Lower Big Quilcene River

Comprehensive Flood Hazard

Management Plan

Quilcene, Washington

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Prepared for:

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QUILCENE, WASHINGTON
FOR
JEFFERSON COUNTY DEPARTMENT OF PUBLIC WORKS

INTRODUCTION

This flood hazard management plan is presented on behalf of the LIT (Local Interagency Team), of which Jefferson County Department of Public Works is the lead agency, to provide a long-term basis for management of flood hazards in the lower Big Quilcene River drainage. The plan was prepared by a project team consisting of Kenneth G. Buss from GeoEngineers, Inc., Redmond, WA; Kent Doughty from Cascade Environmental Services, Bellingham, WA; Jane Preuss from Urban Regional Research, Seattle, WA., and Jefferson County Department of Public Works, as well as the agencies and individuals of the LIT. The location of the river is shown with respect to local features on the Vicinity Map, Figure 1, and the River Segment Maps, Figures 2a through 4b. The area of concern extends from just above the Hiddendale community at about River Mile (RM) 4.0 (approximate river miles from the mouth) down to the mouth of the river in Quilcene Bay. This area of the drainage has been subjected to an increasing frequency of floods and flood damage beginning in the late 1950s and early 1960s. These floods have resulted in considerable damage to public and private property as well as anadromous fish habitat. There has also been an increase in risk to health and safety of the residents living along the river. This is evident as damage to homes and adjacent property as well as risk to health caused by flooding of septic tank/drainfield systems and wells providing water for residential use. Public property including roads, bridges and the Quilcene National Fish Hatchery (QNFH) have also been damaged by these flood events.

Quilcene Bay is home to a major shellfish industry, a resource that has been damaged by deposition of silt and contamination in past floods. Anadromous fish habitat, from the Hiddendale community downstream, has been severely impacted by deposition in the riverbed and erosion of streambanks during flooding. Riparian vegetation along portions of the river has been damaged or destroyed, further contributing to flood damages and degradation of habitat.

GOALS, OBJECTIVES AND LIMITATIONS

Primary goals of the Flood Plan are specifically identified in the Scope of Work provided by Jefferson County Department of Public Works and the State of Washington Department of Ecology (Ecology) regarding the Big Quilcene River Flood Hazard Study (Grant Number G9700029). Specific language comprising "The Scope of Work" presented by Jefferson County and Ecology to the project team is repeated below:

TASK 1

Facilitate coordination between Department of Ecology, Jefferson County, U.S. Fish and Wildlife Service, Quilcene Flood Board, U.S. Forest Service, and the Local Interagency Team to finalize the Big Quilcene River Comprehensive Flood Management Plan. To accomplish this task, the consultant will utilize information provided in the Geomax and Philip Williams Studies, the Big Quilcene Watershed Analysis, the Salmon/Steelhead Habitat Inventory and Assessment Project (SSHIAP), and historical sources. Additional information may be available from GeoEngineers, Inc., and the Dungeness/Quilcene (DQ) Study. The finalized Comprehensive Plan will include recommendations to reduce flood hazard while protecting fish habitat.

TASK 2

Provide a Cost/Benefit Analysis and Financial Plan to support projects proposed in the Comprehensive Plan.

TASK 3

Evaluation of activities completed on the river to date, using existing information only. Additional information regarding the specific goals of this project was provided by Jefferson County Department of Public Works and members of the Local Interagency Team (LIT). The goals conveyed by the County and the LIT are as follows:

- Reduce flood hazard while minimizing impacts to habitat
- Health and Safety
- Habitat restoration

The project team used information and results presented in existing reports to develop a plan of action focused on achieving the goals identified above. The protection of existing fish and aquatic habitat, as well as opportunities to improve habitat during the execution of any and all recommendations, is also clearly identified as a prerequisite of the plan.

Reports reviewed as part of the development of this plan are provided in the

References Section. In addition to cited reports, data and information from representatives of Jefferson County Department of Public Works, Washington State Department of Fish and Wildlife, Jefferson County Conservation District, the LIT, and residents and owners of property near the river were utilized.

The Scope of Work does not provide for the following:

1. Additional reconnaissance or data collection.
2. Additional research.
3. Additional analysis or reworking of existing data.
4. Error analysis or testing of results and hypothesis presented in reports of others.

Because of this, it was necessary to assume that previous data is accurate and represents the current situation. When obvious discrepancies arose, the subject data was not used in development of the Actions recommended in this plan.

The plan is intended to provide guidance for management of hazards associated with flooding of the lower Big Quilcene River. The plan itself cannot control floods or reduce severity or frequency of flooding. However, if implemented, Actions recommended in this plan are intended to provide a systematic approach to reduce flood hazards and assist in long-term stabilization of the lower river system. As such, the various Actions recommended are meant to be implemented in conjunction with each other so that long-term reduction of flood hazards is achieved.

In addition to flood hazard mitigation, the plan intent is to reduce impacts from flooding that directly or indirectly impose adverse impacts to fisheries and other aquatic habitat. It is recommended, as a mandate of the plan, that all Actions be conducted in a manner to minimize disruption of aquatic resources and habitat. It is also recommended that wherever applicable fisheries protection and restoration be implemented as a criterion of all design plans.

Certain assumptions were necessary in development of the plan. As stated earlier, data and information in previous studies were assumed to be accurate. The team also assumed, for purposes of evaluations, that activities on federally-owned lands in the upper watershed, such as logging and road building, will continue to decrease. The State of Washington has adapted into regulatory law prescriptions developed as part of the Big Quilcene River Watershed Analysis. This action will also have a long-term beneficial effect of reducing sediment from nonfederally-owned forested lands in the upper watershed. It was further assumed that flood flows in the future will be at least as great or greater than those experienced in the last 10 to 20 years. Finally, an assumption was made that recommended actions described in the GeoEngineers, Inc. report (1996) prepared for the U.S. Fish & Wildlife Service will be carried out. These recommended actions will reduce the volume of bedload material presently being transported downstream of U.S. Highway 101.

WATERSHED DESCRIPTION

GENERAL

Stated geography of the Big Quilcene River watershed, including geology, topography, hydrology and weather, historical events and flooding history, is based on information from the above-mentioned sources. The Quilcene, Mt. Walker, and Tyler Peak USGS quadrangle maps were also reviewed to determine if any mining claims are located within the watershed.

The Big Quilcene River watershed is located on the east flank of the Olympic Mountain Range (Figure 1). The watershed is bounded by watersheds of the Dungeness, Dosewallips and Little Quilcene rivers. The river is approximately 30 miles long, from its headwaters near the eastern boundary of Olympic National Park to its outlet into Hood Canal near Quilcene, Washington.

TOPOGRAPHIC SETTING

The Big Quilcene watershed drains about 69 square miles of mountainous region bounded on the north by the Quilcene Range, on the west by Mt. Buckhorn, on the south by Crag and Buck Mountains, and on the southeast by Mt. Walker. Watershed terrain is generally steep, with roughly 7,800 feet of total vertical relief.

Terrain surrounding the main stem river above RM 4.0 is typically composed of very steep, rugged slopes that form a narrow upper channel corridor. Area slopes have numerous tributary streams, many of which drain relatively large subbasins. These steep slopes are prone to mass wasting, debris torrents and snow avalanches.

From approximate RM 4.0 to RM 2.5, relief and steep terrain surrounding the main stem decrease slightly, although width of the stream corridor increases significantly. Ravine slopes in this area are drained by a small intermittent tributary stream on the south and a major perennial stream, Penny Creek, that enters the main stem from the north just upstream of the Highway 101 bridge. Penny Creek supplies water to the National Fish Hatchery.

Below RM 2.5 surrounding terrain consists of the northern flank of Mt. Walker, which forms the south ravine slope of the stream, and broad, low-lying, flood-plain terraces located on the north river bank. The flood plain extends northward and merges with similar flood plains associated with the Little Quilcene River. No tributary streams enter the main channel along this lower reach. Below this point, the river flows across the fan-delta and into Quilcene Bay.

WEATHER

The region has a relatively mild maritime climate. Most precipitation for the Big Quilcene watershed originates from weather systems moving across the Olympic Peninsula from the Pacific Ocean. Average annual watershed precipitation is approximately 61 inches, with rainfalls ranging from 51 inches near Quilcene and the river mouth, to 76 inches in the upper watershed. Average annual temperature in the Quilcene area is 50°F (Fahrenheit), ranging from an average summertime high of 78°F to an average wintertime low of 30°F. Extreme temperatures are usually rare and of short duration.

Over 80 percent of the annual precipitation falls between October and April. Winter precipitation usually occurs as snowpack above an elevation of 4,000 feet, as rain and snow between 2,000 and 4,000 feet, and as rain below 2,000 feet. Summer months are relatively dry. Subsequently, most high river flow events result from either brief and intense winter or spring rainstorms or heavy rains falling on existing snowpack.

HYDROLOGY

Limited historical discharge records from USGS gauging stations indicate average low-flow discharge is less than 100 cubic feet per second (cfs), while maximum flows range from 1,500 cfs to 3,050 cfs. Additional flows recorded at the diversion dam (9.5 miles upstream of the river mouth) estimate a maximum flow over the period of 1934 to 1990 of 3,650 cfs. It is estimated that representative flood discharges at the river mouth are approximately 3,580 cfs for the 10-year flood, and 5,900 cfs for the 100-year flood (Big Quilcene Watershed Analysis, 1994).

GEOLOGY, SEDIMENT SUPPLY AND DEPOSITION

Geology

The Big Quilcene River watershed is underlain primarily by three geologic units; bedrock, a unit of various glacial deposits, and alluvial post-glacial deposits.

The bedrock unit consists of rock belonging to the Crescent Formation, which includes erosion resistant volcanic basalt flows inter-bedded with comparatively less resistant siltstones, shales and sandstones. Bedrock is exposed at the surface along river banks above RM 1.8, or buried at shallow depths beneath the channel. Typically, presence of bedrock along riverbanks tends to prevent lateral channel migration.

The unit of glacial deposits is derived from possibly several glaciations and includes lodgement tills interbedded with outwash sands and gravels. The till is composed of dense sandy silt with gravel, cobbles and boulders, and the outwash consists of stratified sand and gravel deposited by meltwater streams flowing off an approaching glacier. The alluvial deposits consist of sand and gravel with local silt or clay, generally derived from bedrock and glacial deposits and deposited by stream flow. Peat deposits are also present locally within the alluvium.

Sediment Supply

Glacial and alluvial deposits as well as siltstone and sandstone members of the Crescent Formation provide a ready source of coarse bedload material to the river and its tributaries above RM 2.0. Glacial deposits are present primarily east of Penny Creek, but also mantle ravine slopes and valley walls upstream of the hatchery and along several tributary channels. Most commonly, sand and gravel are delivered from hill slopes and stream banks to the channel by mass wasting, which includes landslides, debris flows and debris torrents. Stream reaches most historically prone to mass wasting occur upstream of RM 4.0 and between RM 1.3 and 2.0.

