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DISCUSSION OF SKOKOMISH RIVER VALLEY FLOOD AND AVULSION HAZARDS

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Background

A discussion of the general features and trends of the Skokomish River Valley with respect to flood and avulsion hazards is presented based on a review of available mapping, cross-sections, and observations. This discussion proceeds in the downstream direction from the South Fork at the mouth of the canyon to the lower mainstem Skokomish as it flows into Annas Bay on the Hood Canal. The discussion is based on available survey data compiled by KCM and as mapped on Figure 6.1 of the Skokomish River Comprehensive Flood Hazard Management Plan, observations made in July, 1997, a comparison of cross-sections from 1992 to 1997, a discussion with Skokomish Valley residents at the meeting at the Mason County Fairgrounds on September 8, 1997, and previous experience on the Skokomish River and other river systems.

As the South Fork flows out of the relatively steep mountain watershed through the canyon it reaches the upper end of the alluvial valley over which the South Fork and Skokomish River flow. This alluvial valley is formed by the transport and deposition of sediment carried by the river. The general down-valley slope gradually transitions from the steeper slope at the canyon to the flat slope at the bay.

Location of River Within Floodplain

At the upstream end of the valley, the flood plain is relatively flat with the channel bed several feet lower than the flood plain (see cross-sections 68-66). As the South Fork continues downstream, the first of several tributaries from the southern side of the valley flow downstream and toward the South Fork. These tributaries tend to flow in a direction primarily down valley before joining with the South Fork. The first tributary, Kirkland Creek, follows this pattern in the area between cross-sections 66 to 64. In this area there are several low portions primarily on the southern flood plain that are not much higher than the bed of the South Fork. At cross-sections 64 and 63 the flood plain is again very low. The flood plain is a little higher with respect to the bed of the South Fork from cross-sections 62 to 58. Vance Creek parallels and then join with the South Fork from cross-sections 64 to 60.

The North Fork joins the South Fork near cross-sections 55 and 54 forming the Skokomish River. Swift Creek parallels the South Fork and the Skokomish River from cross-sections 60 to 53. In the vicinity of cross-sections 57 to 55, the flood plain is quite low on both sides of the river. Hunter Creek flows parallel to and then joins the

Skokomish River in the reach of river from cross-sections 55 to 37. At cross-sections 54 and 53, the valley floor slopes to the south and Hunter Creek (which is on the southern side of the valley floor) is lower than the Skokomish River. From cross-sections 52 to 46, the flood plain has numerous points which are almost as low, and some cases lower than the main channel on both sides of the river. In the reach from cross-section 45 to 37, the flood plain remains relatively low, with areas nearly as low as the river bed.

From cross-section 39 to 25, Weaver Creek flows parallel to the Skokomish on the southern flood plain. From cross-section 39 to 27 (just upstream of the Highway 101 bridge), the flood plain has numerous points which are nearly as low as the bed of the river. In some places, the bed of Weaver Creek is lower than the bed of the Skokomish River. The southern flood plain is generally a little lower than the northern flood plain. The embankments approaching the Highway 101 bridge block the flow on the low flood plains on both sides of the river. Most of the overbank flood flow then flows over the southern flood plain crossing through bridges for Weaver and Purdy Creeks (which have beds lower than the Skokomish), as well as overtopping the low sections in Highway 101. The lowest portion of the highway is in the vicinity of Purdy Creek.

