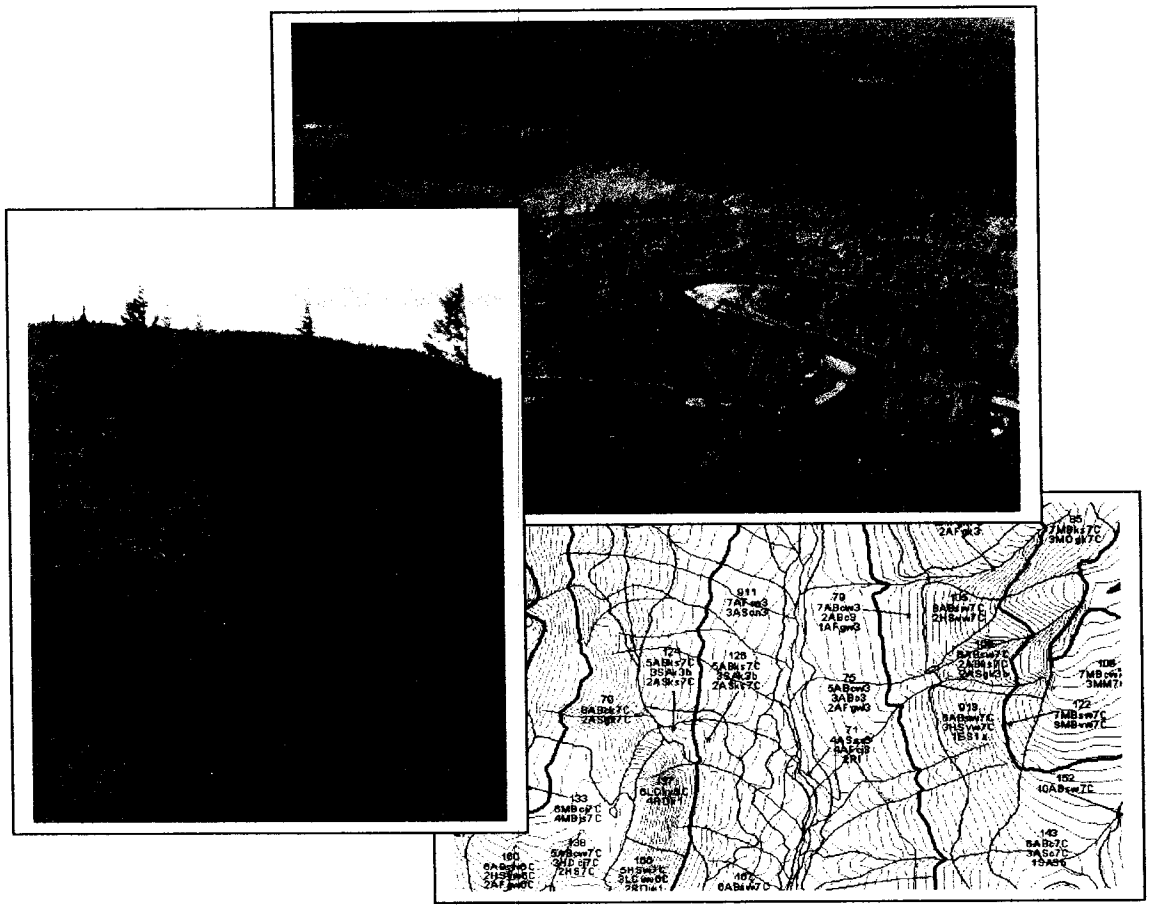
Consolidation of Reports for Selected Watersheds within the Quesnel Forest District



prepared for:

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SUMMARY

At the request of the Ministry of Forests, Quesnel Forest District, a review and interpretation of several assessments and reports was undertaken. The assessments and reports address forest management concerns, and include watershed assessments, channel assessments, reconnaissance fish inventories, fish habitat assessments (overview and level 1), riparian assessments (watershed and site level), sediment source surveys and integrated watershed restoration plans.

The overall objective of consolidating this information is to provide an accurate, up-to-date report that will assist the statutory decision-makers in the planning process. Specific objectives are:

- to provide clear, concise and summarized information to aid decision-making on future harvesting activities outlined in current (1999-2003) forest development plans (FDPs); and
- to describe the risks associated with the harvesting activities outlined in the FDPs, based on hazards and consequences.

The 13 basins (Table I) of interest are located east of Quesnel, mostly within TFL #52. The basins drain into one of three major watersheds, namely the Cottonwood River, the Willow River or the Bowron River.

The risk assessment procedure required the assigning of consequence and hazard ratings for each basin. The risk ratings result from a combination of the consequence and hazard ratings. The consequence ratings were based on concerns regarding fish habitat. The hazard ratings were based on the probability of impacts from the planned harvesting.

Assuming that the planned harvesting activities, including road building and maintenance, follow FPC requirements, then the main hazard to be addressed by this risk assessment was the probability of peak flows increasing and potentially accelerating the delivery of sediment from existing sources. The hazard ratings were determined to be low because the probability of the planned harvesting resulting in impacts to fish habitat, through increases to peak flows, is low. This was assuming that FPC requirements regarding the prevention of sediment from entering streams are met.

TABLE I. Summary of risk assessment ratings for planned harvesting, as outlined in current Forest Development Plans.

Watershed / Basin	Consequence	Hazard	Risk
Cottonwood R.			
Bendixon Cr.	H[1]	L	M
John Boyd Cr.	M	L	L
Reddish Cr.	H	L	M
Sovereign Cr.	H	L	M
Umiti Cr.	M	L	L
Willow R.			
Big Valley Cr.	H	L	M
Crescent Cr.	M	L	L
Rebman Cr.	M	L	L
Tregillus Cr.	H	L	M
Bowron R.			
Indian Point Cr.	M	L	L
Ketcham Cr.	H	L	M
Towkuh Cr.	M	L	L
McKenna Cr.	-[2]	-	-

[1] L = Low, M = Moderate, H = High

[2] no harvesting planned for McKenna Cr., therefore no risk rating assigned

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INTRODUCTION

Numerous assessments have been completed for several basins in the Quesnel Forest District (Table 1) which address forest management concerns. These assessments include watershed assessments, channel assessments, reconnaissance fish inventories, fish habitat assessments (overview and level 1), riparian assessments (watershed and site level), sediment source surveys and integrated watershed restoration plans (Table 2).

At the request of the Ministry of Forests, Quesnel Forest District, a review and interpretation of these assessments was undertaken. The overall objective of consolidating this information is to provide an accurate, up-to-date report that will assist the statutory decision-makers in the planning process. Specific objectives are:

- to provide clear, concise and summarized information to aid decision-making on future harvesting activities outlined in current (1999-2003) forest development plans (FDPs); and
- to describe the risk associated with the planned harvesting activities outlined in the FDPs, based on hazards and consequences.

TABLE 1. Basins of interest (located in or adjacent to TFL #52)

Watershed	Basin				
Cottonwood R.	Sovereign Cr.	Bendixon Cr.	Reddish Cr.	John Boyd Cr.	Umiti Cr.
Willow R.	Big Valley Cr.	Crescent Cr.	Rebman Cr.	Tregillus Cr.	
Bowron R.	Indian Point Cr.	Ketcham Cr.	McKenna Cr.	Towkuh Cr.	

A format for this consolidation report was developed in order to meet the objectives. Information for each watershed is presented in a separate chapter. Each chapter is treated as a distinct unit, so that information which is the same for all the watersheds is repeated in each chapter. In this way, the reader does not need to rely on information found in other chapters.

Within each chapter, there are four sections: Summary of Reports, Risk Assessment of Planned Harvesting, Conclusion and Synopses of Reports. The Summary section provides an integrated summary for the watershed of all the reports available for the individual basins, with an emphasis on the conclusions and recommendations. The Risk Assessment section provides an assessment of the risk associated with the planned harvesting outlined in the current FDPs. Each basin is assessed as a whole, not on an individual reach or planned block basis. The Conclusion section provides a brief discussion of the issues identified in the Summary and Risk Assessment sections. The Synopses of Reports section provides, in point form for each basin, the major results, conclusions and recommendations of the reviewed reports. This section is further divided into General Assessments, which are based on little or no fieldwork, and Detailed Assessments, which are based primarily on field work. The Synopses is intended as a reference for the reader, to provide the information upon which the other sections are based. For further reference purposes, the objectives of the individual assessments and reports are given in Appendix 1.

TABLE 2. Summarized list of reviewed assessments and reports. (See *References* for complete citations.)

	Integrated Watershed Restoration Plan	Interior Watershed Assessment	Amended Equivalent Clearcut Area Calculation	Inventory of Watershed Conditions	Sediment Source Survey	Channel Assessment	Riparian Assessment	Fish Habitat Assessment	Fish Inventory
Cottonwood R.	✓								
Bendixon Cr.			✓			✓	✓	✓	✓
John Boyd Cr.		✓	✓	✓	✓	✓	✓	✓	
Reddish Cr.		✓	✓	✓	✓	✓	✓	✓	✓
Sovereign Cr.		✓	✓	✓	✓	✓	✓	✓	✓
Umiti Cr.		✓	✓	✓	✓	✓	✓	✓	
~~Willow R.~~	✓								
Big Valley Cr.		✓	✓		✓	✓	✓	✓	✓
Crescent Cr.		✓	✓		✓	✓	✓	✓	✓
Rebman Cr.		✓	✓		✓	✓	✓	✓	✓
Tregillus Cr.		✓	✓		✓	✓	✓	✓	✓
Bowron R.	✓								
Indian Pt. Cr.		✓	✓		✓	✓	✓	✓	
Ketcham Cr.		✓	✓		✓	✓	✓	✓	✓
McKenna Cr.		✓	✓		✓	✓	✓	✓	
Towkuh Cr.		✓	✓		✓	✓	✓	✓	✓

COTTONWOOD RIVER WATERSHED

SUMMARY OF REPORTS

The Integrated Watershed Restoration Plan (IWRP) lists a summary of watershed concerns. These concerns include increased rates of sediment transport to streams along the road network, stream channel disturbance resulting from harvesting and/or placer mining in the riparian zone, potentially increased peak flows as a result of logging activities and the proposed rate-of-cut. To address these concerns, the restoration objectives developed by the IWRP are to reduce sediment input to streams from roads and to improve stream and riparian conditions related to fish habitat.

The Interior Watershed Assessments determined that erosion from roads, harvested riparian areas and peak flow represent major potential impacts. The roads built prior to implementation of the Forest Practices Code (FPC) do not have adequate drainage structures and lack proper erosion control.

The Inventory of Watershed Conditions lists a summary of watershed concerns. These concerns include sediment delivery into streams due to placer mining and/or harvesting in the riparian zone, lack of erosion control at road crossings and inadequate drainage structures. Recommendations include adequate protection of riparian zones, rehabilitation of placer mining sites, reduction in peak flow hazard, erosion control at road crossings and enhancing regeneration of recently harvested areas.