Most coarse material contributed to the river is transported as bedload, and fine sediment is usually transported as suspended load. Bedload material, typically mobilized once or twice per year during peak flood events, moves through higher gradient reaches to lower gradient reaches, where it is deposited within and alongside the channel. Most suspended sediment is carried further downstream, where it is deposited on mudflats and discharged into Quilcene Bay.

In general, channel conditions upstream of RM 3.5 are more conducive to rapid transportation of bedload materials through the upper reaches, mostly as a result of very steep channel gradients from 3 to 20 percent, and narrow stream corridors. Conversely, channel conditions downstream of RM 3.5 are more conducive to deposition of bedload materials as a result of lower channel gradients, relatively wide stream corridors and the presence of broad flood plains. Gravel transported by Penny Creek to the main stem is generally removed at the National Fish Hatchery entrance.

Several channel segments downstream of RM 3.5 have been identified as areas of extensive deposition, primarily by bedload transported from upstream reaches. In-channel deposition of bedload is typically a result of several factors, including local decreases in channel gradient, proximity of sediment source areas, migration of gravel bars, and channel width. There are several areas of pronounced bedload accumulation. Between RM 0.0 and RM 0.8, the streambed elevation has increased up to 4 feet in places. (Collins, 1993) Between RM 2.0 and approximate RM 2.3, there is a zone of channel braiding and bar migration active since at least the early 1960's. The reach between RM 2.5 and RM 3.4 has experienced extensive bar building and channel braiding since 1962 (GeoEngineers 1996).

Another area of extensive bedload deposition is located between RM 1.3 and RM 1.8. In addition to deposition of bedload transported from upstream reaches, this area is subject to sediment input from extensive erosion of bank material and slope failure processes. As a result, the area has experienced very rapid channel aggradation, bar accretion and active channel migration.

AQUATIC RESOURCES

Both resident and anadromous salmonids inhabit the lower Big Quilcene River. Fish passage is blocked at RM 7.6 by a natural rock waterfall. Summer-run chum migrate from saltwater to spawn from August through mid-October. This wild fish species has reached critically low population levels in Hood Canal, to which the Big Quilcene River is tributary. Summer chum salmon are proposed for listing as threatened under the Endangered Species Act. A late fall chum salmon run also occurs in the Big Quilcene and is supported by natural spawning from hatchery origin fish as well as artificial production. Late fall chum salmon spawn from mid-November through early January and the population is considered healthy. Coho enter the river in mid-August through mid-November with spawning occurring from November through mid-January. Coho salmon stocks in the Big Quilcene River are predominantly of hatchery origin, and hence are genetically influenced by hatchery production. Winter steelhead spawn from mid-February through May. Their geographic spawning area extends further upstream in the watershed than other anadromous species since the hatchery fish weir is disengaged during migration of steelhead. Summer/fall chinook, no longer raised by the hatchery, are present in sparse numbers. Coho salmon and steelhead and cutthroat trout are the only anadromous species to reside in the river as juvenile fish for extended periods. Pink and sockeye salmon have appeared in the river intermittently. In addition to winter steelhead, cutthroat trout are the primary anadromous species in the river allowed to spawn above the hatchery.

Quilcene Bay and surrounding marine waters include some of the most productive oyster and clam growing areas in Washington State, supporting a major shellfish industry as well as providing recreational opportunities for shellfish harvesting. Coast Seafoods hatchery at Quilcene is considered the world's largest shellfish hatchery. Both the seed and harvested shellfish contribute to the commercial production. Pacific oysters and manila clams are found in local public tidelands. Washington State recently purchased oyster and clam beds near the Big Quilcene mouth, an area comprising the largest State-owned shellfish tidelands in Washington.

Abundant and diverse fish populations are a legacy of the Pacific Northwest, including the Big Quilcene River. Fishing has sustained indigenous peoples of the Northwest for thousands of years and is inseparable from their cultural heritage. The importance of fish to indigenous peoples continues today and is recognized by treaty. The commercial fishing industry is a substantial component of Jefferson County economy. Donaldson and Steele (1994) report the annual commercial salmon catch in local marine waters (Area 12A) is valued at $111,000 (10 year average ending 1992). The Big Quilcene National Fish Hatchery is the primary contributor to this production, with annual release targets of 2.2 million fall chum salmon fry, 450,000 coho salmon smolts, and 400,000 summer chum salmon fry. In addition, there has been an annual release of 300,000 salmon smolts reared in Quilcene waters by the Point No-Point Treaty Council. Sport fishing greatly benefits the local economy. Sportfishing and non-commercial shellfishing in the Quilcene/Dabob Bay area has sustained an annual direct value of approximately $200,000. It is estimated that sport harvesting returns an additional 40 cents on the dollar to the local community (Donaldson and Steele 1994). Commercial oyster and clam production is valued at $6,140,000 per year and supports 65 FTE employees (Donaldson and Steele 1994). In summary, total marine resources have a direct annual value of over $6.3 million plus indirect benefits in support services.

PAST ACTIVITIES IN THE BIG QUILCENE WATERSHED

LOGGING

Early timber harvest activities in the Quilcene area were primarily located in lower elevations, in close proximity to marine or rail transport. Timber harvest began in the upper watershed following the 1925 and 1930 fires in Penny and Marple Creeks, which introduced salvage harvesting. Logging increased steadily during and following World War II, with peak activity occurring from the 1960's to the 1980's. Timber harvesting has been decreasing since the late 1980's.

DEVELOPMENT

The first homestead in Quilcene was established in 1860. The original townsite of Quilcene was located in the river floodplain, but gradually moved to higher ground as a result of continued flooding. It is not known when dikes were first constructed in the lower 0.5 mile of the river. Survey maps circa the 1880s show diked channels, coincident with expansion of railroad and lumber industry in the area.

Construction of the Hiddendale Residential Community development began in 1962. This development is located upstream of the Quilcene National Fish Hatchery, on the south bank. Hiddendale is constructed entirely within the 100-year flood plain; expansion continues at the present time.

In general, areas above RM 4.0 have experienced only limited development over the past few decades, but have been subjected to timber harvesting and road building. From approximate RM 1.5 to RM 4.0, development has increased significantly over the past three decades. This increase is mostly a result of steady growth at Hiddendale, numerous homes situated on ravine slopes on the north side of the river, and expansion of hatchery facilities.

Below RM 1.5 land modifications have also increased over the past several decades, resulting in occupation of historical flood plains by farms, pasture lands and residential homes.

DAMS AND WATER WEIRS

Several small weirs and one dam structure have been constructed in the watershed since 1911. The Quilcene National Fish Hatchery (QNFH) was built in 1911, with a weir to divert water from Penny Creek. With hatchery expansions, additional water was required for operations. A water intake was therefore constructed upstream of the hatchery on the north bank. Subsequently, a second intake was constructed further upstream due to channel migration. At a later date, a low flow weir was constructed to divert more flow into the upstream weir. This low structure, constructed primarily of riprap and concrete ecology blocks, diverts low flows from the south channel over to the intake on the north bank. This diversion structure is designed so that high flows pass over the structure. Another weir, not a diversion structure, is located just downstream of the hatchery. The purpose of this fish weir is to direct returning salmon to the hatchery; the weir is level with the stream bottom, and creates no upstream pool.

While it is probable that the fish weir located at the QNFH causes deposition of sediment immediately upstream, local channel aggradation and braiding is likely a result of reduced channel gradient and increased bedload deposition since 1973. As mentioned above, the hatchery was constructed at its present location in 1911. The present fish weir, which replaced the original weir of 1911, was installed in 1989. The present fish weir is situated roughly 100 feet downstream and 2 feet lower than the original weir. Air photo analysis performed by GeoEngineers for the U.S. Fish and Wildlife Service indicate gravel presently occupying the channel upstream of this weir began accumulating between 1962 and 1973. Prior to 1973, the channel above the hatchery displayed a stable configuration with no apparent braiding or shoaling visible in active channels. For a complete discussion of channel conditions in the vicinity of the hatchery, refer to GeoEngineers' report, Big Quilcene River Gravel Removal Evaluation dated December 20, 1996.

The original Olympic Gravity Water System was built in 1906 to bring water from Snow Creek to Port Townsend. A diversion dam was constructed on the Big Quilcene River at RM 9.5 in 1926 to provide additional water to Port Townsend. Diversion from the Big Quilcene began in 1928. A maximum of 30 cfs is diverted according to a water right issued to the City of Port Townsend (13QWA 1994). As a supplement to this primary source, water is also diverted from the Little Quilcene River. Water is stored in Lords Lake reservoir and used during low flow or high turbidity flow periods in the Big Quilcene. This reservoir is filled with water from both the Little and Big Quilcene Rivers.

FLOODING HISTORY IN THE BIG QUILCENE WATERSHED

Reports that were reviewed describe a great deal of anecdotal information from local sources concerning flooding in the Big Quilcene Watershed. Although there are few reliable streamflow records for significant flood events, sufficient information exists for identification of flood events (Big Quilcene Watershed Analysis, 1994; personal communication). Major flood events within the watershed include:

- December 1926
- November 1951
- February 1954
- January 1959
- January 1960
- December 1966
- January 1968
- March 1971
- December 1979
- November 1986

Recent major flooding events include:

- November/December 1990
- 1993 (flooding breached a levee and almost reached the base of Bonneville electrical transmission lines)
- November/December 1995
- December 1996
- January 1997
- March 1997

The data show a recent substantial increase in flood frequency. In addition to greater precipitation, increased flooding is caused by several factors, including road building over the past several decades, channel confinement below the Hiddendale community, and extensive channel aggradation. This flooding is significant enough to raise water system turbidity in excess of drinking water standards, silt-in fish ponds at the Quilcene National Fish Hatchery, cause septic tanks to overflow, and damage roads and utility lines.

FLOOD IMPACTS

HEALTH AND SAFETY

Impacts experienced from past flooding on the lower Big Quilcene River have been varied and severe. These impacts are likely to increase in frequency and severity as the river continues to aggrade and erode its banks. Of primary concern are those impacts to health and safety of Quilcene residents along the river.

An obvious adverse impact is the threat to homes and residents from rising floodwaters, which could be worsened by sudden breach of existing levees, or abrupt release of a debris jam in the channel. However, a more insidious health impact is rising ground water resulting from streambed. Collins, 1993, showed that streambed elevation has increased nearly 4 feet from 1971 to 1993, between Rodgers Street and Linger Longer Road. Associated with rising ground water levels and flood waters is risk of septic system failure and contamination of residential wells.

