Memorandum

SEABRIDGE GOLD

DATE:	November 28, 2013
TO:	Elizabeth Miller and Brent Murphy (Seabridge Gold)
FROM:	Rescan Environmental Services Ltd.: Christopher Burns, B.Sc., R.P.Bio and Kirsten Seymour, M.Sc., R.P.Bio
SUBJECT:	KSM Project Application/Environmental Impact Statement Memo Ref.: CEAATBL2_CMT2_Fish Salvage Plan

The purpose of this memo is to respond to comments received from the Department of Fisheries and Oceans on the Application/EIS for the proposed KSM project.

Please note that the original comment is provided in italics below for reference. The relevant response follows this.

Comment:

"The Proponent is proposing to salvage the Dolly Varden currently residing in the area of the proposed Tailing Management Facility and relocate them into Treaty Creek. Currently Treaty Creek supports a population of Dolly Varden. The Proponent has provided a rationale outlining that the relocation of the Dolly Varden into Treaty Creek is likely to be successful, however it is DFO's view that there is uncertainty with regard to the survival of the relocated fish and/or whether the relocated fish will displace individuals from the existing population of Dolly Varden.

Primarily, DFO is concerned that there may not be a sufficient amount of existing habitat in Treaty Creek to support both the existing population of Dolly Varden and the relocated fish from the Tailing Management Facility. The description of the existing habitat in Treaty Creek does not clearly identify a specific factor which currently limits the population size of Dolly Varden. Furthermore, the Proponent has not provided a total population estimate of the number of Dolly Varden likely to be relocated from the Tailing Management Facility. Although the density of fish in the proposed Tailing Management Facility indicates it would be a large number of fish. Without fully understanding the habitat which currently limits the population in Treaty Creek, combined with not knowing the total number of fish likely to be relocated into Treaty Creek, it is DFO's view that there remains uncertainty regarding whether there is sufficient habitat available to support the relocated fish.

The Proponent is proposing to construct fish habitat compensation to offset the losses in fish habitat resulting from the project. Proposed fish habitat compensation projects include the development of new habitat or enhancements of existing habitat in Glacier, Taft, Teigen and Treaty Creaks. The additional fish habitat proposed for Treaty Creek habitat is being designed to provide spawning, rearing and overwintering habitat that can be utilized by all life stages of Dolly Varden. To reduce the uncertainty with regard to the success of the relocation of Dolly Varden into Treaty Creek, DFO recommends that the new fish habitat in Treaty Creek be constructed prior to the relocation of the Dolly Varden. If this approach is taken, the relocated Dolly Varden would have access to, and could make use of, 15.35 ha of new habitat in Treaty Creek. The fish habitat loss anticipated as a result of the Tailing Management Facility is approximately 12.9 ha.

DFO recognizes that there would still remain some degree of uncertainty with regard to whether the type of habitat being created will provide a sufficient amount of habitat for the life stages of fish being relocated; however DFO believes that the approach recommended increases the likelihood that

the relocated Dolly Varden will survive and/or reduces the new pressure of increased competition for habitat and food resources with the existing population of Dolly Varden in Treaty Creek.

The proponent is requested to respond to uncertainties with the fish salvage program. The proponent can provide a rationale supporting the assertion that there is enough existing habitat in Treaty Creek to support the number of fish likely to be relocated from the Tailing Management Facility. This rationale should include a discussion on the available habitat in Treaty Creek, the factor currently limiting the population size of Dolly Varden in Treaty Creek and an estimate of the number of fish likely to be relocated into Treaty Creek. Alternatively, the proponent can address the suggestion that fish habitat compensation be implemented prior to the fish salvage from the TMF. "

Response:

Based upon DFO and KSM Fisheries Working Group recommendations on November 15, 2013, the relocation strategy for Dolly Varden requires further assessment to ensure that all potential relocation options are considered and evaluated. To assess all potential relocation options, a general framework for ecological risk assessment was adopted to reduce risks and uncertainties associated with the Dolly Varden relocation. Of the top least risk waterbodies identified in Teigen Watershed, Hodkin Lake is the preferred option to accept Dolly Varden from South Teigen Watershed. Of the top least risk waterbodies identified in Treaty Watershed, Treaty Creek (reaches 2 and 3) is the preferred option to accept Dolly Varden from North Treaty Watershed. Post-relocation effectiveness monitoring will be conducted.

1. Purpose and Background

The purpose of this memo is to respond to comments received from the KSM Fisheries Working Group and public on the Application/EIS for the proposed KSM project.

A tailing management facility (TMF) fish salvage plan was proposed in Section 26.18.3 of the KSM Project Application for an Environmental Assessment Certificate / Environmental Impact Statement (Rescan 2013). The TMF fish salvage plan proposed relocating the salvaged Dolly Varden (*Salvelinus malma*), via helicopter, throughout Treaty Creek mainstem. The rationale for selecting Treaty Creek for relocation was as follows (Rescan 2013):

- Dolly Varden is the most abundant species within Treaty Creek, suggesting suitable biological and physical conditions for survival, growth, and reproduction;
- The low abundance of bull trout reduces the risk of increased hybridization;
- There is a large area of suitable rearing and overwintering habitat available for Dolly Varden;
- There is abundant Dolly Varden spawning habitat within Treaty Creek tributaries;
- The short distance from the TMF provides similar genetic stock and maximizes the survival of relocated fish; and
- North Treaty Creek is located within the Treaty Creek watershed.

Based upon KSM Fisheries Working Group recommendations on November 15, 2013, the relocation strategy for Dolly Varden requires further assessment to ensure that all potential relocation options are considered and evaluated. To assess the relocation options, a general framework for ecological risk assessment (CCME 1996) will be adopted to reduce risks and uncertainties associated with the fish relocation. An ecological risk assessment is the process for evaluating how likely it is that the environment may be impacted as a result of exposure to one or more environmental stressors such as species introductions (CCME 1996).

The objectives for developing the Fish Salvage Relocation Strategy are:

- Identify waterbodies within Teigen and Treaty watersheds that could receive relocated Dolly Varden;
- Conduct a literature review of stocking rates for Dolly Varden and/or similar species;
- Determine the number of Dolly Varden that could be relocated to identified waterbodies;
- Identify the ecological risks associated with relocating Dolly Varden, and compare the risks for each identified waterbody; and
- Propose a TMF Fish Salvage Relocation Strategy for the KSM Project which allows for monitoring and adaptive management.

2. Waterbody Identification

Within Teigen and Treaty watersheds, a number of lakes and streams have the potential to accept relocated Dolly Varden. Table 1 presents a list of potential stream options, including habitat data and species presence information. Table 2 presents a list of potential lake options, including habitat data and species presence information. Figures 1 and 2 show the locations of the selected waterbodies within Teigen and Treaty watersheds, respectively. All of these waterbodies were assessed in baseline studies from 2008 to 2012, except Lake 2 (Rescan 2009a, 2010a, 2011, 2012a, 2012b, 2012c). All of the selected waterbodies are fish-bearing. Dolly Varden are present in all identified waterbodies.

3. Stocking

3.1 Population Size and Demography

Table 3 presents an estimated Dolly Varden population size from South Teigen and North Treaty watersheds within the proposed TMF. The population size was derived from 2009 density (no. fish/100 m^2) assessments conducted within the proposed TMF and known fish habitat area. According to the proposed KSM Project construction schedule, the North and CIL Cells would be constructed in Year 1; therefore Dolly Varden in South Teigen mainstem and tributaries would need to be salvaged prior to Year 1. The South Cell would be constructed in Year 25; therefore Dolly Varden in North Treaty mainstem and tributaries would not need to be salvaged until Year 24.

Mean fork length and weight of Dolly Varden in South Teigen and North Treaty watersheds are presented in Table 4. Generally, smaller Dolly Varden reside in the tributaries than the mainstems (Rescan 2010a). Length-frequency distributions were plotted for all Dolly Varden caught in South Teigen and North Treaty watersheds (Figures 3 and 4). Length classes present in South Teigen tributaries was skewed towards smaller length classes, with fewer larger length classes compared to South Teigen Creek. Length classes present in North Treaty tributaries was shifted towards smaller length classes, with fewer larger length classes, compared to North Treaty Creek. Length class modes were similar between watersheds, with approximate length ranges of 25 – 45 mm for fry, 45 – 70 mm for parr, 70 -85 mm for 2+ fish, and 85 – 105 mm for 3+ fish (Rescan 2010a).

Table 1. Selected Streams within Teigen and Treaty Watersheds

			Physical Information		Species Presence						
Watershed	Stream Name	Reach	Stream Length (km)	Stream Area (ha)	Bull Trout	Chinook Salmon	Coho Salmon	Dolly Varden	Mountain Whitefish	Sockeye Salmon	Rainbow Trout/ Steelhead
Teigen	Teigen Creek	1	7.9	81.4	X	X	X	X	X	X	X
Teigen	Teigen Creek	2	11.4	67.3	X	X	X	X	X	X	X
Teigen	Teigen Creek	3	11	36.3	X	X	X	X	X	X	X
Teigen	West Teigen Creek	1	0.5	0.3	-	-	-	X	-	-	-
Teigen	West Teigen Creek	2	3.3	2.0	-	-	-	X	-	-	-
Teigen	Hodkin Creek	1	0.6	0.4	X	-	-	X	-	-	X
Teigen	Hodkin Creek	2	2.9	2.1	X	-	-	X	-	-	X
Teigen	Snowbank Creek	1	6.1	12.2	X	X	X	X	X	-	X
Treaty	Treaty Creek	1	7.9	27.7	X	X	X	X	X	X	X
Treaty	Treaty Creek	2	18.4	294.4	X	X	X	X	X	X	X
Treaty	Treaty Creek	3	9.2	33.6	-	-	-	X	-	-	-
Treaty	Todedada Creek	1	3.3	6.0	-	X	X	X	-	X	X
Treaty	Todedada Creek	2	3.4	4.8	-	-	X	X	-	-	-
Treaty	East Todedada Creek	1	0.9	0.9	-	-	X	X	-	X	-
Treaty	East Todedada Creek	2	2.6	2.1	-	-	X	X	-	-	-
Treaty	Gilbert Creek	1	1.9	1.3	-	X	X	X	X	-	X

Notes:

X = indicates that Project-specific sampling data was utilized to confirm fish species presence.