Purdy Creek flows in the Skokomish Valley starting a short distance upstream of the Highway 101 bridge. Weaver Creek joins Purdy Creek just downstream of the Highway 101 bridge between cross-sections 26 and 25. Purdy Creek parallels the river and joins the Skokomish River in the vicinity of cross-section 19. From cross-section 26 (just downstream of Highway 101) to cross-section 20, the flood plain on both sides of the river is quite low. At a number of these cross-sections, the lowest portion of the flood plain is lower than the river bed. This portion of the flood plain on the USGS map is designated as a wet area. An old remnant channel of the Skokomish River is located on the north flood plain and Purdy Creek is located on the south flood plain. From cross-section 19 to 16 the Skokomish River swings to the south and flows adjacent to the Purdy Cutoff Road and the south valley wall. The north flood plain is still quite low but not as low as it had been further upstream and not as low or lower than the channel bed. Actually at cross-sections 18 to 16, the north flood plain is mostly higher than the river bank and drains toward the river. From cross-section 15 to 11 (the Highway 106 bridge), the river swings away from the road and the flood plain is mostly higher than the river except for a small, un-named channel which flows across the south flood plain from the valley wall to the river. The roadway embankments leading up to the Highway 106 bridge tend to block any flood plain flow and force water to flow through the bridge opening for most flow conditions.

From the Highway 106 bridge (cross-section 11) down to cross-section 6, the Skokomish River continues to flow in a single channel. Downstream of cross-section 6, the river splits into two branches. There is a channel which flows diagonally across the north flood plain and drains into the north branch of the Skokomish River after the split. From cross-section 10 to 6, the flood plain is generally higher than the channel but sometimes lower than the top of the river bank. The USGS map shows a wet area on the north flood plain from cross-section 9 to the split near cross-section 6.

Downstream of the split below cross-section 6, the river is influenced significantly by the tides. The flood plain is relatively flat farmland and tidal marsh land.

Avulsion Possibilities

The Skokomish River has flowed in its present channel for quite some time without major shifts or avulsions. As aggradation of sediment on the river bed has occurred at an accelerated rate over the past few decades, its capacity to convey floods has decreased. For example, from a comparison of South Fork cross-sections surveyed in 1992 and 1997, there was evidence of about 2 feet of aggradation and corresponding reduction in conveyance capacity. This situation, coupled with the availability of existing parallel tributary channels which are often lower in elevation than the bed of the main river system, has set up the strong possibility of a major avulsion. An avulsion can be defined as a significant and rapid change in channel alignment, typically resulting in the adoption of a new path for the river to follow. The most likely location for an avulsion to occur is in the vicinity of cross-sections 54 and 53, or 49 and 48. These are the areas with the strongest cross valley gradient to the south towards the Hunter Creek channel, which is lower than the Skokomish River bed. The reach of the river from cross-section 54 to 53 has experienced erosion of riparian vegetation and the river bank last winter, and the reach in the vicinity of cross-section 49 and 48 is near a sharp bend in the River and experienced erosion of the river bank dikes during last winter's storms. Although not as likely as the locations discussed above, there is a possibility of an avulsion in the reach near cross-sections 44 and 43 at or near the end of the existing dike and in the low area in the vicinity of cross-sections 39 to 35. If an avulsion occurs in the vicinity of cross-sections 54 and 53, 49 and 48, or 44 and 43, the water would likely flow toward and into Hunter Creek. The flow could re-enter the Skokomish as Hunter Creek currently does, however since the main stem Skokomish would also be at high flood levels, it could jump into the Weaver Creek channel. If an avulsion occurred in the low area near sections 39 to 35 the flow would likely go directly to the Weaver Creek channel. If the avulsion fully develops and follows the Hunter Creek and Weaver Creek channels, this would tend to cause increased flow across Highway 101 in the Weaver and Purdy Creek channels and over the road in these areas. This would cause increased flow and flooding on the southern flood plain downstream of Highway 101.

It is also possible that an avulsion could take place farther upstream on the South Fork in the vicinity of cross-section 64 or 59. These are locations where the South Fork is directed at the south river bank and where overflows occurred during last winter's floods. In the event of an avulsion in either of these locations, either all or more likely a part of the flow would leave the South Fork or Skokomish River and follow the path of least resistance and strongest gradient. This path is generally toward and down existing tributary channels such as Vance Creek, Swift Creek, or Hunter Creek. If an avulsion occurred from the South Fork to Vance or Swift Creeks, it is possible that the water could rejoin the South Fork or the Skokomish River as these creeks currently do. They could, however, be overwhelmed by the magnitude and momentum of flow, adopting a path into Hunter Creek.