The sediment source survey shows that the number of sediment sources associated with harvesting, roads, placer mining and natural occurrences varies between the basins. For each basin, the sources are:

John Boyd Creek – 56 sources - 9 harvesting, 32 roads, 6 placer mining, 9 natural
Reddish Creek – 38 sources - 18 harvesting, 9 roads, 2 placer mining, 9 natural
Sovereign Creek – 73 sources - 30 harvesting, 13 roads, 5 placer mining, 25 natural
Umiti Creek - 58 sources - 8 harvesting, 36 roads, 1 placer mining, 13 natural
Bendixon Creek – not surveyed

The sediment sources related to harvesting are primarily the result of erosion from banks in harvested riparian areas. The survey recommends that a comprehensive access strategy is needed due to the influence of road maintenance and deactivation on sediment sources.

The channel assessments indicate that none of the mainstem channels have been significantly disturbed by increases in peak flows. Channels have been significantly disturbed at placer mining sites in John Boyd Creek, Sovereign Creek and Umiti Creek basins. Lakes, wetlands

and/or beaver ponds are acting as buffers in regulating streamflow in Bendixon Creek and Reddish Creek basins.

The riparian assessments indicate that five reaches within the Reddish Creek, Sovereign Creek and Umiti Creek basins may require rehabilitation due to impacts from placer mining and harvesting. Riparian function in the remainder of these basins, as well as in John Boyd Creek, has been affected, but no rehabilitation is required as the trend is towards proper functioning, with well stocked, vigorous regeneration and old growth compensating for impaired functions. The Bendixon Creek basin does not have any impairments to riparian function.

The detailed fish habitat assessments indicate that Reddish Creek and Sovereign Creek have fair to good spawning habitat and poor to good off-channel habitat. Generally, there is a lack of pools, boulder cover and large woody debris (LWD). Prescriptions were developed to stabilize banks in some reaches of Fontaine Creek (a tributary to Reddish Creek) and Sovereign Creek. It was recommended that placer mining sites also be stabilized. The other basins had only overview assessments, due to their being a lower priority than Reddish Creek and Sovereign Creek. Habitat concerns for these basins include a lack of riparian buffers and possible sediment from road crossings.

The fisheries inventories indicate that rainbow trout is widely distributed in the mainstems of Bendixon Creek, Reddish Creek and Sovereign Creek, as well as the low gradient tributaries of the latter two basins. Chinook salmon were found in the lower reaches of Sovereign Creek. The overall fish production in the basins is rated as good. Inventories were not conducted in the John Boyd Creek and Umiti Creek basins. Given the distribution in the other basins, and the status of the fish habitat, it is assumed that rainbow trout will be present in these two basins as well.

RISK ASSESSMENT OF PLANNED HARVESTING

A risk assessment of planned harvesting within the basins, as outlined in the current FDPs, is based on the formula:

CONSEQUENCE X HAZARD = RISK

where consequence is the effect of a potential event on one or more elements at risk, and hazard is the probability of an event occurring. The risk rating is determined according to the following matrix of consequence and hazard ratings:

Consequence	Hazard			
	High	Moderate	Low	
High	Very High	High	Moderate	Risk
Moderate	High	Moderate	Low	
Low	Moderate	Low	Low	

The primary consequence for this assessment of planned harvesting is impacts to fish habitat. It is assumed that the status of habitat will, in turn, directly influence fish populations. The hazard is the probability of the planned harvesting causing the impacts. The harvesting activities that could result in impacts to habitat include roads and road building (e.g. sediment production), the location of harvesting relative to streams (e.g. riparian concerns) and the amount of area harvested (e.g. potential increases in streamflow). The guiding principle in determining the hazard rating is that the planned harvesting should not result in the degradation of fish habitat. Consequently, a low hazard would indicate that the planned harvesting has little probability of impacting fish habitat. A high hazard would indicate a high probability of impact. This approach will aid in answering the question "What risk does the planned harvesting pose to fish habitat?"

With regards to impacts to fish habitat, the main concern identified by the reports is the delivery of sediment into streams. The primary sources of this sediment are roads built prior to implementation of the FPC and placer mining. A secondary source is eroding banks in harvested riparian areas. The reports speculate that increases in peak flows, if large enough, due to past harvesting have potentially accelerated the delivery of sediment from these sources. The FPC regulates roads (e.g. building, maintenance, deactivation) and riparian management (e.g. buffer zones), and requires that sediment delivery into streams be prevented, in part through the use of proper erosion control techniques and drainage structures. Assuming that the planned harvesting activities, including road building and maintenance, follow FPC requirements, then the main hazard to be addressed by this risk assessment is the probability of peak flows increasing and potentially accelerating the delivery of sediment from existing sources.

Determination of a hazard rating for each basin is based on the information contained in the reports, as well as an examination of the change to the Peak Flow Index (PFI) (i.e. the Equivalent Clearcut Area (ECA) adjusted for elevation effects), the location of the planned blocks, and changes to road density, which can also affect the generation of peak flows. When considering the issue of ECA and PFI, it is important to understand not only the concepts upon which these indices are based, but also that a specific ECA or PFI value should not be a management target. Equivalent Clearcut Area (and hence PFI) and road density are solely indicators of potential changes to peak flow. Actual changes to peak flow are more accurately determined by field observations, such as channel assessments. A further explanation of how ECA and road density are related to peak flow is given in Appendix 2.

Consequence Rating

The consequence rating for each basin is based on the fish habitat assessments and fish inventories. The Bendixon Creek, Reddish Creek and Sovereign Creek basins have high consequence ratings due to the wide distribution of rainbow trout, presence of chinook salmon, overall good fish production and concerns about existing impacts to habitat. The John Boyd Creek and Umiti Creek basins did not have detailed inventories or habitat assessments. Based on the distribution of fish and the status of the habitat in the other basins, it is assumed that rainbow trout are present in these two basins as well. In the absence of confirmation from detailed assessments, they have moderate consequence ratings.

Hazard and Risk Rating

The Bendixon Creek basin did not undergo a sediment source survey. No impairments to riparian function were identified. Fish habitat concerns include a lack of riparian buffers and sediment delivery from road crossings. The channel has not been significantly disturbed by placer mining or increases in peak flows. By the end of planning period, the PFI will have increased by 13%[1]. The planned blocks are distributed throughout the basin and on several tributaries. Approximately half of the blocks are situated above the lake. Due to this distribution, peak flows from the tributaries may become desynchronized[2], resulting in a decreased peak flow in the mainstem channel. In addition, the lake will buffer increases in peak flows originating from the higher elevation blocks. Both the distribution of the blocks and the buffering capacity of the lake will minimize the effect of the increase in PFI. Road

[1] Increases to PFI are based on the amended ECA calculations produced by Western GIS (1999) for the development period ending 2003.

[2] Desynchronization refers to the temporal distribution of streamflow within tributaries and how the separate peak flows from tributaries occur at different times, resulting in a mainstem peak flow that is not the sum of the tributary peak flows. Desynchronization depends primarily on basin morphology and climatic conditions.

density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a high consequence rating, results in a moderate risk rating.

The John Boyd Creek basin has 56 sediment sources, 38 (68%) of which are associated with pre-FPC roads and placer mining. Nine (16%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the trend is towards proper functioning. Fish habitat concerns include a lack of riparian buffers and sediment delivery for road crossings. The channel has been significantly disturbed at the placer mining sites. Overall, the mainstem channel has not been significantly disturbed by increases in peak flows. Because of hydrologic recovery, by the end of the planning period the PFI will have decreased by 6%. The planned blocks are distributed over the lower two-thirds of the basin and on several tributaries. Due to this distribution, peak flows from each of the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a moderate consequence rating, results in a low risk rating.

The Reddish Creek basin has 38 sediment sources, 11 (29%) of which are associated with pre-FPC roads and placer mining. Eighteen (47%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the trend is towards proper functioning. Fish habitat concerns include lack of pools, boulder cover and large woody debris. Fish habitat rehabilitation is prescribed for sections of Fontaine Creek, due to impacts from riparian harvesting and placer mining. The channel has been significantly disturbed at the placer mining sites. Overall, the mainstem channel has not been significantly disturbed by increases in peak flows. By the end of the planning period the PFI will have increased by 3%. The planned blocks are distributed throughout the basin and on several tributaries. Due to this distribution, peak flows from each of the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. In addition, wetlands along the mainstem will buffer increases in peak flows. Both the distribution of the blocks and the buffering capacity of the wetlands will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a high consequence rating, results in a moderate risk rating.

The Sovereign Creek basin has 73 sediment sources, 18 (25%) of which are associated with pre-FPC roads and placer mining. Thirty (41%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the trend is towards proper functioning. Fish

habitat concerns include lack of pools, boulder cover and large woody debris. Fish habitat rehabilitation is prescribed for lower reaches, due to impacts from riparian harvesting and placer mining. The channel has been significantly disturbed at the placer mining sites. Overall, the mainstem channel has not been significantly disturbed by increases in peak flows. By the end of the planning period the PFI will have increased by 3%. The planned blocks are distributed throughout the basin and on several tributaries. Due to this distribution, peak flows from each of the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. The distribution of the blocks will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a high consequence rating, results in a moderate risk rating.

The Umiti Creek basin has 58 sediment sources, 37 (64%) of which are associated with pre-FPC roads and placer mining. Eight (14%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the trend is towards proper functioning. Fish habitat concerns include a lack of riparian buffers and sediment delivery for road crossings. The channel has been significantly disturbed at the placer mining sites. Overall, the mainstem channel has not been significantly disturbed by increases in peak flows. By the end of the planning period the PFI will have increased by 6%. Most of the planned blocks are distributed throughout the upper half of the basin and on several tributaries. Due to this distribution, peak flows from each of the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. The distribution of the blocks will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a moderate consequence rating, results in a low risk rating.

CONCLUSION

The risk assessment ratings for each basin are summarized in Table 3. The Bendixon Creek, Reddish Creek and Sovereign Creek basins have moderate risk ratings, while the John Boyd Creek and Umiti Creek basins have low risk ratings. These risk ratings are due, in part, to the low hazard ratings assigned to each basin. The hazard ratings were determined to be low because the probability of the planned harvesting resulting in impacts to fish habitat, through increases to peak flows, is low. This is assuming that FPC requirements regarding the prevention of sediment from entering streams are met.

