Interior Watershed Assessment Update

McKinley Creek Watershed

1.0 WATERSHED DESCRIPTIVE INFORMATION

Table 1.1 Summary information – Biophysical

Size (km^2)	BEC Zones	Elevation Range (m)	H_{60} Elevation (m)	Stream Density km/km^2	Distribution of slope gradients within the watershed (% of watershed)			
					<10% slope	10 to 30% slope	30 to 60% slope	>60%slope
375.48	ICHmk3 ESSFwk1/ wc3	793 - 2340	1208	1.64	36	53	10	1

Table 1.2. Characteristics of main stream reaches – (assessment is based on a combination of air-photo interpretations, TRIM maps, helicopter over-flight and various reports).

Reach ID	Minimum Elevation (m)	Maximum Elevation (m)	Reach Length (m)	Reach Gradient (%)	Stream Disturbance Assessment
Main-R1	859.99	919.926	4287	1.4%	Stable
Main-R2	919.926	920	3079	0.0%	Stable
Main-R3	920	939.457	4151	0.5%	Stable
Main-R4	939.457	983.628	4228	1.0%	Stable
Main-R5	983.628	1001.33	2261	0.8%	Stable
Main-R6	1001.33	1002	9109	0.01%	Bosk Lake
Main-R7	1002	1019.41	4375	0.4%	Stable
Main-R8	1019.41	1039.83	2673	0.8%	Stable
Main-R9	1039.83	1040.37	4345	0.01%	Stable
Main-R10	1040.37	1063.91	1502	1.6%	Stable

Reach ID	Minimum Elevation (m)	Maximum Elevation (m)	Reach Length (m)	Reach Gradient (%)	Stream Disturbance Assessment
Main-R11	1063.91	1078.85	6317	0.2%	Stable
Main-R12	1078.85	1284.51	4942	4.2%	Stable
Moly-R1	939.457	939.993	4499	0.01%	Low gradient, meandering and stable
Moly-R2	939.993	1285.29	7711	4.5%	Moderate instability
Moly-R3	1285.29	1445.99	6027	2.7%	Stable
Moly-R4	1445.99	1494.73	2720	1.8%	Local instability near mine site

RPg = Riffle-Pool gravel morphology, CPgA2 = Cascade Pool gravel morphology that is aggraded

2.0 WATERSHED HARVESTING, ROADS AND LAND-USE HISTORY

Table 2.1. McKinley Creek Watershed – (entire watershed)

Private	Total harvest 2002 (%)	Current ECA (%)	Planned Harvest (%)	Current ECA below H60 (%)	Current ECA Above H60 (%)	Peak Flow Index		Road Density Active (km/km^2)		Stream Crossing density active (#/km^2)		Road Density De-active (km/km^2)	
						Current (2002) (%)	End of FDP (2007)(%)	Current (2002)	End of FDP (2007)	Current (2002)	End of FDP (2007)	Current (2002)	End of FDP (2007)
0	26.43	24.99	6.23	15.9	9.1	29.5	37.6	0.67	0.75	0.35	0.39	0.43	0.50

Table 2.2. Molybdenite Sub-basin (sub-basin only)

Private	Total harvest 2002 (%)	Current ECA (%)	Planned Harvest (%)	Current ECA below H60 (%)	Current ECA Above H60 (%)	Peak Flow Index		Road Density Active (km/km^2)		Stream Crossing density active (#/km^2)		Road Density De-active (km/km^2)	
						Current (2002)(%)	End of FDP (2007)(%)	Current (2002)	End of FDP (2007)	Current (2002)	End of FDP (2007)	Current (2002)	End of FDP (2007)
0	23.50	23.06	11.47	16.0	7.1	26.6	42.9	0.92	1.04	0.32	0.34	0.53	0.66

3.0 SUMMARY OF EXTENT OF RIPARIAN REMOVAL (agriculture and forestry)

Table 3.1. McKinley Watershed

Watershed name	Length (km) of riparian removal on small tributaries (<5m in width)	Length (km) of riparian removal on large tributaries (>5m)	% Riparian removal of all tributaries	Length (km) of riparian removal on mainstem	% Riparian removal of mainstem	Total length of all tributaries (from Trim) (km)	Total length of mainstem (km)
McKinley above Lake	56.88	0.00	**9.48**	0.31	**1.28**	599.89	24.53

