Water Quality Objective Monitoring, Klondike River Basin, 2013

Hydrologic and Geomorphic Characteristics of the Klondike River Drainage Basin

The Klondike River, a major tributary to the Yukon River, drains an area of approximately 7800 square kilometers and has an overall channel length, including the North Klondike River, of approximately 160 Km.

The North Klondike River, a tributary of the Klondike River, drains an area of approximately 1100 square kilometers. From its headwaters in the Ogilvie Mountains, the North Klondike flows in a southerly direction for approximately 75 kilometers until its confluence with the Klondike. It then flows west, down the valley as the Klondike for approximately 42 kilometers until it joins the Yukon River near Dawson.

The North Klondike, for its first 58 kilometers, flows through a narrow valley entrenched between high mountains, the remaining length of the Klondike River flows south through relatively flat topography. The banks of the river are stable with relatively little erosion except during flood periods.

Water Survey of Canada's gauging stations are located near the mouth of the north Klondike (09EA004, Km 9.5 Dempster Highway), and at the mouth of the Klondike River (09EA003) near Dawson.

North Klondike

Topographical drainage Basin	1100 Sq. Kilometers
Area of Lakes	<2%
Area of Forest	<44%
Channel Length	76.5 Kilometers
Terrain	glaciated

Klondike

Topographical drainage Basin	7800 Sq. Kilometers
Area of Lakes	<1%
Area of Forest	<30%
Channel Length	160 Kilometers
Terrain	Left Limit: non-glaciated Right Limit: glaciated

In 2013, water samples were collected at 27 sites in the Klondike River basin. Sampling commenced on June 11, 2013 and 1203 samples were collected up until the end of the season on September 29th, 2013. A combination of automatic composite sampling and grab sampling methods were used in the basin.

Atmospheric data was collected using seven portable weather stations located at a sites along Hunker Creek , Bonanza Creek, one on the Klondike River just upstream of Bonanza Creek, and another at the North Klondike Fork. Additional information was provided through the Yukon

Government Community Services weather station at the Klondike Fire Center, located at the Dawson City Airport.
Blitz sampling events took place in the Klondike River basin on several occasions throughout the 2013 field season.

Basin total flow data was provided to us by the Water Survey of Canada station located near the mouth of the Klondike River. Flow data for the individual tributaries to the Klondike River was collected at the time of sampling by the staff of E.M.R CS&I using the methodology outlined in the Yukon Placer Secretariats, Water Quality Monitoring Protocol. Level loggers were also installed at 9 sites along Hunker Creek, Bonanza Creek and Eldorado Creek.

SITE_DESCRIPTION	Lat	Long	ISCO	LEVEL	WEATHER_STATION
Klondike River upstream of Bonanza Creek	64.04311	-139.40936	1	WSC	1
Klondike River upstream of Hunker Creek	64.03529	-139.20909	0	0	0
North Klondike River upstream of confluence with Klondike River	64.00195	-138.59622	1	WSC	1
Bonanza Creek below all mining	64.04054	-139.40814	1	1	0
Lower Bonanza Creek downstream of bridge	63.97027	-139.35472	0	0	0
Bonanza Creek upstream of Adams Gulch (bridge to Upper Bonanza)	63.93415	-139.32977	1	1	0
Upper Bonanza Creek upstream of Eldorado Creek	63.91943	-139.31390	1	1	0
Upper Bonanza Creek upstream of Victoria Gulch	63.91261	-139.20930	1	1	1
Eldorado Creek mouth	63.91943	-139.31390	1	1	1
Upper Eldorado Creek background	63.86187	-139.24578	0	0	1
Hunker Creek mouth	64.03382	-139.20634	1	1	0
Hunker Creek below all mining	64.02943	-139.17867	1	1	1
Hunker Creek downstream of Last Chance Creek (at bridge)	64.01345	-139.09187	1	1	0
Last Chance Creek mouth	64.01050	-139.09091	0	0	0
Hunker Creek upstream of Last Chance Creek	64.01050	-139.09091	0	0	0
Hunker Creek downstream of Goldbottom Creek	63.96918	-138.98291	1	1	0
Hunker Creek above all mining and downstream of right and left fork	63.91503	-138.88501	0	0	1

Klondike Placer Authorization

On April 11, 2008, pursuant to Section 35(2) of the Federal *Fisheries Act*; The Minister of Fisheries and Oceans Canada revoked the conditions of the Yukon Placer Authorization (issued June 1993) and all subsequent amendments pertaining to placer mining works or undertakings and sediment discharge standards in the Klondike River watershed.