Some of the sediment sources associated with past harvesting activities are currently being rehabilitated through the Watershed Restoration Program. Consideration should be given to rehabilitating sources not covered by this program, as well as the placer mining sources. It is suggested that the Forest Develop Plan process consider the current status of restoration and rehabilitation, especially as it relates to road deactivation and risk of road failure. Risk assessments of future Forest Development Plans may result in different hazard and risk ratings, depending on the amount and location of the planned harvesting, the amount of new roads, and the success in rehabilitating existing sediment sources.

This risk assessment of planned harvesting is based solely on the documents reviewed. Its emphasis is on the hydrology of the basins, including fish habitat. A limitation of this assessment is that there were no Total Chance Plans or terrain stability maps available for review. However, these documents will likely be reviewed by the regulatory agencies as part of the FDP process, and are inherent in the requirements of the FPC (e.g. roads located on stable terrain and engineered to FPC standards to prevent sediment from entering streams).

TABLE 3. Summary of risk assessment ratings for planned harvesting.

Basin	Consequence	Hazard	Risk
Bendixon Cr.	H[1]	L	M
John Boyd Cr.	M	L	L
Reddish Cr.	H	L	M
Sovereign Cr.	H	L	M
Umiti Cr.	M	L	L

[1] L = Low, M = Moderate, H = High

SYNOPSES OF REPORTS

Cottonwood River Watershed

Integrated Watershed Restoration Plan (Carmanah, 1998g)

Summary of Watershed Concerns

- increased rates of sediment transport to streams along the road network and, in some watersheds, the road network density
- stream channel disturbance resulting from harvesting or mining activities in the riparian zone
- potentially increased peak flows in some watersheds as a result of logging activities
- the proposed rate-of-cut in some watersheds
- no landslides or gullies identified that require formal assessment
- road deficiencies identified and assessed for risk

Watershed Level Objectives

- reduce sediment input to streams from roads by:
    - ensuring access requirements as per the Access Management Map
    - reducing the volume of sediment generated from the road prism
    - increasing the opportunities for sediment deposition and storage before it enters the stream system
- improve stream and riparian conditions related to rainbow and bull trout, and coho, pink and chinook salmon habitat by ameliorating available fish rearing and spawning habitat

Bendixon Creek

General Assessments

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 42%, amended Peak Flow Index (PFI) 58% - rated as potentially high hazard

Riparian Assessment – Watershed Level (Carmanah, 1998d)

- recommendation for site level assessments: no sites with suspected impairments to riparian function (i.e. harvesting within RMA), therefore no site-level assessment required

Fish Habitat Assessment – Overview (Carmanah, 1998a)

- recommendation for Level 1 assessment: 1 reach, totalling 5.3 km
- habitat concerns include lack of riparian buffers

Detailed Assessments

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and decoupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed
- lake, wetlands and beaver ponds act as buffers in regulating peak flows
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Fish Habitat Inventory (Imhof and Sutherland, 1996a)

- 2 sample sites, below and above lake
- rainbow trout captured at both sites
- wide distribution of rainbow trout, and overall fish production is good

John Boyd Creek

General Assessments

Interior Watershed Assessment Procedure (Dobson, 1999)

- surface erosion index 0.83 (potentially high hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 1.00 (potentially high hazard) – 41% of stream edge logged; also placer/beaver activity
- mass wasting index 0.09 (low hazard) – 2 slope failures identified
- pre-FPC roads do not have adequate drainage structures to maintain natural drainage patterns
- lack of sediment control on ditchlines at stream crossings

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 44%, amended Peak Flow Index (PFI) 59% - rated as potentially high hazard

Inventory of Watershed Conditions (Chapman, 1997)

- 25 km of road travelled and 5 stream channel locations visited
- placer mining activity has disturbed stream channels along the mainstem, Alice and Mary Cr.
- harvesting in riparian zone has contributed to bank erosion
- mainstem channel is sensitive to increased peak flows and increased sediment supply resulting from disturbed riparian zone and bank erosion
- Mary Cr. – flooding due to beaver dams
- assessed roads/ditchlines stable
- infrequent cross-drains
- ditchlines discharge into streams at crossings
- recommendations: total development plan re: reduction in peak flow hazard, adequate protection of riparian zones, rehab of placer sites, silviculture to enhance regeneration of recently logged areas

Riparian, Wetland and Terrestrial Assessment (AIM, 1996)

- riparian buffers missing on 9 km of wetland and 27 km of stream – wildlife under hunting pressure, increased risk of sediment input
- low to moderate sensitive habitat concerns
- recommendations: on-site assessment of conditions and design of site-specific solutions (e.g. planting rapidly growing shrubs)

Riparian Assessment – Watershed Level (Carmanah, 1998d)

- recommendation for site level assessments: 1 site with suspected impairments to riparian function (i.e. harvesting within RMA), totalling 0.5 km (NB: only portion of basin within TFL 52 assessed)
- LWD and channel stability most heavily impaired riparian function, with additional impairments to stream shading, SOD and sediment and nutrient filtering

Fish Habitat Assessment – Overview (Carmanah, 1998a)

- recommendation for Level 1 assessment: 13 reaches, totalling 46.1 km
- habitat concerns include aggradation of the creek, lack of riparian buffers and possible sediment from road/bridge crossings

Detailed Assessments

Sediment Source Inventory (CARR, 1996)

- 56 sediment sources (5% of total number of sources (1090) in Cottonwood River watershed) – 47 man-made (15 high/very high risk), 9 associated with harvesting (1 high/very high risk), 32 associated with roads (10 high/very high risk), 6 associated with placer mining (4 high/very high risk); 7 high risk natural sources
- high/very high risk sites associated with forest development should be focal point of initial remedial work or watershed rehabilitation programs
- comprehensive access strategies are needed due to the influence of road maintenance and deactivation on sediment sources

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and partially coupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed, except for placer mining sites
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Riparian Assessment – Site Level (Carmanah, 1998e)

- 1 high priority site assessed, totalling 0.5 km
- high/very high LWD and stream shading impacts (SOD, surface filtering capacity, surficial sediment and channel stability have low to moderate impacts)
- trend is towards proper functioning, with well stocked, vigorous regeneration and old growth compensating for impaired functions - no rehabilitation required

Reddish Creek

General Assessments

Interior Watershed Assessment Procedure (Dobson, 1999)

- surface erosion index 0.70 (potentially moderate hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 0.91 (potentially high hazard) – 27% of stream edge (Fontaine) logged; also placer
- mass wasting index 0.00 (low hazard) – no slope failures identified
- pre-FPC roads do not have adequate drainage structures to maintain natural drainage patterns
- lack of sediment control on ditchlines at stream crossings

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 32%, amended Peak Flow Index (PFI) 44% - rated as potentially moderate hazard

Inventory of Watershed Conditions (Chapman, 1997)

- 3 stream channel locations visited
- no channel disturbances noted – extensive wetland complex
- Fontaine heavily logged – no channel disturbance noted at confluence
- placer mining in Fontaine, source of sediment
- new roads in Fontaine – sediment sources
- old roads stable
- recommendations: total development plan re: reduction in peak flow hazard, sediment control for all new roads

Riparian, Wetland and Terrestrial Assessment (AIM, 1996)

- riparian buffers missing on 5 km of wetland and 8 km of stream – wildlife under hunting pressure, increased risk of sediment input
- 5 high/very high priority sites with sensitive habitat concerns
- recommendations: on-site assessment of conditions and design of site-specific solutions (e.g. planting rapidly growing shrubs)

Riparian Assessment – Watershed Level (Carmanah, 1998d)

- recommendation for site level assessments: 7 sites with suspected impairments to riparian function (i.e. harvesting within RMA), totalling 8.7 km; mainstem is low priority due to wetlands
- stream shading, and sediment and nutrient filtering most heavily impaired riparian functions, with additional impairments to LWD and channel stability

Fish Habitat Assessment – Overview (Carmanah, 1998a)

- recommendation for Level 1 assessment: 9 reaches, totalling 22.6 km
- habitat concerns include lack of riparian buffers, lack of LWD, possible sediment from road/bridge crossings and sediment from placer mining activity

Detailed Assessments

Sediment Source Inventory (CARR, 1996)

- 38 sediment sources (3% of total number of sources (1090) in Cottonwood River watershed) - 29 man-made (9 high/very high risk), 18 associated with harvesting (4 high/very high risk), 9 associated with roads (3 high/very high risk), 2 associated with placer mining (2 high/very high risk); 6 high risk natural sources
- high/very high risk sites associated with forest development should be focal point of initial remedial work or watershed rehabilitation programs
- cumulative impact from numerous lower risk sites should be investigated
- comprehensive access strategies are needed due to the influence of road maintenance and deactivation on sediment sources

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel, extensive wetlands and decoupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed
- wetlands act as buffers in regulating peak flows
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Riparian Assessment – Site Level (Carmanah, 1998e)

- 5 high priority sites assessed, totalling 7.9 km
- high/very high LWD and stream shading impacts (SOD, surface filtering capacity, surficial sediment and channel stability have low to moderate impacts)
- level 2 assessment recommended for 2 sites, totalling 5.2 km – possible rehabilitation required
- trend for remaining 2.7 km is towards proper functioning, with well stocked, vigorous regeneration and old growth compensating for impaired functions - no rehabilitation required, although brushing of competing vegetation recommended for one site

Fish Habitat Assessment – Level 1 (Carmanah, 1998b)

- 3 reaches of Fontaine Cr. assessed (8.0 km)
- generally, lack of pools, boulder cover, LWD (due to harvesting in riparian areas)
- good spawning habitat
- fair/good off-channel habitat
- sites for LWD installations identified
- stabilization of banks and placer mining sites a priority

Fish Habitat Assessment – Level 2 (G3, 1998)

- prescriptions developed for revegetating banks/slumps and installing LWD in Fontaine Cr. and its tributaries (approx. 1.3 km)

Fish Habitat Inventory (Imhof and Sutherland, 1996a)

- 6 sample sites throughout basin
- rainbow trout captured at all 6 sites
- wide distribution of rainbow trout, and overall fish production is good

Reconnaissance Fisheries Inventory (Carmanah, 1998f)

- 33 sample sites throughout basin
- rainbow trout captured in 18 of the 19 fish bearing sites
- widespread distribution of rainbow trout in mainstem and most of the tributaries with gradients <20%
- lake chub and longnose suckers likely present throughout basin in wetlands and ponds
- the lower sections of all tributaries with low gradients should be assumed to be fish bearing
- beaver activity obvious in most areas
- 10 site recommended for further sampling or confirmation of barriers

Sovereign Creek

General Assessments

Interior Watershed Assessment Procedure (Dobson, 1999)

- surface erosion index 0.61 (potentially moderate hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 1.00 (potentially high hazard) – 39% of stream edge logged; also placer
- mass wasting index 0.09 (low hazard) – 2 slope failures identified
- pre-FPC roads do not have adequate drainage structures to maintain natural drainage patterns
- lack of sediment control on ditchlines at stream crossings