Significant flooding currently occurs and will continue to occur on both sides of the river downstream of Highway 101. Purdy Creek rejoins the Skokomish River near cross-section 19. Downstream of this location, there is no available evidence of strong trends of potential avulsions. Thus, it seems likely that the existing channel would continue to persist in the short term downstream from this location.

Disclaimer

It is important to understand that no predictions such as those discussed above are infallible. The discussion presented in this document is based on available data, observations, and experience. While the data are the best available and there is considerable experience which has been applied to this situation, the data and observations may be incomplete and could be affected by the lack of a full and comprehensive understanding of the multi-dimensional dynamic nature of a complex natural system. No liability for any consequences of the above discussion is assumed or accepted by its authors. If we were residents of the valley we would consider the following warning, which we have also drafted.

WARNING TO SKOKOMISH VALLEY RESIDENTS AND OTHER CONCERNED PARTIES REGARDING THE POTENTIAL FOR RIVER AVULSIONS GENERAL DYNAMIC BEHAVIOR AND FLOODING

- Mason County has declared a state of emergency on the Skokomish River and South Fork.
- The state of emergency was declared for a variety of reasons:
    1. The Skokomish River and South Fork have been aggrading, or filling in with sediment, thereby losing their capacity to convey flow, particularly under flooding conditions.
    2. Portions of the Skokomish River and South Fork are perched, that is, the river channel is higher than the surrounding floodplain. Given the perched condition coupled with the continued aggradation and loss of flow conveyance capacity, it is probable that the Skokomish River and/or the South Fork will abandon their present course and develop a new channel on the floodplain. This is called an avulsion. The timing of such an event is difficult to establish but could occur in the very near future. While it is possible that an avulsion will not occur, it is more likely than not, over the long-term.
    3. The recent floods have eroded significant areas of riparian vegetation, have eroded riverbanks, breached dikes and present a continued threat to life and property.
    4. The existing dike system which provides some level of flood protection was not engineered or constructed to any adequate or appropriate engineering

design criteria. As a result they are unreliable and may fail in the same locations as experienced in recent floods, or in other locations.

5. Several efforts have been undertaken by Mason County to mitigate for potential damage. The County has proposed to remove gravel bars and trap and remove coarse sediment from specific areas of the lower South Fork and Skokomish River to control or minimize future aggradation. They have also proposed protecting specific areas of riverbank and dikes which were damaged in recent floods. These efforts, however, have been slowed due to the required review and permitting process by other governmental agencies and the lack of funding sources. As yet none of these measures have been implemented along the river.
6. Time is growing short for any such proposed work to be completed prior to the next flood season, particularly given the available construction window to accommodate fisheries issues.

- It is recommended that residents and property owners along these rivers purchase flood insurance and take other reasonable measures to protect themselves and their property such as floodproofing or raising homes above flood levels and developing emergency evacuation and preparedness plans. It is recommended each property owner consult with a professional engineer in determining appropriate elevations and floodproofing strategies. It is also recommended existing permitting requirements from local, state, or federal governments be followed in any actions taken including diking, riverbank protection, or other river control projects (Note: a summary of these requirements should be provided along with this warning). Failure to do so may result in unforeseen damages or legal issues such as fines or other penalties, or lawsuits.

Background For Warning Statement

The following material provides more detailed support for the warning presented above for those who wish to become more fully informed regarding these issues.

State of Emergency

The Skokomish River system is a dynamic alluvial river system. Alluvial rivers are those which are formed by the sediment which the rivers themselves transport and deposit. The Skokomish River has been experiencing aggradation in recent decades. During the 1996/1997 high flow season, the Skokomish River experienced several significant flood events which seem to have exacerbated its dynamic nature. Mason County is concerned over flooding and channel dynamics trends, and has declared a state of emergency as discussed above.

Current River Conditions and Trends

It is common knowledge that the river has been aggrading, or filling in with sediment and that its capacity to convey has decreased forcing more water overbank thereby causing more frequent and severe flooding. Surveys of channel sections conducted in 1997 when compared to the same sections taken in 1992 showed

approximately 2 feet of aggradation. Thus, the channel continues to decrease in size and ability to convey flow.

