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Interior Watershed Assessment

for the

DUTEAU CREEK WATERSHED

(Vernon Forest District)

Prepared for
RIVERSIDE FOREST PRODUCTS LIMITED
Lumby Division

and

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Lavington Division

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RIVERSIDE FOREST PRODUCTS LIMITED
Lumby Division

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1.0 INTRODUCTION

At the request of Riverside Forest Products Limited, the ***Interior Watershed Assessment Procedure (IWAP)*** for the Duteau Creek watershed was updated to incorporate the terrain mapping information and new inventory data pertaining to logging history and green-up heights.

The purpose of the assessment was to determine current watershed conditions, the effect of past land-use practice on the watershed and the potential impacts from proposed forest development. The assessment follows the Interim Watershed Assessment Procedure as provided by the Ministry of Forests (MoF) and Ministry of Environment, Lands and Parks (MELP) *[refer to Section 4.0]*.

This report replaces the previous watershed assessment completed in 1996.

The Duteau Creek watershed is located southwest of the Village of Lumby within the Vernon Forest District *[Figure 1]*. Duteau Creek is a community watershed providing water for the North Okanagan Water Authority (NOWA). The entire watershed was assessed upstream of the Headgates water intake (referred to as the lower point of interest [POI 1]). The majority of Crown land in the watershed is held under forest license by Riverside Forest Products Limited - Lumby Division, with a minor portion part of a forest license held by Tolko Industries Ltd., Lavington Planer Division. The Small Business Forest Enterprise Program (SBFEP) also has several timber sales proposed within the watershed.

A Watershed Assessment Committee (WAC) including representatives from Riverside Forest Products Limited - Lumby Division, the MoF, MELP, Department of Fisheries and Oceans (DFO), NOWA and Tolko Industries Ltd. was organized to provide input on related issues and concerns, and to review the results *[Appendix A]*.

The Department of Fisheries and Oceans (DFO) did not participate in the initial WAC meeting but requested to be kept informed of assessment results through receipt of the meeting minutes and the final report.

Comments forwarded to the WAC will be discussed at the final WAC meeting.

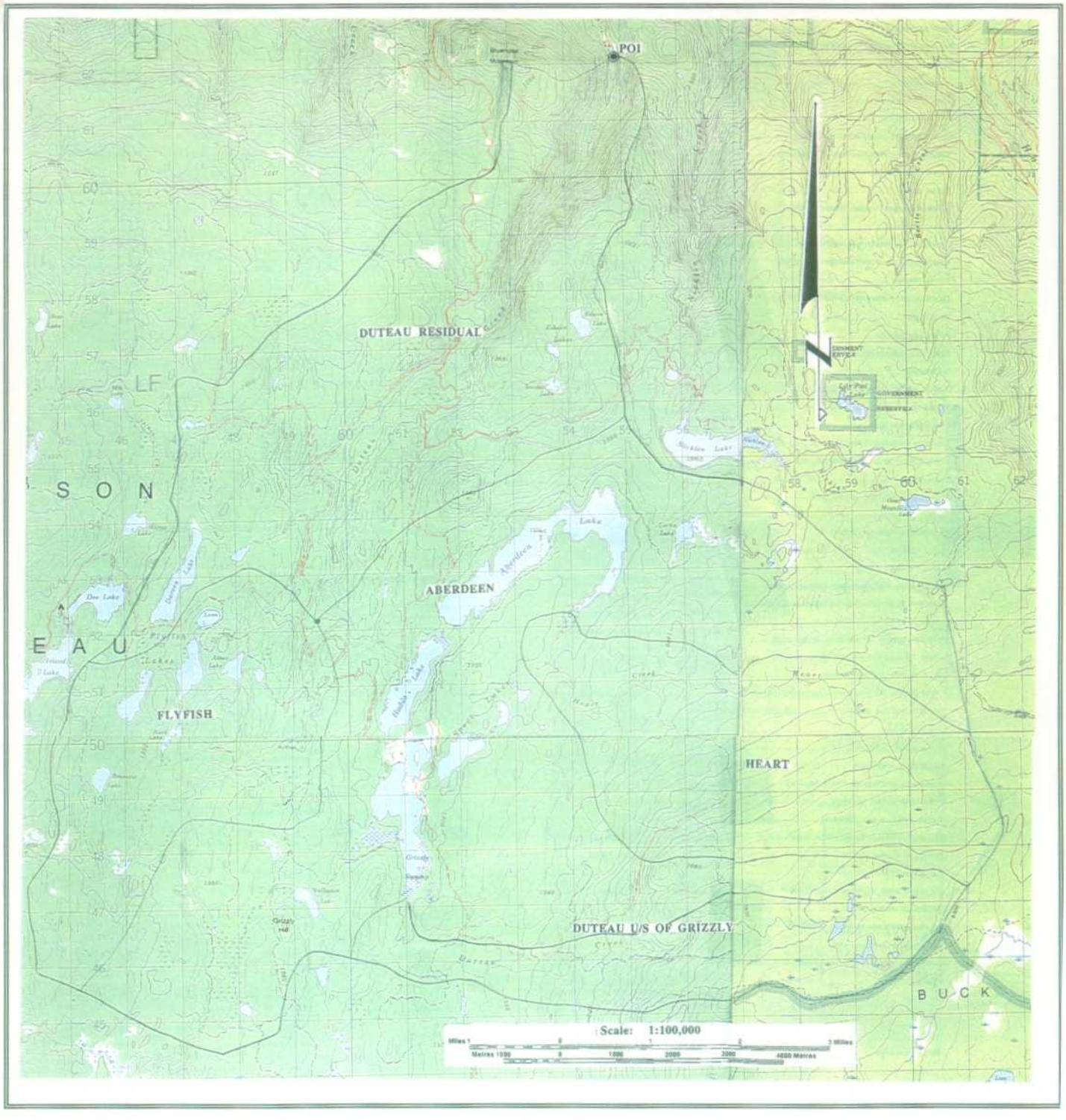

FIGURE 1

Location Map for the Duteau Creek Watershed (showing sub-basins).

2.0 RESULTS OF INITIAL ROUNDTABLE MEETING

2.1 Watershed Concerns

A summary of the comments and concerns presented during the initial roundtable meeting are listed below. Minutes from the meeting are provided in Appendix A.

NOWA

- Primarily concerned with forestry and range management, and their potential effects on water quality and quantity.
- Increases in turbidity and pathogenic organisms are specific concerns that may require special treatment at the intake.
- Cattle are a concern with respect to potential fecal contamination.
- Increased access for recreation and range use that may result from forest road construction is a concern in and around streams.
- The lower residual area adjacent to the canyon reaches are considered the most sensitive areas with respect to forest development.
- The hydrologic effects of the 1998 Aberdeen fire are not known at this time. Without understanding the cumulative effects of increased ECA in the Heart Creek basin, further development in the Aberdeen Residual and Duteau upstream of Grizzly sub-basin is a concern.
- Runoff rates into the upper reservoirs are a concern if accelerated by forest development. Slow, prolonged melt and runoff is desirable to minimize the volume spilled from the reservoirs and maximize the supply in the late summer and early fall low flow periods.
- The reservoirs should not be considered as "settling ponds" for fine sediment resulting from other uses in the watershed.
- Recreation use and cattle access in and around streams below Haddo Lake are concerns that require ongoing management.

Department of Fisheries and Oceans

- DFO was not represented at the meeting but has documented concerns with the mainstem channel downstream of Headgates intake. The channel below the intake has experienced a decline in available salmonid spawning habitat as a result of bedload capture. An agreement is in place with NOWA to maintain specified low flows over set periods of the year.

Ministry of Environment, Lands and Parks

- Similar concerns to those identified by DFO with the mainstem below the Headgates intake.

- Resident trout populations upstream of the intake and reservoirs in the upper watershed are also a concern with regard to channel stability, peak flows and potential increases in sedimentation from roads and cattle activity.

Ministry of Forests

- Specifically concerned with current and proposed ECA's in the watershed.

- Interested in the forest development plan review portion of the IWAP and its potential effects on current watershed conditions.

2.2 Specific Watershed Assessment Items

The points of interest (POI's) for watershed assessment will be at the Headgates intake and on the mainstem at the confluence with Flyfish Creek. Stream channel assessment information will be included for the reaches below Headgates, based on documented DFO fisheries concerns.

Sub-basins will be the same as in the 1996 IWAP and the H60 elevation will remain at 1,323 m. Hazard ratings for the watershed and sub-basins will be reported in tabular format. IWAP calculation data will be presented for all residual areas, sub-basins and the watershed. Specific areas of concern within the Duteau and Aberdeen residual areas will be discussed in the assessment text, but no hazard ratings will be reported for these areas. Residual area hazards are accounted for in the aggregated watershed hazard ratings for the associated POI.

The report should discuss: the hydrologic sensitivity of the watershed and sub-basins with respect to forest and other land-use development; the hydrologic implications of commercial thinning; and proposed aggregate cutblocks.

3.0 BACKGROUND INFORMATION

3.1 Physical Characteristics

Duteau Creek flows north from the Aberdeen Plateau into the White Valley and eventually into Bessette Creek at Lumby. The watershed area is approximately 17,000 ha with elevations ranging from 660 m at Headgates to over 1,800 m in the Grizzlys Hills. Biogeoclimatic zones include Interior Douglas Fir (IDF) at low elevations, and Interior Cedar Hemlock (ICH), Montane Spruce (MS) and Englemann Spruce and Sub-Alpine Fir (ESSF) at mid to upper elevations.

The western half of the watershed is dominated by metamorphic rocks of the Monashee or Shuswap Metamorphic Complexes[1]. These rocks are highly foliated and folded granitic gneisses, slate, schist and quartzite[2]. A pluton of granite and granodiorite of the Nelson Plutonic Rocks is present in the middle eastern section of the watershed. Both the Monashee and Nelson groups are mantled by a discontinuous sheet of basalt lava belonging to the Chilcotin Group. This volcanic sheet has been warped and forms abrupt and conspicuous rock escarpments throughout the area[3].

The watershed upstream of Headgates intake roughly consists of two parts: a canyon section and an upland section. In the upland section, surficial materials consist of moderate to well drained moraine with intervening depressional terrain that is poorly drained and dominated by organic deposits[4]. Moraine commonly consists of a veneer or blanket of sandy bouldery till. Rockfalls exist along the extensive lower escarpments composed of columnar basalt. Steep, short slopes susceptible to small slides (consisting of stratified sands and gravels) exist at the head of the canyon section. Isolated areas of glacio-fluvial outwash are present in the uplands area associated with broad glacial meltwater channels.

The canyon section is mapped as Class IV and V terrain with slopes consisting of rock outcrops, escarpments and steep gravelly colluvium in excess of 80% slope. Most of the landslide activity in the watershed is concentrated in this section, and includes large rockslides, debris torrents and debris avalanches[5]. A very narrow alluvial floodplain exists through the canyon dominated by boulder gravels.

Duteau Creek is a snow dominated hydrologic system with peak flows occurring from late April to mid-June. Hydrometric records are available for Duteau Creek near Lavington (WSC Station No. 08LC006) from 1919 to 1921, 1935 to 1951, and 1959 to 1996. Mean daily discharge is 0.67 m^3/s and maximum daily discharge was 16.2 m^3/s recorded in the spring of 1990. Unfortunately, maximum daily discharge is not available for the regionally high runoff years in 1996 and 1997. Flows with a return period of 30 and 40 years occurred in Bessette Creek downstream of Nicklen Creek immediately east of the Duteau watershed in 1996 and 1997, respectively.

The Duteau Creek system is regulated through three reservoirs in the upper watershed and the Headgates water intake, all operated by NOWA. The hydrologic effect of these reservoirs is to modify the runoff period and peak flows through storage. Depending upon the volume and timing of runoff, the reservoirs will have varying effects on downstream peak flows. For example, peaks will be reduced in low runoff years but may be unaffected in high runoff years.

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[1] Jones, A. G., 1959. Geological Survey of Canada Memoir 296 Vernon Map-Area, British Columbia. Department of Mines and Technical Surveys

[2] Roed, M.A., 1998. Detailed Terrain Stability Mapping of the Duteau and Harris Creek Watersheds.

[3] ibid.

[4] ibid.

[5] ibid.

3.2 History of Past Forest Development

Timber harvesting has occurred in the watershed over the past 60 years. From 1930 to approximately 1950, partial cutting systems were employed in the lower elevation stands. Since the 1950s, clearcutting has been the dominant silviculture treatment in the even-aged Lodgepole pine and Englemann spruce-subalpine fir stands at higher elevation. Over the last 20 years, a significant portion of the annual harvest for Riverside Forest Products Limited and Tolko Industries Ltd. has come from salvage logging of Lodgepole pine stands infested with mountain pine beetle. More recently, an outbreak of spruce bark beetle has resulted in significant salvage harvesting in Englemann Spruce stands in the upper watershed.

In 1997 and 1998, the Small Business Forest Enterprise Program completed two commercial thinning blocks in the Heart Creek sub-basin. Approximately 30% of the basal area was removed from the blocks with the intent to promote more vigorous growth in the remaining Lodgepole pine stems. Two other commercial thinning areas are proposed in the Heart and Aberdeen sub-basins.

In the summer of 1998, the Aberdeen fire burned approximately 700 ha of the area east of Aberdeen and Haddo Lakes. The fire burned a combination of standing timber and existing reforested cutblocks. The majority of the burnt standing timber was salvaged in the fall and winter of 1998 by SBFEB and Riverside Forest Products Limited.

3.3 History of Water Use

Earthfill dams were constructed in the upper watershed on Haddo and Aberdeen Lakes in the early 1900s. A diversion from the Harris Creek watershed into Heart Creek was built in the 1930s and recently refurbished in 1992. Through this diversion, Paradise and Gold Creeks are directed into Heart Creek with a total licensed capacity of 6.5 million m^3 per year of freshet runoff.

In the 1970s, an earthfill dam was constructed at Grizzly reservoir to create a third storage reservoir in the upper watershed. The reservoir was designed with additional storage that would be used to maintain summer and fall low flows for salmon spawning and egg incubation downstream of Headgates. This portion of the Grizzly reservoir project was funded by DFO. Minimum releases below Headgates were to be 0.06 m^3/s between January 1 and March 31, 0.11 m^3/s between April 1 and August 31, and 0.14 m^3/s between September 1 and December 31. DFO also has a special agreement with NOWA to provide a further release of water from Headgates upon special request, provided that the total volume released does not exceed 0.14 million m^3 per year.