The Minister then authorized the "*harmful alteration, disruption or destruction of fish habitat*" resulting from placer mining works or undertakings and the discharge of sediment at concentrations specified in the new authorization, which are uncontaminated by deleterious substances, within certain streams or portions of streams in the Klondike River watershed. The areas of allowable discharge are identified on the *Yukon Placer Fish Habitat Suitability Map for the Klondike River Watershed* (Schedule 1) and the sediment discharge standards for mine discharge (allowable sediment discharge concentrations) detailed in the *Sediment Discharge Standards for Placer Mine Effluent – Klondike River Watershed* (Schedule 2).

Under these new authorizations, it was decided to incorporate a 3-year phase-in schedule for the sediment discharge standards that would apply to each Placer mining operation in the Yukon. This phase-in period would allow both the government mining inspectors and the Yukon Placer Secretariat enough time to ensure that each operator fully understood their requirements to comply with the new authorizations and to operate within the framework of the new management

system for Placer mining in the Yukon. The 3-year phase-in schedule contains the following requirements:

> In 2008 – Licensed placer miners would be informed about the operating practices required to comply with the new system for managing placer mining activity under the *Fisheries Act.* Inspectors and the Yukon Placer Secretariat would ensure that each operator is aware of the specific changes required at his or her site.
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> In 2009 – All licensed placer miners must be oriented to the Design Target and Action Level detailed within the authorization pertaining to the watershed they are operating in and, must comply with a Sediment Discharge Standard for Mine discharge of no greater than 2.5 ml/L, or the standard stipulated in their existing water use license, whichever is more stringent.
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> In addition, in 2011 – All operations must be oriented to operate within the Design Target and Action Level, and must not exceed the Compliance Level stipulated in the table of ***Sediment Discharge Standards for Placer Mine Effluent*** (Schedule 2) for the habitat suitability classification and the watershed in which the mine is located.

The Authorizations 2009 phase-in schedule requiring licensees to comply with an effluent discharge concentration no greater than to 2.5 ml/L effectively cut the existing sediment discharge standards in half for this watershed as the majority of operations were allowed to discharge up to 5.0 ml/L of settleable solids under the YPA. This reduction had a negligible impact on both the operators and the water quality as most operations already typically discharged settleable solids levels well below 2.5 ml/L standard.

Highly sensitive habitat received a high degree of protection under the YPA, and that is maintained in the new system. The degree of disturbance of all mined tributaries in each watershed is recognized under the new rules by the Previous Development designation. The Water Quality Objectives and related discharge standards that are set are designed to mitigate the potentially negative downstream effects of placer mining.

High suitability habitats (Areas of Special Consideration) are defined as watercourses that contain ecologically or culturally important fisheries or aquatic resources. Watercourses assigned this designation may include habitats for rare or locally significant species or areas which directly support subsistence, traditional, commercial or sport fisheries. Areas of Special Consideration (ASC) may be established for either anadromous or nonanadromous species of fish.

In **all cases**, any placer mining activities that are likely to result in the harmful alteration, disruption or destruction of High (ASC) suitability habitats require a site-specific review, and if the activity is deemed to be acceptable, a site-specific authorization issued by Fisheries and Oceans Canada. In order to further protect these ASCs, a full compensation and fish habitat restoration plan must be submitted to Fisheries and Oceans Canada with any proposal to conduct works in or around High (ASC) suitability habitats.

In moderately sensitive habitat where mining has occurred for decades, the *Previous Development* designation results in application of a less stringent discharge standard, recognizing that the habitat features predicted by the classification model likely do not exist.

The degree of disturbance of all mined tributaries is recognized by the Previous Development designation. The development of Hunker and Bonanza Creeks is considered "Extensive" and appropriate discharge and downstream water quality standards apply. The set Water Quality Objectives and related discharge standards are designed to mitigate the potentially negative downstream effects of placer mining. In the case of both Hunker and Bonanza creeks, the effect of these slightly less stringent discharge standards and reduced water quality objectives is decreased naturally by the geographical positioning of these creeks and the nature of the receiving waters they discharge into, in this case the Klondike River, a 5th order stream. The Klondike's high volume, near clear water flow, has a huge dilution and carrying capacity and is capable of easily dispersing the relatively low flow of turbid water from both creeks. In addition, the confluence of both creeks with the Klondike River is but a short distance upstream from the confluence of the Klondike River with the Yukon River, a highly turbid category 8 river.