There are several areas of the river where the bed of the main channel is very high compared to the surrounding floodplain. This is called a perched river. In such a case, when flooding occurs, there is a gradient for water to flow out of the channel and over the floodplain to a greater extent and more strongly than on a river that is not perched. Such a situation tends to lead to avulsions which can be described as the flow in the river abandoning the old channel, and flowing over the floodplain, eventually finding or creating a new channel down the valley.

Geomorphic Analysis

The lower South Fork and upper Skokomish River is located downstream of the mountains of the upper watershed flowing over an alluvial plain. In this zone of the river system, the coarser sized sediments eroded and transported from the upper watershed tend to deposit on the bed of the river because the slope of the river is flatter in this reach compared to upstream. As the slope becomes flatter in the downstream direction, the velocity decreases, thereby decreasing the energy of flow and its sediment transport capacity. The bed of the river in this area responds by aggrading as the coarser sizes of sediment tend to deposit. Over time, the channel's capacity to convey flow decreases, causing more frequent flooding. The tendency increases for the channel to erode its banks, enlarging the channel size, or even to shift position, seeking new alignments or paths to convey the flow.

Historic Conditions

It is important to note that the Skokomish River historically has flooded and has experienced dynamic behavior. Prior to the Cushman Project, built in the 1920's, the Skokomish River experienced significant flooding. The Washington State Department of Ecology (1988) stated:

> *"The Skokomish Valley has always flooded, and this has been a problem since settlement of the area by Caucasians and formation of the Skokomish Indian Reservation in the late 19th Century."*

In comparing the Skokomish to other similar rivers in the Pacific Northwest and specifically mentioning that the Skokomish was typical of such streams, the Department of Ecology in the same report stated:

> *"Historically, the lowland reaches of the larger Pacific Northwest rivers were characterized by multiple channels, numerous sloughs and old side channels, and an abundance of snags and log jams in the channels. Stream flow through the multiple channels was sluggish, and during the winter rainfall and spring snowmelt seasons, the river's flow regularly over topped the channel banks and spread across the entire floodplain for days or weeks at a time, if not the season."*

Older maps of the Skokomish valley, accepted by the Surveyor General in 1861, show significant areas of the floodplain adjacent to the river to be a marshy or wetland type of an area.

Recent aerial photographs, despite agricultural activity and other development, still show evidence of some historic channels on the floodplain. This indicates that the river has shifted alignment over time. Again, this dynamic shifting nature of the Skokomish River is a natural tendency as explained in the literature (Schumm, 1977), a well known geomorphologist, when he stated:

> *"Frequently environmentalists, river engineers, and others involved in navigation and flood control consider that a river should be unchanging in shape, dimensions and pattern. This would be very convenient. However, an alluvial river generally is changing its position as a consequence of hydraulic forces acting on its bed and banks."*

In an attempt to reduce flooding, it was reported by Sedell (1982 and 1984) and others that:

> *"Soon after settlement by Caucasians, a program of river snagging was begun by agriculturalists, and later institutionalized by the U S Army Corps of Engineers, to hasten the drainage of peak flows and drain the floodplain land for agriculture."*

In addition, dikes were also constructed along the river and the delta area to reduce inundation of the land surface. These statements demonstrate that flooding along the Skokomish River is not an issue of relatively recent origin but instead is a natural phenomenon which has occurred historically.