Table 3.2. Molybdenite sub-basin

Watershed name	Length (km) of riparian removal on small tributaries (<5m in width)	Length (km) of riparian removal on large tributaries (>5m)	% Riparian removal of all tributaries	Length (km) of riparian removal on mainstem	% Riparian removal of mainstem	Total length of all tributaries (from Trim) (km)	Total length of mainstem (km)
Molybdenite	7.61	0.00	**7.42**	1.31	**7.17**	102.60	18.28

4.0 SUMMARY OF LARGE SEDIMENT SOURCES

Table 4.1. McKinley Watershed

Watershed Name	Large natural sediment sources		Large natural sediment sources directly connected to a stream		Large land-use related sediment sources		Large land-use related sediment sources directly connected to a stream		Large sediment sources	
	number	density (#/km^2)	number	density (#/km^2)	number	density (#/km^2)	number	density (#/km^2)	number	density (#/km^2)
McKinley above Lake	6	0.016	6	0.016	7	0.019	7	0.019	13	0.035

Table 4.2. Molybdenite Sub-basin

Watershed Name	Large natural sediment sources		Large natural sediment sources directly connected to a stream		Large land-use related sediment sources		Large land-use related sediment sources directly connected to a stream		Large sediment sources	
	number	density (#/km^2)	number	density (#/km^2)	number	density (#/km^2)	number	density (#/km^2)	number	density (#/km^2)
Molybdenite	5	0.061	5	0.061	7	0.085	7	0.085	12	0.147

5.0 SUMMARY OF LAND-USE ACTIVITIES ON UNSTABLE TERRAIN

Table 5.1. McKinley Watershed

Watershed	Length of road on unstable terrain (km)		Area of cut blocks on unstable terrain (km^2)		Road density on unstable terrain (km/km^2)	Source of information for stability assessment
	Active	Proposed	Harvested	Proposed		
McKinley	0	0	0.04	0.06	0.0000	Class U

Table 5.2 Molybdenite Sub-basin

Watershed	Length of road on unstable terrain (km)		Area of cut blocks on unstable terrain (km^2)		Road density on unstable terrain (km/km^2)	Source of information for stability assessment
	Active	Proposed	Harvested	Proposed		
Molybdenite	0	0	0.04	0.06	0.0000	Class U

6.0 SUMMARY OF ROAD RELATED SOURCES OF SURFACE EROSION

Table 6.1 McKinley Watershed - summary of stream crossing sediment source survey –			
Number of crossings surveyed	Estimated total # of crossings (TRIM maps)	Percentage surveyed	Watershed Size (km^2)
94	184	51.1	375.5

Table 6.2 Summary of Water Quality Concern Ratings (WQCR) – McKinley Watershed							
No Concern		**Low**		**Medium**		**High**	
Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
4	4.3	28	29.8	33	35.1	29	30.8

Stream Width Class	Table 6.3 Summary of Water Quality Concern Ratings by Stream Size - McKinley Watershed								# of streams surveyed per class
	None		Low		Medium		High		
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	
1	0	0.0	0	0.0	0	0.0	0	0.0	0
2	0	0.0	2	50.0	2	50.0	0	0.0	4
3	3	20.0	8	53.3	2	13.3	2	13.3	15
4	1	1.5	17	25.4	27	40.3	22	32.8	67
5	0	0.0	1	12.5	2	25.0	5	62.5	8

Table 6.4 ESC Summary - McKinley	
WQCR	"Equivalent" number of stream crossings
No Concern	0.0
Low	16.4
Moderate	45.2
High	56.8
Total	118.4

Table 6.5 Surface erosion hazard – McKinley Watershed	
Equivalent stream crossing density (xings/km^2)	Surface Erosion Hazard
0.32	**High**

Table 6.6 Molybdenite Sub-basin - summary of stream crossing sediment source survey –			
Number of crossings surveyed	Estimated total # of crossings (TRIM maps)	Percentage surveyed	Watershed Size (km^2)
30	34	88.2	81.9

Table 6.7 Summary of Water Quality Concern Ratings (WQCR) – Molybdenite Sub-basin							
No Concern		**Low**		**Medium**		**High**	
Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
0	0.0	15	50.0	2	6.7	13	43.3