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 38%, amended Peak Flow Index (PFI) 50% - rated as potentially high hazard

Inventory of Watershed Conditions (Chapman, 1997)

- 3 stream channel locations visited
- placer mining has impacted the riparian zone resulting in increased bank erosion
- pre-FPC roads generally stable and well armoured, although erosion was noted on some non-deactivated spur roads
- recommendations: total development plan re: reduction in peak flow hazard, detailed channel, riparian and fish habitat assessments

Riparian, Wetland and Terrestrial Assessment (AIM, 1996)

- riparian buffers missing on 7 km of wetland and 19 km of stream – wildlife under hunting pressure, increased risk of sediment input
- 4 high/very high priority sites with sensitive habitat concerns
- recommendations: on-site assessment of conditions and design of site-specific solutions (e.g. planting rapidly growing shrubs)

Riparian Assessment – Watershed Level (Carmanah, 1998d)

- recommendation for site level assessments: 7 sites with suspected impairments to riparian function (i.e. harvesting within RMA), totalling 12.45 km
- all riparian functions significantly impaired

Fish Habitat Assessment – Overview (Carmanah, 1998a)

- recommendation for Level 1 assessment: 10 reaches, totalling 21.0 km
- habitat concerns include aggradation of the creek, lack of riparian buffers, lack of LWD, possible sediment from road/bridge crossings and sediment from placer mining activity

Detailed Assessments

Sediment Source Inventory (CARR, 1996)

- 73 sediment sources (7% of total number of sources (1090) in Cottonwood River watershed) – 49 man-made (12 high/very high risk), 30 associated with harvesting (5 high/very high risk), 13 associated with roads (1 high/very high risk), 5 associated with placer mining (5 high/very high risk); 12 high risk natural sources
- high/very high risk sites associated with forest development should be focal point of initial remedial work or watershed rehabilitation programs
- cumulative impact from numerous lower risk sites should be investigated
- comprehensive access strategies are needed due to the influence of road maintenance and deactivation on sediment sources

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and partially coupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed, except for placer sites
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Riparian Assessment – Site Level (Carmanah, 1998e)

- 3 high priority sites assessed, totalling 8.1 km
- high/very high LWD, stream shading and/or SOD impacts (surface filtering capacity, surficial sediment and channel stability have low to moderate impacts)
- level 2 assessment recommended for portions of 2 sites, totalling 1.1 km, possible rehabilitation required
- trend for remaining 7.0 km is towards proper functioning, with well stocked, vigorous regeneration and old growth compensating for impaired functions - no rehabilitation required, although brushing of competing vegetation recommended for some sites

Fish Habitat Assessment – Level 1 (Carmanah, 1998b)

- 5 reaches assessed (19.3 km)
- generally, lack of pools, boulder cover, LWD (due to harvesting in riparian areas)
- fair spawning habitat
- fair/poor off-channel habitat
- sites for LWD installations identified
- stabilization of banks and placer mining sites a priority

Fish Habitat Assessment – Level 2 (G3, 1998)

- prescriptions developed for stabilizing banks in Reach 2 (approx. 5.6 km) and restoring fish passage at several culverts

Fish Habitat Inventory (Imhof and Sutherland, 1996a)

- 12 sample sites throughout basin
- rainbow trout captured at 10 sites; chinook salmon captured in mainstem near confluence with Cottonwood
- wide distribution of rainbow trout, and overall fish production is good

Reconnaissance Fisheries Inventory (Carmanah, 1998c)

- 64 sample sites throughout basin
- rainbow trout captured in 25 of the 26 fish bearing sites
- widespread distribution of rainbow trout in mainstem and most of the large tributaries
- chinook salmon use the lower reaches of mainstem and Chipp Creek
- lake chub and longnose suckers likely present throughout basin in wetlands and ponds
- the lower sections of all tributaries with low gradients should be assumed to be fish bearing
- beaver activity obvious in most areas
- 19 sites recommended for further sampling or confirmation of barriers

Umiti Creek

General Assessments

Interior Watershed Assessment Procedure (Dobson, 1999)

- surface erosion index 0.51 (potentially moderate hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 0.69 (potentially moderate hazard) – 21% of stream edge logged; also placer/beaver activity
- mass wasting index 0.40 (low hazard) – 12 slope failures identified
- pre-FPC roads do not have adequate drainage structures to maintain natural drainage patterns
- lack of sediment control on ditchlines at stream crossings

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 27%, amended Peak Flow Index (PFI) 37% - rated as potentially moderate hazard

Inventory of Watershed Conditions (Chapman, 1997)

- 3 stream channel locations visited
- lower mainstem has natural bank erosion, as well as channel disturbance and bank erosion associated with placer mining
- harvesting in riparian zone (pre-FPC) has resulted in bank erosion and channel widening in the upper watershed
- beaver dams creating flooding/wetlands
- pre-FPC roads generally stable and well armoured; ditch line and running surface erosion at one site due to inefficient cross-drains allowing sediment to be transported into stream
- recommendations: total development plan re: reduction in peak flow hazard, distribution of harvesting over the basin would reduce the cumulative impacts

Riparian, Wetland and Terrestrial Assessment (AIM, 1996)

- riparian buffers missing on 7 km of wetland and 35 km of stream – wildlife under hunting pressure, increased risk of sediment input
- low to moderate sensitive habitat concerns
- recommendations: on-site assessment of conditions and design of site-specific solutions (e.g. planting rapidly growing shrubs)

Riparian Assessment – Watershed Level (Carmanah, 1998d)

- recommendation for site level assessments: 10 sites with suspected impairments to riparian function (i.e. harvesting within RMA), totalling 14.7 km
- LWD and channel stability most heavily impaired riparian function, with additional impairments to stream shading, SOD and sediment and nutrient filtering

Fish Habitat Assessment – Overview (Carmanah, 1998a)

- recommendation for Level 1 assessment: 6 reaches, totalling 29.5 km
- habitat concerns include possible sediment from road/bridge crossings, inadequate riparian areas and exposed soils close to the creek

Detailed Assessments

Sediment Source Inventory (CARR, 1996)

- 58 sediment sources (5% of total number of sources (1090) in Cottonwood River watershed) – 45 man-made (9 high/very high risk), 8 associated with harvesting (2 high/very high risk), 36 associated with roads (6 high/very high risk), 1 associated with placer mining (1 high/very high risk); 13 high risk natural sources
- high/very high risk sites associated with forest development should be focal point of initial remedial work or watershed rehabilitation programs
- cumulative impact from numerous lower risk sites should be investigated
- comprehensive access strategies are needed due to the influence of road maintenance and deactivation on sediment sources

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and decoupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed, except for placer sites
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Riparian Assessment – Site Level (Carmanah, 1998e)

- 10 sites assessed (including low and medium priority sites), totalling 14.7 km
- high/very high LWD, stream shading and/or SOD impacts (surface filtering capacity, surficial sediment and channel stability have low to moderate impacts)
- level 2 assessment recommended for 1 site (1.4 km) – possible rehabilitation required
- trend for remaining 13.3 km is towards proper functioning, with well stocked, vigorous regeneration and old growth compensating for impaired functions - no rehabilitation required
- 5 sites, totalling 10.3 km, recommended for restoration of wildlife tree habitat

WILLOW RIVER WATERSHED

SUMMARY OF REPORTS

The Integrated Watershed Restoration Plan (IWRP) lists a summary of watershed concerns. These concerns include sediment generation on road surfaces and downslope failures related to drainage problems on roads, sediment generation from cut and fill slope failures, placer mining contribution of fine and coarse sediment directly to streams and fish habitat impacts, such as filling of pools, lack of LWD and the removal of riparian vegetation. To address these concerns, the restoration objectives developed by the IWRP are to reduce sediment input to streams from roads and to improve the quality of fish habitat.

The Interior Watershed Assessments determined that erosion from roads, harvested riparian areas and peak flow represent major potential impacts.

The sediment source survey shows that the number of sediment sources associated with harvesting, roads, placer mining and natural occurrences varies between the basins. For each basin, the sources are:

Big Valley Creek – 134 sources - 18 harvesting, 80 roads, 18 placer mining, 35 natural
Crescent Creek – 10 sources - 1 harvesting, 8 roads, 1 placer mining, 0 natural
Rebman Creek – 18 sources - 8 harvesting, 10 roads, 0 placer mining, 0 natural
Tregillus Creek – 39 sources - 9 harvesting, 13 roads, 10 placer mining, 7 natural

The sediment sources related to harvesting are primarily the result of erosion from banks in harvested riparian areas. The survey suggests that there is a substantial impact from roads, due to sediment delivery resulting from lack of maintenance of drainage networks. Placer mining has a significant impact in the Tregillus Creek basin.

The channel assessments indicate that the mainstem channels of Big Valley Creek, Crescent Creek and Tregillus Creek have not been significantly disturbed by increases in peak flows. Channels have been significantly disturbed at placer mining sites in Big Valley Creek and Tregillus Creek basins. The mainstem channel of Rebman Creek has been disturbed due to the input of coarse and fine sediment from harvested riparian areas, potentially accelerated by increased peak flows. Lakes, wetlands and beaver ponds are acting as buffers in regulating streamflow in Crescent Creek basin.

The riparian assessments indicate that for all the basins, growth of natural or planted vegetation will provide the fastest route to the repair of riparian functions. Due to the good shrub growth, stocking in newer blocks and the structure of the IU stands, no vegetation

management actions are required unless there is instream or related engineering activity that requires rapid vegetation establishment. Where LWD is needed, suitable materials could be placed instream.

The fish habitat assessments indicate that the concerns related to habitat are poor ratings for deep pools, wood cover, off-channel habitat, and gravel quality, and the inadequate amount of LWD in many reaches. There are few fish barriers, with little impact on habitat. Bank erosion was noted where mature trees in riparian areas have been removed. Fish production is possibly limited by the lack of suitable instream rearing habitat and off-channel habitat.

The fisheries inventories indicate that rainbow trout is widely distributed in the mainstems and low gradient tributaries of Big Valley Creek and Tregillus Creek. Crescent Creek and Rebman Creek were each sampled at one location, and rainbow trout were found. The overall fish production in the basins is rated as fair.