O = indicates that other sources of existing inventory data (e.g., historical literature) was used to confirm fish species presence.

Dashes indicate sampled and not present.

Table 2. Selected Lakes within Teigen and Treaty Watersheds

		Physical Information			Species Presence							
Watershed	Lake Name	Maximum Depth (m)	Mean Depth (m)	Surface Area (ha)	Bull Trout	Chinook Salmon	Coho Salmon	Dolly Varden	Longnose Sucker	Mountain Whitefish	Sockeye Salmon	Rainbow Trout/ Steelhead
Teigen	Teigen Lake	39	20.8	210.0	X	O	-	O	O	X	-	O
Teigen	Hodkin Lake	58	22.0	161.7	-	-	-	X	O	-	-	O
Teigen	West Teigen Lake	13	UNK	33.4	-	-	-	X	-	-	-	-
Treaty	Gilbert Lake	8	UNK	51.4	-			X		X		X
Treaty	Todedada Lake	16	UNK	24.4	-	-	-	X	-	-	-	X
Treaty	Lake 1	10	UNK	8.0	-	-	-	X	-	-	-	X
Treaty	Lake 2	UNK	UNK	11.8	-	-	-	X*	-	-	-	X*

Notes:

UNK = unknown because bathymetry data not available

X = indicates that Project-specific sampling data was utilized to confirm fish species presence.

O = indicates that other sources of existing inventory data (e.g., historical literature) was used to confirm fish species presence.

Dashes indicate sampled and not present.

** Species assumed based upon species presence downstream*

PROJECT # 0196301-0028-0003 GIS No. KSM-06-182_T November 26, 2013

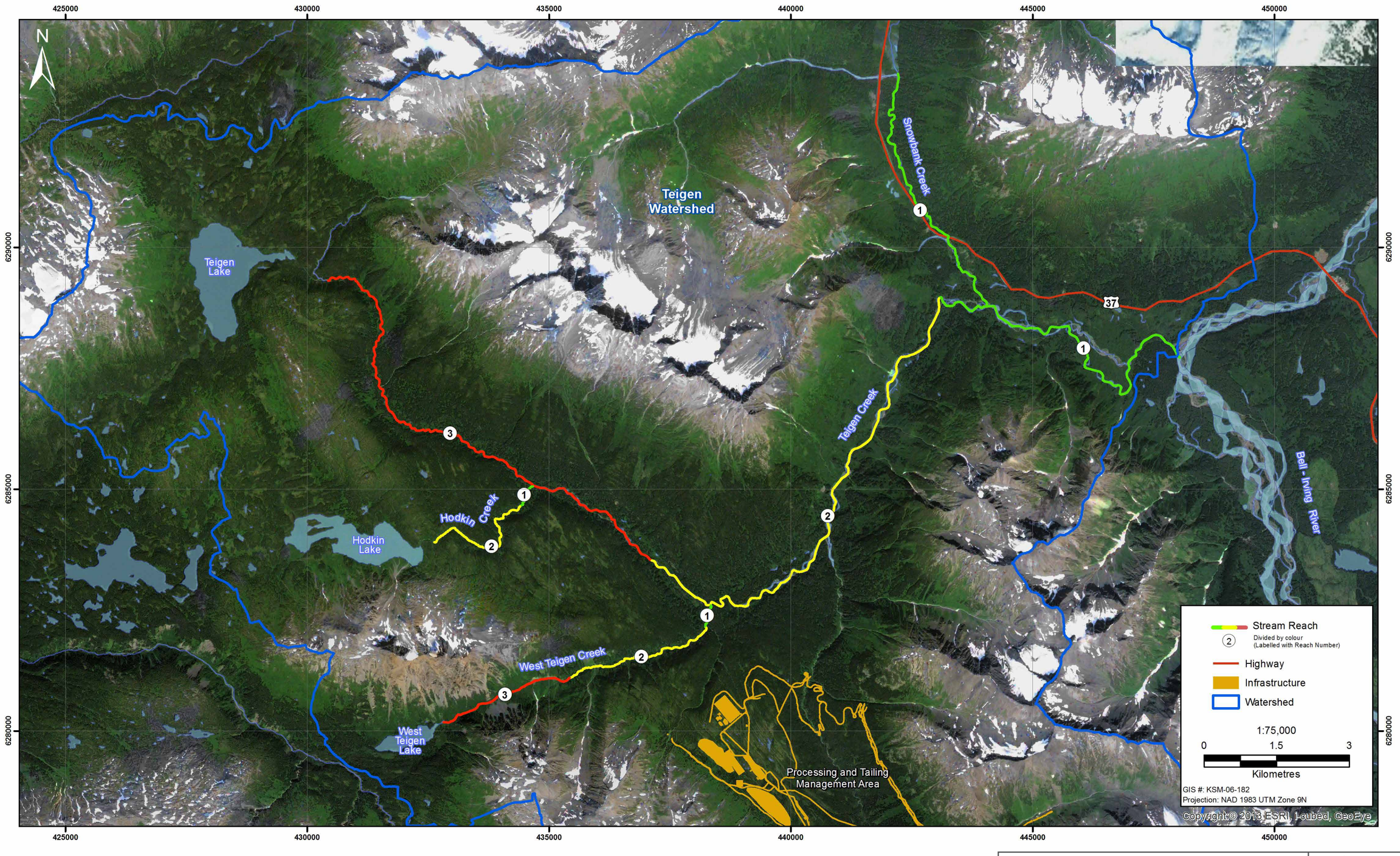


Figure 1

SEABRIDGE GOLD
KSM PROJECT

Rescan Engineers & Scientists

Location of Selected Waterbodies within the Teigen Watershed

PROJECT # 0196301-0028-0003 GIS No. KSM-06-181_T November 26, 2013

435000 440000 445000 450000 455000 460000

6275000 6270000 6265000 6260000

Processing and Tailing Management Area

Treaty Saddle Road

Treaty Creek Access Road

37

Lake 2

Lake 1

Gilbert Lake

Treaty Creek

Gilbert Creek

Todedada Creek

East Todedada Creek

Treaty Watershed

Todedada Lake

N

Stream Reach
2 Divided by colour (Labelled with Reach Number)
Highway
Infrastructure
Watershed

1:80,000

0 2 4
Kilometres

GIS #: KSM-06-181
Projection: NAD 1983 UTM Zone 9N

Figure 2

SEABRIDGE GOLD
KSM PROJECT

Rescan Engineers & Scientists

Location of Selected Waterbodies within the Treaty Watershed

Table 3. Mean Estimated Dolly Varden Population Size within the Proposed TMF

TMF Cell	Habitat Type	Population Size
North Cell and CIL Cell	South Teigen Mainstem	5,204
	South Teigen Tributaries	510
South Cell	North Treaty Mainstem	21,960*
	North Treaty Tributaries	3,339

** High standard error associated with density estimate because habitat complexity and diverse habitat units*

Note: Standard error associted with densiity estimates are provided in Rescan 2010a.

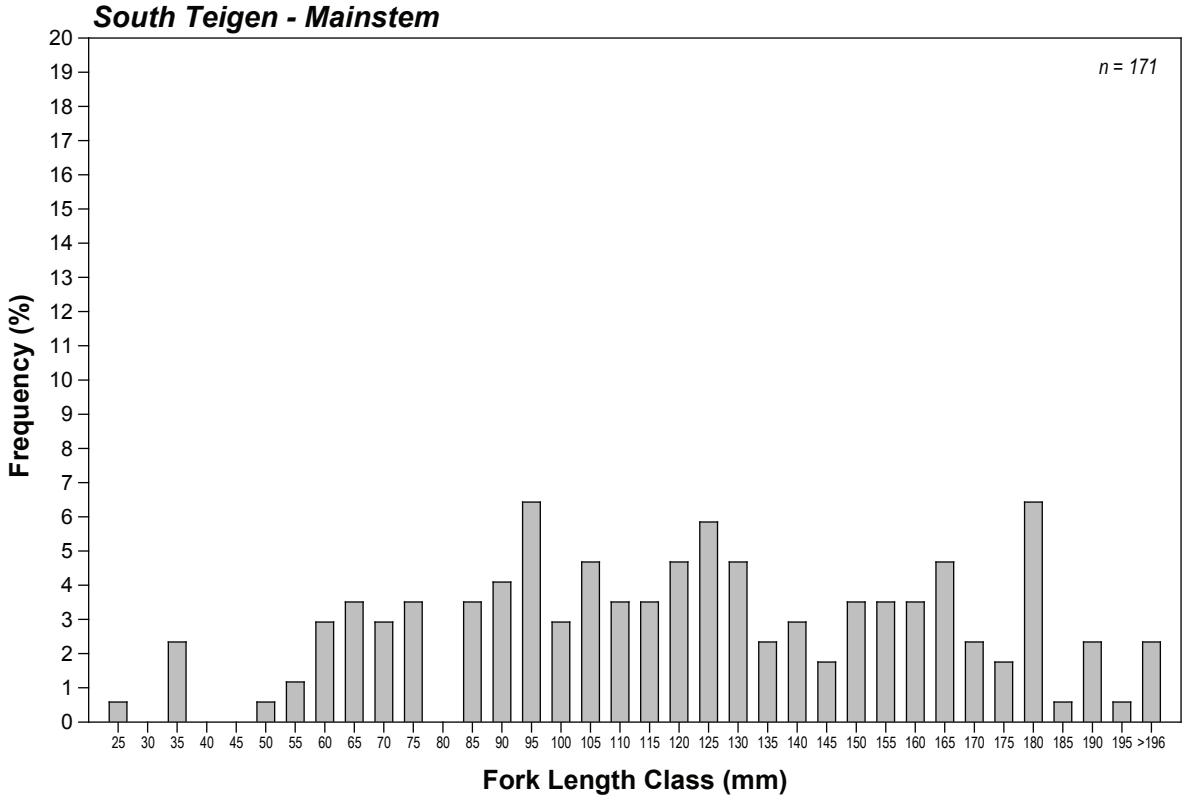
Table 4. Mean Fork Length and Weight of Dolly Varden Captured in South Teigen and North Treaty Watersheds, 2009

