

Seabridge Gold Inc.

KSM PROJECT 2009 Fish and Fish Habitat Baseline Report

SEABRIDGE GOLD



KSM PROJECT

2009 FISH AND FISH HABITAT BASELINE REPORT

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SEABRIDGE GOLD

Seabridge Gold Inc.

Prepared by:



Engineers and Scientists

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia

Executive Summary

The purpose of the 2009 KSM (Kerr-Sulphurets-Mitchell) Fish and Fish Habitat Baseline Program was to provide baseline information on fish and fish habitat, within the Project area, that may be impacted by the proposed mine and infrastructure development. This report describes sampling procedures and results of the KSM Fish and Fish Habitat Baseline Program conducted in 2009. Baseline data collection took place within study area boundaries, and includes tributaries of Teigen Creek, Treaty Creek, and the Unuk River. The results presented in this report are a continuation of the 2008 Fisheries Baseline Report.

Access Roads

Stream classifications, along the proposed access roads, were determined using various habitat criteria including: channel width, gradient, and fish presence. Of the 106 sites classified as streams, the majority of sites (92 sites, 54%) were considered non-fish bearing due to habitat limiting conditions; such as high channel gradient (>30%), natural barriers, and poor quality fish habitat present to support the various fish life history stages. There were a total of 24 fish bearing crossings along the proposed access road routes. Seven of these crossings were fisheries sensitive zones and the remaining crossings were streams.

Tailing Management Facility and Plant Site

Within South Teigen Watershed, a total of 15.4 km/6.8 ha of stream fish habitat was mapped and assessed within the footprint of the proposed tailing management facility (TMF), of which 7.6 km/4.9 ha was the mainstem and 7.8 km/1.9 ha was tributaries. A total of 5.0 km/6.0 ha of South Teigen Creek was mapped and assessed downstream of the TMF to the confluence with Teigen Creek.

Within North Treaty Watershed, a total of 8.3 km/2.4 ha of stream fish habitat was mapped and assessed within the TMF, of which 2.8 km/1.7 ha was the mainstem and 5.5 km/0.7 ha was tributaries. A total of 1.2 km/0.9 ha of North Treaty Creek was mapped and assessed downstream of the TMF to the confluence with a large tributary from the eastern hillslope.

Within South Teigen and North Treaty watersheds, a total 0.2 ha and 0.9 ha of wetland fish habitat was mapped and assessed within the TMF, respectively.

Dolly Varden was the only species present in North Treaty and South Teigen creeks within the TMF. Dolly Varden, bull trout, mountain whitefish, and rainbow trout were present in South Teigen Creek downstream of a 2.5 m falls and outside of the TMF. No salmon species are present within South Teigen Creek based upon sampling data, spawning surveys, and habitat assessments. Fair or better Dolly Varden rearing habitat quality was observed at a high percentage of South Teigen and North Treaty watersheds. North Treaty Watershed possessed higher quality rearing habitat because of greater habitat diversity and fish habitat cover compared to South Teigen Watershed. Mean Dolly Varden population densities were higher in North Treaty Creek compared to South Teigen Creek. Mean Dolly Varden population densities were higher in North Treaty tributaries compared to South Teigen tributaries. South Teigen tributaries provide the majority of Dolly Varden fry and parr rearing habitat within South Teigen Watershed. North Treaty Creek provides suitable rearing habitat for Dolly Varden fry and parr.

South Teigen Creek provided none to poor suitable spawning habitat. The high composition of glacial fine substrates and high flows during the spawning season do not provide suitable spawning habitat for Dolly Varden. South Teigen tributaries provided suitable spawning habitat. North Treaty Creek and tributaries provided good and abundant Dolly Varden spawning habitat due to suitable substrate and habitat characteristics, suitable flow, and good water quality.

All reaches of South Teigen and North Treaty creeks provide good over-wintering habitat for Dolly Varden. The tributaries of these creeks provide over-wintering in certain stream reaches. All reaches of South Teigen and North Treaty creeks provided important fish habitat for Dolly Varden. Important habitat quality was observed at 68 % for South Teigen tributaries and 59 % for North Treaty tributaries.

Stream 1010, above a series of cascades, was classified as non-fish bearing because sufficient sampling effort demonstrated no fish present. Therefore, all streams above the cascades and in the location on the proposed plant site were classified as non-fish bearing.

Receiving Environment - Stream and Wetland Habitat

Teigen, Treaty and Unuk Watersheds

For the purposes of data analysis and comparison, three watersheds were selected for detailed fish and fish habitat analysis. The three watersheds were Teigen Creek, Treaty Creek, and the Unuk River.

Dolly Varden was the most widely distributed species within Teigen, Treaty and Unuk watershed reaches. Dolly Varden and bull trout coexist in Teigen Creek. Teigen and Treaty creeks support summer run populations of steelhead. Pacific salmon species, such as coho and Chinook are present in Treaty and Teigen creeks. Sockeye salmon are only present in Teigen Creek.

Salmon species are present in the Unuk River, with the majority of salmon spawning and rearing occurring in the lower 39 km of the Alaska section. Chinook and coho salmon are known to extend as far upstream as Storie Creek, which is approximately 15 km east of Sulphurets Creek confluence with the Unuk River. Only Dolly Varden was captured, in this study and others, within the Unuk River upstream of Storie Creek.

In Teigen Creek, Chinook salmon fry were the most abundant and rainbow trout/steelhead fry were the second most abundant species present. Chinook parr were not present in Teigen Creek Watershed. Rainbow trout/steelhead fry had a high abundance in the upper watershed on Teigen Creek, upstream of Hodkin Creek confluence. Rainbow trout/steelhead parr were distributed throughout the mainstem. Dolly Varden parr and adults were present throughout the mainstem, although the species abundance was less compared to Treaty Creek and the Unuk River. Bull Trout parr and adults were more abundant in the mainstem compared to Dolly Varden. Coho salmon fry and parr were most abundant species present within side channels and off channel wetlands of Teigen watershed. Dolly Varden fry, parr and adults also occupied the side channels and off channel wetlands.

In Treaty Creek, Dolly Varden parr and adults were the most abundant and present throughout the mainstem. Rainbow trout/steelhead parr were the second most abundant species present; however the species distribution was restricted to downstream of the Todedada Creek confluence. Mountain whitefish were present downstream of the Todedada Creek confluence. Dolly Varden fry, parr and adults were most abundant species present within side channels and off channel wetlands throughout Treaty watershed. Based upon previous fisheries assessments, coho salmon fry and parr also occupied the side channels and off channel wetlands, downstream of Todedada Creek confluence.

In the Unuk River, Dolly Varden parr and adults were the most abundant species and present throughout the mainstem. Coho fry were the second most abundant species present in the mainstem downstream of the Storie Creek confluence. Sockeye fry were present in the mainstem downstream of the Harymel Creek confluence.

Other Watersheds

A number of other watersheds, within the study area, were assessed for fish and fish habitat values. These other watersheds were: Bowser, South Unuk and Bell-Irving rivers, Oweegee, Snowbank, West Teigen, Sulphurets, and Coulter creeks.

There are a number of fish species present in the Bell-Irving River, Oweegee and Snowbank creeks. There are a number of fish species present in the Bowser River; however only Dolly Varden were present in the glacial headwaters at site BR1 in the upper reaches of the Bowser River. Only Dolly Varden were present in West Teigen Creek and were significantly longer and heavier compared to populations in other watersheds.

Dolly Varden were present in Sulphurets Creek below a 200 m cascade, which was approximately 300 m upstream from the Unuk River. Sulphurets Creek, above the cascade, was classified as non-fish bearing because sufficient sampling effort demonstrated no fish present. Therefore, all streams above the cascades were classified as non-fish bearing.

Dolly Varden and coho salmon were present below a large falls in Coulter Creek. Coulter Creek, above the falls, was classified as non-fish bearing because sufficient sampling effort demonstrated no fish present. Therefore, all streams above the falls were classified as non-fish bearing.

Receiving Environment - Lake Habitat

The three assessed lakes were: West Teigen Lake, Sulphurets Lake, and Todedada Lake. Dolly Varden was caught in West Teigen Lake. Dolly Varden and rainbow trout were caught in Todedada Lake. No fish were caught in Sulphurets Lake for a total of 45 hrs gillnetting effort and 235 hrs minnow trap effort. Sulphurets Lake was sampled in 2008 and no fish were caught, therefore Sulphurets Lake was classified as non-fish bearing.

KSM PROJECT

2009 FISH AND FISH HABITAT BASELINE REPORT

Table of Contents

Executive Summary	i
Table of Contents	v
List of Figures	viii
List of Tables	x
List of Plates	xiii
List of Appendices	xv
Acronyms and Abbreviations	xvii
1. KSM Project Location	1-1
2. Introduction	2-1
2.1 Project Proponent	2-1
2.2 KSM Project Description	2-1
2.2.1 Mining Area	2-1
2.2.2 Processing and Tailing Management Area	2-3
3. Objectives	3-1
4. Study Area	4-1
5. Methods	5-1
5.1 Fish Habitat Components	5-1
5.2 Access Roads	5-1
5.2.1 Study Design	5-1
5.2.2 Fish Habitat	5-1
5.2.3 Fish Community	5-2
5.2.3.1 Community Composition	5-2
5.2.3.2 Stream Classification	5-3
5.3 Tailing Management Facility and Plant Site	5-4
5.3.1 Study Design	5-4
5.3.2 Fish Habitat	5-4
5.3.2.1 Sensitive Habitat Inventory Mapping	5-4
5.3.2.2 Fish Habitat Assessment Procedures	5-5
5.3.3 Fish Community	5-5

5.3.3.1	Stream Rearing Habitat	5-5
5.3.3.2	Wetland Rearing Habitat	5-7
5.3.3.3	Spawning Habitat.....	5-8
5.3.3.4	Population Density	5-8
5.3.3.5	Dolly Varden Genetics	5-8
5.4	Receiving Environment	5-10
5.4.1	Stream Habitat.....	5-10
5.4.1.1	Study Design.....	5-10
5.4.1.2	Fish Habitat	5-10
5.4.1.3	Fish Community.....	5-10
5.4.1.4	Whole-Body Fish Tissue Metals	5-10
5.4.1.5	Fish Diet and Fecundity	5-11
5.4.1.6	Spawning Habitat.....	5-12
5.4.1.7	Instream Flow.....	5-12
5.4.2	Wetlands	5-14
5.4.2.1	Study Design.....	5-14
5.4.2.2	Fish Habitat	5-14
5.4.2.3	Fish Community.....	5-14
5.4.3	Lakes.....	5-14
5.4.3.1	Study Design.....	5-14
5.4.3.2	Fish Habitat	5-15
5.4.3.3	Fish Community.....	5-15
5.5	Data Analysis	5-15
5.5.1	Fish Habitat and Community.....	5-15
5.5.2	Statistical Analysis.....	5-17
5.5.3	Metal Mining Effluent Regulation Analysis	5-17
5.6	Quality Assurance / Quality Control.....	5-18
6.	Results	6-1
6.1	Access Roads	6-1
6.1.1	Stream Fish Habitat	6-1
6.1.1.1	Site Classification of Access Roads	6-1
6.1.1.2	Individual Stream Crossing Characteristics.....	6-1
6.1.2	Stream Fish Community	6-1
6.1.2.1	Species Presence and Community	6-1
6.2	Tailings Management Facility and Plant Site.....	6-2
6.2.1	Watershed Setting	6-2
6.2.2	Stream Habitat.....	6-2
6.2.2.1	Summary.....	6-2
6.2.2.2	Channel Characteristics	6-16
6.2.2.3	Channel Morphology and Instream Habitat.....	6-16
6.2.2.4	Riparian Vegetation and Stream Bank Characteristics	6-32