RISK ASSESSMENT OF PLANNED HARVESTING

A risk assessment of planned harvesting within the basins, as outlined in the current FDPs, is based on the formula:

CONSEQUENCE X HAZARD = RISK

where consequence is the effect of a potential event on one or more elements at risk, and hazard is the probability of an event occurring. The risk rating is determined according to the following matrix of consequence and hazard ratings:

Consequence	Hazard			
	High	Moderate	Low	
High	Very High	High	Moderate	Risk
Moderate	High	Moderate	Low	
Low	Moderate	Low	Low	

The primary consequence for this assessment of planned harvesting is impacts to fish habitat. It is assumed that the status of habitat will, in turn, directly influence fish populations. The hazard is the probability of the planned harvesting causing the impacts. The harvesting activities that could result in impacts to habitat include roads and road building (e.g. sediment production), the location of harvesting relative to streams (e.g. riparian concerns) and the amount of area harvested (e.g. potential increases in streamflow). The guiding principle in determining the hazard rating is that the planned harvesting should not result in the degradation of fish habitat. Consequently, a low hazard would indicate that the planned harvesting has little probability of impacting fish habitat. A high hazard would indicate a high probability of impact. This approach will aid in answering the question "What risk does the planned harvesting pose to fish habitat?"

With regards to impacts to fish habitat, the main concern identified by the reports is the delivery of sediment into streams. The primary sources of this sediment are roads built prior to implementation of the FPC and placer mining. A secondary source is eroding banks in harvested riparian areas. The reports speculate that increases in peak flows, if large enough, due to past harvesting have potentially accelerated the delivery of sediment from these sources. The FPC regulates roads (e.g. building, maintenance, deactivation) and riparian management (e.g. buffer zones), and requires that sediment delivery into streams be prevented, in part through the use of proper erosion control techniques and drainage structures. Assuming that the planned harvesting activities, including road building and maintenance, follow FPC requirements, then the main hazard to be addressed by this risk assessment is the probability of peak flows increasing and potentially accelerating the delivery of sediment from existing sources.

Determination of a hazard rating for each basin is based on the information contained in the reports, as well as an examination of the change to the Peak Flow Index (PFI) (i.e. the Equivalent Clearcut Area (ECA) adjusted for elevation effects), the location of the planned blocks, and changes to road density, which can also affect the generation of peak flows. When considering the issue of ECA and PFI, it is important to understand not only the concepts upon which these indices are based, but also that a specific ECA or PFI value should not be a management target. Equivalent Clearcut Area (and hence PFI) and road density are solely indicators of potential changes to peak flow. Actual changes to peak flow are more accurately determined by field observations, such as channel assessments. A further explanation of how ECA and road density are related to peak flow is given in Appendix 2.

Consequence Rating

The consequence rating for each basin is based on the fish habitat assessments and fish inventories. The Big Valley Creek and Tregillus Creek basins have high consequence ratings due to the wide distribution of rainbow trout and bull trout, overall fair fish production and concerns about existing impacts to habitat. The Crescent Creek and Rebman Creek basins were inventoried at only one site each, where rainbow trout were found. Due to the apparent limited distribution of fish, these basins have moderate consequence ratings.

Hazard and Risk Rating

The Big Valley Creek basin has 134 sediment sources, 98 (73%) of which are associated with pre-FPC roads and placer mining. Eighteen (13%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the growth of existing vegetation will provide the fastest route to proper functioning. Fish habitat concerns include a lack of riparian buffers, and a lack of pools and large woody debris. The channel has been significantly disturbed at the placer mining sites. Overall, the mainstem channel has not been significantly disturbed by increases in peak flows. By the end of planning period, the PFI will have increased by 8%[3]. The planned blocks are distributed throughout the basin, primarily on the south side, and on several tributaries. Due to this distribution, peak flows from the tributaries may become desynchronized[4], resulting in a decreased peak flow in the mainstem channel. The distribution of the blocks will minimize the effect of the increase in PFI. Road density

[3] Increases to PFI are based on the amended ECA calculations produced by Western GIS (1999) for the development period ending 2003.

[4] Desynchronization refers to the temporal distribution of streamflow within tributaries and how the separate peak flows from tributaries occur at different times, resulting in a mainstem peak flow that is not the sum of the tributary peak flows. Desynchronization depends primarily on basin morphology and climatic conditions.

will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a high consequence rating, results in a moderate risk rating.

The Crescent Creek basin has 10 sediment sources, 9 (90%) of which are associated with pre-FPC roads and placer mining. One (10%) of the sources is associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the growth of existing vegetation will provide the fastest route to proper functioning. Fish habitat concerns include a lack of riparian buffers, and a lack of pools and large woody debris. The mainstem channel has not been significantly disturbed by placer mining or increases in peak flows. By the end of planning period, the PFI will have increased by 11%. The planned blocks are distributed throughout the basin and on several tributaries. Approximately half of the blocks are situated above the lakes. Due to this distribution, peak flows from the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. In addition, the lakes will buffer increases in peak flows originating from the higher elevation blocks. Both the distribution of the blocks and the buffering capacity of the lakes will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a moderate consequence rating, results in a low risk rating.

The Rebman Creek basin has 18 sediment sources, 10 (56%) of which are associated with pre-FPC roads. Eight (44%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the growth of existing vegetation will provide the fastest route to proper functioning. Fish habitat concerns include a lack of riparian buffers, and a lack of pools and large woody debris. The mainstem channel has been disturbed due to the input of coarse and fine sediment from harvested riparian areas, potentially accelerated by increased peak flows. There is no placer mining activity in this basin. By the end of the planning period the PFI will have increased by 3%. The planned blocks are located at the upper end of the basin, away from stream channels. The size and location of the blocks will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a moderate consequence rating, results in a low risk rating.

The Tregillus Creek basin has 39 sediment sources, 23 (59%) of which are associated with pre-FPC roads and placer mining. Nine (23%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the growth of existing vegetation will provide the fastest route to proper functioning. Fish habitat concerns include a lack of riparian buffers, and a lack of

pools and large woody debris. The channel has been significantly disturbed at the placer mining sites. Overall, the mainstem channel has not been significantly disturbed by increases in peak flows. By the end of planning period, the PFI will have increased by 3%. The planned blocks are located throughout the basin and on several tributaries. Most of the blocks are situated above the lake. Due to this distribution, peak flows from the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. In addition, the lake will buffer increases in peak flows originating from the higher elevation blocks. Both the distribution of the blocks and the buffering capacity of the lake will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a high consequence rating, results in a moderate risk rating.

CONCLUSION

The risk assessment ratings for each basin are summarized in Table 4. The Big Valley Creek and Tregillus Creek basins have moderate risk ratings, while the Crescent Creek and Rebman Creek basins have low risk ratings. These risk ratings are due, in part, to the low hazard ratings assigned to each basin. The hazard ratings were determined to be low because the probability of the planned harvesting resulting in impacts to fish habitat, through increases to peak flows, is low. This is assuming that FPC requirements regarding the prevention of sediment from entering streams are met.

Some of the sediment sources associated with past harvesting activities are currently being rehabilitated through the Watershed Restoration Program. Consideration should be given to rehabilitating sources not covered by this program, as well as the placer mining sources. It is suggested that the Forest Develop Plan process consider the current status of restoration and rehabilitation, especially as it relates to road deactivation and risk of road failure. Risk assessments of future Forest Development Plans may result in different hazard and risk ratings, depending on the amount and location of the planned harvesting, the amount of new roads, and the success in rehabilitating existing sediment sources.

This risk assessment of planned harvesting is based solely on the documents reviewed. Its emphasis is on the hydrology of the basins, including fish habitat. A limitation of this assessment is that there were no Total Chance Plans or terrain stability maps available for review. However, these documents will likely be reviewed by the regulatory agencies as part of the FDP process, and are inherent in the requirements of the FPC (e.g. roads located on stable terrain and engineered to FPC standards to prevent sediment from entering streams).

TABLE 4. Summary of risk assessment ratings for planned harvesting.

Basin	Consequence	Hazard	Risk
Big Valley Cr.	H[1]	L	M
Crescent Cr.	M	L	L
Rebman Cr.	M	L	L
Tregillus Cr.	H	L	M

[1] L = Low, M = Moderate, H = High

SYNOPSES OF REPORTS

Willow River Watershed

Integrated Watershed Restoration Plan (NHC, 1998a)

Summary of Concerns

- sediment generation on road surface and downslope failures related to drainage problems on road
- sediment generation form a stability perspective – cut and fill slope failures; too steep or in erodible materials
- road washout from location in gully
- placer mining contribution of fine and coarse sediment directly to streams
- fish habitat impacts - filling of pools and loss of surface flow as a result of bar growth and channel deposition; lack of LWD; lack of off-channel habitat
- removal of riparian vegetation

Watershed Level Objectives

- reduce sediment input to streams from roads
- improve the quality of stream habitat for rainbow and bull trout

Summary of Riparian Assessment (conducted by Symmetree Consulting Group, 1998[5])

- for all reaches assessed, growth of natural or planted vegetation will provide fastest route to repair of riparian functions
- recommendations: (1) due to good shrub growth, stocking in newer blocks and the structure of the IU stands, no vegetation management actions are required unless there is instream or related engineering activity that requires rapid vegetation reestablishment; (2) where LWD needed, place suitable materials instream

[5] original report not available for review

Summary of Fish Habitat Assessment (conducted by LGL Limited, 1998[6])

- target species for rehabilitation: rainbow and bull trout
- few fish barriers identified, little impact on habitat
- concerns: filling of pools and loss of surface flow; in some basins, poor rating of deep pools, wood cover, off-channel habitat, gravel quality; inadequate amount of LWD in many reaches;
- channel instability where mature trees in riparian areas have been removed
- fish production possibly limited by lack of suitable instream rearing habitat and lack of off-channel habitat
- recommendations provided to enhance habitat, such as placement of LWD and boulders

[6] Ibid.

