon A culverts

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CA-14

CANYON A
CULVERT CLEANING
BETWEEN LYLE AND HANFORD AVENUES

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	CULVERT CLEANING*	9	EA	$2,000.00	$18,000
				SUBTOTAL:	$18,000

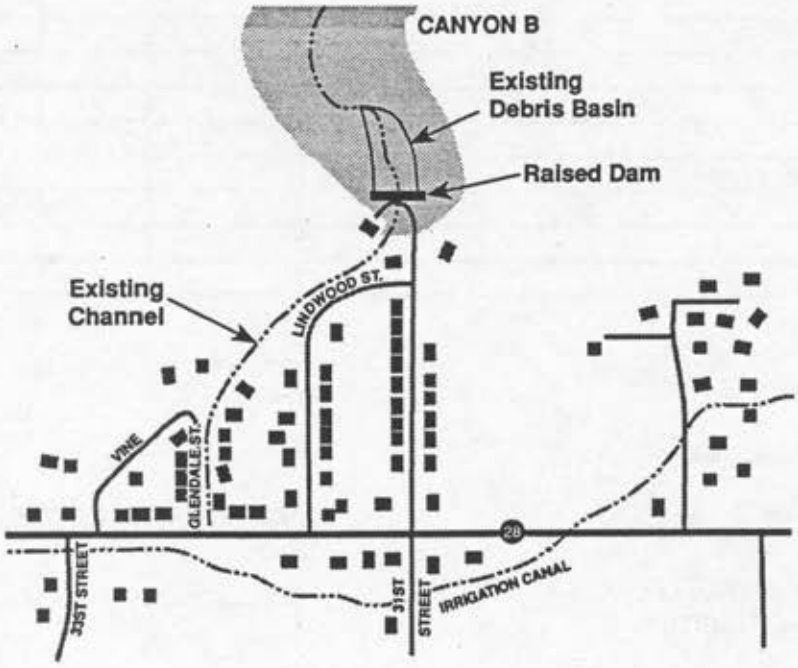
TOTAL ESTIMATED PROJECT COST: $18,000

* Cost for cleaning each culvert is lump sum, and includes all labor, administration, and contingencies anticipated for work to be performed by County personnel. Costs provided by County.

PROJECT SUMMARY SHEET

Project Title:	Canyon B - Increase size of debris basin to 100-year sediment capacity
Project Description:	The existing Canyon B debris basin is sized for the debris volume associated with the 25-year flood. This capacity would be increased to the 100-year sediment volume by raising the height of the existing berm.
Design Criteria:	100-year sediment volume of 25,000 cubic yards (15 acre feet).
Design Requirements:	3-foot high concrete check dam on top of existing berm with improved outlet.
Issues:	**Safety and Permits**: Dam safety rules would apply if water is stored behind impoundment or if dam failure would cause release of a sediment slurry.
Maintenance:	Removal of accumulated sediments after each runoff event.

Estimated Project Cost: $291,000.



Enlarged Canyon B debris basin

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CB-5

CANYON B
ENLARGE SEDIMENTATION BASIN
FOR 100-YEAR VOLUME

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$7,000.00	$7,000
2	RIPRAP FILL - HEAVY PLACED	900	CY	$30.00	$27,000
	RIPRAP FILL - LIGHT LOOSE	75	CY	$25.00	$1,875
	EXCAVATION - STRUCTURAL/TRENCH	500	CY	$15.00	$7,500
	CONCRETE STRUCTURAL	100	CY	$500.00	$50,000
	MISC STEEL	1	LS	$15,000.00	$15,000
3	OUTLET MODIFICATIONS	1	LS	$20,000.00	$20,000
	EROSION/SEDIMENT CONTROL	1	LS	$10,000.00	$10,000
	(Quantities from NHC)				
				SUBTOTAL:	$138,375

SALES TAX	7.80%		$10,793
		SUBTOTAL:	$149,168
CONTINGENCY	50%		$74,584
		CONSTRUCTION COST SUBTOTAL:	$223,752
ENGINEERING, LEGAL & ADMIN.	30%		$67,126
LAND ACQUISITION	AC		
		SUBTOTAL:	$290,878
		TOTAL ESTIMATED PROJECT COST:	**$291,000**

PROJECT SUMMARY SHEET

Project Title: Canyon B - Drainage channel for 25-year flood

Project Description: The existing Glendale flood channel, which is designed for a 25-year flood, would be extended to the Columbia River via a culvert under SR 28, improved channels through orchards, and existing natural channels. A flood easement would be established along the corridor to preserve the channel indefinitely. Current orchard activities would be allowed in the channel easement.

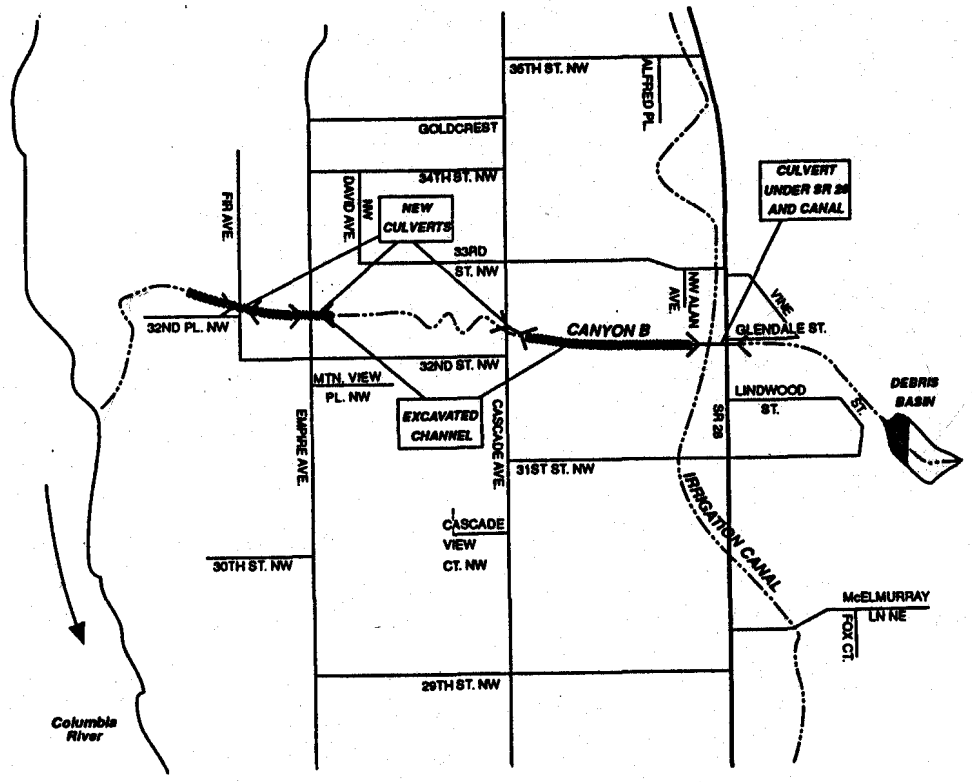
Design Criteria: 25-year flood flow of 300 cfs.

Design Requirements: Single culvert under SR-28 and irrigation canal, 20 foot wide excavated channel with 8H:1V side slopes through two orchard areas, and multiple culverts under Empire, Cascade, and Fir Avenues.

Issues: **Construction:** Disruption of traffic on SR 28 and coordination with irrigation district.
Permits: Washington Department of Transportation and HPA.

Maintenance: Repair of channel erosion and removal of sediments following flood events.

Estimated Project Cost: $923,000



Single Canyon B channel below SR28 with 25-year flow capacity

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CB-6

CANYON B
INSTALL CULVERT UNDER SR 28 AND CANAL
FOR 25-YEAR FLOOD FLOW (300 CFS)

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$11,000.00	$11,000
2	EXCAVATION - COMMON	14,000	CY	$4.75	$66,500
	EXCAVATION - STRUCTURAL/TRENCH	660	CY	$15.00	$9,900
	SOIL DISPOSAL - OFFSITE	190	CY	$1.50	$285
	GRAVEL FILL - PIPE BEDDING	185	CY	$20.00	$3,700
	COMPACTED BACKFILL - PIPE TRENCH	970	CY	$12.00	$11,640
3	60 INCH CMP CULVERT	450	LF	$100.00	$45,000
	72 INCH CMP CULVERT	170	LF	$135.00	$22,950
	CMP FLARED END SECTION - 72 INCH	1	EA	$2,700.00	$2,700
4	ASPHALT ROAD	400	SY	$25.00	$10,000
	PAVEMENT CUTTING	80	LF	$3.00	$240
	PAVEMENT RESTORATION	30	SY	$50.00	$1,500
5	EROSION/SEDIMENT CONTROL	1	LS	$25,000.00	$25,000
	TRAFFIC CONTROL	40	DY	$300.00	$12,000
	TRENCH SAFETY SYSTEM	170	FT	$7.00	$1,190
				SUBTOTAL:	$223,605

SALES TAX	7.80%			$17,441
HOME PURCHASE & RELOCATION	1	EA	$125,000.00	$125,000
FLOOD EASEMENT - ORCHARD	9	AC	$20,000.00	$180,000
			SUBTOTAL:	$546,046
CONTINGENCY	30%			$163,814
			CONSTRUCTION COST SUBTOTAL:	$709,860
ENGINEERING, LEGAL & ADMIN.	30%			$212,958
			SUBTOTAL:	$922,818
			TOTAL ESTIMATED PROJECT COST:	**$923,000**

PROJECT SUMMARY SHEET

Project Title: Canyon B - Upgraded channel for 100-year flood (new secondary channel)

Project Description: After the existing Glendale flood channel is extended to the Columbia River, as identified in Project CB-6, a second channel would be constructed to carry flows in excess of the Glendale channel capacity. The second overflow channel would begin at the debris basin, travel westward along undeveloped property south of 31st Street, and then follow an existing drainage pathway to the river.

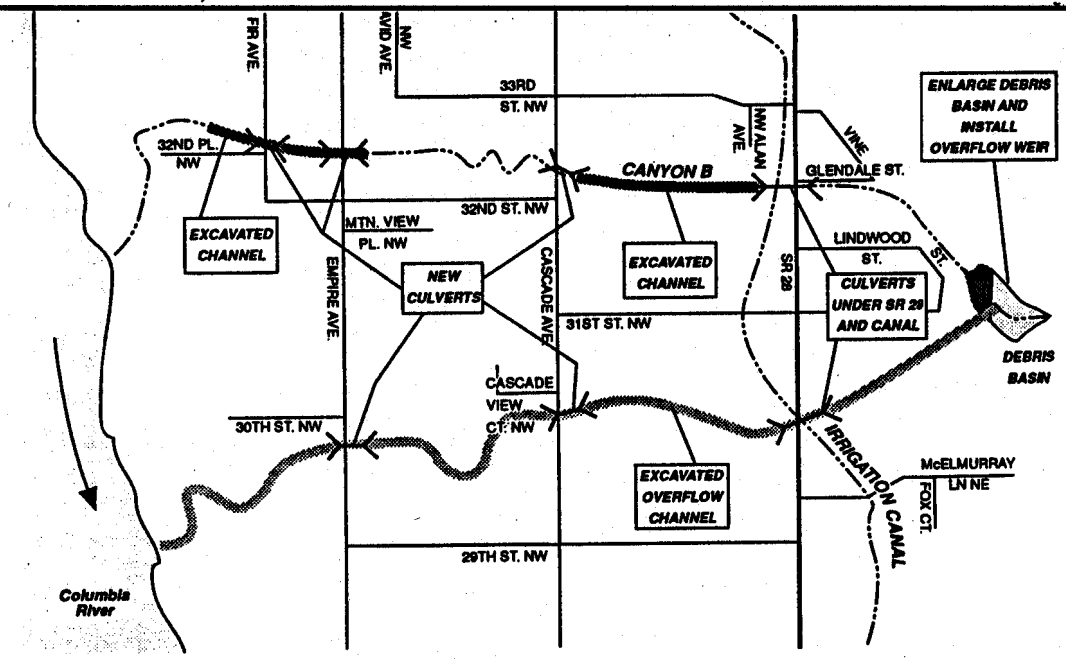
Design Criteria: Total flow capacity of 500 cfs, equal to 100-year flood. The existing Glendale channel would carry 300 cfs and the overflow channel 200 cfs.

Design Requirements: Enlarged debris basin with second outlet, concrete-lined channel from debris basin to SR 28, 60 inch culvert under SR 28 and irrigation canal, improved channel to river, and culverts under Cascade and Empire Avenues.

Issues: **Design:** Debris basin should be enlarged to accommodate 100-year sediment volume (Project CB-5). Two channels leading from debris basin would be safer than a single channel (Project CB-7).
Construction: Disruption of traffic on SR 28 and coordination with irrigation district.
Permits: Washington Department of Transportation and HPA.

Maintenance: Repair of channel erosion and removal of sediments following flood events.

Estimated Project Cost: $785,000 (not including enlarged debris basin CB-5 or primary channel CB-6).



Primary and Secondary Canyon B channels below SR28 with 100-year flow capacity

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CB-8

CANYON B
SECONDARY CHANNEL
100-YEAR FLOW CAPACITY

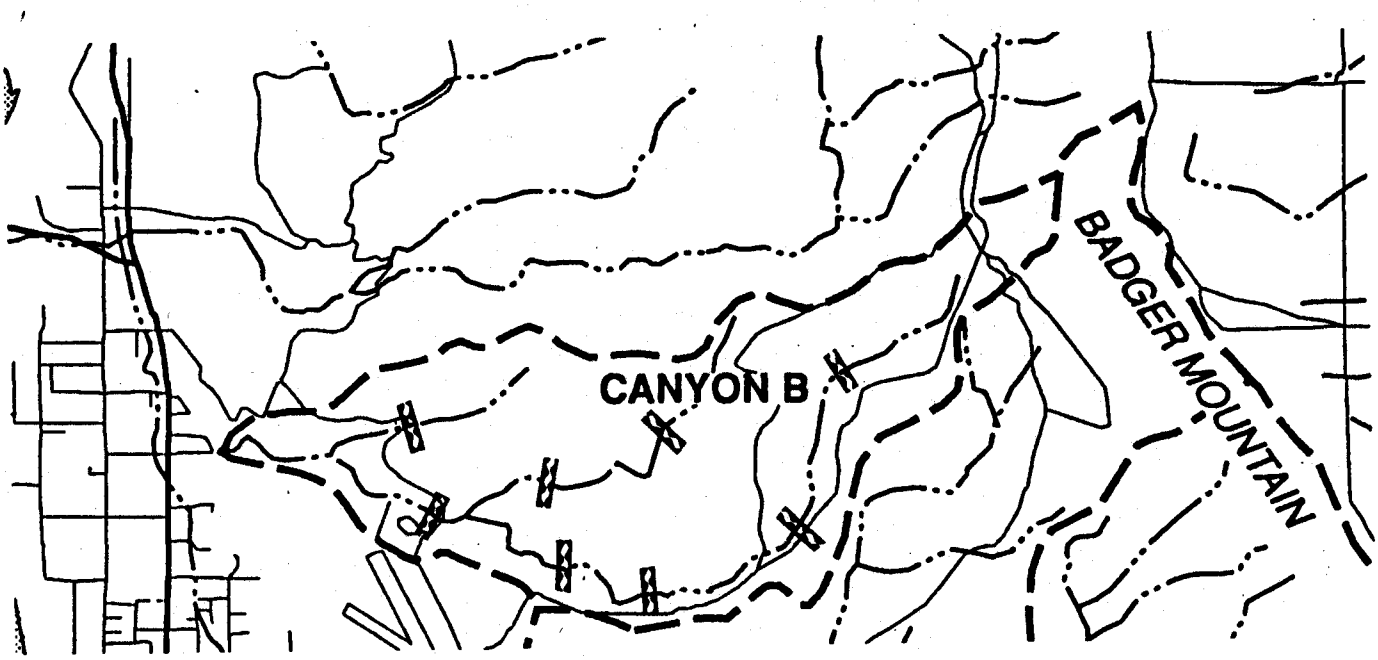
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$9,000.00	$9,000
2	60 INCH CMP CULVERT	450	LF	$100.00	$45,000
	72 INCH CMP CULVERT	170	LF	$135.00	$22,950
	CMP FLARED END SECTION - 72 INCH	1	EA	$2,700.00	$2,700
3	EXCAVATION - DRAINAGE DITCH	1,200	CY	$15.00	$18,000
	CANAL LINING (GUNITE), 4" MIN	1,100	SY	$15.00	$16,500
4	DETENTION BASIN OUTLET	1	EA	$20,000.00	$20,000
5	CHANNEL BELOW SR28 (LIKE CB-6 2/2)	1	LS	$130,000.00	$130,000
				SUBTOTAL:	$264,150

SALES TAX	7.80%			$20,604
FLOOD EASEMENT - ORCHARD	9	AC	$20,000.00	$180,000
			SUBTOTAL:	$464,754
CONTINGENCY	30%			$139,426
			CONSTRUCTION COST SUBTOTAL:	$604,180
ENGINEERING, LEGAL & ADMIN.	30%			$181,254
			(SECONDARY CHANNEL):	$785,434
			TOTAL ESTIMATED PROJECT COST:	**$785,000**

PROJECT SUMMARY SHEET

Project Title:	Canyon B - Check dams in upper basin
Project Description:	A series of low, earth-filled dams would be built in upper Canyon B to detain and infiltrate stormwater or snowmelt runoff. These dams would be a maximum of six feet high (to avoid dam safety regulations) and have storage capacities of up to several acre feet. Property owner has expressed willingness to grant easements to County to construct and maintain these facilities.
Design Criteria:	Detention capacity depends on site characteristics.
Design Requirements:	Earthen berms with concrete or rock-filled overflow structure. Low level outlet to slowly release stored runoff.
Issues:	**Design:** Many check dams would be required to achieve a significant reduction in flow. Site surveys are needed before usefulness can be assessed.
Maintenance:	Occasional inspection and repair if necessary.

Estimated Project Cost: $100,000.



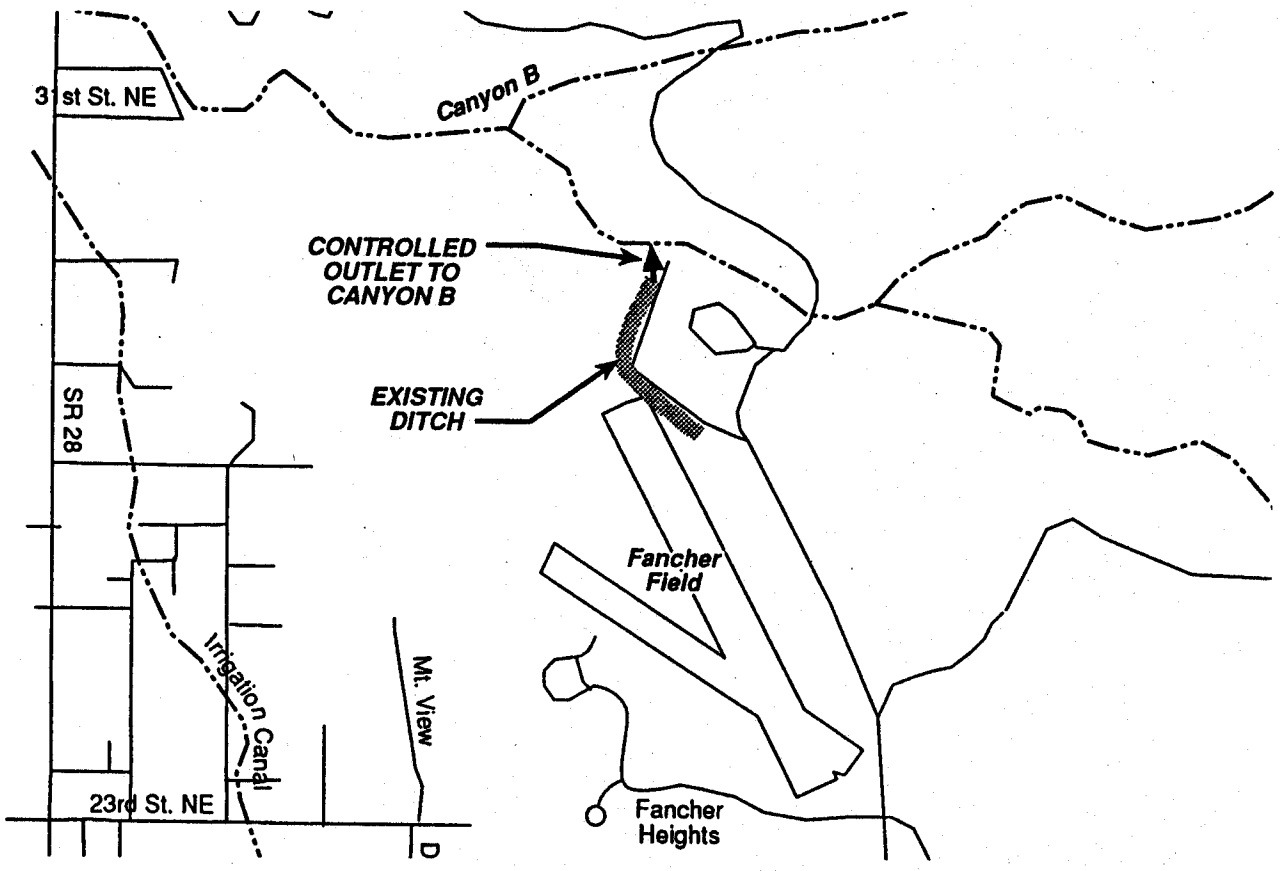
Potential check dam sites in upper Canyon B

(Detailed cost estimate not prepared for this project)

PROJECT SUMMARY SHEET

Project Title:	Canyon B - Detention facility at existing ditch at Fancher Field near gun club
Project Description:	A large earthen ditch that drains to Canyon B is located on the eastern side of the gun club. It was formed during construction of a sound barrier that separates the gun club from the nearby residential development. This ditch could be modified to detain runoff eminating from the Fancher Field plateau. This would help mitigate flash floods in Canyon B, such as occured during the 1989 flood.
Design Criteria:	Detention capacity depends on site topography, which has not been surveyed.
Design Requirements:	Concrete or rock-filled dam structure located at the southwestern end of the ditch. Low level outlet to slowly release stored runoff.
Issues:	**Design:** Site surveys are needed before feasibility of detention facility can be assessed.
Maintenance:	Occasional inspection and repair if necessary.