Flooding creates an additional safety risk when Linger Longer Road is covered by floodwaters. This road provides the only access to approximately 70 residences. Any medical, fire or accident emergency response would be severely hampered should they occur when the road is flooded.

PROPERTY DAMAGE

Extensive damage to private and public property has occurred during past floods. This has included damage to residences and other structures. Also, some property owners have experienced substantial loss of land. For example, at least one home will likely need to be moved due to threat of continued toe erosion and shallow landsliding along a 75- to 100-foot bank at RM 1.4. Other residences are threatened as well, but not so dramatically. Property is also being lost from large landslides between RM 1.7 and RM 1.9, as a result of river migration and subsequent erosion of the hillside toe.

Shellfish beds in Quilcene bay have suffered damage from sediments deposited during flood flows. As discussed in a previous section, the shellfish industry is a major contributor to the local economy, with one report (Donaldson and Steele, 1994) stating a value of $6,140,000 per year. Flood impacts also include possible contamination of shellfish beds from failed septic systems.

Public property along the river is at risk from flooding. Local streets and county roads are regularly inundated by flood waters and suffer damage from erosion of embankments and pavement. There is also potential impacts on bridges and culverts. Some local shellfish beds are publicly owned, and have suffered damage along with privately owned beds. The hatchery has suffered flood damages in the past, and may again in the future if flood hazards are not reduced.

RESOURCE DAMAGE

Past floods have had a detrimental impact on many resources in the lower Big Quilcene River system. Reduced water depth caused by channel aggradation poses an upstream fish passage problem for returning summer chum salmon. Channel bed destabilization, channel shifting and aggradation can either bury or scour coho and chum salmon eggs incubating in the gravel, thereby hindering survival. Low summer flows, which dramatically reduce channel wetted perimeter in aggraded areas, are generally harmful to fish runs. Increased fine sediment in spawning gravels, especially in the lower river mile, also reduce spawning success.

Channel aggradation has diminished pool frequency as well as pool volume. Subsequent loss of channel complexity reduces winter habitat for coho salmon, and steelhead and cutthroat trout, the only three anadromous species which overwinter as juveniles in the Big Quilcene River. Summer rearing habitat for juvenile coho has also been damaged by flooding. Loss of pool volume is considered a limiting factor for coho (WDFW 1994). Summer rearing habitat for juvenile steelhead and anadromous cutthroat trout are similarly degraded in lower reaches of the river.

Reductions in density and size of riparian trees in the watershed due to logging and other land uses have greatly reduced availability of large woody debris (LWD). LWD can increase habitat diversity and provide sediment sorting and storage in balanced river systems. Loss of riparian vegetation and in-channel wood degrades both summer and winter rearing fisheries habitat, and impacts other riparian-dependent wildlife as well.

Shellfish beds in Quilcene Bay have also suffered damage from flood flows. In the mid to late 1980's high levels of fecal coliform bacteria were detected in the north end of Quilcene Bay (Jefferson County Study 1986, as cited in Reichmuth and Welch 1993). Ground water in the river fan delta is within 0 to 18 inches of the ground surface during winter months. Aggradation of the river bed causes elevated groundwater levels, which contribute to septic system failure and risk of biological contamination to shellfish beds. Jefferson County initiated a water quality project and analysis in 1986 which identified agricultural practices, failing septic systems, and resident seal populations as primary sources of bacterial pollution in Quilcene Bay. Also, sediment from landslides and bank erosion is deposited downstream in spawning gravels as well as the bay, adversely affecting public and commercial shellfish beds.

PREVIOUS REMEDIAL ACTIONS

GENERAL

Numerous actions have been implemented in past years in an attempt to reduce hazards from flooding or to mitigate damage caused by flooding. These measures have included dredging, gravel removal, bank protection, levee construction, levee removal, property acquisition and bridge removal. There has been varying degrees of success, although it is nearly impossible to accurately determine effectiveness since little or no regular monitoring was completed. Many of the measures were completed without design drawings or other documentation. However, anecdotal evidence of success has been obtained from discussions with local residents and review of available documents. More detailed discussion of these past remedial actions are presented in the following paragraphs.

GRAVEL TRAPS AND GRAVEL REMOVAL

Over the last 25 years, much material has been removed from the river by means of gravel traps or bar removal (personal communications). The gravel traps installed lately (since 1994) have been relatively small, generally less than approximately 2,000 cubic yards (yds^3). They have been excavated on bars as gravel trap cells, without any excavation in moving water of the stream channel. The other primary method of gravel removal has been extraction of material from gravel bars, generally above average low water level. No measurements are available to assess effectiveness of this bar removal. Local residents and others involved in monitoring the river feel gravel removal efforts have been successful in reducing channel aggradation and level of flood flows. Also, there are no documented adverse impacts to the river resulting from these gravel removal efforts.

DREDGING

As flooding of the river became more frequent and severe, channel dredging took place downstream of Rodgers Street and Linger Longer bridge. There is little or no documentation regarding effectiveness of these mitigation efforts, although it is likely that damage/overflow of levees was reduced for a few years after dredging was completed. Dredging was eventually discontinued because of possible risks to fisheries and shellfish resources. The lower river was also dredged in March 1992 and December 1993. Three to six feet of channel bottom was removed from the powerline crossing to the river mouth. However, the channel aggraded following the first major storm event (personal communication). Additional dredging has been performed periodically by private property owners.

LEVEE CONSTRUCTION

Over the years, protection of streambanks on the Big Quilcene River has taken many forms. The most obvious has been construction of levees on both banks from Rodgers Street to the river mouth and on the south bank for a short distance upstream of

Rodgers Street. These levees have protected residential areas from flood during periods of low to moderate flows, but at present, high flows with a 2 or 3 year recurrence interval overtop levees and flood property on the north side of the river.

In 1993, the river breached the south bank levee downstream of the Linger Longer bridge. Flood waters cut a channel through the Newman property and abandoned lower reaches of the former channel. Subsequently, the levee was repaired and flow was re-routed to the former channel.

In 1995 a portion of the north dike was removed downstream of Linger Longer bridge. Property on the north bank was acquired by Jefferson County in conjunction with this dike removal, providing an area of public property where overland flows can occur.

STREAMBANK PROTECTION

Other forms of streambank protection formerly implemented include placement of logs, riprap, stumps, rock and log barbs, soil reinforcement and toe stabilization. The most recent efforts incorporating these materials were completed in 1996 at the Hiddendale development upstream of the hatchery, and on the north bank at about RM 1.5. These efforts have performed quite well in flooding during the winter of 1996/1997. Further loss of riverbank was prevented, and the amount of sediment added to the river system was reduced. However, in a major storm in March 1997, river flow was diverted by a landslide on the south bank at about RM 1.8, and directed toward the north bank where flood flows eroded the upstream end of recently completed log barb bank protection.

WOOD REMOVAL

In the past, sporadic efforts have been made to remove large log jams and debris piles from the river. Mostly, these were obstructions deposited during high flows, and were not located in the low flow channel. There is no documented effects of wood removal, although loss of woody debris can result in pool loss which affects fish habitat. Another effect of LWD removal is the loss of sediment sorting and storage sites.

RECOMMENDED ACTIONS

INTRODUCTION

Natural resource management and particularly flood hazard management must recognize both natural processes and the realities of balancing public safety, property protection, and public resource protection. The following sections of the plan present Actions that are recommended to provide mitigation of repetitive flood hazards evident on the lower Big Quilcene River and discussed in a previous section of this plan.

Actions are presented as separate and individual, but each should be considered as only part of a systematic approach to mitigation of hazards on the entire lower river. Many of the Actions will only affect a specific reach of the river, but when combined as recommended in this plan, they provide a comprehensive approach to mitigate hazards as well as improve conditions for fisheries and other resources. The measures recommended in the plan to reduce repetitive flood hazards are separated into two general categories; those affecting health and safety, and those affecting sediment supplied to the river and channel stability. Information reviewed for development of this plan clearly demonstrates the many contributions to conditions and hazards presently existing in the lower river basin, including historical activities in the watershed, development, local geology, and weather patterns. Recommended Actions have been developed to both remedy these local conditions to the highest possible degree, and provide mitigation of overall hazards.

The recommended Actions are concepts for treatment of especially problematic reaches on the Big Quilcene River. While all such areas of concern are vitally important, they are generally regarded in the following priority.

1. Linger Longer and Rodgers St. area, approximate RM 0.5
2. Landslides, slope failure, bank erosion, approximate RM 1.5-2.5
3. Aggradation at the river mouth, approximate RM 0.0-0.5

Actions are presented in an order consistent with treatment of these areas in the priority above. However, the Action concepts address flooding and habitat concerns simultaneously. Therefore, the Actions are not mutually exclusive, but may be implemented concurrently, as funding becomes available, or as conditions evolve on the river.

Design and implementation of the Actions will be completed in a manner that minimizes impacts to fisheries and other resources. Many of the recommended Actions will enhance fisheries habitat; this is an important criterion for the design effort.

Land use in the lower Big Quilcene River drainage is currently governed by the Jefferson County Flood Damage Prevention Ordinance, #18-1120-95. The ordinance prohibits building in the floodway, and mandates specific flood-proofing measures needed for structures to be built in the Flood Hazard Area (100-year flood plain). The following methods and provisions for accomplishing flood management are included in this ordinance:

1. Restricting or prohibiting uses which are dangerous to health, safety, and property due to water or erosion hazards, or which result in damaging increases in erosion or in flood height or velocities.
2. Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction.

3. Controlling the alteration of natural flood plains, stream channels, and natural protective barriers, which help accommodate or channel flood waters.
4. Preventing or regulating the construction of flood barriers which will unnaturally divert flood water or may increase flood hazards in other areas.

The ordinance also states that all developments in the flood plain should be consistent with the Jefferson County Comprehensive Plan and subsequent amendments, as well as the Jefferson-Port Townsend Shoreline Management Master Program. Therefore, since responsible policies are in place, this plan does not specifically discuss further land use regulations.

ACTIONS TO MITIGATE REPETITIVE HEALTH AND SAFETY HAZARDS WHILE RESTORING FISH HABITAT

General

The Actions recommended subsequently in this section of the plan are designed to provide specific mitigation for hazards to health, safety and property in the floodway and lower flood basin. As discussed in the introduction to this section, it is intended that these Actions be considered as parts of the whole Plan. Individual Actions will be beneficial for specific sections of the river; however to fully mitigate hazards the plan recommends that Actions be implemented as a whole as funding becomes available.

Action A.1 - Reconfigure Linger Longer Road Bridge and Access to Accommodate Flood Flows and Traffic.

This Action is necessary to mitigate health and safety risk regarding access to some 70 residences and businesses during periods of high-water flood flows. Careful attention to design features will be necessary to assure that adequate flow capacity is provided for floodwaters that now flow over the road. The plan recommends consideration of a bridge extension with causeway approaches to allow all flows to pass under the bridge and causeway.