Future Trends

As a result of diking and general development of the floodplain, coupled with the flood control provided by the Cushman Project, residents of the valley from the 1920's through fairly recent decades did not have to contend with the amount of flooding described for historic conditions. With the natural aggradational trend and increased sediment load, these flood control benefits have been gradually diminishing to the point today where flooding has become quite common and may be approaching the historic flooding conditions which could be characterized as chronic and extensive. In addition, the Skokomish River and South Fork are on the threshold of potentially major avulsions, or in other words, major shifts of channel alignment. What is now floodplain could become a new path for the river. Existing channel segments could be abandoned. There are several strong indications for such potentially major avulsions. The Skokomish River system is perched. In other words, the channel is at a generally higher elevation than the surrounding floodplain. Perched channels are inherently unstable, and if the banks are breached the river may simply adopt a new path on the existing floodplain. The gradient across the valley floor in some cases is larger than the gradient downstream. The path of least resistance for water is often the steepest. The general cross valley slope or gradient for the upper Skokomish and lower South Fork tends to be to the south. Thus, the floodplain to the south of the river is particularly vulnerable. During the floods of the 1996/1997 season, there were several overflow paths which flowed to the south from the river. During the site visit, the remains of one actively flowing channel was observed leaving the Skokomish and flowing toward the south even at relatively low flow.

Although this channel turns down valley and returns to the Skokomish, it is a strong indication of the potential for a more significant avulsion and the creation of a new channel.

Probable Consequences for Inaction

In evaluating the benefits of the proposed gravel bar removal, sediment traps, and riverbank protection in contrast with potential adverse consequences, several concepts should be considered. Not removing gravel bars or trapping the upstream coarse sediment load in order to control aggradation, and the lack of riverbank protection will more than likely result in a number of adverse consequences. Data show that the historic aggradation has decreased the bankfull conveyance capacity of the Skokomish River (Evaluation of the data has shown that the natural trend of aggradation in the Skokomish River has been accelerated primarily by the increase in sediment supplied to the river due to such activities as timber harvesting and building of roads in the contributing subwatersheds). This aggradational trend means that the river conveys progressively smaller flows within its banks resulting in increased overbank flooding and decreased total quantity of water which flows within the banks of the river which is needed for the fish. Eventually, as the channel capacity continues to decrease, assuming no sediment control action or riverbank protection is taken, the channel will experience significant avulsions, probably during a flood event. The old channel, or portions thereof, will be abandoned and new channels will be formed in the flood plain. There may be a period of a number of years when the water is forced out of the existing channel and will flow in an ill-defined path over the flood plain until a new channel is formed. While this is the dynamic nature of channels in the deposition zone of the fluvial system, this will result in a call for action which will be very expensive and quite disruptive to those who live along the river, as well as to the fish who live in the river. A decision needs to be made whether it is better to attempt to maintain the existing river channel by removing gravel bars, trapping coarse sediment, and riverbank protection as proposed in an effort to maintain the channel in its present location, or to deal with the consequences when the river experiences avulsions. Of course, other options exist including large-scale dredging of the entire river on a periodic basis, extending/strengthening/raising of existing dikes in response to increases in bed elevation, long-term sediment supply reduction through watershed management practices, or more permanent sediment trapping facilities. However, these options are either more environmentally disruptive, more expensive, or require more time to become effective than the gravel removal, sediment traps, and riverbank protection which have been proposed for consideration this season.

Thoughts to Consider

It is necessary to understand that to maintain and control the Skokomish River in its current channel would require significant effort and expense over the long-term. To do so requires a major commitment to force the river into a fixed pattern and controlled behavior rather than to let it naturally adjust its bed, banks, and alignment. Such an effort may not be feasible and the river may experience major change before any such

commitments are developed and implemented. Remember that the Skokomish River, before significant development, was subject to significant channel change and extensive flooding. There has been a brief respite for several decades due primarily to flood control on the North Fork. Because of the tendency for increased sediment deposition as bed slopes and flow velocities decrease in the downstream direction and because of recent increases in sediment loading from the upstream watershed, the river is reverting to its historic dynamic and flooding conditions. It is expected these conditions will prevail in the future.