Estimated Project Cost: Approx. $46,000.



Detention facility location at Fancher Field

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CB-11

CANYON B
DETENTION FACILITY AT EXISTING DITCH AT FANCHER FIELD NEAR GUN CLUB

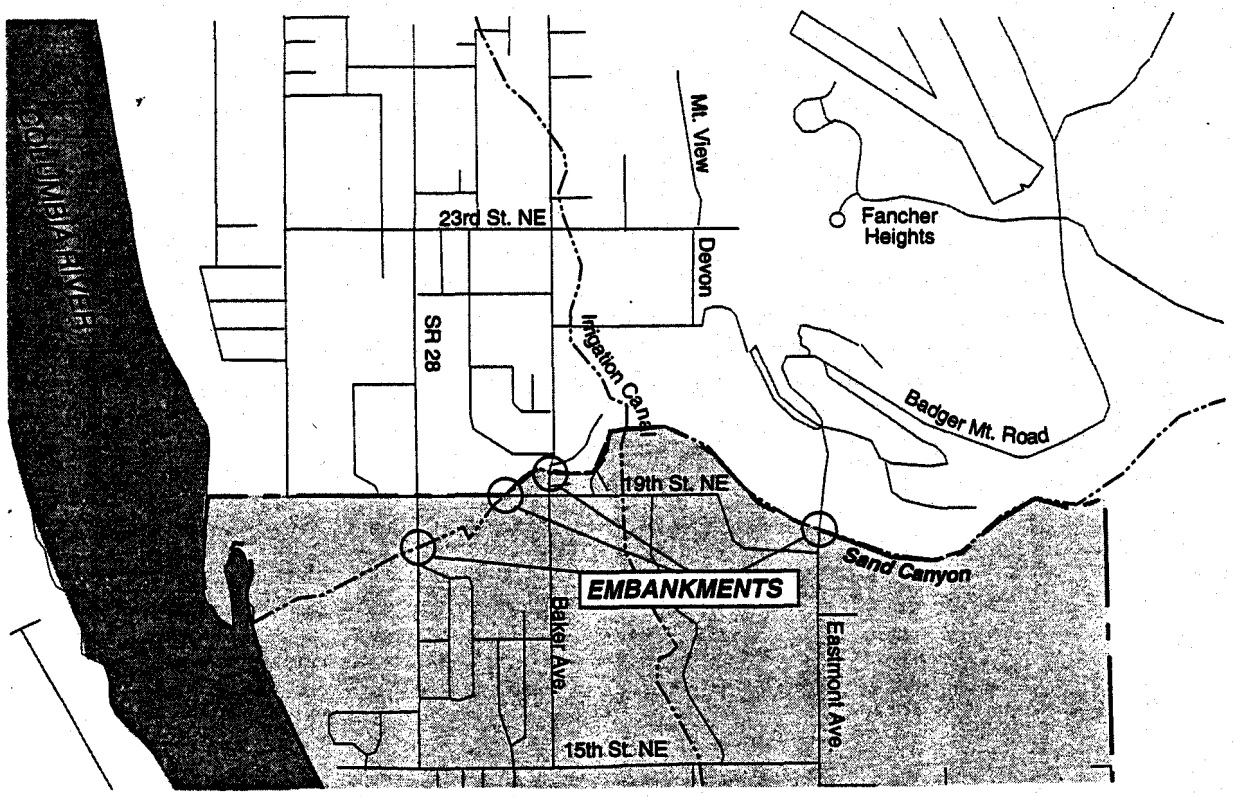
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$1,000.00	$1,000
2	COMPACTED FILL - IMPORTED IMPERV.	350	CY	$12.00	$4,200
3	DETENTION POND OUTLET	1	EA	$20,000.00	$20,000
				SUBTOTAL:	$25,200

SALES TAX	7.80%		$1,966
		SUBTOTAL:	$27,166
CONTINGENCY	30%		$8,150
		CONSTRUCTION COST SUBTOTAL:	$35,315
ENGINEERING, LEGAL & ADMIN.	30%		$10,595
SURVEY	1 LS	$10,000.00	$10,000
		SUBTOTAL:	$45,910
		TOTAL ESTIMATED PROJECT COST:	**$46,000**

PROJECT SUMMARY SHEET

Project Title:	**Alternatives 7-A and 7-C.** Sand Canyon - Reinforce roadway embankments
Project Description:	Road embankments at Eastmont Avenue, Baker Avenue, 19th Street, and SR 28 would be reinforced to prevent failure during overtopping. Overtopping would occur if culvert capacity is exceeded (currently at between 10 and 25-year flood) or if sediment plugs culvert.
Design Criteria:	Sufficient protection for overtopping of 100-year flood.
Design Requirements:	Paved roadway shoulders, flatter side slopes, and riprap embankement.
Issues:	**Permits:** Washington Department of Transportation, HPA
Maintenance:	Inspection and repair (if needed) after flood events.

Estimated Project Cost: $35,000



Sand Canyon roadway embankements

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CS-2

SAND CANYON
REINFORCE ROAD EMBANKEMENTS

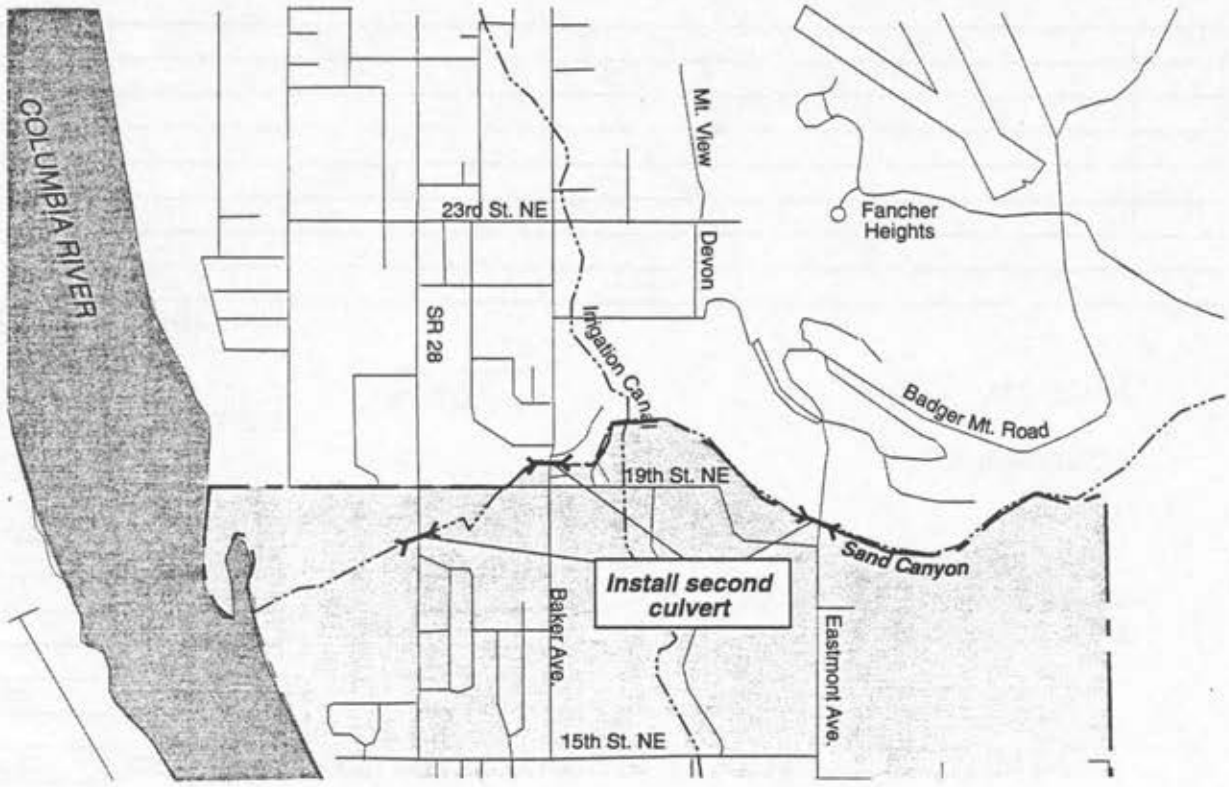
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$1,000.00	$1,000
2	RIPRAP FILL - HEAVY PLACED	350	CY	$30.00	$10,500
3	SHOULDER PAVING	300	SY	$25.00	$7,500
				SUBTOTAL:	$19,000

SALES TAX	7.80%		$1,482
		SUBTOTAL:	$20,482
CONTINGENCY	30%		$6,145
		CONSTRUCTION COST SUBTOTAL:	$26,627
ENGINEERING, LEGAL & ADMIN.	30%		$7,988
LAND ACQUISITION	AC		
		SUBTOTAL:	$34,615
		TOTAL ESTIMATED PROJECT COST:	**$35,000**

PROJECT SUMMARY SHEET

Project Title:	Sand Canyon - Increase capacity of roadway culverts to 25-year flood
Project Description:	Replace or upgrade culverts along Sand Canyon between Eastmont Avenue and SR 28 to increase flow capacity. Currently, three of four culverts can pass only the 10-year flood. The fourth, at 19th Street, has a 25-year design flow. Replacement would reduce localized flooding in residential areas and also reduces the risk of road overtopping and failure.
Design Criteria:	25-year flow capacity at all culverts.
Design Requirements:	Add an additional 48-inch culvert at Eastmont Avenue, Baker Avenue, and SR 28.
Issues:	**Downstream Impacts**: The larger culverts would change the storage characteristics of the road embankments. Flows would increase (relative to current conditions) during more common floods (i.e., 10 year or less) but would decrease during less frequent floods. **Permits:** Washington Department of Transportation, HPA
Maintenance:	Sediment removal.

Estimated Project Cost: $220,000



Upgraded Sand Canyon culverts

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CS-3

SAND CANYON
EASTMONT AVE TO SR 28
UPGRADE CULVERTS TO 25-YR CAPACITY

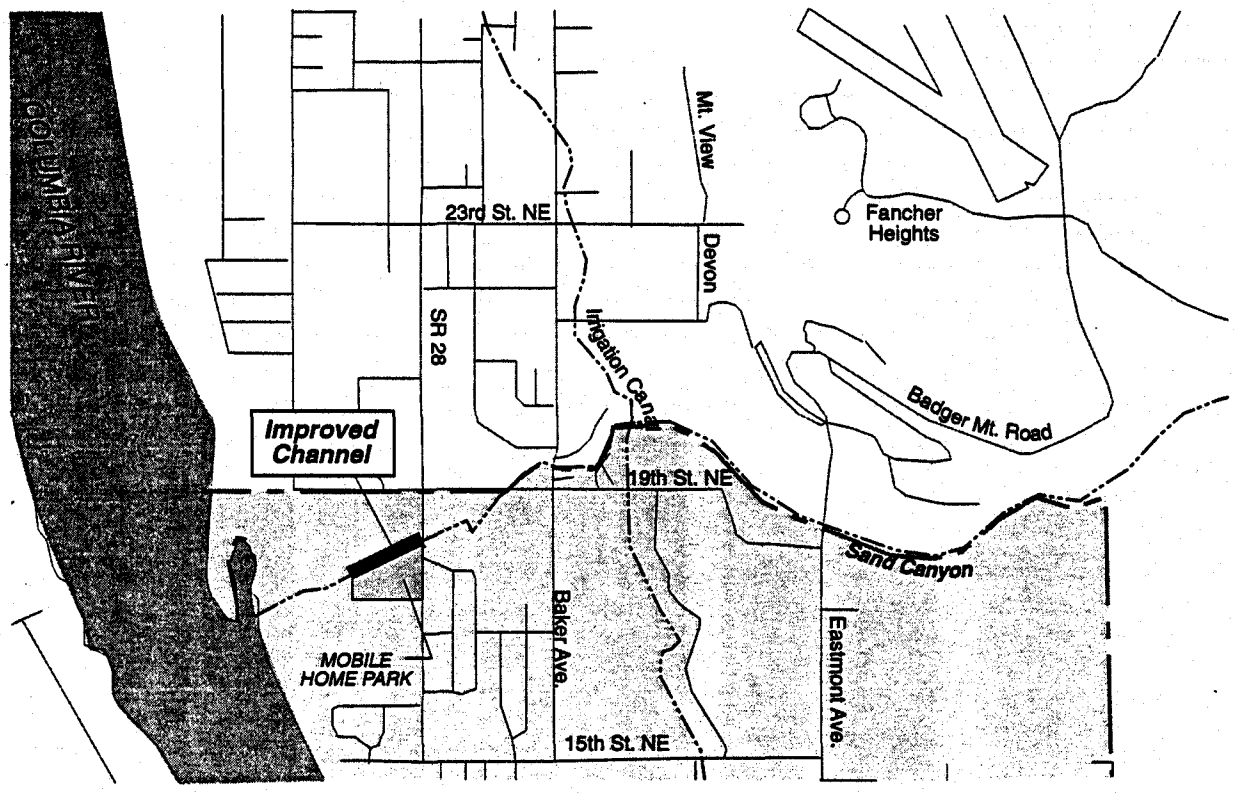
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$6,000.00	$6,000
2	EXCAVATION - STRUCTURAL/TRENCH	1,670	CY	$15.00	$25,050
	SOIL DISPOSAL - OFFSITE	270	CY	$1.50	$405
	GRAVEL FILL - PIPE BEDDING	100	CY	$20.00	$2,000
	COMPACTED BACKFILL - PIPE TRENCH	1,420	CY	$12.00	$17,040
3	48 INCH CMP CULVERT	583	LF	$65.00	$37,895
4	PAVEMENT RESTORATION	90	SY	$50.00	$4,500
5	EROSION/SEDIMENT CONTROL	1	LS	$15,000.00	$15,000
	TRAFFIC CONTROL	30	DY	$300.00	$9,000
	TRENCH SAFETY SYSTEM	583	FT	$7.00	$4,081
				SUBTOTAL:	$120,971

SALES TAX	7.80%		$9,436
		SUBTOTAL:	$130,407
CONTINGENCY	30%		$39,122
		CONSTRUCTION COST SUBTOTAL:	$169,529
ENGINEERING, LEGAL & ADMIN.	30%		$50,859
LAND ACQUISITION	AC		
		SUBTOTAL:	$220,387
		TOTAL ESTIMATED PROJECT COST:	**$220,000**

PROJECT SUMMARY SHEET

Project Title:	Sand Canyon - Improve channel along mobile home park
Project Description:	The Sand Canyon channel below SR 28 would be enlarged, or a berm constructed on the south side, to protect the existing mobile home park. The channel in this area is not well defined.
Design Criteria:	Protection from 100-year flood.
Design Requirements:	Excavated channel or earthen berm.
Issues:	**Permits:** Possible fishery issue in lower Sand Canyon. HPA required.
Maintenance:	None

Estimated Project Cost: $70,000



Channel improvements in lower Sand Canyon next to mobile home park

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

CS-4

SAND CANYON
IMPROVE CHANNEL ALONG MOBILE HOME PARK

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$2,000.00	$2,000
2	EXCAVATION - CHANNEL	2,500	CY	$7.50	$18,750
3	QUARRY SPALLS	350	CY	$14.00	$4,900
4	EROSION/SEDIMENT CONTROL	1	LS	$5,000.00	$5,000
5	URBAN SEEDING & FERTILIZATION	2	AC	$1,000.00	$2,000
	TEMPORARY IRRIGATION SYSTEM	2	AC	$1,000.00	$2,000
	LANDSCAPING	1.50	AC	$2,500.00	$3,750
				SUBTOTAL:	$38,400
	SALES TAX	7.80%			$2,995
				SUBTOTAL:	$41,395
	CONTINGENCY	30%			$12,419
				CONSTRUCTION COST SUBTOTAL:	$53,814
	ENGINEERING, LEGAL & ADMIN.	30%			$16,144
	LAND ACQUISITION		AC		
				SUBTOTAL:	$69,958
				TOTAL ESTIMATED PROJECT COST:	**$70,000**

PROJECT SUMMARY SHEET

Project Title: Sand Canyon - Relocate homes in floodplain

Project Description: Homes within the existing 100-year floodplain would be removed and a permanent flood easement or right-of-way established to prevent future encroachment on the floodplain. The existing channel and culvert crossings would not be improved. One home, plus possibly the mobile home park would require relocation.

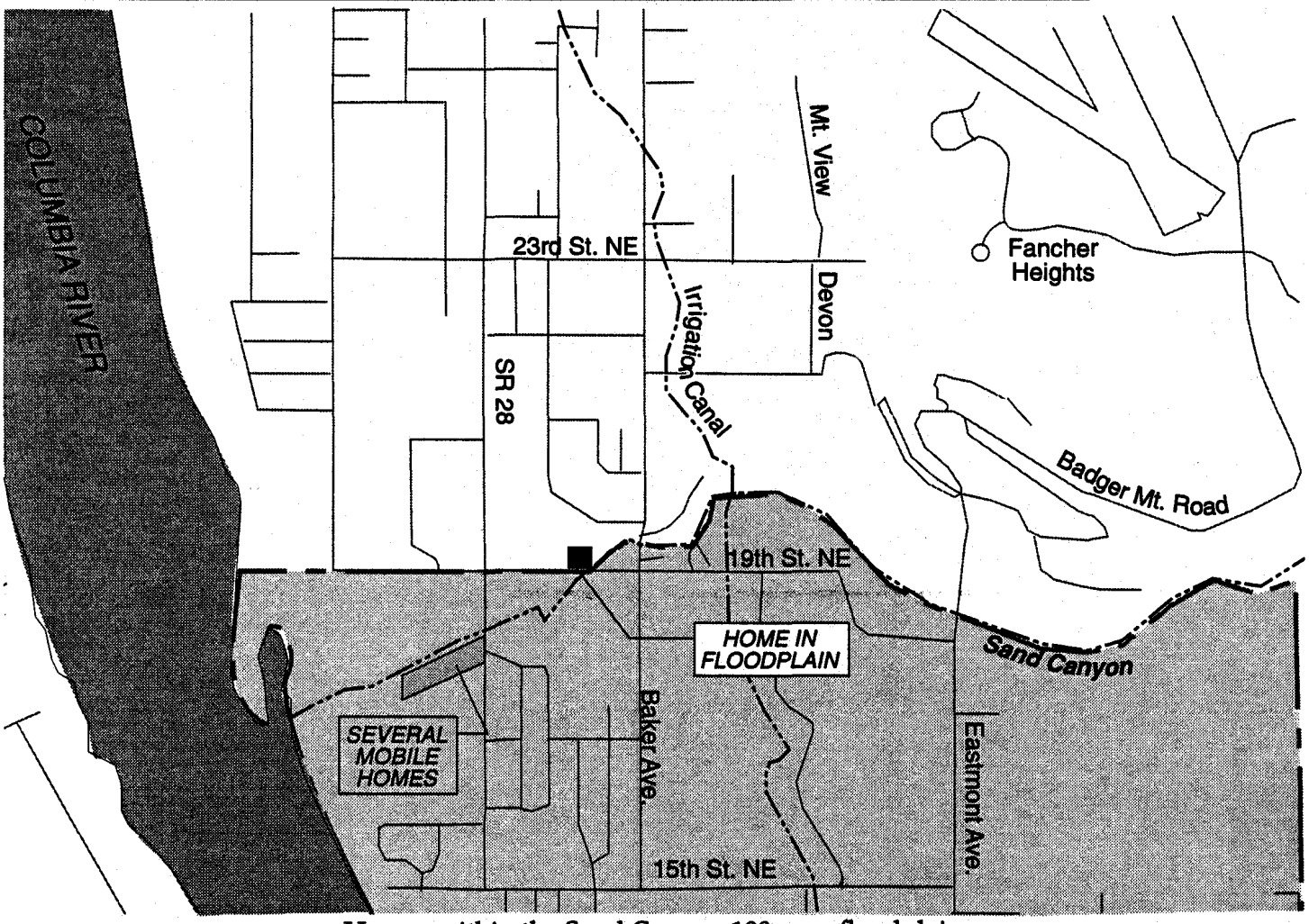
Design Criteria: Limits of existing 100-year floodplain.

Design Requirements: Purchase and removal of one home and an undetermined number of mobile homes.

Issues: None.

Maintenance: None.

Estimated Project Cost: $200,000 (for one home). Higher if mobile homes are included.