6.2.2.5	Habitat Quality	6-33
6.2.2.6	Spawning Habitat Assessment	6-44
6.2.3	Stream - Fish Community	6-44
6.2.3.1	Length, Weight and Condition	6-44
6.2.3.2	Age and Growth	6-44
6.2.3.3	Population Density	6-50
6.2.3.4	Dolly Varden Genetics	6-53
6.2.4	Wetland - Habitat	6-54
6.2.5	Wetland - Fish Community	6-57
6.3	Receiving Environment - Stream and Wetland Habitat	6-57
6.3.1	Watershed Setting	6-57
6.3.2	Teigen, Treaty and Unuk Watersheds - Fish Habitat	6-57
6.3.3	Teigen, Treaty and Unuk Watersheds - Fish Community	6-74
6.3.3.1	Fish Presence	6-74
6.3.3.2	Relative Abundance	6-79
6.3.3.3	Population Demography	6-87
6.3.3.4	Habitat Quality	6-91
6.3.4	Other Watersheds - Fish Habitat	6-91
6.3.4.1	Channel Characteristics	6-94
6.3.4.2	Habitat	6-94
6.3.5	Other Watersheds - Fish Community	6-101
6.3.5.1	Fish Presence and Distribution	6-101
6.3.5.2	Relative Abundance and Density	6-105
6.3.5.3	Population Demography	6-106
6.3.6	Instream Flow Habitat	6-110
6.3.7	MMER	6-110
6.3.7.1	Relative Abundance	6-116
6.3.7.2	Energy Use	6-116
6.3.7.3	Energy Storage	6-121
6.3.7.4	Survival	6-121
6.3.8	Whole Body Tissue Metals	6-130
6.3.9	Fish Diet	6-139
6.4	Receiving Environment - Lake Habitat	6-139
6.4.1	Fish Habitat	6-139
6.4.1.1	Todedada Lake	6-139
6.4.2	Fish Community	6-147
6.4.3	Fish Diet	6-150
7.	Conclusion	7-1
	References	R-1

List of Figures

FIGURE	PAGE
Figure 1-1. KSM Project Location	1-2
Figure 2.2-1. 2009 KSM Project Layout and Road Access	2-2
Figure 4.1-1. KSM Fisheries Study Area, 2009	4-3
Figure 6.1-1. Location of Fish Bearing Stream Crossings for the Teigen, Plant Site and Tunnel Access Roads	6-3
Figure 6.1-2. Location of Fish Bearing Stream Crossings for the Coulter Creek Access Road	6-5
Figure 6.1-3. Site Classifications of Access Road Streams, 2009	6-6
Figure 6.2-1. Tailing Management Facility and Plant Site Watersheds: Channel Morphology.....	(map pocket)
Figure 6.2-2. Tailing Management Facility and Plant Site Watersheds: Rearing Habitat.....	(map pocket)
Figure 6.2-3. Tailing Management Facility and Plant Site Watersheds: Spawning Habitat...	(map pocket)
Figure 6.2-4. Tailing Management Facility and Plant Site Watersheds: Over-Wintering Habitat	(map pocket)
Figure 6.2-5. Tailing Management Facility and Plant Site Watersheds: Overall Habitat.....	(map pocket)
Figure 6.2-6. Fork Length Class Distribution of Dolly Varden within South Teigen Watershed, 2009..	6-47
Figure 6.2-7. Fork Length Class Distribution of Dolly Varden within North Treaty Watershed, 2009..	6-48
Figure 6.2-8. Weight-Length Regressions of Dolly Varden within South Teigen and North Treaty Watersheds, 2009	6-49
Figure 6.2-9. Age Class Distribution of Dolly Varden within South Teigen and North Treaty Watersheds, 2009	6-51
Figure 6.2-10. Von Bertalanffy Growth Models of Dolly Varden within South Teigen and North Treaty Watersheds, 2009	6-52
Figure 6.2-11. Microsatellite DNA Allele Frequency Differences of Dolly Varden from Teigen and Treaty Watersheds	6-55
Figure 6.3-1. Stream Reaches within the Receiving Environment Watersheds	6-61
Figure 6.3-2. Teigen Creek Watershed Fish and Fish Habitat Assessment Sites, 2009	6-63
Figure 6.3-3. Treaty Creek Watershed Fish and Fish Habitat Assessment Sites, 2009	6-67
Figure 6.3-4. Unuk River Watershed Fish and Fish Habitat Assessment Sites, 2009	6-71
Figure 6.3-5. Weighted Mean Bed Substrate Composition of Teigen Creek, 2009	6-76
Figure 6.3-6. Weighted Mean Bed Substrate Composition of Treaty Creek, 2009	6-77
Figure 6.3-7. Weighted Mean Bed Substrate Composition of the Unuk River, 2009	6-78

Figure 6.3-8. Weighted Mean Habitat Unit Composition within Teigen Creek, 2009	6-80
Figure 6.3-9. Weighted Mean Habitat Unit Composition within Treaty Creek, 2009	6-81
Figure 6.3-10. Weighted Mean Habitat Unit Composition within the Unuk River, 2009	6-82
Figure 6.3-11. Weighted Mean Cover Composition within Teigen Creek, 2009.....	6-83
Figure 6.3-12. Weighted Mean Cover Composition within Treaty Creek, 2009.....	6-84
Figure 6.3-13. Weighted Mean Cover Composition within the Unuk River, 2009.....	6-85
Figure 6.3-14. Fork Length Class Distribution of Dolly Varden within Teigen, Treaty and Unuk Watersheds, 2009	6-92
Figure 6.3-15. Weight-Length Regression of Dolly Varden within Teigen, Treaty and Unuk Watersheds, 2009	6-93
Figure 6.3-16. Age Class Distribution of Dolly Varden within Treaty and Unuk Watersheds, 2009	6-95
Figure 6.3-17. Von Bertalanffy Growth Models of Dolly Varden within Treaty and Unuk Watersheds, 2009	6-96
Figure 6.3-18. Fork Length Class Distribution of Dolly Varden within West Teigen Watershed, 2009	6-108
Figure 6.3-19. Weight-Length Regressions of Dolly Varden within Other Watersheds, 2009.....	6-109
Figure 6.3-20. Instream Flow Habitat Assessment Transects within South Teigen Creek, 2009	6-111
Figure 6.3-21. Instream Flow Habitat Assessment Transects within North Treaty Creek, 2009	6-112
Figure 6.3-22. Von Bertalanffy Growth Models (Weight) of Dolly Varden from Receiving and Reference Environment Sites, 2009	6-117
Figure 6.3-23. Von Bertalanffy Growth Models (Length) of Dolly Varden from Receiving and Reference Environment Sites, 2009	6-118
Figure 6.3-24. Mean Fork Length and Weight of Dolly Varden Sampled in Reference and Receiving Environment Sites, 2009	6-120
Figure 6.3-25. Mean Gonadosomatic Index of Dolly Varden Sampled in Reference and Receiving Environment Sites, 2009	6-123
Figure 6.3-26. Weight-Length Regressions for Dolly Varden Sampled from Receiving and Reference Environment Sites, 2009	6-124
Figure 6.3-27. Mean Condition of Dolly Varden Sampled in Reference and Receiving Environment Sites, 2009.....	6-125
Figure 6.3-28. Liver Weight-Body Weight Regressions for Dolly Varden Sampled from Receiving and Reference Environment Sites, 2009.....	6-126
Figure 6.3-29. Liver Weight-Fork Length Regressions for Dolly Varden Sampled from Receiving and Reference Environment Sites, 2009.....	6-127

Figure 6.3-30. Mean Liversomatic Index of Dolly Varden Sampled in Reference and Receiving Environment Sites, 2009	6-128
Figure 6.3-31. Mean Age of Dolly Varden Sampled in Reference and Receiving Environment Sites, 2009	6-129
Figure 6.3-32. Mean Fork Length of Dolly Varden Sampled for Metals Concentrations from Receiving and Reference Environment Sites, 2009	6-131
Figure 6.3-33. Mean Principle Component Scores (PC1 and PC2) for Dolly Varden Whole Body Tissue Metals Concentrations from Receiving and Reference Environment Stream Sites, 2009	6-136
Figure 6.3-34. Mean Principle Component Scores (PC3 and PC4) for Dolly Varden Whole Body Tissue Metals Concentrations from Receiving and Reference Environment Stream Sites, 2009	6-137
Figure 6.3-35. Mean Principle Component Scores (PC5) for Dolly Varden Whole Body Tissue Metals Concentrations from Receiving and Reference Environment Stream Sites, 2009	6-138
Figure 6.3-36. Percent Diet Composition (by Number) of Dolly Varden Captured in Receiving and Reference Environment Sites, 2009	6-141
Figure 6.3-37. Percent Diet Composition (by Weight) of Dolly Varden Captured in Receiving and Reference Environment Sites, 2009	6-142
Figure 6.4-1. Shoreline and Littoral Zone Fish Habitat Assessment for Todedada Lake	6-143
Figure 6.4-2. Weight-Length Regression of Dolly Varden within West Teigen and Todedada lakes, 2009	6-149
Figure 6.4-3. Fork Length Frequency Distribution of Dolly Varden within West Teigen and Todedada lakes, 2009	6-151
Figure 6.4-4. Age Frequency Distribution of Dolly Varden within West Teigen and Todedada Lakes, 2009.....	6-152
Figure 6.4-5. Von Bertalanffy Growth Model for Dolly Varden within West Teigen and Todedada Lakes, 2009.....	6-153
Figure 6.4-6. Percent Diet Composition (by Number) of Dolly Varden Captured in West Teigen and Todedada Lakes, 2009.....	6-154
Figure 6.4-7. Percent Diet Composition (by Weight) of Dolly Varden Captured in West Teigen and Todedada Lakes, 2009.....	6-155

List of Tables

TABLE	PAGE
Table 4.1-1. Watersheds within the Fisheries Study Area, 2009.....	4-1
Table 5.2-1. Attributes Measured during Habitat Assessments at Stream Crossing Sites, 2009	5-2

Table 5.2-2. Life History Habitat Suitability and Overall Habitat Quality Criteria Assessed at Stream Crossing Sites	5-3
Table 5.2-3. Forest Practices Code Stream Classification Width Criteria	5-4
Table 5.3-1. Fish Habitat Attributes Assessed and Mapped for each Stream Segment.....	5-6
Table 5.3-2. FHAP Attributes Assessed and Measured at Stream Sites	5-7
Table 5.4-1. Whole-Body Fish Tissue Quality Variables and Detection Limits for KSM Project, 2009 ..	5-11
Table 5.4-2. KSM Spawning Habitat Surveys, 2009.....	5-13
Table 5.4-3. KSM Receiving Environment Lake Sites, 2009	5-14
Table 5.5-1. Summary of Three Principal Endpoint Responses for Environmental Effects Monitoring	5-17
Table 6.1-1. Individual Fish Bearing Stream Crossing Details, 2009.....	6-7
Table 6.1-2. Summary of Known Fish Species by Access Road and Stream, 2009.....	6-9
Table 6.1-3. Electrofishing Effort, Catch and CPUE of Streams along the Proposed Access Roads, 2009	6-10
Table 6.2-1. South Teigen Mainstem: Channel Characteristics	6-17
Table 6.2-2. South Teigen Watershed Tributaries: Channel Characteristics.....	6-18
Table 6.2-3. North Treaty Mainstem: Channel Characteristics	6-20
Table 6.2-4. North Treaty Watershed Tributaries: Channel Characteristics.....	6-21
Table 6.2-5. South Teigen Mainstem: Instream and Riparian Habitat Characteristics	6-23
Table 6.2-6. South Teigen Watershed Tributaries: Instream and Riparian Habitat Characteristics...	6-25
Table 6.2-7. North Treaty Mainstem: Instream and Riparian Habitat Characteristics.....	6-29
Table 6.2-8. North Treaty Watershed Tributaries: Instream and Riparian Habitat Characteristics ...	6-30
Table 6.2-9. South Teigen Mainstem: Habitat Quality Characteristics	6-34
Table 6.2-10. South Teigen Watershed Tributaries: Habitat Quality Characteristics	6-35
Table 6.2-11. North Treaty Mainstem: Habitat Quality	6-38
Table 6.2-12. North Treaty Watershed Tributaries: Habitat Quality Characteristics.....	6-39
Table 6.2-13. Summary of Spawning Habitat Assessments within South Teigen and North Treaty Watersheds, 2009	6-42
Table 6.2-14. Mean Length, Weight and Condition of Dolly Varden Captured in South Teigen and North Treaty Watersheds, 2009.....	6-46
Table 6.2-15. Mean Age of Dolly Varden Captured in South Teigen and North Treaty Watersheds, 2009	6-50