The Headgates intake was originally constructed in the 1920s and rebuilt in the 1960s along with the construction of a new distribution system. The total licensed diversion through the Headgates facility exceeds 25 million m^3 per year.

4.0 PREVIOUS ASSESSMENTS/COMPLETED WORK

Funded by Forest Renewal BC, watershed assessments were completed for the watershed in March 1996 by Riverside Forest Products Limited. Components of the project included an Interior Watershed Assessment, Road Assessment, Channel Assessment, Gully Assessment and Riparian Assessment. A landslide rehabilitation assessment was also completed for the S33.1 road in the Duteau watershed of the Grizzly sub-basin in 1998.

NOWA has initiated a water quality monitoring program at three sites in the watershed. NOWA was the proponent on a recent (1998) landslide rehabilitation project on the Duteau mainstem, and has participated with MoF Range and Recreation Branches, and Riverside Forest Products Limited on several projects to control cattle and recreational access to the mainstem channel and reservoir area in 1998.

Terrain mapping, at TSIL level C, was completed for the watershed in 1998.

4.1 IWAP

The condition of the Duteau Creek watershed was rated as good in 1996 based on the results of the IWAP assessment. Moderate peak flow hazard ratings were calculated for all sub-basins and the watershed primarily as a result of the road densities above the H60 elevation. A moderate surface erosion hazard rating was calculated for the Flyfish sub-basin based on the length of road within 100 m of a stream and the number of active stream crossings. A moderate riparian hazard rating was calculated for the Aberdeen sub-basin based on the length of stream harvested to the bank. All other hazard ratings were low.

It was recommended that cumulative impacts from forest development should be maintained at a low level since Duteau Creek is a community watershed. A review and implementation of recommendations from other watershed restoration project components was suggested along with an update of the IWAP in 1997 following completion of Level C terrain mapping.

4.2 Road Condition Assessment

Approximately 300 km of road was surveyed in 1995 and 11 high risk sites were identified. Five of the 11 high priority sites were located on private land downstream of the Headgates intake.

The 11 high priority sites were recommended for prescriptions in 1996. Work on low and moderate priority sites was recommended if equipment was available during work on the higher priority areas.

Drainage improvement on the Haddo FSR east of the Duteau Creek mainstem crossing (high priority site) were undertaken by Riverside Forest Products Limited in 1998. A high priority bridge crossing was also removed from a tributary to Heart Creek in 1998.

In conjunction with NOWA, Riverside Forest Products Limited also completed road drainage improvement works on the Specs Lake Recreation Site and Grizzly reservoir access roads.

Work at Specs Lake included road relocation away from the stream channel and revegetation of a disturbed riparian area along the channel. The access road on the west side of Grizzly reservoir was deactivated to limit unauthorized vehicle access and prevent cattle from moving north along the reservoir.

4.3 Gully Assessment

Six defined gullies that were direct tributaries to the lower mainstem channel were identified and assessed using the *Gully Assessment Procedure Guidebook.* All assessed gullies were classified as low risk and no remedial works were required.

4.4 Channel Assessment

High and moderate sensitivity channel reaches were identified on aerial photography and assessed in the field. Bank erosion and sediment contribution was observed at one site downstream of the Aberdeen FSR road crossing above Grizzly reservoir. No remedial works were recommended for this or any other channel site in the watershed. An assessment of the channel on private land downstream of Headgates was recommended to identify sediment sources that may affect fish and fish habitat.

4.5 Riparian Assessment

Riparian zones along all channels in the watershed were assessed for proper riparian function. High priority sites for restoration were identified in the Heart Creek sub-basin and in a tributary channel flowing through polygon #482. Direct cattle access to tributary and mainstem channels was identified as a concern throughout the watershed upstream of the canyon. No remedial works have been undertaken on the high priority sites to date.

4.6 Water Quality Monitoring

In 1995, grab samples were gathered at seven sites in the watershed as part of the ongoing FRBC watershed project. NOWA continued the sampling program at one site in 1996 and three sites in 1997 on the Duteau Creek mainstem channel. The data is currently being catalogued and analyzed by MELP and NOWA.

4.7 Landslide Reports

In the spring of 1997, a slump occurred from road 533.1 at 2.4 km in the upper Duteau U/S of Grizzly sub-basin. Dobson Engineering Ltd. inspected the site in the fall of 1997 to determine the cause of the failure, and to recommend short and long-term remedial works.

The road was constructed in glacio-fluvial and glacio-lacustrine deposits, and the failure was caused by road drainage saturation of fine sediment overlying an impermeable clay layer. Deactivation of the road was recommended with bank protection along Duteau Creek.

In the fall of 1998, Riverside Forest Products Limited pulled back the headscarp of the failure to minimize further raveling and sediment input to the channel. A joint review of the site with Dobson Engineering Ltd., NOWA and Riverside Forest Products Limited is planned in 1999 to discuss further rehabilitation options.

Also in July of 1997, a landslide occurred on the west bank of Duteau Creek approximatley 0.5 km downstream of the Haddo FSR crossing near Edwin Lakes. The slide occurred on an undisturbed slope as a result of saturated soil conditions and possibly localized blowdown. An older slide scar was observed immediately upstream of the recent slide site. Bioengineering prescriptions were completed by Dobson Engineering Ltd. and the work was completed by Bar-Ten Springs Enterprises and NOWA in the fall of 1998.

4.8 Range and Recreation Management

In conjunction with range tenure holders and the Ministry of Forests, Recreation Section, the following fencing and site restrictions were completed by NOWA in 1998:

- Fencing and random camping site access restrictions along Duteau Creek downstream of Haddo Lake.
- Recreational vehicle access restriction to the foreshore of Grizzly Reservoir.
- Fencing and cattle guard placement in the Flyfish and Duteau Creek confluence area to prevent access to sensitive sites, and corral construction in the area to allow quick removal of stray cattle for relocation in permitted range areas (south of Haddo Lake and west of Grizzly Reservoir).

The general intent of NOWA's collaborative efforts with the MoF Range Section and grazing licensees are to restrict uncontrolled range and recreation use from the areas immediately surrounding the upper reservoirs, and riparian zones along the mainstem channel between Haddo Lake and the canyon section.

Fencing projects were completed along the Aberdeen FSR in the 1970s; between Doreen and Streak lakes in the 1980s; and along the east side of the Haddo Lake in 1991.

5.0 METHODS

The watershed assessment presented in this report is based on the 1998 interim watershed assessment procedure provided by the Kamloops Forest Region and BC Environment.

In summary, the assessment process consists of two primary components: an office assessment and a field assessment. The office assessment consists of the compilation and analysis of data to describe the basic geophysical characteristics of the watershed, along with the extent and location of past forest harvesting activities (the watershed report card).

The field assessment consists of a reconnaissance overview of the watershed to determine actual hydrologic hazards. The field assessment includes a reconnaissance level sediment source survey and channel assessment to identify sensitive and/or disturbed road segments and channel reaches. The reconnaissance level channel assessment procedure (ReCAP) is based on the *Channel Assessment Procedure Field Guidebook - December 1996.*

Accessible roads in the watershed were driven or walked where overgrown. Evidence of sediment movement on the running surface or in the ditchline was recorded and the potential delivery to streams was assessed. Stream channels were reviewed by reach at accessible sites. Evidence of flow or sediment loading related disturbance was assessed with reference to expected natural conditions. Harvested riparian areas were reviewed on aerial photographs and during the channel assessment. Riparian functions of shade, bank stability and large woody debris input were considered. Aerial photographs were used to map landslides and determine their size, age and connectivity to the channel system.

6.0 ASSESSMENT

Calculation results are presented in Table 1. A discussion of current watershed conditions based on the field assessment is provided in the following sections. Current watershed hazard ratings for each sub-basin and the watershed are listed in Table 2. Hazards for residual areas are considered in the greater sub-basin or watershed ratings and not presented in the table. A brief discussion of residual hazards has been included in the text based on a specific WAC request.

TABLE 1
Watershed Report Card 1999

Watershed Inventory Category	Duteau Residual	Flyfish Sub-basin	Aberdeen Sub-basin (POI 2)	Aberdeen Residual Area	Heart Sub-basin	Duteau U/S of Grizzly Sub-basin	Watershed (POI 1)
Area (ha)	4,355	2,129	10,480	7,129	2,087	1,264	16,962
H60 Elevation (m)	1,325	1,325	1,325	1,325	1,325	1,325	1,325
Total Area Harvested/Burnt (ha)	2,230	557	4,655	3,579	691	385	7,441
Percent Area Harvested/Burnt (%)	51	26	44	50	33	30	44
Equivalent Clearcut Area (ECA) (ha)	1,003	200	2,670	1,875	603	192	3,873
Equivalent Clearcut Area (ECA) (%)	23.0	9.4	25.5	26.3	28.9	15.2	22.8
ECA Above H60 (ha)	434	147	2,189	1,441	569	179	2,770
ECA Above H60 (%)	10.0	6.9	20.9	20.2	27.3	14.2	16.3
Road Density (km/km2)	1.9	1.3	1.6	1.7	1.1	1.4	1.6
High Sediment Source Roads (km)	0.2	0	0.1	0	0	0.1	0.3
Landslides (#)*	6	0	3	1	0	2	9
Road on Potentially Unstable Terrain (km)	6.6	0	1.2	0.2	0.0	1.0	7.7
Stream Crossings (#)	45	15	91	69	19	3	151
Stream Logged to the Bank (km)	22.8	6.5	46.7	36.2	9.3	1.2	76.0
Unstable Mainstem Channel (km) **	0.0	0.0	8.9	0.0	0.0	8.9	8.9

* Slides clearly visible on most recent aerial photography. Does not include channel bank failures. Additional slides which may be marked on terrain mapping are either historic and overgrown or classified as bank failures for the purpose of the watershed assessment.

** Only moderately disturbed mainstem channels upstream of POI have been included in the unstable mainstem channel calculations. There are no severely disturbed channels in the watershed.

6.1 Peak Flow

6.1.1 ECA

The upper watershed above Haddo Lake has gentle rolling terrain, porous sandy soils and a low drainage density[6]. Based on these topographic characteristics and the presence of the reservoirs in the system, the upper watershed (Aberdeen, Heart and Duteau U/S of Grizzly sub-basins) is considered to have a low sensitivity to changes in peak flow, volume and timing associated with forest development. Much of the runoff generated by snowmelt in this area contributes to local and regional groundwater flows rather than surface flow. This contribution to groundwater either emerges in the reservoirs downstream (local groundwater), or in the case of regional groundwater, possibly in the fan downstream of Whitevale Road. The mainstem channels in all sub-basins showed no evidence of recent peak flow related disturbance (Section 6.1.3), particularly following high 1996 and 1997 runoff years, indicating the effectiveness of the system in managing above average snowpack conditions. The current ECA in each of these basins is not a concern with respect to potential channel disturbance *[Table 1]* (Section 6.1.3).

Terrain in the Flyfish sub-basin and major tributary drainages upstream of the canyon in the residual area is also low and rolling. Beaver dams and marshland complexes that exist in the headwater regions of Flyfish and Crescent Creeks also assist in buffering peak flows. However, based on the direct connection of the lower drainage areas to the mainstem channel, the hydrologic sensitivity with respect to forest development is considered moderate for the Flyfish sub-basin and other direct tributary drainages in the residual area above the upstream of the canyon. The current ECA in the Flyfish sub-basin is low and not a concern with respect to potential channel disturbance *[Table 1]*.

The area along the canyon reaches (in the Duteau Residual area) and back from the break in slope above the canyon is considered highly sensitive to potential surface and groundwater alterations associated with forest development. As described in the terrain stability mapping reports, forest harvesting back from the break in slope can affect groundwater recharge and emergence along the steep canyon walls, which can further affect terrain stability. Very limited forest development has occurred along or above the canyon reaches, and no road or cutblock related landslides were recorded.

Partial cut harvesting by the Small Business Forest Enterprise program was completed in 1997 for several blocks in the Heart Creek basin. Approximately 30% of the basal area was removed in these areas to allow the suppressed Lodgepole pine to release. The harvesting occurred in the summer using low ground pressure equipment that required only narrow surface trails. No drainage infrastructure was required for the trails, and soil compaction and sub-surface drainage interruption has been negligible.

[6] Drainage density refers to the length of stream channel per kilometre squared.

Based on snow pack measurements made elsewhere in the Kamloops Forest Region under similar stands, the effect on snow accumulation and melt with up to 30% basal area removal is negligible. Based on the snow research, the past and proposed partial cut harvest blocks with approximately 30% basal area removal have not been included in ECA calculations. A field review of the SBFEP commercial thinning blocks supported the research findings. Thinning had removed only the lower and intermediate layers with minimum affect on canopy closure.

6.1.2 Roads

Roads upstream of the canyon section in the Duteau Residual area are located on generally benign terrain where drainage diversion and concentration concerns are minimal. No evidence of ditchline scour resulting from drainage concentration was noted.

The Aberdeen mainline has been built well back of the break in slope above the canyon reaches in the Duteau Residual area. Temporary access structures (roads) have been used where possible in steeper terrain along the canyon to minimize potential effects on natural hillslope drainage *[Photo 1]*.

6.1.3 Channels

Tributary channels upstream of the canyon show no evidence of peak flow related disturbance *[refer to Section 6.5]*. The mainstem channel through the canyon was active[7] during the 1996 and 1997 spring freshets, but disturbance has been limited to minor bank erosion. Stable old growth riparian vegetation has also limited potential disturbance. The upper watershed reservoirs, beaver dams and marshland complexes in the Flyfish sub-basin and Crescent Creek drainage appear to have effectively buffered the lower mainstem channel from the effects of these recent high flows. The rolling topography, porous soils and low drainge densitiy in the upper watershed has also reduced any potential peak flow effects on channels.

6.1.4 Peak Flow Hazard

Based on observed channel stability throughout the upper tributaries and lower mainstem channel, overall topographic conditions of the watershed upstream of the canyon, and presence of three large reservoirs in the system, the current peak flow hazard associated with past forest development is considered low for all sub-basins and the watershed *[Table 2]*. Peak flow hazards for the residual areas are considered within the greater basin or watershed hazards. It is, therefore, inferred that peak flow hazards are also low for residual areas.