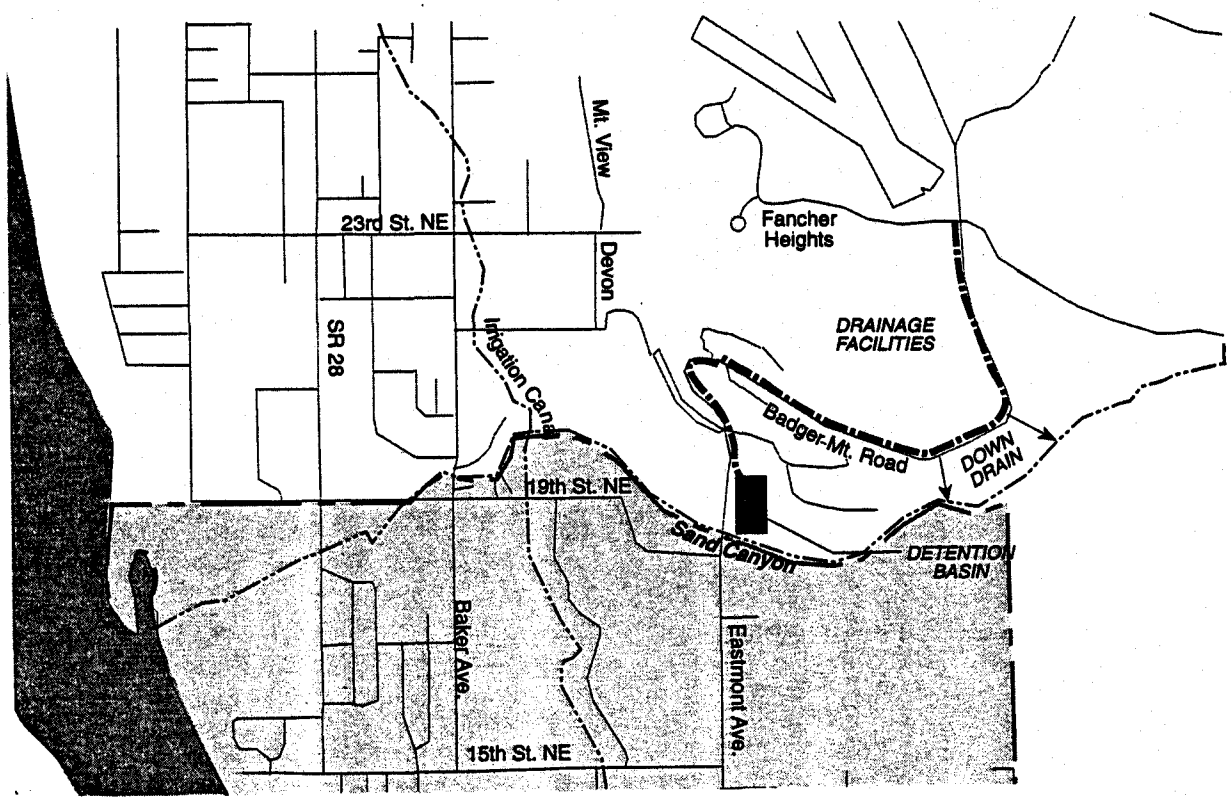
Homes within the Sand Canyon 100-year floodplain

(Detailed cost estimate not prepared for this project)

PROJECT SUMMARY SHEET

Project Title:	Urban Area - Drainage improvements to Badger Mountain Road
Project Description:	A drainage system would be constructed to safely convey roadway runoff to Sand Canyon. This would occur as part of road reconstruction or as a separate drainage improvement project. Improved road drainage would solve erosion problems along road and prevent flooding of homes at the base of the roadway (Valley View and 21st Street).
Design Criteria:	2" of rainfall in 90 minutes.
Design Requirements:	Lined ditches, catch basins, downdrains, and detention pond above Eastmont Avenue.
Issues:	**Permits**: HPA.
Maintenance:	Normal inspection and maintenance (clean out after storms and repair erosion).

Estimated Project Cost: Funded by Road Improvement District bond.



Badger Mountain Road drainage improvements

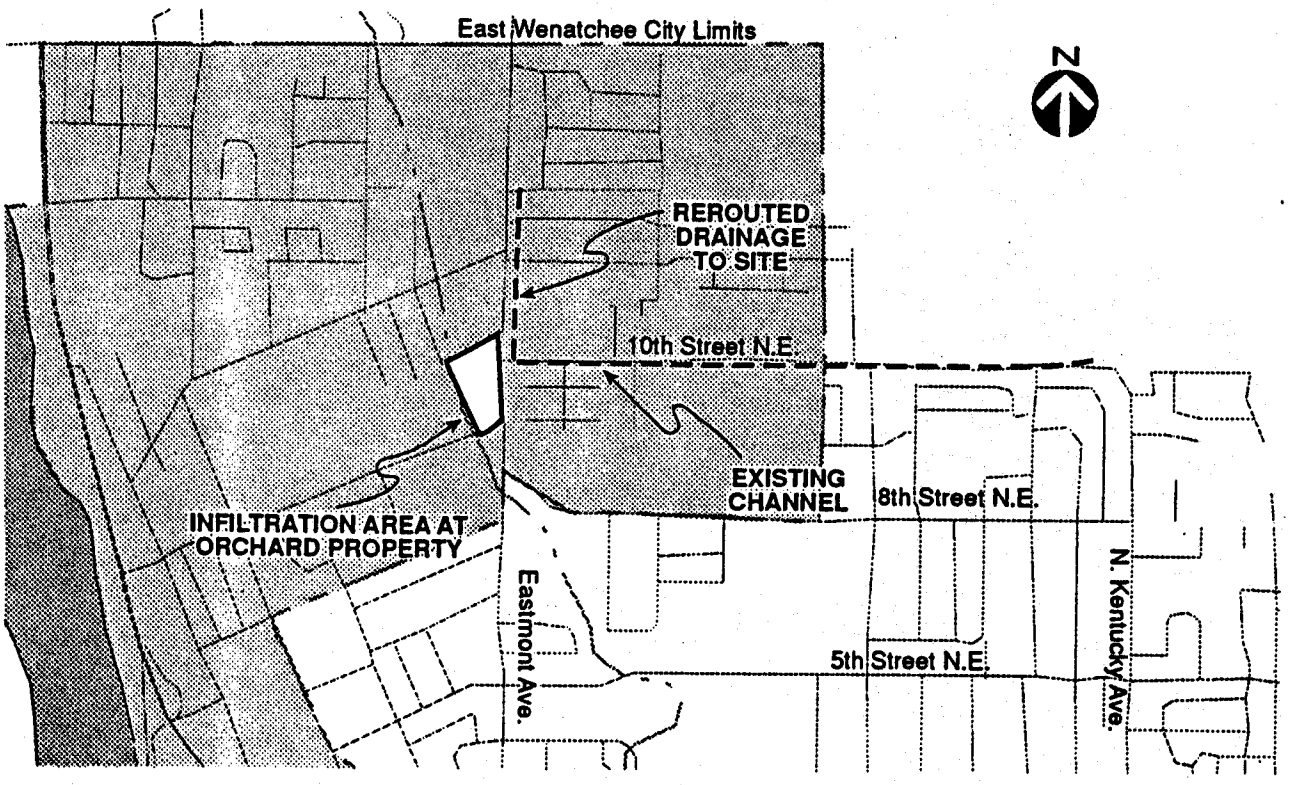
(Detailed cost estimate not prepared for this project)

—Funded separately, under construction, 1994

PROJECT SUMMARY SHEET

Project Title:	Urban Area - Infiltration areas above canal at 10th N.E. and Eastmont
Project Description:	Existing orchard area just above the canal will be purchased and its current land use preserved. Improvements will be made to allow controlled infiltration. Other compatible uses, such as a park or recreational facility, may be integrated with infiltration facility. This area currently receives stormwater runoff from urban areas. Runoff will be prevented from entering the canal.
Design Criteria:	Based on design of upstream drainage facilities (25-year rainfall event).
Design Requirements:	Purchase of land. Improvements will be made to prevent runoff from entering canal and help contain runoff within the property.
Issues:	**Land acquisition**: Large cost associated with purchase. Less land would be needed for engineered infiltration structure.
Maintenance:	Cleanup and erosion repair after runoff events.

Estimated Project Cost: $400,000 (4 acres of land at $75,000/acre plus $100,000 for improvements).

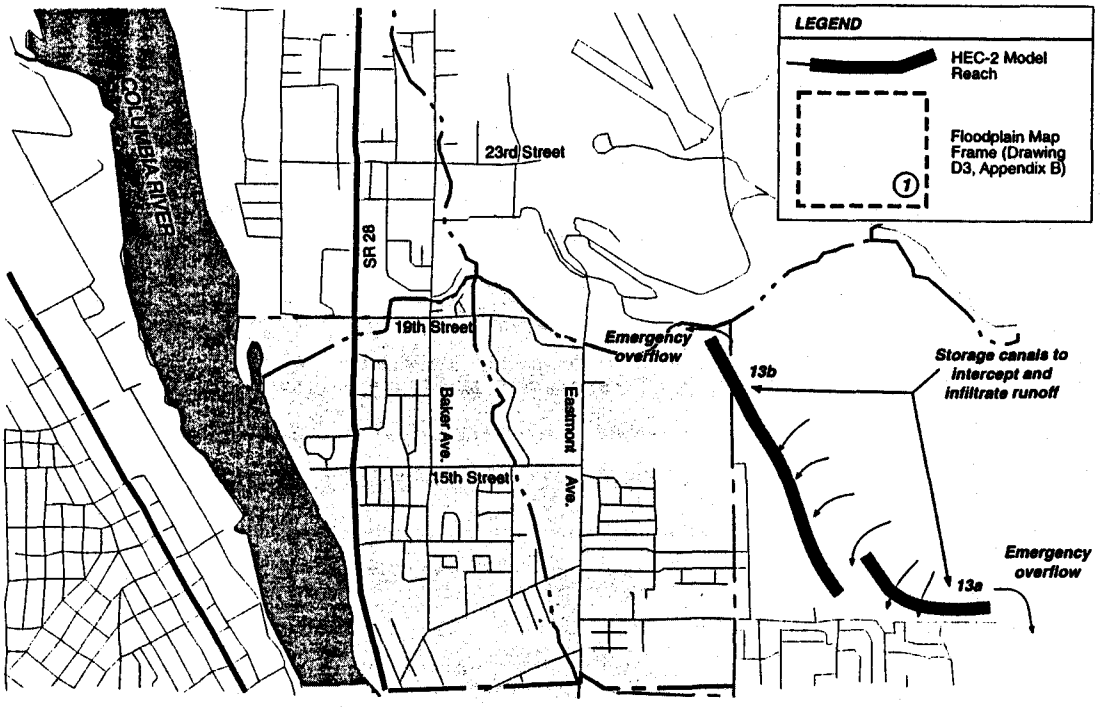


Infiltration area at 10th N.E. and Eastmont Avenue

(Detailed cost estimate not prepared for this project)

PROJECT SUMMARY SHEET

Project Title:	Urban Area - Interceptor canals to infiltrate agricultural runoff (overflow to Canyon A).
Project Description:	Runoff from the agricultural areas will be intercepted and fully contained by a flat storage canal located at the base of the farmland area. The canal will extend from north of 10th Street to a tributary of Canyon A. It will be sized to accommodate sediment inflow. Under normal conditions no discharge to Canyon A is anticipated. Overflow may occur if design is exceeded or infiltration is prevented. A second canal will be located at the base of the bluff and will extend from north of 10th Street to Sand Canyon (Project UA-13b).
Design Criteria:	100-year runoff volume of approximately 13 acre feet and 100-year sediment volume of 8 acre feet. Two feet of freeboard on the canal.
Design Requirements:	Unlined open channel with emergency overflow structure to Canyon A. Lined downstream canal sides at locations of major inflow.
Issues:	**Design:** Adequacy of soils for infiltration. Potential for incorporation into road extensions if completed. **Phasing:** This Project is the first of two phases. The Canyon A canal will be constructed first and the Sand Canyon canal second.
Maintenance:	Sediment removal and routine inspection.
Estimated Project Cost:	Approx. $1 million.



Interceptor canals for agricultural runoff (overflow to Canyon A)

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-13a

INTERCEPTOR/INFILTRATION CANAL FOR AGRICULTURAL RUNOFF (OVERFLOW TO CANYON A)

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$22,000.00	$22,000
	Phase I - Canal to Canyon A				
2	EXCAVATION - COMMON	83,000	CY	$3.00	$249,000
3	EMBANKMENT COMPACTION	83,000	CY	$2.00	$166,000
4	URBAN SEEDING & FERTILIZATION	17	AC	$1,000.00	$17,000
5	OUTLET STRUCTURE	1	EA	$10,000.00	$10,000
				SUBTOTAL:	$464,000
	SALES TAX	7.80%			$36,192
	LAND PURCHASE - DRYLAND FARM	17	AC	$3,500.00	$59,500
				SUBTOTAL:	$559,692
	CONTINGENCY	30%			$167,908
				CONSTRUCTION COST SUBTOTAL:	$727,600
	ENGINEERING, LEGAL & ADMIN.	30%			$218,280
				SUBTOTAL:	$945,879
				TOTAL ESTIMATED PROJECT COST:	**$946,000**

PROJECT SUMMARY SHEET

Project Title: Urban Area - Interceptor canals to infiltrate agricultural runoff (overflow to Sand Canyon).

Project Description: Runoff from the agricultural areas will be intercepted and fully contained by a flat storage canal located at the base of the farmland area. The canal will be located at the base of the bluff and will extend from north of 10th Street to Sand Canyon. It will be sized to accommodate sediment inflow. Under normal conditions no discharge to Sand Canyon is anticipated. Overflow may occur if design is exceeded or infiltration is prevented. The first canal will extend from north of 10th Street to a tributary of Canyon A (Project UA-13a).

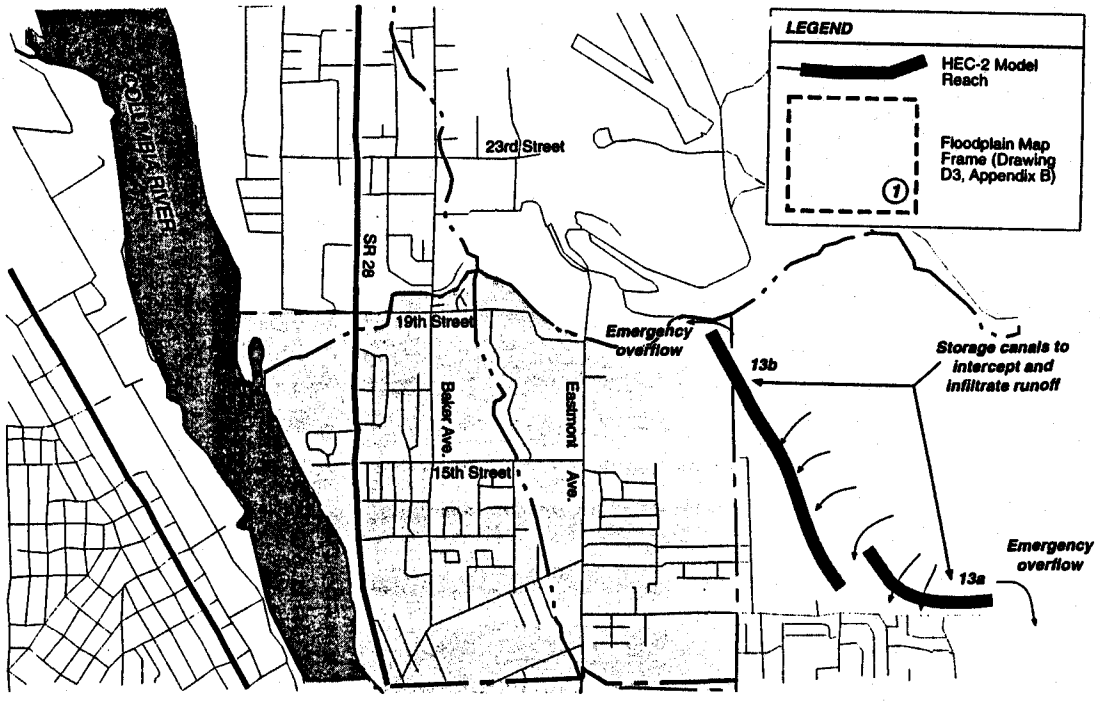
Design Criteria: 100-year runoff volume of approximately 15 acre feet and 100-year sediment volume of 11acre feet. Two feet of freeboard on the canal.

Design Requirements: Unlined open channel with emergency overflow structures to Sand Canyon. Lined downstream canal sides at locations of major inflow.

Issues: **Design:** Adequacy of soils for infiltration. Potential for incorporation into road extensions if completed.
Phasing: This Project is the second of two phases. The Canyon A canal will be constructed first and the Sand Canyon canal second.

Maintenance: Sediment removal and routine inspection.

Estimated Project Cost: Approx. $2 million.



Interceptor canals for agricultural runoff (overflow to Sand Canyon)

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-13b

INTERCEPTOR/INFILTRATION CANAL FOR AGRICULTURAL RUNOFF (OVERFLOW TO SAND CANYON)

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$41,000.00	$41,000
	Phase II - Canal to Sand Canyon				
2	EXCAVATION - COMMON	118,500	CY	$4.75	$562,875
3	EMBANKMENT COMPACTION	118,500	CY	$2.00	$237,000
4	URBAN SEEDING & FERTILIZATION	13	AC	$1,000.00	$13,000
5	OUTLET STRUCTURE	1	EA	$10,000.00	$10,000
				SUBTOTAL:	$863,875

SALES TAX	7.80%		$67,382
LAND PURCHASE - DRYLAND FARM	13	$3,500.00	$45,500
LAND PURCHASE - ORCHARD	15	$20,000.00	$300,000
		SUBTOTAL:	$1,276,757
CONTINGENCY	30%		$383,027
		CONSTRUCTION COST SUBTOTAL:	$1,659,784
ENGINEERING, LEGAL & ADMIN.	30%		$497,935
		SUBTOTAL:	$2,157,720
		TOTAL ESTIMATED PROJECT COST:	**$2,158,000**

PROJECT SUMMARY SHEET

Project Title: Urban Area - Autumn Drive drainage system improvements.

Project Description: Three new drywells would be installed under Autumn Drive to infiltrate runoff from Autumn Drive and Autumn Place and reduce flooding in the vicinity.

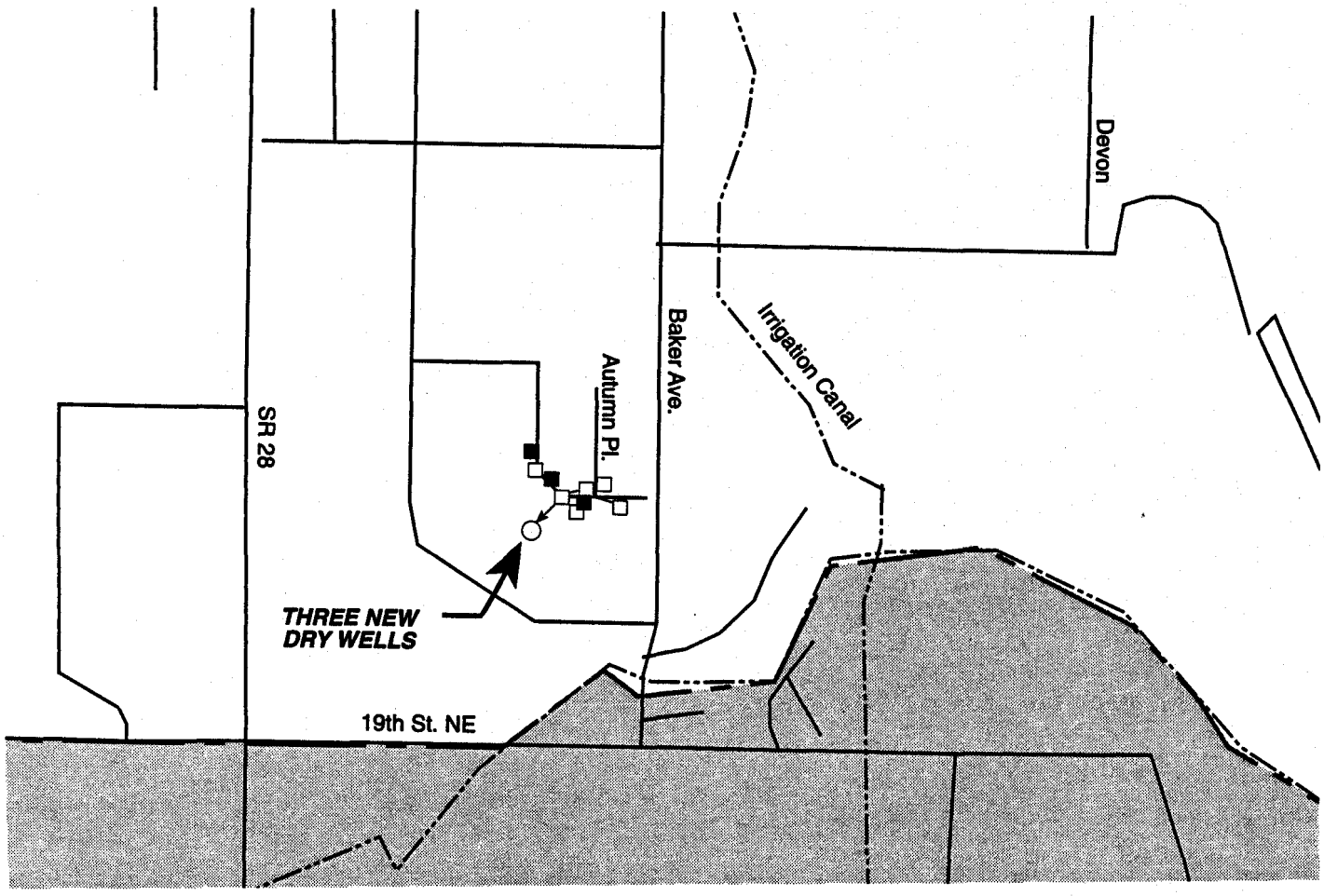
Design Criteria: 2" of rainfall in 90 minutes.