Stream Width Class	Table 6.8 Summary of Water Quality Concern Ratings by Stream Size – Molybdenite Sub-basin								# of streams surveyed per class
	None		Low		Medium		High		
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	
1	0	0.0	0	0.0	0	0.0	0	0.0	0
2	0	0.0	1	100.0	0	0.0	0	0.0	1
3	0	0.0	4	80.0	1	20.0	0	0.0	5
4	0	0.0	9	40.9	1	4.5	12	54.5	22
5	0	0.0	1	50.0	0	0.0	1	50.0	2

Table 6.9 ESC Summary – Molybdenite	
WQCR	"Equivalent" number of stream crossings
No Concern	0.0
Low	5.1
Moderate	1.6
High	14.7
Total	21.4

Table 6.10 Surface erosion hazard – Molybdenite Sub-basin	
Equivalent stream crossing density (xings/km^2)	Surface Erosion Hazard
0.26	**Moderate**

7.0 SUMMARY OF MAINSTEM CHANNEL CONDITIONS

Table 7.1. Extent of channel disturbance

Reach ID	Reach Length (m)	Reach Gradient (%)	Length disturbed (m)	% of channel disturbed	Level of channel disturbance	Probable cause of disturbance
Main-R1	4287	1.4%	0	0	Undisturbed	-
Main-R2	3079	0.0%	0	0	Undisturbed	-
Main-R3	4151	0.5%	0	0	Undisturbed	-
Main-R4	4228	1.0%	0	0	Undisturbed	-
Main-R5	2261	0.8%	0	0	Undisturbed	-
Main-R6	9109	0.01%	0	0	Undisturbed	-
Main-R7	4375	0.4%	0	0	Undisturbed	-
Main-R8	2673	0.8%	0	0	Undisturbed	-
Main-R9	4345	0.01%	0	0	Undisturbed	-
Main-R10	1502	1.6%	0	0	Undisturbed	-
Main-R11	6317	0.2%	0	0	Undisturbed	-
Main-R12	4942	4.2%	0	0	Undisturbed	-
Moly-R1	4499	0.01%	525	12	Undisturbed	-
Moly-R2	7711	4.5%	1410	18	Moderate	Riparian harvest
Moly-R3	6027	2.7%	0	0	Undisturbed	-
Moly-R4	2720	1.8%	0	0	Localized disturbance	Open Pit Mining

8.0 SUMMARY OF FISHERIES RESOURCES IN THE WATERSHED

Table 8.1. Documented fish species presence

Category	Common Name	Latin Name	Species Code	Reference
Anadromous salmonids	Chinook Salmon	*Oncorhynchu tshawytschas*	CH	Fish Wizard[1]
	Coho Salmon	*Oncorhynchus kisutch*	CO	Fish Wizard[1]
	Sockeye Salmon	*Oncorhynchus nerka*	SK	Fish Wizard[1]
Freshwater game species	Kokanee	*Oncorhynchus nerka*	KO	Fish Wizard[1]
	Burbot	*Lota lota*	BB	Fish Wizard[1]
	Lake Trout	*Salvelinus namaycush*	LT	Fish Wizard[1]
	Rainbow Trout	*Oncorhynchus mykiss*	RB	Fish Wizard[1]
	Mountain Whitefish	*Prosopium williamsoni*	MW	Fish Wizard[1]
Non-game species N/A	Leopard Dace	*Rhinichthys falcatus*	LDC	Fish Wizard[1]
	Longnose Dace	*Rhinichthys* cataractae	LNC	Fish Wizard[1]
	Redside Shiner	*Richardsonius balteatus*	LSU	Fish Wizard[1]
	Largescale Sucker	*Catostomus macrocheilus*	CSU	Fish Wizard[1]
	Longnose Sucker	*Catostomus catostomus*	LSU	Fish Wizard[1]
	Peamouth Chub	*Mylocheilus caurinus*	PCC	Fish Wizard[1]
	Northern Pikeminnow	*Ptychocheilus oregonensis*	NSC	Fish Wizard[1]

[1]Fish Wizard available at http://pisces.env.gov.bc.ca

9.0 SUMMARY OF HAZARDS FOR THE McKINLEY WATERSHED

Table 9.1. Watershed assessment hazards

Watershed	Sub-basin	Hazard Ratings[2]						Generalized Channel Disturbance[1]
		Increases in peak-flows (Current/ Proposed)	Reduction in riparian functions	Large logging related sediment sources	Road related sediment sources (field work)	Accelerated surface erosion from GIS (Current/ proposed)	Accelerated mass wasting	
McKinley above Lake		L/M	L	H	H	M/M	VL	3
	Molyb-denite	L/M	M	VH	M	M/M	VL	4

