BRITISH COLUMBIA

March 25, 1998

File No. 76840-60 Mission Creek

Status Report on Mission Creek and Upper Mission atershed:

1.0 Purpose

The purpose of this report is to investigate the extent of perceived increases in flooding, erosion, and channel instability in the reach of Mission Creek directly upstream and downstream of the Highway 33 bridge. The investigation has concentrated on:

- analysis of the hydrology and possible peak flow trends of Mission, Pearson and upper Mission Creeks.
- possible man-made impacts to both the channels of mainstem Mission Creek, mainly upstream of Highway 33, and Pearson Creek; including sediment sources, and impacts to the riparian areas and active floodplains from developments on both Crown and private lands.
- past flood effects, measures taken, and their impacts, both positive and negative.

Some recommendations for future work are given.

Acknowledgements

To the following, for technical assistance and advice in preparing this report: from Ministry of Forests, Rita Winkler, Research Hydrologist, Tim Giles, Research Geomorphologist, and Jake Devlin, Watershed Restoration Officer; from MELP, Ted Fuller, Regional Geomorphologist, Brian Symonds, Water Management Engineering Section Head, Ray Jubb, Deputy Dike Inspector, Bruce Shepherd, Sr Fisheries Biologist, and Phil Epp, Watershed Restoration Coordinator.

1.1 The Pre-development Watershed

To fully understand the problems of today, it is informative to take a brief look at the form and function of the Mission Creek watershed in its pre-development or 'natural' condition, and how that differs from today's conditions.

In the uplands tributary areas, forest fires historically played a major role in the succession of vegetation. Forests would become mature, the incidence of dead bug-killed trees would rise, and the forest would become more susceptible to fire. Fire would sweep through varying proportions of the watershed, and for a short time the runoff from those areas would increase due to changes in snow accumulation, melt rate, and decreased vegetation use of the groundwater. Depending on the location of the burns, and whether the climate was in a wet or dry cycle, the increased groundwater may have increased landslide activity by varying amounts, causing an increase in the 'sediment and bedload in

Ministry of Environment. Lands and Parks | Environment and Lands | Telephone: (250) 490-8200 Facsimile: (250) 492-1314 | Mailing Address 6 Location: Suite 201-3547 Skaha Lake Rd, Penticton, B.C. V2A 7K2

the stream. The increased flows and sediment from burns would have caused increased bank erosion and lateral movement, resulting in an increase in the amount of Large Wood Debris (LWD) in the stream, which in turn helped to re-stabilize the bed and banks.

Forest fires are no longer allowed to burn unchecked. The result has been an increase in the amount of mature forest, with an increase in its susceptibility to 'forest health' problems, such as the Mountain Pine Beetle and Spruce Bark Beetle. This has resulted in extensive reactive 'beetle-chasing' forest harvest in the 1980's, through much of the mid-elevation Mission Creek watershed, with its huge clearcuts and accompanying road systems. While the clearing of the trees itself may have had a similiar effect to a burn, there are some differences. Most notable is the added impact of the road system and skid trails, which are discussed later in this report. Also, pre-code harvesting allowed harvest to the streambank, so that any increased bank erosion through areas of riparian harvest had no compensating increase in LWD introduced to the stream to aid in re-stabilization of the channel and bedload.

In lower Mission Creek (and the lower portions of some of its tributaries) the difference in pre-development natural conditions and those existing today is more extreme. These are largely the privately owned lands on the floodplains and alluvial fan or delta areas. Prior to any development on these lands, in high flow years the stream was able to flood out of its channel, so that a large proportion of the flow was not confined to the meandering channel. This overbank flow had many beneficial side effects, including:
-reducing the erosive forces to which the stream banks were subjected.
- deposition of many of the finer silt and sand sediments on the flood plain, fertilizing the flood plain, and reducing the amount of sand/silt size sediments left in the channel gravels after a flood.
-connecting, for varying periods of time, the wetlands of the floodplain with Mission Creek, providing rearing areas and nutrition input for fish.

Banks were generally well treed and stable, with beaver, bank erosion, and blowdown providing LWD to slow water velocities both in the channel and overland flow areas, and create abundant and diverse fish habitat. In years of high bedload movement, channels could infill with bedload deposition, old channels could be reactivated, and/or new channels formed anywhere the stream pleased on the fan or delta area.

In contrast, today the majority of lower Mission Creek is straightened, diked and riprapped, to protect private property from the natural overland flow on the floodplain, and prevent the lateral movement or shifting of the channel. Tributary floodplains, while not generally diked, have often been cleared to the streamside (or a very minimal riparian strip) for agriculture or subdivisions. LWD which previously slowed flow velocities and formed the basis for fish habitat has been generally removed in the interest of flood control, resulting in a dramatic decrease in fish habitat and higher flow velocities. Silt and sand proportions in the spawning gravels have risen, resulting in a loss of spawning habitat through much of the 'Greenway' reach of lower Mission Creek.

Any look at the current state of Mission Creek therefore must consider both the impacts of forest management and private property owners actions. It is a complicating factor that much of the clearing and encroachment on the creek and floodplains was done at a period when peak flows would have been at a relative minimum; that is, during a period when there were no large burns in the Mission watershed due to fire-fighting, and forest harvesting was at a low level, prior to Mountain Pine Beetle getting into the even-age maturing Pine which covered much of the mid-elevation Mission Creek watershed.

2.0 Hydrology of Mission Creek and Upper Mission Creek

2.1 Background discussion

There are three aspects of forest hydrology in which forest development can affect the quantity and timing of runoff from a watershed. These are; spring snowmelt freshet flows, total yearly water yield (including low flow periods), and watershed response to rainfall. Comments on each of these aspects follow. A good discussion of the possible impacts of logging and roadbuilding on flooding in general, and on Mission Creek flows in particular, can be found in the attached letter report by Rita Winkler, MoF Regional Forest Hydrologist, (Appendix 2).

In general, peak flows in Mission Creek and other regional watersheds are the result of spring snowmelt, with lesser peaks occurring due to prolonged and/or extreme rainfall. Peak spring freshet flows originate mainly when rapid snow melt occurs in the elevation band just above the "H60" line. The H60 line is the contour line which has 60% of the area of the basin above it. In Mission Creek, the H60 line is at approximately 1300 meters elevation. Peak spring flows in Mission Creek usually occur when the snowline is around 1600 to 1700 meters, meaning active melt is occurring in the 1600 to 1800 meter plus elevation band. At that point in time the majority of snow melt from lower sub-basins and elevations has already occurred. Extensive harvest in that upper elevation band would be predicted to potentially cause a significant increase in peak spring freshet flows, depending on temperature and rainfall patterns in a given year. Although much depends on the aspect and size of clearcuts, studies have shown that snow accumulation and rate of melt can both be increased in cleared areas. Spring freshet flows can also be increased dramatically by rain on snow events, such as occurred in the June 1997 freshet flood.

Total water yield from a watershed is affected by harvest or clearing at any elevation, as there is less interception of rain and snow by vegetation (which can then evaporate or sublimate without hitting the ground), and less transpiration. In simple terms, there are less trees to intercept precipitation or 'drink' the groundwater. The BC Environment 'Manual of Operational Hydrology' gives transpiration rates for this area which are in the range of 300 to 500 mm per year, depending on vegetation, soil types, etc. Given a range of precipitation in the Mission Creek basin of 350 mm at the lower end to 1100 plus mm in the Greystokes, it can be seen that the effect on water yield and groundwater content from a high percentage of clearcut areas may be quite significant, although caution should be exercised in extending general results of studies to site specific applications. Generally, the higher groundwater content associated with harvesting will result in higher runoff from prolonged or extreme rainfall. This will be more pronounced in a high runoff, high groundwater levels year, and will probably be having a noticeable effect currently in the sub-basins of Mission which are in the 23 to 48% Equivalent Clearcut Area (ECA) range (i.e., Belgo, Daves, Hydraulic, & KLO sub-basins).