Table 6.2-16. Mean CPUE and Density of Dolly Varden Captured in South Teigen and North Treaty Watersheds, 2009	6-53
Table 6.2-17. Summary of Wetland Characteristics within South Teigen and North Treaty Watersheds, 2009	6-56
Table 6.2-18. Summary of Wetland Habitat within South Teigen and North Treaty Watersheds, 2009	6-56
Table 6.2-19. Wetland Sampling Effort, CPUE and Catch Statistics in South Teigen and North Treaty Watersheds, 2009	6-58
Table 6.2-20. Mean Length, Weight and Condition of Dolly Varden Captured in South Teigen and North Treaty Wetlands, 2009.....	6-58
Table 6.3-1. Summary of Stream Reaches within the Receiving Environment Watersheds, 2009	6-59
Table 6.3-2. Summary of Channel Statistics in Teigen, Treaty and Unuk Watersheds, 2009	6-75
Table 6.3-3. Summary of Channel Characteristics in Teigen, Treaty and Unuk Watersheds, 2009	6-75
Table 6.3-4. Summary of LWD Abundance and Distribution, and Riparian Characteristics in Teigen, Treaty and Unuk Watersheds, 2009	6-79
Table 6.3-5. Summary of Known Fish Species by Watershed.....	6-86
Table 6.3-6. Summary Statistics of Electrofishing Effort, Catch and CPUE in Teigen, Treaty and Unuk Watershed Mainstems, 2009	6-87
Table 6.3-7. Summary Statistics of Electrofishing Effort, Catch and CPUE in Teigen, Treaty and Unuk Watershed Mainstems by Site, 2009.....	6-88
Table 6.3-8. Summary Statistics of Minnow Trap and Electrofishing Effort, Catch and CPUE in Teigen, Treaty and Unuk Watershed Wetlands, 2009	6-89
Table 6.3-9. Mean Length, Weight and Condition of Fish Captured in Teigen, Treaty and Unuk Watersheds, 2009	6-90
Table 6.3-10. Mean Age of Fish Captured in Teigen, Treaty and Unuk Watersheds, 2009	6-94
Table 6.3-11. Species Life History Periodicity and Distribution for Teigen Watershed	6-97
Table 6.3-12. Species Life History Periodicity and Distribution for Treaty Watershed	6-98
Table 6.3-13. Summary of Channel Statistics for Other Watersheds, 2009	6-103
Table 6.3-14. Summary of Channel Characteristics for Other Watersheds, 2009	6-103
Table 6.3-15. Summary of Weighted Mean Substrate Composition for Other Watersheds, 2009.....	6-103
Table 6.3-16. Summary of Habitat and Fish Cover Characteristics for Other Watersheds, 2009	6-104
Table 6.3-17. Summary of LWD Abundance and Distribution, and Riparian Characteristics for Other Watersheds, 2009.....	6-104
Table 6.3-18. Summary of Fish Habitat Suitability and Quality in Other Watersheds, 2009	6-104

Table 6.3-19. Summary Statistics of Electrofishing Effort, Catch and CPUE in Other Watershed Mainstems, 2009	6-107
Table 6.3-20. Mean Length, Weight and Condition of Fish Captured in Other Watersheds, 2009	6-107
Table 6.3-21. Mean Age of Fish Captured in the Bell-Irving Watershed, 2009	6-110
Table 6.3-22. Summary of Instream Flow Transect Data within South Teigen and North Treaty Creeks, 2009	6-113
Table 6.3-23. Summary of Instream Flow Substrate Composition and Habitat Cover within South Teigen and North Treaty Creeks, 2009	6-114
Table 6.3-24. Summary Statistics of Electrofishing Effort, Catch and CPUE in Receiving and Reference Environment Sites, 2009	6-116
Table 6.3-25. Summary Fork Length and Weight Statistics for Dolly Varden Captured in Receiving and Reference Environment Sites, 2009	6-119
Table 6.3-26. Summary Gonad Statistics for Dolly Varden Captured in Receiving and Reference Environment Sites, 2009	6-122
Table 6.3-27. Metals Included in Dolly Varden Whole Body Tissue Analysis, 2009.....	6-132
Table 6.3-28. Summary of Dolly Varden Mean Whole Body Tissue Metal Concentrations, 2009	6-133
Table 6.3-29. Significance of Whole Body Tissue Metal Concentrations in Receiving and Reference Environment Sites, 2009	6-134
Table 6.3-30. Loadings of Metals on Principal Components	6-135
Table 6.3-31. Fullness, Digestion and Stomach Content Weight of Dolly Varden from Receiving and Reference Environment Sites, 2009	6-140
Table 6.4-1. Summary Statistics of Gillnet Effort, Catch and CPUE in Lakes, 2009	6-147
Table 6.4-2. Summary Statistics of Minnow Trap Effort, Catch and CPUE in Lakes, 2009	6-147
Table 6.4-3. Mean Length, Weight and Condition of Fish Captured in Lakes, 2009	6-148
Table 6.4-4. Mean Age of Fish Captured in Lakes, 2009	6-148
Table 6.4-5. Fullness, Digestion and Stomach Content Weight of Dolly Varden from West Teigen and Todedada Lakes, 2009.....	6-150

List of Plates

PLATE	PAGE
Plate 6.2-1. South Teigen Creek along Eastern Hillslope.	6-11
Plate 6.2-2. South Teigen Creek within Flat Valley.....	6-11
Plate 6.2-3. South Teigen Creek within Confined Valley.	6-12

Plate 6.2-4. South Teigen Creek Falls.....	6-12
Plate 6.2-5. South Teigen Creek Downstream of Falls.	6-13
Plate 6.2-6. North Treaty Creek along Eastern Hillslope.	6-13
Plate 6.2-7. North Treaty Creek Wetland Complex.	6-14
Plate 6.2-8. North Treaty Creek within Low Gradient Valley.	6-14
Plate 6.2-9. North Treaty Creek within Confined Valley.....	6-15
Plate 6.2-10. Large Tributary Downstream of North Treaty Creek Confluence.	6-15
Plate 6.2-11. Typical Dolly Varden Spawning Habitat.	6-45
Plate 6.2-12. Dolly Varden within Cover near Spawning Habitat	6-45
Plate 6.2-13. Stream 1010 Cascades.	6-54
Plate 6.3-1. Teigen Creek Upper Reaches.....	6-65
Plate 6.3-2. Teigen Creek Middle Reaches.	6-65
Plate 6.3-3. Teigen Creek Lower Reaches.....	6-66
Plate 6.3-4. Treaty Creek Upper Reaches.	6-69
Plate 6.3-5. Treaty Creek Middle Reaches.	6-69
Plate 6.3-6. Treaty Creek Lower Reaches.....	6-70
Plate 6.3-7. Unuk River Lower Reaches.	6-73
Plate 6.3-8. Unuk River Middle Reaches.	6-73
Plate 6.3-9. Unuk River Upper Reaches.....	6-74
Plate 6.3-10. Bowser River.....	6-99
Plate 6.3-11. South Unuk River - Side Channel.	6-99
Plate 6.3-12. Coulter Creek.	6-100
Plate 6.3-13. Sulphurets Creek	6-100
Plate 6.3-14. West Teigen Creek.	6-101
Plate 6.3-15. Oweegee Creek.	6-102
Plate 6.3-16. Snowbank Creek.	6-102
Plate 6.3-17. Sulphurets Creek Cascade.....	6-105
Plate 6.3-18. Coulter Creek Falls.	6-106
Plate 6.4-1. Aerial view of West Teigen Lake	6-144
Plate 6.4-2. Aerial view of Sulphurets Lake.....	6-145

Plate 6.4-3. Ground view of Todedada Lake.....	6-146
Plate 6.4-4. Shoreline and LWD within Todedada Lake.	6-146

List of Appendices

Appendix 6.1-1. FDIS Fish Habitat Data with KSM Study Area (attached CD)	
Appendix 6.1-2. Biological Fish Data From Stream Sites	
Appendix 6.1-3. Stream Electrofishing Effort and Catch Data	
Appendix 6.2-1. KSM SHIM Data	
Appendix 6.2-2. Detailed Fish Habitat Assessment of Streams in South Teigen and North Treaty Watersheds	
Appendix 6.2-3. South Teigen and North Treaty Watersheds Dolly Varden Spawning Survey Data	
Appendix 6.2-4. South Teigen, North Treaty, and West Teigen Watersheds Dolly Varden Population Density Assessment Data	
Appendix 6.2-5. Dolly Varden Microsatellite Genetic Study	
Appendix 6.2-6. Biological Fish Data From Wetland Sites	
Appendix 6.2-7. Wetland Habitat Minnow Trap Effort and Catch Data	
Appendix 6.3-1. Detailed Fish Habitat Assessment of Streams in Receiving and Reference Environment Watersheds	
Appendix 6.3-2. Receiving Environment Instream Flow Data	
Appendix 6.3-3. Receiving and Reference Environment MMER Sites Biological Fish Data	
Appendix 6.3-4. Receiving and Reference Environment Stream and Lake Fish Fecundity Data	
Appendix 6.3-5. Tissue Metal Concentrations from Fish Captured at Receiving and Reference Environment Sites	
Appendix 6.3-6. Receiving and Reference Environment Stream and Lake Fish Diet Data by Number	
Appendix 6.3-7. Receiving and Reference Environment Stream and Lake Fish Diet Data by Weight	
Appendix 6.4-1. Todedada Lake Habitat Data	
Appendix 6.4-2. Biological Fish Data from Receiving and Reference Environment Lakes	
Appendix 6.4-3. Receiving and Reference Environment Lake Habitat Gillnet Effort and Catch Data	
Appendix 6.4-4. Receiving and Reference Environment Lake Habitat Minnow Trap Effort and Catch Data	

Acronyms and Abbreviations

ANCOVA	Analyses of Covariance
ANOVA	Analyses of Variance
BCIFM	British Columbia Instream Flow Methodology
CPUE	Catch-per-unit-effort
DFO	Department of Fisheries and Oceans
EPA	Environmental Protection Agency
FCA	Factorial Correspondence Analysis
FDIS	Field Data Inventory System
FHAP	Fish Habitat Assessment Procedure
FISS	Fisheries Information Summary System
FSZ	Fisheries Sensitive Zone
GLM	General Linear Model
GPS	Global Positioning System
ICP-MS	Inductively Coupled Plasma - Mass Spectroscopy
ILP	Interim Locational Point
KSM	Kerr-Sulphurets-Mitchell
LWD	Large Woody Debris
MDL	Method Detection Limits
MOE	Ministry of Environment
MOF	Ministry of Forests
MMER	Metal Mining Effluent Regulations
NCD	Non-Classified Drainage
NTL	Northwest Transmission Line
NVC	No Visible Channel
PCA	Principle Component Analysis
QA/QC	Quality Assurance/Quality Control
RISC	Resource Inventory Standards Committee
SHIM	Sensitive Habitat Inventory Mapping
TMF	Tailing Management Facility
UBC	University of British Columbia

1. KSM Project Location

The KSM Project is a gold/copper project located in the mountainous terrain of northwestern British Columbia, approximately 950 km northwest of Vancouver, British Columbia, and approximately 65 km northwest of Stewart, British Columbia (Figure 1-1). The proposed Project lies approximately 20 km southeast of Barrick Gold's recently-closed Eskay Creek Mine and 30 km northeast of the Alaska border. The proposed processing plant and tailing management facility will be located about 15 km southwest of the community of Bell II on Highway 37.

The north and west parts of the Project area drain towards the Unuk River, which crosses into Alaska and enters the Pacific Ocean at Burroughs Bay. The eastern part of the Project area drains towards the Bell-Irving River, which joins the Nass River and empties into the Canadian waters of Portland Inlet. Elevations in the Project area range from under 240 m at the confluence of Sulphurets Creek with the Unuk River, to over 2,300 m at the nearby peak of the Unuk Finger.



FIGURE 1-1

2. Introduction

2.1 PROJECT PROPONENT

The proponent for the KSM (Kerr-Sulphurets-Mitchell) Project is Seabridge Gold Inc. (Seabridge), a publicly traded junior gold company with common shares trading on the Toronto Stock Exchange in Canada and on the American Stock Exchange in the United States.

2.2 KSM PROJECT DESCRIPTION

The KSM Project is a large proposed gold-copper mining project. Reserve figures released in a preliminary feasibility study announced on March 31, 2010 include 1.6 billion tonnes of ore containing 30.2 million ounces of gold, 7 billion pounds of copper, 133 million ounces of silver and 210 million pounds of molybdenum in the proven and probable categories. This environmental baseline study was designed to address a wide range of alternatives that have been assessed from engineering and cost perspective at various times during the baseline studies. The following project description is the base case for the March 2010 Preliminary Feasibility Study. Maps in subsequent sections of this baseline report may depict slightly different footprint configurations relating to earlier designs that prevailed at the time the fieldwork was completed.