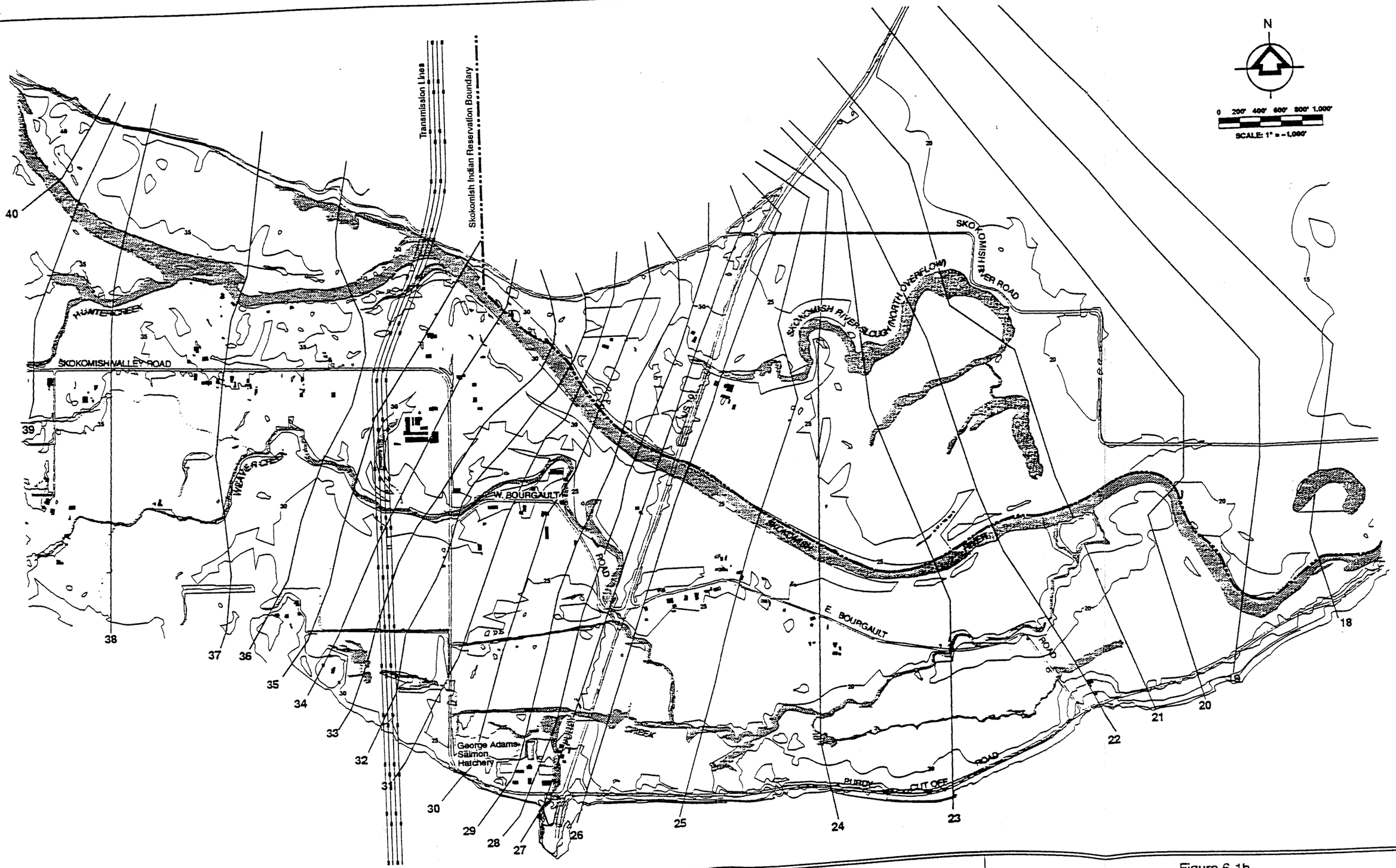