	Length (mm)					Weight (g)				
Watershed	N	Mean	SE	Min	Max	N	Mean	SE	Min	Max
North Treaty (Mainstem)	261	97.4	2.14	28.0	185.0	261	13.1	0.77	0.20	66.5
North Treaty (Tributaries)	303	68.2	1.61	22.0	180.0	258	4.8	0.44	0.20	59.6
South Teigen (Mainstem)	171	120.2	3.21	25.0	210.0	170	25.1	1.72	0.20	101.9
South Teigen (Tributaries)	398	71.2	2.05	23.0	179.0	293	9.4	0.70	0.10	61.0

Notes:

SE = standard error

N= sample size



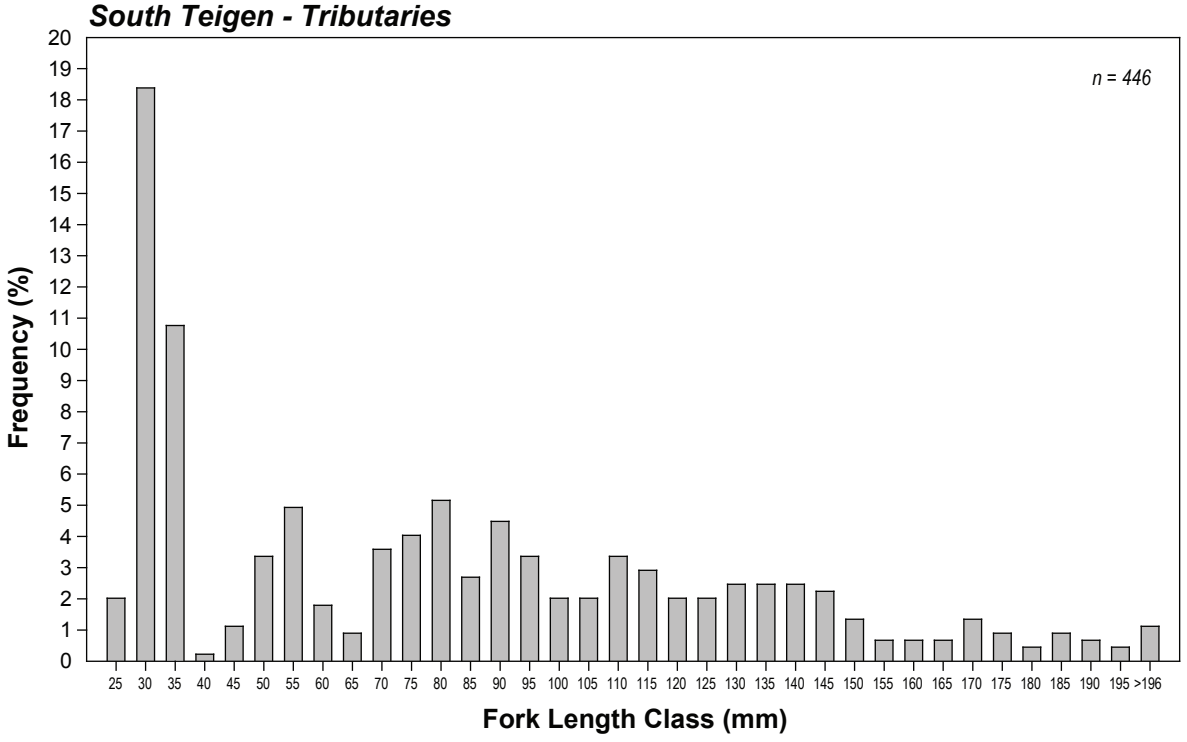
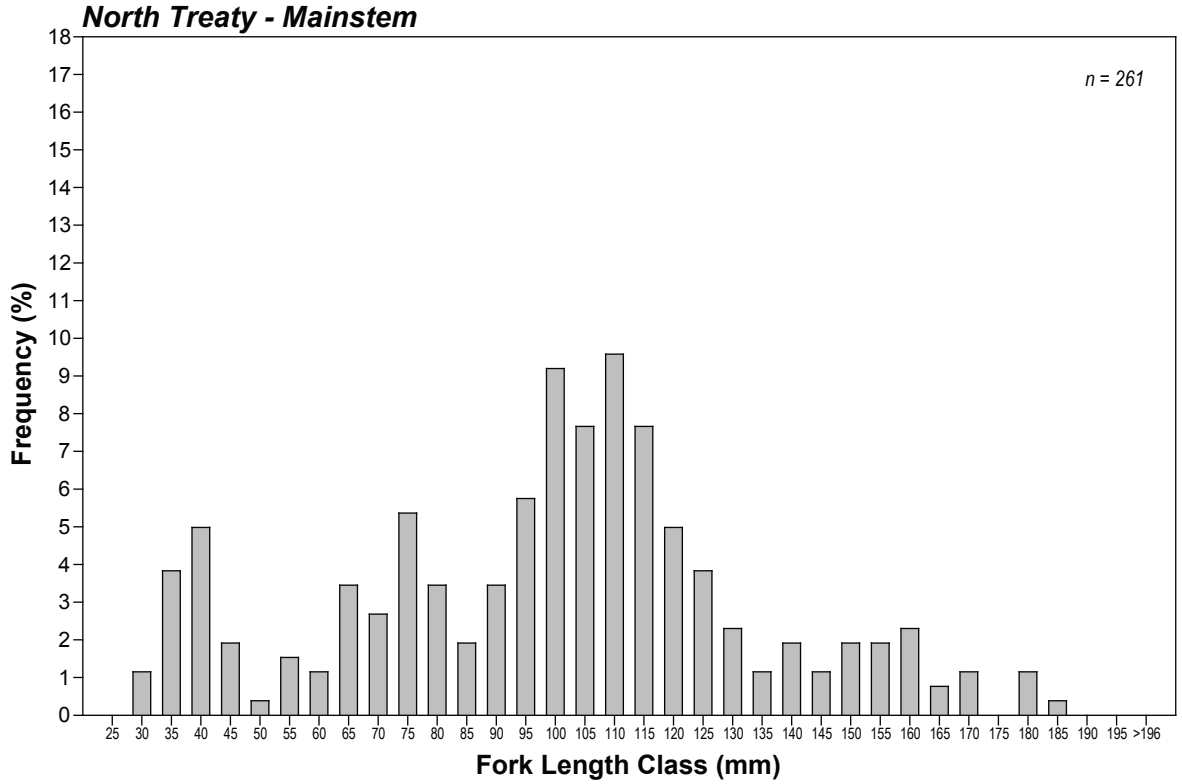


Figure 3

Fork Length Class Distribution of Dolly Varden within South Teigen Watershed, 2009

SEABRIDGE GOLD
KSM PROJECT

Rescan™
Engineers & Scientists



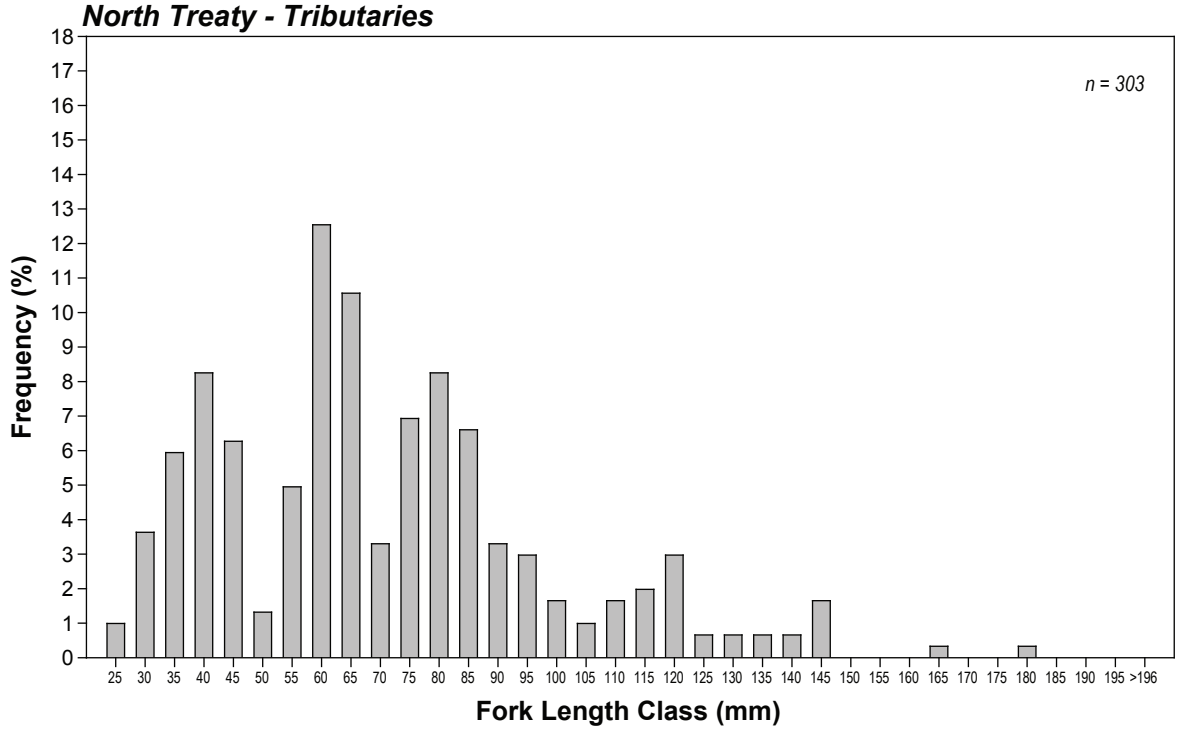


Figure 4

Fork Length Class Distribution of Dolly Varden within North Treaty Watershed, 2009

SEABRIDGE GOLD
KSM PROJECT

Rescan
Engineers & Scientists

3.2 Stocking Rates

A fish salvage and relocation activity of this scope and size is similar to a provincial or federal waterbody stocking program. Stocking fish can be used for multiple management objectives. In this case, the objectives are Dolly Varden relocation are:

- Provide survival of relocated Dolly Varden effected by TMF development; and
- Reduce environmental risks associated with Dolly Varden relocation.