In the 1997 Interior Watershed Assessment, ECA's in the Upper Mission above Pearson Creek and Pearson sub-basins are reported as 13% and 16% If the clearcuts were small and well distributed, any increase in flood flows caused by slightly increased groundwater levels would not on its own be measurable However, these cuts are concentrated as large clearcuts which, since the mid 80's, have covered a major portion of the ridges / plateaux between Belgo and Mission Creeks, and Mission and Pearson Creeks, in the area from above their confluences to 15 kilometers upstream of the Highway 33 bridge. The elevation of these large clearcuts is between 1200 to 1500 metres. These large clearcuts will be having impacts on local and downslope groundwater levels, and also on local drainage patterns These impacts may be showing up in the form of increased slope instability where the ground drops off sharply to the creek A number of new landslides (post 1974 and post 1984) were found on these banks in an air photo analysis These slides are discussed more fully in Section 4.0 of this report titled "Sediment Source Survey". An increase in groundwater must be considered in planning the percent of ECA and road locations which should be allowed upslope of steep, unstable streamside slopes Examples of this type of topography in Mission Creek are found in the Belgo, Upper Mission and Pearson sub-basins, as well as the lower 'canyon' which stretches approximately from Cardinal Creek to KLO Creek

Watershed response to rainfall is affected by both the road density and the ECA within the watershed. Roads includes everything from skidroads to highways. Ditchlines or any cuts by roads or trails intercept surface and subsurface flow, short circuiting the normal drainage pattern and conveying water rapidly down roads and ditches to streams. This tends to reduce the time of concentration, making smaller basins 'flashier', with streamflows rising more rapidly in rain events. In a prolonged rainfall, peak streamflows can be increased due to the interaction of roads short circuiting drainage patterns and increased water yield and groundwater levels from clearcuts. At the current levels of road density and harvest throughout the Mission Creek watershed, an increase in the magnitude of rain-response peak streamflows at Kelowna would be expected to be occurring. No analysis of individual Mission Creek rain-response flows has been done for this report, however, from literature review of studies on the effects of roads and clearcutting on peak flows, it would be expected that the rain-response flows from the entire Mission basin would have increased from pre-harvesting response in the range of 15 to 20% at Kelowna As these are in general smaller peaks than the spring snowmelt flows, they will generally be well within the capacity of the channel, and if the riparian zone was in good condition, should not have serious consequences.

In the Upper Mission and Pearson sub-basins increases in streamflows associated with rainfall events would be expected to be in the range of 5 to 10%; again, well within the capacity of the channel through the Three Forks reach, provided the riparian zone is maintained in a healthy condition and the flood plain is left unobstructed. No quantitative analysis has been done on rain on snow events, however it would be expected that, with the proportion of the watershed below the 1500 meter elevation level which has been cut, a heavy rainfall a the time when the snowline is at the 1200 to 1400 meter elevation could have a significant effect on the resulting quantity and rate of runoff.

2.2 Contribution of Pearson and Upper Mission to Peak Flows in Kelowna

As part of the hydrologic investigation of Mission Creek, the contributions of tributary streams to the peak flow affecting Kelowna were analyzed. Concurrent flow records for all the major tributaries were maintained for a six year period from 1977 to 1982 (see appendix 1). Peak flows, and flows at the time of peak flow at WSC station 08NM116, (Mission Creek at East Kelowna), are given for each major tributary. For three of the six years listed, Pearson Creek, and Mission Creek above Pearson, together contributed approximately 90% of the peak flow in Kelowna. The average contribution of these two sub-basins to the peak flow at East Kelowna was 74%, coming off of an area comprising only 30.2% of the Mission Creek Watershed. The average contribution of Mission Creek above Pearson by itself was approximately 57%, although this sub-basin only comprises 21.7% of the entire Mission Creek watershed. Proper planning of any developments, (including maintaining drainage patterns and consideration of whether orientation of cutblocks will delay or advance snowmelt) in Pearson and especially Mission above Pearson, to minimize the increases the peak flows from those sub-basins, are therefore not only of importance to the Three Forks area, but to the City of Kelowna.

2.3 Peak Flow ('Flood Frequencv') Analysis

Spring 1997 flows at both Three Forks and Kelowna were fairly extreme, peaking at WSC station 08NM116 (Mission at East Kelowna) at 11:51 PM on May 31 at 97.6 CMS, the identical flow to the previous record instantaneous flow in 1969. In terms of 'Maximum Daily Flow' (average flow for peak day), the 1997 flow was 83.6 CMS, second highest in the records to the May 13, 1969 peak day's average flow of 87.5 CMS. Flood frequency analysis puts both the Maximum Instantaneous and the Maximum Daily Flows for 1997 in the range of 25 to 30 year return period flows. A 25 year return period flow is that flow rate which is exceeded once in 25 years.

To give an idea of the magnitude of the 1997 flood in relation to both Mean Annual Flood and more extreme estimated return period floods, the following table is included:

Table 1: Flood Frequency Analysis for Mission Creek at East Kelowna

Return Period (r.p.)	Peak Instantaneous Flow (cubic meters/second)	Maximum Daily Flow (cubic meters/second)
Mean Annual Flood	60.0	48.7
5 year r.p.	76.0	62.0
10 year r.p.	86.5	71.5
20 year r.p.	96.6	80.3
50 year r.p.	109.5	92.0
100 year r.p.	119.0	100.5
200 year r.p.	129.0	109.0

Note: A 10% increase in peak flows due to development causes the 100 yr r.p. flow to occur at a 50 yr r.p., while a 25% increase in peak flows would shift the 100 yr r.p. flow to a 20 yr r.p.

2.4 Peak Flow Trend Analysis

Peak flows in Mission Creek at East Kelowna, due to its long period of record (1949 to 1997) were analyzed for trend in magnitude of the peak flow, using the method of cumulative deviation from the mean, and by graphing a five year running average of peak flows (Appendix 1). No long term trend of increase could be found. This is consistent with the current lower levels of development in the zone of active melt at the time of peak snowmelt flows discussed in the previous section. What does appear in the five year running average is a more cyclical pattern which coincides with the precipitation pattern of the entire Okanagan basin (wet in the early 70's, drier in the 80's, wetter in the 90's). It is worth noting in a discussion of flooding in 1997 that annual inflow to Okanagan Lake for 1997 was approximately 1.4 times the previous record year, which was 1996.

Graphing 'five year average' hydrographs for Mission @ East Kelowna, we see a predictable, gradual and consistent shift in the onset of the spring melt to approximately 17 days earlier since the large Mountain Pine Beetle harvests began. Investigation of any significant changes in operations of the storage reservoirs on Mission Creek's tributaries must be done to assess whether they have contributed to this earlier onset of high spring flows. No shift in the timing of the peak of snowmelt freshet was apparent, however this is also predictable, based on a literature review, as the extreme upper watershed, from which the majority of this freshet originates, has had less development than the lower portions of the watershed.

3.0 Current Watershed Condition (FRBC/WRP Assessments)

Due to its importance as a Community Watershed, its high fisheries values for both Trout and Kokanee, and flooding experienced through Kelowna, Mission Creek was one of the first watersheds to be assessed by the FRBC/WRP process. A "Mission Creek Watershed Stream Assessment" was done in 1995 by Summit Environmental Consultants. As this study was done early in FRBC/WRP process, prior to publication of the IWAP and Channel Assessment Procedure (CAP) Guidebooks, it is somewhat non-standard, but includes a form of channel assessment, a basic Fish Habitat Assessment (FHAP), and a Sediment Source Survey (SSS). A standard level 1 Interior Watershed Assessment Procedure (IWAP) was done in 1996197 by Dobson Engineering, which calculated the hazard indexes for Peak Flow, Surface Erosion, Riparian Buffers, and Mass Wasting (landslides).

Summary of the Assessments

3.1 Stream Assessment:

Pearson Creek- Two sites of concern were identified in the report as having Forestry-related impacts. 'Site #4' is a slide from below a logging road to the floodplain, approximately one kilometer upstream of the confluence with Mission Creek. The debris track ends about 5 metres above the floodplain, but may have contributed sediment in the 1994 freshet. This slide shows substantial revegetation in the 1996 air photos. 'Site #6' is a damaged culvert outfall pipe approximately 3 km upstream of the Mission confluence which was contributing fine sediments to Pearson Creek. While none of the listed sites appear to have significant effects on bedload in the Three Forks area, if this site has not been repaired yet, it would be a high priority for work in the immediate future due to its impact on water quality.