[7] Active refers to the recent movement of boulder and cobble bed materials in the channel.

6.2 Surface Erosion

6.2.1 Roads

Roads on the plateau section of the watershed (Duteau Residual area above the canyon and all basins above) are located on benign terrain and surface erosion concerns are low *[Photo 2]*.

Sediment sumps are in place where feasible at road crossing locations and maintenance appears to be good. Inactive roads on the plateau are revegetated with grass and surface erosion is not a concern. Potential sediment delivery to channels in this area is very low to low, according to terrain hazard maps.

Cattle access to the channels at road crossings is causing some sedimentation *[Photos 3 and 4]*. Particular areas of concern include the Flyfish sub-basin, Aberdeen Residual area, Crescent Creek and Curtis Creek drainages.

One high and one moderate sediment source road section was identified in the watershed. The moderate sediment source location is on the Haddo FSR in the residual area immediately beyond the Duteau mainstem crossing. This road section termed "throttle hill" is a chronic source of fine sediment to the channel and has undergone recent ditchline cleaning and sediment sump construction. In spite of these works, sand and silt are still being washed into the mainstem channel, particularly during active hauling in wet weather *[Photos 5 and 6]*. Further sediment control works are required to reduce sediment input.

The high sediment source section is the failure on road 533.1 and the road running surface beyond the slide in the Duteau U/S of Grizzly sub-basin *[Photo 7]*. Secondary erosion of sand, silt and clay is occurring. A field review of this site with Riverside Forest Products Limited, NOWA and Dobson Engineering Ltd. is planned for 1999 to determine remediation alternatives.

Roads in the Duteau Residual area have been constructed well back of the canyon reaches and surface erosion concerns are low. Recent development in the Duteau Residual area upslope of the mainstem channel has utilized temporary access structures (roads) where possible that have been permanently deactivated *[Photo 1]*. These types of structures reduce both short and long-term sedimentation that can occur from forest roads and should continue where possible for blocks in this sensitive hydrologic area.

The recent (1997, 1998) partial cut harvesting in Heart Creek basin was done using low ground pressure equipment in the dry summer season. An assessment of these areas revealed that ground disturbance was negligible and there were no surface erosion concerns.

6.2.2 Hillslopes

The landslide scar below the 533.1 road is an active source of fine sediment to the channel (as outlined above). The recent (1997) landslide in the upper canyon below the Haddo FSR bridge was bioengineered in the fall of 1998 to reduce erosion and stabilize the hillslope. There were no other hillslope related sediment sources noted.

6.2.3 Surface Erosion Hazard

Based on the low sediment delivery potential from roads (as determined in the field assessment and terrain maps) and limited number of past forest development related landslides in the watershed, the surface erosion hazard is considered low for the Heart, Flyfish and Aberdeen sub-basins, and the entire watershed *[Table 2]*. The surface erosion hazard in the Duteau U/S of Grizzly sub-basin is moderate based on the recent input of sand and silt to the channel from the failure on the 533.1 road, and ongoing secondary erosion of the exposed soils. This moderate hazard can be reduced after slope and channel bank restoration has been completed. The surface erosion hazards are low in both the Aberdeen and Duteau residual areas.

6.3 Landslides

Nine landslides were mapped in the watershed *[Appendix F]*. Six slides have occurred in the canyon reach of the Duteau Residual area, five of which directly impacted the channel. One rockfall mapped in the Aberdeen sub-basin did not deposit in the channel, and two slides were mapped from the 533.1 road into upper Duteau Creek

All slides through the canyon reaches are natural and additional slides in this area can be expected given Class IV and V terrain conditions. Consideration of potential groundwater flow effects should be given to new development in and around the canyon reaches.

The most recent slide in the canyon, approximately 0.5 km downstream of the Haddo FSR bridge *[Photo 8]*, had a bioengineering prescription implemented in the fall of 1998 and will be monitored by NOWA for sediment stabilization.

The landslides from the 533.1 road occurred in an isolated glacio-fluvial sand and silt deposit along the Duteau U/S of Grizzly mainstem channel in the upper watershed *[Photos 9 and 10]*. Other similar surficial deposits have been mapped as Class IV or V terrain along the Duteau Creek downstream of Haddo Lake and Crescent Creek mainstem channels. The completion of terrain stability field assessments and surface soil erosion hazard assessments where required for proposed roads and cutblocks in these areas should identify any terrain or surface erosion concerns prior to development.

6.3.1 Landslide Hazard

Based on the low frequency of past forest development related slides, the landslide hazard is considered low for the Flyfish, Heart and Aberdeen sub-basins, residual areas and the entire watershed *[Table 2]*. The landslide hazard remains moderate in the Duteau U/S of Grizzly sub-basin based on the recent road failure and potential for similar occurrences at that location. The landslide hazard in the Duteau U/S of Grizzly sub-basin can be reduced through site rehabilitation. Landslide hazards in both residual areas are also low.

6.4 Riparian

According to forest cover mapping, 76 of 226 km of stream channel has been harvested to the banks. The majority of this riparian harvesting occurred in the Flyfish basin, Crescent Creek and Curtis Creek drainages, and Aberdeen Residual area.

Small tributary channels in the sub-basins and around the reservoirs that were harvested to the banks in the past are low gradient with stable banks. The loss of riparian cover in these areas may have affected stream temperature over the short-term, but vigorous regeneration of alder, willow and conifers is now occurring. Large woody debris is still present and functional in the assessed tributaries.

Both natural and cutblock boundary blowdown has occurred in the riparian zone between Haddo Lake and the upper canyon *[Photo 11]*. Partial salvage of accessible timber was completed in 1997 (CP 599). These reaches appear to be susceptible to blowdown and are sensitive to disturbance from increased woody debris input and possible avulsions. A Riparian Management Area (RMA) strategy should be developed for these reaches – one that reduces the risk of blowdown in the RMA and recommends possible salvage methods where blowdown occurs to be implemented on a site specific basis.

Cattle access to channels through old cutblocks in the Flyfish basin, Crescent Creek and Curtis Creek drainages, and Aberdeen Residual area is causing localized bank shearing and stream sedimentation. These areas should be brought to the attention of the MoF Range Section for assessment through the range use plan process.

6.4.1 Riparian Hazard

Based on the extent of riparian regeneration along previous harvested streambanks, the riparian hazard with respect to past forest development is considered low for all sub-basins and the watershed *[Table 2]*. Direct cattle access to tributary channels in the Flyfish and Crescent Creek basins, and Aberdeen Residual area remains a channel sedimentation concern. Blowdown along the mainstem channel below Haddo Lake is also a concern that requires management attention. Riparian hazards in both residual areas are also low.

TABLE 2
Watershed Hazards 1999

	HAZARD CATEGORY			
Drainage Area	**Peak Flows**	**Surface Erosion**	**Landslides**	**Riparian**
Flyfish Basin	Low	Low	Low	Low
Aberdeen Basin	Low	Low	Low	Low
Heart Basin	Low	Low	Low	Low
Duteau U/S of Grizzly Basin	Low	Moderate	Moderate	Low
Watershed	**Low**	**Low**	**Low**	**Low**

6.5 Channel Assessment

The mainstem channel was divided into 12 reaches based on distinct changes in channel morphology, channel gradient, or major tributary or sediment input *[Appendix D]*. At least two channel assessment sites were surveyed on each of the sub-basin tributary channels including Curtis Creek in the Heart basin and Crescent Creek in the residual area. Overview channel assessment information was also gathered for the reaches below the water intake (POI 1).

No channels in the watershed are highly disturbed. The upper Duteau Creek mainstem is moderately aggraded as a result of the 1997 and previous slides, and the lower Duteau mainstem below the intake is degraded as a result of bedload capture in the Headgates intake *[Appendix E]*. Channel descriptions are presented in descending order from the upper basins to the mouth and photographs can be found in Appendix C.

6.5.1 Duteau U/S of Grizzly Basin

Three mainstem channel reaches (J, K and L) were delineated in the Upper Duteau basin.

Reach L is a stable cascade-pool channel with large woody debris control *[Photo 12]*. The break between reaches K and L is at the landslide input location from the 533.1 road. Below this point, reach K, is moderately aggraded with sand and gravel from the most recent (1997) and previous slides (1980s) *[Photo 13]*.

The lower reach (J) is a moderately aggraded riffle-pool channel with large woody debris control *[Photo 14]*. This reach is acting as a deposition zone for gravel from upstream slide input. Sand-size sediment is actively being transported through this reach and may eventually reach the Grizzly reservoir.

Channel restoration activity on the two lower reaches is not feasible to reduce sediment transport. Stabilization of upstream sediment sources (slides at the 533.1 road) is the most effective long-term remediation alternative.

6.5.2 Heart Creek Basin

No reaches were delineated on Heart Creek. The mainstem channel has a low gradient stable riffle-pool morphology with large woody debris control *[Photo 15]*. Localized natural blowdown in the riparian zone is providing some sand and gravel input. No channel concerns were noted.

The Aberdeen fire in 1998 may have affected stream channel stability in the Heart Creek basin which could lead to increased sedimentation in the channel and downstream reservoirs. A joint MELP and NOWA review of stream channel conditions at the request of the SBFEP in Heart Creek is planned for 1999 to determine if any channel or riparian restoration activities are required.

6.5.3 Aberdeen Residual Area

Channels eligible for assessment (according to the CAP procedure) in the Aberdeen Residual area include the Curtis Creek tributary and the outlet from Haddo Lake to the Flyfish Creek confluence. Diversion ditches that connect the Grizzly reservoir (reach I), Aberdeen Lake and Haddo Lake are not applicable to channel assessment procedures.

Curtis Creek was assessed at the Curtis Mainline Road crossing. The channel has a stable riffle-pool morphology. Harvesting to the banks occurred in the 1980s but regeneration of alder, willow and some conifers has since colonized the riparian zone *[Photo 16]*. Cattle grazing on old adjacent blocks is allowing some direct access to the channel. Minor bank shearing and fine sediment input from range use is occurring.

The outlet of Haddo Lake (reach H) is identical to reach G which is discussed in Section 6.5.5.

6.5.4 Flyfish Basin

Flyfish Creek has numerous marshland complexes, beaver ponds and small lakes in the upper basin. The lower channel has a stable cascade-pool morphology with woody debris control *[Photo 17]*. At the confluence with the Duteau Creek mainstem, Flyfish Creek is a low gradient riffle-pool channel with no evidence of sedimentation or peak flow related concerns *[Photo 18]*.

6.5.5 Duteau Residual Area

Downstream of Haddo Lake the mainstem channel was divided into five reaches to Headgates (POI 1). Reaches H and G, immediately downstream of Haddo Lake, are low gradient riffle-pool channels. Large woody debris is abundant in these channels as a result of localized natural and cutblock boundary related blowdown in the riparian zone *[Photos 19 and 20]*. The channel bed and banks are stable through reaches H and G, and no cattle access to the channel was noted during the assessment. Lower reach G flows through Class V terrain where one old (pre-1972) bank failure was mapped. The channel banks and adjacent hillslopes in lower reach G are a natural source of sand and gravel to the channel. NOWA and Riverside Forest Products have noted cattle in the riparian areas along Reaches H and G. This area is sensitive to cattle disturbance and efforts to prevent access should continue.

Reach F is also a low gradient riffle-pool channel extending to the head of the canyon. Large woody debris is abundant from localized blowdown, particularly along old block boundaries *[Photos 11 and 21]*. The majority of blowdown was observed to be spanning the channel at the assessment location and partial salvage had already been undertaken in the adjacent block (CP 599).

Cresent Creek is a small tributary that joins reach F approximately 1.5 km downstream of the Doreen Creek confluence. NOWA has expressed concern with the channels in Crescent Creek based on observed sand and gravel bars, and direct cattle access in the upper drainage. Aggraded channel conditions were observed in the lower channel *[Photo 22]* and range use in the riparian zone was noted above and below the Aberdeen FSR crossing. In the upper drainge, a large sediment wedge was observed in the main channel from a beaver dam release in the early 1990s *[Photo 23]*. NOWA documented increased turbidity at the Headgates intake following the event[8]. This event is the source of gravel bar deposits in the lower drainage.

The upper Duteau canyon reach (E) is a stable cascade-pool channel with increased sand and gravel bedload from the recent (1997) slide approximately 0.5 km downstream of the Haddo FSR crossing *[Photos 8 and 24]*. The slide had a bioengineering prescription implemented in the fall of 1998 and no further hillslope or channel restoration is required.

Upstream of Headgates (reach D) the channel has a stable cascade-pool morphology with some temporary sand and gravel deposition from upstream slides *[Photos 25 and 26]*. The riparian vegetation is in tact along the entire canyon reach and the channel banks are stable. Woody debris accumulations are present along the channel margins throughout the canyon upstream of Headgates.

[8] Clark, R., 1998. Personal Communication, NOWA.

The intake pond was drained and dredged in the summer of 1997 as a result of increased sedimentation from upstream sources. This elevated sedimentation trend will continue over the next two to five years barring additional landslides into the canyon reaches.

An old trail paralleling the mainstem channel with a cattle bridge approximately 2,000 m upstream of the Headgates intake was noted. Minor channel bank erosion and road fill failure was observed on the road *[Photo 27],* and the bridge is rotting and will soon collapse into the channel *[Photo 28].* According to the range permit holder for the area, the bridge and access trail is no longer required. The bridge should be removed as soon as possible and eroding fill locations along the trail should be pulled back and either bioengineered or armoured.

6.5.6 Mainstem Channel Downstream of Headgates

Downstream of Headgates (reaches B and C), the channel has a moderately degraded cascade-pool morphology as a result of bedload capture in the intake pond *[Photo 29].* No bank disturbance or recent bedload movement was observed from the 1996 and 1997 spring freshet flows.

On the fan (reach A), the channel is also moderately degraded downstream of the Whitevale road crossing *[Photos 30 and 31].* All of reach A is a riffle-pool channel flowing through alluvial deposits which are easily eroded if bedload supply or flow regimes are altered. The channel on the fan is valuable salmonid and resident trout spawning and rearing habitat and should be considered for enhancement. The re-introduction of spawning sized substrate below Headgates may be a possible mitigation alternative.

The lower fan channel closer to Highway 6 was not reviewed in the field. According to forest cover maps and aerial photographs, sections of the channel have been cleared to the banks for agricultural purposes.