Prior to stocking a waterbody, an appropriate fish stocking rate is determined based on the intended stocking objective and the physical, chemical and biological parameters of the waterbody being stocked. Provincial and federal fish stocking guidelines provide general standards for fish stocking rates based on the species, fish size and parameters of the waters being stocked. These guidelines serve as a starting point for stocking, with a requirement for monitoring and adaptive management (OMNR 2002).

Dolly Varden are not stocked in provincial, federal or state agencies throughout the species range; therefore existing stocking rate guidelines are not available. Given the lack of existing Dolly Varden stock rates, a review of stocking rates for similar species within the same genus, *Salvelinus*, was conducted.

Bull Trout (*Salvelinus confluentus*) are a closely related species to Dolly Varden (McPhail and Baxter 1995; McPhail 2007; Baxter et al. 1997; Redenback 2000; Redenback and Taylor 2002). However, Bull Trout are not currently stocked in provincial, federal or state agencies throughout the species range. In 1980, an experimental Bull Trout stocking program was conducted at the Hill Creek hatchery near Upper Arrow Lake, BC (Montana Bull Trout Scientific Group 1996; Toth and Tsumura 1996). However, stocking rates for the Bull Trout experimental program are unavailable and post-stocking success of this program was inadequate to assess its outcome (Montana Bull Trout Scientific Group 1996). Furthermore, the hatchery production was reduced and then suspended in the late 1990s. Bull Trout were stocked from the Whitehorse Rapids Fish Hatchery to Long Lake, YK. In 2009 this program was discontinued, stocking rates were not developed, and post-stocking success of this program was inadequate to assess its outcome (O. Barker, pers. comm.).

Arctic Char (*Salvelinus alpinus*) are a closely related species to Dolly Varden (Brunner et al 2001; McPhail 2007; Phillips et al. 1999). Arctic char are currently stocked in Alaska. Arctic char are stocked in landlocked interior and south-central Alaskan lakes and the success of the stocking program have been evaluated (Havens, Bradley and Baer 1995). Arctic char have been stocked in Yukon lakes for more than 20 years. In 2009 this program was discontinued as many of the stocked lakes naturalized to established self-reproducing populations, and stocking rates were not developed (O. Barker, pers. comm.). The Arctic Char stocking rate for Alaska are provided in Table 5.

Brook Trout (*Salvelinus fontinalus)* are an eastern char species closely related to Dolly Varden (McPhail 2007). Brook Trout are stocked in lakes and stream throughout Canada. In BC, Brook Trout are stocked into isolated lake systems or waterbodies where they are already established (McPhail 2007). Ontario has a long history of stocking Brook Trout and has completed extensive literature review of stocking management within North America, including stocking rates (Kerr 2000; OMNR 2002). The Brook Trout stocking rates within selected jurisdictions are provided in Table 5.

The agency stocking rates are variable depending upon the local productivity of the receiving waterbodies. For lake habitats, five of the ten agencies stock at a rate of 100 fish/ha. Therefore, the weight of evidence suggests that 100 fish/ha would be an appropriate initial stocking rate for Dolly Varden in lakes. For stream habitats, stocking rates are variable. The Province of Quebec has a history of successful stocking assessments in low species diversity watersheds in Eastern Canada (Kerr 2000), therefore application of the Quebec stocking rate of 60/m * no. km (maximum of 1,200/km) of stream habitat would be an appropriate initial stocking rate for Dolly Varden in streams.

Table 5. Government Agency Stocking Rates for Arctic Char and Brook Trout

Habitat	Species	Agency	Stocking Rate (no./ha)	Stocked Size
Lake	Arctic Char	Alaska	247/ha	Fingerling
	Brook Trout	Alberta	75-100/ha	Fingerling
		Michigan	50-150/ha	Fingerling
		Saskatchewan	100/ha	Fingerling
		Minnesota	370-494/ha	Fingerling
		Ohio	100/ha	Fingerling
		Pennsylvania	185-1,544/ha	Fingerling
		British Columbia	150/ha	Fingerling
		Québec	100/ha	Fingerling
		Ontario	375/ha for lake littoral area < 6 m depth	Fingerling
Stream	Brook Trout	Michigan	247-494/ha	Fingerling
		Pennsylvania	185/ha	Fingerling
		Québec	60/m * no. km of stream (maximum of 1,200/km)	Fingerling
		Vermont	125/km	Fingerling

The stocking rates for Brook Trout and Arctic Char are typically for fingerling-sized fish. Fingerlings are typically 80 mm in fork length and have a weight of 12 g (OMNR 2000), which are approximately 10% smaller than the mean fork length and weight of Dolly Varden in South Teigen and North Treaty Creek (Table 4). Because larger fish require greater resources (i.e., prey availability) than smaller fish, the initial stocking rates should be reduced by 10% to account for the larger size Dolly Varden. Therefore, the recommended stocking rates are 90 fish/ha for lake habitats and 54/m * no. km (maximum of 1,080/km) of stream habitat for stream habitats.

Tables 6 and 7 present the total number of Dolly Varden that could be stocked in each of the selected lakes and streams based upon the recommended stocking rates. In the Teigen Watershed, Teigen Lake, Hodkin Lake, Snowbank Creek and Teigen Creek individually provide sufficient amount of area to accept the estimated population size of relocated Dolly Varden from South Teigen Creek. In the Treaty Watershed, Treaty Creek provides sufficient amount of area to accept the estimated population size of relocated Dolly Varden from North Treaty Creek.

Table 6. Population Abundance Estimate of Dolly Varden that Could be Relocated into Selected Lakes

Watershed	Lake Name	Relocation Estimate (No.)
Teigen	Teigen Lake	18,900
Teigen	Hodkin Lake	14,490
Teigen	West Teigen Lake	2,970
Treaty	Gilbert Lake	4,590
Treaty	Todedada Lake	2,160
Treaty	Lake 1	720
Treaty	Lake 2	1,080

Table 7. Population Abundance Estimate of Dolly Varden that Could be Relocated into Selected Streams

Watershed	Stream Name	Reach	Relocation Estimate (No.)
Teigen	Teigen Creek	1	9,480
Teigen	Teigen Creek	2	13,680
Teigen	Teigen Creek	3	13,200
Teigen	West Teigen Creek	1	600
Teigen	West Teigen Creek	2	3,960
Teigen	Hodkin Creek	1	720
Teigen	Hodkin Creek	2	3,480
Teigen	Snowbank Creek	1	7,320
Treaty	Treaty Creek	1	9,480
Treaty	Treaty Creek	2	22,080
Treaty	Treaty Creek	3	11,040
Treaty	Todedada Creek	1	3,960
Treaty	Todedada Creek	2	4,080
Treaty	East Todedada Creek	1	1,080
Treaty	East Todedada Creek	2	3,120
Treaty	Gilbert Creek	1	2,280

4. Ecological Risk Assessment

4.1 Potential Risks

Introducing and relocating species into other waterbodies may have a number of environmental consequences ranging from the introduction of disease and parasites, loss of genetic diversity among source and target populations, increased inter- and intra-specific competition, and failure of the relocated population (Fischer and Lindenmayer 2000; DFO 2003; Dunham et al. 2011). Minckley (1995) proposed a variety of conditions that must be met in order for relocation of fish to be successful. Relocated sites must:

- contain the resources and habitat conditions necessary for the relocated species to exist;
- be able to support populations large enough to be self-sustaining;
- have sufficient within-boundary replication of habitat types to be able to withstand local extirpations;
- be protected from edge and external effects (e.g., water sources, hybridization); and
- be replicated by similar areas distant enough that they will not all be affected by the same natural disaster (in the case of relocations to restore populations).

Relocation success is generally more likely for native species within their own range (Williams et al. 1988; Griffith et al. 1989).

A risk assessment was conducted to assess the specific risks associated with relocating Dolly Varden from the KSM TMF in North Treaty and South Teigen Creeks to other waterbodies within Teigen and Treaty watersheds. The primary effects discussed below include disease transfer, genetic diversity,

inter- and intra-specific competition, and predation. For each proposed relocation, the potential risks, mitigation measures, and residual effects are discussed.

4.1.1 Disease and Fish Health

4.1.1.1 Risk Identification

The transmission of fish parasites or other types of disease carried by relocated fish can have impacts on fish populations (Ruesink et al. 1995; Gaughan 2002; DFO 2003). The relocation of individuals can introduce pathogens to a previously-unexposed population or increase the density of existing pathogens.

4.1.1.2 Risk Mitigation

The introduction of pathogens is generally low when fish are relocated within a watershed (Williams et al. 1988). North Treaty Creek discharges into Treaty Creek, and it is likely that the two waterbodies will have similar pathogen types. South Teigen Creek discharges into Teigen Creek, and it is likely that the two waterbodies will have similar pathogen types. Furthermore, Treaty Creek and Teigen Creek watersheds are closely linked by the Bell-Irving River.

During fish salvage, individual fish will be measured to obtain basic information regarding length and weight, providing an opportunity to inspect the salvaged fish for evidence of disease or parasites. A biologist will be involved in all salvage activities and any fish showing evidence of disease or external parasites will be inspected. Professional judgment will be used to determine the risks of relocating diseased fish or fish with high parasite loads, and fish with a high risk of serving as a vector may not be released. As per the British Columbia Introductions and Transfers policy (DFO 2013), the potential effects on the incidence, distribution and/or impact of pathogens and parasites on resident species will be considered prior to any relocation of fish.

4.1.1.3 Residual Effects

Within most of the Teigen Creek Watershed, the risk of pathogen and disease transfer is low because there is currently a disease and gene transfer pathway among fish from South Teigen Creek to Teigen Creek. As a result of this connectivity, pathogen types and gene frequencies are likely similar among these waterbodies.

Similarly, connectivity exists between the fish populations in North Treaty Creek and those populations found in Gilbert Lake, Todedada Lake, Treaty Creek, Todedada Creek, East Todedada Creek, and Gilbert Creek. Although the Gilbert and Todedada systems are located on the opposite side of Treaty Creek from North Treaty Creek, it may be reasonable to assume that the potential for disease transfer exists among these populations due to the lack of fish migration barriers.

Hodkin Lake in Teigen Creek Watershed, and Lakes 1 and 2 in the Treaty Creek Watershed are not part of the existing disease and gene transfer pathway due to barriers to upstream fish movement located downstream of those waterbodies. Thus, the fish populations are isolated from disease and parasite transfer from in-migration of fish from Teigen and Treaty creeks. It is unknown if the Dolly Varden populations in these isolated lakes have a similar pathogen load to the populations from South Teigen Creek and North Treaty Creek. Therefore, relocating fish from the TMF to these lakes represents a greater risk to the resident fish populations.