Mission Creek Mainstem- Although a number of sites were found to have bank erosion and there was much woody debris in the mainstem Mission Creek, only four sites were determined by this report to have had direct forest harvesting related channel impacts. The most severe impacts of ongoing bank erosion recorded were in an area of private land logging above the Forest Service bridge located just above the confluence of Pearson Creek.

3.2 Level 1 IWAP results:

Hazard Indexes calculated for Pearson Creek, Mission Creek above Pearson, and for the entire Mission Creek watershed, from the Dobson report were;

Table 2: Partial IWAP results for Mission Creek

March 1997 Results	Peak Flow	Surface Erosion	Riparian Buffers	Landslides
Pearson Creek	Low	High	Low	Low*
Mission above Pearson	Low	Moderate	Low	Moderate
Belgo Creek	Moderate	High	High	Low
Joe Rich Creek	Low	High	High	Low
Entire Mission Creek	Moderate	High	High	Low

* with the number of landslides revised from 4 to 12 this becomes a moderate hazard rating. (See the section 'Sediment Source Survey' for reasons for this revision.)

Recommendations in the IWAP for further works included:

1. level 2 channel assessments in Belgo, Daves, Hydraulic, KLO, and Priest Creeks, and mainstem Mission Creek below Pearson.
2. remedial work & prescriptions (ie road deactivation) to reduce the surface erosion hazard.
3. efforts to minimize cattle activity in riparian areas.
4. remedial prescriptions for sub-basins with high Riparian Hazard Indexes, to be based on channel assessments and discussed with BC Environment.

As a follow-up to the Level 1 IWAP, an Access Management Plan, which included consultation with MoF, Timber Licencees, MELP (Water Management, Habitat Protection, and Fish & Wildlife), and other interested parties, was completed in early 1997. This plan identified which roads should be kept open, which should be gated, and which should be de-activated. Road deactivation in the Mission Creek watershed, following the recommendations of the IWAP and Access Management Plan, was begun in some sub-basins in the summer of 1997. Road de-activation includes culvert removal (to remove the risk of unmaintained culverts blocking, causing road fill failures and erosion), and construction of water bars and cross ditches which attempt to restore natural drainage patterns. Some minor siltation is to be expected immediately after deactivation, however, risk of major slides is reduced. Also, flood response should be closer to natural pre-harvest conditions, due to ditch flows being returned to the forest floor and groundwater, and less flow being concentrated in ditches and flowing rapidly down them into streams.

The IWAP Guidebook requires that for the hazard index levels found in Mission Creek watershed as a whole, a round table be formed to discuss the results of the IWAP, to initiate any further FRBC / WRP studies or works required, and to discuss harvesting implications.

4.0 Sediment Source Suwey

The two sub-basins of Pearson and Upper Mission, as well as KLO sub-basin (which has not been studied here), are by far the most slide-prone in the entire Mission Creek watershed, due to the steeper terrain surrounding the stream channels, the higher levels of precipitation, and soil types. As part of this investigation, a historic air photo study (1974, 1984 and the most recent photo 1996) of landslide activity in this area was done by Ted Fuller, MELP Regional Geomorphologist. The 1996 air photos showed two slides between the Highway 33 bridge at Three Forks and the Pearson and Upper Mission confluence, twenty-five slides in the Upper Mission sub-basin, and twelve in the Pearson sub-basin, all on the steep valley sides adjacent to the respective flood plains. Of the 12 landslides in the Pearson sub-basin, five of those found on the 1996 air photos were not found on the 1984 photos, and a further two were not found on 1974 photos. Of the 25 slides on 1996 air photos of the Mission above Pearson sub-basin, twelve were not found on the 1984 photos, and a further two were not found on the 1974 air photos. It is worth noting that every one of the post 1984, and the two 1974 to 1984 slides in Mission above Pearson, found in this air photo study, are located downslope of the large Mountain Pine Beetle cutblocks and their associated road systems. While a few of these have been identified by MoF and Riverside Forest Products as sidecastings of shot rock from road building, further investigation of those unidentified in the Sediment Source Survey of the IWAP should be carried out, to determine impacts and possible remedial action.

Additional landslides, not included in the above count, which have occurred since the 1996 air photos were taken, have been reported by Penticton MoF and Riverside Forest Products both upstream and downstream of the upper limit of harvest activities. Recent high groundwater levels and streamflows have no doubt been contributing factors to the large number of newer landslides, however they emphasize the sensitivity of the terrain along the steep slopes of Pearson and Upper Mission Creeks. Terrain Stability Mapping being done by Penticton MoF is near completion in the Mission Creek watershed. Development upslope of the final mapped areas of high risk should be done with extreme care for both possible increases in groundwater flows and disruption of natural drainage patterns, which can concentrate surface flows onto areas which are unable to handle them. The 1997 Level 1 IWAP found the road systems in Mission Creek fairly stable, with 'only a limited number of priority sites overall', however, with the high density of the road system in all but the highest elevations of the watershed, some siltation will be occurring. As is discussed more fully in the following section, accelerated bank erosion on some private properties has also contributed to the sediment loading of Mission Creek.

5.0 Bank Stability Study

5.1 Background

To discuss bank erosion and stability problems in a given stream it is necessary to have some understanding of the proper functioning condition of a stream in nature Reaches of streams with a flood plain, such as the reach from above the Pearson Creek confluence to a distance below the Highway 33 bridge across Mission Creek, have a channel which generally has a bankfull capacity adequate to accommodate approximately the two to five year return period flood. This is the flood which is exceeded, on average, once every two to five years. Larger flows (i.e, flows of a higher return period) are accommodated by overbank flow across the active flood plain. During large floods the main channel gradually erodes the forested banks (riparian areas) on the outside of bends, causing a lateral shifting of the channel over time. This erosion introduces large woody debris, or trees with root wads attached, into the stream. This debris in turn helps to stabilize the heads of backchannels (forming log jams there), stabilizes the heads of gravel bars allowing them to revegetate, and provides scour holes and cover for important fish rearing habitat. Log jams and all large woody debris also slow water velocities and general bed load movement. In the flood plain, fallen trees slow overbank flow, reducing erosion and channel cutting through the overbank area. The root masses of the riparian area on the floodplain reduce and control both the rate of bank erosion, and channel cutting from overbank flow. The confining effect of the riparian vegetation helps to keep the channel narrow and deep.

The Forest Practices Code (FPC) recognized the importance of the riparian zone in maintaining stream health and stability by creating, for streams above a certain size, a Riparian Reserve Zone (RRZ), in which no harvesting is allowed. For a stream greater than 20 metres in width, the RRZ is 50 metres each side of the natural boundary of the stream, for a stream from 5 to 20 metres in width the RRZ is 30 metres. Unfortunately, no equivalent regulation has existed for private lands, or for Crown lands previous to the FPC. As a result, whether for pre-FPC harvesting, agricultural land clearing, private land logging, or private settlement clearing, many riparian areas throughout BC have been cleared to, or close to, the streambank. These areas may appear stable in years of low peak flows, and then in extreme flood years will experience often massive bank erosion and channel shifting.

Even a 'stable' stream has a large bedload movement at times of high flows. As an example of the magnitude of bedload movement in streams which have had similiar levels of development to Mission Creek, over the last 6 to 8 years Water Management has removed the following quantities of settled out bedload from sediment basins in Shuttleworth, Shingle and Ellis Creeks:

Table 3: Yearlv Volumes removed from Sediment Basins (cubic meters)
(figures from R Jubb, Sr. Engineering Officer, Water Management)

Stream	*Average*	*Minimum*	*Maximum*	*Wafershed size (sq km)*
Shuttleworth	12,000	8,800	23,000	90
Shingle	3,000	2,100	4,400	308
Ellis	1,600	900	3,300	158

By comparison, Pearson and Mission above Pearson watersheds combined have an area of approximately 160 square kilometers. It is estimated that maximum bedload transported during 1997 was in actuality much higher, as the sediment basin at Shuttleworth filled after only 3 or 4 days of the 7 or 8 day peak freshet flows. (Note: Shuttleworth Creek has a disturbed channel which has still not recovered from dam failures in 1936 and 1944.)