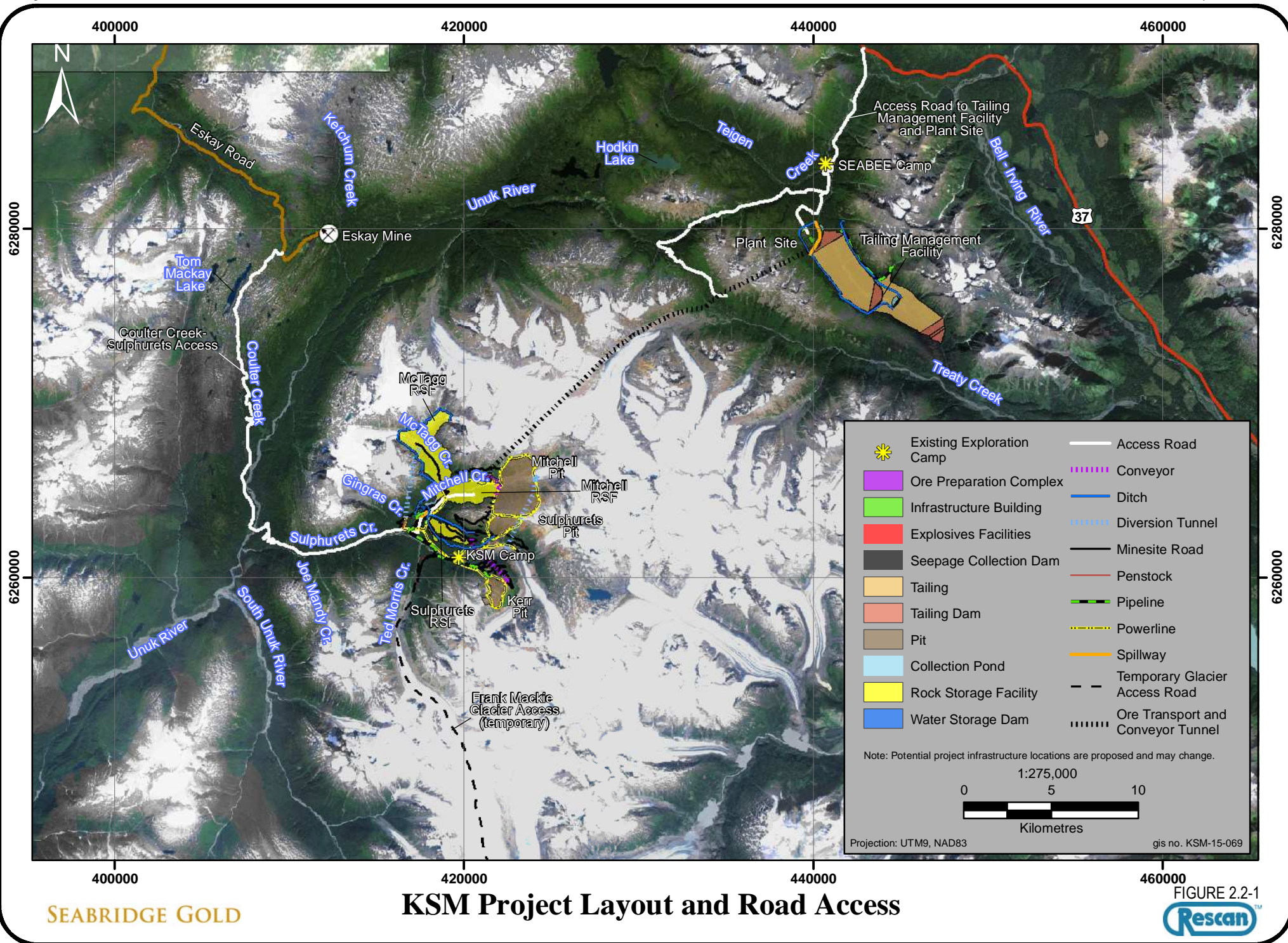
The proposed Project as defined for the purposes of this environmental baseline study will be comprised of two distinct and geographically separate areas (the mining area and processing plant and tailing management area), shown in Figure 2.2-1. The proposed mining area is located in the drainage basin of Sulphurets Creek, a major tributary of the Unuk River. The proposed location of the processing plant and tailing management facility is in the headwaters of tributaries of Teigen and Treaty Creeks, which flow to the Bell-Irving River. The two areas will be connected by a pair of parallel tunnels. An overview of these proposed mine components is provided in the following two Sections.

2.2.1 Mining Area

It is proposed that the mining area will be accessed by a new road to be constructed from the current Eskay Creek mine road. The access road will be used to transport personnel, heavy mining equipment, mining supplies, and explosives. This new road will trend southwestwards to the headwaters of Coulter Creek and then follow the general course of Coulter Creek to the Unuk River. After crossing the Unuk River it will follow the north side of the Sulphurets Creek Valley and cross Mitchell Creek. The Unuk River is considered navigable water under the *Navigable Waters Protection Act*. Branch roads will lead to each of the Kerr, Sulphurets and Mitchell deposits. Another branch road will head south parallel to Ted Morris Creek towards the toe of the north flowing tongue of Frank Mackie Glacier to provide access to the explosives manufacturing plant and related explosives magazines.

The support facilities for the mining area are proposed in the vicinity of the confluence of Sulphurets and Mitchell creeks. They will include accommodation for mine employees and administration and maintenance facilities.

The ore deposits will be bulk mined with large shovels and trucks and will use conventional drilling and blasting methods. The Kerr deposit is located on a ridge south of Sulphurets Lake. It is proposed that ore and non-ore mined rock will be transported from the Kerr deposit by conveyor to a tunnel portal (Sulphurets Mitchell tunnel) on the north side of Sulphurets Creek. These materials will be transported through the tunnel by conveyor to the Mitchell Creek Valley where they will be transported to the ore preparation complex or the Mitchell-McTagg rock storage facilities, respectively.



The Sulphurets deposit is located on the south side of the ridge north of Sulphurets Lake. It is proposed that ore will be transported by truck to the Sulphurets Mitchell tunnel and then by conveyor to the ore preparation complex. Non-ore mined rock will be transported to the Sulphurets rock storage facility on the south side of the ridge between the Mitchell Creek and Sulphurets Creek valleys, or to the Mitchell-McTagg rock storage facilities.

The Mitchell deposit straddles the Mitchell Creek Valley in an area recently exposed by the recession of the Mitchell Glacier. Mining of the deposit is proposed on both sides of the valley and to a depth of over 400 m below the current valley bottom. Seabridge proposes to construct a diversion tunnel from near the toe of the Mitchell Glacier, southwards towards the Sulphurets Creek Valley upstream of Sulphurets Lake to divert the flow of Mitchell Creek away from the proposed open pit area. It is proposed that the significant hydraulic head created by this tunnel will be used to drive a hydro-electric plant to generate a small portion of the electricity requirements of the Project.

Large volumes of low grade or barren rock will be removed in order to access the ore in each of the deposits. Non-ore rock removed to access ore will consist of both potentially acid generating (PAG) and not potentially acid generating (not PAG) rock. Rock storage areas have been defined in the Mitchell Creek and McTagg Creek valleys and on the south-facing side of the ridge between Sulphurets Creek and Mitchell Creek valleys. Runoff and seepage from the rock storage areas will be collected in a water storage facility contained behind a dam, to be located in the lower reaches of Mitchell Creek, and treated prior to discharge to the environment. The piped flow from the storage facility to the water treatment plant may be used to drive a hydro-electric plant.

A second diversion tunnel is proposed to direct the flow of McTagg Creek to the Sulphurets Creek Valley, thus avoiding the rock storage areas. The discharge from this tunnel will be available to drive a hydro-electric plant.

A run-of-river hydro-electric plant is proposed to harness the hydraulic head of the cascade in the lower reaches of Sulphurets Creek.

Ore from the deposits will be transported to an ore preparation complex, consisting of crushing and grinding facilities and related ore storage stockpiles, located on the north side of the Mitchell Creek Valley west of the Mitchell pit. Prepared ore will be mixed with water and pumped through one of two parallel 23 km-long tunnels to the process plant, proposed to be located in the drainage of a north-flowing tributary of Teigen Creek. The tunnels will daylight for a short distance near the divide between the Unuk River drainage and Treaty Creek before proceeding to the plant site in the Teigen Creek drainage. They will accommodate two pipelines to transport ore slurry as well as a return water pipeline, a diesel fuel pipeline, and a transmission line. The tunnels will slope towards Mitchell Creek so that all drainage can be controlled at the mine site and treated as necessary prior to release to the environment.

2.2.2 Processing and Tailing Management Area

The tunnel from the Mitchell Creek Valley will terminate on the south side of the valley formed by a north flowing tributary of Teigen Creek (South Teigen Creek) and a south flowing tributary of Treaty Creek (North Treaty Creek Tributary), adjacent to the plant site.

The plant will use a conventional grinding and flotation flowsheet to produce separate copper/gold and molybdenum concentrates, gold doré and tailing. It will process up to 120,000 tonnes per day of ore to produce an average of 1,200 tonnes per day of concentrate. The concentrate will be dried and

transported to the port of Stewart by truck. It is anticipated that approximately 20 to 30 round trips per day will be required using 40 tonne payload trucks.

Vehicle access to the plant site will be by a 14 km long road along Teigen Creek from Highway 37. This road will require bridges to cross Teigen creek, which may be considered to be navigable water, and smaller tributaries.

The tailing will be pumped through pipelines to the tailing management facility located in the upper reaches of the Teigen Creek Valley, extending southeast over the divide into a tributary of the Treaty Creek drainage. The facility will be constructed in two phases: the north cell will be developed between a north dam, to be located across the valley of the south tributary of Teigen Creek near the plant site, and a south dam, to be located near the crest of the valley floor; and a south cell that will be retained by a southeast dam, to be located in the headwaters of the north tributary of Treaty Creek. The proposed facility will have storage capacity for the life of the Project within an area about 8 km long and 1.5 km wide. Seepage from the south and southeast dams will be pumped back into the impoundment to reduce any potential impact on the Treaty Creek drainage. Water diversion channels will be constructed on both flanks of the impoundment, where feasible, to divert clean water away from the impoundment. Supernatant water will be recovered from the impoundment using barge mounted pumps and recycled to the plant for process water. In the event that discharge is required, the excess water in the impoundment will be pumped over the northern dam towards the Teigen Creek drainage. Treatment of discharge water may be required to meet permit conditions.

It is assumed that electricity to power the plant and mine site will be obtained from the provincial electricity grid. A secondary transmission line will be constructed from a switching station, to be located near the point where Highway 37 crosses Snowbank Creek. The secondary line will follow the general alignment of the access road, to the plant site, and then pass through the tunnel to the mine site.

3. Objectives

The Unuk and Bell-Irving rivers are large river systems that provide spawning migration routes for all five species of Pacific salmon and anadromous rainbow trout (known as steelhead trout), as well as habitat for resident trout (cutthroat and rainbow), resident char (Dolly Varden and bull trout) and whitefish.

The purpose of the 2009 KSM Fish and Fish Habitat Baseline Program was to provide baseline information on fish and fish habitat within the Project area that may be impacted by the proposed mine and infrastructure development. The objectives were as follows:

- Determine fish presence, community, distribution and barriers to fish movement for watercourses within the study area, with an emphasis on non-fish bearing stream reaches identified in 2008;
- Assess the quantity and quality of fish habitat in watercourses within the study area, with a detailed emphasis on streams within the footprint of the proposed TMF;
- Determine fish community composition and fish habitat quality of lakes and wetlands within the study area; and
- Measure whole-body fish tissue metals concentrations, fish diet, fish health and fish energy and reproductive investments at potential monitoring sites that may be required under the MMER.