4.1.2 Genetics

4.1.2.1 Risk Identification

Relocation may result in hybridization of closely related species. Dolly Varden and Bull Trout have been found to hybridize naturally throughout northwest British Columbia (Baxter et al. 1997). Hybridization can result in loss of genetic information and reduced hybrid fitness; however, both Dolly Varden and Bull Trout tend to maintain their genetic integrity in spite of gene flow between the species (Hagen and Taylor 2001).

Relocation of animal species may also result in a bottleneck effect that ultimately causes a reduction in genetic diversity and the loss of rare and/or unique alleles in relocated populations (Stockwell, Mulvey, and Vinyard 1996). This may be caused when the number of individuals relocated is too small to capture the full range of genetic diversity in the source population, or it may occur when relocated populations fail and are reduced to few individuals. A genetic analysis of Dolly Varden captured in Treaty and Teigen Creeks in 2009 showed that there were population distinctions, but not at the species level. Within Treaty Creek, there was a distinction between samples collected from the lower watershed and those from the upper watershed (Rescan 2010a). Within Teigen Creek, there was also a distinction between Dolly Varden captured above and below a putative barrier in South Teigen Creek. Furthermore, some fish captured below this barrier were homozygous for an allele at Sfo18 that is normally diagnostic for Bull Trout.

4.1.2.2 Risk Mitigation

The primary mitigation measure to reduce the effects of hybridization and loss of genetic diversity is to relocate fish salvaged from the TMF to locations within their own watersheds. Thus, Dolly Varden salvaged from South Teigen Creek should be kept within the Teigen Creek Watershed, while Dolly Varden salvaged from North Treaty Creek should be kept within the Treaty Creek Watershed.

4.1.2.3 Residual Effects

The risk of hybridization among Dolly Varden and Bull Trout can be mitigated by relocating Dolly Varden to watersheds where Bull Trout are not known to be present; however, the risk presented by hybridization is likely low due to the natural tendency for the species to maintain their genetic integrity through behavioural changes (Hagen and Taylor 2001).

Bull Trout are known to be present in Teigen Lake and Teigen Creek and are assumed to be present in Hodkin Creek and Snowbank Creek in the Teigen Watershed. The lowest risk for hybridization in the Teigen Watershed occurs in Hodkin Lake where Bull Trout are not present. Bull Trout are not known to occur in West Teigen Lake or West Teigen Creek; however, there are no barriers to fish movement between these waterbodies and streams that are known to contain Bull Trout.

Bull Trout are present at low densities in Treaty Creek. Within the Treaty Watershed, there is a moderate risk that hybridization will occur in Gilbert Lake and Gilbert Creek due to the presence of Bull Trout spawning habitat in these waterbodies. There may be an increased risk of hybridization in lower Treaty Creek. Low rates of hybridization have been reported in the lower reaches of Treaty Creek; however, few have been sampled. The lowest risk of hybridization occurs in Lakes 1 and 2 because these lakes do not contain Bull Trout and barriers downstream of the lakes prevents upstream migration of fish. Bull Trout have not been documented in Todedada Lake, Todedada Creek, and East Todedada Creek; however, no barriers exist to prevent gene transfer.

The potential for loss of genetic diversity may be higher than the risk of hybridization because genetic analysis has shown that populations living in the upper reaches of the Treaty and Teigen watersheds are distinct from those living further downstream. Relocation of these fish to other streams, even within the same watershed, may result in homogenization of the population. It is unknown if any of the alleles present in the Dolly Varden populations within the TMF are rare or unique.

4.1.3 Intraspecific Competition

4.1.3.1 Risk Identification

Intraspecific competition occurs when Dolly Varden density is increased to the point where it exceeds the carrying capacity of the stream in terms of prey and habitat resources. The carrying capacity of a stream is determined by its productivity (i.e., primary and secondary production, prey production), and by the amount and complexity of habitat, as well as by the amount of critical or limiting habitat.

The presence of suitable, available habitat for all life stages is an important factor in successful translocation of fish (Williams et al. 1988). Dolly Varden life history requires a variety of habitat types for spawning, juvenile rearing, and adult rearing (McPhail 2007). Insufficient habitat for any life stage will limit population growth and potentially result in a genetic bottleneck that will increase the loss of genetic diversity and contribute to genetic drift.

4.1.3.2 Risk Mitigation

Relocations over short distances and between similar populations and geographic areas are more likely to be successful, as closely related populations are more likely to have similar habitat requirements (Williams et al. 1988). Identifying an ideal stocking density for fish in natural systems is extremely difficult due to many confounding factors. Ideal locations for relocating Dolly Varden from the TMF will have high productivity, high habitat complexity, low existing densities of fish, and sufficient limiting habitat (e.g., spawning sites) to support large fish population.

4.1.3.3 Residual Effects

The lowest potential for residual effects from intraspecific competition occurs in waterbodies where Dolly Varden density is relatively low and productivity is relatively high. Within the Teigen Watershed, the lowest risk is presented in Teigen Lake and Teigen Creek. In these waterbodies, suitable habitat is abundant, existing populations of Dolly Varden are low, and primary and secondary production are relatively high. High risks of intraspecific competition are present in Hodkin Lake, Hodkin Creek, and West Teigen Creek. In these waterbodies, Dolly Varden are already the dominant species, primary and secondary productivity are low or moderate, and there is a low abundance of suitable habitat.

Within the Treaty Watershed, the highest risks of intraspecific competition occur in Todedada Creek. In this waterbody, Dolly Varden are already the dominant species; however, productivity is low due to low temperatures, and habitat availability is low due to limited habitat complexity. The lowest risk occurs in Gilbert Creek where productivity is high and Dolly Varden abundance is low; however, there is a limited abundance of suitable habitat. Moderate risks are presented by Treaty Creek, East Todedada Creek, Lakes 1 and 2, and Todedada Lake. These waterbodies have moderate productivity and abundant suitable habitat; however, Dolly Varden are already abundant.

4.1.4 Interspecific Competition

4.1.4.1 Risk Identification

Sympatric fish species often compete for food, space, or other resources, with negative effects to one or both populations (Connell 1983). Fish species that occur in sympatry may also adjust their behaviour or distribution to avoid competition (Andrusak and Northcote 1971; Nakano and Furukawa-Tanaka 1994; Nakano, Fausch, and Kitano 1999). Relocating Dolly Varden from other areas may result in an increased density of Dolly Varden relative to other fish species. Increased interspecific competition from Dolly Varden could have negative effects on the other fish species present, or on the Dolly Varden themselves.

Interspecific competition between Rainbow Trout and Dolly Varden has been observed, but where the two species exist sympatrically, Rainbow Trout out-compete Dolly Varden (Baxter et al. 2004). In general, Dolly Varden and other salmonid species show high plasticity in their feeding strategies, and niche partitioning reduces direct competition and density compensation (Andrusak and Northcote 1971; Hume and Northcote 1985; Hindar et al. 1988; Dolloff and Reeves 1990; Andrew et al. 1992).

There is little information available regarding possible interspecific competition between Dolly Varden and Mountain Whitefish (IDFG 2007). However, Mountain Whitefish habitat preference is for deep channels and pools, in contrast with the smaller streams preferred by Dolly Varden, and therefore little interspecific competition is expected (McPhail 2007).

Bull Trout were observed at very low densities in Treaty Creek (Rescan 2010a). Bull Trout and Dolly Varden occupy similar niches in regards to habitat and food preferences (McPhail 2007). Where Bull Trout and Dolly Varden exist sympatrically, there is evidence of niche partitioning between the two species to reduce the effects of competition (Hagen and Taylor 2001).

Juvenile Dolly Varden and Coho Salmon tend to exhibit slight differences in habitat preferences, with Dolly Varden selecting stream-bottom positions and Coho selecting mid-water positions (Dolloff and Reeves 1990). Additionally, Dolly Varden tend to prefer smaller tributary streams to the mainstem rivers that are more often occupied by Coho Salmon and Steelhead (Bramblett et al. 2002). This may also serve to reduce interspecific competition with Chinook Salmon, which generally spawn and rear in larger rivers (McPhail 2007).

4.1.4.2 Risk Mitigation

Dolly Varden show some plasticity in behaviour that reduces competition with other species (Andrusak and Northcote 1971; Hume and Northcote 1985; Hindar et al. 1988; Andrew et al. 1992). Specifically, they are able to adapt to differing food sources and habitat types with apparent ease. However, relocating them to waterbodies with fewer competitors will reduce the potential impacts on both the relocated population and the resident fish community.

4.1.4.3 Residual Effects

Within the Teigen Watershed, the highest risk of effects from interspecific competition occurs in Teigen Creek, Hodkin Creek, and Snowbank Creek where multiple species occur and compete for prey and habitat resources. The lowest risks occur in West Teigen Creek, Hodkin Lake, and West Teigen Lake where no other species are present.

Within the Treaty Watershed, the highest risk of effects from interspecific competition occurs in East Todedada Creek and Gilbert Creek where Dolly Varden and Coho Salmon are the most dominant

species. Increasing the density of Dolly Varden may have a negative effect on rearing Coho Salmon. The lowest risk occurs in Todedada Lake, Todedada Creek, Lake 1, Lake 2, and Treaty Creek. In these waterbodies, Dolly Varden are already the dominant species and other species are either absent or occur at low densities.

4.1.5 Predation

4.1.5.1 Risk Identification

Relocation of Dolly Varden may increase predation on other species present, or put Dolly Varden at risk from predation. Dolly Varden may feed extensively on salmon eggs and fry when they are available (Dunham et al. 2008; Denton, Rich, and Quinn 2009). Increased densities of Dolly Varden in waterbodies where salmon spawn may increase predation pressure on those species. The presence of river otters (*Lutra canadensis*) may exert significant predation pressure on resident salmonids, including Dolly Varden (Dolloff 1993).

4.1.5.2 Risk Mitigation

Dolly Varden predate upon salmon eggs and fry, and therefore salmon species may experience increased predation pressure due to increased densities of Dolly Varden. This can be mitigated by limiting the number of relocated Dolly Varden to important salmon spawning streams.