[1] Note: Generalized channel disturbance codes: 1 = no disturbance identified, 2 = localized channel disturbance, 3 = minor localized land-use related disturbance, 4 = moderate land-use related channel disturbance, 5 = extensive land-use related channel disturbance.
[2] Note: Hazard ratings: VL=very low, L=low, M=moderate, H=high, VH=very high

10.0 INTERPRETATIONS

10.1 Peakflow Hazards

The peak flow index (PFI) for McKinley Creek watershed is currently 29% (Low hazard) and will increase to 38% (Moderate hazard) by the end of the forest development plan (FDP). For the Molybdenite sub-basin these values are 27% (Low hazard) and 43% (Moderate hazard) for current and end of FDP, respectively. I believe that the moderate peak flow hazard for McKinley above McKinley Lake is a relatively low risk because of the numerous large lakes that buffer peak flows and the stable nature of the lower reaches on McKinley Creek above McKinley Lake (Table 7.1).

For Molybdenite Creek, the moderate peak flow hazard (at the end of FDP) is also a low risk because reach Moly-R1 of this watershed (i.e. the point of interest) is very low gradient, stable and has had no riparian logging (Table 7.1). There is a moderately unstable reach in the Molybedenite watershed but it is located upstream of most of the current logging. Most of the logging in this watershed has occurred on a tributary watershed that flows into the lower stable reach. However, the FDP does indicate plans for numerous cut-blocks located in the upper watershed area of Molybedenite Creek. This does have the potential to have a negative impact on the unstable sections of Reach #2 of Molybdenite Creek. Davis and Wilson (2002) also reported channel instability and a high risk of erosion and mass along Reach #2. Instability along this reach should be monitored.

10.2 Hazards Associated with a loss in Riparian Functions

The riparian hazard is **Low** for McKinley Creek above McKinley Lake because no riparian harvesting has occurred along the lower reaches of the mainstem. However, there are some sections of Molybdenite Creek where localized riparian harvest has occurred and this appears to have contributed to channel instability. The riparian hazard for Molybdenite Creek is **Moderate.** This may have caused a localized reduction in the quality of fish habitat and may have contributed to downstream channel aggradation in the lower parts of Reach #2.

10.3 Hazards Associated with Large Sediment Sources

There are numerous large slope failures that have occurred along the banks of Molybdenite Creek (Table 4.1, photograph #1020 and #1025). Several of these appear to have been initiated by forest harvesting activities on a landform often identified as “flat over steep”. These failures have resulted in a **Very High** hazard for Molybdenite creek sub-basin. I believe that these, in association with the riparian logging are responsible for channel instability in Moly-reach #2. Davis and Wilson (2002) report that the larger slides likely predate the logging and mining development, as they are clearly evident on 1971 air-photos.

The large open pit mine, located at the headwaters of the Molybdenite watershed has created some significant sediment source problems (photographs #1004 and #1009). Davis and Wilson (2002) have classified these sediment source as a very high risk for the aquatic environment.

The large sediment source hazard for McKinley watershed is **High**. The landslides that are responsible for this High value are the same ones that are located in Molybdenite sub-basin. These landslides do not appear to have created any stability problems in the lower reaches of McKinley Creek.

10.4 Hazards Associated with Roads Related Surface Erosion

A total of 94 stream crossings were surveyed in the McKinley Creek watershed. Of these only 32 crossings (34%) had no or low surface erosion concerns (Table 6.2). A majority of the stream crossings surveyed (66%) had medium or high concerns (Table 6.2). Although most of the medium and high concerns were located on small streams, there were several crossings of larger streams that also had concerns (Table 6.3). Based on our field sampling, the calculated "equivalent stream crossing density" was computed as 0.32 crossings/km^2. This includes all active and de-activated stream crossings. This number has generated a **High** hazard value (Table 6.5).

For the Molybdenite Creek watershed, the equivalent stream crossing density was computed as 0.26 crossings/km^2 and this generated a **Moderate** hazard

10.5 Hazards Associated with Accelerated Mass Wasting (from logging on steep slopes).

There is no steep slope logging in this watershed. Consequently, there is no hazard associated with this IWAP indicator. However, as indicated in section 10.3, there are some mass wasting hazards along Reach #2 of Molybdenite Creek where logging has occurred up to the edge of this deeply incised stream (flat over steep situation).