6.6 Watershed Restoration Opportunities

- Surface erosion controls on "throttle hill" immediately beyond the Duteau mainstem crossing on the Haddo FSR.
- Removal of old cattle bridge from reach D upsteam of Headgates.
- Improvement or deactivation of the access road through the canyon above Headgates.
- Joint review of the 533.1 road failures with Dobson Engineering Ltd., Riverside Forest Products Limited and NOWA to determine remediation alternatives.

- Continued range and recreation management with the intent to control sedimentation in the reservoirs, tributaries and mainstem channels through controlled watering access or the provision of off-channel watering sites.

- Salmon and trout spawning and rearing habitat enhancement of lower Duteau Creek through aggregate input to the mainstem channel below Headgates.

7.0 PROPOSED FOREST DEVELOPMENT

Development is proposed by Riverside Forest Products Limited, Tolko Industries Ltd. and the Small Business Forest Enterprise Program for the period 1999 to 2005. All proposed blocks with harvest dates between 1999 and 2005 are either approved or proposed category "A" blocks *[Appendix B]*. Cutblocks with harvest dates of 2006 are being proposed by Riverside Forest Products Limited as category "I" or information blocks.

A total of 16 clearcut blocks are proposed by Riverside Forest Products Limited and Tolko Industries Ltd. as category "A" over the period 1999 to 2005. An additional 13 commercial thinning blocks are proposed by Riverside Forest Products Limited over the same period. One commercial thinning block is proposed by SBFEP in 1999. Approximately 30% basal area removal is planned for the commercial thinning blocks, which will have a negligible effect on canopy closure and snow accumulation (as demonstrated in the 1997 SBFEP commercial thinning blocks in the Heart Creek sub-basin). For this reason, commercial thinning block areas have not been included in ECA calculations. Two group selection blocks and one shelterwood block is proposed by Riverside Forest Products Limited in the lower residual area. Approximately 50% basal area removal is planned for these blocks which were assigned a 50% ECA for calculation purposes.

Beyond 2005, Riverside Forest Products Limited has four clearcuts and three commercial thinning blocks proposed as category "I."

Approximately 9.1 km of road is required to access all blocks from 1999 to 2006 with one new stream crossing. Hydrologic concerns specific to proposed forest development are discussed below.

7.1 Peak Flow

7.1.1 ECA

Over the development plan period (1999 to 2005), hydrologic recovery on old cutblocks and burns will exceed the rate of proposed development. The current watershed ECA of 22.8% (1999) will decrease to 20.8% (2005) with proposed development *[Table 3]*. With the inclusion of category "I" blocks scheduled for 2006, the watershed ECA will increase to 21.5%. Above the H60 elevation, the current watershed ECA will also be reduced from 16.3% (1999) to 14.9% (2005) despite proposed development. Category "I" blocks above the H60 elevation would increase the ECA to 15.5% (2006).

The current and proposed level of development is not expected to affect peak or low flows in the Duteau Creek mainstem channel.

The current and proposed level of development is not expected to affect peak or low flows in the Duteau Creek mainstem channel.

Proposed development will increase the ECA both above the H60 elevation and overall in the Duteau U/S of Grizzly sub-basin. In spite of the ECA increase, 2005 and 2006 levels are still considered low for the sub-basin and changes in peak or low flows are not anticipated.

Other minor ECA changes in the sub-basins and residual areas are not expected to affect discharge levels.

Proposed aggregate cutblocks in the Aberdeen sub-basin will not have an increased hydrologic effect over smaller cutblocks between 10 and 20 ha in size. Snow accumulation, melt rates and overall water yield should be generally consistent between small blocks and larger aggregate blocks.

TABLE 3
ECA Trends

Drainage	1999		2005		2006	
	ECA >H60	ECA Total	ECA >H60	ECA Total	ECA >H60	ECA Total
Flyfish	6.9	9.4	5.5	7.0	5.7	7.5
Aberdeen (POI 2)	20.9	25.5	19.1	23.4	19.9	24.0
Aberdeen Residual*	20.2	26.3	17.7	23.4	18.5	23.8
Duteau U/S of Grizzly	14.2	15.2	15.7	17.0	16.6	17.9
Heart	27.3	28.9	26.1	27.4	26.9	28.3
Duteau Residual*	10.0	23.0	9.2	21.4	9.8	22.2
Watershed (POI 1)	16.3	22.8	14.9	20.8	15.5	21.5

* **Note:** ECA values for residual areas are not normally included in this table, but due to expressed concerns by members of the watershed assessment committee, they are provided here for discussion purposes only.

7.1.2 Roads

Road construction to access proposed blocks in or above the canyon reaches in the residual area is a potential concern with respect to sub-surface and surface runoff flow alterations. The use of temporary access structures where possible or deactivation of conventional roads immediately following harvest will reduce this concern.

Proposed road construction in the Aberdeen and Flyfish sub-basins is located on benign terrain where the risk of drainage alteration and/or concentration is low.

There are no other road related drainage or peak flow concerns.

7.2 Surface Erosion

Increased cattle and recreation access in and around streams and reservoirs is a potential surface erosion and water quality concern with proposed development. Road layout and deactivation plans that address future access can reduce this concern.

Limited new road construction is required to access proposed development. One short section of road in the canyon section is proposed on soils with a high or very high erosion potential according to terrain maps. Completion of surface soil erosion assessments where required will address this concern. All other proposed road is located on soils with low or moderate erosion potential.

Aggregate blocks in the Aberdeen sub-basin have been proposed according to the Total Chance Plan (TCP). The intent of these larger blocks is to utilize temporary access structures where possible and minimize the length of active road that must be maintained to access operable timber in the watershed. This strategy maximizes the amount of available timber from a single access road, allowing the road to be deactivated sooner rather than maintained to access other small blocks along the road. The overall effect is to reduce the length of active, maintained road in the watershed which subsequently reduces the surface erosion potential over the long-term.

7.3 Landslides

Development proposed within the canyon section or back of the break in slope can affect sub-surface and surface drainage both within the block and downslope. Two partial cutblocks proposed in the upper canyon section are located on the canyon wall within Class IV or V terrain. Terrain stability field assessments (TSFA) that address both within block and downslope areas should be completed to determine suitability for development, and recommend road construction and harvest methods to reduce the risk of failures. In the lower canyon section, a partial cutblock is proposed above Class IV and V terrain. While a TSFA is not formerly required on this block, there are potential downslope stability concerns.

There are no other landslide concerns with proposed development.

7.4 Riparian

Increased access for range and recreation use in riparian areas is a potential concern with proposed development. As mentioned in Section 7.2, road layout and deactivation plans that address future range and recreation access should address this concern.

No blocks are currently proposed along the Duteau Creek mainstem between Haddo Lake and the canyon. Blowdown has occurred along this reach in the past and further salvage activity may be required. A Riparian Management Area (RMA) strategy should be developed for these reaches – one that reduces the risk of blowdown in the RMA and recommends possible salvage methods where blowdown occurs to be implemented on a site specific basis.

There are no other riparian concerns with proposed development.

8.0 SUMMARY

8.1 Watershed Assessment Results

- The surface erosion and landslide hazards are moderate for the Duteau U/S of Grizzly sub-basin based on the 1997 slide event from the 533.1 road and active secondary erosion of the slide scar. All other watershed and sub-basins hazards are low.

- Road related surface erosion concerns were noted on Haddo FSR at "throttle hill" and the failure site on the 533.1 road. A field review of the 533.1 road site is planned for 1999.

- No channels in the watershed were determined to be highly disturbed. The Duteau U/S of Grizzly mainstem was moderately aggraded as a result of the 1997 and previous slides, and the lower Duteau mainstem below the intake is degraded as a result of bedload capture in the Headgates intake.

- Channel effects on Heart Creek from the Aberdeen fire are not known at this time. A joint MELP/NOWA field review of the area is planned for 1999 to determine if channel bank or riparian restoration is warranted.

- Tributary channels upstream of the canyon show no evidence of peak flow related disturbance. The mainstem channel through the canyon was active during the 1996 and 1997 spring freshets, but disturbance has been limited to minor bank erosion. The three reservoirs in the upper watershed, and beaver dams and marshland complexes in the Flyfish sub-basin and Crescent Creek drainage have effectively buffered the lower mainstem channel from the full effects of these recent high flows.

- An old cattle bridge and eroding access trail upstream of Headgates was noted in the field assessment. The bridge is rotting and will eventually collapse into the channel. Bridge removal and trail upgrading or deactivation would address these concerns.

- Based on topographic and soils characteristics, and the presence of the reservoirs in the system, the upper watershed (Aberdeen, Heart and Duteau U/S of Grizzly sub-basins) is considered to have a low sensitivity to changes in peak flow associated with forest development.

- Based on the direct connection of the lower drainage areas to the mainstem channel, the hydrologic sensitivity with respect to forest development is considered moderate for the Flyfish sub-basin and tributary areas in the residual area above the upstream of the canyon.

- The area along the canyon reaches and back of the break in slope above the canyon is considered highly sensitive to potential surface and groundwater alterations associated with forest development. The majority of mapped natural ~~landscape~~ LANDSLIDE activity has occurred in this area.

- Range use in and around streams in the Crescent, Curtis and Flyfish drainages and Aberdeen Residual area is a concern with respect to bank shearing and sedimentation.

8.2 Proposed Forest Development

- Development is proposed by Riverside Forest Products Limited, Tolko Industries Ltd. and the Small Business Forest Enterprise Program for the period 1999 to 2005. Cutblocks with harvest dates of 2006 are being proposed by Riverside Forest Products Limited as category "I" or information blocks.

- A total of 16 clearcuts and 17 partial cutblocks are proposed over the period 1999 to 2005. An additional four clearcuts and three partial cutblocks are planned as category "I" blocks in 2006. Riverside Forest Products Limited has proposed aggregate cutblocks in the Aberdeen sub-basin.

- Over the development plan period (1999 to 2005), hydrologic recovery on old cutblocks and burns will exceed the rate of proposed development. The current watershed ECA of 22.8% (1999) will decrease to 20.8% (2005) with proposed development. Changes in peak or low flows are not expected in the Duteau Creek mainstem channel.

- Proposed development will increase the ECA both above the H60 elevation and overall in the Duteau U/S of Grizzly sub-basin. In spite of the ECA increase, 2005 and 2006 levels are still considered low for the sub-basin and changes in peak or low flows are not anticipated.

- Other minor ECA changes in the sub-basins with proposed development are not expected to affect discharge levels.

- There are potential hillslope stability concerns with three blocks proposed along the canyon section of the residual area. Two blocks fall within and the third blocks drains onto areas mapped as Class IV and V terrain. Terrain stability field assessments that review surface and sub-surface hydrology both within and downslope of the blocks should address this concern.

- Proposed aggregate cutblocks will not have an increased hydrologic effect over smaller cutblocks between 10 and 20 ha in size. Snow accumulation, melt rates and overall water yield should be generally consistent between small blocks and larger aggregate blocks.

- The goal of larger aggregate blocks is to minimize the amout of active road required to access available timber in the watershed. This strategy maximizes the amount of available timber from a single access road, allowing the road to be deactivated sooner rather than maintained to access other small blocks along the road. The overall effect is to reduce the length of active, maintained road in the watershed which subsequently reduces the surface erosion potential over the long-term.

- Increased access for range and recreation use in riparian areas in and around streams and reservoirs is a potential concern with proposed development. Road layout and deactivation plans that address future range and recreation access should address this concern.

- Blowdown has occurred both naturally and along cutblock boundaries along Duteau Creek between Haddo Lake and the canyon. A blowdown salvage plan that permits the removal of woody debris from stream channels, based on an assessment of natural woody debris supply levels, may expedite the process and reduce potential channel disturbance. No blocks are currently proposed along these reaches.

9.0 RECOMMENDATIONS

9.1 Forest Development Plan Recommendations

- Complete terrain stability field assessments on the three partial cutblocks in the canyon section that address the potential hydrologic effects of harvesting both within cutblocks and on downslope areas.

- Design road construction and deactivation plans for proposed blocks in and around streams and reservoirs that limit future range and recreation access to the channels or lakes.

- Utilize temporary access structures where possible to harvest cutblocks along the canyon reaches. If a permanent road is required, deactivate as soon as possible following harvest.

- Review the landslide site on road 533.1 in upper Duteau Creek prior to any upstream harvesting to determine further mitigation alternatives.

- Improve sediment controls on "throttle hill" immediately beyond the Duteau Creek mainstem crossing on the Haddo FSR.

- Develop a Riparian Management Area (RMA) strategy for mainstem channels between Haddo Lake and the canyon – one that reduces the risk of blowdown in the RMA and recommends possible salvage methods where blowdown occurs to be implemented on a site specific basis.

9.2 Other Recommendations

- Remove the cattle bridge from lower reach D and upgrade or deactivate the trail adjacent to the channel to reduce erosion and sedimentation.

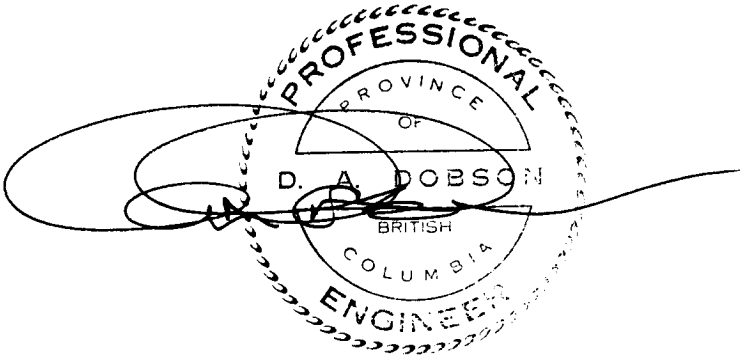
- Continue proactive cattle management in conjunction with range permit holders and the MoF Range and Recreation Branches, particularly between Haddo Lake and the canyon and area around the upper reservoirs.

- Consider spawning substrate input to the Duteau Creek mainstem channel downstream of the Headgates intake.

- Complete the planned MELP/NOWA and SBFEP review of stream channels potentially affected by the Aberdeen fire, and rehabilitate disturbed stream channels and riparian areas where required.

- Assess observed bank shearing and channel sedimentation concerns in the Crescent, Flyfish and Curtis drainages and Aberdeen Residual area through the range use plan process.