Most predators of Dolly Varden are highly mobile; therefore, it is unlikely that Dolly Varden can be relocated to areas where predators do not occur. However, complex habitats are generally associated with the ability of fish to avoid predation, and locating fish in waterbodies with complex habitat will likely mitigate the effects of predation on relocated populations.

4.1.5.3 Residual Effects

The highest risks of predation of Dolly Varden on resident fish populations occur in waterbodies where salmon species spawn and rear. In the Teigen Watershed, these include Teigen Creek and Snowbank Creek, which are important spawning streams for Coho and Chinook Salmon, as well as Steelhead and Rainbow Trout. Moderate risks are present in Hodkin Creek, which contains spawning habitat for Rainbow Trout. The lowest risks are presented in Hodkin Lake, West Teigen Lake, Teigen Lake, and West Teigen Creek where few other species are present.

In the Treaty Watershed, the risk of predation on other species is highest in East Todedada Creek and Gilbert Creek, which are important salmon spawning streams. The lowest risks of predation occur in Todedada Lake, Gilbert Lake, Lake 1, Lake 2, Treaty Creek, and Todedada Creek. In these waterbodies, few other species are present, or they occur at low densities compared to Dolly Varden.

4.2 Risk Evaluation

To evaluate the risks associated for each potential receiving waterbody, a holistic evaluation approach was adopted. This approach entailed ranking the potential risks for each stressor (i.e., disease, genetics, competition, and predation) as either none, low, moderate, or high risk. The potential risk ranks (e.g., low, high) were assigned based upon baseline data, scientific literature, and professional judgement. Each rank was then assigned a numerical score from one to four (None – 4, Low - 3, Moderate – 2, and High – 1). The numerical scores for each rank were not weighted for any stressor (e.g., disease, genetics) as all stressors were treated of equal importance. An overall score was summed for each waterbody, with the highest score indicating the preferred waterbody.

Table 8 shows the results of the relocation risk assessment to each potential receiving waterbody. For the genetics risk evaluation, it was assumed that Dolly Varden would only be relocated into their respective watersheds as recommended by the Fisheries Working Group and Provincial Fish Transfer Policy (DFO 2013). For example, Dolly Varden from South Teigen Creek would only be relocated in Teigen Watershed. For the disease risk evaluation, it was assumed that a proportion of the relocated Dolly Varden would be tested for any diseases or disease agents according to the Provincial Fish Transfer Policy (DFO 2013). Isolated waterbodies were ranked as higher risk with respect to gene flow and disease transfer. In contrast, isolated or waterbodies without Bull Trout presence were ranked as lower risk with respect to hybridization with Dolly Varden. For the intraspecific competition risk evaluation, it was assumed that intraspecific competition would occur at all selected waterbodies because Dolly Varden are present in each waterbody (Tables 1 and 2). Waterbodies with Dolly Varden as the dominant species, relative high abundance of Dolly Varden, and low primary and secondary productivity were ranked as higher risk. Primary and secondary productivity was assessed based upon aquatics baseline data (Rescan 2009b and 2010b), elevation, and water quality (cold, glaciated, high TSS streams versus warmer, lake headwater, low TSS streams). For the intraspecific competition risk evaluation, multiple species occupying the same habitat niche as Dolly Varden were ranked as higher risk than one competing species present. Predation risk was ranked as high if multiple salmonid fry/parr species were present at high relative abundance.

Based upon this risk analysis, the top least risk waterbodies in the Teigen Watershed are:

- West Teigen Lake;
- Hodkin Lake; and
- West Teigen Creek – Reaches 1 and 2.

Similarly, the top least risk waterbodies in the Treaty Watershed are:

- Treaty Creek – Reach 1 to 3;
- Lakes 1 and 2; and
- Todedada Lake.

5. Relocation Strategy

5.1 Approach

The results of the environmental risk analysis indicate the waterbody options of least risk for Teigen and Treaty watersheds. Based upon the risk analysis and estimated population size, informed management decisions can be made to recommend a reasonable strategy for Dolly Varden relocation.

According to the proposed KSM Project construction schedule, the North and CIL Cells would be constructed in Year 1; therefore Dolly Varden in South Teigen mainstem and tributaries would need to be salvaged prior to Year 1. To further reduce environmental risks associated with Dolly Varden relocation, it would be appropriate to select one waterbody to accept all the relocated fish from South Teigen Watershed. Of the top least risk waterbodies identified in Teigen Watershed, Hodkin Lake is the preferred option because it can accept all the relocated Dolly Varden (Tables 3 and 6), whereas multiple options would be required if the other least risk waterbodies were selected.

Table 8. Dolly Varden Relocation Risk Assessment Evaluation

Watershed	Habitat Type	Waterbody Name	Reach	Isolation (Disease and Genetics)			Hybridization			Intraspecific Competition		
				Rank	Score	Comment	Rank	Score	Comment	Rank	Score	Comment
Teigen	Lake	Teigen Lake	NA	Low	3	Existing disease and gene transfer pathway to lake because South Teigen fish can move downstream to Teigen Creek	High	1	Increased risk of hybridzation with Bull Trout and spawning tributaries discharge into the lake	Low	3	Historical presence of species in lake, but not confirmed during baseline sampling; Abundance low; Abundant suitable habitat
Teigen	Lake	Hodkin Lake	NA	Moderate	2	Permanent barrier to upstream fish movement from Hodkin Creek; No existing disease and gene transfer pathway from downstream environments (Hodkin Creek) into lake	None	4	Permanent barrier to upstream fish movement from Hodkin Creek; No risk of hybridization with Bull Trout as they are not present in lake	High	1	Dolly Varden dominant species; Low primary and secondary productivity; Abundant suitable habitat
Teigen	Lake	West Teigen Lake	NA	Low	3	Existing disease and gene transfer pathway to lake because South Teigen fish can move downstream to Teigen Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in lake, but barriers to fish movement are absent	Moderate	2	Dolly Varden dominant species; High primary and secondary productivity; Abundant suitable habitat
Teigen	Stream	Teigen Creek	1	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	High	1	Increased risk of hybridzation with Bull Trout, spawning occurs in mainstem, and Bull Trout more abundant than Dolly Varden	Low	3	Low abundance within mainstem; Dolly Varden reside in off-channel wetlands with limited fish access
Teigen	Stream	Teigen Creek	2	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	High	1	Increased risk of hybridzation with Bull Trout, spawning occurs in mainstem, and Bull Trout more abundant than Dolly Varden	Low	3	Low abundance within mainstem; High primary and secondary productivity; Dolly Varden reside in off-channel wetlands with limited fish access
Teigen	Stream	Teigen Creek	3	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	High	1	Increased risk of hybridzation with Bull Trout, spawning occurs in mainstem, and Bull Trout more abundant than Dolly Varden	Low	3	Low abundance within mainstem; High primary and secondary productivity; Dolly Varden reside in off-channel wetlands with limited fish access
Teigen	Stream	West Teigen Creek	1	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in stream, but barriers to fish movement are absent	High	1	Dolly Varden dominant species within reach; Moderate primary and secondary productivity; Low suitable habitat area
Teigen	Stream	West Teigen Creek	2	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in stream, but barriers to fish movement are absent	High	1	Dolly Varden dominant species within reach; Moderate primary and secondary productivity; Low suitable habitat area
Teigen	Stream	Hodkin Creek	1	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	Moderate	2	Increased risk of hybridization with Bull Trout	High	1	Dolly Varden present within reach; Moderate primary and secondary productivity; Low suitable habitat area
Teigen	Stream	Hodkin Creek	2	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	Moderate	2	Increased risk of hybridization with Bull Trout	High	1	Dolly Varden present within reach; Moderate primary and secondary productivity; Low suitable habitat area
Teigen	Stream	Snowbank Creek	1	Low	3	Existing disease and gene transfer pathway to stream because South Teigen fish can move downstream to Teigen Creek	Moderate	2	Increased risk of hybridization with Bull Trout	Moderate	2	Dolly Varden present within reach; Moderate primary and secondary productivity; Abundant suitable habitat area

(continued)

Table 8. Dolly Varden Relocation Risk Assessment Evaluation (continued)

Watershed	Habitat Type	Waterbody Name	Reach	Isolation (Disease and Genetics)			Hybridization			Intraspecific Competition		
				Rank	Score	Comment	Rank	Score	Comment	Rank	Score	Comment
Treaty	Lake	Gilbert Lake	NA	Low	3	Existing disease and gene transfer pathway to lake because North Treaty fish can move downstream to and upstream from Treaty Creek	Moderate	2	Increased risk of hybridzation with Bull Trout and spawning habitat present in Gilbert Creek.	Moderate	2	Dolly Varden dominant species; High primary and secondary productivity; Abundant suitable habitat
Treaty	Lake	Todedada Lake	NA	Low	3	Existing disease and gene transfer pathway to lake because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in lake, but barriers to fish movment are absent	Moderate	2	Dolly Varden dominant species; High primary and secondary productivity; Abundant suitable habitat
Treaty	Lake	Lake 1	NA	Moderate	2	Temporary barrier (beaver dam) to upstream fish movement from Treaty Creek; No existing disease and gene transfer pathway from downstream environments (Treaty Creek) although the barrier is temporary and the pathway for disease and gene transfer would have been open in the past	None	4	No risk of hybridization with Bull Trout as they are not present in lake and barriers are present	Moderate	2	Dolly Varden dominant species; Moderate primary and secondary productivity; Abundant suitable habitat
Treaty	Lake	Lake 2	NA	Moderate	2	Temporary barrier (beaver dam) to upstream fish movement from Treaty Creek; No existing disease and gene transfer pathway from downstream environments (Treaty Creek) although the barrier is temporary and the pathway for disease and gene transfer would have been open in the past	None	4	No risk of hybridization with Bull Trout as they are not present in lake and barriers are present	Moderate	2	Dolly Varden dominant species; Moderate primary and secondary productivity; Abundant suitable habitat
Treaty	Stream	Treaty Creek	1	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Increased risk of hybridization with Bull Trout, but few have been sampled; Low abundance	Moderate	2	Dolly Varden dominant species within reach; Low primary and secondary productivity; Abundant suitable habitat area
Treaty	Stream	Treaty Creek	2	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Increased risk of hybridization with Bull Trout, but few have been sampled; Low abundance	Moderate	2	Dolly Varden dominant species within reach; Low primary and secondary productivity; Abundant suitable habitat area
Treaty	Stream	Treaty Creek	3	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in stream reach, but barriers to fish movment are absent	Moderate	2	Dolly Varden dominant species within reach; Low primary and secondary productivity; Abundant suitable habitat area
Treaty	Stream	Todedada Creek	1	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in stream reach, but barriers to fish movment are absent	High	1	Dolly Varden dominant species within reach; Low primary and secondary productivity; Low suitable habitat area
Treaty	Stream	Todedada Creek	2	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in stream reach, but barriers to fish movment are absent	High	1	Dolly Varden dominant species within reach; Low primary and secondary productivity; Low suitable habitat area
Treaty	Stream	East Todedada Creek	1	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in stream reach, but barriers to fish movment are absent	Moderate	2	Dolly Varden dominant species within reach; Moderate primary and secondary productivity; High suitable habitat area
Treaty	Stream	East Todedada Creek	2	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Low	3	Low risk of hybridization with Bull Trout as none have been documented in stream reach	Moderate	2	Dolly Varden dominant species within reach; Moderate primary and secondary productivity; High suitable habitat area
Treaty	Stream	Gilbert Creek	1	Low	3	Existing disease and gene transfer pathway to stream because North Treaty fish can move downstream to and upstream from Treaty Creek	Moderate	2	Increased risk of hybridzation with Bull Trout and spawning habitat present in Gilbert Creek.	Low	3	Dolly Varden abundance low within reach; High primary and secondary productivity; Low suitable habitat area