10.6 Watershed Cumulative Effects and Channel Stability

It is my opinion that there are no significant negative cumulative effects for the lower reaches of McKinley Creek. This is in large part due to: 1) current low peak flow hazard, 2) the buffering effects of the large lakes located within the watershed and 3) the retention of riparian forests along the lower reaches. However, I believe that there may be negative cumulative effects in Reach #2 of the Molybdenite sub-basin because of slope failures, and localized riparian harvesting. The extensive proposed harvesting in the upper sections of the Molybdenite watershed may aggravate the localized instability.

Although the extensive surface erosion problems in McKinley Creek may not have a negative impact on the lower reaches, it may have localized impacts on small tributary streams. Plans to address these problem stream crossings should be made by the Forest Service (non-status roads) and the appropriate licensees. In many cases the extent of the

problem may be significant, but the solution is often simple (e.g. grass seeding, cross drain, sediment fence or small sediment dike).

11.0 RECOMMENDATIONS

11.1) Recommendations for the Forest Development Plan (landscape level)

I have not identified any landscape level concerns with either the present situation or that provided in the FDP for the McKinley Creek watershed as a whole. However, there are some landscape level concerns in the Molybdenite Creek sub-basin because of the moderate peak flow hazard, local stream instability and the logging related slope failures. Considerations about increased peak flow hazards will need to be made for the Molybdenite Creek sub-basin.

11.2) Recommendations for Site Specific Activities (site level)

McKinley Creek watershed:

The main recommendation for the watershed as a whole is to deal with the numerous stream crossings that have been rated as having a moderate or high "water quality concern rating (WQCR)". These crossings will need additional or more effective erosion and sediment control to maintain good water quality. The list of crossings that were surveyed and their respective scores is provided in Appendix 3 of this report and their locations are plotted on the accompanying map (Appendic C). I suggest that the licensees maintain effective Erosion and Sediment Control (ESC) plans for the McKinley watershed. This would include: a) Development of a plan with precise objectives and standards and clear operating procedures, b) clearly define the types of erosion and sediment control practices that need to be implemented, c) regular maintenance of any ESC structure that has been installed, d) regular field monitoring to evaluate the effectiveness of the plan.

Molybdenite Creek sub-basin:

The following items should be part of the management plan for this sub-basin:

- Improve the erosion and sediment control at the stream crossings that have a moderate or high WQCR.
- Continued effective de-activation of roads in an effort to maintain natural drainage patterns should be considered an important objective for this watershed.
- Leave 20-30% canopy cover in partial retention over the block area. This will decrease the impact on increased snow accumulation and melt rates compared to complete clearcut. The rational for this recommendation is provided in Section 11.2 of the Moffat report (bullet number 3).
- Blocks that are NSR should be dealt with aggressively so that the ECA can be lowered.
- For higher elevation blocks (ESSF) retain understory (broken-up by skid trails). A significant amount of understory can have a positive effect on the mitigation of

peak flow increases. A significant amount of "tall" understory can have a positive effect on the mitigation of peak flow increases if it is distributed throughout the cut-block. I recognize that by itself, this mitigative measure may only have a limited value. However, it could contribute to positive cumulative effects when implemented with other associated measure

- Improved drainage and erosion control at the site of the old Boss Mountain Mine located in the headwaters of Molybdenite watershed.

See the Moffat Creek report for a discussion about setting threshold limits for extent of harvest within the watershed (Section 11.1).

The Molybdenite stream channel is showing signs of localized instability and may get worse if extensive harvesting occurs above reach #2. It would be a good idea to monitor changes in channel morphology every couple of years (say every three years) for signs of increased instability if you want to know if increased logging is having detrimental impacts on channel stability. The monitoring would involve detailed channel assessments in the field to see if indicators of channel instability are increasing. This could be done by anyone qualified to do a detailed channel assessment (i.e. someone with local experience in fluvial geomporphology and forestry related impacts).