In an 'undisturbed' watershed, this bedload movement exists in a state of 'dynamic equilibrium', with material input to the system, from natural landslides and bank erosion, a stream power capacity to transport the material, and a channel which has formed under the influence of unique factors of grades, vegetation, precipitation, geography and soil types. Alteration. of any of these factors (increasing flows or sediment input, increasing grade by dredging, increasing velocities by removal of large wood debris or blocking of the flood plain, etc) creates an unstable situation which the stream does its best to restore. Therefore, works which are done in one section of a stream may often have unexpected results downstream or upstream. Dredging, for instance, steepens the grade at the upstream end of the works, causing downcutting there and deposition of the materials where the grade has been lessened at the downstream end of the works. Replacing vegetation and a floodplain with riprap and dikes, creates higher velocities through the reach and downstream, increasing the rate of erosion and sediment transport through the reach, with eventual increased deposition where the grade lessens further downstream.

5.2 Field Inspections and Air Photo Analysis of the Three Forks to Pearson Reach

An example of the impacts of private land logging of the riparian area is found above and below the Pearson Creek confluence, where historic selective, and recent clearcut, logging to the streambank have resulted in weakened bank structure, with serious bank erosion and stream widening occurring during the 1997 flooding. Other cases of increased erosion as a result of private land clearing/ logging are found in a number of other locations in the reach of Mission Creek between Pearson Creek to downstream of the Highway 33 bridge. An example of the impacts of agricultural clearing, leaving an inadequate vegetated riparian strip, and of the removal of large wood debris from the channel, is to be found on Joe Rich Creek in the large field visible from Highway 33. This reach shows the typical large 'bites' taken out of the bank once the sparse riparian root zone is breached. As well as the localized impact of this increased bank erosion, the eroded materials are transported downstream, increasing the bedload the stream must transport and which settles out eventually in another stretch of the stream.

Previous dredging and widening of the channel upstream of the Highway 33 bridge, undertaken by BC Environment at the request of some local residents, has not had any real long term beneficial effect. Bed load movement into the dredged area from upstream was accelerated, and some aggradation of the bed from original levels has likely been a result due to a widened channel, and associated slower water velocities, causing increased deposition of bed load in the channel. The result has been a wider, more unstable channel which, due to its newness, is less consolidated than the previous channel, resulting in increased tendency for flows to go sub-surface during periods of low flows. Fish habitat has also been negatively impacted in this reach due to shallower flow depths, and the loss of pools and large wood debris. According to locals, this work is also alleged to have increased ice jams in this reach.

Prior to development in the Three Forks area, large floods were allowed unrestricted use of the flood plain, relieving pressure on the main channel, and reducing velocities and hence erosive power. Construction in 1997 of a riprap berm, built just upstream of the B. Morris residence during the flood emergency to protect his home, (which is built on an island in the middle of the active flood plain), has completely blocked the flood plain. The entire flow has consequently been confined to the main channel at extreme floods, and is directed into a sand/silt bank on the opposite side of the stream. This confined, higher velocity flow has probably also increased bank erosion on other landowner's properties directly downstream. Comments on the additional negative impacts this berm may have can be found in the attached letter from Bruce Shepherd, MELP Sr. Fisheries Biologist. (Appendix 2)

6.0 Conclusions

While no trend of an increase in the magnitude of peak flows during spring freshet is apparent, the onset of high spring flows in Mission at Kelowna appears to have gradually moved approximately 17 days earlier since the Mountain Pine Beetle harvests began. Future harvesting activities currently being planned for the upper watershed have the potential to increase peak flows, as this zone is where the main freshet flows originate. There also are strong indications of stability problems along the steep streamside slopes of Pearson Creek, and more so on Mission Creek above Pearson Creek, which must be investigated further. While forest harvesting and its associated roadbuilding activity would appear to have currently had some impact on the hydrology and sediment loading of Mission Creek, activities associated with the development and protection of private lands have also significantly impacted the stream's stability and fish habitat. Cautious forest development within the Provincial Forest will be ineffective in either water quality protection, flood control, or fish habitat protection, without private property owners taking responsibility for proper treatment of their riparian areas and floodplains.

Although outside of the study area for this report, the channelization and diking of lower Mission Creek through the flood plain in Kelowna has been previously identified as the the most severe impact on fish habitat within the entire watershed. As development spreads up the watershed, care must be taken not to duplicate this impact on the stream channels in the upper flood plains.

7.0 Recommendations

1. The IWAP process must be completed, including a proper Channel Assessment Procedure (CAP). Considering the number of landslides found in the air photo analysis of the Pearson and Upper Mission sub-basins, the CAP should include those reaches of stream as well.

2. A field inspection of all post 1974 slides in these sub-basins should be done, including those listed in the IWAP, those located in Ted Fuller's air photo analysis, and those reported in 1997198. Some of these have already been inspected by MoF. A report detailing findings and possible present or future impacts on sediment loading of the stream should be prepared.

3. This study has highlighted the hydrologically sensitive nature of the 1500 to 1800 metre elevation band in the Upper Mission watershed in regards to peak snowmelt flows. Prior to any further significant amount of harvesting above the 1400 meter level, a detailed study of the possible hydrologic effects should be done. Modelling of elevation, aspect and slope of proposed clearcuts, and their impacts on snowmelt scenarios over the life of the Forest Development Plans, should be incorporated into the planning of access and forest harvest in this higher elevation Mission Creek watershed. As Joe Rich and Belgo Creeks also have areas in this upper elevation band, and their peak flows sometimes are synchronized with those of Pearson Creek and Mission Creek above Pearson Creek, planned developments in those sub-basins should be included in the above modelling and design process.

4. On conclusion of the above assessments, including the Terrain Stability mapping, and the hydrologic modeling of proposed harvesting plans, a round table of all interested parties should be convened to discuss the results of the above-mentioned assessments. and possible harvesting and roadbuilding implications arising from these. A round table of some type is normal procedure at that stage of the Watershed Assessment process.

5. Covenants and/or by-laws, for the protection of the riparian zone and maintenance of an unobstructed floodplain through private lands, in both the municipality of Kelowna and the Regional District, should be established and, if in place, enforced. These should include restricting building locations and protection of vegetation within a riparian reserve zone similiar to that in the FPC.

6. Efforts should be made wherever possible to remove man-made obstructions of the active flood plain, and to revegetate both the riparian areas and extensive gravel bars in de-stabilized sections of the stream channel, such as above both the Highway 33 bridge and the FSR bridge near the Pearson Creek confluence.