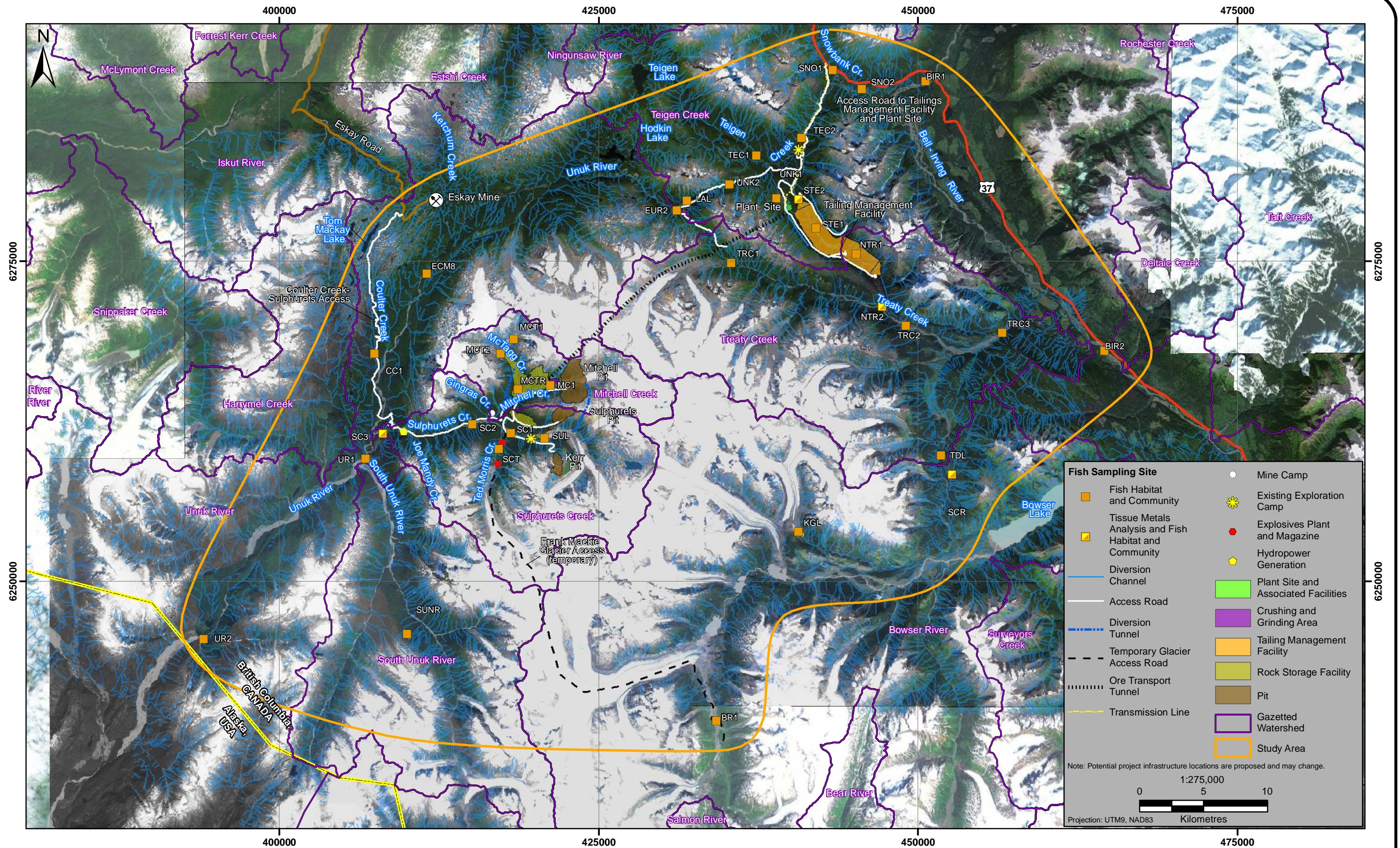
These objectives were achieved through field work in 2009 and review of 2008 baseline data and relevant background information about fish and fish habitat distribution, abundance and habitat use within the study area.

4. Study Area

The fish and fish habitat study area encompasses three major watersheds: Unuk, Bell-Irving and Bowser rivers. The resulting study area is based upon the locations of the proposed mine development infrastructure. A number of smaller sub-watersheds are included within the study area (Table 4.1-1 and Figure 4.1-1).

Table 4.1-1. Watersheds within the Fisheries Study Area, 2009

Unuk River Watershed	Bell-Irving River Watershed	Bowser River Watershed
Coulter Creek	Snowbank Creek	Bowser River
Mitchell Creek	Teigen Creek	Scott Creek
McTagg Creek	South Teigen Creek	
Tom McKay Creek	Treaty Creek	
South Unuk River	North Treaty Creek	
Sulphurets Creek	Bell-Irving River	
Ted Morris Creek		
Unuk River		



5. Methods

5.1 FISH HABITAT COMPONENTS

Fish habitat was separated into three distinct components for the purposes of this report: streams, lakes and wetlands. Streams were defined as watercourses that flow seasonally or perennially, possess a continuous channel bed that is scoured by water and which contain observable deposits of mineral alluvium (MOF 1998). Lakes were defined as an open waterbody with depths greater than 2 m and with less than 25% of its surface area covered with wetland vegetation (RISC 1999a). Wetlands were defined as any waterbody that is classified as lentic (i.e., still water as opposed to lotic, which means flowing water) with depths less than 2 m (RISC 1999a).

Fish habitat assessment and fish sampling methodologies differed between each habitat component, therefore each component was separated for the purposes of analysis and reporting.

For the purpose of this program, assessed sites were divided into three categories: proposed access roads, proposed TMF and plant site and receiving environment. The access road category included all streams crossed by the proposed road alignments. The TMF and plant site category was defined as all watersheds (i.e., South Teigen and North Treaty) associated within the TMF and plant site footprint. Receiving environment was defined as all watersheds downstream of the proposed project infrastructure within the study area.

5.2 ACCESS ROADS

5.2.1 Study Design

There are three proposed access roads for KSM. Sites along the proposed roads consisted of streams that may potentially be affected by road development. For the purpose of comparing fish and fish habitat in the study area, the streams assessed were grouped with their respective access roads.

The proposed access roads lie within a number of watersheds. They are as follows:

- Teigen Access and Plant Site Road - Snowbank, Teigen and South Teigen creeks;
- Tunnel Divide Portal Spurs Road - West Teigen Creek and Unuk River; and
- Coulter Creek Access Road - Coulter, Tom MacKay, Sulphurets and Mitchell creeks and Unuk River.

Streams crossing the access road corridors were assessed from July 6 to 18 and from September 8 to 19, 2009. The objectives of the stream assessments were to confirm fish presence, describe fish habitat, rank fish habitat suitability and determine “end of fish use” in a standardized approach.

5.2.2 Fish Habitat

The location of the proposed access roads were ground-truthed and flagged by surveyors prior to the start of the fisheries fieldwork. Field crews ground-truthed the proposed access road alignments for locations of streams, non-classified drainages (NCD) and no visible channels (NVC). Stream sites were classified as “true streams” if they met the definition of a stream - a continuous, defined channel for at least 100 m. Sites with partial or discontinuous channelization were categorized as NCDs. Sites where water seeped or flowed overland, or where water pooled at a potential road crossing but where

no channelization was apparent, were classified as NVC. For NCDs and NVCs, photos were taken facing upstream and downstream, GPS coordinates (+/- 10 m) were obtained and sites were flagged.

For all site classifications (i.e., NVC, NCD or stream), a unique identifying site number, or Interim Locational Point (ILP), was assigned.

At each stream crossing location, streams were assessed using methods based on the *Reconnaissance 1:20,000 Fish and Fish Habitat Inventory Protocol* (RISC 2001) and the *Reconnaissance 1:20,000 Fish and Fish Habitat Inventory: Site Card Field Guide* (RISC 1999b). This protocol involved characterizing fish habitat over a 100 m section of stream by measuring physical attributes (e.g., channel width, gradient, temperature and water quality), characterizing cover types and substrate (dominant and subdominant cover and substrate type, cover abundance and location) and describing stream morphology. Table 5.2-1 presents a complete list of attributes measured at each stream crossing. Based on the attributes collected at the stream crossing in the field, professional expertise was used to rank habitat suitability for each fish life history stage (i.e., spawning, rearing and over-wintering) and overall habitat quality. Table 5.2-2 presents habitat suitability and overall habitat quality ranks and their corresponding criteria.

A minimum of two photographs were taken to document each site, one each facing upstream from the crossing and on facing downstream from the crossing. Additional photographs were taken of barriers or features. GPS coordinates were obtained and the site was flagged.

Table 5.2-1. Attributes Measured during Habitat Assessments at Stream Crossing Sites, 2009

Substrate	Physical Measurements	Habitat	Cover
Dominate type	Bankfull width (m)	Stream morphology	Total amount
Sub-dominant type	Wetted width (m)	Presence of bars	Dominant, sub-dominant and trace cover types
D (cm)	Residual pool depth (cm)	Presence of islands	Cover location
D95 (cm)	Bankfull depth (m)	Bank shape	Canopy closure (%)
Bank texture	Gradient (%)	Stream pattern	Riparian vegetation
	Temperature (°C)	Confinement	Riparian vegetation stage
	Conductivity (µS/cm)	Hillslope coupling	
	pH (log units)	Spawning, rearing, overwintering suitability	
	Turbidity	Overall habitat quality	
		Riparian function	

D = largest stone that will move in a normal flood period (measured along the intermediate axis; cm) (RISC 2001).

D95 = stone that is in the top 5th percentile (by size) (measured along the intermediate axis; cm) (RISC 2001).

Turbidity was visually estimated.

5.2.3 Fish Community

5.2.3.1 Community Composition

Streams were sampled using backpack electrofishers following *RISC Fish Collection Methods and Standards* (RISC 1997), *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) and the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Fish Collection Field Guide* (RISC 1999c). The primary objective of fish sampling was to confirm fish

presence and the secondary objective was to determine the fish community composition (MOF 1998). Fish sampling occurred in the same locations where the habitat assessments occurred.

Table 5.2-2. Life History Habitat Suitability and Overall Habitat Quality Criteria Assessed at Stream Crossing Sites

Life Stage Suitability	
Ranks	Criteria
None	No habitat present for any life history stage
Poor	Most of the necessary physical/biological components of the habitat for this life history stage are missing or severely deficient
Fair	Some of the necessary physical/biological components of the habitat for this life history stage are present, but a key component is missing
Good	All of the necessary physical/biological components of the habitat for this life history stage are present
Overall Habitat Quality	
Ranks	Criteria
None	No habitat present at crossing
Marginal	Low productive capacity
Important	Common habitat which supplies needs of fish - typically rearing/over-wintering and some potential and commonly observed spawning substrate
Critical	Rare or exceptionally productive or unusual habitat with very high habitat values which are of uncommon and/or highly valuable production

Electrofishing was conducted over a minimum 100 m-long stream section (50 m both upstream and downstream of each crossing site); and for approximately 500 electrofishing seconds at each site. Only one electrofishing pass was made and no stop nets were used to prevent fish movement. Electrofishing in spawning areas during fish spawning activity was avoided to reduce the chance of harming fish and impacting spawning activities.

Biological information was collected on captured fish including species and length (to the nearest 1 mm). All fish were then returned live to the stream.

5.2.3.2 Stream Classification

A defensible, systematic approach was adopted to classify the fish bearing status of a stream at a road crossing. Streams were classified according to the *Forest Practices Code of British Columbia Fish-Stream Identification Guidebook* (MOF 1998). Under this procedure, streams were classified based on mean channel width (m) and fish-bearing status, as measured from surveys conducted in 2008 (Rescan 2009) and 2009 (this report). A summary of stream classes are presented in Table 5.2-3. The guidebook provides criteria for classifying streams as either fish bearing (i.e., Classes S1, S2, S3, S4) or non-fish bearing (i.e., S5 and S6). The guidebook classifies streams as non-fish bearing if the average gradient is greater than 20%. However, it is recognized that Dolly Varden and bull trout have the ability to move upstream in channels gradients up to 30% if adequate step pools are present (MOF 1998; McPhail and Lindsey 1970). Therefore, stream reaches were “confirmed” as non-fish bearing using gradient criteria alone if the average channel gradient was greater than 30%, channels were not defined, step-pool morphology is absent, pools are shallow and void of alluvial deposits (i.e., over-wintering habitat is absent), habitat was exceptionally marginal and no lakes were present in the headwaters.