This Action is especially critical to reduce risk to health and safety should a life-threatening situation arise during a period of high water, and will be more effective when combined with other recommended Actions.

Action A.2 - Property Buyout and Conversion of Use

This Action alone will eliminate damages relating to properties that are purchased. However, when combined with other recommended Actions, it will be very effective in mitigating hazards and reducing future costs of flood damage. Obviously, it also will reduce health and safety hazards, particularly those associated with the purchased properties.

Criteria for selection of properties include such factors as owner willingness to participate, utility of the property with respect to flood storage capacity/accommodation of overflow, relationship of property to other overflow properties, and amenability to habitat restoration. Specific properties which will be selected for purchase should maximize as many of these criteria as possible. Participation in a buyout program would be voluntary.

Action A.3 - North-Side Floodway Conveyance Improvement, Below RM 1.1.

This Action entails the study and design of floodway and habitat improvements, which will move flood flows through this area in a more beneficial manner. Flood flows currently overtop the north bank upstream of Rodgers Street, starting at RM 1.1, and are stored in a large floodplain area behind Rodgers St. This water then flows over Rodgers Street which acts as a defacto spillway. The proposed Action may include setback or removal of dikes on the north river bank, a controlled overflow at Rodgers St., and acquisition of associated floodplain easements or properties. Implementation of this Action would take advantage of the historical overflow path in the north floodway. This Action may also include construction of new levees on the north floodplain near 100-year flood limits to protect homes and historic structures from flood overflows. Determination of the need and location of these levees must be part of the detailed design effort that evaluates Actions A.1, A.2, A.3 and A.4.

Action A.4 - Levee Repair/Maintenance

This Action provides an essential element to overall mitigation of flood hazards imposed on existing homes along the lower river. Implementation of Actions A.1, A.2 and A.3 will reduce pressures exerted on the levees during flood events. The intent of this Action is to allow landowners to repair and maintain levees/dikes as needed to protect their property. The primary sections that will likely require maintenance and repair are on the south bank, below RM 1.1.

ACTIONS TO REDUCE SEDIMENT AND STABILIZE THE CHANNEL

General

Every stream must be considered as a system of integrated elements. As a consequence, any action in the stream produces an effect elsewhere in the system. This is very apparent for the lower Big Quilcene, which is plagued by chronic problems of channel aggradation and high rates of bank erosion. A number of factors have contributed to these problems: channel constriction (bridges and dikes), loss of floodplain area and forested riparian zone, increased sediment input throughout the system, and loss of tidal energy inputs. Aggradation of the channel has increased hazards associated with flooding and damage to property, residences and fish habitat.

This plan recommends a comprehensive series of Actions which, when implemented, will reduce flood hazards and bed aggradation, provide a more stable configuration for the channel, and restore fish habitat.

Action B.1 - Identification and Acknowledgment of Sediment Sources

Various studies, information and data exists regarding sources of sediment in the Big Quilcene River system. Using this existing information, sediment source areas should be inventoried and considered in the planning stages of project implementation. While acknowledgment of these sediment sources is recognized as an important issue, completion of such an inventory should not prevent, hinder, or delay project development.

Action B.2 - Landslide Stabilization

Unstable slopes and shallow landslides present along the lower river corridor are located primarily between RM 1.3 and RM 1.8. The landslides typically occur along slopes with gradients of 50 percent or greater, in response to erosion and undercutting along the river bank as river flow removes support from the slope base. Evidence suggests that confinement of the river channel against high slopes of Mt. Walker between roughly RM 1.6 and RM 2.3 has likely forced the river to erode into these slopes.

The plan recommends both structural and non-structural approaches for design and implementation of measures to stabilize landslides, reducing deposition of sediment into the river. Structural measures must be designed to provide support for the slide mass, as well as to prevent erosion of additional material from the hillside toe. Structural methods include rock buttressing, biotechnical treatments, toe berms, drainage, mechanically stabilized earth, and revegetation of exposed soil.

Non structural approaches include measures that allow the river to move away from these potentially massive sediment sources, producing favorable benefits and long term cost effectiveness. Allowing channel sinuosity to increase without eroding into high bluffs would decrease the river's erosive energy. Each project location will require development of a site specific design, as well as cooperation of affected landowners. All stabilization measures must be compatible with other recommended flood hazard mitigation Actions, to assure the most effective treatment and reduction of these hazards.

Bank erosion can be a result of natural channel meandering across the floodplain.

However, bank erosion can also be accelerated by a number of factors. These factors include removal of riparian forest, channel straightening and diking, confinement of the river against unstable slopes, depletion of stable logjams, and bed aggradation. Actions to reduce bank erosion problems should address these root causes.

Action B.3 - Streambank Stabilization

Bank erosion has destroyed a large area of pasture land between RM 1.5 and 1.6, as the south bank landslide at approximate RM 1.8 causes channel aggradation and subsequently diverts flow across the river to the north bank. Bank stabilization measures may include structural and non-structural methods. Wherever practical, flood easements may be acquired from erosion susceptible properties, given willing landowners, allowing the river to return to natural processes, and avoiding the need for conscious efforts at bank stabilization. The most appropriate stabilization method for any particular section of streambank should be determined after systemic, local evaluation of streamflow, topography, soil condition, and other resource requirements. This Action should be part of a comprehensive approach for reduction of hazards in order to realize maximum effectiveness.

Streambank stabilization design should include consideration of riprap, barbs, trees, artificial log jams, channel reconstruction, dike setback or removal, revegetation of exposed soil and enhancement of riparian habitat.

Action B.4 - Gravel Removal

In past years, gravel has been removed from the river in varying amounts to maintain open channels and to reduce the elevation of flood flows. Without a monitoring program it is difficult to quantify the effectiveness of this removal. Therefore, an appropriately scaled gravel transport evaluation should be performed. Based on results of the evaluation, specific areas should be identified from which gravel is to be removed. The removal plan should include a program to monitor effectiveness and impacts of the removal. In general, evaluation of gravel removal from the reach below Rodgers Street and Linger Longer Road, as well as the severely aggraded and braided reach between RM 1.3 and RM 1.8 is recommended. The program should be designed such that removal occurs only when predetermined quantities have accumulated. In particular, the design should identify those areas where gravel removal will provide channel stability and reduce hazards resulting from aggradation and associated flooding. It is expected that successful implementation of other Action items will reduce future dependence on gravel removal.

Location and timing of gravel removal should not degrade fish habitat or seasonal fish use. Mid to late summer generally presents the least impact to fisheries.

Hydraulic permits issued by Washington Department of Fisheries are required for gravel removal within the ordinary high water channel.

Action B.5 - Large Woody Debris Management

The Big Quilcene River currently has low levels of stable Large Woody Debris (LWD) and few sources of large diameter LWD. LWD structures store sediment and reduce stream energy which can result in a more stable channel. LWD also creates more diverse fish habitat. Removal of LWD may have the effect of increased conveyance of water and sediment. However, increased conveyance of water is equivalent to increased velocity, which leads to bank erosion and more sediment input into the river system. Another effect of LWD removal is loss of sediment storage sites and fish habitat.

The objective of LWD management upstream of Rodgers Street is to increase the amount of stable LWD. Between Rodgers St. and the BPA Powerlines, the objective is to ensure that LWD does not create a flood hazard. Below the powerlines, LWD is generally not a flood hazard. To reduce flood hazards, options for relocation of LWD to areas of high habitat value and low flood risk should be considered preferable to complete debris removal from the channel system.

Action B.6 - Channel Reconstruction

Channel relocation and reconstruction should be considered as a means of moving the river away from high, erosive bluffs, adding channel length to reduce erosive energy, creating improved, stable fish habitat, and healthy riparian vegetation. Channel reconstruction will require the participation/cooperation of willing landowners. The channel reconstruction must be carefully designed to duplicate characteristics of the former stable channel and reduce risk of future braiding. This Action is intended to reduce flood damage by reducing sediment inputs from unstable slopes, and decreasing stream energy and associated bank erosion.

Action B.7 - Dredging

For purposes of the plan, dredging is defined as removal of material from the primary channel to provide more capacity for flood flows or to specifically rechannel the river. The plan recommends that dredging be implemented only after proper evaluation, and only as part of the larger comprehensive approach to reduce hazards. The plan does not recommend dredging as a routine maintenance measure, but as an emergency response to catastrophic events, or as a component of other Actions.

Action B.8 - Estuary Restoration

In the lower reaches of tidally influenced rivers worldwide, the loss of tidal prism (the intertidal area functionally connected to the stream) has often been associated with dramatic stream channel buildup and plugging. Especially within protected bays, tidal estuaries provide a critical mechanism for transporting stream sediments into the marine environment. Tidal flushing minimizes the rate of sediment buildup in the lower reaches of creeks and rivers and upon their deltas. A stream's energy becomes virtually zero at its mouth. This abrupt loss of energy would seemingly cause an enormous decline in the stream's ability to move sediment and therefore lead to rapid stream channel filling and delta enlargement. In areas of great tidal range, however, highly functional estuaries harness tidal energy for moving sediment using a network of tidal surge plains and channels. These features comprise the tidal prism which serves functionally as a tributary of the freshwater stream. Within the tidally influenced area, declining stream energy is replaced by increasing tidal energy which transports and distributes sediment further into the marine environment than can be attributed to stream energy alone. Over durations of considerable time, mud flats aggrade with stream-born sediment, become vegetated into salt marsh wetlands dissected by tidal channels and stream distributaries, and the estuary advances seaward. The linking of streams with tidal energy is a necessary mechanism to create stable, slowly evolving, complex and productive estuaries. On the northern Olympic Peninsula, estuary-intact stream systems generally extend their deltas seaward (prograde) less than 2 feet per year. Olympic Peninsula streams that drain into protected bays but lack a significant linkage with an intertidal estuary commonly prograde their deltas 10 feet or more per year on average.

Channelization, river diking, and bay diking have virtually eliminated the Big Quilcene River's historical tidal prism and intertidal estuary. Since these impacts began some 11 or 12 decades ago, the river mouth has advanced approximately 1,700 feet into Quilcene Bay. Increasingly severe flooding and the degradation of fish, shellfish, and waterfowl habitat are problems commonly observed at stream mouths where these human impacts have occurred (e.g. Little Quilcene and Dungeness Rivers, Snow, Morse, and Jimmycomelately Creeks). The plan recommends the design and implementation of measures to restore tidal energy and intertidal estuary habitat at the mouth of the Big Quilcene River. These measures may include the removal of large quantities of sediment from the delta cone area, possible relocation of the lower river channel, the removal of certain dikes downstream of Linger Longer Road, and possibly the removal of dikes in adjacent marine areas. Although considerable further study is necessary to properly design this action, the importance of estuary restoration cannot be over-emphasized.