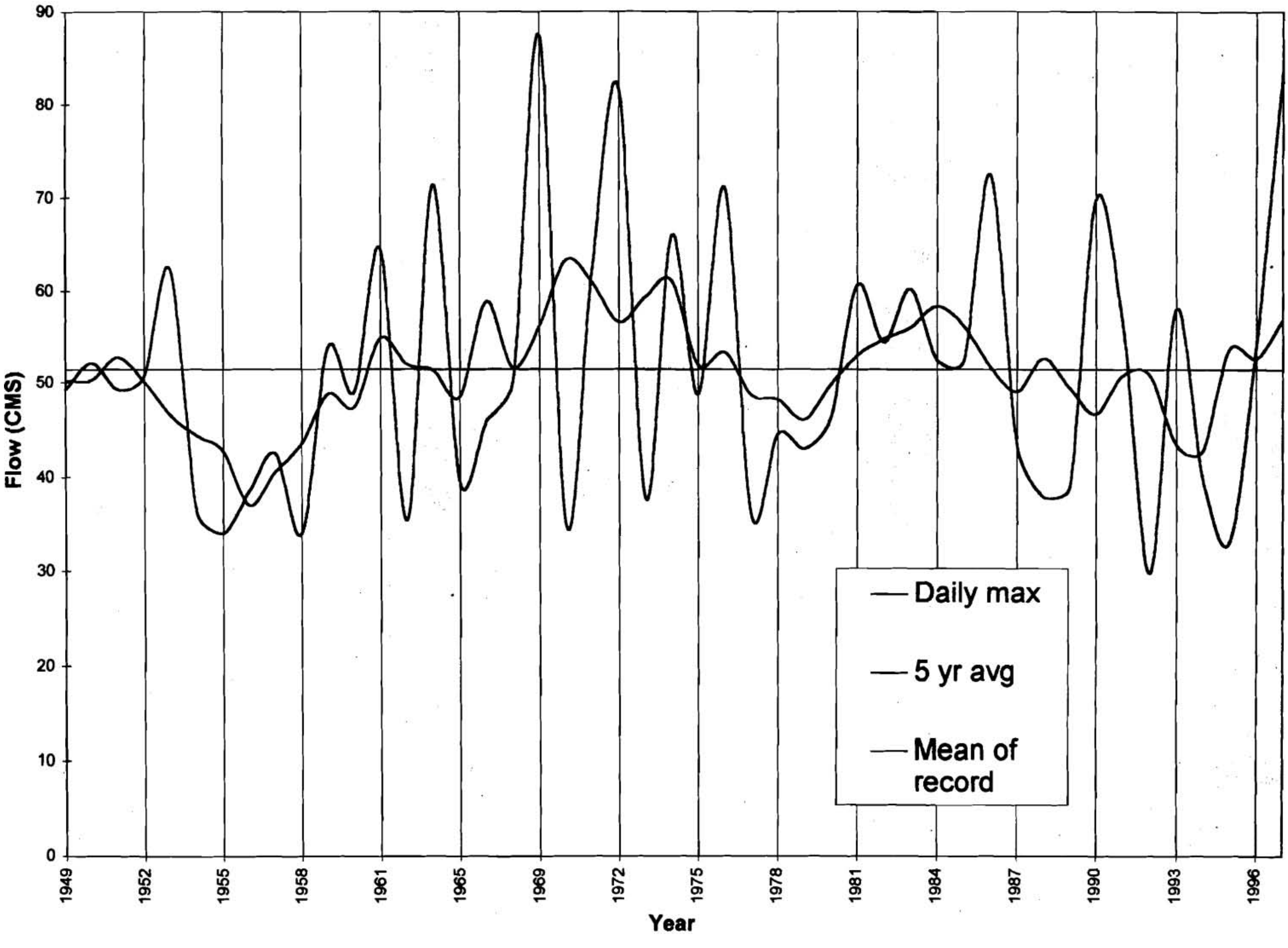
7. Any dredging, gravel bar scalping, or log jam removals done for the current flood recovery operations should be planned carefully and kept to the bare minimum necessary to remove immediate flood threats to existing, legal development. These activities must be recognized as having only at best short term benefits, and potential for long term damage to both stream stability and fish habitat.

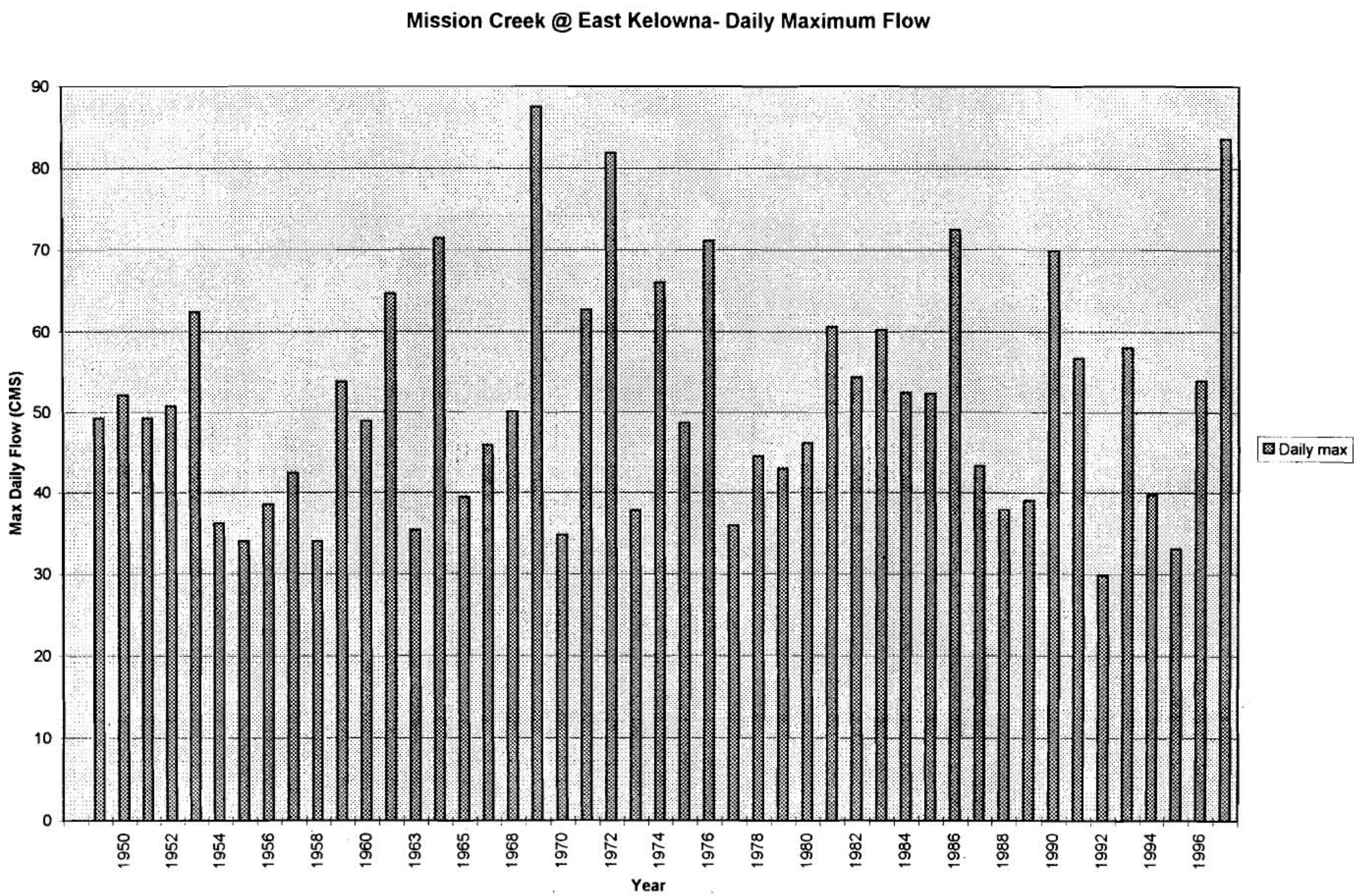
D. Gooding, P.Eng.
Regional Forest Hydrologist
Ministry of Environment, Lands and Parks