Table 5.2-3. Forest Practices Code Stream Classification Width Criteria

Stream Classification	Mean Channel Width (m)	Fish Present?
S1	> 20.0	Yes
S2	5.0 to 20.0	Yes
S3	1.5 to 5.0	Yes
S4	< 1.5	Yes
S5	> 3.0	No
S6	≤ 3.0	No

Barrier searches and assessments were conducted on streams downstream of the road crossing. The presence of falls greater than 2 m high and steep cascades can restrict fish dispersal upstream and may “confirm” non-fish bearing status to the upstream reaches if falls are permanent and adequate sampling effort is conducted. Adequate sampling effort (based upon habitat features), in connection with habitat assessments, was conducted to confirm streams as non-fish bearing.

The rationale for changing stream classifications from “default” fish bearing to “confirmed” fish bearing included the following criteria:

- previous records showed fish present at crossing;
- fish were observed or sampled at or upstream of the crossing;
- fish were observed or sampled downstream of the crossing:
 - TRIM map gradients demonstrated that no part of the drainage downstream of the crossing flowed through gradients greater than 30%; and
- fish were present downstream of a man-made obstruction (e.g., hanging culvert) and there was an absence of natural barriers upstream of the obstruction.

5.3 TAILING MANAGEMENT FACILITY AND PLANT SITE

5.3.1 Study Design

The TMF and plant site category was defined as all watersheds associated within the TMF and plant site footprint (Figure 4.1-1). Stream and wetland habitat within the TMF and plant site footprint was mapped and assessed from July 6 to 18 and from August 4 to 16. Streams and wetland habitat fish community sampling, within the TMF and plant site footprint, was assessed from July 6 to 18, August 4 to 16 and September 8 to 19.

5.3.2 Fish Habitat

5.3.2.1 Sensitive Habitat Inventory Mapping

All streams and wetlands located within the proposed TMF and plant site footprint were ground-truthed and mapped, and habitat was assessed, through the implementation of the Sensitive Habitat Inventory Mapping (SHIM) protocol. In addition, the SHIM was conducted for South Teigen Creek downstream of the proposed TMF north dam to the confluence with Teigen Creek, and for North Treaty Creek downstream of the proposed TMF south dam to its confluence with the large tributary from the east. The SHIM method is intended by the BC Ministry of Environment (MOE) to be a standard for watercourse and fish habitat mapping in British Columbia (Mason and Knight 2001). This method attempts to ensure

the collection and mapping of reliable, high quality, current and spatially accurate information about fish habitats and watercourses.

Streams and wetlands were located in the field and their locations were mapped with a differential GPS unit (± 1 m). Moving in an upstream direction, streams were mapped, barriers were identified and habitat assessments were conducted. The presence of falls greater than 2 m high, steep cascades and channel gradients greater than 30% were determined as the point of “end of fish use”. The “end of fish use” for each stream was further validated with fish sampling (Section 5.3.3.1).

Detailed fish habitat data was collected in the field as streams and wetlands were mapped. The spatial data was tied to fish habitat data collected in the field. Habitat data collected was a combination of the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) and *BC Watershed Restoration Protocol* (Johnston and Slaney 1996) data. Table 5.3-1 presents the types of habitat data that were collected and mapped for each stream segment.

5.3.2.2 Fish Habitat Assessment Procedures

Detailed fish habitat assessments (FHAP) were conducted at representative sites for each stream and reach (Johnston and Slaney 1996). FHAP assessment lengths were 100 m for South Teigen and North Treaty creek mainstems and 50 m for all other tributaries. At each site, UTM coordinates were recorded with a differential GPS unit. Temperature ($^{\circ}\text{C}$), pH, and conductivity ($\mu\text{S}/\text{cm}$) were recorded using electronic meters.

FHAP assessments involved differentiating the stream into separate habitat units such as riffles, cascades, glides and pools, and then recording an array of habitat attributes for each unit. These attributes included data on substrate composition, cover for fish and fish habitat type. A complete list of the attributes measured is presented in Table 5.3-2. Data were collected with a measuring tape, metre stick, or visual estimation. Stream habitat within these sites were separated into the following habitat units:

- pool - low velocity area with smooth, non-turbulent flow, low gradient (near 0%), and a concave bottom;
- glide - an area of smooth, non-turbulent flowing water with moderate velocity and gradient less than 4%;
- riffle - an area of turbulent, fast-flowing water with a gradient less than 4%; and
- cascade - high gradient (>4%) area of turbulent, fast-flowing water.

5.3.3 Fish Community

5.3.3.1 Stream Rearing Habitat

In August, tributary streams mapped, excluding South Teigen and North Treaty creek mainstems, were sampled to confirm fish presence and validate rearing habitat quality ranks. Sampling crews commenced electrofishing at the tributary confluence, with South Teigen or North Treaty creek mainstems, upstream beyond the point of “end of fish use”. For each stream segment sampled, sampling crews recorded the number of fish caught and electrofishing effort (s), and provided a rearing habitat quality summary for each stream. Fish caught, effort and habitat summary data was reviewed and changes were made to the rearing habitat quality segments, if required.

Table 5.3-1. Fish Habitat Attributes Assessed and Mapped for Each Stream Segment

Locational and Physical Data	Channel Characteristics		Riparian Habitat Characteristics		Habitat Quality Characteristics	
	Attribute	Descriptors	Attribute	Descriptors	Attribute	Descriptors
Stream # (ILP)	Channel Morphology	Rifle-Pool	Bank Stability	Stable - Undercut	Spawning/Rearing/Over-Wintering Habitat Quality	Good
Reach #		Cascade-Pool		Stable - No Undercut		Fair
Segment #		Step-Pool		Aggrading		Poor
Wetted Width (m)		Large Channel		Eroding		None
Bankfull Width (m)	Dominant/Sub-Dominant Bed Substrate	Organics	Riparian Type	None	Potential Spawning Habitat	Abundant
Gradient (%)		Fines		Natural Wetland		Moderate
		Gravel		Shrubs		Micropatches
		Cobble		Coniferous Forest		None
		Boulder		Deciduous Forest	Overall Habitat Quality	Critical
		Bedrock		Mixed Forest		Important
	Dominant Bank Substrate	Organics	Riparian Structural Stage	Low Shrub (<2m)		Marginal
		Fines		Tall Shrub (2-10m)		
		Gravel		Sapling (>10m)		
		Cobble		Young Forest		
		Boulder		Mature Forest		
		Bedrock		Old Growth Forest		
	Water Stage	High	Crown Closure	0		
		Moderate		1-20%		
		Low		21-40%		
	Water Turbidity	High		41-70%		
		Moderate		71-90%		
		Low		>90%		
		Clear				

Table 5.3-2. FHAP Attributes Assessed and Measured at Stream Sites

Habitat Type	Substrate Type	Physical Measurements	Habitat	Cover
% Pool	% Sand	Length (m)	Pool Type	% Deep Pool
% Riffle	% Gravel	Wetted Depth (m)	Pool Residual Depth (m)	% Boulder
% Glide	% Cobble	Bankfull Depth (m)	Fish Passage Barriers	% Instream Vegetation
% Cascade	% Boulder	Wetted Width (m)	Off Channel Type	% Overhanging Vegetation
	% Bedrock	Bankfull Width (m)	Islands/Bars	% Undercut Bank
		Gradient (%)	Functional LWD Size Distribution	% LWD
		Bank Height (m)		% SWD
		Temperature (°C)		
		pH		
		Conductivity (µS/cm)		

LWD = large woody debris

SWD = small woody debris

Biological information was collected on captured fish including species, length (to the nearest 1 mm) and wet weight (to the nearest 0.01 g with an Ohaus 200 g scale. Aging structures (scales and pelvic fin rays) were collected from all fish greater than 90 mm in length.

Age analyses were conducted by North/South Consultants of Winnipeg, MB. Fish age was assessed primarily through the use of first two to three leading fin rays, with scales used as a secondary measurement whenever possible. This introduced a measure of inaccuracy into the results, because collecting scales from immature fish of certain species with small scales (e.g., Dolly Varden) was difficult and scales were not always obtained, while taking otoliths for aging requires sacrificing the fish. Fish age was assessed with otoliths only for individuals that died during capture and handling or that were sacrificed for tissue metals analysis.

Age of individual fish was estimated from fin rays, scales or otoliths by counting the number of annuli (or yearly rings). In the laboratory, fin rays were cross-sectioned, each section was attached to a glass slide, and annuli were counted using a compound microscope. Scales were attached directly to plastic fiches and scale annuli were counted using a microfiche reader. Otoliths were placed in a shallow dish filled with a clearing medium such as oil of wintergreen and the annuli were counted using a dissecting microscope and reflected light. A small number of structures were aged as replicate samples, using different structures where possible, and the estimate with the highest confidence was assigned to the sample.

5.3.3.2 Wetland Rearing Habitat

In July and August, mapped wetlands were sampled to confirm fish presence. Baited minnow traps were randomly set in wetlands overnight. Biological information was collected on captured fish including species, length (mm) and wet weight (g). Aging structures (i.e., scale and pelvic fin ray) were collected from a sub-set of fish greater than 90 mm in length.

5.3.3.3 *Spawning Habitat*

Dolly Varden spawning surveys were conducted in mapped streams within the TMF from September 17 to 19. In addition, spawning surveys were conducted for South Teigen Creek downstream of the proposed TMF north dam to the confluence with Teigen Creek, and for North Treaty Creek downstream of the proposed TMF south dam to the confluence with the large tributary from the East.

Spawning surveys were conducted to confirm Dolly Varden spawning locations and validate spawning habitat quality ranks. In tributaries, field crews commenced surveys at the tributary confluence, with South Teigen or North Treaty creek mainstems, upstream beyond the point of “end of fish use”. In South Teigen and North Treaty creek mainstems, field crews conducted spot surveys in stream segments. For each stream segment surveyed, sampling crews recorded water clarity, temperature (°C), number of fish observed spawning, number of redds observed, the UTM location of these observations and a habitat summary. Field crews used the methods and data cards from the *Redd Enumeration Field Guide* (RISC 2003), if redds were observed. Fish spawning survey and habitat summary data was reviewed and changes were made to the spawning habitat quality segments, if required.

5.3.3.4 *Population Density*

Dolly Varden population density assessments were conducted in mapped North Treaty and South Teigen tributary streams within the TMF, North Treaty Creek, and West Teigen Creek (reference stream) in August. Density assessments could not be conducted in South Teigen Creek in August due to high flows; therefore assessments were delayed and conducted in early September.

Density sites were randomly selected within stream reaches that were deemed to be representative of the stream reach habitat composition (i.e., riffle, pool, glide or cascade). The multiple removal/depletion method was adopted (Johnson et al. 2007) to determine density instead of mark/recapture methods due to the remote location and difficult accessibility of streams. Site length was 50 m for tributary streams and 25 m for mainstem streams. Stop nets were installed at upstream and downstream site boundaries. The entire bankfull width of the site was blocked to prevent fish immigration and emigration of the site; except South Teigen Creek mainstem. Due to the large bankfull width and discharge of South Teigen Creek, the bankfull width of the site could not be closed off; however currents were utilized to coral fish into the stop nets and the entire site was effectively sampled.

Three passes were conducted using a backpack electrofisher from the downstream stop net in an upstream direction then returning downstream. Electrofishing effort varied among sites; but was relatively consistent within site passes. The entire wetted area within the site was electrofished. Fish were enumerated, processed in a standardized manner and released downstream of the site after each pass. Biological information was collected on captured fish including species, length (mm) and wet weight (g). Aging structures (i.e., scales and pelvic fin rays) were collected from a sub-set of fish greater than 90 mm in length.

5.3.3.5 *Dolly Varden Genetics*

A Dolly Varden genetic study was conducted within Teigen and Treaty watersheds. Dolly Varden was present in South Teigen Creek above and below a potential barrier to fish movement. Dolly Varden was present in North Treaty Creek, and there exists a potential for headwater exchange between watersheds during high flood events. The objectives of the study were to answer the following questions:

- Are there significant genetic differences in Dolly Varden between Teigen and Treaty watersheds?
- Are there significant genetic differences in Dolly Varden within Teigen and Treaty watersheds?
- Are there significant genetic differences between the South Teigen Creek Dolly Varden population, above the barrier, and Dolly Varden populations throughout the Province?