ACTION FUNDING PLAN

Implementation of this comprehensive multi-Action plan must balance objectives, which have been articulated in the various reference documents, with accessibility of available funds. Reference documents reviewed by the project team all address surface water resource management. However, emphasis of these studies ranges from flood control to habitat restoration to aquatic resources. Likewise, reviewers of the various funding sources will reflect slightly different priorities and objectives.

Each Action or proposed project is intended to satisfy several objectives that have been identified as important by the LIT members. As objectives of each Action are identified, they can be used to satisfy various eligibility criteria for specific funds. The ability to document such multi-objective project management practices is cited by a variety of funding agencies as one of the most important criteria in qualifying for funding.

The first component of the Action Funding Plan involves Local Improvement Districts, or LIDs. Policy, procedure and limitations for implementation of LIDs are dictated by Revised Code of Washington chapters 86 and 36. LIDs are a means of assisting benefited properties in financing needed capital improvements, such as river management projects. Two initialization methods can be utilized in the LID formation: The resolution of intention method, which allows the legislative body to initiate an LID; and the petition method, by which property owners petition to initiate the LID. In this funding mechanism, potential projects will be identified and prioritized by the impacted property owners, local flood boards, and the LIT. An annual budget will then be established based on the priority projects. Fees necessary to meet this budget will be equally distributed among those properties benefited by the improvement, per the above referenced RCWs.

Another important source of potential funding may be realized from taxation of the Big Quilcene, Little Quilcene, and Dosewallips Flood Sub-zones. Additional information and limitations for this funding method are stated in RCW 86.15.160. Both the LID and flood sub-zone taxation funding methods are applicable to all Actions proposed in this plan.

ELIGIBILITY

Additional sources of potential funding to implement the Actions are provided below. Each individual program has specific eligibility requirements, target areas, advantages and limitations. Funding competitiveness and application time frames are subject to change; the appropriate listed agency should be contacted for further information. Potential funding sources are presented with respect to Actions recommended in the plan.

ACTIONS TO MITIGATE REPETITIVE HEALTH AND SAFETY HAZARDS WHILE RESTORING FISH HABITAT

Action A.1 - Reconfigure Linger Longer Road Bridge and Access to Accommodate Flood Flows and Traffic.

Objectives. Address the chronic flooding situation as previously described in this plan. It is anticipated that this can be accomplished using the existing right-of-way (i.e., no additional right-of-way need be acquired). Presently when the roadway is flooded, no access is available into or out of the area, representing health and safety risks. The proposed Action will eliminate this condition.

Possible Funding Sources:

Agency:	Federal Emergency Management Agency (FEMA)
Possible Programs:	"Section 406" Program Hazard Mitigation Grant Program (HMGP)
Remarks:	Linger Longer Road impacted by the November 1995 and February 1996 storms. If damage was identified on a Damage Survey Report (DSR) the project could be eligible for Section 406 funding under the infrastructure repair program. Funds are a grant; 75% Federal, with 25% match (12% paid by the State). Funds are for design and construction. If a DSR was not prepared, the project is ineligible for Section 406 funding, but still may be eligible for HMGP consideration.
Agency:	Economic Development Administration
Possible Programs:	Title 9-Special Adjustment Grant
Remarks:	The grant program requires a 25% local match. It is intended to make a community more economically resilient. Funds are to improve beyond what existed prior to the flood.

Action A.2 - Property Buyout and Conversion of Use

Objectives. A number of homes near the lower reaches of the river have been subjected to repetitive damage from flooding. Acquiring these properties will permanently solve health and safety hazards for impacted residents.

As stated in Action B.2, criteria for selection of properties include such factors as owner willingness to participate, utility of the property with respect to flood storage capacity/accommodation of overflow, relationship of property to other overflow properties, and amenability to habitat restoration. Specific properties which will be selected for purchase should maximize as many of these criteria as possible. Participation in a buyout program would be voluntary.

Possible Funding Sources:

Agency:	Federal Emergency Management Agency (FEMA)
Possible Programs:	HMGP

Agency:	Department of Housing and Urban Development
Possible Programs:	Community Development Block Grant Funds
Remarks:	This funding can be used for matching other federal funds.

Agency:	State Trade and Economic Development
Possible Programs:	Emergency Funding-Public Works Grant Program

Action A.3 - North-Side Floodway Conveyance Improvement, Below RM 1.1.

Objectives. Implementation would effectively mitigate floodwaters in this location, utilizing historical overflow routes in the north-bank floodway.

Possible Funding Sources:

Agency:	Federal Emergency Management Agency (FEMA)
Possible Programs:	FEMA 406 Public Faculties Program
Remarks:	This measure would mitigate damage to a previously damaged facility (i.e., Linger Longer Road), and could therefore be part of the repair and mitigation under Section 406.

Agency:	Natural Resources Conservation Service
Possible Programs:	Emergency Watershed Protection Service Watershed Protection & Flood Protection Program Technical Assistance Program

Agency: Farm Services Agency
Possible Programs: Conservation Easement
Remarks: May be used for portions of the overflow channel not acquired outright.

Action A.4 - Levee Repair/Maintenance

Objectives. The intent of this Action is to allow landowners to repair and maintain dikes as needed to protect their property.

Possible Funding Sources:

Agency: See agencies and programs listed for the above three actions

Agency: US Army Corps of Engineers (USACOE)
Possible Programs: Flood Control Works : Flood Control Projects
Remarks: This funding may be available only if the project meets certain eligibility requirements.

ACTIONS TO REDUCE SEDIMENT AND STABILIZE THE CHANNEL

Action B.1 - Identification and Acknowledgment of Sediment Sources.

Objectives There is much information in existence relating to sources of sediment in the Big Quilcene River. The Action is intended to simply call attention to this fact, and gain acknowledgment of this information to managers or proponents of projects. Since the activity is intended to be completed as part of the planning/design phase of project development, no additional special funding for this specific task will be needed. Further consideration or study of sediment sources should not prevent, hinder or delay project development.

Action B.2 - Landslide Stabilization

Objectives. Utilize both structural and non-structural methods to stabilize landslides and reduce deposition of sediment into the river.

Possible Funding Sources:

Remarks: See Streambank Stabilization below.

Action B.3 - Streambank Stabilization

Objectives. Implement measures to stabilize streambanks, reducing erosion and subsequent recession of the streambanks. This Action may include structural and non-structural methods.

Possible Funding Sources:

Agency:	FEMA
Possible Programs:	Section 406 or HMGP
Remarks:	Eligible for 406 if channel damage was included in the DSR.

Agency:	Farm Services Agency
Possible Programs:	Environmental Quality Incentives Program; Emergency Conservation Program
Agency:	Forest Service
Possible Programs:	Urban and Community Forestry Program, Stewardship Incentive Program*
Remarks:	*Administered jointly with NRCS and FSA

Agency:	Natural Resources Conservation Service
Possible Programs:	Emergency Watershed Protection Program, Technical Assistance, Watershed Protection and Flood Prevention

Agency:	National Park Service
Possible Programs:	Rivers, Trails and Conservation Assistance Program
Remarks:	Technical assistance for greenway planning & restoration projects. (Cost share required.)

Agency:	Washington State Department of Fish & Wildlife
Possible Programs:	Technical Assistance for Emergency Flood Projects
Remarks:	Very pertinent for Habitat restoration projects.

Agency:	Economic Development Administration
Possible Programs:	Title 9 Special Economic Adjustment Grant
Remarks:	Purpose of this program is to improve the economic resilience of the county.

Agency: Rural Development
Possible Programs: Water and Waste Water Disposal Loans and Grants
Remarks: Communities smaller than 5,500 will be given priority in this program.

Agency: US Army Corps of Engineers (USACOE)
Possible Programs: Flood Control Works : Flood Control Projects
Remarks: This funding may be available only if the project meets certain eligibility requirements.

Action B.4 - Gravel Removal

Objectives. This Action will reduce aggradation, braiding and blockage of the channel in a manner that does not degrade fish habitat or seasonal fish use.

Possible Funding Sources:

Remarks: The programs and associated agencies listed above under Action B.3 Streambank Stabilization are also appropriate for this Action.

Action B.5 - Large Woody Debris Management

Objectives. Inventory existing Large Woody Debris (LWD) in the river system. Identify and relocate high hazard debris, to enhance bank stability and low flow habitat.

Possible Funding Sources:

Remarks: The programs and associated agencies listed above under Action B.3 Streambank Stabilization are also appropriate for this Action.

Action B.6 - Channel Reconstruction

Objectives. This Action is intended to reduce flood damage by reducing sediment inputs from unstable slopes, decrease stream energy and associated bank erosion, and to provide for more channel stability.

Possible Funding Sources:

Remarks: The programs and associated agencies listed above under Action B.3 Streambank Stabilization are also appropriate for this Action.

Action B.7 - Dredging

Objectives. Dredging, defined as removal of material from the primary channel to improve flood flow capacity, is recommended only after proper evaluation, and as part of a larger comprehensive approach for hazard reduction. Dredging is not recommended as a routine maintenance measure.

Possible Funding Sources:

Remarks: The programs and associated agencies listed above under Action B.3 Streambank Stabilization are also appropriate for this Action.

Action B.8 - Estuary Restoration

Objectives. The plan recommends design and implementation of measures to restore tidal energy and intertidal estuary habitat at the mouth of the Big Quilcene River. These measures may include removal of large quantities of sediment from the delta cone area, possible relocation of the lower river channel, removal of certain dikes downstream of Linger Longer Road, and possibly removal of dikes in adjacent marine areas.

Possible Funding Sources:

Remarks: The programs and associated agencies listed above under Action B.3 Streambank Stabilization are also appropriate for this Action.

BENEFIT COST ANALYSIS

GENERAL

The following analysis is useful for realization/comparison of benefits and costs that each proposed Action is likely to present, as well as to help identify those Actions of the plan which will return higher benefits for relative incurred costs. The analysis is not intended to be the sole decision making factor regarding project prioritization, but rather a helpful tool to assist with this process. Recommended plan Actions include measures of fisheries restoration and/or shellfish bed preservation. Reasonable monetary estimates of these benefits are very difficult to obtain or generate; therefore the analysis includes only relative benefit/cost discussion.

Some Actions recommended in the plan are intended to be implemented in conjunction with other Actions. These were considered both separately and jointly. Additional combinations are possible. The following sections detail particular assumptions for each recommended Action.

MITIGATE REPETITIVE HEALTH AND SAFETY HAZARDS WHILE RESTORING FISH HABITAT

Action A.1 - Reconfigure Linger Longer Road Bridge and Access to Accommodate Flood Flows and Traffic.