(continued)

Table 8. Dolly Varden Relocation Risk Assessment Evaluation (continued)

Watershed	Habitat Type	Waterbody Name	Reach	Interspecific Competition			Predation			Overal Score
				Rank	Score	Comment	Rank	Score	Comment	
Teigen	Lake	Teigen Lake	NA	Moderate	2	Mountain Whitefish and Dolly Varden consume similar prey resources; Multiple species present in lake	Low	3	Coho Salmon juveniles present in lake and could rear in littoral zone of lake; Increased risk of predation in lake by adult Dolly Varden	12
Teigen	Lake	Hodkin Lake	NA	None	4	Low probability of Rainbow Trout presence in lake	None	4	Low probability of Rainbow Trout presence in lake; Juvenile Rainbow Trout rear in tribuaries; Less risk of predation in lake by adult Dolly Varden	15
Teigen	Lake	West Teigen Lake	NA	None	4	No other species present in lake	None	4	No other salmonid species present in lake	16
Teigen	Stream	Teigen Creek	1	High	1	Multiple species present in stream competing for prey resources	High	1	Chinook, Sockeye, Coho, and Rainbow Trout juveniles rearing in stream; Increased risk of predation by adult Dolly Varden	9
Teigen	Stream	Teigen Creek	2	High	1	Multiple species present in stream competing for prey resources	High	1	Chinook, Sockeye, Coho, and Rainbow Trout juveniles rearing in stream; Increased risk of predation by adult Dolly Varden	9
Teigen	Stream	Teigen Creek	3	High	1	Multiple species present in stream competing for prey resources	High	1	Chinook, Sockeye, Coho, and Rainbow Trout juveniles rearing in stream; Increased risk of predation by adult Dolly Varden	9
Teigen	Stream	West Teigen Creek	1	None	4	No other species present in stream	None	4	No other salmonid species present in stream	15
Teigen	Stream	West Teigen Creek	2	None	4	No other species present in stream	None	4	No other salmonid species present in stream	15
Teigen	Stream	Hodkin Creek	1	Moderate	2	Dolly Varden and Rainbow Trout compete for prey resources	Moderate	2	Juvenile Rainbow Trout rear in stream	10
Teigen	Stream	Hodkin Creek	2	High	1	Multiple species present in stream competing for prey resources	Moderate	2	Juvenile Rainbow Trout rear in stream	9
Teigen	Stream	Snowbank Creek	1	High	1	Multiple species present in stream competing for prey resources	High	1	Chinook, Coho, and Rainbow Trout juveniles rearing in stream; Increased risk of predation by adult Dolly Varden	9

(continued)

Table 8. Dolly Varden Relocation Risk Assessment Evaluation (completed)

Watershed	Habitat Type	Waterbody Name	Reach	Interspecific Competition			Predation			Overal Score
				Rank	Score	Comment	Rank	Score	Comment	
Treaty	Lake	Gilbert Lake	NA	Moderate	2	Mountain Whitefish and Dolly Varden consume similar prey resources; Multiple species present in lake	Low	3	Coho Salmon juveniles could rear in littoral zone of lake although species not confirmed in lake	12
Treaty	Lake	Todedada Lake	NA	Low	3	Rainbow Trout and Dolly Varden consume similar prey resources; Low abundance of Rainbow Trout in lake compared to Dolly Varden abundance	Low	3	Juvenile Rainbow Trout rear in tribuaries; Less risk of predation in lake by adult Dolly Varden	14
Treaty	Lake	Lake 1	NA	Low	3	Rainbow Trout and Dolly Varden consume similar prey resources; Low abundance of Rainbow Trout in lake compared to Dolly Varden abundance	Low	3	Juvenile Rainbow Trout rear in tribuaries; Less risk of predation in lake by adult Dolly Varden	14
Treaty	Lake	Lake 2	NA	Low	3	Rainbow Trout and Dolly Varden consume similar prey resources; Low abundance of Rainbow Trout in lake compared to Dolly Varden abundance	Low	3	Juvenile Rainbow Trout rear in tribuaries; Less risk of predation in lake by adult Dolly Varden	14
Treaty	Stream	Treaty Creek	1	Low	3	Dolly Varden dominant species; Multiple species present competing for prey resources but in low abundance	Low	3	Coho Salmon and juvenile Rainbow Trout rear in stream at low productivity and abundance compared to Dolly Varden	14
Treaty	Stream	Treaty Creek	2	Low	3	Dolly Varden dominant species; Multiple species present competing for prey resources but in low abundance	Low	3	Coho Salmon and juvenile Rainbow Trout rear in stream at low productivity and abundance compared to Dolly Varden	14
Treaty	Stream	Treaty Creek	3	None	4	No other species present in stream	None	4	No other salmonid species present in stream	16
Treaty	Stream	Todedada Creek	1	Low	3	Dolly Varden dominant species within reach; Coho Salmon present, but in low abundance	Low	3	Coho Salmon rear in stream but at low productivity and abundance compared to Dolly Varden	13
Treaty	Stream	Todedada Creek	2	Low	3	Dolly Varden dominant species within reach; Coho Salmon present, but in low abundance	Low	3	Coho Salmon rear in stream but at low productivity and abundance compared to Dolly Varden	13
Treaty	Stream	East Todedada Creek	1	High	1	Dolly Varden and Coho Salmon co-dominant species within reach	High	1	Coho Salmon rear in stream at high productivity and abundance compared to Dolly Varden	10
Treaty	Stream	East Todedada Creek	2	High	1	Dolly Varden and Coho Salmon co-dominant species within reach	High	1	Coho Salmon rear in stream at high productivity and abundance compared to Dolly Varden	10
Treaty	Stream	Gilbert Creek	1	High	1	Multiple species present in stream competing for prey resources	High	1	Chinook, Coho, and Rainbow Trout juveniles rearing in stream; Increased risk of predation by adult Dolly Varden	10

According to the proposed KSM Project construction schedule, the South Cell would be constructed in Year 25; therefore Dolly Varden in North Treaty mainstem and tributaries would not need to be salvaged until Year 24. To further reduce environmental risks associated with Dolly Varden relocation, it would be appropriate to select one waterbody to accept all the relocated fish from North Treaty Watershed. Of the top least risk waterbodies identified in Treaty Watershed, Treaty Creek (Reaches 2 and 3) is the preferred option because it can accept all the relocated Dolly Varden (Tables 3 and 7), whereas multiple options would be required if the other least risk waterbodies were selected.

Dolly Varden population size within the proposed TMF are to be considered estimates based upon the three-pass removal density assessments conducted in 2009 (Rescan 2010a). The fish salvage will validate the results of the density estimates, and will provide an accurate population size for relocation. At that time, this strategy will be reviewed if the preferred waterbody options can support the potential for more relocated Dolly Varden.

Prior to relocation, a British Columbia Freshwater Transport Authorization will be obtained.

5.2 Monitoring

Dolly Varden relocation will be monitored in the preferred least risk waterbodies. The approach to monitoring will follow a Before-After-Control-Impact (BACI) experimental design for Hodkin Lake and Treaty Creek. Two years of pre-relocation monitoring data will be gathered to account for inter-annual variances in the BACI experimental design. Post-relocation effectiveness monitoring will follow with two years of data collection to allow for inter-annual variances and separate statistical testing (Pearson et al. 2005).

Unuk Lake was selected as the control waterbody for Hodkin Lake. Unuk Lake was selected for the following reasons:

- adjacent to Hodkin Lake;
- same elevation;
- similar size, mean depth and bathymetry; and
- same species composition (Dolly Varden).

Todedada Creek was selected as the control waterbody for Treaty Creek. Todedada Creek was selected for the following reasons:

- within same watershed;
- same elevation;
- similar water quality (cold, glaciated system with high TSS); and
- same species composition (Dolly Varden).

To assess the potential effects of Dolly Varden relocation, multiple key performance criteria will be evaluated within a two-tier approach. The first tier includes individual-based metrics for inferring changes in the receiving waterbody. These metrics include condition and growth, which are indicators of prey availability and are sensitive indicators of environmental change (Pearson et al. 2005). Condition is used as a measure of fish nutritional status, and fish of “good condition” leading into the onset of winter months have an increased likelihood of survival (Anderson and Neumann 1996; Pope and Kruse 2007). The second tier includes population-based assessment methods for measuring changes in the receiving

waterbody. This metric will include abundance (relative catch per unit effort) and survival of marked relocated Dolly Varden. All relocated fish will be marked with either PIT (Passive Integrated Transponder) tags, fin clips, or VIE (Visible Implant Elastomer) tags depending upon fish size.