During August and September, samples of adipose fin were taken and preserved in 95% ethanol from a subset of Dolly Varden captured from four areas: upstream of South Teigen Creek falls (Teigen Watershed); downstream of South Teigen Creek falls (Teigen Watershed); North Treaty Creek within the TMF (Treaty Watershed); and Treaty Creek (Treaty Watershed). Genetic analyses were performed by Dr. Eric Taylor at the University of British Columbia (UBC) in Vancouver, BC.

Dolly Varden and bull trout coexist in Teigen and Treaty watersheds. Natural hybridization between bull trout and Dolly Varden is known to occur in these watersheds, as identified in the 2008 baseline studies (Rescan 2009) and in other watersheds (Baxter et al. 1997). Therefore, samples were initially screened at two microsatellite markers - Sfo-18 and Omm-1128 - to obtain a broad overview of the species status and distribution of char within different watersheds. If the two markers were 100% diagnostic for either Dolly Varden or bull trout, then no additional markers were assayed. If either (or both) of the markers displayed species differences, or were comprised of alleles from both species (i.e., hybrid at that given marker), then the remaining markers - Sco-216, MTB and FOK223 - were screened to verify and/or add to the results of the first two markers. Char sampled were scored as either homozygous bull trout, homozygous Dolly Varden or heterozygote (hybrid) at each of the diagnostic genetic markers. Individuals that were identified as homozygous at the markers were categorized as pure-type for that species. First generation (F1) hybrid fish would be expected to be heterozygous at all markers screened, while backcross and higher-order hybrids were those individuals with a mix of homozygous and heterozygous markers.

Tests for differences in allele frequencies, pooled across loci, were conducted using Weir and Cockerham's (1984) θ statistic, with significance tested using permutation analyses. This analysis was completed using GENETIX (Belkhir et al. 2004). The relative similarity among samples was visualized using Factorial Correspondence Analysis (FCA) and population means were compared, in microsatellite allele frequency space, using GENETIX. FCA is a type of factor analysis that finds the best linear combination of variables (in this case allele frequencies at different loci) to describe variation between individual observations (fish). In general terms, FCA is best suited for categorical (rather than continuous) data and determines the first K axis of an orthogonal number of axes that describe the most variance from a "cloud" of observations.

For tests of population differentiation within creek, the Bayesian, model-based clustering algorithm contained in the program STRUCTURE (version 2.3.2) was used (Pritchard et al. 2000). This algorithm does not assume any population structure a priori and uses a likelihood approach to find the most likely number of K populations in the total data set that minimizes departures from Hardy-Weinberg equilibrium and linkage equilibrium. Such deviations are common when a single sample of individuals actually consists of a mixture of fish from two or more genetically differentiated populations.

5.4 RECEIVING ENVIRONMENT

5.4.1 Stream Habitat

5.4.1.1 Study Design

Receiving environment was defined as all watersheds downstream of the proposed project infrastructure within the study area. Reference sites were selected and could potentially be used in the future to determine if any changes observed at sites downstream of mine features were due to mining activities or to natural changes in the environment. Streams sites were assessed from July 6 to 18, from August 4 to 16 and from September 8 to 19.

5.4.1.2 Fish Habitat

Fish habitat assessments were based on the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001), *Reconnaissance 1:20,000 Fish and Fish Habitat Inventory: Site Card Field Guide* (RISC 1999b) and the detailed *Fish Habitat Assessment Protocol* (Johnston and Slaney 1996). Reconnaissance fish habitat assessments were conducted in accordance to the methods described in Section 5.2.2. Detailed FHAP assessments were conducted within study area watersheds and sites were 200 m in length. At each site, UTM coordinates were recorded at the beginning and end of each site with a hand-held GPS receiver (+/- 10 m). Data was collected in a similar manner as previously discussed in Section 5.3.2.

5.4.1.3 Fish Community

Fish sampling was conducted at the same location as the FHAP assessment sites. Electrofishing was conducted over a minimum 200 m-long stream section and for a total of approximately 1,000 electrofishing seconds. Only one electrofishing pass was made, and no stop nets were used to prevent fish movement. Biological data was collected in the same manner as stated in Section 5.3.3.

5.4.1.4 Whole-Body Fish Tissue Metals

Dolly Varden were collected from three receiving environment sites: SC3 (downstream of the proposed mine), STE2 (downstream of the proposed TMF northern dam) and NTR2 (downstream of the proposed TMF southern dam). Dolly Varden were collected from one reference environment site - SCR - in Scott Creek. Eight whole-body fish samples, from a range of fork lengths, were selected from each of the sites. Sex and maturity was determined through an examination of internal sex organs and gonads (RISC 1997). Maturity was classified as one of six stages of sexual maturity (i.e., immature, maturing, mature, spawning, spent and resting). Gonad, liver, and stomach samples were weighed using an Ohaus 200 g scale, with weights reported with two decimal points.

Fish stomachs were removed and preserved in 10% formalin for diet analysis. Developed ovaries were removed and preserved in 10% formalin for fecundity analysis. Whole fish were weighed and stored in labeled plastic bags and immediately frozen. Frozen samples were sent to ALS Environmental in Vancouver, BC, for analysis according to standardized procedures adapted from the United States' Environmental Protection Agency (EPA) guidelines. At ALS Environmental, samples were dried and moisture content was measured. Samples were then homogenized and digested in acid. Total concentrations of 30 metals in the processed samples were measured by Inductively Coupled Plasma - Mass Spectroscopy (ICP-MS). Total concentrations of mercury were measured with Cold Vapour Atomic Spectrophotometry. Metal concentrations were reported as mg/kg wet weight (wwt). Detection limits for the 30 metals are listed in Table 5.4-1.

Table 5.4-1. Whole-Body Fish Tissue Quality Variables and Detection Limits for KSM Project, 2009

Parameter	Abbreviation	Detection Limit (mg/kg ww)
<i>Physical Tests</i>		
Moisture		0.10%
<i>Total Metals</i>		
Aluminum	T-Al	2
Antimony	T-Sb	0.01
Arsenic	T-As	0.01
Barium	T-Ba	0.01
Beryllium	T-Be	0.1
Bismuth	T-Bi	0.03
Cadmium	T-Cd	0.005
Calcium	T-Ca	2
Chromium	T-Cr	0.1
Cobalt	T-Co	0.02
Copper	T-Cu	0.01
Iron	T-Fe	0.2
Lead	T-Pb	0.02
Lithium	T-Li	0.1
Magnesium	T-Mg	1
Manganese	T-Mn	0.01
Mercury	T-Hg	0.001
Molybdenum	T-Mo	0.01
Nickel	T-Ni	0.1
Phosphorus	T-P	5
Potassium	T-K	20
Selenium	T-Se	0.2
Sodium	T-Na	20
Strontium	T-Sr	0.01
Thallium	T-Tl	0.01
Tin	T-Sn	0.05
Titanium	T-Ti	0.1
Uranium	T-U	0.002
Vanadium	T-V	0.1
Zinc	T-Zn	0.1

5.4.1.5 Fish Diet and Fecundity

Diet and fecundity analyses were conducted from Dolly Varden collected for whole-body metals analysis. The stomach samples were sent to Applied Technical Services of Victoria, BC, for enumeration and identification. Each stomach was rinsed with water to remove the preservative. The stomach was carefully slit open and the contents were removed and blotted on filter paper to remove excess moisture. They were then weighed to the nearest milligram on a Denver TL-603D electronic balance.

Prey items were identified to the lowest possible taxonomic level and weighed. Where there were large numbers, a known number of each species was weighed; and the total number and weights were then extrapolated from those weights. Percent fullness (a measure of how full the stomach was) and percent digestion (the percentage of food, by weight, already digested and hence, unidentifiable) of the stomach contents were estimated.

Stomach contents were grouped by order and major life-history groups. This method was used because many taxonomic groups had so few representatives in the diet that obtaining the weight of the group was not possible. Therefore, stomach contents were organized by a few large taxonomic groups, (i.e., Diptera (minus Chironomidae), Chironomidae, Arachnida and Oligochaeta). The remaining individuals in the diet were organized into two major life history groups: the Hemimetabola (those insects with three life stages), and the Holometabola (those insects with four life stages). Data were presented by proportional number and weight of each taxonomic group.

The ovaries were removed from the fish and placed in a labelled bag with 10% formalin added as a preservative. The ovary samples were sent to Applied Technical Services of Victoria, BC, for fecundity counts. The ovaries were washed in water to remove the preservative, dried on filter paper to remove excess water, and weighed to the nearest 1 mg on a Denver TL-603D electronic balance. Depending on the apparent number of eggs, 10% by weight of the eggs were counted. Eggs usually fell into three size (diameter) categories: mature (large), immature (small) and future (extremely small). Only the first two categories were counted. Total numbers were then extrapolated from the sub-sample.

5.4.1.6 *Spawning Habitat*

Spawning surveys were conducted for a number of species (bull trout, steelhead, coho salmon, Chinook salmon, sockeye salmon) in the Teigen, South Teigen, Treaty, and North Treaty watersheds. The objectives, timing, and areas of the spawning surveys varied depending upon the target species (Table 5.4-2). In addition, Dolly Varden spawning surveys were conducted downstream of the TMF in South Teigen and North Treaty creeks as described in Section 5.3.3.3.

Generally, for each spawning survey field crews recorded water clarity and temperature (°C), number of fish observed spawning, number of redds observed, the UTM location of these observations and a habitat summary. Field crews used the methods and data cards from the *Redd Enumeration Field Guide* (RISC 2003), if redds were observed.

5.4.1.7 *Instream Flow*

The British Columbia Instream Flow Methodology (BCIFM) was conducted in North Treaty and South Teigen creeks downstream of the proposed TMF (Lewis et al. 2004) to determine flow data in-relationship to fish habitat data. Two instream flow sampling events were conducted from August 12 to 14 and from September 14 to 17. The purpose of the BCIFM is to provide a standardized approach to the collection of instream flow information in relation to fish and fish habitat. The BCIFM is complementary to other existing provincial methods and relies in part on data collection standards outlined in *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) and *BC Watershed Restoration Protocol* (Johnston and Slaney 1996). Stratified-random transects were established based upon hydraulic habitat type (i.e., pool, riffle, glide or cascade) for fish habitat measurements with the objective of describing and quantifying habitat.

Table 5.4-2. KSM Spawning Habitat Surveys, 2009

Target Species	Objective	Surveyed Stream	Stream Section	Survey Date
Bull Trout	Determine Spawning use in South Teigen and North Treaty creeks	South Teigen Creek	Confluence with Teigen Creek upstream to falls	September 15-16, 2009
		North Treaty Creek	Reaches below proposed TMF	
Steelhead	Determine spawning use and distribution in South Teigen and North Treaty creeks. Confirm spawning use downstream of South Teigen and North Treaty creek confluences in Teigen and Treaty creeks.	Teigen Creek	1 km downstream and 1 km upstream of South Teigen Creek confluence	June 5 to 7, 2009
		South Teigen Creek	Confluence with Teigen Creek upstream to falls	
		Treaty Creek	1 km downstream and 1 km upstream of North Treaty Creek confluence	
		North Treaty Creek	Confluence with Treaty Creek upstream to tributary confluence from eastern slopes	
Chinook and Sockeye	Determine spawning use in South Teigen and North Treaty creeks. Determine spawning distribution within Teigen and Treaty creeks.	Teigen Creek	Spot surveys from Snowbank Creek confluence to Teigen Lake Outlet	August 4 to 16, 2009
		South Teigen Creek	Confluence with Teigen Creek upstream to falls	
		Treaty Creek	Spot surveys from Bell-Irving River confluence to North Treaty confluence.	
		North Treaty Creek	Confluence with Treaty Creek upstream to tributary confluence from eastern slopes	
Coho	Determine spawning use in South Teigen Creek.	South Teigen Creek	Confluence with Teigen Creek upstream to falls	October 22 to 23, 2009

Depth (cm) and velocity (cm/s) data at transect verticals was collected with a Swoffer 2100 (2" propeller) according to the BCIFM methods. Each transect's cross sectional profile in South Teigen Creek was surveyed with a standard surveyor's level and rod according to the BCIFM methods. Habitat data collected at each vertical included; bed substrate composition and cover habitat type (e.g., boulder, pool, instream vegetation, etc). Stream temperature data loggers were installed in South Teigen and North Treaty Creeks downstream of the TMF. Dataloggers were wired to a steel bar staked into the stream bed. A piece of white PVC piping was used as a shield to protect the temperature loggers from direct exposure to the sun and from contact with bed load. Data loggers were deployed for a period of one year to record daily fluctuations in stream temperature.