For this Action, the proposed project will include construction of a bridge extension with causeway approaches of sufficient length to allow all flood flows to pass unimpeded. Cost to construct a structure of this length to current acceptable standards may be quite high. However, if no action is taken, over time the existing condition may also present costs that must be considered, such as emergency replacement of the existing channel-constricting bridge in case of possible destruction by flood, and opportunity cost of gradually declining habitat and riverine environment.

Construction of the proposed bridge/causeway would offer major long term benefits for fisheries and associated wildlife habitat. Further, as described below in the combined Action proposal, the causeway is vitally important to other plan recommendations, such as the North-side floodway conveyance improvement described in Action A.3. Other immediate benefits of this proposal include improved fire and medical emergency access to some 70 residential properties, and commercial access to the Coast Oyster shellfish facility, as well as the Quilcene Marina. It must be noted that a high percentage of retirees reside at the impacted properties; as access is compromised by flooding conditions approximately 5 days per year at present, the issue of medical emergency response is a very real concern.

Action A.2 - Property Buyout and Conversion of Use

Anticipated costs for this Action include property purchase price, relocation expenses, and removal of existing structures from the site. Benefits are permanent mitigation of flood safety concerns and future flood damages for impacted residents, and reduction of health hazard by removal of failing septic systems. Acquisition of appropriate properties will allow implementation of other proposed Actions, further benefiting both chronic flooding conditions and habitat issues.

As previously discussed in the Action description, criteria for property selection includes owner willingness to participate, utility of property with respect to flood storage capacity/accommodation of overflow, relationship of property to other flood impacted properties, and amenability to habitat restoration. Properties selected for purchase should maximize as many of these criteria as possible, and participation in a buyout program would be voluntary.

Actions A.3 and A.4 - North-Side Floodway Conveyance Improvement, Below RM 1.1., and Levee Repair/Maintenance.

These Actions may include setback or removal of dikes on the north river bank, a controlled overflow at Rodgers Street, acquisition of associated floodplain easements or properties, the construction of new levees on the north floodplain near the 100-year flood limits, and repair/maintenance of existing levees on the south river bank. Depending upon the project scope, some of these proposals may also require implementation of Actions A.1 or A.2. Applicable costs may therefore also include construction of a bridge extension with flood causeway on Linger Longer road, and acquisition of selected flood impacted properties.

Benefits of this Action are long term mitigation of chronic flooding conditions endured by residents of Quilcene adjacent to the lower river, on both the north and south banks. Also, habitat will be improved by the wider channel corridor (and associated lower flood-flow water velocities) presented by dike setbacks and the controlled overflow.

Actions A.1, A.2, A.3, and A.4 - Linger Long Road Access, Property Buyout, North-Side Floodway Conveyance Improvement and Levee Repair/Maintenance.

This option combines the Actions in a comprehensive manner to mitigate hazards in the lower river. Costs related to the following activities must be considered: Completing the Linger Longer road bridge/causeway, acquiring key flood impacted properties from willing sellers, constructing a floodway conveyance improvement on the north bank, and repairing/maintaining levees on the south bank.

As a benefit of these Actions, the lower river corridor will be vastly improved for flood damages and safety/health concerns, as well as fish and wildlife habitat. Chronic flooding conditions long endured by residents will be alleviated, access to various properties south of the river during flood events will be secured, and high flood-flow velocities harmful to fish runs will be mitigated by a wider channel cross section. A functional, natural, healthy, and beautiful riverine environment will result.

REDUCE SEDIMENT AND STABILIZE THE CHANNEL

Action B.2 - Landslide Stabilization

This Action includes both structural and non-structural approaches for landslide stabilization from RM 1.6 to 2.3. Structural landslide stabilization costs include placement of approximately 800 linear feet of slope toe buttress, preventing erosion and further introduction of sediments to the river system. (This represents a total length of toe buttress necessary from RM 1.6 to 2.3, and not a continuous length.)

Non-structural measures primarily involve increasing channel sinuosity, allowing the river to move away from massive sediment sources located in these areas. However, acquisition of associated floodplain easements or properties would be necessary. Such costs are directly proportional to specific project scopes and require willing landowner participation.

Benefits of this Action include saving a residence currently jeopardized at an over-steeped riverside bluff, preventing further property loss at landslide areas, and reduced aggradation of the river channel. Fisheries restoration and oyster bed preservation are also benefits of this Action, as a result of less sediment introduced into the river.

Action B.3 - Streambank Stabilization

This Action consists of repairing and stabilizing the streambank in high erosion areas, utilizing riprap bank armor, barbs, trees, artificial log jams, channel reconstruction, dike setback, and revegetation of exposed soil. Approximately 1,600 linear feet of streambank stabilization may be necessary.

Benefits for this option include preventing property losses which would result from erosion, and positive impacts to fish habitat, including fisheries restoration and oyster bed preservation.

Actions B.2, B.3 and B.6 - Landslide Stabilization, Streambank Stabilization and Channel Reconstruction.

This option combines the Actions listed above. In Action B.6 Channel Reconstruction, property acquisition as well as excavation costs for a new, more sinuous channel (approximately 2000 linear feet) must be considered. Possible costs for Actions B.2 and B.3, Landslide Stabilization and Streambank Stabilization, are discussed above.

Potential benefits for Actions B.2 and B.3 are as previously stated. The benefit of Action B.6 consists of removing future possibility of further bank erosion by channel reconstruction. This option has significant benefits for fisheries restoration, oyster bed preservation, and flooding/erosion conditions, largely due to the combination of the Actions.

Action B.4 - Gravel Removal

This Action includes the removal of gravel in areas where such removal will provide channel stability and reduce flood hazards. The gravel is removed in relatively small excavated cells of 500-1000 cubic yards, located on aggraded gravel bars. Gravel cells typically fill to pre-excavation elevation each season. Benefits for this Action are prevention of further bank erosion and flood damage, both in the gravel removal area as well as downstream.

Action B.8 - Estuary Restoration

This Action includes removal of large quantities of sediment from the river delta area, possible relocation of the lower river channel, removal of certain dikes downstream of Linger Longer Road, and possible removal of dikes in adjacent marine areas. As discussed above in the description of Action B.8, the purpose is to restore tidal energy and intertidal estuary habitat. This is potentially a large scale project; excavation of 250,000 cubic yards of material from the river mouth and Quilcene Bay has been proposed. Cost for such a project may be somewhat offset by salvage of material, if gravels suitable for off-site construction purposes are resident.

Fully described previously in this report, the project will be beneficial to both anadromous fish and shellfish habitat. Also, flooding impacts in the lower river will be greatly reduced, due to increased downstream channel gradient. By reestablishment of marine and riverine interactions, habitat, water quality, and flooding conditions will be improved.

Actions B.4, B.6 and B.8 - Gravel Removal, Channel Reconstruction, and Estuary Restoration.

Relevant costs and benefits for Actions B.4, B.6 and B.8 are discussed above. However, it must be stressed that combining Actions, such as in this option, will dramatically increase project effectiveness. Benefits of each individual Action can be fully realized only when complimenting projects are completed in a comprehensive fashion. Further, some benefits are especially difficult to quantify or measure, such as preservation of human health and lives, and conservation/restoration of a healthy, enjoyable riverine environment.

DISCUSSION

Action A.1 (Linger Longer Bridge Reconfiguration) has many real world benefits that are very difficult to quantify monetarily. The proposed bridge/causeway would permanently remove safety risks associated with flooding access for numerous residents, as well as Coast Oyster and the Quilcene Marina, while allowing dike setbacks as a benefit to fish habitat. There have been chronic flood and habitat issues in this location for over 20 years; the proposal would provide a solution to the problem rather than another short term fix. It must also be noted that Actions A.2-A.4 have some dependence on Action A.1. When considering benefit/cost ratios, the advantages of implementing recommended Actions in a comprehensive, integrated manner is clear.

It is anticipated that project level benefits and costs will be developed for each proposed Action as further prioritization is completed, and specific funding sources are secured. The above analysis is useful for realization/comparison of costs and benefits that each Action is likely to present. As mentioned above, definite monetary benefits resulting from reduced streambed aggradation, increased channel stability, and habitat enhancement are difficult to quantify. Further, improvement of well water quality and septic system functions that will follow as aggradation is reduced and the channel is stabilized are long term benefits nearly impossible to quantify.

LIMITATIONS

This report is for use by Jefferson County Department of Public Works, the Big Quilcene Local Interagency Team, and their appointed representatives to assist in long-term flood hazard management on and adjacent to the lower Big Quilcene River, Quilcene, Washington. The report is not intended to be used for design of specific remediation measures or for preparation of specific construction documents.

Within limitations of scope, schedule and budget, services of the team have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

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GLOSSARY OF TERMS

Aggradation: Increasing the elevation of the streambed by deposition of alluvial sediment.

Alluvial Deposit: Sediment transported by water and deposited in and along stream channels, on flood plains, deltas and alluvial fans.

Anadromous: A species of fish which ascend rivers from the sea to spawn.

Bar Accretion: Growth of sand and gravel bars by gradual deposition.

Basalt: A fine-grained igneous rock.

Bedload: Sediment transported downstream by sliding, rolling, or bouncing along the streambed.

Bedrock: Solid rock, such a sandstone or basalt, overlain by unconsolidated soil.

Bar Building: Slow to rapid growth of meander or braid bars.

Bar Migration: Unidirectional growth of a bar, usually in the downstream or cross stream directions.

Barbs: Long, slender projections placed along river banks and oriented at various angles into streamflow. The purpose of barbs is to reduce velocity along river banks and encourage deposition as a protection measure. Barbs may consist of logs, tree trunks, riprap spurs, to name a few examples.

Base Flood: The flood having a one-percent chance of being equaled or exceeded in any given year.

Channel Complexity: The spatial pattern of fish habitat types (pool, riffle, run etc) and habitat cover.

Channel Corridor: The area occupied by active and inactive channels.

Channel Migration: The lateral change in the position or configuration of the channel resulting from bar growth and river bank erosion.

Comprehensive: Complete or broad coverage.

Debris Flow: The rapid downslope movement of soil, rock, wood, dislodged vegetation and water.

Debris Torrent: The rapid flow of water, soil woody debris within an existing stream channel.

Dikes: Used in this report synonymously with levee.

Ecology Blocks: Precast concrete blocks designed to fit closely together to form a wall or barrier.

Fan-Delta: The alluvial deposit at the mouth of a river.

Flank: The slope or side of a ridge or mountain.

Floodplain: The area adjoining rivers, streams, lakes or coastal waters subject to flooding.

Floodplain Terrace: A broad plain adjacent to a river channel formed by deposition of fine sediment during flood overflow.

Floodway: 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 one foot.

Glacial Deposit: Sediment deposits of glacial origin.

Intermittent: A stream which flows only part of the time, such as after it receives water after a storm.