Design Requirements: Drywells, catch basins along streets and conveyance piping to drywells

Issues: **Design:** Adequacy of soils for infiltration.
Easements: Additional drainage easement width may be required for 100-year flood path.
Construction: Traffic disruptions on Autumn Drive.

Maintenance: Sediment removal and routine inspection.

Estimated Project Cost: $18,000 (if completed by county crews)



Autumn Drive new drywells

(Detailed cost estimate not prepared for this project)

PROJECT SUMMARY SHEET

Project Title:	Urban Area - Fancher Heights Drainage Improvements.
Project Description:	Five new drywells would be installed under Monument and Twin Peaks to collect runoff and prevent flooding and downstream hillside erosion.
Design Criteria:	2" of rainfall in 90 minutes.
Design Requirements:	Drywells, catch basins and conveyance system along streets
Issues:	**Design:** Adequacy of soils for infiltration. **Construction:** Traffic disruptions on Monument & Twin Peaks.
Maintenance:	Sediment removal and routine inspection.
Estimated Project Cost:	$25,000 (Installation by county crews; four completed during 1994)

Figure not available for this project

Fancher Heights new drywells

(Detailed cost estimate not prepared for this project)

Estimate provided by Douglas County

—Under construction, 1994

PROJECT SUMMARY SHEET

Project Title: Urban Area - Vista View/Ski View Drainage Improvements.

Project Description: The existing culvert crossing Vista View Pl. just south of Ski View Drive will be plugged and drainage from upper Ski View Dr. will be routed down Vista View Pl. in a new ditch to the next culvert crossing and then directly through an orchard to Sand Canyon.

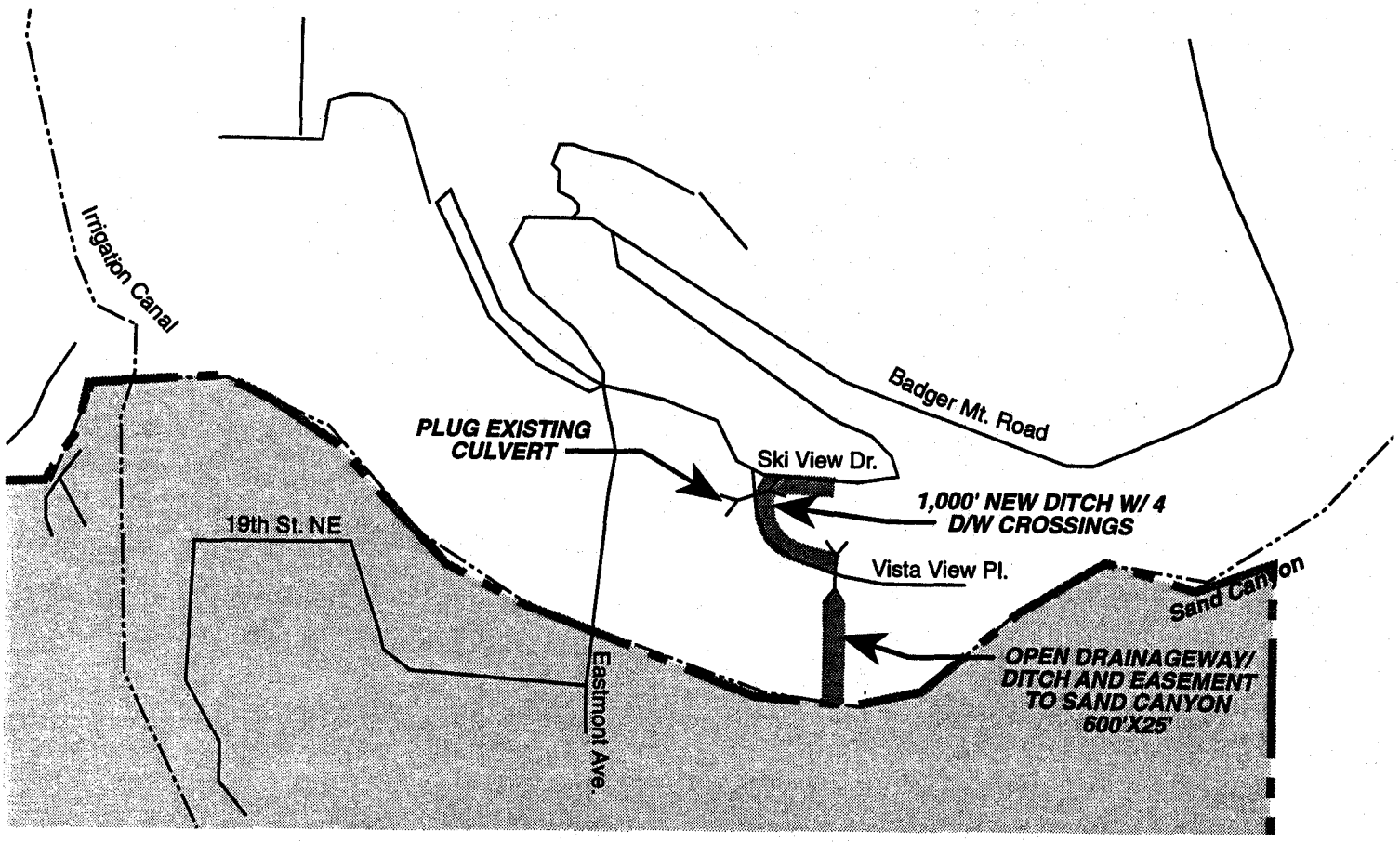
Design Criteria: 2" of rainfall in 90 minutes. One foot freeboard on ditch.

Design Requirements: Ditches, culverts, and unlined open drainageway to Sand Canyon.

Issues: **Design:** Capacity of existing culvert crossing Vista View Pl. to orchard and Sand Canyon.
Construction: Traffic disruptions on Vista View & Ski View. Potential for erosion.
Easements: Permanent drainage easement through orchard.

Maintenance: Routine inspection of, and sediment removal from, ditches and culverts. Maintenance of drainageway through orchard to Sand Canyon.

Estimated Project Cost: $108,000.



Vista View/Ski View Drainage Improvements

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-16

VISTA VIEW/SKI VIEW

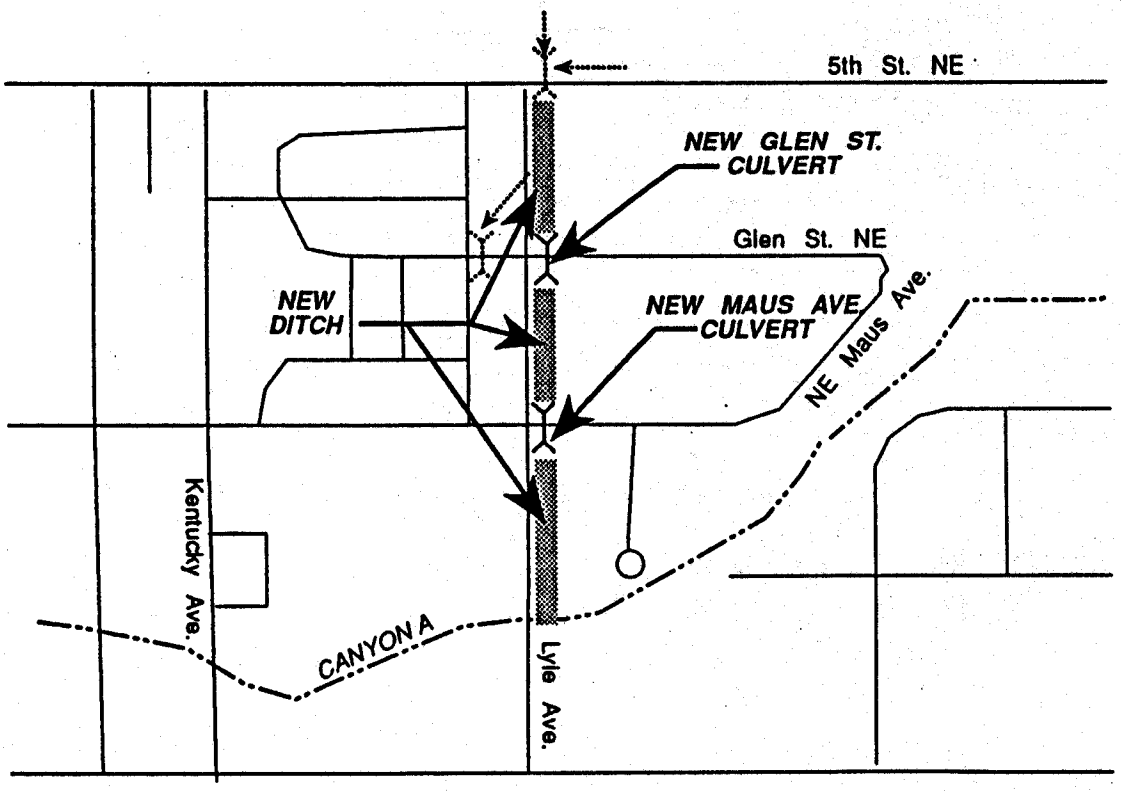
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$2,000.00	$2,000
2	EXCAVATION - STRUCTURAL/TRENCH	30	CY	$15.00	$450
	DITCH	1600	LF	$16.00	$25,600
3	GRAVEL FILL - PIPE BEDDING	5	CY	$20.00	$100
	COMPACTED BACKFILL - PIPE TRENCH	20	CY	$12.00	$240
4	18 INCH REINFORCED CONCRETE PIPE	80	LF	$22.00	$1,760
5	PAVEMENT CUTTING	160	LF	$3.00	$480
	PAVEMENT RESTORATION	30	SY	$50.00	$1,500
6	EROSION/SEDIMENT CONTROL	1	LS	$500.00	$500
	TRAFFIC CONTROL	5	DY	$300.00	$1,500
	TRENCH SAFETY SYSTEM	80	FT	$7.00	$560
				SUBTOTAL:	$34,690

SALES TAX	7.80%				$2,706
LAND PURCHASE - RESIDENTIAL	0.35	AC	$75,000.00		$26,250
			SUBTOTAL:		$63,646
CONTINGENCY	30%				$19,094
			CONSTRUCTION COST SUBTOTAL:		$82,740
ENGINEERING, LEGAL & ADMIN.	30%				$24,822
			SUBTOTAL:		$107,561
			TOTAL ESTIMATED PROJECT COST:		**$108,000**

PROJECT SUMMARY SHEET

Project Title:	Urban Area - Lyle Avenue drainage improvements below 5th St NE.
Project Description:	Along Lyle Avenue, the existing ditch and culvert system capacity would be increased from 5th St NE all the way to Canyon A.
Design Criteria:	2" of rainfall in 90 minutes. One foot freeboard on ditches.
Design Requirements:	New ditches, and culverts. Outlet armoring at Canyon A.
Issues:	**Design:** Minimal cover over culverts, shallow ditches. **Construction:** Traffic disruptions on Lyle.
Maintenance:	Routine inspection of, and sediment removal from, ditches and culverts.

Estimated Project Cost: $73,000.



Lyle Avenue drainage improvements

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-17

5TH & LYLE TO CANYON A

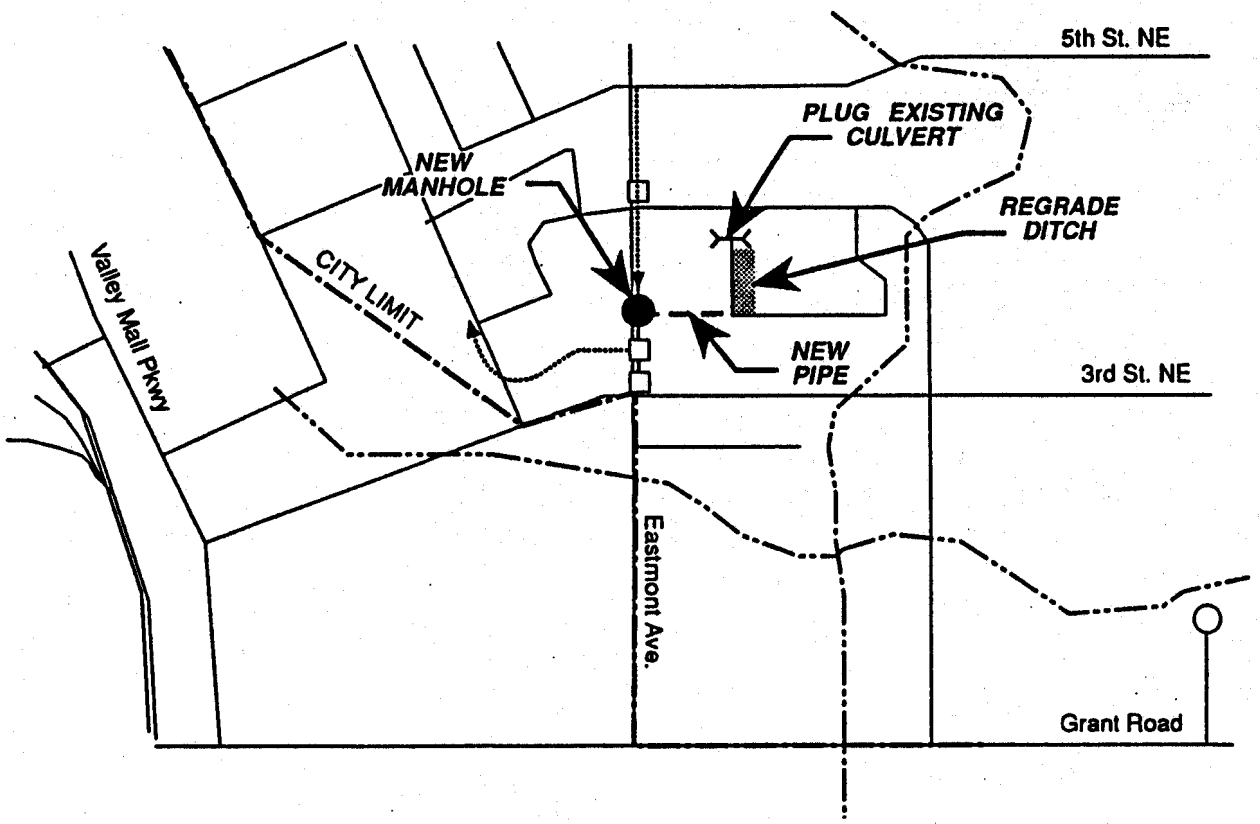
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$2,000.00	$2,000
2	EXCAVATION - STRUCTURAL/TRENCH	80	CY	$15.00	$1,200
	DITCH	1650	LF	$16.00	$26,400
3	GRAVEL FILL - PIPE BEDDING	10	CY	$20.00	$200
	COMPACTED BACKFILL - PIPE TRENCH	25	CY	$12.00	$300
4	18 INCH REINFORCED CONCRETE PIPE	200	LF	$22.00	$4,400
5	PAVEMENT CUTTING	120	LF	$3.00	$360
	PAVEMENT RESTORATION	35	SY	$50.00	$1,750
6	EROSION/SEDIMENT CONTROL	1	LS	$1,000.00	$1,000
	TRAFFIC CONTROL	5	DY	$300.00	$1,500
	TRENCH SAFETY SYSTEM	100	FT	$7.00	$700
				SUBTOTAL:	$39,810

SALES TAX	7.80%		$3,105
		SUBTOTAL:	$42,915
CONTINGENCY	30%		$12,875
		CONSTRUCTION COST SUBTOTAL:	$55,790
ENGINEERING, LEGAL & ADMIN.	30%		$16,737
	AC		
		SUBTOTAL:	$72,527
		TOTAL ESTIMATED PROJECT COST:	**$73,000**

PROJECT SUMMARY SHEET

Project Title:	Urban Area - Eastmont/Fire Station drainage improvements between 3rd & 4th Streets NE.
Project Description:	A new pipe would be installed to convey flows across the Fire Station parking lot to the Eastmont drainage system. The existing ditch along Degage Street would be improved.
Design Criteria:	25-year runoff event (or 2" rainfall in 90 minutes). One foot freeboard on ditch.
Design Requirements:	New pipe, ditch improvements, new manhole.
Issues:	**Downstream Impacts:** 3rd Street pipeline must be in place first. **Construction:** Traffic disruptions on Eastmont, loss of use of parking/training area for fire department during construction.
Maintenance:	Routine inspection of, and sediment removal from, ditch, manhole and pipe.

Estimated Project Cost: $78,000.



Eastmont/Fire Station drainage improvements

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-18

DEGAGE STREET TO EASTMONT UNDER FIRE STATION

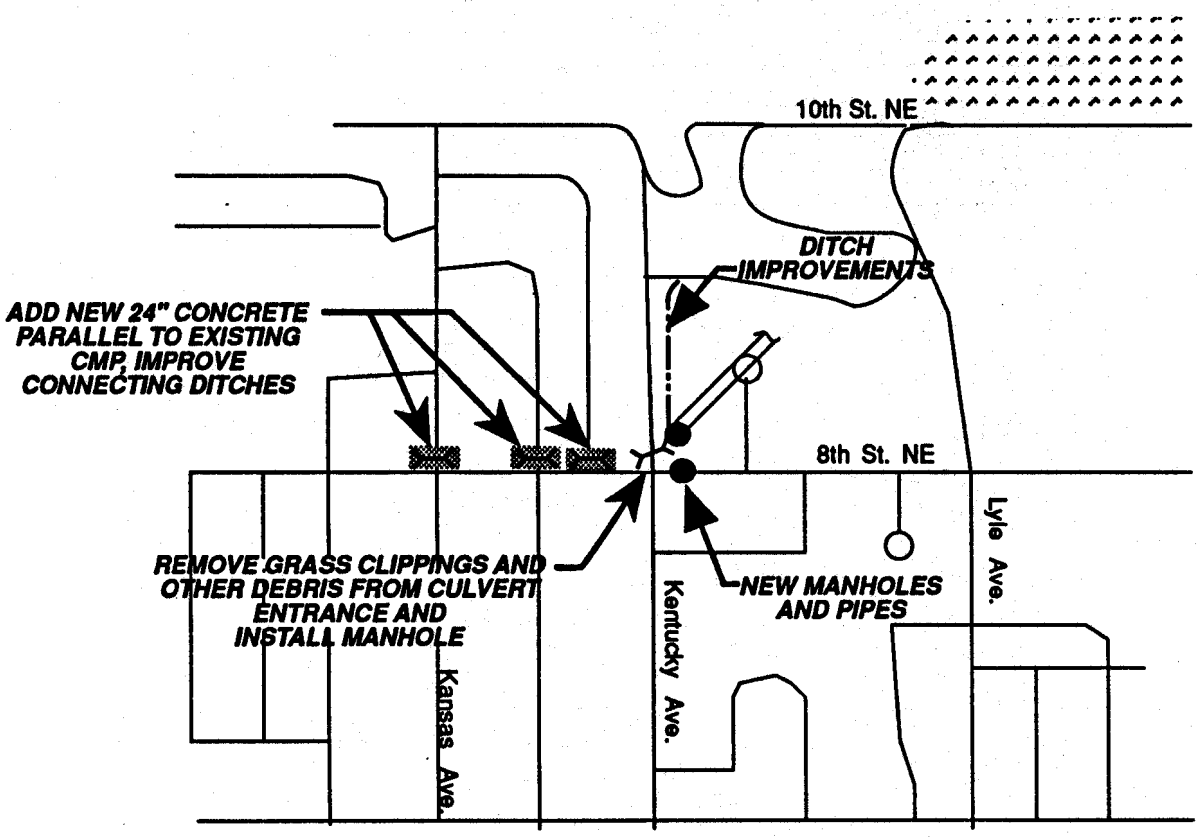
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$2,000.00	$2,000
2	EXCAVATION - STRUCTURAL/TRENCH	170	CY	$15.00	$2,550
	DITCH	250	LF	$16.00	$4,000
3	GRAVEL FILL - PIPE BEDDING	21	CY	$20.00	$420
	COMPACTED BACKFILL - PIPE TRENCH	85	CY	$12.00	$1,020
4	24 INCH REINFORCED CONCRETE PIPE	370	LF	$35.00	$12,950
5	72 INCH MANHOLE	1	EA	$5,000.00	$5,000
6	PAVEMENT CUTTING	740	LF	$3.00	$2,220
	PAVEMENT RESTORATION	125	SY	$50.00	$6,250
7	EROSION/SEDIMENT CONTROL	1	LS	$1,000.00	$1,000
	TRAFFIC CONTROL	10	DY	$300.00	$3,000
	TRENCH SAFETY SYSTEM	370	FT	$7.00	$2,590
				SUBTOTAL:	$43,000

SALES TAX	7.80%		$3,354
		SUBTOTAL:	$46,354
CONTINGENCY	30%		$13,906
		CONSTRUCTION COST SUBTOTAL:	$60,260
ENGINEERING, LEGAL & ADMIN.	30%		$18,078
	AC		
		SUBTOTAL:	$78,338
		TOTAL ESTIMATED PROJECT COST:	**$78,000**

PROJECT SUMMARY SHEET

Project Title:	Urban Area - 8th & Kentucky culvert and ditch improvements.
Project Description:	Existing culverts and ditches will be increased so that all flows in this vicinity can be conveyed down 8th Street NE.
Design Criteria:	2" of rainfall in 90 minutes. One foot freeboard on ditch.
Design Requirements:	New culverts, new ditches and ditch improvements.
Issues:	**Design:** Minimal cover over culverts, shallow ditches. **Downstream Impacts:** Flows on 8th downstream will increase, need to construct downstream detention first (UA-23). **Construction:** Traffic disruptions on 8th.
Maintenance:	Routine inspection of, and sediment removal from, ditches, and culverts.

Estimated Project Cost: $85,000.