Appendix 1

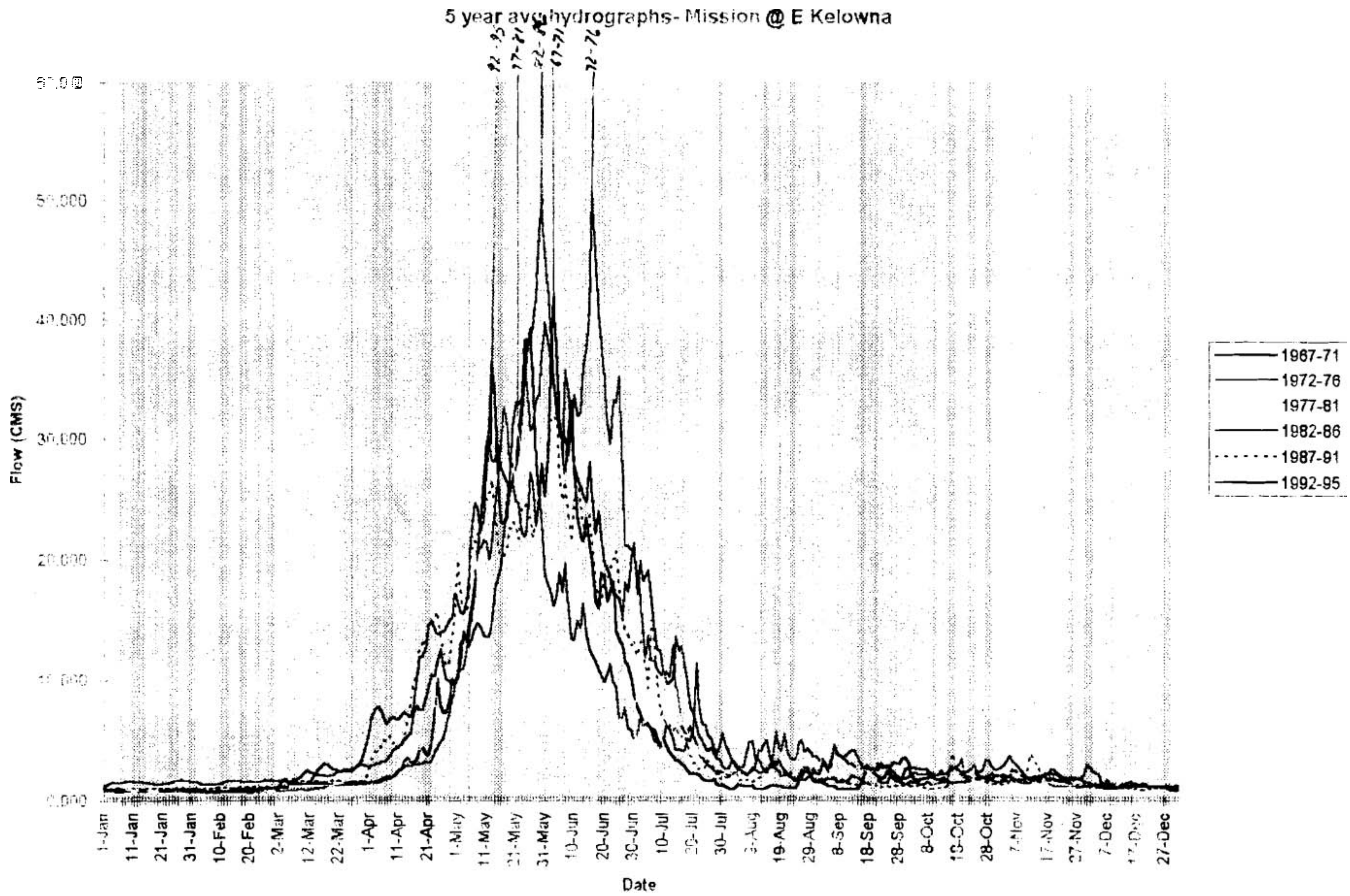
Station 08nm116 Mission Creek at East Kelowna			
Date	Daily max (CMS)	Inst rnax (CMS)	Peaking Factor (Inst/Daily)
1949	49.3		
1950	52.1		
1951	49.3		
1952	50.7		
1953	62.3		
1954	36.2		
1955	34		
1956	38.5		
1957	42.5		
1958	34		
1959	53.8		
1960	49		
1961	64.6		
1963	35.4		
1964	71.4		
1965	39.4		
1967	45.9		
1968	50.1		
1969	87.5	97.7	1.12
1970	34.8	48.1	1.38
1971	62.6	70.2	1.12
1972	81.8	91.2	1.11
1973	37.7	43.9	1.16
1974	66	77.6	1.18
1975	48.7	56.4	1.16
1976	71.1	76.5	1.08
1977	36	45.3	1.26
1978	44.5	54.4	1.22
1979	43	55.2	1.28
1980	46.2	57.2	1.24
1981	60.6	72.5	1.20
1982	54.4	55.9	1.03
1983	60.2	69.4	1.15
1984	52.4	61.1	1.17
1985	52.3	69	1.32
1986	72.5	84.9	1.17
1987	43.4	49.4	1.14
1988	37.9	49	1.29
1989	39	45.4	1.16
1990	69.9	75.5	1.08
1991	56.7	65.5	1.16
1992	29.8	39	1.31
1993	58	66.4	1.14
1994	39.7	42.8	1.08
1995	33.1	40.8	1.23
1996	53.9	63.1	1.17
1997	83.6	97.7	1.17
MEAN	**51.4**	**62.80**	**1.22**

Maximum Daily Flow, 5 year average of maximum daily flows, and mean flow for Mission Creek at East Kelowna 08nm116




Mission Creek @ East Kelowna- Daily Maximum Flow
Max Daily Flow (CMS)
0
10
20
30
40
50
60
70
80
90
1950
1952
1954
1956
1958
1960
1963
1965
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
Year
Daily max

Mission Creek and tributary max daily flows 1977 to 1982			Flows in Cubic Meters per Second										
Year	08nm116		08nm225			08nm137			08nm010			08nm129		
	Mission @East Kelowna		Belgo near mouth			Daves near mouth			Hydraulic near mouth			Joe ~ nr Rutland		
					flow on			flow on			flow on			flow on
	flow	date	pk flow	date	Kel pk day	pk flow	date	Kel pk day	pk flow	date	Kel pk day	pk flow	date	Kel pk day
1977	36	3-May	9.49	2-May	6.77	1.16	3-May	1.16	1.39	3-May	1.39	1.11	6-May	1.09
1978	44.5	6-Jun	9.77	21-May	5.61	1.33	29-Apr	0.204	2.14	28-Apr	0.059	1.05	19-May	0.6
1979	43	27-May	11	5-May	6.33	1.34	4-May	0.224	1.97	30-Apr	0.119	2.71	6-May	0.709
1980	46.2	6-May	7.97	29-Apr	7.16	1.16	20-Apr	0.389	1.27	20-Apr	0.25	1.16	10-Jun	0.824
1981	60.6	21-May	13.1	21-May	13.1	1.4	24-Apr	0.974	2.07	1-May	1.33	2.39	26-May	1.47
1982	54.4	5-Jul	12.7	5-Jul	12.7	1.63	17-May	1.53	1.68	16-Jul	1.33	1.85	18-May	1.83
Avg	47.45		10.67		8.61	1.34		0.75	1.75		0.75	1.71		1.09
			08nm226			08nm233			08nm172					
			KLO @ McCul Rd			Mission above Pearson			Pearson near mouth					
					flow on			flow on			flow on			
			pk flow	date	Kel pk day	pk flow	date	Kel pk day	pk flow	date	Kel pk day			
			2.27	2-May	1.81	33.7	7-Jun	13.8	7.02	7-Jun	5.15			
			2.94	3-Jun	2.02	37.7	5-Jun	32	8.89	5-Jun	7.73			
			6.25	5-May	1.52	31.7	26-May	30.3	7.73	27-May	7.73			
			1.19	10-Jun	0.85	33.4	6-May	33.4	8.78	6-May	8.78			
			13	25-May	11.9	29.4	26-May	25.0	10.6	26-May	7.42			
			8.99	17-May	4.5	36.3	2-Jul	28.7	9.33	5-Jul	9.33			
			5.77		3.11	33.70		27.33	8.73		7.69			



5 year avg hydrographs- Mission @ E Kelowna
92-95
77-81
82-86
67-71
72-76
60,000
50,000
40,000
30,000
20,000
10,000
0,000
Flow (CMS)
1-Jan
11-Jan
21-Jan
31-Jan
10-Feb
20-Feb
2-Mar
12-Mar
22-Mar
1-Apr
11-Apr
21-Apr
1-May
11-May
21-May
31-May
10-Jun
20-Jun
30-Jun
10-Jul
20-Jul
30-Jul
9-Aug
19-Aug
29-Aug
8-Sep
18-Sep
28-Sep
8-Oct
18-Oct
28-Oct
7-Nov
17-Nov
27-Nov
7-Dec
17-Dec
27-Dec
Date
1967-71
1972-76
1977-81
1982-86
1987-91
1992-95

Appendix *2*

Province of
British Columbia

Ministry of
Forests

Regional Manager
Kamloops Forest Region
515 Columbia Street
Kamloops. British Columbia
V2C 2T7
Telephone: (604) 828-4131
Facsimile: (604) 828-4154

December 12, 1997

Jerome Jang
Timber Officer
Penticton Forest District
102 Industrial Place
Penticton, B.C. V2A 7C8

Re: Letter from B. Morris, rural property owner, dated November 5,1997 regarding Mission Cr.