Levee: An artificial bank or wall confining a stream to its channel and limiting the area of river flooding.

Lodgement Till: Sediment deposited beneath a moving glacier.

Main Stem: The main (primary) channel of a river.

Mass Wasting: The slow to rapid downslope movement of earth materials.

Meltwater Stream: A stream resulting from the melting of an approaching or retreating glacier.

Mitigation Measure: An action designed to reduce or eliminate an adverse impact.

Outwash: Sand and gravel deposited by meltwater streams flowing from a glacier.

Perennial: Streams that flow throughout the year, and from source to mouth.

Relief: The difference in elevation between the high and low points of a land surface.

Riffle: An area of shallow flow extending across the bed of a stream causing fast current.

Riparian: The plant and soil environment existing along stream banks and lakes.

Rock Buttress: A wall composed of large riprap or stream boulders designed to stabilize, reinforce or protect the toe of a slope or streambank.

Stratified: Sediment sorted by size, and layered, implying deposition by moving water.

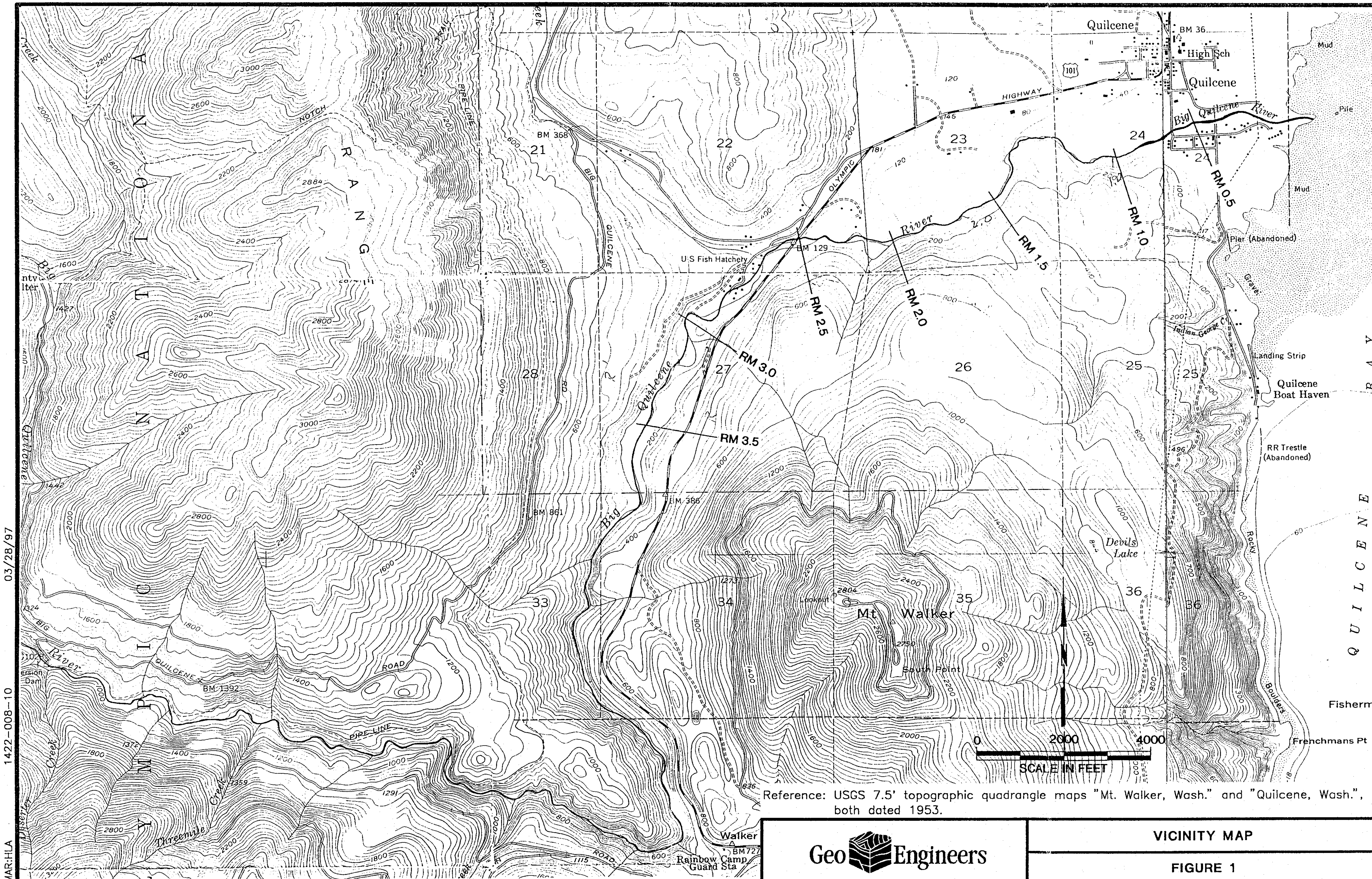
Subbasin: A smaller drainage basin than that of the watershed

Suspended Load: That portion of the sediment load transported in the upper 2/3 of a water column (i.e., held in suspension).

Systemic: Affecting the system as a whole.

Toe Berms: A berm of rock or soil placed at the toe of a slope to resist failure.

Weir: A low dam that creates a pool while allowing water to pass over the top.



Reference: USGS 7.5' topographic quadrangle maps "Mt. Walker, Wash." and "Quilcene, Wash.", both dated 1953.

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VICINITY MAP

FIGURE 1

03/28/97

1422-008-10

MAR:HLA

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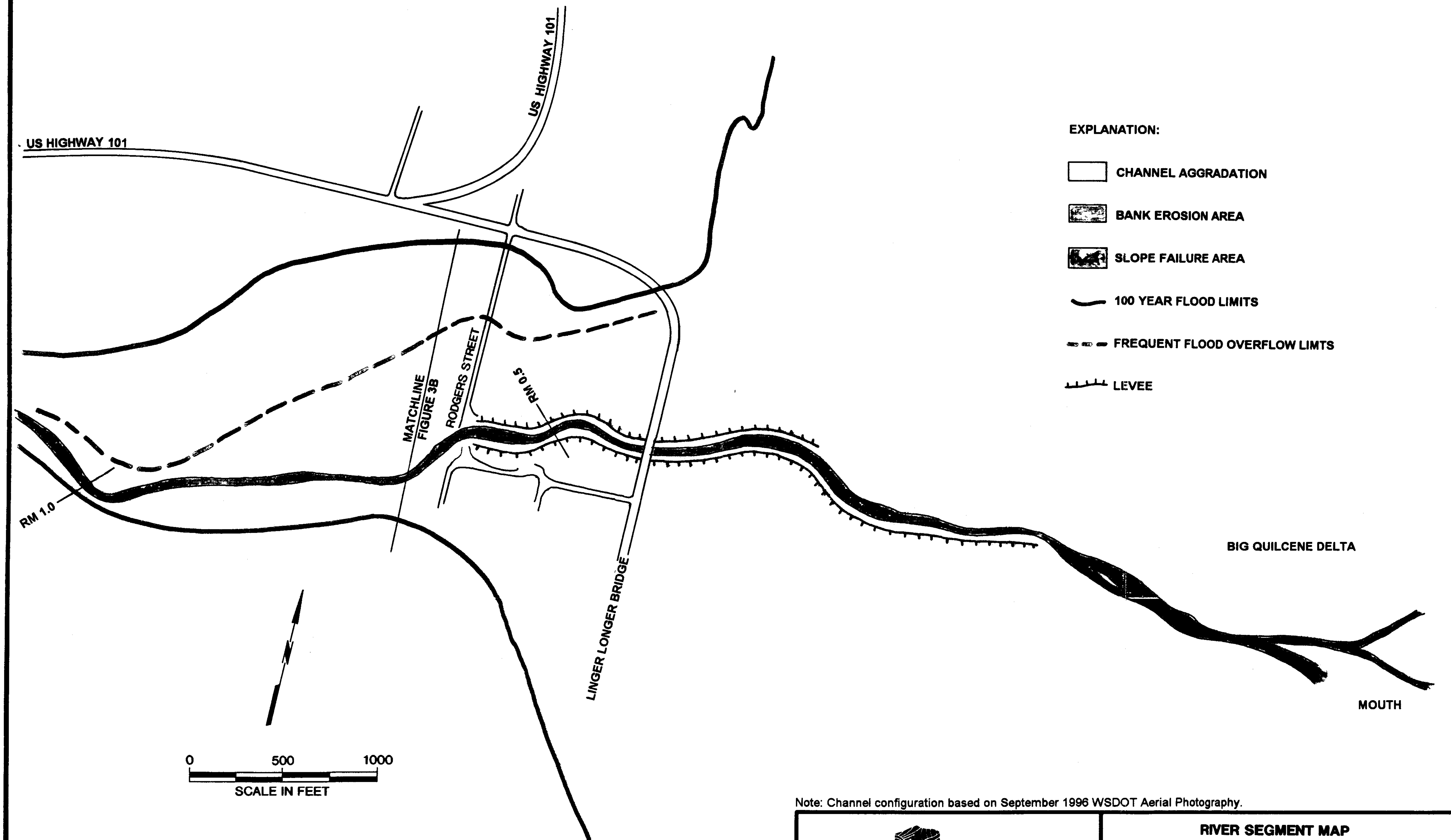
RIVER SEGMENT MAP

FIGURE 2A



Note: Channel configuration based on September 1996 WSDOT Aerial Photography.