8th & Kentucky culvert and ditch improvements

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-19

8TH & KENTUCKY CULVERT IMPROVEMENTS

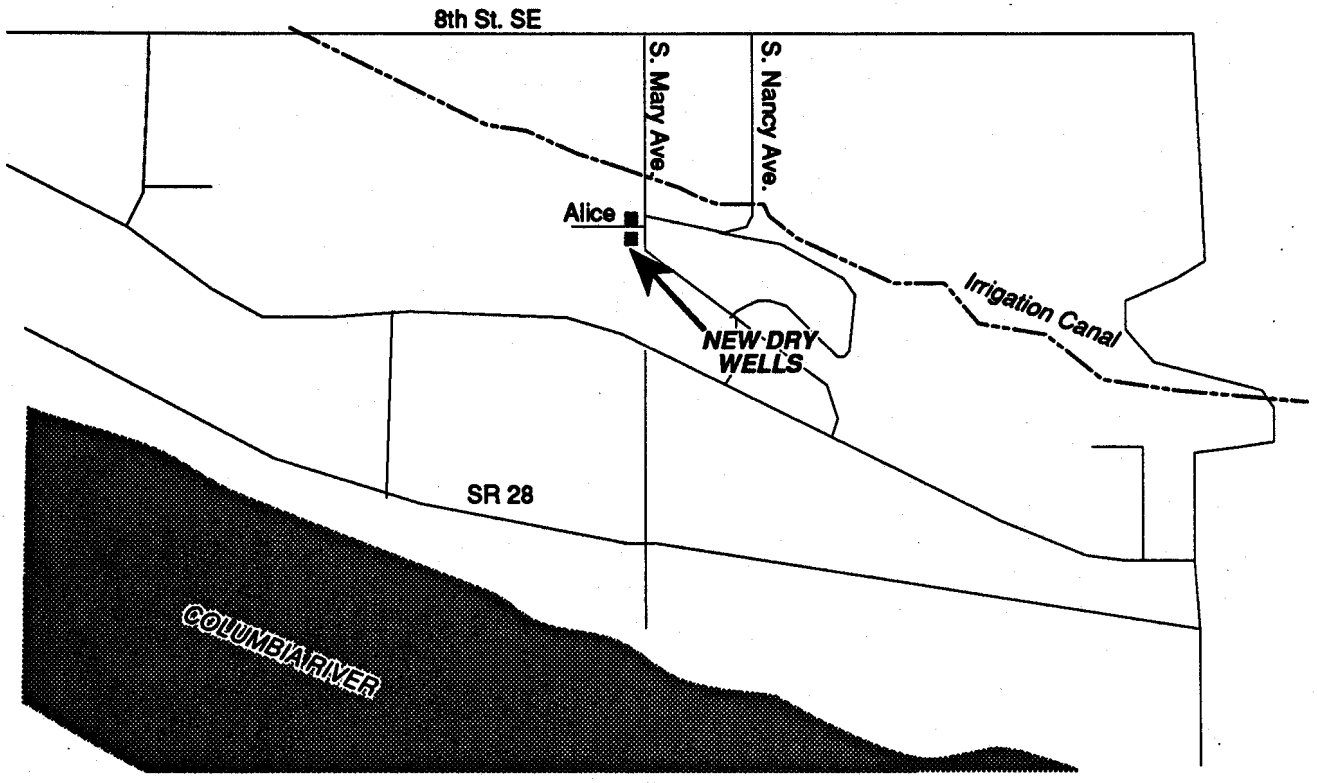
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$2,000.00	$2,000
2	EXCAVATION - STRUCTURAL/TRENCH	120	CY	$15.00	$1,800
	DITCH	1000	LF	$16.00	$16,000
3	GRAVEL FILL - PIPE BEDDING	15	CY	$20.00	$300
	COMPACTED BACKFILL - PIPE TRENCH	60	CY	$12.00	$720
4	24 INCH REINFORCED CONCRETE PIPE	200	LF	$35.00	$7,000
5	72 INCH MANHOLE	2	EA	$5,000.00	$10,000
6	PAVEMENT CUTTING	240	LF	$3.00	$720
	PAVEMENT RESTORATION	55	SY	$50.00	$2,750
7	EROSION/SEDIMENT CONTROL	1	LS	$1,000.00	$1,000
	TRAFFIC CONTROL	10	DY	$300.00	$3,000
	TRENCH SAFETY SYSTEM	200	FT	$7.00	$1,400
				SUBTOTAL:	$46,690

SALES TAX	7.80%		$3,642
		SUBTOTAL:	$50,332
CONTINGENCY	30%		$15,100
		CONSTRUCTION COST SUBTOTAL:	$65,431
ENGINEERING, LEGAL & ADMIN.	30%		$19,629
	AC		
		SUBTOTAL:	$85,061
		TOTAL ESTIMATED PROJECT COST:	**$85,000**

PROJECT SUMMARY SHEET

Project Title:	Urban Area - S. Mary & S. Alice drainage system improvements.
Project Description:	Two new drywells would be installed near the intersection of S. Mary and S. Alice to infiltrate runoff and reduce flooding in the vicinity.
Design Criteria:	2" of rainfall in 90 minutes.
Design Requirements:	Drywells, catch basins along streets and conveyance piping to drywells
Issues:	**Design:** Adequacy of soils for infiltration. **Construction:** Traffic disruptions on Lyle.
Maintenance:	Sediment removal and routine inspection.

Estimated Project Cost: $12,000 (by county crews)



S. Mary & S. Alice drainage system improvements

(Detailed cost estimate not prepared for this project)

PROJECT SUMMARY SHEET

Project Title: Urban Area - Grover Avenue drainage system improvements.

Project Description: Three new drywells would be installed near along Grover Aveune between France Steet and 13th Street to infiltrate runoff and reduce flooding in the vicinity.

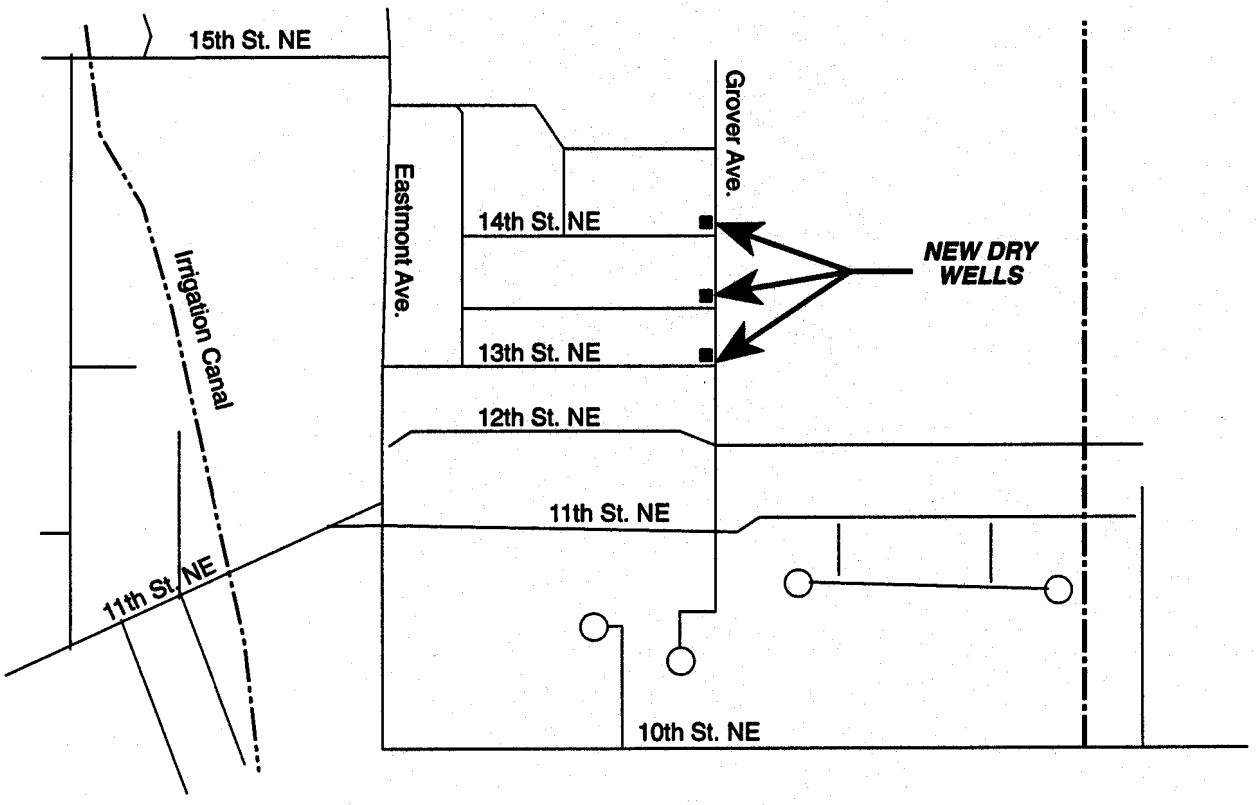
Design Criteria: 2" of rainfall in 90 minutes.

Design Requirements: Drywells, catch basins along streets and conveyance piping to drywells

Issues: **Design:** Adequacy of soils for infiltration.
Construction: Traffic disruptions on Grover.

Maintenance: Sediment removal and routine inspection.

Estimated Project Cost: $18,000 (by county crews)



Grover Avenue drainage system improvements

(Detailed cost estimate not prepared for this project)

PROJECT SUMMARY SHEET

Project Title: Urban Area - 8th Street and 5th Street Detention Facilties.

Project Description: Two multi-purpose detention facilities would be constructed. The first would be at the soccer field at 8th & Iowa. The second would be downstream at the parking area at 5th and the canal. Some drainage ditch and culvert improvements would be included with the downstream facility.

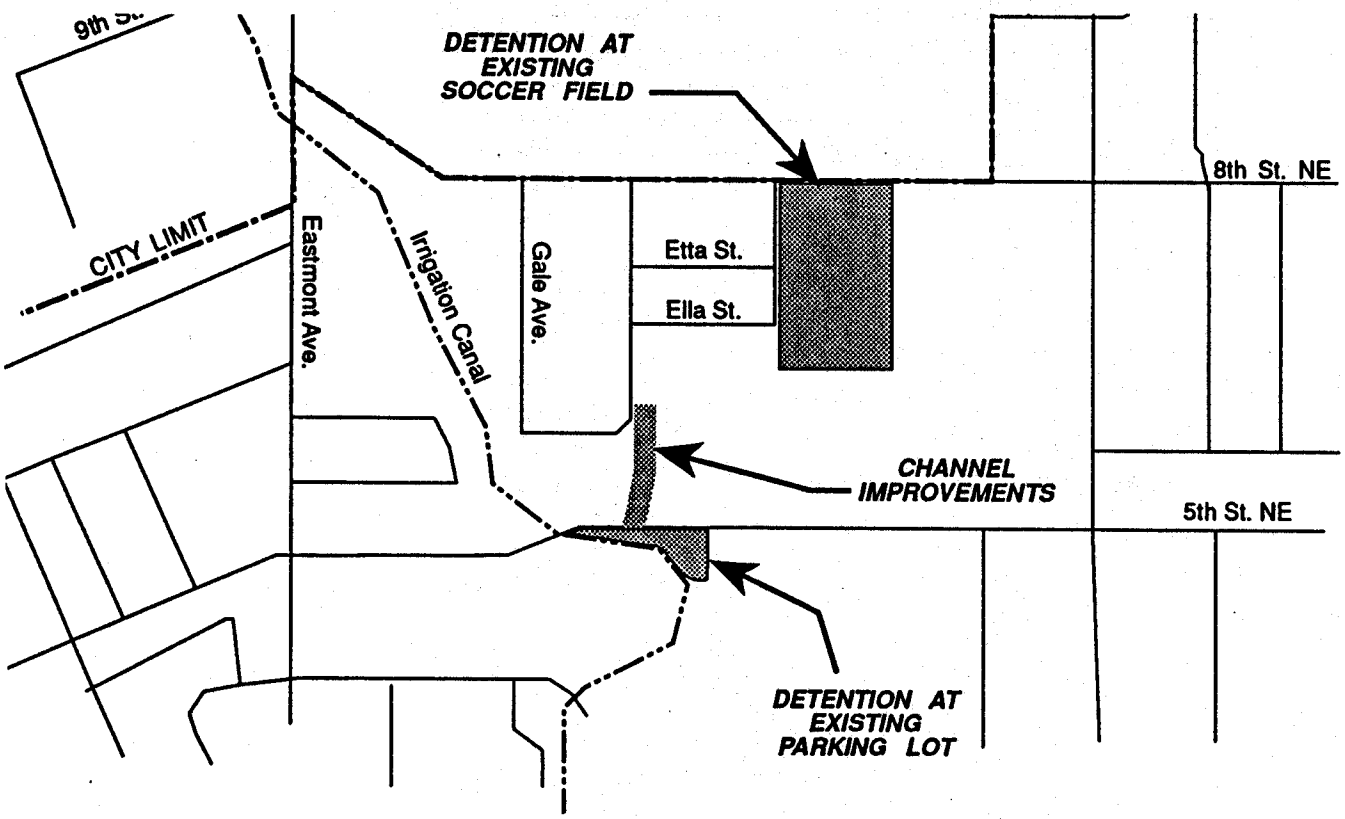
Design Criteria: 100-year runoff event

Design Requirements: Detention basins, inlet and outlet control structures, downstream drainage ditch and culvert. New soccer field surface and new gravel parking surface.

Issues: **Design:** Adequacy of soils for infiltration. Availability of embankment material
Construction: Would need to occur during school breaks for work on school properties. Traffic disruptions on 5th.
Easements: Both facilities would require easements for construction and maintenance

Maintenance: Sediment removal and routine inspection.

Estimated Project Cost: $247,000



8th Street and 5th Street Detention Facilties

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-23

HALE AND 5TH STREETS DETENTION/INFILTRATION FACILITIES

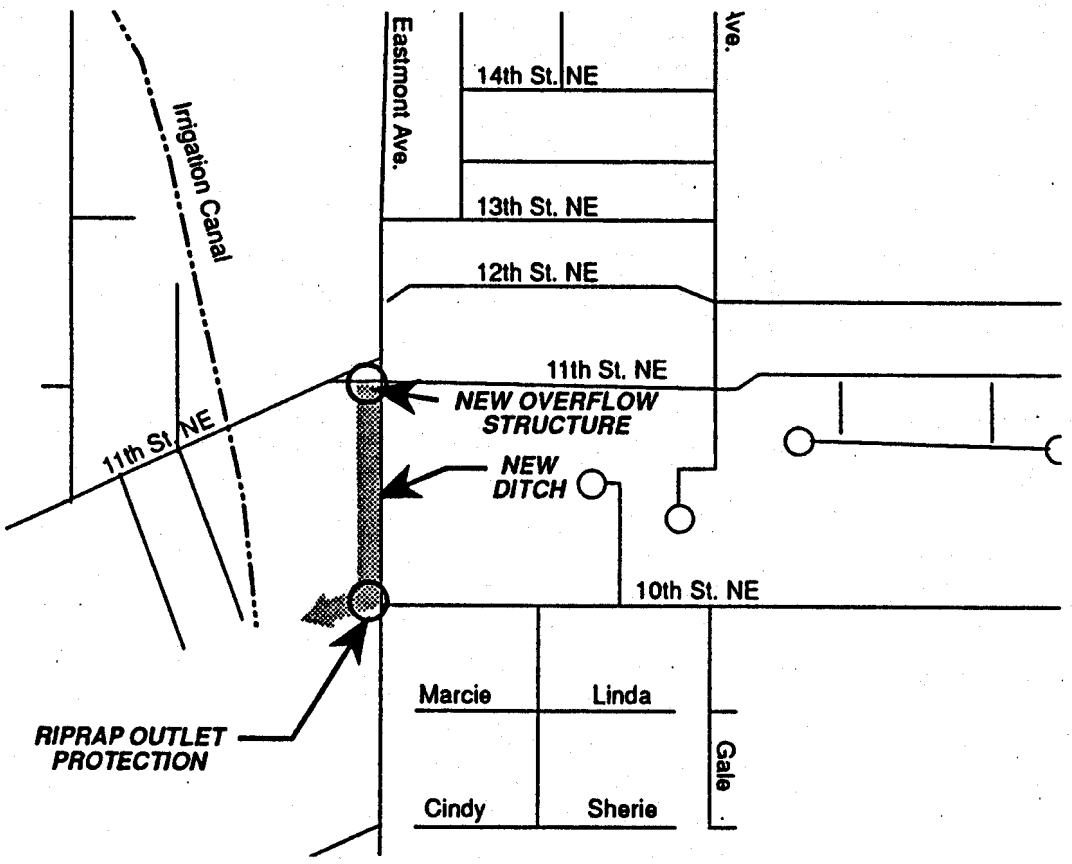
ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$6,000.00	$6,000
	8TH ST NE FACILITY				
2	EXCAVATION - BULK	11670	CY	$2.00	$23,340
3	EMBANKMENT COMPACTION	11,670	CY	$2.00	$23,340
4	INFILTRATION POND INLET/OUTLET	2	EA	$15,000.00	$30,000
5	EROSION/SEDIMENT CONTROL	1	LS	$2,000.00	$2,000
6	URBAN SEEDING & FERTILIZATION	5	AC	$1,000.00	$4,800
7	IRRIGATION REPAIR/REPLACEMENT	5	AC	$1,000.00	$5,000
	5TH ST NE FACILITY				
8	EXCAVATION - STRUCTURAL/TRENCH	24	CY	$15.00	$360
	DITCH	400	LF	$16.00	$6,400
9	GRAVEL FILL - ROAD BALLAST	930	CY	$4.75	$4,418
	GRAVEL FILL - PIPE BEDDING	3	CY	$2.00	$6
	COMPACTED BACKFILL - PIPE TRENCH	4	CY	$12.00	$48
10	18 INCH REINFORCED CONCRETE PIPE	50	LF	$22.00	$1,100
11	DETENTION POND OUTLET	1	EA	$20,000.00	$20,000
12	PAVEMENT REMOVAL	5,555	SY	$1.00	$5,555
	PAVEMENT CUTTING	100	LF	$3.00	$300
	PAVEMENT RESTORATION	17	SY	$50.00	$850
13	EROSION/SEDIMENT CONTROL	1	LS	$1,000.00	$1,000
14	URBAN SEEDING & FERTILIZATION	1	AC	$1,000.00	$1,100
				SUBTOTAL:	$135,617

SALES TAX	7.80%		$10,578
		SUBTOTAL:	$146,195
CONTINGENCY	30%		$43,858
		CONSTRUCTION COST SUBTOTAL:	$190,053
ENGINEERING, LEGAL & ADMIN.	30%		$57,016
		SUBTOTAL:	$247,069
		TOTAL ESTIMATED PROJECT COST:	**$247,000**

PROJECT SUMMARY SHEET

Project Title:	Urban Area - Ditch to divert 11th Street drainage to 10th Street infiltration area.
Project Description:	A new ditch would convey flows from 11th Street to the 10th Street infiltration area west of Eastmont.
Design Criteria:	2" of rainfall in 90 minutes. One foot freeboard on ditch.
Design Requirements:	New ditch, diversion structure at 11th, ditch outlet protection.
Issues:	**Design:** Topography favorable to constructing ditch along Eastmont **Construction:** Traffic disruptions on Eastmont and potential underground utility interference. **Easements:** 11th Street infiltration area must be secured before constructing this project.
Maintenance:	Sediment removal and routine inspection.