Big Valley Creek

General Assessments

Interior Watershed Assessment Procedure (FORMIS, 1997)

- surface erosion index 0.42 (low hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 0.52 (potentially moderate hazard) – 16% of stream edge logged
- mass wasting index 0.12 (low hazard) – 3 slope failures identified

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 31%, amended Peak Flow Index (PFI) 39% - rated as potentially moderate hazard

Detailed Assessments

Sediment Source Inventory (NHC, 1998b)

- 134 sediment sources (31% of total number of sources (434) in Willow River watershed) – 116 man-made (58 high risk), 18 associated with harvesting (14 high risk), 80 associated with roads (26 high risk), 18 associated with placer mining (18 high risk); 3 high risk natural sources
- relative forestry impacts – high; relative mining impacts - low
- substantial impact from forest harvesting, particularly from roads
- road sources due to lack of maintenance of drainage networks and high density of logging trails
- connection between high sediment supply from roads and landslides and channel conditions
- fine sediment source impacts more significant than coarse sediment impacts

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and partially coupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed, except for placer sites
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Integrated Watershed Restoration Plan (NHC, 1998a)

- priority for rehabilitation re: riparian assessment – high, fish habitat assessment - low

Reconnaissance Fisheries Inventory (Carmanah, 1998h)

- 74 sample sites throughout basin
- rainbow trout captured at 16 of 22 fish bearing sites
- widespread distribution of rainbow trout in the mainstem and most large tributaries
- bull trout captured at 7 sites in mainstem and two tributaries (sugar Cr. and an unnamed tributary)
- 52 of 74 sites (1^{st} and 2^{nd} order tributaries) did not produce any fish
- the lower sections of all tributaries with low gradients should be assumed to be fish-bearing
- beaver activity encountered
- few natural migration barriers exist
- 34 sites recommended for further sampling or confirmation of barriers

Fish Habitat Inventory (Imhof and Sutherland, 1996b)

- 7 sample sites throughout basin
- rainbow trout captured at 5 sites in mainstem and major tributaries
- wide distribution of rainbow trout, and overall fish production is fair

Crescent Creek

General Assessments

Interior Watershed Assessment Procedure (FORMIS, 1997)

- surface erosion index 0.52 (potentially moderate hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 1.00 (potentially high hazard) – 42% of stream edge logged
- mass wasting index 0.50 (potentially moderate hazard) – 3 slope failures identified

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 53%, amended Peak Flow Index (PFI) 69% - rated as potentially high hazard

Detailed Assessments

Sediment Source Inventory (NHC, 1998b)

- 10 sediment sources (2% of total number of sources (434) in Willow River watershed) – 10 man-made (1 high risk), 1 associated with harvesting (0 high risk), 8 associated with roads (1 high risk), 1 associated with placer mining (0 high risk); 0 high risk natural sources
- relative forestry impacts – moderate; relative mining impacts - low
- substantial impact from forest harvesting, particularly from roads
- road sources due to lack of maintenance of drainage networks and high density of logging trails
- connection between high sediment supply from roads and landslides and channel conditions
- fine sediment source impacts more significant than coarse sediment impacts

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and partially coupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed
- lakes, wetlands and beaver ponds act as buffers in regulating peak flows
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Integrated Watershed Restoration Plan (NHC, 1998a)

- priority for rehabilitation re: riparian assessment – low, fish habitat assessment - low

Fish Habitat Inventory (Imhof and Sutherland, 1996b)

- 1 sample sites near confluence with Willow
- rainbow trout captured
- overall fish production is fair

Rebman Creek

General Assessments

Interior Watershed Assessment Procedure (FORMIS, 1997)

- surface erosion index 0.37 (low hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 1.00 (potentially high hazard) – 69% of stream edge logged
- mass wasting index 0.00 (low hazard) – 0 slope failures identified

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 56%, amended Peak Flow Index (PFI) 65% - rated as potentially high hazard

Detailed Assessments

Sediment Source Inventory (NHC, 1998b)

- 18 sediment sources (4% of total number of sources (434) in Willow River watershed) – 18 man-made (3 high risk), 8 associated with harvesting (0 high risk), 10 associated with roads (3 high risk), 0 associated with placer mining (0 high risk); 0 high risk natural sources
- relative forestry impacts – moderate/high; relative mining impacts - low
- substantial impact from forest harvesting, particularly from roads
- road sources due to lack of maintenance of drainage networks and high density of logging trails
- connection between high sediment supply from roads and landslides and channel conditions
- fine sediment source impacts more significant than coarse sediment impacts

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and highly coupled hillslopes
- coarse sediment and debris can easily enter the mainstem and be transported downstream
- lower reaches of channel have been moderately disturbed
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Integrated Watershed Restoration Plan (NHC, 1998a)

- priority for rehabilitation re: riparian assessment – high, fish habitat assessment - high

Fish Habitat Inventory (Imhof and Sutherland, 1996b)

- rainbow trout captured at 1 sampling site in mainstem
- overall fish production is fair

Tregillus Creek

General Assessments

Interior Watershed Assessment Procedure (FORMIS, 1997)

- surface erosion index 0.30 (low hazard) – road within 100m of stream, no. of crossings
- riparian buffer index 0.38 (potentially moderate hazard) – 11% of stream edge logged
- mass wasting index 0.05 (low hazard) – 1 slope failure identified

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 22%, amended Peak Flow Index (PFI) 28% - rated as potentially low hazard

Detailed Assessments

Sediment Source Inventory (NHC, 1998b)

- 39 sediment sources (9% of total number of sources (434) in Willow River watershed) – 32 man-made (2 high risk), 9 associated with harvesting (0 high risk), 13 associated with roads (0 high risk), 10 associated with placer mining (2 high risk); 0 high risk natural sources
- relative forestry impacts – moderate; relative mining impacts - high
- substantial impact from forest harvesting, particularly from roads
- road sources due to lack of maintenance of drainage networks and high density of logging trails
- connection between high sediment supply from roads and landslides and channel conditions
- fine sediment source impacts more significant than coarse sediment impacts

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and partially coupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed, except for placer sites
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Integrated Watershed Restoration Plan (NHC, 1998a)

- priority for rehabilitation re: riparian assessment – high, fish habitat assessment - high

Fish Habitat Inventory (Imhof and Sutherland, 1996b)

- 6 sample sites throughout basin
- rainbow trout captured at 4 sites in mainstem and major tributaries
- wide distribution of rainbow trout, and overall fish production is fair

BOWRON RIVER WATERSHED

SUMMARY OF REPORTS

The Integrated Watershed Restoration Plan (IWRP) lists a summary of watershed concerns. These concerns include sediment generation on road surfaces and downslope failures related to drainage problems, impact of sediment deposition on fish habitat and the removal of riparian vegetation. To address these concerns, the restoration objectives developed by the IWRP are to reduce the input of sediment originating from roads and hillslopes into streams, to reduce the number of barriers to fish passage and to increase the quality of stream habitat for fish.

The Interior Watershed Assessments determined that erosion from roads, harvested riparian areas and peak flow represent major potential impacts. The main concern is the amount of fine sediment that was potentially delivered to streams during the intensive road building and harvesting that occurred due to beetle salvage.

The sediment source survey shows that the number of sediment sources associated with harvesting, roads, placer mining and natural sources varies between the basins. For each basin, the sources are:

Indian Point Creek – 10 sources - 4 harvesting, 6 roads, 0 placer mining, 0 natural
Ketcham Creek – 25 sources - 3 harvesting, 20 roads, 2 placer mining, 0 natural
McKenna Creek – 8 sources - 0 harvesting, 3 roads, 0 placer mining, 5 natural
Towkuh Creek – 5 sources - 2 harvesting, 3 roads, 0 placer mining, 0 natural

The sediment sources related to harvesting are primarily the result of erosion from banks in harvested riparian areas. The survey suggests that there is a substantial impact from roads, due to sediment delivery resulting from lack of maintenance of drainage networks and lack of erosion control.

The channel assessments indicate that the mainstem channels of Indian Point Creek, Ketcham Creek, and Towkuh Creek have not been significantly disturbed by increases in peak flows. The mainstem channel of McKenna Creek has been disturbed in the lower reaches. Lakes, wetlands and/or beaver ponds are acting as buffers in regulating streamflow in Indian Point Creek, Ketcham Creek and Towkuh Creek basins.

The riparian assessments indicate that one reach within the Ketcham Creek basin may require rehabilitation due to impacts from harvesting. Riparian function in the remainder of this basin, as well as in Indian Point Creek, McKenna Creek and Towkuh Creek basins, has been

affected, but no rehabilitation is required as the trend is towards proper functioning, with well stocked, vigorous regeneration and old growth compensating for impaired functions.

The detailed fish habitat assessments indicate that Ketcham Creek and Towkuh Creek have moderate to high spawning habitat and moderate rearing. Generally, there is abundant LWD and good cover. The main limitations to habitat appear to be a high proportion of sands in the bed material and a lack of pools. The other basins had only overview assessments, due to their being a lower priority than Ketcham Creek and Towkuh Creek. Habitat concerns for these basins include a lack of riparian buffers and possible sediment from road crossings.

The fisheries inventories indicate that rainbow trout is widely distributed in the mainstem and low gradient tributaries of Ketcham Creek. Chinook salmon were also present in the lower reaches of the mainstem. Rainbow trout and chinook salmon were found in the lower reaches of Towkuh Creek, below the waterfalls. No fish were found above the falls. Inventories were not conducted in the Indian Point Creek and McKenna Creek basins. Given the distribution in the other basins, and the status of the fish habitat, it can be assumed that rainbow trout will be present in these two basins as well.

RISK ASSESSMENT OF PLANNED HARVESTING

A risk assessment of planned harvesting within the basins, as outlined in the current FDPs, is based on the formula:

CONSEQUENCE X HAZARD = RISK

where consequence is the effect of a potential event on one or more elements at risk, and hazard is the probability of an event occurring. The risk rating is determined according to the following matrix of consequence and hazard ratings:

Consequence	Hazard			
	High	Moderate	Low	
High	Very High	High	Moderate	Risk
Moderate	High	Moderate	Low	
Low	Moderate	Low	Low	

The primary consequence for this assessment of planned harvesting is impacts to fish habitat. It is assumed that the status of habitat will, in turn, directly influence fish populations. The hazard is the probability of the planned harvesting causing the impacts. The harvesting activities that could result in impacts to habitat include roads and road building (e.g. sediment production), the location of harvesting relative to streams (e.g. riparian concerns) and the amount of area harvested (e.g. potential increases in streamflow). The guiding principle in determining the hazard rating is that the planned harvesting should not result in the degradation of fish habitat. Consequently, a low hazard would indicate that the planned harvesting has little probability of impacting fish habitat. A high hazard would indicate a high probability of impact. This approach will aid in answering the question "What risk does the planned harvesting pose to fish habitat?"

With regards to impacts to fish habitat, the main concern identified by the reports is the delivery of sediment into streams. The primary sources of this sediment are roads built prior to implementation of the FPC and placer mining. A secondary source is eroding banks in harvested riparian areas. The reports speculate that increases in peak flows, if large enough, due to past harvesting have potentially accelerated the delivery of sediment from these sources. The FPC regulates roads (e.g. building, maintenance, deactivation) and riparian management (e.g. buffer zones), and requires that sediment delivery into streams be prevented, in part through the use of proper erosion control techniques and drainage structures. Assuming that the planned harvesting activities, including road building and maintenance, follow FPC requirements, then the main hazard to be addressed by this risk assessment is the probability of peak flows increasing and potentially accelerating the delivery of sediment from existing sources.

Determination of a hazard rating for each basin is based on the information contained in the reports, as well as an examination of the change to the Peak Flow Index (PFI) (i.e. the Equivalent Clearcut Area (ECA) adjusted for elevation effects), the location of the planned blocks, and changes to road density, which can also affect the generation of peak flows. When considering the issue of ECA and PFI, it is important to understand not only the concepts upon which these indices are based, but also that a specific ECA or PFI value should not be a management target. Equivalent Clearcut Area (and hence PFI) and road density are solely indicators of potential changes to peak flow. Actual changes to peak flow are more accurately determined by field observations, such as channel assessments. A further explanation of how ECA and road density are related to peak flow is given in Appendix 2.