APPENDIX 1 – Database of disturbed riparian areas

ID	Channel Width	Stream Type	One or 2 sided	Length of RL (km)	Landuse
McKinRL-001	3	2	2	3.0088	1
McKinRL-002	3	2	1	0.5372	1
McKinRL-003	3	2	2	0.7714	1
McKinRL-006	3	2	2	0.5852	1
McKinRL-004	3	2	2	0.4391	1
McKinRL-005	3	2	2	0.2313	1
McKinRL-012	4	3	2	2.168	1
McKinRL-013	4	3	2	1.445	1
McKinRL-014	4	3	2	1.007	2
McKinRL-015	4	3	2	1.202	1
McKinRL-016	4	3	2	0.7048	1
McKinRL-010	4	3	2	2.704	1
McKinRL-011	4	3	2	0.4265	1
McKinRL-018	4	3	2	1.306	1
McKinRL-017	4	3	2	0.6182	1
McKinRL-019	4	3	2	0.9239	1
McKinRL-020	4	3	2	0.576	1
McKinRL-022	4	3	2	0.6801	1
McKinRL-023	4	3	2	1.084	1
McKinRL-021	4	3	2	0.2496	1
McKinRL-025	4	3	2	0.4155	1
McKinRL-026	4	3	2	0.4577	1
McKinRL-024	4	3	2	0.1878	1
McKinRL-032	4	3	2	0.8396	1
McKinRL-033	4	3	2	0.5926	1
McKinRL-027	4	3	2	0.621	1
McKinRL-028	4	3	1	1.549	1
McKinRL-031	4	3	2	0.5351	1
McKinRL-029	4	3	2	0.6897	1
McKinRL-030	4	3	2	0.1805	1
McKinRL-035	4	2	2	0.8674	1
McKinRL-040	4	2	2	0.4525	1
McKinRL-039	4	2	2	0.3131	1
McKinRL-038	4	2	2	0.5862	1
McKinRL-041	4	3	2	0.3049	1

ID	Channel Width	Stream Type	One or 2 sided	Length of RL (km)	Landuse
McKinRL-042	4	3	2	0.7866	1
McKinRL-043	4	3	2	0.5105	1
McKinRL-044	4	3	2	0.3946	1
McKinRL-048	4	3	2	0.6228	1
McKinRL-050	4	3	2	1.138	1
McKinRL-052	4	3	2	1.357	1
McKinRL-053	4	3	2	0.9246	1
McKinRL-045	4	3	2	0.5061	1
McKinRL-046	4	3	2	0.4441	1
McKinRL-051	4	3	2	1.407	1
McKinRL-047	4	3	2	0.6139	1
McKinRL-067	4	3	2	1.609	1
McKinRL-056	4	3	2	0.8461	1
McKinRL-068	4	3	2	0.6909	1
McKinRL-069	4	3	2	0.8606	1
McKinRL-070	4	3	2	0.6625	1
McKinRL-037	4	2	2	0.2855	1
McKinRL-036	4	2	2	0.5931	1
McKinRL-071	4	3	2	0.3824	1
McKinRL-007	4	3	2	0.4159	1
McKinRL-008	4	3	2	0.4784	1
McKinRL-009	4	3	2	0.4825	1
McKinRL-054	4	3	2	0.4097	1
McKinRL-055	4	3	2	0.3679	1
McKinRL-049	4	3	2	0.206	1

APPENDIX 2 – Database of large sediment sources

ID	Type	Cause	Deliverability	Degree of Revegetation	Activity Level
Moly-01	9	11	3	1	3
Moly-02	3	9	3	1	3
Moly-03	3	9	3	1	3
Moly-04	3	3	3	1	3
Moly-05	3	3	3	1	3
Moly-06	3	3	3	1	3
Moly-07	3	3	3	1	3
Moly-08	3	3	3	1	3
Moly-09	3	2	3	1	3
Moly-10	3	2	3	1	3
Moly-11	3	2	2	1	3
Moly-12	3	2	2	1	3
McKin-01	3	4	3	1	3

APPENDIX 3 – Database of stream crossing survey (surface erosion)