Jerome.

I am writing in regard to your request for a response to several of Mr. Brian Morris's forestry related hydrologic concerns outlined in his November 1997 letter. My comments focus mainly on broadly applicable, basic hydrologic principles. I have also reviewed the Mission Creek Watershed IWAP (March 1997) and have discussed the issues raised in Mr. Morris's letter with Don Dobson (Dobson Engineering) prior to preparing this response. It may be beneficial for a small group of MOF, MELP and Dobson Engineering hydrologists and geomorphologists to meet with Mr. Morris to discuss some fundamental principles of hydrology and geomorphology.

As you know, intervention in any stream system, particularly one as large as Mission Cr. requires: extreme caution, a complete understanding of the river system, clear objectives for the long-term form and function of the river at specific locations as well as downstream, and the technical expertise of hydraulic and bio-resource engineers, hydrologists and geomorphologists. Rivers are dynamic systems, changing form continuously in response to natural events, such as variations in annual discharge and the associated channel aggredation and degration processes, as well as in response to human activities in and adjacent to the channel. Any hydraulic errors at Mr. Morris's property will affect adjacent properties, his neighbors upstream and downstream and will also have the potential to affect the city of Kelowna.

My understanding of Mr. Morris's letter is as follows. Mr. Morris has concerns regarding the physical functioning of the upland, riparian and stream channel portions of the Mission Cr. watershed, the involvement of various bureaucracies in the management of the watershed and funding for the construction of hydraulic structures. His forest hydrology concerns centre on the effects of forest removal and road construction on peak flows and water quality, as well as on the

Forest Service's ability to effectively manage the crown forest portion of the watershed. Being a forest hydrologist. I will address those hydrologic concerns which relate to the forested portion of the watershed.

Mr. Moms states that "extensive clear-cut logging in the entire watershed" has resulted in "an unchecked torrent in a short period of time, filling all of the creek and river channels to overcapacity". It is clear, from the hydrologic literature, that snowrnelt from the upper reaches of a watershed generates the large peak spring discharges which occur in interior streams. Removal of forest vegetation may result in up to 30 to 40% more water in the snowpack at peak accumulation than under a mature forest canopy. The snowpack in openings also melts more rapidly and disappears, on average, ten to fourteen days sooner in the open than in a mature forest.

The effects of site treatments, however, can not be linearly extrapolated to the entire watershed. Snow accumulation and melt patterns vary from site to site in an undisturbed watershed depending on slope, aspect, position in the watershed and on the structure of the forest canopy (i.e. density, height, crown form and distribution of stems etc). This variation results in the sychronization, or desynchronization, of snowmelt runoff from different parts of the watershed. Flow from the openings may be desynchronized from that of adjacent forests reducing stream discharge. Flows from clearcuts at high elevations may become synchronized with that from lower elevation forests. increasing discharge. Clearcut/forest differences may be exceeded by landscape effects. For example, we have repeatedly measured greater differences in April 1 snow water equivalent between two clearcuts located 5 kilometres apart along a flat stretch of road in Upper Penticton Cr. than between either of these clearcuts and the forests adjacent to them. So, once again, the effects of watershed disturbance vary depending on position. year and characteristics of the site and watershed. The combined effect of climatic conditions each spring and the physiographic. vegetative and disturbance characteristics of the watershed produce the hydrograph for that watershed.

If all of the snow in all cutover areas in a watershed were to melt in a very short period of time, for example during an unusually warm period in spring, large flow events would be expected. During such warm periods the snow in the forest would also be melting and would become synchronized with that from the openings. This situation, as well as one in which soils are saturated from prolonged periods of rain or above normal snowpack, are the one most likely to cause extreme events or floods.

Increased snow accumulation observed in openings has led to the maximum rate of cut guidelines suggested in association with the Forest Practices Code. These guidelines suggest that forest removal be restricted to 20 to 30% of the "snowzone" in order to minimize the risk of increased spring peak flow volumes. These rates of cut are based on research, reported in the literature, which has consistently shown that such levels of harvest result in increased total annual and peak discharge. The magnitude of these increases varies depending on location and climate but is generally somewhat less than directly proportional.

To identify the "snowzone" in the Mission Cr. watershed, I have plotted all of the May 15 and June 1 snow water equivalents measured at MELP stations throughout the Okanagan (published in the MELP Snow Survey Bulletins) from 1987 to 1997. This chart, which is attached, shows that by the mid-May to early June onset of peak discharge period, the snow cover has disappeared from elevations below 1400 to 1600 metres. Consequently, snowpack management above 1400 to 1600 metres is important to the control of spring peak flows in Mission Cr. at Mr. Morris's property.

Levels of harvest in the Mission Cr. watershed above its confluence with Joe Rich Cr. are in the range of 11% for the Joe Rich subbasin to 16% for Mission Cr. above Pearson Cr. according to the IWAP prepared by Dobson Engineering. The maps accompanying the IWAP show that most of the forest removal has taken place at elevations below 1600 metres, the elevation expected to have significant snowcover at the onset of peak flow. The forests above 1700 metres, i.e. the forests covering the headwaters of Mission Cr., are completely intact. Consequently, the removal of forest cover alone does not explain the alleged "massive water release". Rapid regeneration and the promotion of vigorous second growth will ameliorate any increases in water yield following forest removal.

Logging also involves the construction of roads. Roads often have a far greater hydrologic effect on streamflow quantity, timing and quality than simply removing the forest cover. Roads intercept the downslope movement of near-surface water, channelize this water in ditches and thereby increase the rate at which water is delivered to streams (i.e. reduced times of concentration). Erosion of road running surfaces, cuts and fills, by downslope or concentrated water movement, and the deposition of this material into the stream channel can affect both the stability of the stream channel itself and water quality. From the IWAP maps, the road network at lower elevations in the Mission Cr. watershed above Mr. Morris's property appears to be extensive. High road densities are likely to increase the size of rain generated streamflow events. In an average year these events will be much smaller than the spring snowrnelt peak. If, however, snowpacks have been higher than normal, or if snowmelt is prolonged, or if the duration of rainfall is long or if soils are saturated these peaks can have significant consequences. The road density should certainly not be increased in the Mission Cr. watershed. Unfortunately, Mr. Morris's suggestion of reducing cutblock "size to one hectare blocks, spaced at least **3** blocks apart" would result in an even higher road density and compound any road related problems which already exist.

The way in which the effects of roads can be ameliorated is by road deactivation, contrary to Mr. Morris's contention that flow problems are "enhanced by a program of road deactivation and water barriers". Road deactivation involves removal of obstructions to downslope water movement and the dispersal of water across the slope as would have occurred if the road were not there. This requires the construction of frequent cross-drains or ripping the road and recontouring the slope. The redispersal of water across the slope will increase the time of concentration back to predisturbance conditions and will promote the filtration and deposition of sediment over the land surface prior to the water entering a stream channel. This view is supported by the IWAP recommendations, provided to the Ministry of Forests by Dobson Engineering, which recommend that any remedial work in the watershed should focus on the reduction of surface erosion.