Consequence Rating

The consequence rating for each basin is based on the fish habitat assessments and fish inventories. The Ketcham Creek basin has a high consequence rating due to the wide distribution of rainbow trout, presence of chinook salmon and concerns about existing impacts to habitat. The Towkuh Creek basin has a moderate consequence rating due to the presence of rainbow trout and chinook salmon in only the reach below the falls. The Indian Point Creek and McKenna Creek basins did not have detailed inventories or habitat assessments. Based on the distribution of fish and the status of the habitat in the other basins, it is assumed that rainbow trout are present in these two basins as well. In the absence of confirmation from detailed assessments, they have moderate consequence ratings.

Hazard and Risk Rating

The Indian Point Creek basin has 10 sediment sources, 6 (60%) of which are associated with pre-FPC roads. Four (40%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the trend is towards proper functioning. Fish habitat concerns include a lack of riparian buffers, and possible sediment delivery from road crossings. The mainstem channel has not been significantly disturbed by increases in peak flows. There is no placer mining activity in this basin. By the end of planning period, the PFI will have increased by 7%[7]. The planned blocks are distributed throughout the basin and on several tributaries. Due to this distribution, peak flows from the tributaries may become

[7] Increases to PFI are based on the amended ECA calculations produced by Western GIS (1999) for the development period ending 2003.

desynchronized[8], resulting in a decreased peak flow in the mainstem channel. In addition, the wetlands will buffer increases in peak flows. Both the distribution of the blocks and the buffering capacity of the wetlands will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a moderate consequence rating, results in a low risk rating.

The Ketcham Creek basin has 25 sediment sources, 22 (88%) of which are associated with pre-FPC roads and placer mining. Three (12%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the trend is towards proper functioning. Fish habitat concerns include a low occurrence of cobble cover and pool areas. The mainstem channel has not been significantly disturbed by increases in peak flows or placer mining. By the end of planning period, the PFI will have increased by 3%. The planned blocks are distributed throughout the basin and on several tributaries. Due to this distribution, peak flows from the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. In addition, extensive wetlands will buffer increases in peak flows. Both the distribution of the blocks and the buffering capacity of the wetlands will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into streams. The hazard rating is, therefore, low. This rating, combined with a high consequence rating, results in a moderate risk rating.

The Towkuh Creek basin has 5 sediment sources, 3 (60%) of which are associated with pre-FPC roads. Two (40%) of the sources are associated with harvesting, including harvested riparian areas. There have been impairments to riparian function, but no rehabilitation is required as the trend is towards proper functioning. Fish habitat concerns include a low occurrence of cobble cover and pool areas. The mainstem channel has not been significantly disturbed by increases in peak flows. There is no placer mining activity in this basin. By the end of planning period, the PFI will have increased by 5%. The planned blocks are distributed throughout the basin and on several tributaries. Due to this distribution, peak flows from the tributaries may become desynchronized, resulting in a decreased peak flow in the mainstem channel. In addition, extensive beaver ponds along the mainstem will buffer increases in peak flows. Both the distribution of the blocks and the buffering capacity of the ponds will minimize the effect of the increase in PFI. Road density will not be increased significantly, and may actually decrease, depending on deactivation. Consequently, peak flows are unlikely to increase sufficiently, if at all, to adversely affect sediment delivery into

[8] Desynchronization refers to the temporal distribution of streamflow within tributaries and how the separate peak flows from tributaries occur at different times, resulting in a mainstem peak flow that is not the sum of the tributary peak flows. Desynchronization depends primarily on basin morphology and climatic conditions.

streams. The hazard rating is, therefore, low. This rating, combined with a moderate consequence rating, results in a low risk rating.

The McKenna Creek basin has 8 sediment sources, 3 (38%) of which are associated with pre-FPC roads. Five (62%) of the sources are naturally occurring. There have not been any impairments to riparian function. Fish habitat concerns include possible sediment delivery from road crossings. Lower reaches of the mainstem channel have been moderately disturbed, probably by increases in peak flows. There is no placer mining activity in this basin. No further harvesting is planned for this basin, therefore hazard and risk ratings were not assigned.

CONCLUSION

The risk assessment ratings for each basin are summarized in Table 5. The Ketcham Creek basin has a moderate risk rating, while the Indian Point Creek and Towkuh Creek basins have low risk ratings. The McKenna Creek basin does not have a risk rating because no harvesting is planned. These risk ratings are due, in part, to the low hazard ratings assigned to each basin. The hazard ratings were determined to be low because the probability of the planned harvesting resulting in impacts to fish habitat, through increases to peak flows, is low. This is assuming that FPC requirements regarding the prevention of sediment from entering streams are met.

Some of the sediment sources associated with past harvesting activities are currently being rehabilitated through the Watershed Restoration Program. Consideration should be given to rehabilitating sources not covered by this program, as well as the placer mining sources. It is suggested that the Forest Develop Plan process consider the current status of restoration and rehabilitation, especially as it relates to road deactivation and risk of road failure. Risk assessments of future Forest Development Plans may result in different hazard and risk ratings, depending on the amount and location of the planned harvesting, the amount of new roads, and the success in rehabilitating existing sediment sources.

This risk assessment of planned harvesting is based solely on the documents reviewed. Its emphasis is on the hydrology of the basins, including fish habitat. A limitation of this assessment is that there were no Total Chance Plans or terrain stability maps available for review. However, these documents will likely be reviewed by the regulatory agencies as part of the FDP process, and are inherent in the requirements of the FPC (e.g. roads located on stable terrain and engineered to FPC standards to prevent sediment from entering streams).

TABLE 5. Summary of risk assessment ratings for planned harvesting.

Basin	Consequence	Hazard	Risk
Indian Point Cr.	M[1]	L	L
Ketcham Cr.	H	L	M
Towkuh Cr.	M	L	L
McKenna Cr.	-[2]	-	-

[1] L = Low, M = Moderate, H = High
[2] no harvesting planned for McKenna Cr., therefore no risk rating assigned

SYNOPSES OF REPORTS

Bowron River Watershed

Integrated Watershed Restoration Plan (Brave, 1999)

Summary of Concerns

- sediment generation on road surface and downslope failures related to drainage problems on road
- fish habitat impacts – sediment deposition
- removal of riparian vegetation

Watershed Level Objectives

- reduce input of sediment originating from roads and hillslopes into streams by:
  - reducing volume of sediment from roads generated by hydrological processes
  - reducing the hydrological and gravitational effect of hillslope sediment sources
- reduce the number of barriers to fish passage at stream crossings
- increase the quality of stream habitat for rainbow trout, bull trout, chinook salmon and sockeye salmon

Indian Point Creek

General Assessments

Interior Watershed Assessment Procedure (Bowron, 1997)

- surface erosion index 0.63 (potentially moderate hazard)
- riparian buffer index 0.78 (potentially high hazard)
- mass wasting index 0.63 (potentially moderate hazard)
- basin less sensitive to logging impacts due to topography and channel type
- residual vegetation may be sufficient to maintain productive fish habitat
- medium level of hydrologic concern related to harvesting
- main concern is the amount of fine sediment that was potentially generated and delivered during the intensive road building, harvesting and hauling that occurred due to beetle salvage

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA (for entire drainage) 29%, amended Peak Flow Index (PFI) 32% - rated as potentially low hazard

Riparian Assessment – Watershed Level (Carmanah, 1998k)

- recommendation for site level assessments: 1 site with suspected impairments to riparian function (i.e. harvesting within RMA), totalling 0.3 km
- stream shading, and sediment and nutrient filtering most heavily impaired riparian functions, with additional impairments to LWD and channel stability

Fish Habitat Assessment – Overview (Carmanah, 1998i)

- recommendation for Level 1 assessment: 1 reach, totalling 1.6 km
- habitat concerns include lack of riparian buffers and possible sediment from road crossing

Detailed Assessments

Sediment Source Inventory (based on IWRP, Brave, 1999)

- 10 sediment sources – 10 man-made (10 high risk), 4 associated with harvesting (4 high risk), 6 associated with roads (6 high risk),
- 3 sites high or medium priority for rehabilitation

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and decoupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed
- lake, wetlands and beaver ponds act as buffers in regulating peak flows
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Ketcham Creek

General Assessments

Interior Watershed Assessment Procedure (Bowron, 1997)

- surface erosion index 0.99 (potentially high hazard)
- riparian buffer index 1.00 (potentially high hazard)
- mass wasting index 0.45 (low hazard)
- potential for negative cumulative effects quite high
- channel less sensitive to destabilization
- high level of hydrologic concern related to harvesting
- main concern is the amount of fine sediment that was potentially generated and delivered during the intensive road building, harvesting and hauling that occurred due to beetle salvage

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 44%, amended Peak Flow Index (PFI) 58% - rated as potentially high hazard

Riparian Assessment – Watershed Level (Carmanah, 1998k)

- recommendation for site level assessments: 12 sites with suspected impairments to riparian function (i.e. harvesting within RMA), totalling 7.4 km
- LWD, SOD and stream shading most heavily impaired riparian functions

Fish Habitat Assessment – Overview (Carmanah, 1998i)

- recommendation for Level 1 assessment: 8 reaches, totalling 14.7 km
- habitat concerns include lack of riparian buffers

Detailed Assessments

Sediment Source Inventory (based on IWRP, Brave, 1999)

- 25 sediment sources – 25 man-made (25 high risk), 3 associated with harvesting (3 high risk), 20 associated with roads (15 high risk), 2 associated with placer mining (2 high risk)
- 10 sites high or medium priority for rehabilitation

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and decoupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed
- lake, wetlands and beaver ponds act as buffers in regulating peak flows
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Riparian Assessment – Site Level (Carmanah, 1998l)

- 7 high priority sites assessed, totalling 4.3 km
- high/very high LWD impacts
- level 2 assessment recommended for 1 site (1.2 km) – possible rehabilitation required
- trend for remaining 3.1 km is towards proper functioning, with well stocked, vigorous regeneration and old growth compensating for impaired functions - no rehabilitation required
- 4 sites, totalling 2.7 km, recommended for restoration of wildlife tree habitat

Fish Habitat Assessment – Level 1 (Carmanah, 1998j)

- 2 reaches assessed, totalling 8.9 km
- moderate/high spawning habitat
- moderate rearing habitat
- limited overwintering capabilities
- abundant LWD – good cover
- main limitations to spawning and rearing habitat appear to be high proportion of sands in the bed material and the low occurrence of cobble cover and pool areas
- recommend placement of boulder groups

Reconnaissance Fisheries Inventory (Carmanah, 1998m)