MM/dd/jb



APPENDICES

APPENDIX A

Watershed Assessment Committee Members and Meeting Minutes

Watershed Assessment Committee Members

Department of Fisheries and Oceans	Bob Harding P.O. Box 1160 1751 – 10th Avenue Salmon Arm, BC V1E 4P3 Phone: (250) 832-8037
Ministry of Environment, Lands and Parks	Susan Latimer BC Environment, Lands and Parks 2501 – 14th Avenue Vernon, BC V1T 8Z1 Phone: (250) 558-1719
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Ministry of Forests	Rita Winkler Kamloops Forest Region 515 Columbia Street Kamloops, BC V2C 2T7 Phone: (250) 828-4131
	Eric Goodman Vernon Forest District 2501 – 14th Avenue Vernon, BC V1T 8Z1 Phone: (250) 558-1700
North Okanagan Water Authority	Renee Clark 9848 Aberdeen Road Vernon, BC V1B 2K9 Phone: (250) 545-5368
Riverside Forest Products Limited	Harold Waters and Peter Love Lumby Division RR#2, Lumby, BC V0E 2G0 Phone: (250) 547-2111
Tolko Industries Ltd.	John Jobst Lavington Division P.O. Box 1540 Vernon, BC V1T 6C2 Phone: (250) 545-4992

Duteau Creek Watershed Assessment Committee Meeting
Initial Round Table

Date: March 12, 1999

Place: Vernon Forest District

Attendees: Eric Goodman - Ministry of Forests
Susan Latimer - Ministry of Environment, Lands and Parks
Renee Clark - North Okanagan Water Authority
Harold Waters - Riverside Forest Products Limited
Peter Love - Riverside Forest Products Limited
John Jobst - Tolko Industries Ltd.
Michael Milne - Dobson Engineering Ltd.

Absent: Rita Winkler - Ministry of Forests
Dave Gooding - Ministry of Environment, Lands and Parks
Bob Harding - Department of Fisheries and Oceans

Introduction of Attendees

Those present at the meeting agreed that the absent members would be kept apprised through the distribution of the initial meeting minutes and completed IWAP report. Known issues and concerns of those absent were to be discussed by the group where known.

Discussion of IWAP and WAC

The new IWAP procedure was discussed with reference to the older 1996 version. Changes in the new procedure include an amalgamation of IWAP levels 1, 2, and 3 into one field and office based process, and elimination of the old spreadsheet calculated hazard ratings. The current watershed condition and hazards are determined in the field by the hydrologist, and a forward-looking five-year development plan review is conducted.

The watershed assessment committee (WAC) is formed at the outset of the process and sets the terms of reference for the contract. Members of the WAC are required to attend both the initial and final round table meetings, unless alternate arrangements have been made (such as in Duteau Creek). If a WAC member cannot attend the final meeting then either; their concerns or comments should be forwarded to the co-chairs (Latimer/Goodman) prior to the meeting, an alternate representative should be sent, or the WAC member should opt out of the process.

Previous Work and Concerns

Results of the road condition report, channel, gully and riparian assessments, and landslide rehabilitation reports were discussed. Range management actions conducted in 1998 by NOWA, MoF and Riverside were also discussed.

Specific watershed concerns were presented:

NOWA - Primarily concerned with forestry and range management and their potential effects on water quality and quantity.
Turbidity and pathogenic pollutants are specific concerns that may require special treatment at the intake.
Cattle are a concern with respect to potential pathogenic contamination.
Increased access for recreation and range use that may result from forest road construction harvesting is a concern in and around streams.
The lower residual area adjacent to the canyon reaches are considered the most sensitve areas with respect to forest development.
The hydrologic effects of the recent Aberdeen fire are not known at this point. Without understanding the cumulative effects of increased ECA in the Heart Creek basin, further development in the Aberdeen residual and Duteau U/S of Grizzly basin is questionable.
Runoff rates into the upper reservoirs are a concern if accelerated by forest development. Slow, prolonged melt and runoff is desirable which minimizes the volume spilled from the reservoirs and maximizes the supply in the late summer and early fall low flow periods.
The upper reservoirs should not be considered at catchment basins for fine sediment generated by forestry and range.
Recreation and cattle access in and around streams below Haddo Lake are concerns that require ongoing management.

DFO - Were not represented at the meeting, but have documented concerns with the mainstem channel downstream of Headgates reservoir. The channel below the reservoir has experienced a decline in available salmonid spawning habitat as a result of bedload capture. An agreement is in place with NOWA to maintain specified low flows over set periods of the year.

MELP - Similar concerns as DFO with mainstem below Headgates reservoir.
Resident trout populations upstream of the intake and reservoirs in the upper watershed are also a concern with respect to potential sedimentation from roads and cattle access to channels.

MoF - Specifically concerned with current and proposed ECA's in the watershed. Interested in the development plan review portion of the IWAP and its potential effects on current watershed conditions. Proposed aggregate cutblocks are a potential concern that should be explained in the report.

POI and Boundaries

The watershed boundaries from the 1996 IWAP will be used, but the POI will now be at the Headgates reservoir. This will exclude the private land downstream of the intake and the watershed boundaries will be amended to reflect this. Due to documented DFO and MELP concerns on the channel below the POI, channel assessment information for those reaches and a discussion of the current concern and potential restoration alternatives will be included in the report.

Current Watershed Condition

Overall, the watershed was described by the hydrologist as being in good condition with very limited detrimental effects from past forest development. Stream channels in the watershed are stable and the effects of high freshet flows in 1996 and 1997 were not seen. A buffering of peak flow effects was attributed to a combination of reservoirs and benign terrain in the upper watershed. The watershed upstream of the reservoirs was considered to have a low sensitivity to harvesting and increased water yield. Downstream of Haddo Lake, direct tributary drainages are considered more sensitive to potential changes in flows and sediment budgets.

Two road sections were identified as problem sediment source locations and possible remediation alternatives were discussed. Cattle grazing was identified as a cumulative sediment source concern, particularly downstream of the Haddo reservoir. Collaborative efforts on the parts of NOWA, MoF, Riverside Forest Products Limited and range tenure holders has helped to restrict cattle access to sensitive watershed areas. Efforts will be continued where possible.

Recently completed commercial thinning blocks in Heart and Aberdeen sub-basins were observed in the field and determined to have a negligible effect on canopy closure and ground disturbance.

Harold Waters detailed several forest development plan scenarios for the watershed, describing the area paralleling the canyon reaches as the most sensitive with respect to terrain stability and forest development. For the final report, a development plan scenario which accounts for watershed sensitivity will be presented. Currently, Riverside Forest Products Limited is seeking an increase in maximum cutblock size above the reservoirs which will parallel natural disturbance patterns, and help to reduce required access roads.

Tolko Industries Ltd. has development proposed along the south and west boundaries of the Flyfish sub-basin.

Post Fire Status

The field assessment was conducted in the summer of 1998 and the hydrologic effects of the Aberdeen fire are not known at this time. MELP has planned a field review of affected stream channels in 1999 to determine if rehabilitation measures are required and/or possible.

Terms of Reference

The final IWAP report will discuss:

- Hydrologic sensitivity with respect to forest and other land-use development by sub-basin, residual and total watershed.
- Proposed aggregate cutblocks in the watershed and their overall effects on hydrology and road densities.
- Commercial thinning and its hydrologic implications.
- Cattle management in and around streams with a focus on reducing sedimentation.
- Natural blowdown conditions and salvage opportunities to minimize potential channel disturbance.
- COMPLAN development plan scenarios with respect to differing hydrologic implications.
- Current condition and rehabilitation alternatives for the mainstem channel downstream of the POI (Headgates reservoir).

Final Meeting

The final report will be circulated to all WAC members on the 22nd of March. A final meeting is scheduled for 9:00 A.M. on March 29, 1999 at the Vernon Forest District boardroom.

APPENDIX B

Map

APPENDIX C

Field Photographs

PHOTO 1. Temporary access structure (road) from Aberdeen FSR to recent cutblock upslope of canyon section.

PHOTO 2. New road on the plateau section of the watershed. Coarse surfaced and well drained.

PHOTO 3. Direct cattle access and sedimentation in Duteau Creek at Philpot Road crossing upstream of Grizzly swamp.

PHOTO 4. Cattle access to lower Curtis Creek at Curtis Mainline crossing.

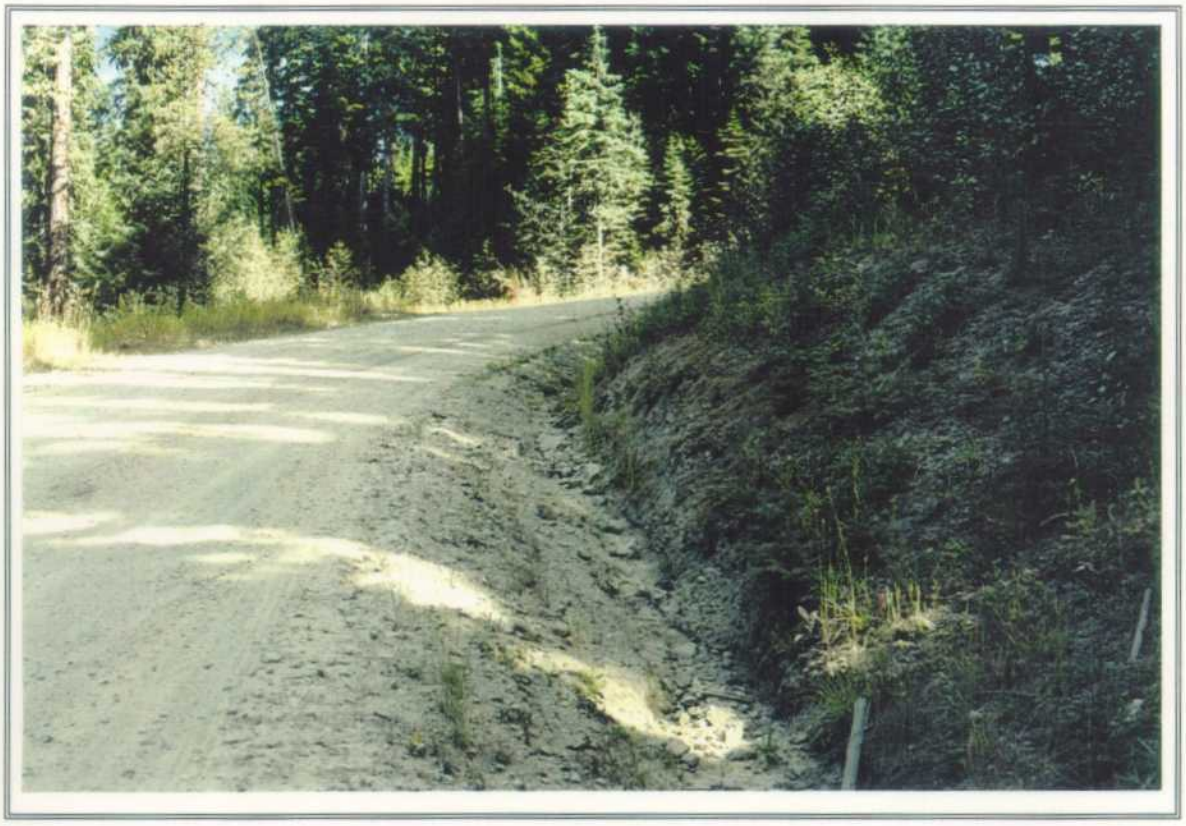


PHOTO 5. Evidence of ditchline scour beyond Duteau Creek crossing on Haddo FSR. Climbing section of road locally known as "throttle hill".

PHOTO 6. Recent (1998) ditchline cleaning and sump construction downslope of "throttle hill". Fine sediment (sand and silt) still reaching Duteau Creek.

PHOTO 7. Failure from the 533.1 road in the upper Duteau Creek sub-basin.

PHOTO 8. 1997 slide into Duteau Creek from canyon wall approximately 0.5 km downstream of the Haddo FSR road crossing. This site was bioengineered in the fall of 1998.

PHOTO 9. Failure from the 533.1 road showing cross-bedding in isolated glacio-fluvial gravel, sand and silt deposits in the upper watershed.

PHOTO 10. Older failure immediately upstream of the 533.1 road slide. This event is assumed to be between 10 and 15 years old.

PHOTO 11. Blowdown along the Duteau Creek mainstem adjacent to opening CP 599. This woody debris will eventually rot and may lead to dams in the channel with avulsions and downstream sedimentation at the water intake.

PHOTO 12. Reach L upstream of the 533.1 road failure. Stable cascade-pool morphology with large woody debris control.

PHOTO 13. Reach K downstream of the 533.1 road failure. Channel is aggraded from sand and gravel input.

PHOTO 14. Reach J upstream of Grizzly swamp showing sand and small gravel bars transported downstream from slides on the 533.1 road. The sand and small gravel aggragate is mobile in the system.

PHOTO 15. Heart Creek upstream of the Curtis mainline crossing. Stable cascade-pool and riffle-pool morphologies throughout with minor sand input from localized natural blowdown in the riparian zone.

PHOTO 16. Alder and willow regeneration on the banks of Curtis Creek. The channel was logged to the banks in the mid-1980s. Direct cattle access to the channel was observed upstream and downstream of this location.

PHOTO 17. Lower Flyfish Creek with a stable cascade-pool morphology and regenerated alder, willow and conifer riparian zone.

PHOTO 18. Flyfish Creek at the confluence with Duteau Creek. No evidence of peak flow related disturbance or increased sediment load.

PHOTO 19. Duteau Creek downstream of Haddo Lake (reach H). Stable riffle-pool morphology with large woody debris control.

PHOTO 20. Duteau Creek downstream of the Flyfish Creek confluence (reach G). Large woody debris is abundant in the channel from natural blowdown in the riparian zone. The channel bed and banks are stable at this location.

PHOTO 21. Stable riffle-pool channel (reach F) with abundant large woody debris from blowdown in adjacent opening CP 599.

PHOTO 22. Crescent Creek upstream of the Aberdeen FSR road crossing. Sand and gravel bar deposits are present from early 1990s beaver dam release in the headwaters, and minor sediment input from direct cattle access to the channel.

PHOTO 23. **PHOTO 23.** Upper Crescent Creek showing large mid-channel gravel and sand wedge formed during flood following beaver dam release.

PHOTO 24. Woody debris introduced to reach D from the slide approximately 0.5 km downstream of the Haddo FSR crossing.