Lake habitats will be sampled with trap nets and/or hoop nets, rather than gillnets to reduce incidental mortality of sampling gear. Therefore, pre-relocation monitoring will determine the most appropriate time frame for post-relocation monitoring in lake habitats.

Stream habitats will be sampled with a backpack electrofisher. Post-relocation monitoring would commence the following summer after relocation.

References

Anderson, N.O., and R.M. Neumann. 1996. Length, weight, and associated structural indices. In Fisheries Techniques, 2nd Edition. Ed. B. R. Murphy, and D. W. Willis. Bethesda, MD: American Fisheries Society.

Andrew, J. H., N. Jonsson, B. Jonsson, K. Hindar, and T. G. Northcote. 1992. Changes in use of lake habitat by experimentally segregated populations of cutthroat trout and Dolly Varden char. Ecography 15: 245-52.

Andrusak, H. and T. G. Northcote. 1971. Segregation between adult cutthroat trout (*Salmo clarki*) and Dolly Varden (*Salvelinus malma*) in small coastal British Columbia lakes. Journal of the Fisheries Research Board of Canada 28: 1259-68.

Baxter, J.S., E. Taylor, R. Devlin, J. Hagen, and J.D. McPhail. 1997. Evidence for natural hybridization between Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in a north central British Columbia watershed. Can. J. Fish. Aquat. Sci. 54: 421-429.

Baxter, C. V., K. D. Fausch, M. Murakami, and P. L. Chapman. 2004. Fish invasion restructures stream and forest food webs by interrupting reciprocal prey subsidies. Ecology 85: 2656-63.

Bramblett, R. G., M. D. Bryant, B. E. Wright, and R. G. White. 2002. Seasonal use of small tributary and main-stem habitats by juvenile Steelhead, Coho Salmon, and Dolly Varden in a Southeastern Alaska drainage basin. Transactions of the American Fisheries Society 131: 498-506.

Brunner, D.M., M.R. Douglas, A. Osinov, C.C. Wilson, and L. Bernatchez. 2001. Holarctic phylogeography of Arctic charr (*Salvelinus alpinus*) inferred from mitochondrial DNA sequences. Evolution: 55573-586.

CCME. 1996. A framework for ecological risk assessment: General guidance. The National Contaminated Sites Remediation Program. Winnipeg, MB.

Connell, J. H. 1983. On the prevalence and relative importance of interspecific competition: Evidence from field experiments. The American Naturalist 122: 661-96.

Denton, K. P., H. B. Rich, and T. P. Quinn. 2009. Diet, movement, and growth of Dolly Varden in response to Sockeye Salmon subsidies. Transactions of the American Fisheries Society 138: 1207-1219.

DFO. 2003. National code on introductions and transfers of aquatic organisms. Fisheries and Oceans Canada: Ottawa, ON.

DFO. 2013. British Columbia Introductions and Transfers. http://www.pac.dfo-mpo.gc.ca/aquaculture/licence-permis/intro-trans/index-eng.html (accessed November 2013).

Dolloff, C. A. 1993. Predation by river otters (*Lutra canadensis*) on juvenile Coho Salmon (*Oncorhynchus kisutch*) and Dolly Varden (*Salvelinus malma*) in Southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 50: 312-15.

Dolloff, C. A. and G. H. Reeves. 1990. Microhabitat partitioning among stream-dwelling juvenile coho salmon, *Oncorhynchus kisutch*, and Dolly Varden, *Salvelinus malma*. Canadian Journal of Fisheries and Aquatic Sciences 47: 2297-306.

Dunham, J., C. Baxter, K. Fausch, W. Fredenberg, S. Kitano, I. Koizumi, K. Morita, T. Nakamura, B. Rieman, K. Savvaitova, J. Stanford, E. Taylor, and S. Yamamoto. 2008. Evolution, ecology, and conservation of Dolly Varden, White Spotted Char, and Bull Trout. Fisheries 33: 537-50.

Dunham, J. B., K. Gallo, D. Shively, C. Allen, and B. Goehring. 2011. Assessing the feasibility of native fish reintroductions: A framework applied to threatened Bull Trout. North American Journal of Fisheries Management 31: 106-15.

Fischer, J. and D. B. Lindenmayer. 2000. An assessment of the published results of animal relocations. Biological Conservation 96: 1-11.

Gaughan, D. J. 2002. Disease-translocation across geographic boundaries must be recognized as a risk even in the absence of disease identification: the case with Australian Sardinops. Reviews in Fish Biology and Fisheries 11: 113-23.

Griffith, B., J. M. Scott, J. W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: Status and strategy. Science 245: 477-79.

Hagen, J. and E. B. Taylor. 2001. Resource partitioning as a factor limiting gene flow in hybridizing populations of Dolly Varden char (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*). Canadian Journal of Fisheries and Aquatic Sciences 58: 2037-47.

Havens, A., T. Bradley, and C. Baer. ADFG. 1995. Lake stocking manual for nonanadromous fisheries in southcentral Alaska. Fishery Data Series No. 95-2. Alaska Department of Fish and Game. n.p.

Hindar, K., B. Jonsson, J. H. Andrew, and T. G. Northcote. 1988. Resource utilization of sympatric and experimentally allopatric cutthroat trout and Dolly Varden charr. Oecologia 74: 481-91.

Hume, J. M. B. and T. G. Northcote. 1985. Initial changes in use of space and food by experimentally segregated populations of Dolly Varden (*Salvelinus malma*) and cutthroat trout (*Salmo clarki*). Canadian Journal of Fisheries and Aquatic Sciences 42: 101-09.

Idaho Department of Fish and Game (IDFG). 2007. Mountain Whitefish conservation and management plan for the Big Lost River drainage, Idaho. Idaho Department of Fish and Game, Boise, Idaho.

Kerr, S.J. 2000. Brook trout stocking: An annotated bibliography and literature review with an emphasis on Ontario waters. Ontario Ministry of Natural Resources. Peterborough, ON.

McPhail, J. D. 2007. The freshwater fishes of British Columbia. University of Alberta Press. Edmonton, AB.

McPhail, J. D. and J.S. Baxter. 1995. A review of bull trout (*Salvelinus confluentus)* life history and habitat use in relation to compensation and improvement opportunities. Prepared for Fisheries and Oceans Canada. Vancouver, BC.

Minckley, W. L. 1995. Translocation as a tool for conserving imperiled fishes: experiences in western United States. Biological Conservation 72: 297-309.

Montana Bull Trout Scientific Group. 1996. The role of stocking in bull trout recovery. Prepared for Montana Bull Trout Recovery Team by Montana Bull Trout Scientific Group: Helena, MT.

Nakano, S., K. D. Fausch, and S. Kitano. 1999. Flexible niche partitioning via a foraging mode shift: a proposed mechanism for coexistence in stream-dwelling charrs. Journal of Animal Ecology 68: 1079-92.

Nakano, S. and T. Furukawa-Tanaka. 1994. Intra- and interspecific dominance hierarchies and variation in foraging tactics of two species of stream-dwelling chars. Ecological Research 9: 9-20.

OMNR. 2002. Guidelines for stocking fish in inland waters of Ontario. Fisheries Section: Fish and Wildlife Branch. Peterborough, ON.

Pearson, M. P., J. T. Quigley, D. J. Harper, and R. V. Galbraith. 2005. Monitoring and assessment of fish habitat compensation and stewardship projects: Study design, methodology and example case studies. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2729. Vancouver, BC: Oceans, Habitat and Enhancement Branch, Fisheries and Oceans Canada.

Phillips, R.B., L.I. Gudex, K.M. Westrich, and A.L. DeCicco. 1999. Combined phylogenetic analysis of ribosomal ITs1 sequences and new chromosome data supports three subgroups of Dolly Varden char (*Salvelinus malma*). Can. J. Fish. Aquat. Sci. 56: 1504-1511.

Pope, K. L, and C. G. Kruse. 2007. Condition. In Analysis and interpretation of freshwater fisheries data. Ed. C.S. Guy and M.L. Brown. 423-473. Bethesda, MD: American Fisheries Society.

Redenbach, Z.R. 2000. Patterns of hybridization between Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in nature. M.Sc. thesis, Department of Zoology, University of British Columbia, Vancouver.

Redenbach, Z.R. and E.B. Taylor. 2002. Evidence for historical introgression along a contact zone between two species of char (Pisces: Salmonidae) in northwestern North America. Evolution, 56: 1021-1035.

Rescan. 2009a. KSM Project: 2008 fish and fish habitat baseline report. Seabridge Gold: Vancouver, BC.

Rescan. 2009b. KSM Project: 2008 aquatics baseline report. Seabridge Gold: Vancouver, BC.

Rescan. 2010a. KSM Project: 2009 fish and fish habitat baseline report. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2010b. KSM Project: 2009 aquatics baseline report. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2011. KSM Project: 2010 fish and fish habitat baseline report. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2012a. KSM Project: 2012 fish and fish habitat compensation baseline report. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2012b. KSM Project: 2012 fish and fish habitat baseline report. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2012c. KSM Project: 2012 fish bearing status assessment. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2013. KSM Project: Application for an environmental assessment certificate/environmental impact statement. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Ruesink, J. L., I. M. Parker, M. J. Groom, and P. M. Kareiva. 1995. Reducing the risks of nonindigenous species introduction. BioScience 45: 465-77.

Stockwell, C. A., M. Mulvey, and G. L. Vinyard. 1996. Translocations and the preservation of allelic diversity. Translocaciones y la Preservación de la Diversidad Alélica. Conservation Biology 10: 1133-41.

Toth, B.M. and K. Tsumura. 1996. Arrow Lakes rainbow trout brood stock collection. Ministry of Environment, Lands and Parks: Fisheries Branch. Vancouver, BC.

Williams, J. E., D. W. Sada, C. D. Williams, J. R. Bennett, J. E. Johnson, P. C. Marsh, D. E. McAllister, E. P. Pister, R. D. Radant, J. N. Rinne, M. D. Stone, L. Ulmer, and D. L. Withers. 1988. American fisheries society guidelines for introductions of threatened and endangered fishes. Fisheries 13: 5-11.

Personal Communication

Barker, O. 2013. Fisheries Biologist, Environment Yukon, Whitehorse. Personal Communication: November 22, 2013.