Site Codes and Global Position of Water Quality Sampling Locations in the Klondike River Watershed

SITE_DESCRIPTION	SITE_CODE	LATITUDE_DD	LONGITUDE_DD
Klondike River mouth	KL01	64.05348	-139.43961
Klondike River upstream of Bonanza Creek	KL02	64.04311	-139.40936
Klondike River upstream of Hunker Creek	KL03	64.03619	-139.20204
Klondike River downstream of Goring Creek and upstream of Hunker Creek	KL04	64.05810	-139.03092
Klondike River at Dempster Highway	KL05	63.99030	-138.74612
Klondike River downstream of Too Much Gold Creek and upstream of Dempster highway	KL06	63.95778	-138.69030
Klondike River upstream of Too Much Gold Creek	KL07	63.95131	-138.66690
Klondike River at highway washout downstream of Flat Creek	KL08	63.95782	-138.69005
North Klondike River upstream of confluence with Klondike River	KL_NK01	64.00195	-138.59622
Adams Creek mouth	KL_BO_AD01	63.93412	-139.33099
All Gold Creek below all mining	KL_AL01	63.94263	-138.61734
Eldorado Creek mouth	KL_BO_EL01	63.91943	-139.31390
Elodorado Creek Left Fork	KL_BO_EL06	63.86261	-139.24573
Eldorado Creek Right Fork	KL_BO_EL05	63.86261	-139.24573
Eldorado Creek downstream of French Gulch	KL_BO_EL02	63.91267	-139.31483
Eldorado Creek upstream of French Creek	KL_BO_EL03	63.90855	-139.31382
Upper Eldorado Creek background	KL_BO_EL04	63.86187	-139.24578
Flat Creek below all mining	KL_FL01	63.94308	-138.60225
French Gulch mouth	KL_BO_EL_FR01	63.90865	-139.31442
Goldbottom Creek mouth	KL_HU_GO01	63.96433	-138.96706
Last Chance Creek mouth	KL_HU_LA01	64.01050	-139.09091
Too Much Gold Creek mouth	KL_TO01	63.95132	-138.66708
Victoria Gulch mouth	KL_BO_VI01	63.91261	-139.20930
Bonanza Creek below all mining	KL_BO01	64.04054	-139.40814
Lower Bonanza Creek	KL_BO02	64.01295	-139.37022
Lower Bonanza Creek downstream of bridge	KL_BO03	63.97027	-139.35472
Bonanza Creek downstream of Adams Gulch	KL_BO04	63.93550	-139.32798
Bonanza Creek upstream of Adams Gulch	KL_BO05	63.93415	-139.32977
Bonanza Creek downstream of Eldorado Creek	KL_BO06	63.92047	-139.31600
Upper Bonanza Creek upstream of Eldorado Creek	KL_BO07	63.91943	-139.31390
Upper Bonanza Creek upstream of Victoria Gulch	KL_BO08	63.91261	-139.20930
Hunker Creek below all mining	KL_HU01	64.02943	-139.17867
Hunker Creek mouth - most upstream fork	KL_HU01C	64.03619	-139.20204
Hunker Creek mouth fork with multiple channels - larger creek bed	KL_HU01B	64.03592	-139.20201
Hunker Creek mouth behind Fischer's gas station	KL_HU01A	64.03382	-139.20634
Hunker Creek downstream of Henrry Gulch	KL_HU02	64.02838	-139.17522
Hunker Creek downstream of Last Chance Creek	KL_HU03	64.01345	-139.09187
Hunker Creek upstream of Last Chance Creek	KL_HU04	64.01050	-139.09091
Hunker Creek downstream of Goldbottom Creek	KL_HU05	63.96918	-138.98291
Hunker Creek upstream of Goldbottom Creek	KL_HU06	64.96433	-138.96706
Hunker Creek above all mining left fork	KL_HU07	63.91105	-138.88522
Hunker Creek right fork	KL_HU08	63.89025	-138.92522
Hunker Creek above all mining and downstream of right and left fork	KL_HU09	63.91503	-138.88501

Water Quality Objective monitoring, Klondike River Watershed – Summary

Because of extensive monitoring activities conducted in this watershed between 2004 and 2012, which provided vast amounts of data for comparative purposes, and due to a large number of both active and historic mines in the drainage area, the Klondike River Watershed was once again designated a '*major'* watershed for monitoring in 2013.