PHOTO 25. Duteau mainstem upstream of the Headgates reservoir (reach D). The channel bed and banks are stable through this reach and disturbance from high 1996 and 1997 flow events is not evident.

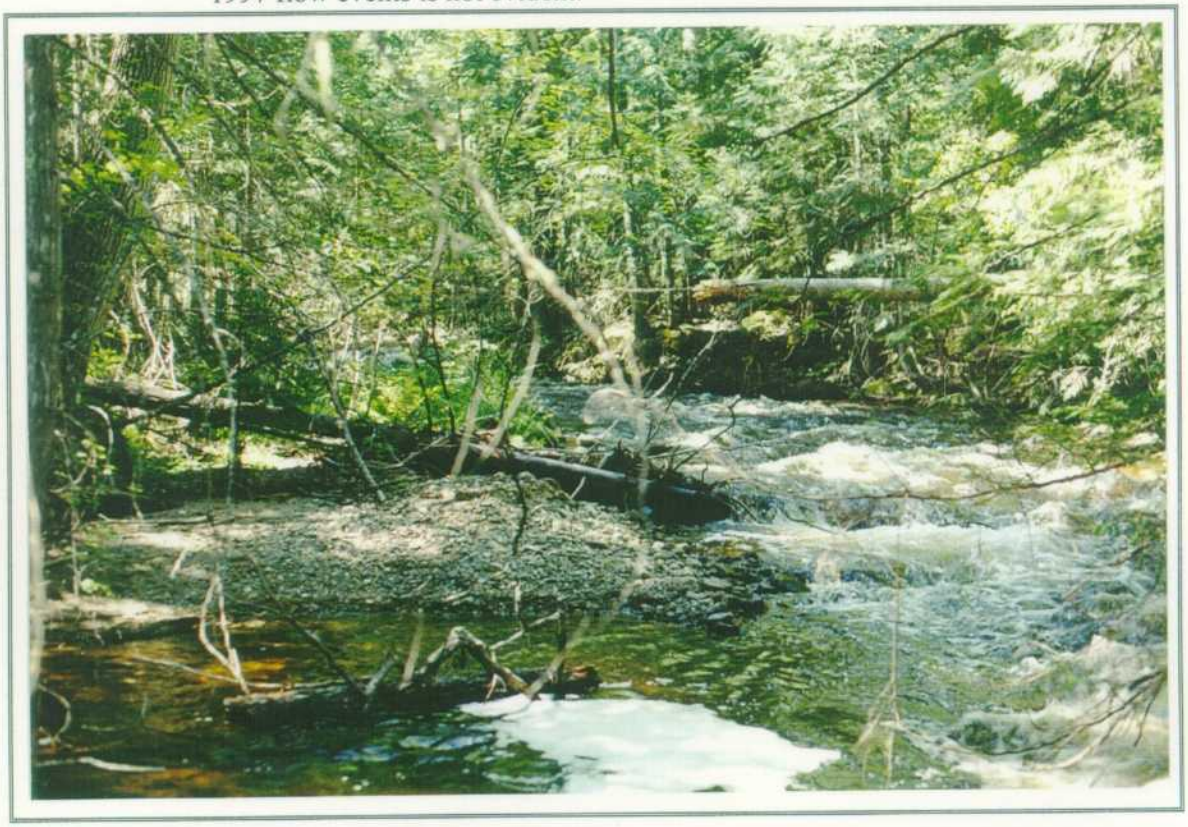


PHOTO 26. Sand and gravel bar accumulations from upstream slide input in reach D upstream of the Headgates reservoir. Elevated sedimentation levels in the reservoir can anticipated until stored bar deposits are transported through the system.

PHOTO 27. Minor channel bank erosion and road fill input to the channel on old trail upstream of Headgates reservoir.

PHOTO 28. Old cattle bridge over mainstem channel (reach D) above Headgates reservoir.

PHOTO 29. Duteau Creek mainstem channel downstream of Headgates reservoir (reaches B and C). The channel is armoured (degraded) and lacks sand and gravel bedload which is being captured in the reservoir upstream.

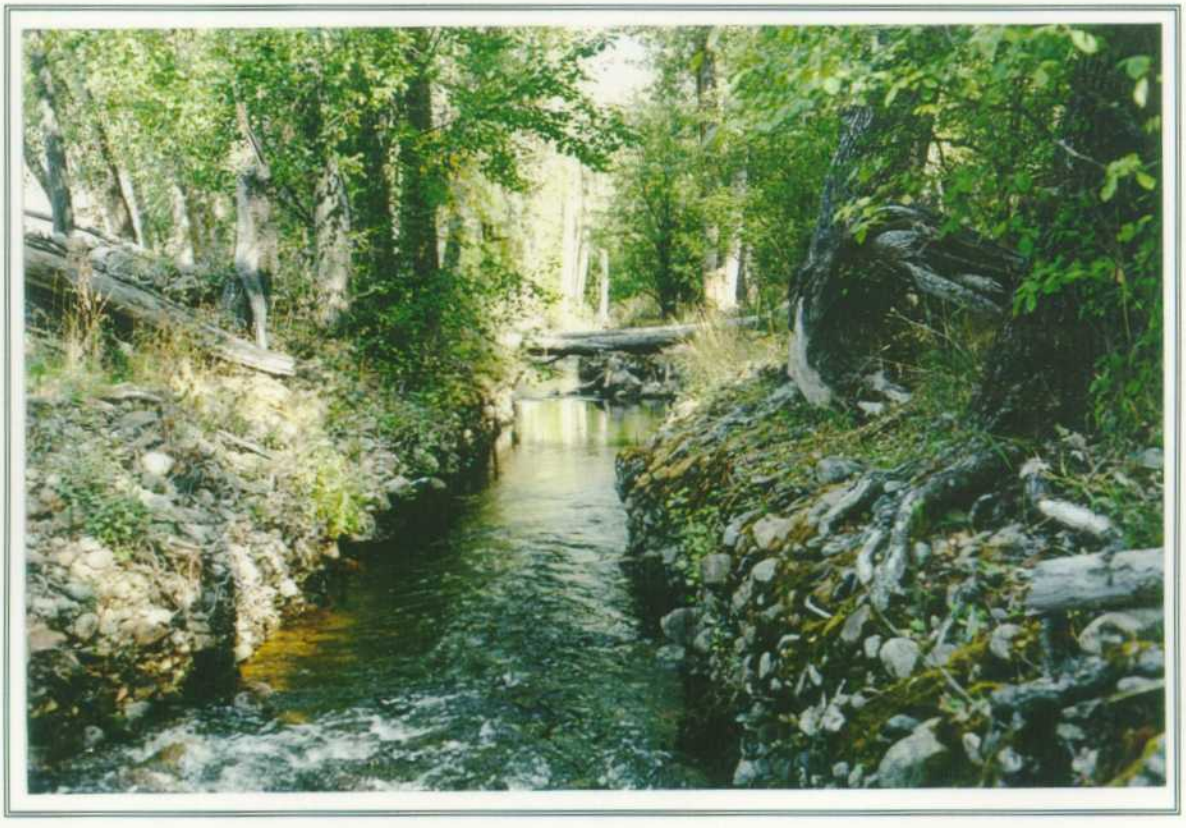
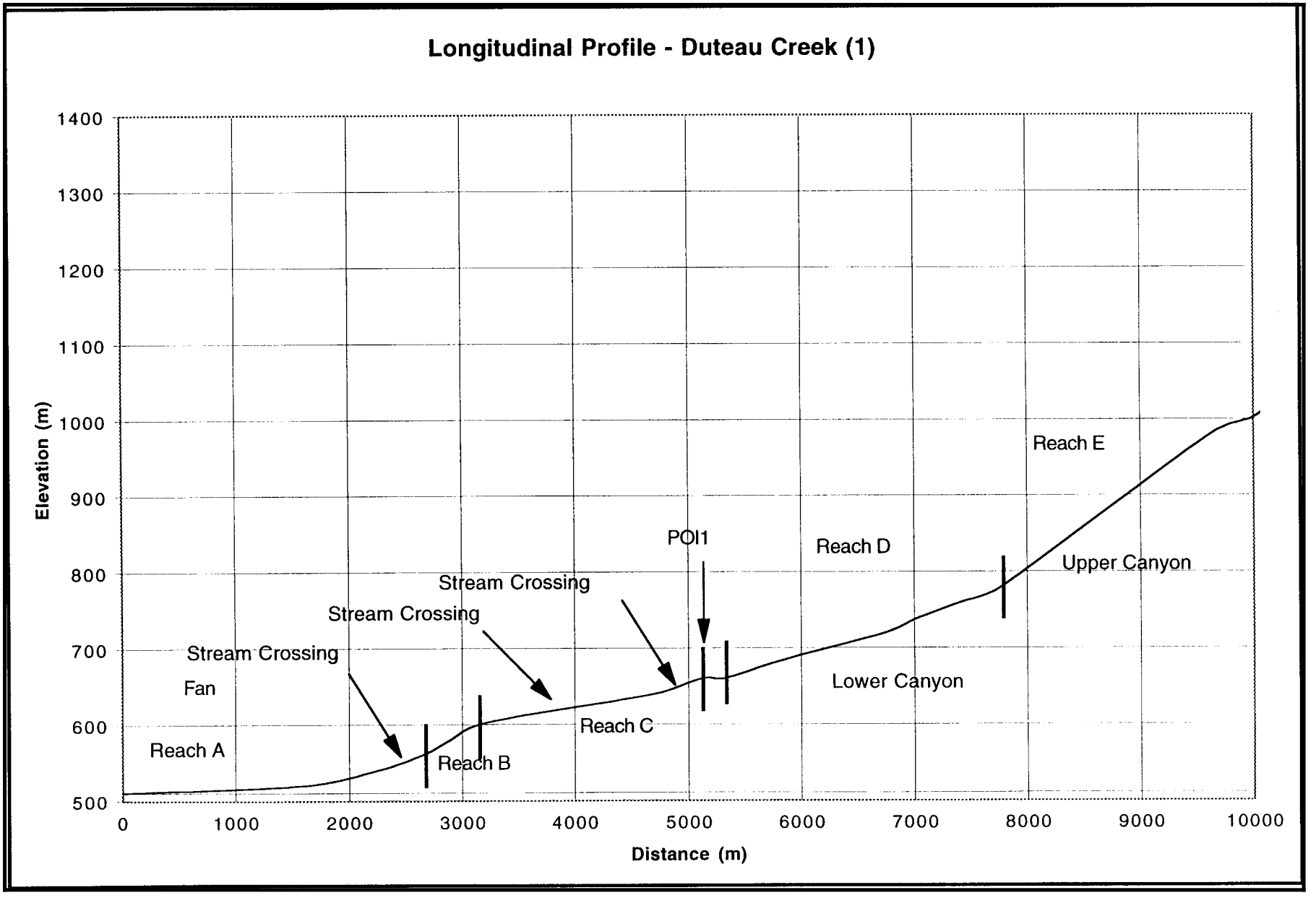


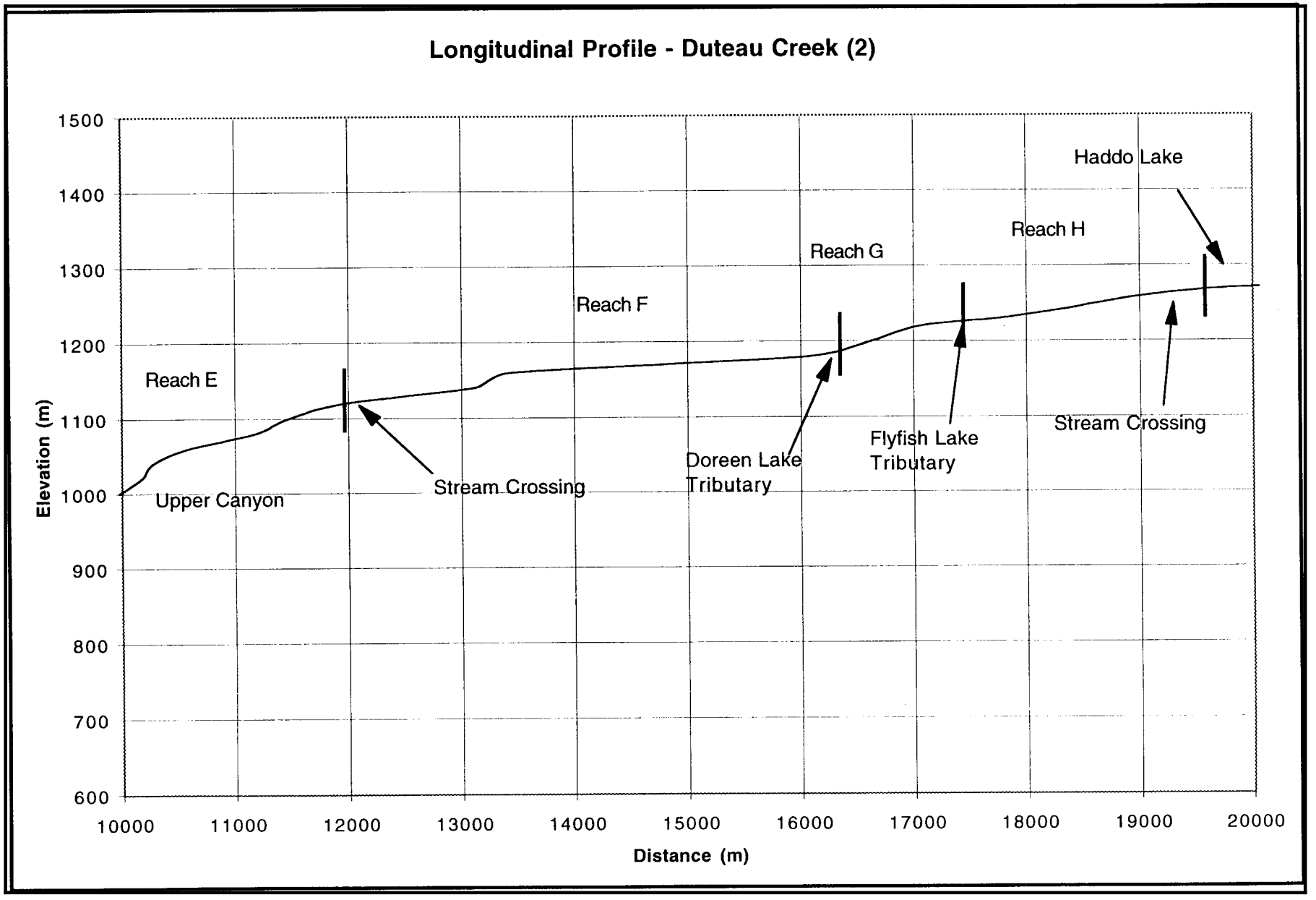
PHOTO 30. Scoured mainstem channel of Duteau Creek on the alluvial fan downstream of the Whitevale road crossing.