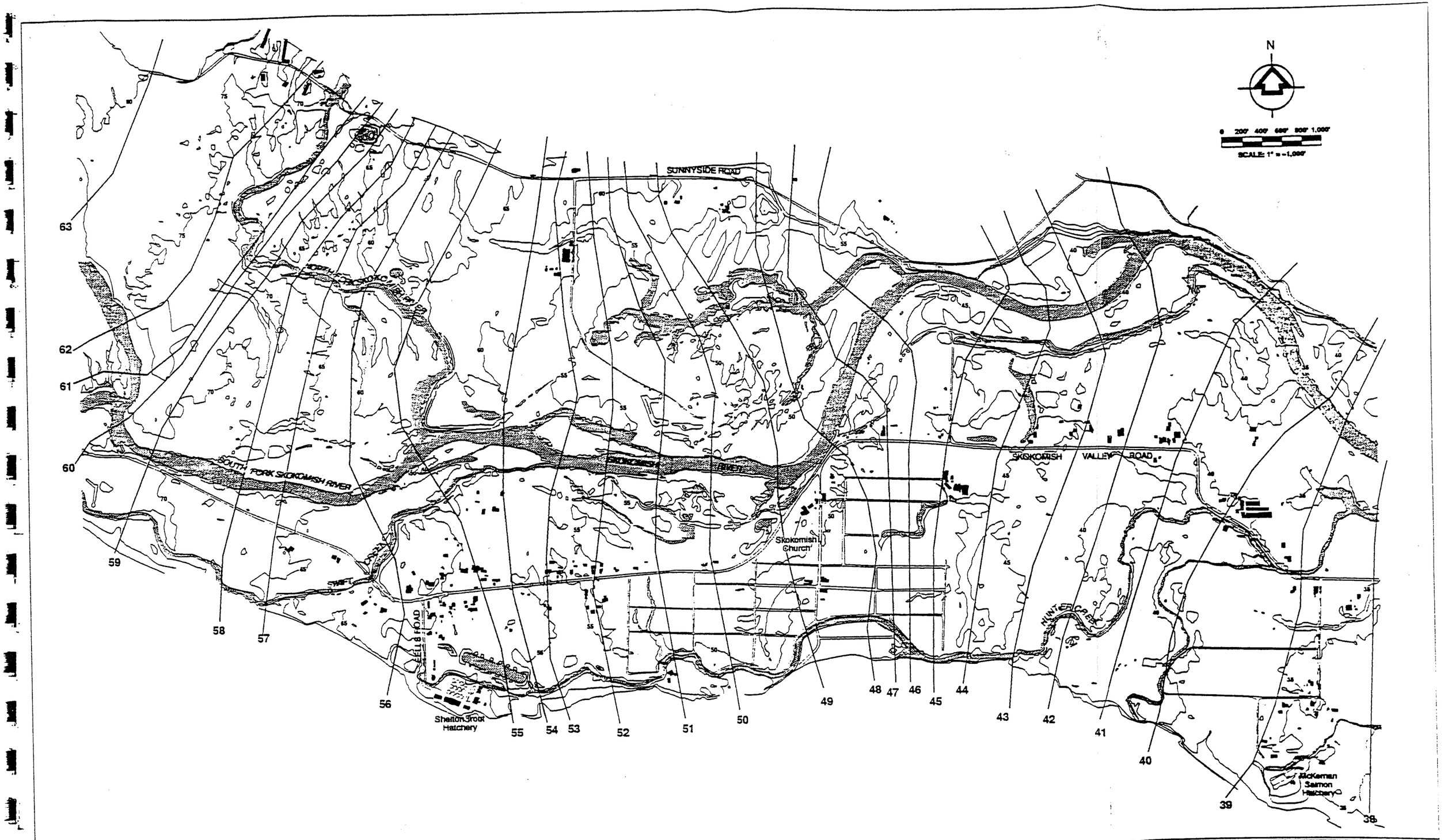