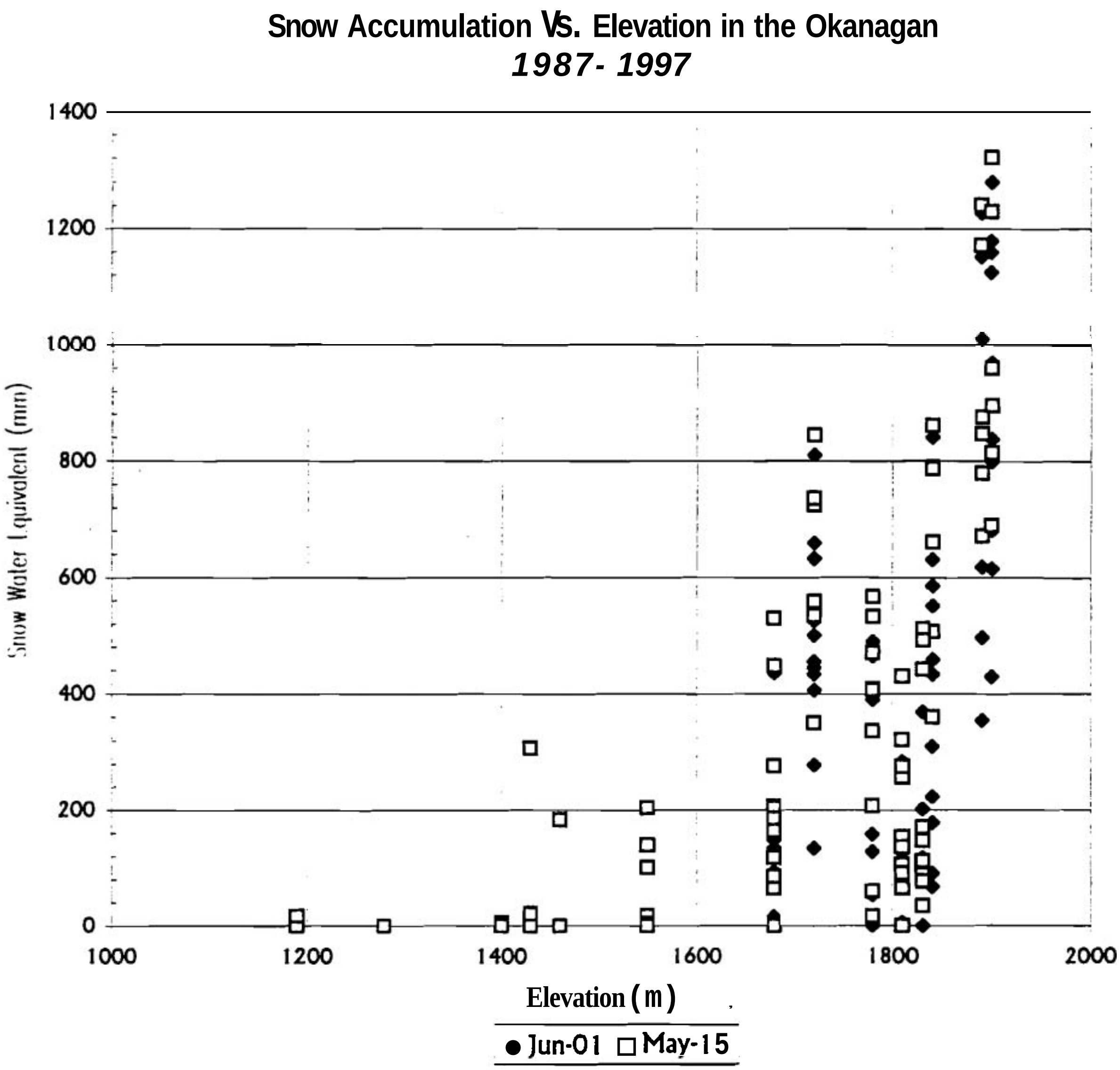
Mr. Morris alleges that "massive, short term water flow moves massive amount of trees, rocks, gravel and topsoil down the slopes into the main creek channel". This is a serious allegation and, if it hasn't been already, should be investigated immediately. Significant channel destabilization can occur if landslides, natural or road related, enter the main channel. If this is actually occurring, repair works should be undertaken immediately.

The above comments outline the potential effects, or risks, associated with forest removal and/or road construction. The procedures used to assess forestry related effects on a watershed do not incorporate the risks associated with annual variability in climatic conditions or with human intervention in the stream channel. The magnitude of stream channel change which can be produced by these latter two factors most commonly exceeds that of forest removal during extreme events and must not be overlooked. Assessing actual hydrologic impacts, as opposed to risk, in a watershed requires a field assessment of the stream channel and floodplain itself. A channel assessment of Mission Cr. below Pearson Cr., and also of the main tributaries to Mission Cr. below this point, is one of the recommendations contained in the report by Dobson Engineering. It is my understanding that such an assessment has been undertaken and is being reviewed by Ted Fuller, a Geomorphologist with the Ministry of Environment.

In summary, the removal of forest cover in the Mission Creek watershed above Mr. Morris's property is unlikely to be of sufficient extent, or to be positioned in such a way as, to have caused a detectable increase in peak flows. The high density of roads in the area which has been logged may be concentrating discharge and so could be having some effect on hydrograph peaks. Roads should be completely deactivated, wherever possible. The channel assessment and review, as well as a review by Ted Fuller of historic air photographs. should provide a clear indication of whether the problems observed by Mr. Morris in Mission Cr. have increased as a result of upland disturbance, or are related to disturbance in or around the floodplain, or are the result of natural events.

R. Winkler.

Rita Winkler
Regional Hydrologist


Snow Accumulation Vs. Elevation in the Okanagan
1987- 1997
Snow Water Equivalent (mm)
1400
1200
1000
800
600
400
200
0
1000
1200
1400
1600
1800
2000
Elevation (m)
Jun-01
May-15

BRITISH COLUMBIA
Ministry of Environment, Lands and Parks
Environment and Lands Southern Interior Region

MEMORANDUM

3547 Skaha Lake Road, Suite 201, Penticton BC V2A 7K2 Telephone:(250)490-8200 Fax:(250)492-1314

Water Management Program
Southern Interior Region

January 9,1998

File: 39780-25
(Mission Creek)

Attention: Dave **Gooding**

Re: <u>Fisheries Reaction to Morris Provosal</u>

In reaction to the letter proposal of Mr. Brian A Moms dated November 10, 1997, entitled "Mission Creek Watershed Flooding and Erosion Report - Action Plan Implementation", I had drafted the following response on behalf of Fisheries:

*Thank you for your letter proposal of November 10, 1997. As your proposal relates primarily to the correction ofperceived forestry-induced impacts and the associated riparian corridor, I have forwarded copies to Phil Epp, our FRBC Watershed Restoration Program Coordinator, and to Brian **Symonds**, the Engineering Section Head for our Water Management Program, for their consideration and comments.*

*As you probably already know, the primary objective of the 1996-2000 Fisheries Program Strategic Plan is to conserve **wild fish** populations and their habitat. Thus the Fisheries Program will support projects that demonstrate responsible stewardship offish resources, and extends to the protection and restoration of aquatic habitats and the preservation of ecological integrity of riparian areas.*

*You also are probably already aware of a stream's basic hydrological need **for freedom** to move laterally. **Flood** protection measures undertaken in the past on the lower reaches of Mission Creek have greatly restricted this stream's ability to **shift** sideways, **and fish** production has declined severely. Thus we would be very concerned as to the potential impacts on the fish resources associated with the suggestion found on pages 2 and 3 of your proposal, namely: "**The** stream beds between these basins should be cleaned up, the main channel deepened and the banks **dyked** and rip-rapped as necessary to prevent erosion...." From the fish resource point of view, any **dyking** should be set back to at least the **1:200 year** contour on the naturalfloodplain. Dredging, rip-rapping, and removal of large organic debris with the flood channel would have to approached <u>very</u> cautiously, and then only with due regard for the maintenance offish production.*

These considerations, I hope, would be incorporated into any further detailedplanning associated with your proposal.

Subsequent to my drafting of the above response, you reviewed with me some photos of flood-protection actions undertaken just upstream of the Morris property. With specific reference to the berm construction at the upper end of the island in this reach, this is a good example of what Fisheries does not want to see happen. This berm undoubtedly has restricted the floodplain in this vicinity, and appears to have shunted flows across the creek and up against a bank composed of fine material. Subsequent increased erosion of this bank will aggravate siltation of downstream fish habitats.

Due to the expressed desire for a coordinated Ministry response, I have not replied directly to Mr. Morris to date. I would appreciate it if you could incorporate these comments into the Ministry response that you are drafting. If this is not possible, please advise and I will send Mr. Morris a separate response on behalf of Fisheries, and per the above comments.

B.G. Shepherd, RPBio
Senior Fisheries Biologist
Fish, Wildlife and Habitat Protection
Southern Interior Region

BGS/S\smc

cc: Phil Epp, Planning and Assessment, Penticton
Brian Symonds, Water Management, Penticton
Dave Gooding, Water Management, Penticton
Dave Smith, Fisheries, Penticton
Ian McGregor, Fisheries, Kamloops