Sub Basin	Cros-sing ID	UTM Easting	UTM Northing	Structure type	Size of Culvert	Crossing Erosion Score	WQCR	Stream width Class	Stream gradient Class
McKinley	O01	651830	5777539	5	800	0.4	Med	4	2
McKinley	O02	653095	5777190	5	500	0.6	Med	4	3
McKinley	O03	652548	5777877	5	1000	0.4	Med	4	4
McKinley	O04	651080	5780380	1		0.3	Low	3	3
McKinley	O05	650432	5780979	5	600	0.7	Med	4	2
McKinley	O06	649711	5781315	1		0.9	High	5	3
McKinley	O07	649650	5781837	5	800	0.9	High	4	3
McKinley	O08	648973	5782109	5	600	0.4	Med	4	2
McKinley	O09	648741	5782184	1		0.5	Med	3	3
McKinley	O10	648152	5782712	5	900	0.5	Med	4	3
McKinley	O11	647935	5783353	5	1600	0.6	Med	4	4
McKinley	O12	647216	5784352	5	300	1.0	High	4	6
McKinley	O13	646545	5785157	5	600	0.4	Med	5	5
McKinley	O14	646386	5785267	5	800	0.5	Med	4	4
McKinley	O50	649216	5791072	3	2100	0.4	Low	3	2
McKinley	O51	658718	5786145	6		0.5	Med	4	6
McKinley	O53	658400	5786311	6		0.4	Med	5	6
McKinley	O54	658453	5786430	6		0.5	Med	4	6
McKinley	O55	658330	5786477	6		0.6	Med	4	6
McKinley	O51	658718	5786143			0.0	s.pt		0
McKinley	O56	658313	5786472	6		0.4	Med	4	6
McKinley	O57	658219	5786465	6		0.4	Med	4	6
McKinley	O58	658046	5786439	6		0.4	Low	4	6
McKinley	O59	657879	5786425	6		0.6	Med	4	6
McKinley	O60	657873	5786463	6		0.6	Med	4	6
McKinley	O61	658083	5786635	6		0.5	Med	4	6
McKinley	O62	658123	5786660	6		0.6	Med	4	6
McKinley	O63	658236	5786898	6		0.9	High	5	6
McKinley	O64	658047	5786866	6		0.8	High	4	6
McKinley	O65	657933	5786847	6		0.5	Med	4	6
McKinley	O66	657893	5786828	6		0.5	Med	4	6
McKinley	O67	657737	5786813	6		0.4	Low	4	4
McKinley	O68	657612	5786827	6		0.5	Med	4	2
McKinley	O69	656345	5786925	5	1800	0.0	None	3	4
McKinley	O70	656132	5786896			0.0	s.pt		0

Sub Basin	Cros-sing ID	UTM Easting	UTM Northing	Structure type	Size of Culvert	Crossing Erosion Score	WQCR	Stream width Class	Stream gradient Class
McKinley	O71	655605	5786937	5	500	0.9	High	4	3
McKinley	O72	655469	5786950	5	600	0.8	High	4	2
McKinley	O73	655299	5786919	5	500	0.4	Med	4	2
McKinley	O74	655175	5786905	5	500	0.5	Med	4	2
McKinley	O75	655022	5786896	5	600	0.4	Low	4	2
McKinley	O76	654258	5786597	5	900	0.4	Low	4	4
McKinley	O77	652778	5782657	5	500	0.3	Low	4	2
McKinley	O78	652009	5784156	5	1800	0.0	None	3	2
McKinley	O79	652649	5784066	5	1200	0.0	None	3	4
McKinley	O80	653358	5786119	5	500	0.5	Med	4	4
McKinley	O81	653380	5786713	5	1800	0.5	Med	2	3
McKinley	O82	652893	5788715	5	900	0.4	Med	4	2
McKinley	O83	649766	5790166	5	3000	0.3	Low	3	2
McKinley	O84	649725	5790169	s.pt.		0.0	s.pt		0
McKinley	O85	648273	5788073	s.pt.		0.0	s.pt		0
McKinley	O86	643740	5780613			0.0	s.pt		0
Molybden	Q50	647290	5775258	s.pt.		0.0	s.pt		0
Molybden	Q51	646997	5775433	5	600	0.4	Low	5	3
Molybden	Q52	646743	5775563	5	500	0.9	High	4	2
Molybden	Q53	646548	5775742	5	600	0.9	High	5	3
Molybden	Q54	646520	5775837	s.pt.		0.0	None		0
Molybden	Q55	646152	5776234	5	500	0.9	High	4	3
Molybden	Q56	645900	5776713	5	600	0.9	High	4	4
Molybden	Q57	645550	5777609	5	500	1.0	High	4	4
Molybden	Q58	645293	5778029	5	500	0.5	Med	4	4
Molybden	Q59	645164	5778303	s.pt.		0.0	s.pt		0
Molybden	Q60	645148	5778560	5	500	0.4	Low	4	4
Molybden	Q61	645331	5778748	s.pt.		0.0	s.pt		0
Molybden	Q62	644907	5779151	5	500	0.4	Low	4	2
Molybden	Q63	644890	5779340	5	500	0.4	Low	4	2
Molybden	Q64	644828	5779581	5	500	0.9	High	4	1
Molybden	Q65	644704	5779575	s.pt.		0.0	s.pt		0
Molybden	Q66	644516	5779678	s.pt.		0.0	s.pt		0
Molybden	Q67	644229	5779847	5	600	0.9	High	4	2
Molybden	Q68	644261	5780188	5	500	0.3	Low	4	2
Molybden	Q69	640215	5783098	5	600	0.9	High	4	3
Molybden	Q70	640462	5783122	5	1200	0.2	Low	3	4