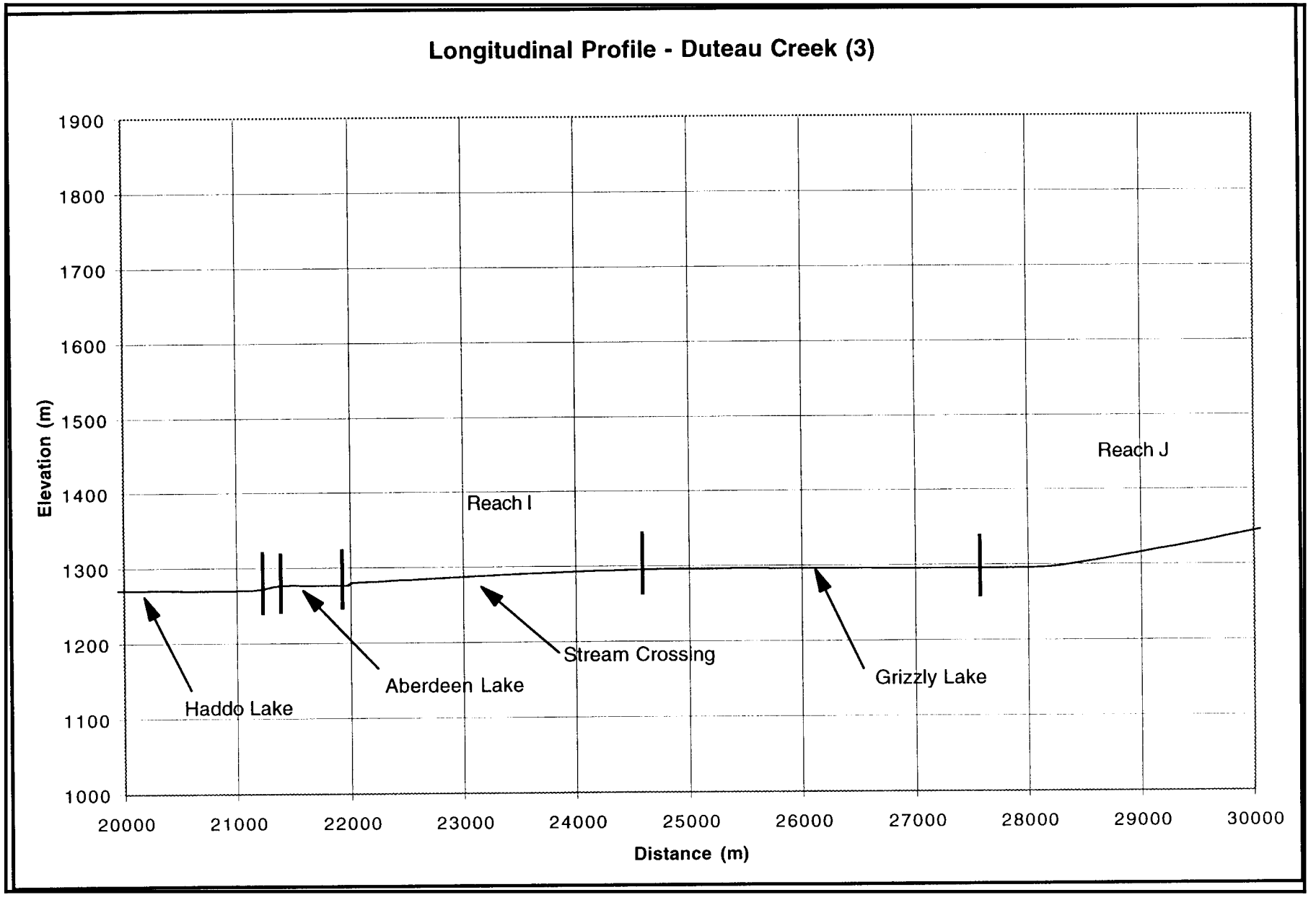
PHOTO 31. Mature poplar trees stabilizing bank materials in scoured section of Duteau Creek downstream of Whitevale road.

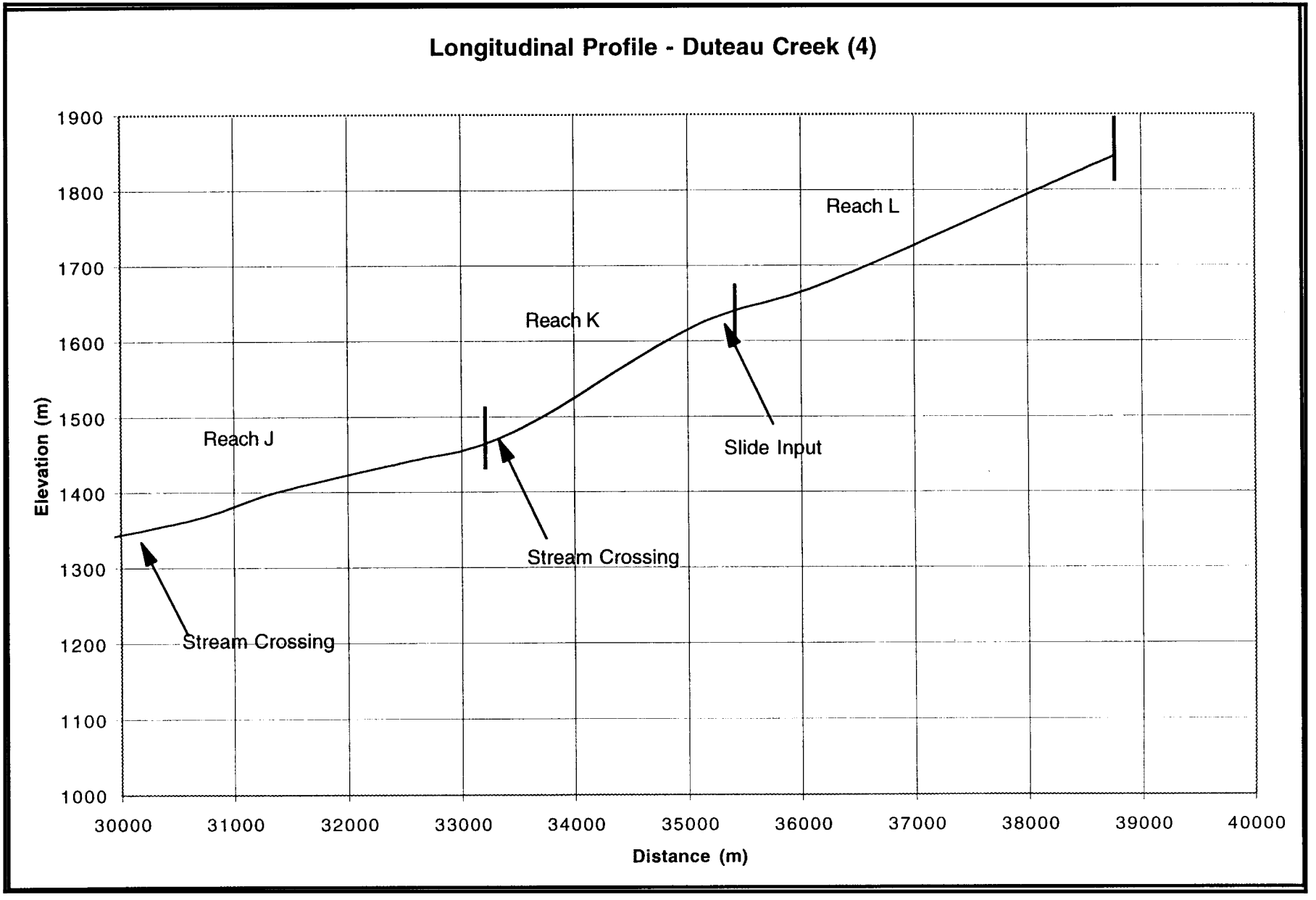
APPENDIX D

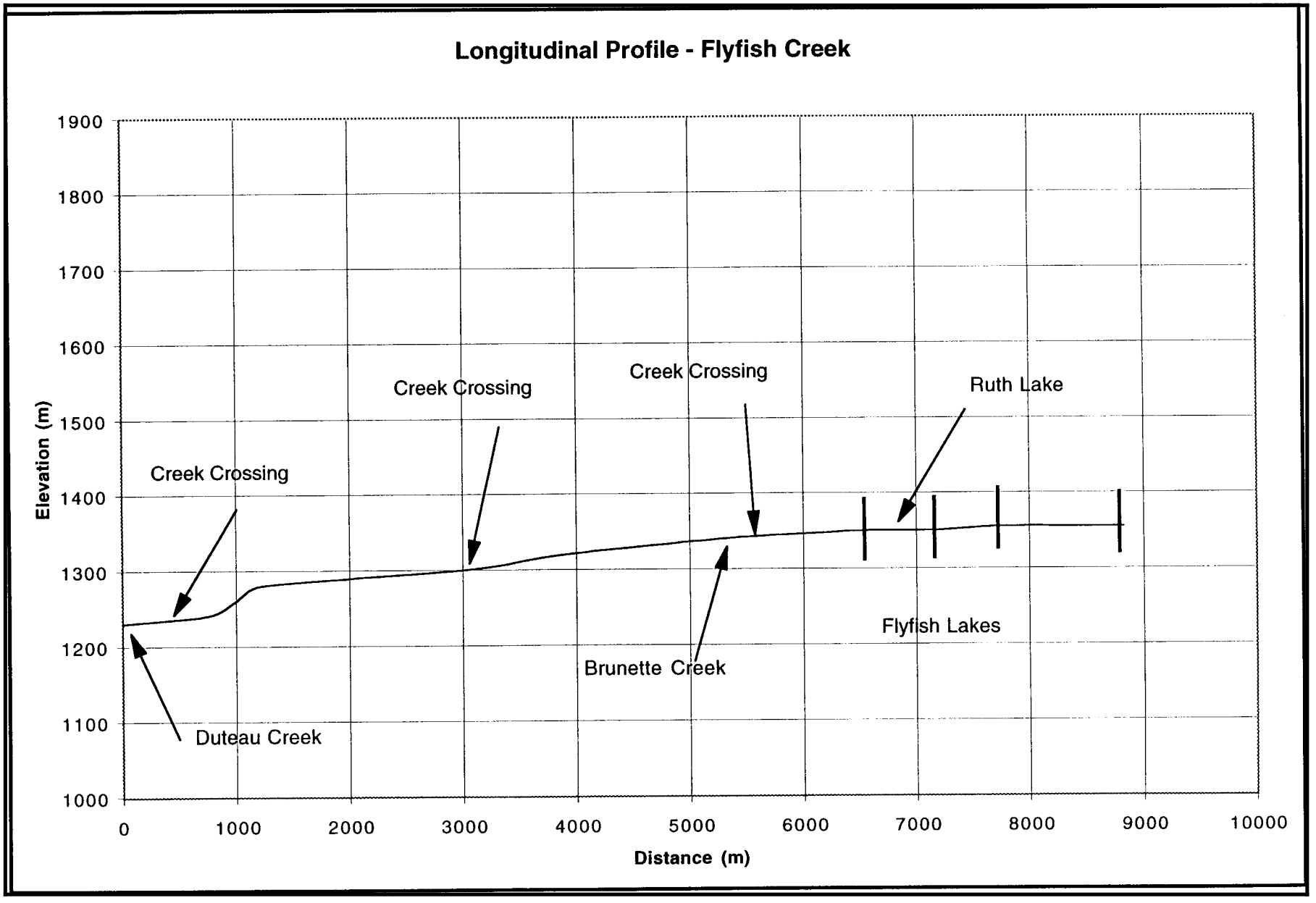
Longitudinal Profiles

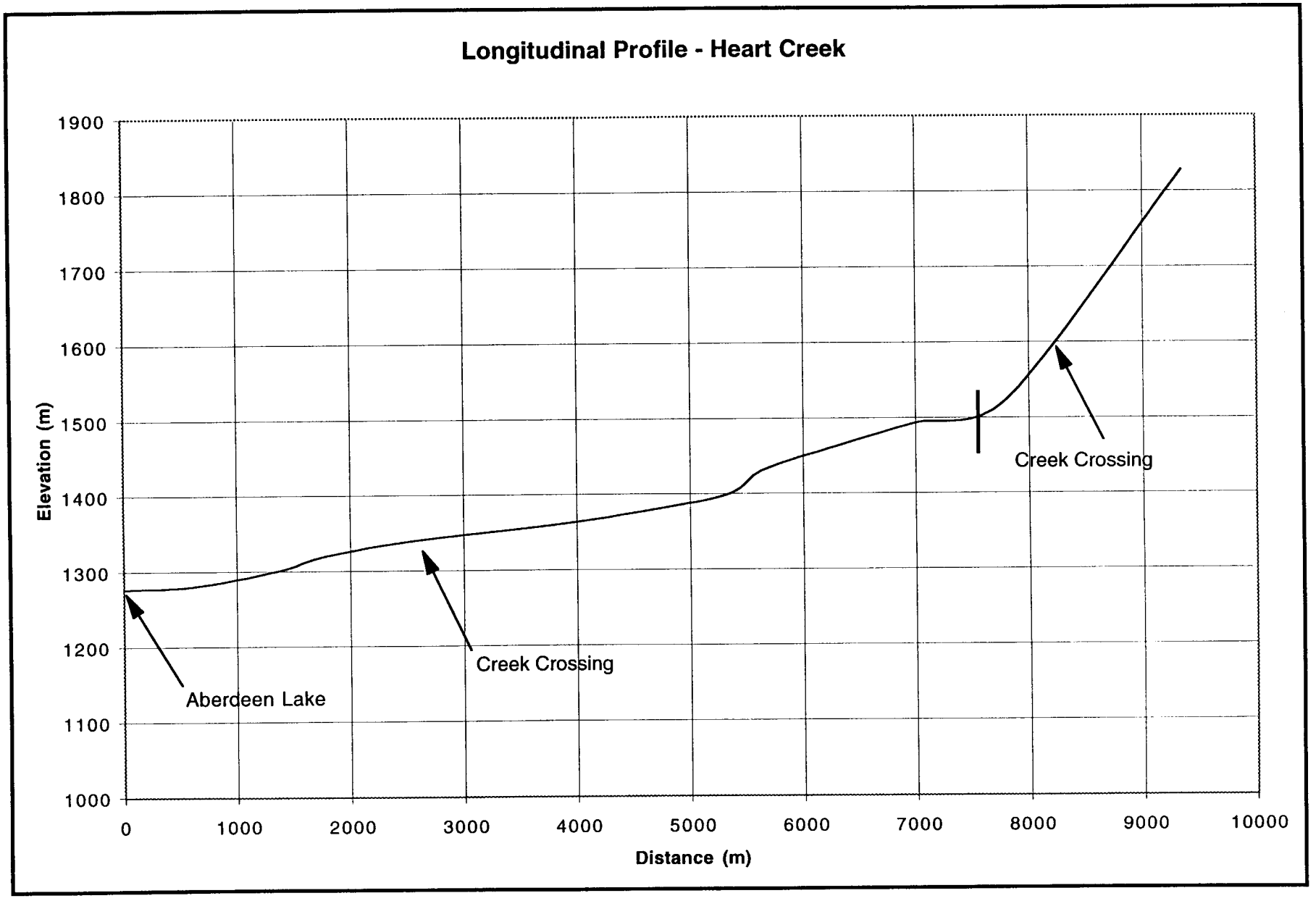

Longitudinal Profile - Duteau Creek (1)
Elevation (m)
1400
1300
1200
1100
1000
900
800
700
600
500
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Distance (m)
Reach A
Fan
Stream Crossing
Stream Crossing
Stream Crossing
Reach B
Reach C
POI1
Reach D
Lower Canyon
Upper Canyon
Reach E