Estimated Project Cost: $63,000



Ditch to divert 11th Street drainage to 10th Street infiltration area

File: DC-COST.XLS

DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

UA-24

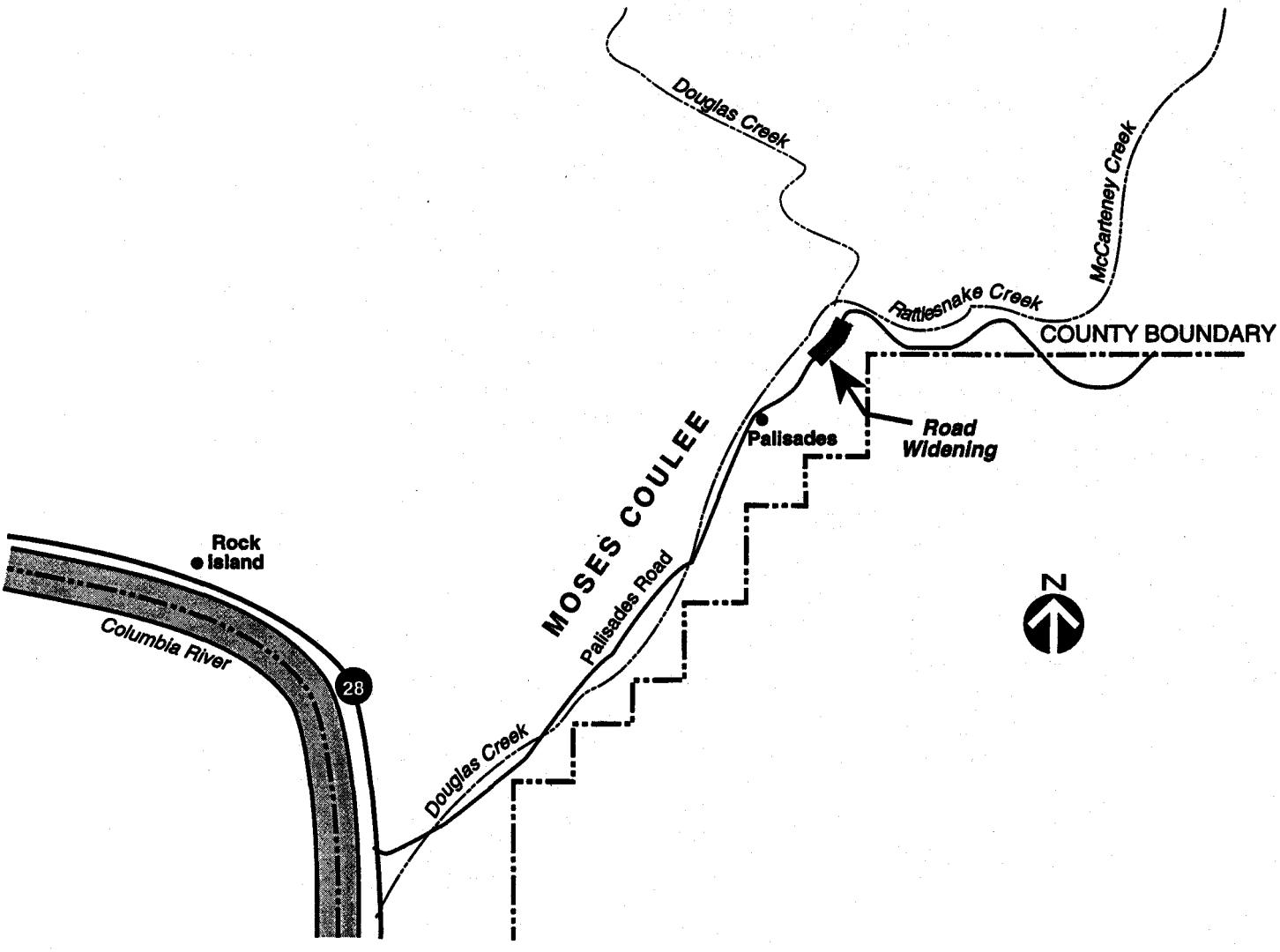
EASTMONT DITCH 11TH TO 10TH ST INFILTRATION FACILITY

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$2,000.00	$2,000
2	DITCH	800	LF	$16.00	$12,800
3	RIPRAP FILL - HEAVY PLACED	20	CY	$30.00	$600
4	INFILTRATION POND INLET/OUTLET	1	EA	$15,000.00	$15,000
5	EROSION/SEDIMENT CONTROL	1	LS	$1,000.00	$1,000
	TRAFFIC CONTROL	10	DY	$300.00	$3,000
				SUBTOTAL:	$34,400

SALES TAX	7.80%		$2,683
		SUBTOTAL:	$37,083
CONTINGENCY	30%		$11,125
		CONSTRUCTION COST SUBTOTAL:	$48,208
ENGINEERING, LEGAL & ADMIN.	30%		$14,462
		SUBTOTAL:	$62,671
		TOTAL ESTIMATED PROJECT COST:	**$63,000**

PROJECT SUMMARY SHEET

Project Title:	Moses Coulee - Douglas Creek widening
Project Description:	Widen 6000 feet of Moses Coulee and raise the adjacent County road 2 feet one mile upstream of Palisades. Relocate one home.
Design Criteria:	A five-year flood event must be contained in the channel with at least 1 foot of freeboard.
Issues:	**Design:** Instream habitat. **Construction:** Traffic disruptions on County road.
Maintenance:	Routine inspection of new stream channel
Estimated Project Cost:	$851,000.



Douglas Creek widening

File: DC-ROAD.XLS

DOUGLAS COUNTY
PRELIMINARY COST ESTIMATE

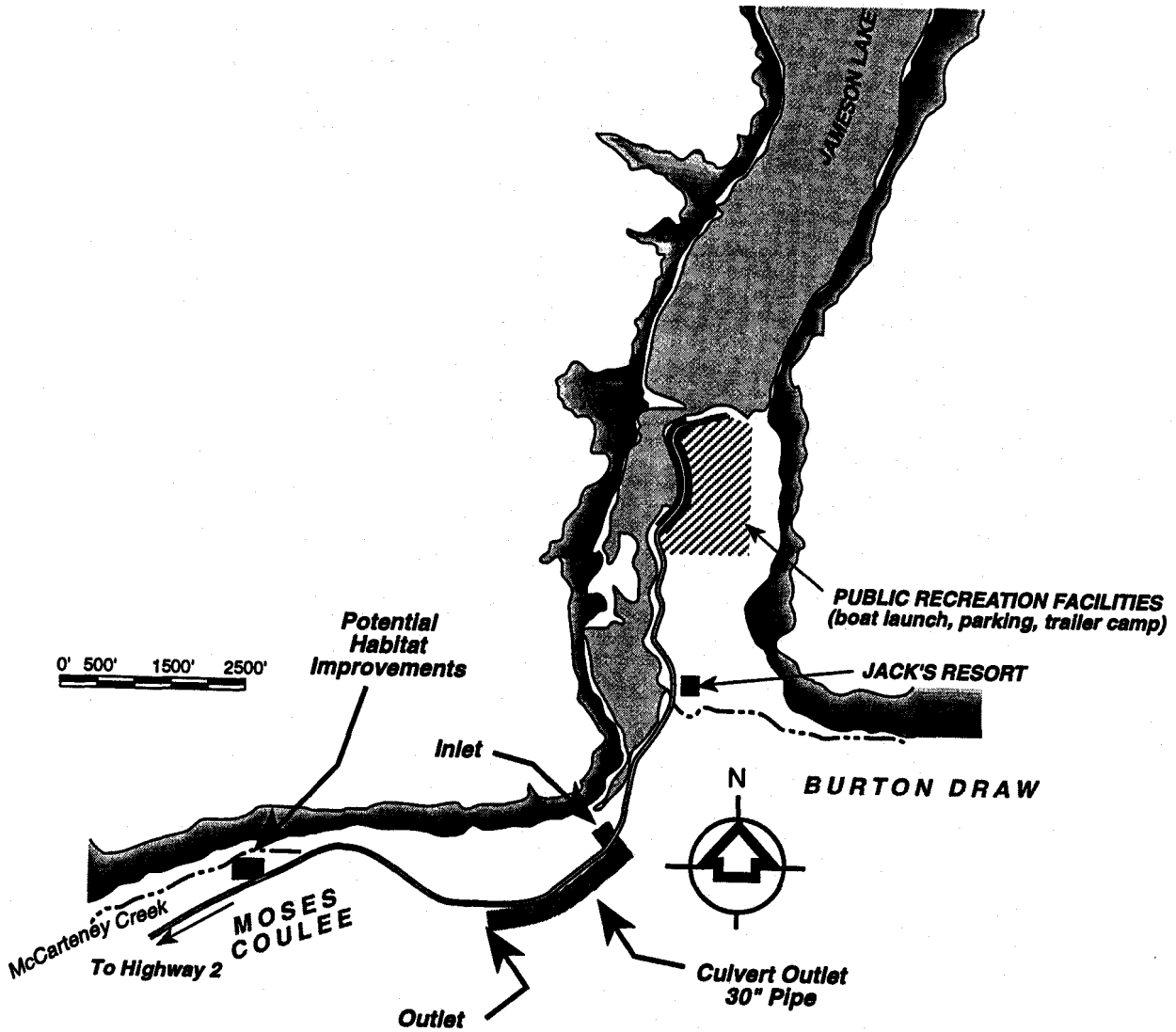
DC-1R + DC-2R

DOUGLAS CREEK CHANNEL WIDENING AND RAISING ROADWAY
STA 640+00 TO STA 700+00

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION (7%)	1	LS	$32,000.00	$32,000
2	EROSION/SEDIMENT CONTROL	1	LS	$5,000.00	$5,000
3	STRIPPING INCL. HAUL	4,700	CY	$6.00	$28,200
4	BREAK-UP EXISTING ROADWAY	1	LS	$5,000.00	$5,000
5	EMBANKMENT COMPACTION	15000	CY	$2.00	$30,000
6	EXCAVATION - CHANNEL	45,000	CY	$4.75	$213,750
7	CRUSHED SURFACING	3,563	TON	$16.00	$57,008
8	ASPHALT CONCRETE PAVEMENT	2,740	TON	$38.00	$104,120
9	TRAFFIC CONTROL	1	LS	$12,000.00	$12,000
10	SEEDING AND FERTILIZING	1	ACRE	$1,000.00	$1,000
11	REVEGETATION	5.0	ACRE	$1,000.00	$5,000
	(Assumes no haul of excavated materials)				
	(Assumes 3 in. ACP, 4 in. CSTC)				
	(Assumes embankment fill from channel excavation)				
				SUBTOTAL:	$493,078
	SALES TAX	7.80%			$38,460
				SUBTOTAL:	$531,538
	CONTINGENCY	25%			$132,885
				CONSTRUCTION COST SUBTOTAL:	$664,423
	ENGINEERING, LEGAL & ADMIN.	25%			$166,106
	HOUSE RELOCATION	1	EACH	$20,000	$20,000
				SUBTOTAL:	$850,528
				TOTAL ESTIMATED PROJECT COST:	**$851,000**

PROJECT SUMMARY SHEET

Project Title:	Outlet pipeline.
Project Description:	Construct an outlet pipline from Jameson Lake south across the County road to daylight into an existing channel. Flows would be metered to allow the lake to rise during large events but not overtop until a 50-year or greater event occurs.
Design Criteria:	Establish normal lake level at no higher than 8 feet. below the existing outfall.
Issues:	**Design:** Adequacy of downstream channels.
Maintenance:	Routine inspection.
Estimated Project Cost:	$269,000



Jameson Lake outfall

File: DC-COST.XLS

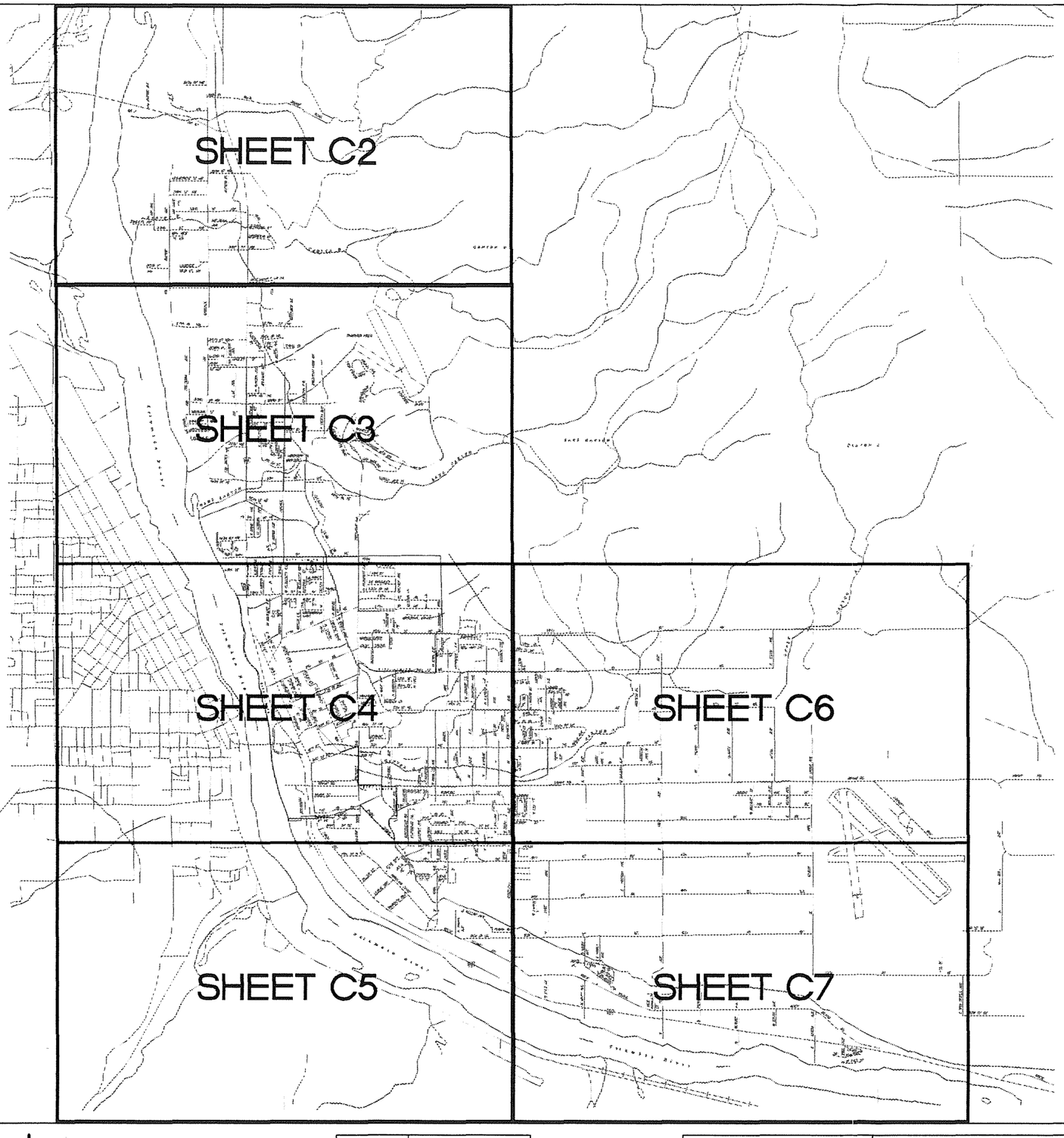
DOUGLAS COUNTY CFHMP
PRELIMINARY COST ESTIMATE

JL-1

JAMESON LAKE OUTLET

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
1	MOBILIZATION/DEMOBILIZATION	1	LS	$7,000.00	$7,000
2	EXCAVATION - DRAINAGE DITCH	1500	CY	$15.00	$22,500
3	30 INCH REINFORCED CONCRETE PIPE	1,300	LF	$60.00	$78,000
	72 INCH MANHOLE	4	EA	$5,000.00	$20,000
	COMPACTED BACKFILL - PIPE TRENCH	1,300	CY	$12.00	$15,600
	GRAVEL FILL - PIPE BEDDING	100	CY	$20.00	$2,000
	CULVERT INLET	1	EA	$2,500.00	$2,500
				SUBTOTAL:	$147,600
	SALES TAX	7.80%			$11,513
				SUBTOTAL:	$159,113
	CONTINGENCY	30%			$47,734
				CONSTRUCTION COST SUBTOTAL:	$206,847
	ENGINEERING, LEGAL & ADMIN.	30%			$62,054
		1			
				SUBTOTAL:	$268,901
				TOTAL ESTIMATED PROJECT COST:	**$269,000**

APPENDIX C.
STORM DRAIN INVENTORY MAPS



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DOUGLAS COUNTY
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

STORM DRAINAGE INVENTORY OF
EAST WENATCHEE AREA
VICINITY / KEY MAP

drawing number C1
sheet number
of

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

STORM DRAINAGE INVENTORY OF EAST WENATCHEE AREA

drawing number C2

sheet number of

LEGEND

- STREETS
- CITY LIMITS
- EXISTING CREEK, STREAM
- EXISTING CANAL
- EXISTING CATCH BASIN
- EXISTING MANHOLE
- EXISTING CULVERT / SIZE
- EXISTING STORM DRAIN PIPE / SIZE
- EXISTING DITCH
- EXISTING FLOW DIRECTION / ROAD DITCH
- DRAINAGE SUBBASIN BOUNDARY

SHEET KEY

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C3	
C4	C6
C5	C7

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

STORM DRAINAGE INVENTORY OF
EAST WENATCHEE AREA

drawing number C3
sheet number
of

LEGEND

- STREETS
- CITY LIMITS
- EXISTING CREEK, STREAM
- EXISTING CANAL
- EXISTING CATCH BASIN
- EXISTING MANHOLE
- EXISTING CULVERT / SIZE
- EXISTING STORM DRAIN PIPE / SIZE
- EXISTING DITCH
- EXISTING FLOW DIRECTION / ROAD DITCH
- DRAINAGE SUBBASIN BOUNDARY

C2
C3
C4 C6
C5 C7

SHEET KEY

N

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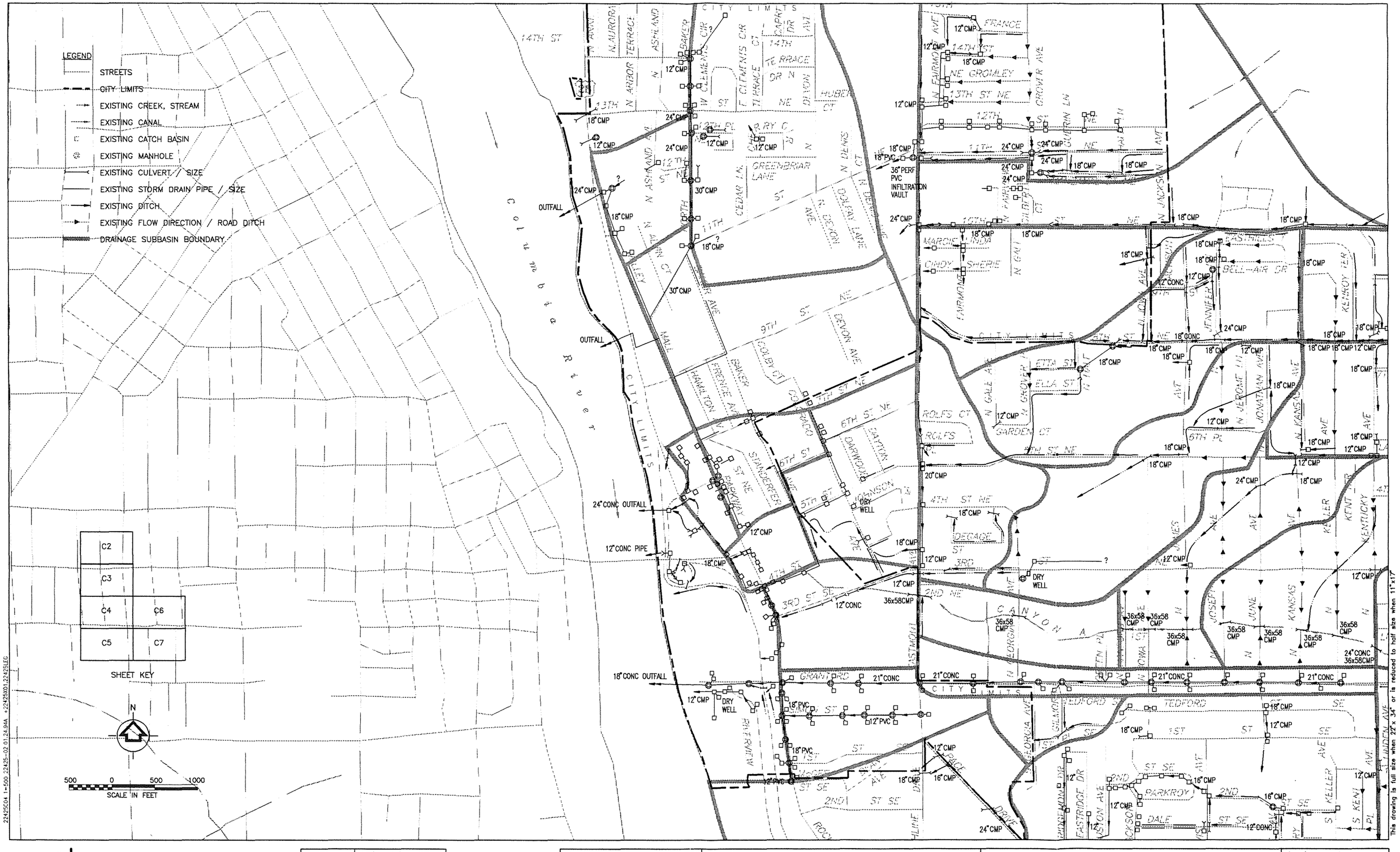

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

STORM DRAINAGE INVENTORY OF EAST WENATCHEE AREA

drawing number C4

sheet number of

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LEGEND

- STREETS
- CITY LIMITS
- EXISTING CREEK, STREAM
- EXISTING CANAL
- EXISTING CATCH BASIN
- EXISTING MANHOLE
- EXISTING CULVERT / SIZE
- EXISTING STORM DRAIN PIPE / SIZE
- EXISTING DITCH
- EXISTING FLOW DIRECTION / ROAD DITCH
- DRAINAGE SUBBASIN BOUNDARY

C2
C3
C4 C6
C5 C7

SHEET KEY

N

500 0 500 1000

SCALE IN FEET

Columbia River

S KELLER RD
S KELLER AVE
S HIGHLINE DRIVE
S 47TH ST
S 47TH PL
S 47TH CT
S 46TH ST
S 45TH ST
S 45TH PL
S 44TH ST
S 43RD ST
S 42ND ST
S 41ST ST
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S 5TH ST
S 4TH ST
S 3RD ST
S 2ND ST
S 1ST ST
ELVA WAY
JULIA WAY
CAROLYN ST SE
LESLIE WAY
KIMROCK WAY
FILLER ST
IOWA AVE
S JARVIS AVE
S KENTUCKY AVE
FLORA ST
ROCK
28

18"CONC
24"CMP
12"
16"CMP
12"CMP
12"CONC
60"CMP
48"CMP

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

STORM DRAINAGE INVENTORY OF EAST WENATCHEE AREA

drawing number C5

sheet number of

LEGEND

- STREETS
- CITY LIMITS
- EXISTING CREEK, STREAM
- EXISTING CANAL
- EXISTING CATCH BASIN
- EXISTING MANHOLE
- EXISTING CULVERT / SIZE
- EXISTING STORM DRAIN PIPE / SIZE
- EXISTING DITCH
- EXISTING FLOW DIRECTION / ROAD DITCH
- DRAINAGE SUBBASIN BOUNDARY