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RIVER SEGMENT MAP

FIGURE 2B

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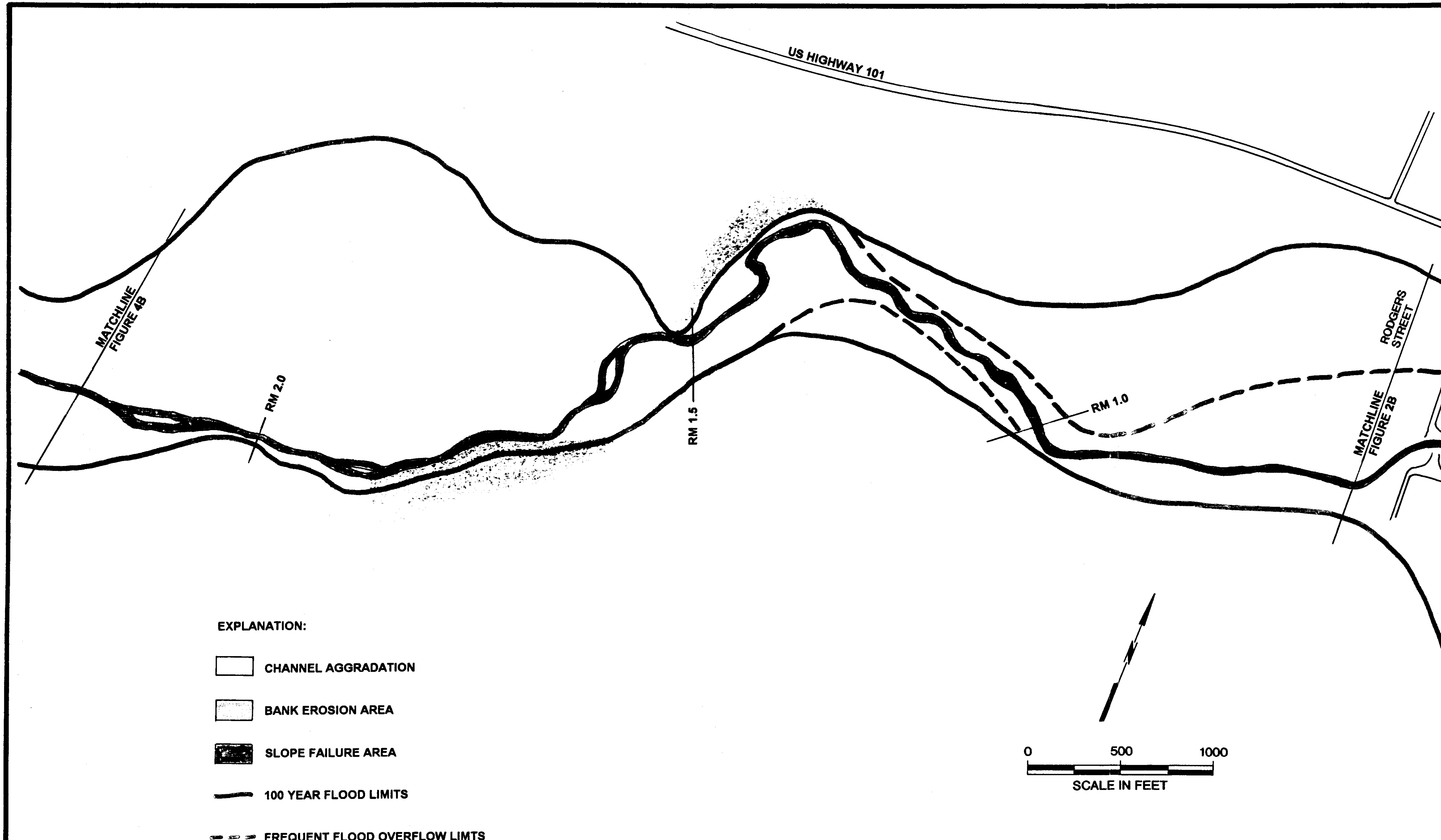
RIVER SEGMENT MAP

FIGURE 3A



Note: Channel configuration based on September 1996 WSDOT Aerial Photography.

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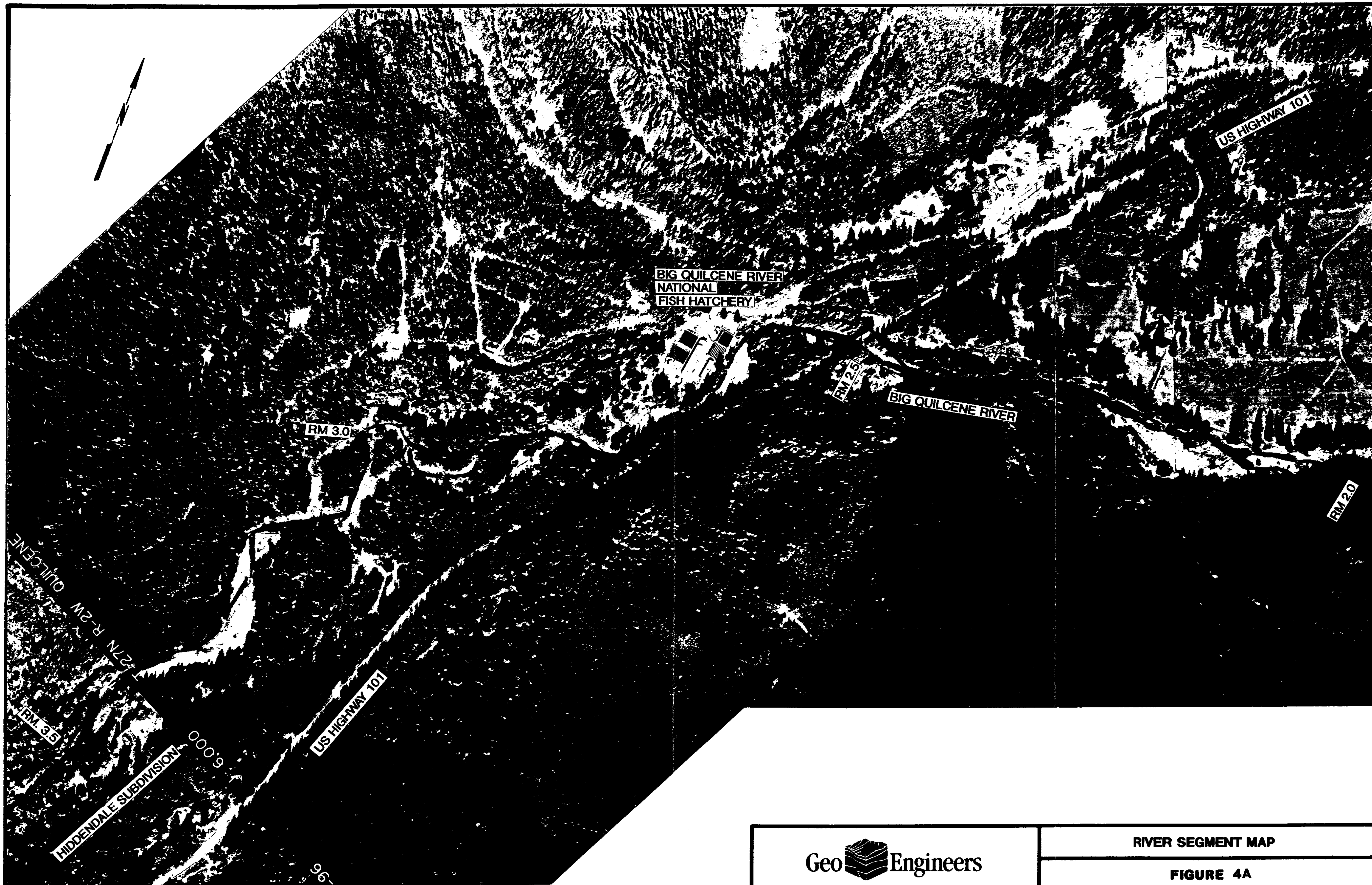
RIVER SEGMENT MAP

FIGURE 3B

MAR:HLA 1422-008-10 03/28/97



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RIVER SEGMENT MAP

FIGURE 4A

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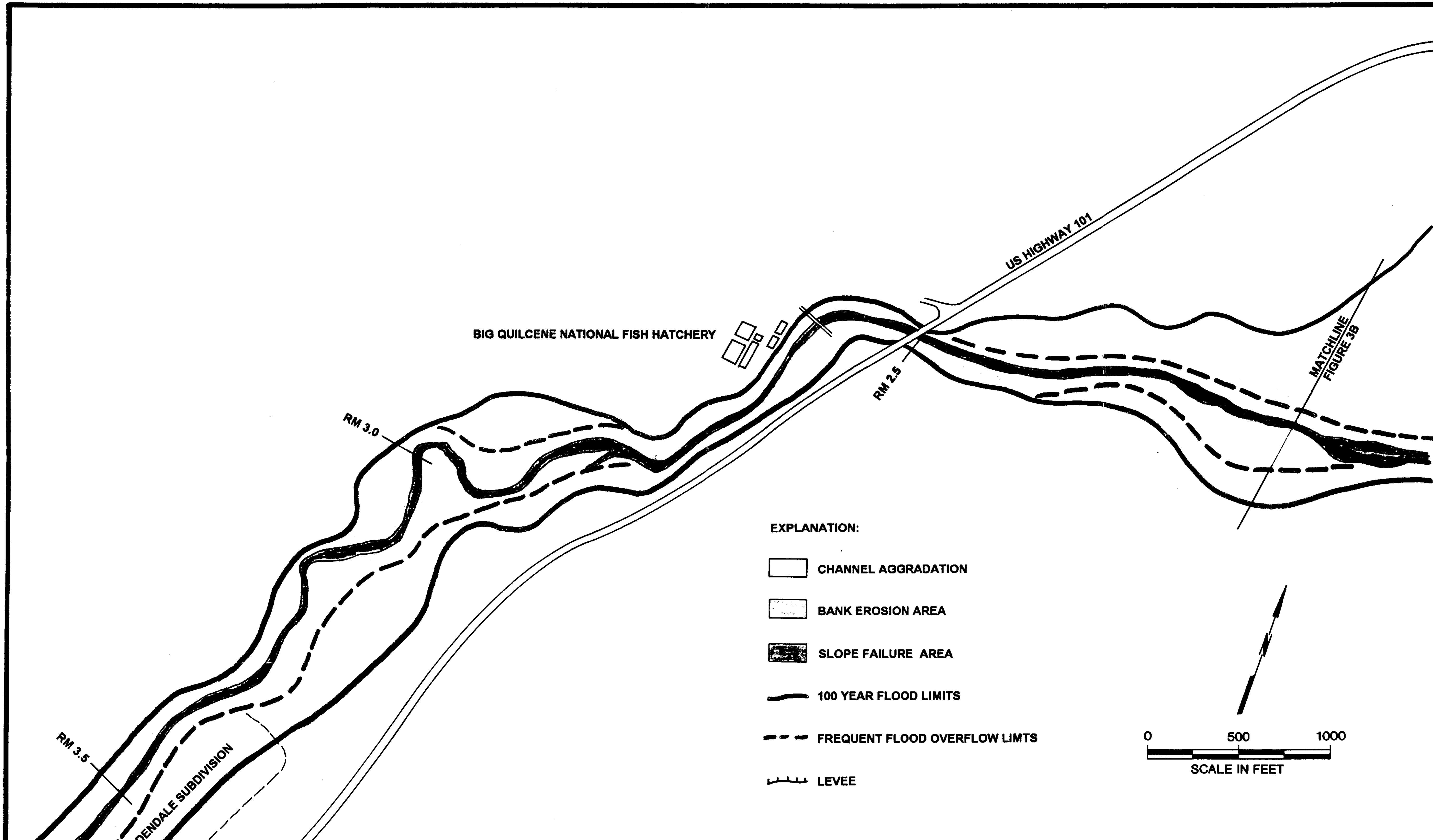

Note: Channel configuration based on September 1996 WSDOT Aerial Photography.

GeoEngineers	RIVER SEGMENT MAP
	FIGURE 4B

MAR:HLA 1422-008-10 03/28/97