Longitudinal Profile - Duteau Creek (2)
1500
1400
1300
1200
1100
1000
900
800
700
600
Elevation (m)
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
Distance (m)
Reach E
Reach F
Reach G
Reach H
Haddo Lake
Upper Canyon
Stream Crossing
Doreen Lake Tributary
Flyfish Lake Tributary
Stream Crossing


Longitudinal Profile - Duteau Creek (3)
Elevation (m)
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
20000
21000
22000
23000
24000
25000
26000
27000
28000
29000
30000
Distance (m)
Reach I
Reach J
Haddo Lake
Aberdeen Lake
Stream Crossing
Grizzly Lake


Longitudinal Profile - Duteau Creek (4)
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Elevation (m)
30000
31000
32000
33000
34000
35000
36000
37000
38000
39000
40000
Distance (m)
Reach L
Reach K
Reach J
Slide Input
Stream Crossing
Stream Crossing


Longitudinal Profile - Flyfish Creek
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Elevation (m)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Distance (m)
Creek Crossing
Creek Crossing
Creek Crossing
Ruth Lake
Flyfish Lakes
Brunette Creek
Duteau Creek


Longitudinal Profile - Heart Creek
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Elevation (m)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Distance (m)
Aberdeen Lake
Creek Crossing
Creek Crossing

APPENDIX E

Channel Assessment Forms

Form 1 - Classifying Channel Reaches

Sub-basin	Reach Letter	Reach Length (km)	Reach Slope (%)	Drainage Network Class	CAP Applies (Y/N)
D/S Residual	A	2.65	1.9	CA1aii	Y
D/S Residual	B	0.50	8.0	CA1bii	Y
D/S Residual	C	1.98	3.0	CA1aii	Y
Residual	D	2.45	4.9	CA1bii	Y
Residual	E	4.20	8.1	CA2bii	Y
Residual	F	4.10	1.5	CA1aii	Y
Residual	G	1.70	2.9	CA1bii	Y
Aberdeen	H	2.15	1.9	CA1bii	Y
Aberdeen	I	2.70	0.7	N/A	N (ditch)
Duteau U/S of Grizzly	J	6.15	3.3	CA1aii	Y
Duteau U/S of Grizzly	K	2.70	7.1	CA1bii	Y
Duteau U/S of Grizzly	L	2.35	6.6	CA1aii	Y

Forms 2, 3, 4, 5, and 6 (Assessment of Large Channels) - N/A

No aerial photograph assessments were conducted on the channels in Duteau Creek. The mainstem downstream of the Headgates reservoir is below the POI and beyond the terms of reference for the contract. Based on documented DFO interests, overview channel assessment field measurements and observations were made on these reaches to ascertain the nature of disturbance and to determine possible mitigation alternatives. Mainstem channels upstream of the POI are obscured by the forest canopy and not visible on aerial photographs. All mainstem and major tributary channels were field assessed as part of the IWAP procedure.

Field Form 2 - Disturbance Summary

Sub-basin: **Total Watershed**

Reach Letter	Reach Length (km)	Channel Type	Stream Length in Each Disturbance Class (km)			
			None (S or other)	Low (A1, D1)	Moderate (A2, D2)	High (A3, D3)
A	2.65	$RP_{c\text{-}w}$:D2			2.65	
B	0.50	CP_{h}:D2			0.50	
C	1.98	CP_{h}:D2			1.98	
D	2.45	$CP_{B\text{-}w}$:S	2.45			
E	4.20	$CP_{h\text{-}w}$:S	4.20			
F	4.10	$RP_{gs\text{-}w}$:S	4.10			
G	1.70	RP_{c}-w:S	1.70			
H	2.15	RP_{c}-w:S	2.15			
I	2.70	Ditch	2.70			
J	6.15	$CP_{g\text{-}w}$:A2			6.15	
K	2.70	$CP_{g\text{-}w}$:A2			2.70	
L	2.35	CP_{h}:S	2.35			
	Σ=33.63 km		Σ=19.65	Σ=0.0	Σ=13.98	Σ=0.0

Sum of moderate and high disturbance channels = 13.98 km
Sum % of moderate and high disturbance channels = 41.5%

Form 7 - Mainstem Channel Impact Values (Completed Based on Field Assessment Information - Field Forms 1 And 2)

Sub-basin Name	(a) Total Mainstem Channel Length (km)	(b) Total Length of Moderate and High Disturbed Channel (km)	(c) Impact Ratio = (b/a)	Mainstem Channel CIV	Channel Impact/Instability Rating
Mainstem below Headgates	5.13	5.13	1.0	1.0	High
Residual	12.45	0.0	0.0	0.0	Low
Aberdeen	4.85	0.0	0.0	0.0	
Duteau U/S of Grizzly	11.20	8.85	0.8	0.95	High
Total	**33.63**	**13.98**	**0.4**	**0.8**	**High**

Form 8 - Summary of Assessments Performed

Sub-basin Name	General Assessment	Detailed Assessment		CIV
		Air Photograph	Field	
Mainstem below Headgates	N/A*	N/A*	x	1.0
Residual	N/A	N/A	x	0.0
Aberdeem	N/A	N/A	x	0.0
Duteau U/S of Grizzly	N/A	N/A	x	0.95
Total	**N/A**	**N/A**	**x**	**0.4**

* **Note:** Channels downstream of the Headgates reservoir are below the POI and outside of the terms of reference for the IWAP contract. Overview field assessment measurements and observations were completed on reaches A, B and C but no aerial photograph analysis was done.

GENERAL ASSESSMENT
Analysis completed by: **N/A**
Date of analysis: **N/A**
DETAILED ASSESSMENT - AERIAL PHOTOGRAPH
Analysis completed by: **N/A**
DETAILED ASSESSMENT - FIELD (September/October, 1998)
Analysis completed by: **Michael Milne and Harold Waters**

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **A**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	4.0	100	1.9	30	RP_{c-w}:D2

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A3/4	RP_{c-w}:D2	S1, S5, C2	30, 31

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Channel is degraded as a result of bedload capture in Headgates reservoir. Riparian vegetation is intermittant along reach from agricultural land clearing.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **B**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	7.0	75	8.0	50	CP_b:D2

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A4/5	CP_b:D2	S1, S5	N/A

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Degraded channel from bedload capture in Headgates reservoir. Riparian vegetation is mostly intact and the banks are stable.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **C**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	7.0	75	3.0	30	CP_b:D2

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A4/5	CP_b:D2	S1, S5	29

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Degraded channel from bedload capture in Headgates reservoir. Riparian vegetation is mostly intact and the banks are stable.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **D**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	6.5	100	4.9	30	CP_{B-w}:S

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A4/5	CP_{B-w}:S	---	25, 26

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Riparian zone in intact old growth. The channel and banks are stable. 1996 and 1997 peak flows have been buffered through upstream reservoirs which has limited direct channel disturbance. Sand and gravel bars are present along the channel margins from landslide input to reach E.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **E**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters/Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	7.0	100	8.1	50	CP_{b-w}:S

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A4/5 and N3	CP_{b-w}:S	D3	24

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Slide input at 0.5 km downstream of Haddo FSR crossing has created two debris jams at the site. The channel has re-routed through the debris and removal is not required. The channel is stable through the canyon but is carrying increased sand, gravel and cobbles from 1997 landslide input.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **F**
Map-Sheet:

Date:**August 1998**
Crew: **Milne and Waters/Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	10.0	100	1.5	15	RP_{gs-w}:S

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A2/3	RP_{gs-w}:S	D2	21

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: The channel is stable with abundant LWD from blowdown in the riparian zone. Partial salvage of blowdown has occurred in the old blocks along the channel (CP 599). Abundant debris will eventually rot, form debris jams and cause avulsions. Sedimentation at the water intake will result from avulsions. A windthrow management strategy should be developed along the mainstem below Haddo Lake to determine how much blowdown should be removed from the channel during salvage to reduce the risk of avulsion.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **G**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
Average	10.0	100	2.9	15	RP_{gs-w}:S

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
Average	A2/3	RP_{gs-w}:S	D3	20

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Natural blowdown in the riparian zone is causing small debris jams in the channel with minor bank slumping and erosion.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **H**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters/Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	10.0	100	2.9	15	$RP_{gs\text{-}w}$:S

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A2/3	$RP_{gs\text{-}w}$:S	---	19

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: The channel is stable but the riparian zone is prone to windthrow and should be managed as such.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **J**
Map-Sheet:

Date: **August 1998**
Crew: **Milne and Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	3.5	50	3.3	20	CP_{g-w}:A2

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A3/4	CP_{g-w}:A2	S4, C2	14

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Channel is aggraded from upstream 1980's and 1997 slide events. Sand and small gravel is mobile in the system and can be expected to deposit on the fan at Grizzly swamp.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **K**
Map-Sheet:

Date: **09/30/98**
Crew: **Milne and Waters**
Weather: **Sunny**

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	3.0	50	7.1	35	CP_{g-w}:A2

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A3/4/5 N3	CP_{g-w}:A2	S4	13

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Channel is aggraded from upstream 1980's and 1997 slide events.

Duteau Channel Assessment - Field Form 1

Sub-basin: **Duteau Creek**
Reach: **L**
Map-Sheet:

Date: **09/30/98**
Crew: **Milne and Waters**
Weather:

Station	Wb (m)	d (cm)	s (%)	D (cm)	Channel Type
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
Average	2.5	50	6.6	45	CP_{b-w}:S

Distance	Bank Type	Channel Type	Disturbance Indicators	Photo Roll and Frame
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
Average	A4/5	CP_{b-w}:S	---	12

S1 Homogenous bed texture	C1 Extensive riffles or cascades	B1 Abandoned channels
S2 Sediment fingers	C2 Minimal pool area	B2 Eroding banks
S3 Sediment wedges	C3 Elevated mid-channel bars	B3 Avulsions
S4 Extensive bars	C4 Multiple channels or braids	D1 Small woody debris
S5 Extensive scoured zones	C5 Disturbed stone lines	D2 LWD function
		D3 Recently formed LWD jams

A (Erodible): 1=Silt, 2=Sand, 3=Gravel, 4=Cobble, 5=Boulder
N (Non-erodible): 1=Till, 2=Colluvium, 3=Bedrock

Comments: Stable channel with woody debris control.

APPENDIX F

Sediment Source Survey Table

Watershed Name: Duteau Creek

Sub-basin Residual

Sediment Point Source Survey Inventory

#	Type	Origin	Cause	Delivery Route	Length (m)	Width (m)	Total Area (ha)	Comments
L1	DS	os	N	os	350	40	1.40	not connected to Duteau Creek, vegetated
L2	DS	os	N	os	250	40	1.00	vegetated
L3	DS	os	N	os	25	20	0.05	connected to Duteau Creek, non-vegetated, 500 m u/s Edwin Lake Trib.
L4	DS	os	N/R	os	75	10	0.08	nonvegetated pre-1972, currently vegetated
L5	DS	os	R	os	75	20	0.15	connected to Duteau Creek, non-vegetated, occurred between 94 and 97, possible initiated from old skid trail
L6	DS	os	N	os	50	40	0.20	nonvegetated, pre-1972

Sub-basin Aberdeen

Sediment Point Source Survey Inventory

#	Type	Origin	Cause	Delivery Route	Length (m)	Width (m)	Total Area (ha)	Comments
L7	F	os	N	os	300	50	1.50	north of Aberdeen Lake, Class IV terrain

Sub-basin Duteau U/S of Grizzly

Sediment Point Source Survey Inventory

#	Type	Origin	Cause	Delivery Route	Length (m)	Width (m)	Total Area (ha)	Comments
L8	DS	os	R	os	30	15	0.05	see report "Failure on Road #533.1 @ 2.4 km in the Duteau Creek Watershed" by Dobson Engineering Ltd, dated July 1998
L9	DS	os	N	os	30	15	0.05	adjacent to L8, estimated to be 10-15 years old

Note: Terminology from Landslide Rehabilitation Assessment Procedure Short Course Notes
Types: Falls (F), Creep (C), Slumps and Earthflows (S or EF), Bedrock Failure (BF), Debris Avalanche/Slide (DA or DS), Debris Flow/Torrent (DF or DT)
Cause: Road (R), Clearcut (Cc), Natural (N), Other (O)
Origin/Delivery Route: Open Slope (os), Fill slope (fs), Cut slope (cs), Gully headwall (gh), Gully channel (gc), gully sidewall (gs)