- 37 sample sites throughout basin
- rainbow trout captured at 10 of 14 fish bearing sites, chinook salmon captured in lower reach
- widespread distribution of rainbow trout in lower reaches of the mainstem and most large tributaries
- 16 sites recommended for further sampling or confirmation of barriers

Towkuh Creek

General Assessments

Interior Watershed Assessment Procedure (Bowron, 1997)

- surface erosion index 1.00 (potentially high hazard)
- riparian buffer index 1.00 (potentially high hazard)
- mass wasting index 0.40 (low hazard)
- high level of hydrologic concern related to harvesting
- main concern is the amount of fine sediment that was potentially generated and delivered during the intensive road building, harvesting and hauling that occurred due to beetle salvage

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 49%, amended Peak Flow Index (PFI) 63% - rated as potentially high hazard

Riparian Assessment – Watershed Level (Carmanah, 1998k)

- recommendation for site level assessments: 3 sites with suspected impairments to riparian function (i.e. harvesting within RMA), totalling 1.3 km
- stream shading, LWD, SOD and channel stability most heavily impaired riparian functions, with additional impairments to sediment and nutrient filtering

Fish Habitat Assessment – Overview (Carmanah, 1998i)

- recommendation for Level 1 assessment: 1 reach, totalling 1.5 km
- habitat concerns include lack of riparian buffers and possible sediment from upstream sources

Detailed Assessments

Sediment Source Inventory (based on IWRP, Brave, 1999)

- 5 sediment sources – 5 man-made (5 high risk), 2 associated with harvesting (2 high risk), 3 associated with roads (3 high risk),
- 2 sites high or medium priority for rehabilitation

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and partially coupled hillslopes
- coarse sediment and debris cannot easily enter the mainstem and be transported downstream
- channel has not been significantly disturbed
- lake, wetlands and beaver ponds act as buffers in regulating peak flows
- planned harvesting, as identified in development plans, should not adversely affect peak flows, sediment transport or channel morphology
- when harvesting near stream channels, sediment and debris must be prevented from entering the channels

Riparian Assessment – Site Level (Carmanah, 1998l)

- 1 high priority site assessed, totalling 0.6 km
- very high LWD impact
- trend is towards proper functioning, other sources providing LWD - no rehabilitation required

Fish Habitat Assessment – Level 1 (Carmanah, 1998j)

- 1 reach assessed, totalling 1.5 km
- moderate spawning habitat
- moderate rearing habitat
- limited overwintering capabilities
- abundant LWD – good cover
- main limitations to spawning and rearing habitat appears to be high proportion of sands in the bed material and the low occurrence of cobble cover and pool areas

Reconnaissance Fisheries Inventory (Carmanah, 1998m)

- 7 sample sites throughout basin
- rainbow trout and chinook salmon captured at 1 site, below the falls, which act as a barrier

McKenna Creek

General Assessments

Interior Watershed Assessment Procedure (Bowron, 1997)

- surface erosion index 0.75 (potentially high hazard)
- riparian buffer index 0.52 (potentially moderate hazard)
- mass wasting index 0.00 (low hazard)
- low level of hydrologic concern related to harvesting
- main concern is the amount of fine sediment that was potentially generated and delivered during the intensive road building, harvesting and hauling that occurred due to beetle salvage

Amended Equivalent Clearcut Area (ECA) Calculation (Western, 1999)

- amended ECA 32%, amended Peak Flow Index (PFI) 36% - rated as potentially moderate hazard

Riparian Assessment – Watershed Level (Carmanah, 1998k)

- recommendation for site level assessments: no riparian function concerns identified; harvested areas recovering well from any impairments

Fish Habitat Assessment – Overview (Carmanah, 1998i)

- recommendation for Level 1 assessment: 5 reaches, totalling 8.3 km
- habitat concerns include lack of riparian buffers and possible sediment from road crossings

Detailed Assessments

Sediment Source Inventory (based on IWRP, Brave, 1999)

- 8 sediment sources – 3 man-made (3 high risk), 0 associated with harvesting, 3 associated with roads (3 high risk), 5 high risk natural sources
- 3 sites high or medium priority for rehabilitation

Channel Assessment (FORMIS, 2000)

- small, low gradient mainstem channel and highly coupled hillslopes
- coarse sediment and debris can easily enter the mainstem and be transported downstream
- lower reaches of the channel have been moderately disturbed

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APPENDIX 1

Objectives of Assessments and Reports

Integrated Watershed Restoration Plan

General objectives are to:

1. protect, restore and maintain fisheries, aquatic and forest resources that have been adversely impacted by past forest harvesting practices
2. ensure that the whole range of logging-related resource impacts are identified and rehabilitated in a systematic, co-ordinated manner at the watershed level (NHC, 1998a).

Interior Watershed Assessment Procedure – Level 1

1. To assess a watershed for the potential for cumulative hydrologic impacts due to past forest development and road construction (Dobson, 1999).

Inventory of Watershed Conditions

General objectives were to:

1. inventory current physical conditions in the Cottonwood, Cariboo and Horsefly watersheds that might affect fish habitat.
2. define potential risks to fish resources.
3. assess and interpret the land use impacts in each watershed that could potentially result in a risk to the fish resource.
4. assess and interpret the watershed conditions with regards to proposed harvesting as outlined in the current five-year forest development plans (Chapman, 1997).

Sediment Source Inventory/Survey

1. To identify and map the active and potential erosion sites within a watershed.
2. To rate the sites as to their capability for sediment generation and potential resource impact.
3. To recommend direction for the development of watershed restoration projects (CARR, 1996).

Channel Assessment Procedure

1. To identify disturbed channels in a consistent and repeatable process (FORMIS, 2000).

Riparian, Wetland and Terrestrial Assessment

1. To evaluate access and loss or damage to riparian, wetland and terrestrial habitats as a result of forest harvesting, range use, silviculture and recreation activities (AIM, 1996).

Riparian Assessment and Prescription Procedures – Watershed Level

1. To classify riparian vegetation into relatively uniform classes where the loss or impairment of ecological function and rehabilitation prescriptions are consistent.
2. To identify stream reaches where riparian ecological function has been lost or impaired as a result of forest harvesting or as a result of activities related to forest harvesting such as road building, river crossings and other developments.
3. To prioritize these reaches for site assessments, with the intention of developing rehabilitation prescriptions for riparian areas impacted by forest harvesting (Carmanah, 1998d).

Riparian Assessment and Prescription Procedures – Site Level

1. To characterize the ecological parameters of Riparian Vegetation Types and the degree of impairment if ecosystem function.
2. To develop preliminary rehabilitation prescriptions to restore lost or impaired riparian function (Carmanah, 1998e).

Fish Habitat Assessment Procedure – Overview

1. To identify opportunities and appropriate techniques to restore and rehabilitate impacted fish habitat to increase depressed stocks of fish in streams.
2. To provide a preliminary indication of the factors that limit fish production and fish habitat (Carmanah, 1998a).

Fish Habitat Assessment Procedure – Level 1

To identify:
1. areas of concern with respect to impacts on fish habitat within developed watersheds
2. general assessment of rehabilitation needs and potential
3. requirements for more detailed investigations to further define specific impacts and associated opportunities for restoration or rehabilitation of degraded habitat (Carmanah, 1998b).

Fish Habitat Assessment Procedure – Level 2

1. To determine the feasibility of remediating fish habitat.
2. To provide prescriptions for instream and channel stabilization (G3 Consulting, 1998).

Fish Habitat Inventory

1. To gather fish and fish habitat data (Imhof and Sutherland, 1996a).

Reconnaissance Fisheries Inventory

1. To gather biophysical and distribution data of fish and fish habitat to increase the quantity and quality of fisheries information in the watershed (Carmanah, 1998c).

APPENDIX 2

Equivalent Clearcut Area and Peak Flows

Equivalent Clearcut Area is an index of hydrologic recovery only. Because it is an index, it can be used solely as an *indicator* of the *potential* for peak flows to be increased following disturbance to the forest canopy. Actual changes to peak flow are more accurately determined by field observations.

Equivalent Clearcut Area is not a measure of rate-of-cut, nor is it a measure of the percentage of a watershed harvested over time. It is specific to forest hydrology only.

According to the current Watershed Assessment Procedure (WAP), the most important component of hydrological recovery involves snow accumulation and melt. Therefore, the determination of ECA is based on snowpack recovery, and its influence on snowmelt peak flows. In the Interior, snowmelt peak flows are typically the highest flows of the year.

Equivalent clearcut area is determined in the WAP using four parameters: (1) the area of a watershed that has been harvested, cleared or burned, (2) the silvicultural system used, (3) height of regeneration, and (4) the elevation of the disturbed area within the watershed. Adjustment factors are applied to these parameters to reflect snowpack recovery. The adjustment factors are based on empirical research being conducted in the southern Interior, and are applied to the entire province. The factors are a "first approximation" only and revisions will be considered as new information becomes available.

What constitutes a high ECA differs around the province. Whether peak flows actually increase, or decrease, (i.e. the hydrologic response) depends on how flows from various source areas originally combined to produce snowmelt streamflow. Some of the basic hydrological parameters which influence streamflow are:

- type of disturbance (e.g. harvesting vs. wildfire)
- type of forest (e.g. species, density)
- relative amount of forest and non-forest
- watershed size, shape and aspect
- watershed drainage pattern
- topography
- stream density

- connection of slopes to streams
- location of lakes and wetlands within the watershed
- type of soils and soil moisture characteristics
- degree of ground surface disturbance, including roads
- proximity of harvesting activity to streams
- location of harvesting and roads within the watershed (relative to elevation and drainage pattern, e.g. lower slopes are fully recharged due to melt, therefore harvesting lower slopes could affect recharge, which in turn affects routing of groundwater snowmelt from upper slopes)
- aspect of harvested blocks and/or disturbed areas
- local climatic conditions (the dominant control on the magnitude of peak flows)

This partial list of the hydrological parameters that affect streamflow is intended to demonstrate that the current procedure for determining ECA, based on only four parameters, gives only a rough approximation of the actual hydrologic response and so results must be used in context with other watershed characteristics. Indeed, as stated in the current Watershed Assessment Procedure (1999):

> "The ECA methodology used here to estimate changes in peak flow produces an approximation based on limited data; it must not be used in isolation, but can be useful in combination with other factors to assess the impact of timber harvesting on stream channels. There is little evidence to link channel disturbance with ECA alone, in isolation from other effects such as riparian logging and changes to sediment supply. *ECA values should not be a management target.*"

It should be noted that in addition to ECA, the WAP also considers road density to be a primary factor affecting peak flows. Roads can influence peak flows by intercepting sub-surface flows and transferring the water to streams much faster than through the soil. Also, the compacted surfaces of roads reduce infiltration and transfer intercepted precipitation and snowmelt to ditchlines, and hence to streams.