Eleven automatic water-sampling stations, seven portable weather-monitoring stations and nine level loggers were set up and maintained from June 11th, 2013 until shutdown on September 29th, 2013. Water sampling sites in the Klondike received multiple visits during the monitoring season owing to their close proximity to Dawson.

From the data obtained by these instruments and through on site visits and sampling conducted by CS&I staff, the following observations regarding the water quality in the basin can be made:

> On average, at the five Klondike River sites monitored during the 2013 season, the water quality of the Klondike River, met the minimum objectives set under the *Fish Habitat Management System*. On those occasions when the WQO were not met and the Total Suspended Solids levels were greater than the objectives, a direct correlation between environmental conditions and the volume of solids in the water was observed.
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> In most cases, rainfall, as either localised events or basin wide occurrences, increased the amount of surface run off and subsequent soil erosion from the land, increasing the input of sediment into the receiving waters. These increases occurred simultaneously at the time of the rain event or immediately in a period of one or two days after the rain event, as surface water continued draining from the land and ground water infiltrated the watercourse.
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> Increases in sediment-laden ground and surface water entering the system add to the amount of sediment in the water. The ability of the receiving water to dilute these inputs of sediment is negated by the re-suspension of streambed material and by the further erosion of the streams banks that occurs along with the increased flows that are generated by the aftermath of these rain events.

All of these factors; precipitation leading to increased sediment input and increased flows from these rain events re-suspending and further eroding material, lead to an increase in suspended solids concentrations in 2013 when compared with the results from 2012 and a decrease in overall water quality. The seasonal average TSS for 2013 was 52.9 mg/L, which is approximately 25 mg/L higher than in 2012 at 27.8 mg/L.

This is a direct result of increased surface water runoff and increased ground water infiltration, in part, due to above average seasonal rainfall and higher than average seasonal air temperatures, which resulted in more saturated ground, warmer ground temperatures and a greater degradation of the permafrost as well to higher discharge flows from disturbed and previously developed areas.

It is important to note that the average water quality of the Klondike River at site KL03, which is up stream of the major discharge of Hunker and Bonanza Creeks, both areas of significant previous development, was 10.3 mg/L, 14.7 mg/L lower than the water quality objective of 25 mg/L. This means that the drainage area downstream of KL03 had a significant effect on the contribution of solids to the watercourse and an increase in the downstream concentration vs. flow gradient.

KL01	KL_BO01	KL02	KL_HU01A	KL_HU01	KL03	KL05	KL06	KL_NK01	KL_ FL01
Mouth	BAM	u/s KL_BO01	Mouth	BAM	u/s KL_HU01	at demptser hwy	u/s dempster hwy	u/s of Klondike R	Mouth
Grab	Auto/Grab	Grab	Auto/Grab	Auto/Grab	Grab	Grab	Grab	Auto/Grab	Grab
64.05348	64.04054	64.04237	64.03382	64.02943	64.03529	63.99030	63.95778	64.00195	63.94316
-139.43961	-139.40814	-139.40956	-139.20634	-139.17867	-139.20909	-138.74612	-138.69030	-138.59622	-138.60188
Area of special consideration	Moderate-L	Area of special consideration	Moderate-L	Moderate-L	High	High	High	High	Moderate-L
25	**80**	**25**	**80**	**80**	**25**	**25**	**25**	**25**	**80**
33.0	**9.0**								
26.0	**26.0**	**32.0**		**233.0**	**38.0**				
	14.0	**26.0**							
	10.0	**22.0**		**152.0**					
	20.0	**23.0**		**365.0**		**11.0**		**6.0**	**6.0**
	8.0	**29.0**		**252.0**				**13.0**	
	22.0	**61.0**		**336.0**				**16.0**	
	20.0	**21.0**		**270.0**				**8.0**	
	13.0	**13.0**		**263.0**				**17.0**	
	60.0	**9.0**		**482.0**				**50.0**	
	97.0	**83.0**		**688.0**				**18.0**	
	473.0	**78.0**		**1827.0**				**16.0**	
	2369.0	**52.0**		**8350.0**				**10.0**	