AGRICULTURAL RUNOFF

SHEET KEY

C2	
C3	
C4	C6
C5	C7

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

STORM DRAINAGE INVENTORY OF EAST WENATCHEE AREA

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COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

STORM DRAINAGE INVENTORY OF EAST WENATCHEE AREA

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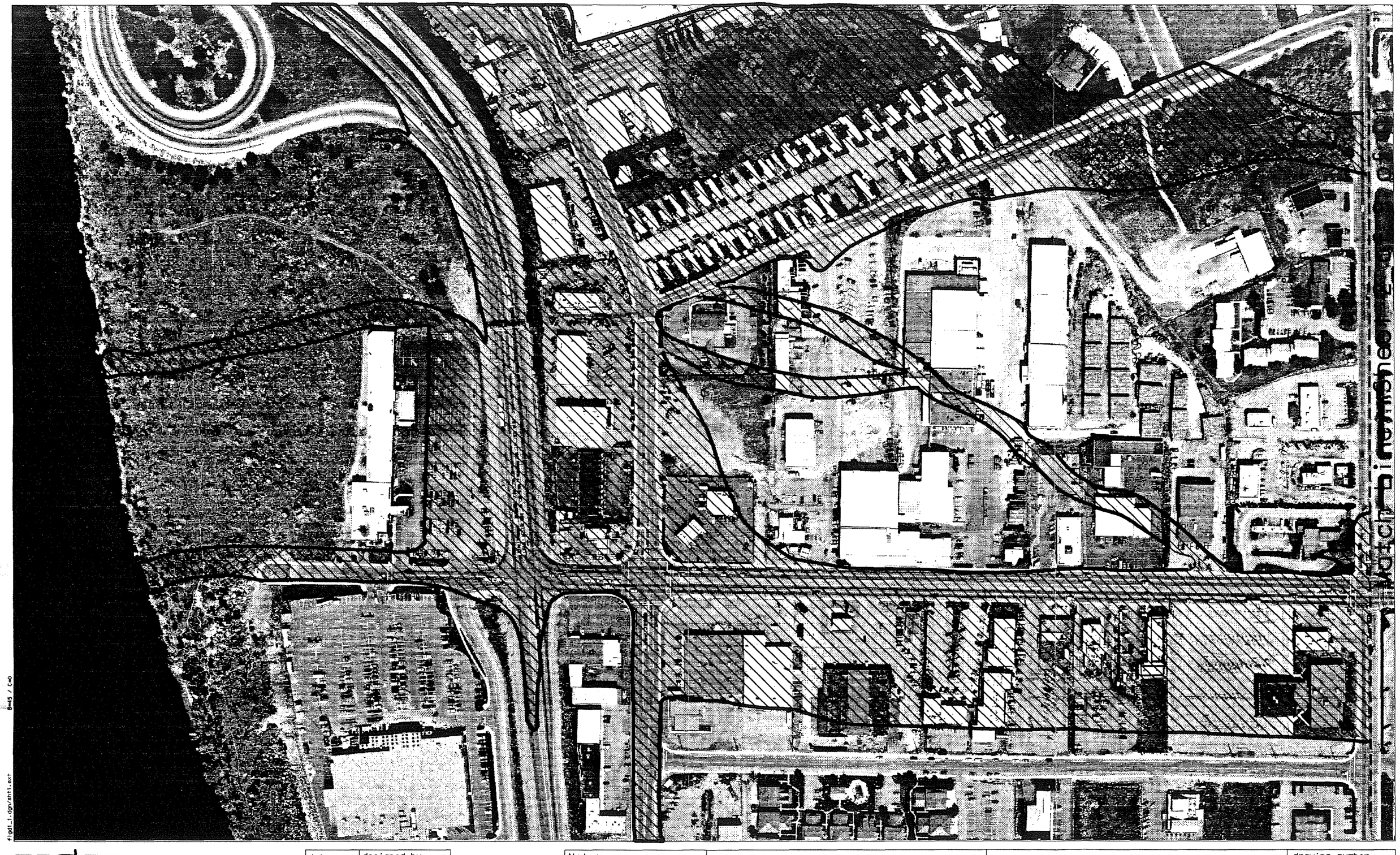
of

APPENDIX D.
FLOODPLAIN AND FLOODWAY MAPS



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Note:
Flood boundaries on this sheet from SCS (1983)

DOUGLAS COUNTY

COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS

CANYON A

drawing number D1

sheet number 1 of 9

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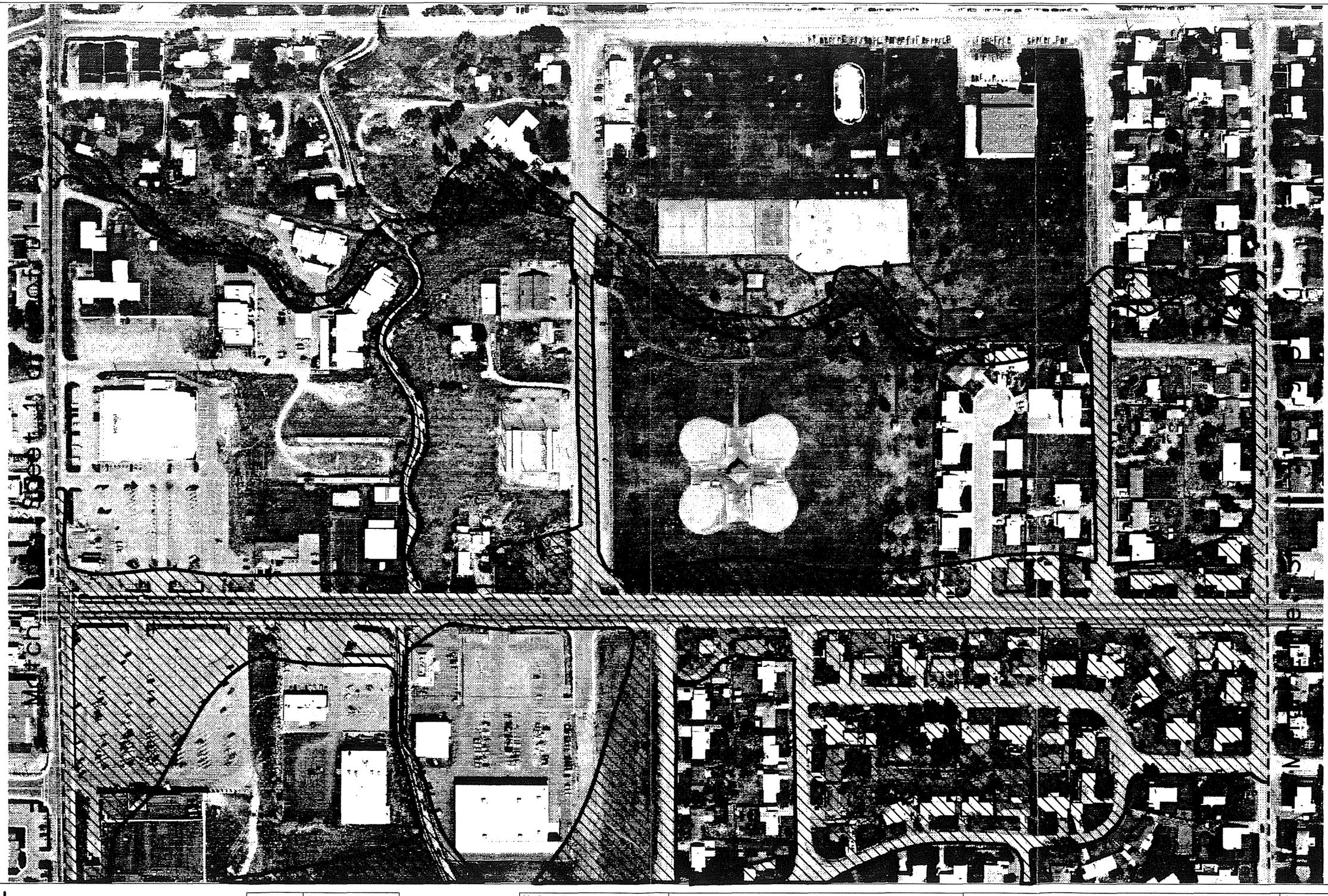

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Note: Flood boundaries along Grant Road from SCS (1983)

DOUGLAS COUNTY

COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS

CANYON A

drawing number	D1
sheet number	2 of 9

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DOUGLAS COUNTY

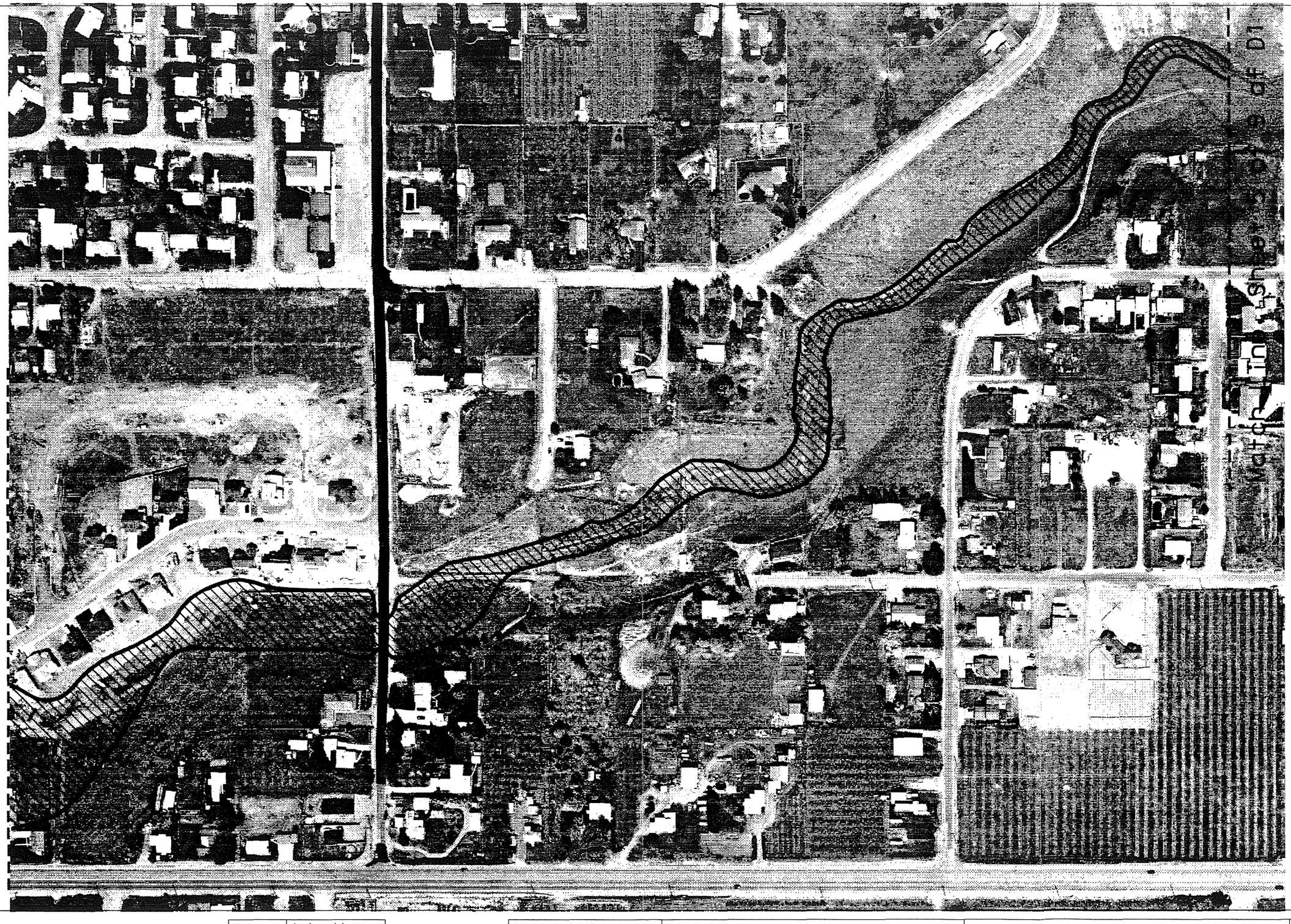
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS

CANYON A

drawing number D1

sheet number 3 of 9



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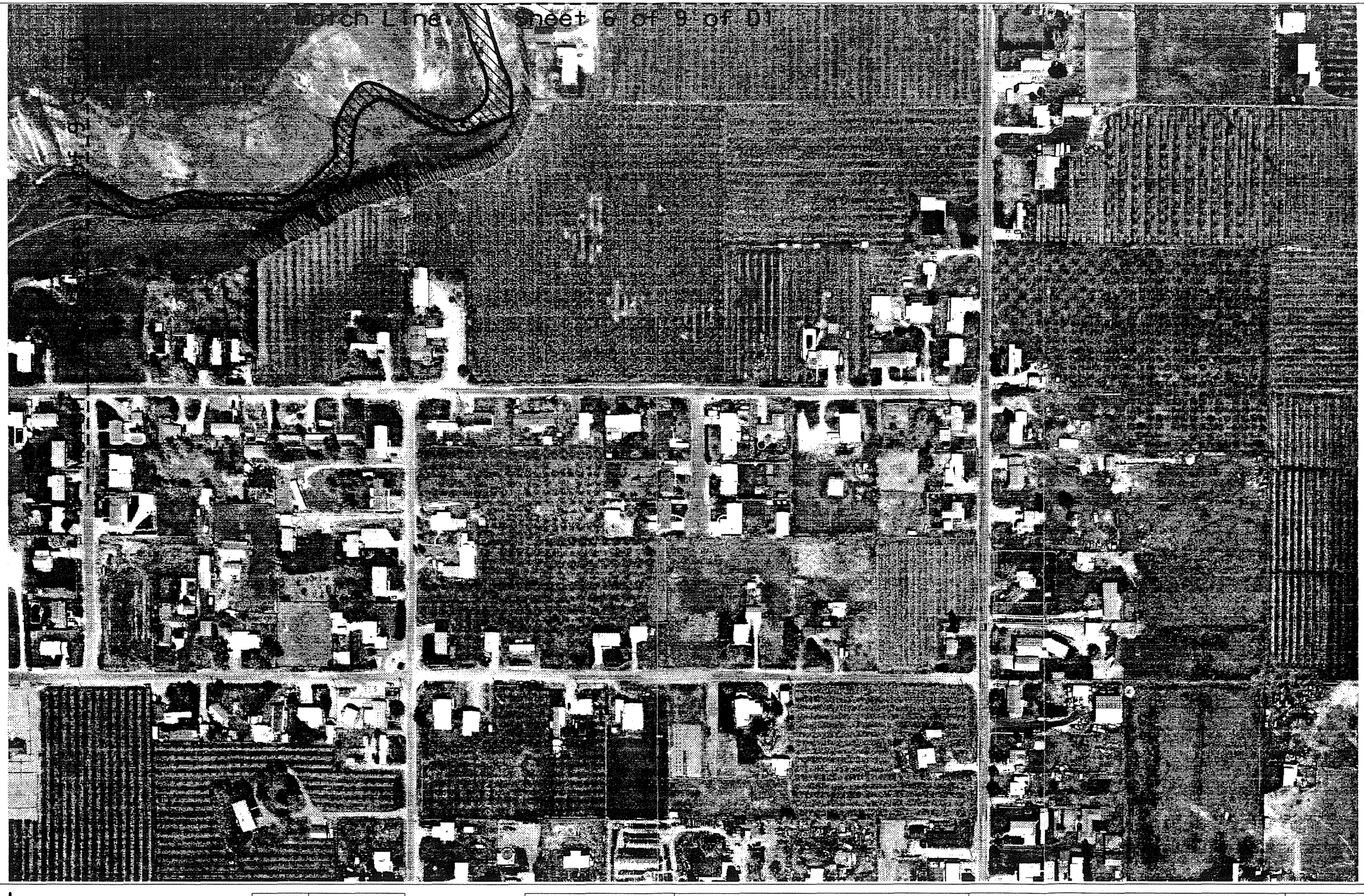
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS
CANYON A

drawing number D1

sheet number 4 of 9



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DOUGLAS COUNTY

COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS

CANYON A

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sheet number	5 of 9

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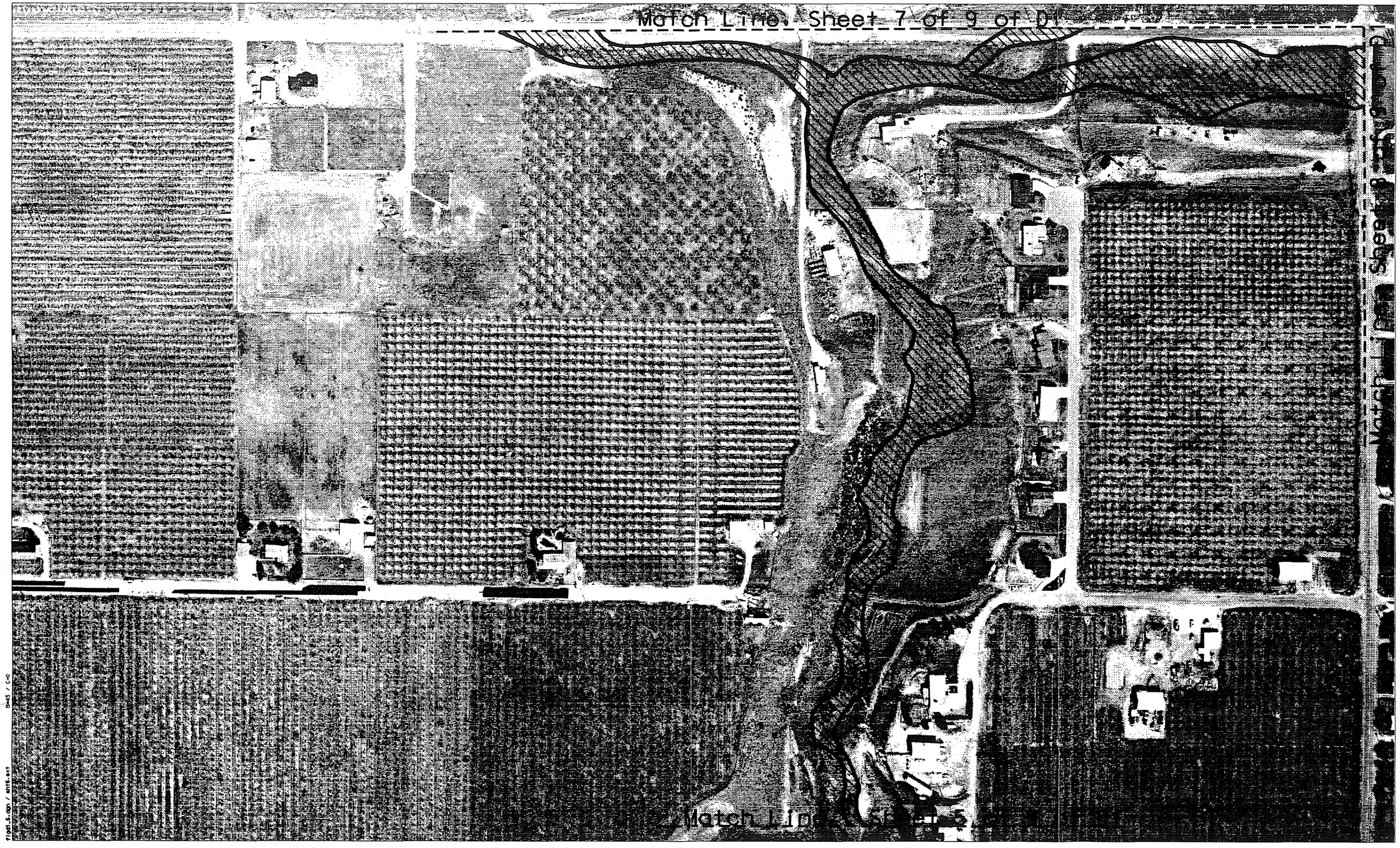