Figure 6-1b.
TOPOGRAPHIC MAP OF THE SKOKOMISH VALLEY—
WEAVER/PURDY CREEK VICINITY

Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

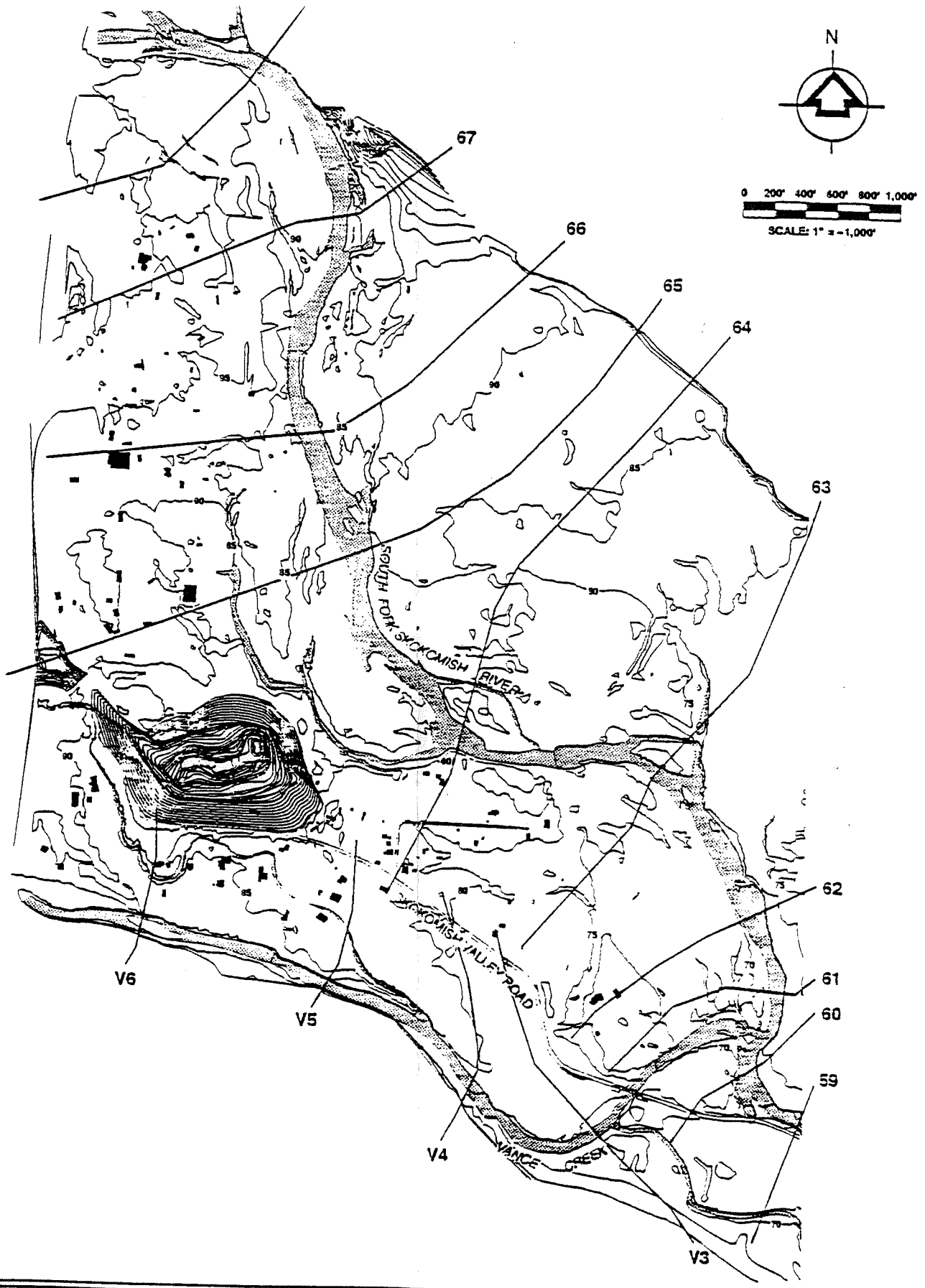
KCM
1917 First Avenue



KCM
1917 First Avenue
Seattle, Washington 98101

Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-1c.
TOPOGRAPHY AND HEC-2 CROSS-SECTIONS OF THE
SKOKOMISH VALLEY—HUNTER CREEK VICINITY



KCM
1917 First Avenue
Seattle, Washington 98101

Mason County
SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 6-1d.
TOPOGRAPHIC MAP OF THE SKOKOMISH VALLEY—FIVE MILE CORNER/ VANCE CREEK VICINITY