Sub Basin	Cros-sing ID	UTM Easting	UTM Northing	Structure type	Size of Culvert	Crossing Erosion Score	WQCR	Stream width Class	Stream gradient Class
Molybden	Q71	641942	5782351	s.pt.		0.0	s.pt		0
Molybden	Q72	641352	5782419	5	500	0.4	Low	4	2
Molybden	Q73	641036	5782560	5	500	0.9	High	4	3
Molybden	Q74	640596	5783400	5	600	0.3	Low	4	4
Molybden	Q75	640499	5783900	5	900	0.4	Med	3	3
Molybden	Q76	639862	5784435	s.pt.		0.0	s.pt		0
Molybden	Q77	640357	5784445	5	900	0.1	Low	3	2
Molybden	Q78	639768	5787994	3	1800	0.2	Low	4	2
Molybden	Q79	639848	5787225	5	600	0.9	High	4	2
Molybden	Q80	640018	5787076	1	N/A	0.3	Low	3	2
Molybden	Q81	640404	5786849	1	N/A	0.2	Low	3	2
Molybden	Q82	640989	5786253	5	600	0.2	Low	4	2
Molybden	Q83	641136	5786223	2	N/A	0.1	Low	2	2
Molybden	Q84	641830	5786291	5	1000	0.3	Low	4	2
Molybden	Q85	643317	5786848	5	450	0.9	High	4	4
Molybden	Q86	643742	5786903	5	500	1.0	High	4	4
Molybden	Q87	643924	5786878	5	500	0.9	High	4	3

APPENDIX 4- Inventory of disturbed channel reaches

ID	Length (m)	Instability level	Source	Reach
Moly-02	446.3536	L	1	MolyR2
Moly-03	495.697	L	1	MolyR2
Moly-04	256.2084	L	1	MolyR2
Moly-06	154.4992	M	1	MolyR2
Moly-05	57.1791	M	1	MolyR2

APPENDIX 5 – Selected photographs

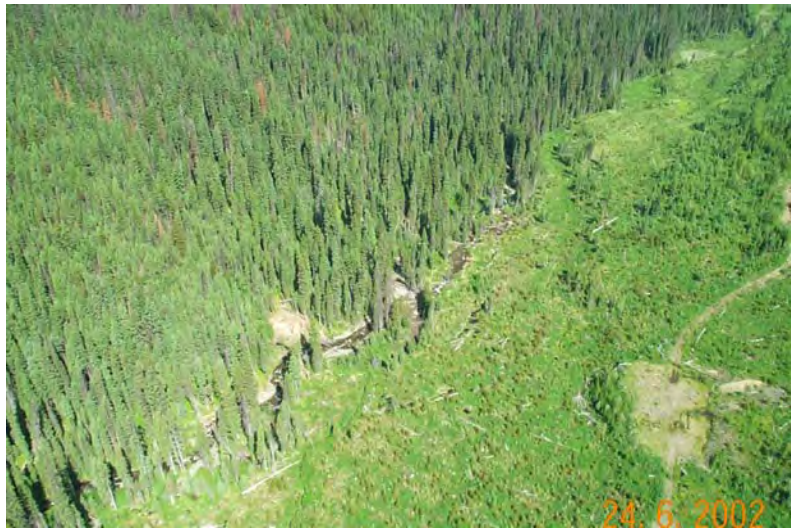
Photograph #966. McKinley Reach #1

Photograph #973. Natural sediment source McKinley Creek.

Photograph # 1004 Mine at headwaters of Molybdenite Creek

Photograph #1009. Headwater stream of Molybdenite Creek

APPENDIX 5 – Selected photographs



Photograph #1020 Channel instability Moly Reach #

Photograph #1024. Natural landslides Moly Reach #

Photograph #215-20. Moly crossing Q64, score=0.9 (high)

Photograph #215-23. Moly crossing Q81, score = 0.2 (low)