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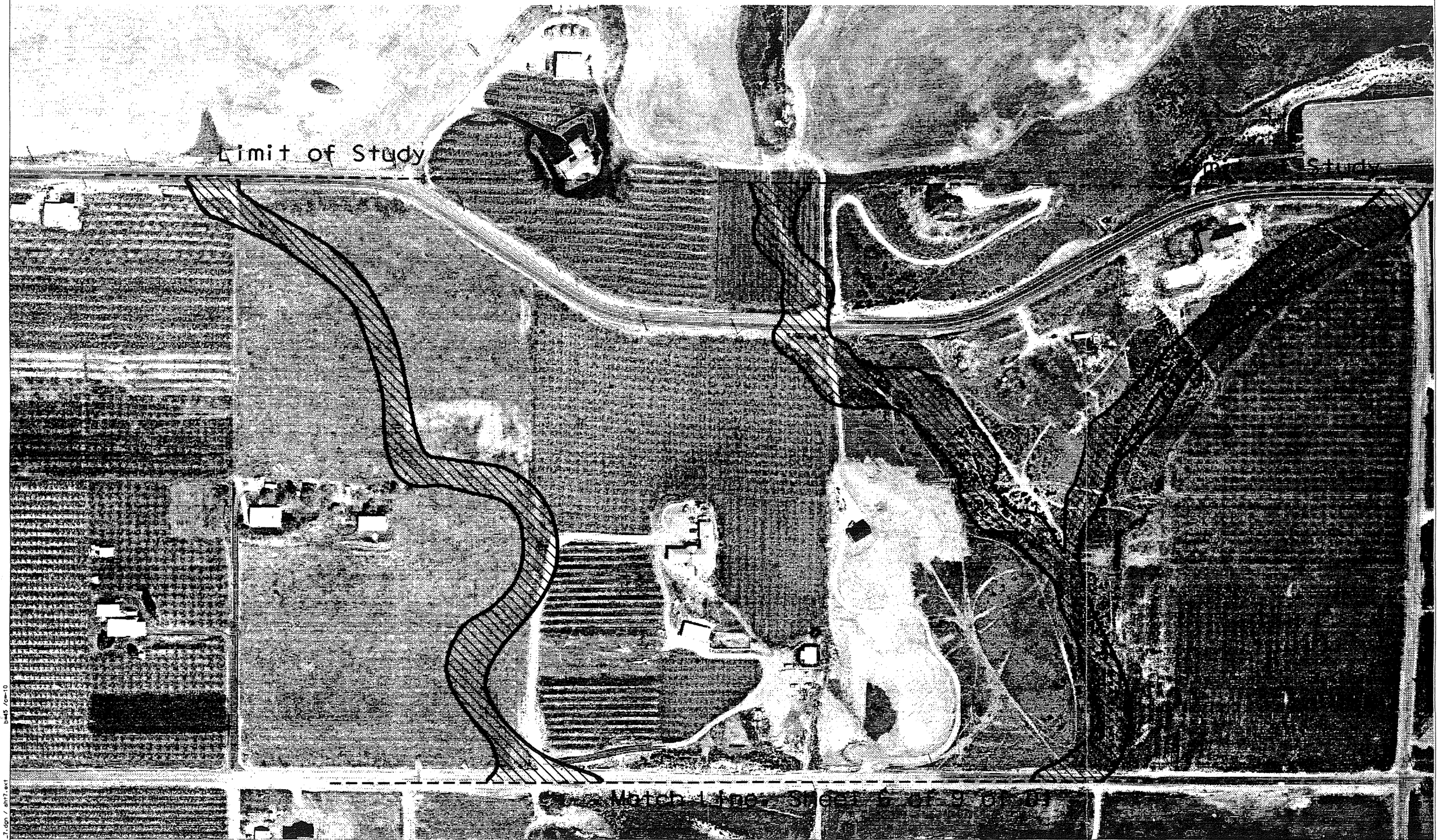
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS
CANYON A

drawing number D1

sheet number 6 of 9



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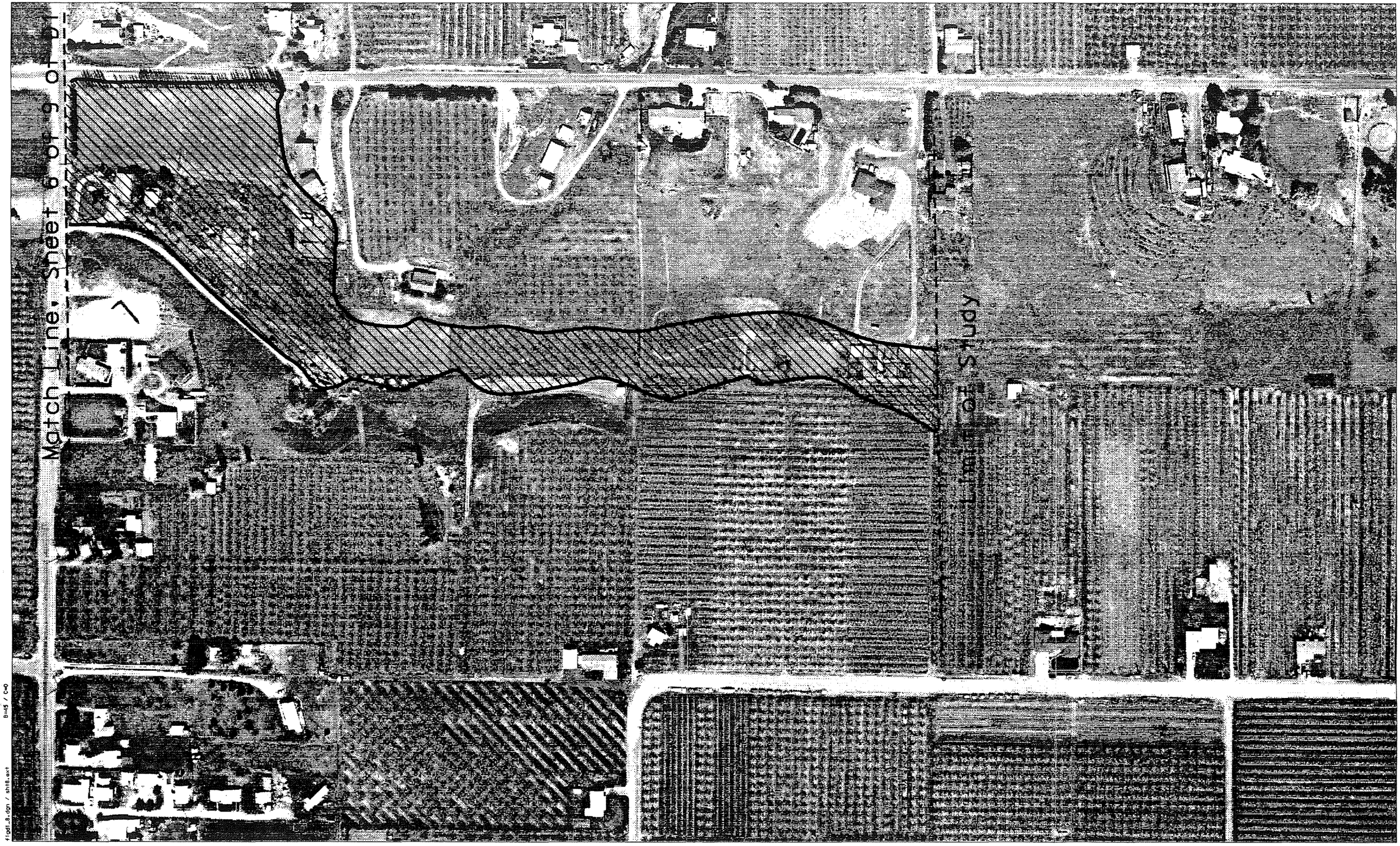

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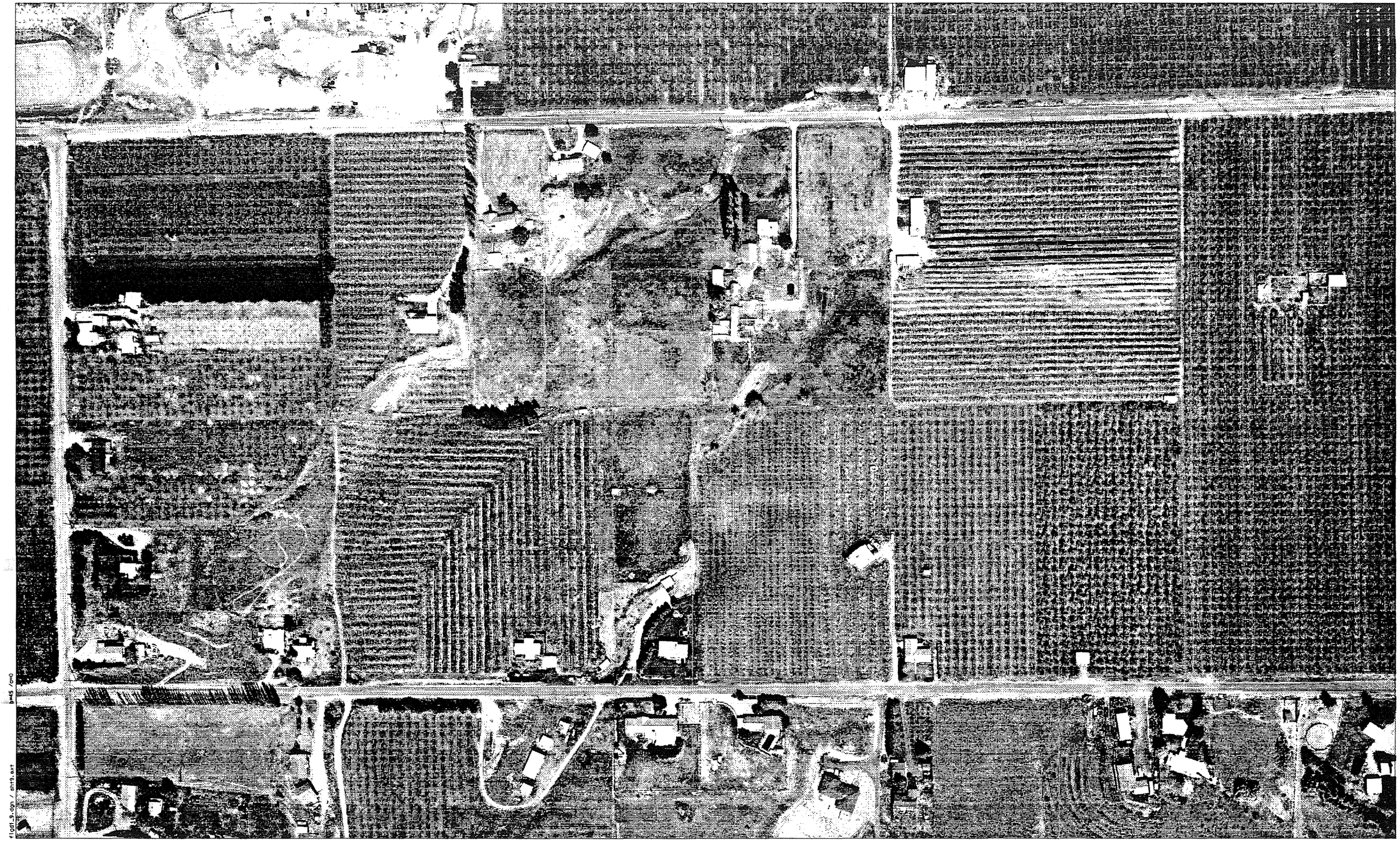

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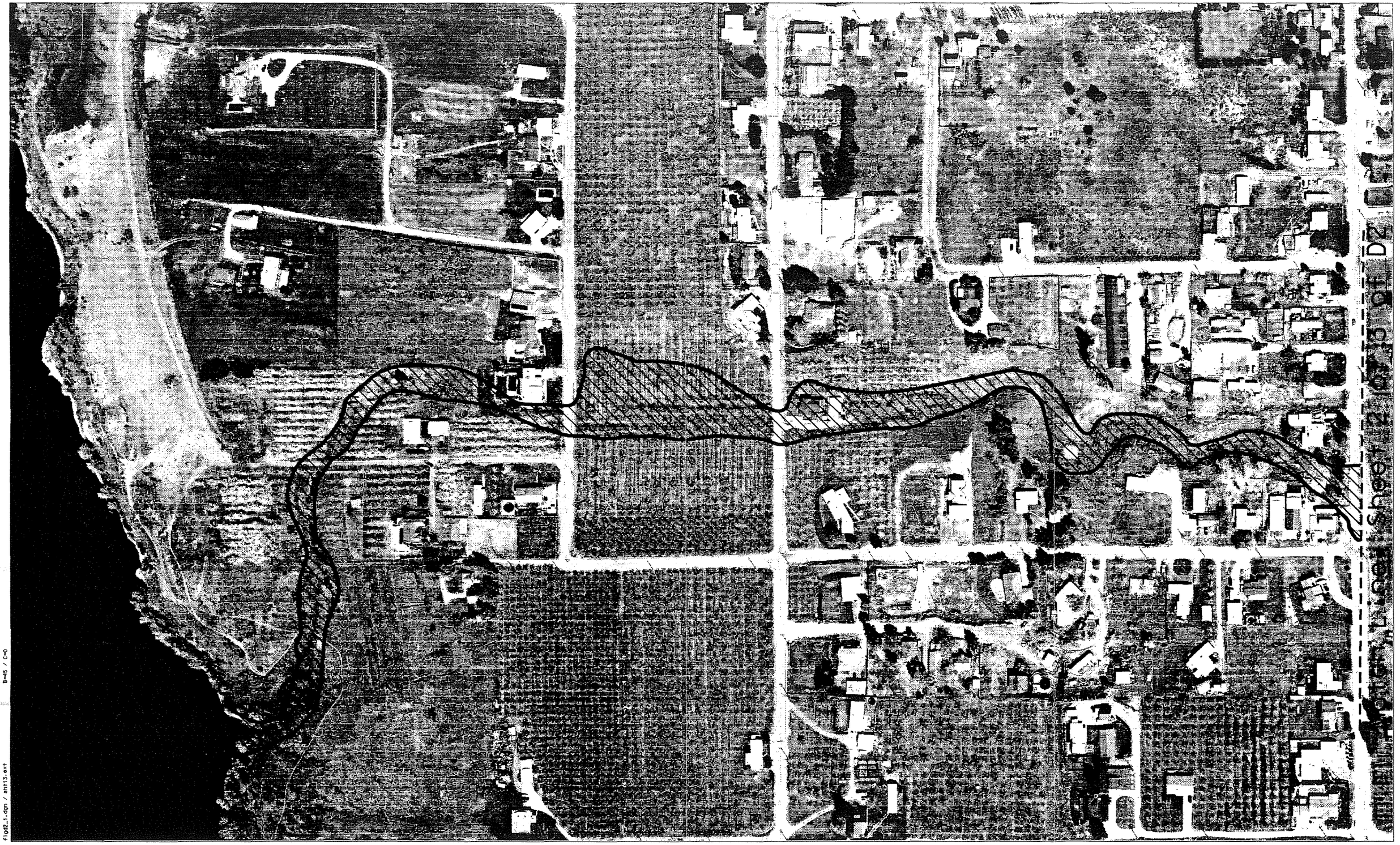
revisions	DOUGLAS COUNTY COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	100 YEAR FLOODPLAIN - EXISTING CONDITIONS CANYON A	drawing number D1 sheet number 9 of 9



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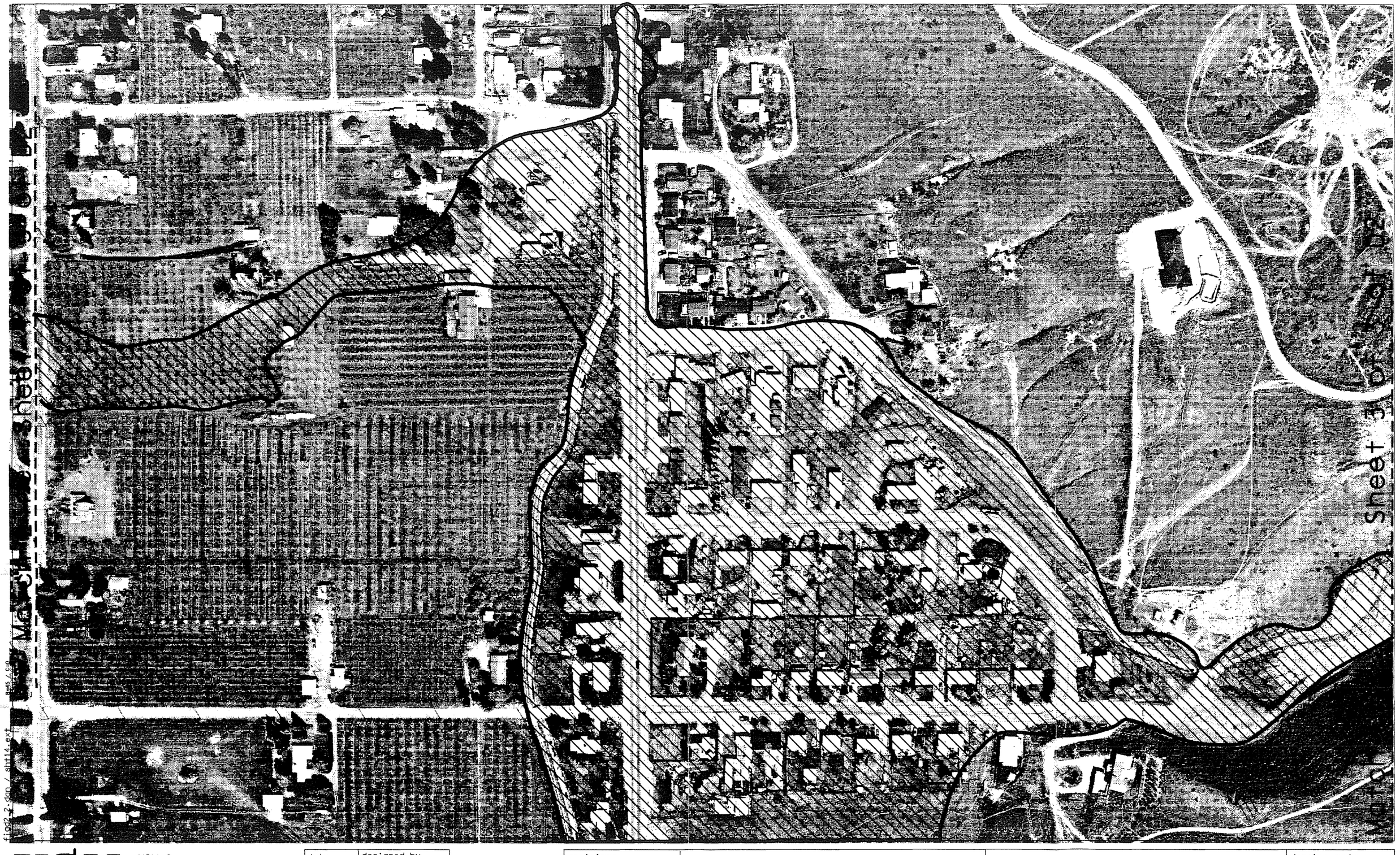
DOUGLAS COUNTY
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS
CANYON B

drawing number D2

sheet number 1 of 3



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Sheet 2 of 3 of D2

Match L

Bar45 / Col0

fig02_3_dgrpan15.dxf

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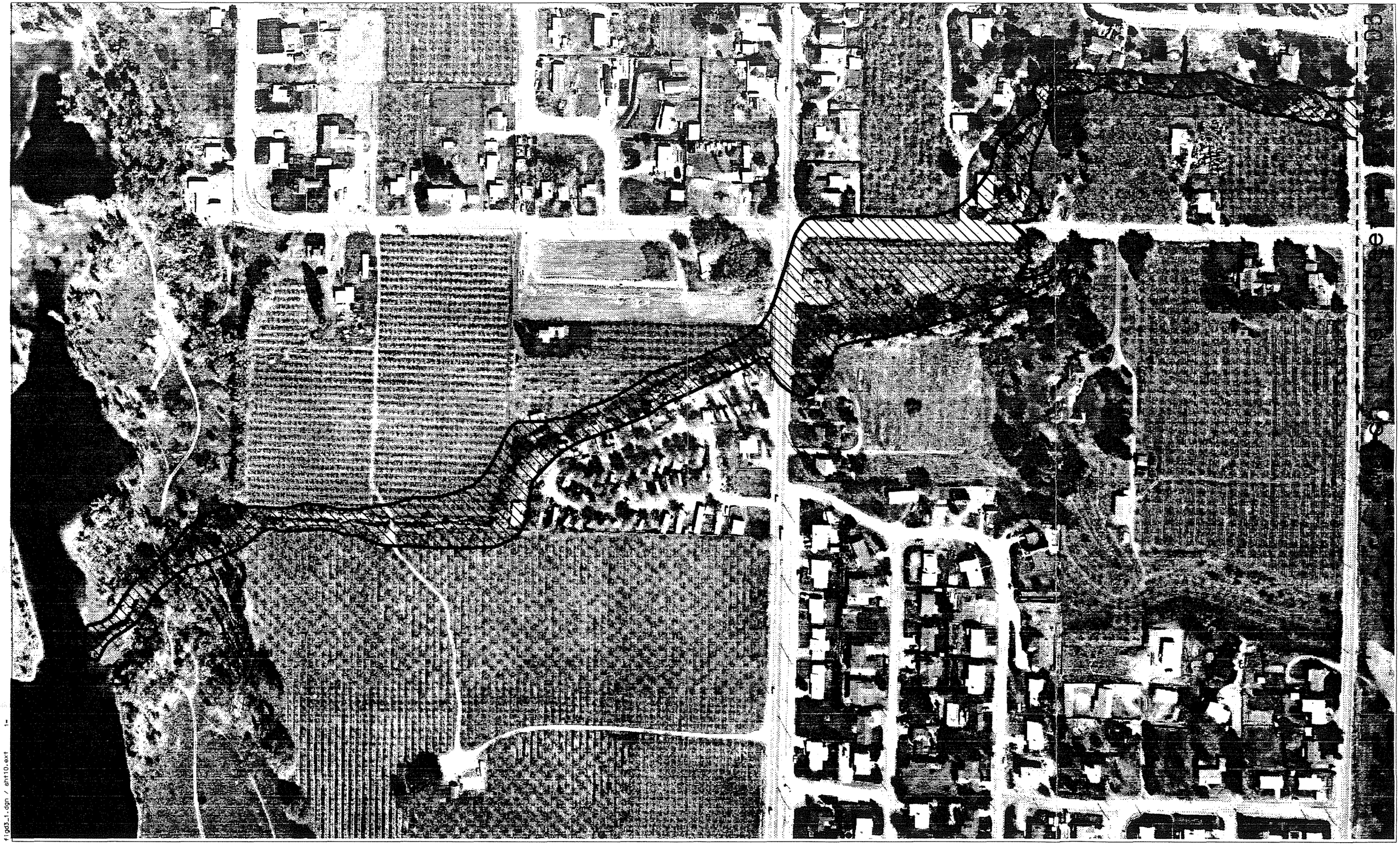

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fig03_2.dgn / sht11.ext
bm45 / am0

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DOUGLAS COUNTY

COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

100 YEAR FLOODPLAIN - EXISTING CONDITIONS

SAND CANYON

drawing number D3

sheet number 3 of 3

figd3_3.dgn / ent12.ext
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