	241.0	28.0						7.0	
	84.0	15.0						10.0	
	42.0	10.0						6.0	
	39.0	10.0						9.0	
	38.0	9.0		2518.0				9.0	
	303.0	54.0		1172.0				10.0	
	111.0	27.0						10.0	
	64.0	17.0						8.0	
	252.0	31.0		158.0				9.0	
	53.0	14.0		179.0				28.0	31.0
7.0	25.0	8.0	100.0	65.0				7.0	
7.0	57.0	8.0	20.0	84.0	8.0	6.0		7.0	
	28.0	7.0	27.0	110.0				2.0	
	24.0	7.0	21.0	149.0				3.0	
	23.0	7.0	26.0	111.0				3.0	
	26.0	7.0	27.0	138.0				6.0	
	16.0	7.0	33.0	86.0				5.0	
	37.0	5.0	31.0	77.0				3.0	
	15.0		37.0	99.0				5.0	
	19.0		39.0	135.0				1.0	
	12.0		25.0	233.0				5.0	
	13.0		13.0	309.0				2.0	
	10.0		17.0	575.0				3.0	
	15.0		13.0	362.0				4.0	
	84.0		11.0	281.0				4.0	
	28.0		14.0	420.0				5.0	

	21.0		7.0	374.0				3.0	
	17.0		7.0	818.0				6.0	
	13.0		11.0	496.0				5.0	
5.0	14.0	6.0	9.0	365.0				3.0	
	22.0	6.0	9.0	605.0				3.0	
4.0	25.0	10.0	15.0	354.0				1.0	
3.0	15.0	3.0	13.0	192.0				3.0	5.0
5.0	8.0	4.0	13.0	376.0				4.0	
	10.0		8.0	30.0				2.0	
	7.0	3.0	6.0	39.0				3.0	
	14.0	5.0	4.0	137.0				5.0	
	7.0	5.0	4.0	94.0				7.0	
	9.0	7.0	6.0	103.0				5.0	
	37.0	7.0	7.0	49.0				4.0	
	94.0	3.0	4.0	30.0				6.0	
	1940.0	5.0	4.0	37.0				4.0	
	237.0	5.0	5.0	39.0				3.0	
	29.0	5.0	3.0	45.0				4.0	
	18.3	0.7	4.0	26.0				6.0	
	34.7	3.2	5.0	57.0	7.0			4.0	
4.0	13.0	4.3	7.7	25.3				5.0	
	9.0	1.6	6.0	57.5		4.0		5.0	5.0
	8.7	2.9	3.3	95.5				1.7	
	6.0	3.2	3.3	43.8				3.0	
	8.0	2.4	6.0	60.7				1.0	
	66.8	1.9	7.2	114.6				1.2	

	65.2	2.3	9.6	99.8				0.0	
	24.7	2.2	5.6	60.6				0.3	
	91.3	1.8	1.6	74.2				0.3	
	22.0	2.2	4.0	50.0				0.7	
	9.2	0.2	2.0	60.5				3.0	
	3.6	1.0	11.2	138.0				0.5	
	10.0	1.3	1.2	447.2				0.3	
	10.0	3.2	1.6	547.2				1.0	
0.6	13.7	0.8	4.3	465.6	1.5	2.0		0.3	1.6
1.5	14.3	0.8	2.4	189.3				3.2	
	1622.4	28.0	91.6	1386.5				24.4	
	128.4	67.6	50.4	317.7				7.2	
	104.0	8.8	9.6	176.0				4.8	
	67.2	7.6	10.4	123.2				1.2	
	40.7	6.0	8.4	81.6				3.6	
	16.0	7.6	14.8	88.0				4.0	
	23.7	7.6	7.6	129.7				0.0	
	47.6	3.6	12.0	178.0				2.8	
	38.4	18.4	21.2	376.0				0.8	
	33.6	8.0	27.2	270.0				3.2	
	27.3	6.8	45.6	132.0				2.0	
	29.0	3.2	34.0	158.0				0.4	
	50.0	0.4	17.2	316.3				1.2	
	15.7	4.0	18.8	180.8				4.0	
	18.8	3.6	14.4	164.4				2.4	
1.1	35.6	16.4	20.4	137.6				2.4	

3.0	26.4	4.8	20.0	163.2				0.4	
1.1	31.0		26.4		2.1	2.9		2.0	3.6
6.6	94.2	11.1	12.8	322.0	10.3	5.3		5.5	8.7
17	110	97	92	100	6	6		105	6

Not continuously monitored

Water Samples that are: Above / Below the Water Quality Objective