5.4.2 Wetlands

5.4.2.1 Study Design

In September, wetland sites were selected within Teigen and Treaty Creek watersheds to determine fish species utilization, species distribution within watersheds, fish habitat quality and fish habitat connectivity to mainstem creeks.

5.4.2.2 Fish Habitat

Open water wetland habitat was qualitatively described and connectivity to mainstem creeks was documented. The width and length of open water wetland habitats were estimated, amount of cover and dominant cover type were recorded. Professional expertise was used to rank habitat suitability for each fish life history stage (i.e., spawning, rearing and overwintering) and overall habitat quality. Table 5.2-2 presents habitat suitability and overall habitat quality ranks and their corresponding criteria. For connecting stream habitats, fish habitat assessments were conducted based on the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) and *Reconnaissance 1:20,000 Fish and Fish Habitat Inventory: Site Card Field Guide* (RISC 1999b).

5.4.2.3 Fish Community

The fish community in each wetland was sampled using a combination of electrofishing and baited minnow traps. Electrofishing was conducted in narrow or shallow channels. Each wetland was electrofished for approximately 500 to 1,000 seconds, depending on catch rate. Minnow traps were set in deeper water habitats overnight. Fish caught were processed in a standardized manner as discussed in Section 5.3.3.

5.4.3 Lakes

5.4.3.1 Study Design

Receiving environment lake sites are those that may be directly or indirectly influenced by proposed mine development, and are located downstream or near proposed mine features. Reference lakes were selected and will be used in the future to determine if any changes observed at sites near or downstream of mine features are the result of potential mining activities, or due to natural changes in the environment. Lakes were assessed from July 8 to 11. Figure 4.1-1 shows the locations of the lakes. Table 5.4-3 provides a location, site description and rationale for each site.

Table 5.4-3. KSM Receiving Environment Lake Sites, 2009

Watershed	Gazetted Waterbody Name	Assigned Name	Site Code	Location		Site Description
				Easting	Northing	
Sulphurets Creek	-	Sulphurets Lake	SUL	420785	6261192	Sulphurets Lake is downstream of Sulphurets ore deposit. A glacial headwater lake
West Teigen Creek	-	West Teiegn Lake	LAL	431909	6279726	West Teigen Lake in upper West Teigen Creek Watershed
Todedada Creek	Todedada Lake	-	TDL	451692	6259677	Todedada Lake in upper watershed

Dashes indicates not applicable

5.4.3.2 Fish Habitat

In 2008, fish habitat assessments were conducted for West Teigen and Sulphurets lakes (Rescan 2009). Therefore, in 2009 fish habitat was only assessed for Todedada Lake. Shoreline and littoral zone substrates were mapped and categorized with a GPS and an inflatable boat. Shoreline and littoral zone substrate segments were categorized by dominant and subdominant substrates present. Shoreline type was described and categorized by one of the following types: beach, low-rocky, cliff/bluff, wetland and vegetated (mixed, shrub, coniferous or deciduous). Extensive submergent and emergent vegetation beds were described and mapped with a GPS. Cover and fish habitat was described for the lake. Inlets and outlets were located, photographed and described. Surface water temperature, pH and conductivity were measured.

5.4.3.3 Fish Community

Each lake was assessed using methodology based on the *Reconnaissance 1:20,000 Fish and Fish Habitat Inventory Protocol* (RISC 2001). Lakes were sampled with RISC standard sinking gillnets and baited minnow traps. A sinking gillnet net consisted of six panels, 15.2 m long and of different mesh sizes (25, 76, 51, 89, 38 and 64 mm), that were strung together in a “gang” to form a net 91.2 m long and 2.4 m deep. Gillnets were set randomly throughout the lake for a period of one hour to minimize fish mortality. If an unacceptable level of fish mortality occurred, then the durations of net sets were shortened. If fish were not caught with one hour net sets, then the durations of the net sets were lengthened. Overnight gillnet sets were set in lakes where previous netting efforts resulted in no fish caught or evidence suggested that no fish are present in the lake. Minnow traps were randomly set in the littoral zone (< 2 m water depth) along the lake shoreline overnight.

Fish caught were processed in a standardized manner as discussed in Section 5.3.3. Fish caught from West Teigen and Todedada lakes that were inadvertently killed during capture and handling were sampled for diet and fecundity analysis as discussed in Section 5.4.1.4.

5.5 DATA ANALYSIS

5.5.1 Fish Habitat and Community

Data collected during the fish habitat assessment and fish sampling associated with stream habitats were transcribed from field notes into the BC MOE Field Data Inventory System (FDIS) for data storage and interpretation. Fish habitat was characterized using mean lengths, widths and depths of the attributes collected in the field.

Fish communities were characterized using mean length (mm), mean weight (g), mean age (years) and catch-per-unit-effort (CPUE). CPUE is an index of relative abundance that can be used to compare fish populations among different areas. This was based on the assumption that catch is proportional to fishing effort (Hubert and Fabrizio 2007). It is defined as the number of fish captured per sampling device per unit time.

For electrofishing, the CPUE was calculated from the number of fish captured per 100 seconds:

$$1) \quad \text{CPUE} = \text{number of fish caught} * (100 / \text{electrofishing effort (s)})$$

For minnow traps, CPUE was calculated from the number of fish captured per trap per day (24 h).

$$2) \quad \text{CPUE} = \text{number of fish caught per trap} * (24 \text{ h/day} / \text{set time (h)})$$

For gillnets, CPUE was calculated from the number of fish captured per 100 m² of net per hour. Gillnet area (m²) was standard for all net sets, with an area of 218.88 m².

$$3) \quad \text{CPUE} = \text{number of fish caught per gillnet} * (100 / 218.88) * (1 / \text{set time (h)})$$

Estimates of fish density were generated from data collected by the multiple-pass removal method using software called "PopEst7.xls" that was developed by the environmental division of BC Hydro (Bruce and Z'Graggen 1995). Density was estimated using the multiple-pass removal method. For sites with a clear trend of declining catch per pass, estimates of the number of fish were generated using a maximum likelihood method. For sites in which catch increased with successive passes or which did not decline with successive passes, Bayesian methods were used to estimate numbers. Bayesian population estimates are robust to violations of the assumption of constant probability of capture.

The program derived variances, standard errors, and confidence limits for each population size estimate. Estimates of population density were obtained by dividing the population size by the surface area of the site (i.e., fish/100 m²). Surface area was calculated as the length of a stream site multiplied by its mean wetted width. Estimates of population density were averaged for similar types of sites (e.g., mainstem or tributary sites) in South Teigen, North Treaty and West Teigen watersheds.

Length-frequency distributions were constructed to visualize the distribution of fish among size classes. Length-frequency distributions were generated if there were adequate sample sizes. One of the interpretation assumptions of the distributions is that fish of all size classes have an equal probability of being captured. Also, a large sample size is required to ensure that all size classes are represented (Johnson et al. 2007).

Age-frequency distributions were constructed to present the distribution of fish in differing age classes.

Condition is an index of the relative health of fish. It was calculated for all fish for which length and weight data were obtained, and was based on the following formula from Ricker (1975):

$$4) \quad \text{Condition} = \text{weight (g)} \times 10^5 / \text{length (mm)}^3$$

Von Bertalanffy growth models (Ricker 1975) were fit to length-age data using SigmaPlot's (SYSTAT 2006) non-linear regression function. The equation for this model is:

$$5) \quad L_t = L_{\infty} (1 - e^{-K(t - t_0)})$$

where L_t is the length (mm) at age t (years), L_{∞} is the length (mm) that the fish would attain if it were allowed to grow for an infinitely long time, K is a growth coefficient (year⁻¹), and t_0 is the age (years) at zero length.

Von Bertalanffy growth models (Ricker 1975) were fit to weight-age data using SigmaPlot's (SYSTAT 2006) non-linear regression function. The equation for this model is:

$$6) \quad W_t = W_{\infty} (1 - e^{-K(t - t_0)})^3$$

where W_t is the weight (g) at age t (years), W_{∞} is the weight (g) that the fish would attain if it were allowed to grow for an infinitely long time, K is a growth coefficient (year⁻¹), and t_0 is the age (years) at zero weight.

5.5.2 Statistical Analysis

SYSTAT statistics software (SYSTAT 2004) was used for all statistical analyses. Data outlier tests (i.e., box plots) were employed to look for outliers that may have been caused by recording errors or transcription errors.. Normal probability plots were employed to test for normality of variables. Data were transformed with natural logarithms to meet assumptions of normality. Where applicable, data were represented as means and the statistic of dispersion was the standard error (SE) of the mean. Analyses of variance (ANOVA) were used to test for differences among means. Analyses of covariance (ANCOVA) were used to test for differences in intercepts of linear regressions. Results of statistical tests and regressions were considered significant if the probability (P) of a false significant result was less than 5% (i.e., $P < 0.05$). Results of all regression analyses were reported with a coefficient of determination (r^2) that was adjusted for the number of degrees of freedom.

A general linear model (GLM) was used to test for equality in the slopes of the fish weight-length regressions among receiving environment streams. If the slopes were equal (i.e., there was no significant interaction between length and stream on the weight of fish tested), then ANCOVA, with length as the covariate, was used to test for differences in mean weight (i.e., the y-intercepts of the regressions) among sites. If the slopes of the regressions were not equal, this indicated that the relationship between length and weight differed among sites and the y-intercepts of the regressions could not be compared.

5.5.3 Metal Mining Effluent Regulation Analysis

For the purposes of the MMER, only specified biological response data (i.e., effect endpoints) generated from the fish data will be used to assess the presence of an effect. To determine whether or not there is an effect on the fish population, statistical analyses of the data are conducted. Three principal type responses to the fish population are shown in Table 5.5-1. Each of the responses, their respective effect endpoints and supporting response variables, are presented in the following sections as baselines conditions.

Table 5.5-1. Summary of Three Principal Endpoint Responses for Environmental Effects Monitoring

Type of Response	Effect Endpoint	Statistical Analysis	Supporting Response Variable	Statistical Analysis
Energy Use	Size at age (body weight against age)	ANCOVA	Body Weight	ANOVA
	Relative gonad size (gonad weight against body weight)	ANCOVA	Length	ANOVA
			Size at age (length against age)	ANCOVA
			Relative gonad size (gonad weight against length)	ANCOVA
			Relative fecundity	ANCOVA
Energy Storage	Condition	ANCOVA	Relative liver size (liver weight against length)	ANCOVA
	Relative liver size (liver weight against body weight)	ANCOVA	Relative egg size	ANCOVA
Survival	Age	ANOVA		

Dolly Varden was selected as the fish species because they are a resident species to the study area watersheds and are the most abundant species within the study area watersheds. Dolly Varden from three receiving environment sites (SC3, STE2 and NTR2) and one reference environment site (SCR) were sampled in August to establish baseline conditions relating to the MMER.

For analysis of tissue metals concentrations, metals in which 80% of the concentrations were below the method detection limit (MDL) were excluded from analyses. For the included metals, all values below the MDL were assigned values of one-half the MDL in order to use those values in statistical analyses.

Mean metal concentrations—with standard error (SE), minimum and maximum—were calculated from that dataset for each stream. To compare mean tissue metal concentrations among streams, concentrations were ln-transformed to normalize their frequency distributions—a pre-requisite of parametric statistics. Then, ln(concentrations) were compared among the streams with one-way ANOVA. For significant ANOVAs, multiple comparisons were conducted between the means of the streams using the Bonferonni correction for degrees of freedom.

Principle Component Analysis (PCA) was used to reduce redundancy in the tissue metals data set and to allow clearer interpretation of trends in the data. PCA is a statistical routine that reduces a dataset containing a large number of correlated observations into a smaller number of uncorrelated artificial variables called components. PCA is also called data reduction because there are always fewer components than original variables once the redundant information has been removed.

PCA was applied to a single matrix containing the ln-transformed tissue metal concentrations (in mg/kg WW) and ln-transformed fish length. To help interpret the components, the loadings on the components (i.e., the correlation coefficients between the components and the original metal concentrations) were rotated with the Varimax option and sorted by their relative magnitude. The amounts of variance explained by each component and a scree plot (not shown here) were used to determine how many of those components were important and which were trivial. A scree plot is a plot of the variance explained by a component against the order in which the components were extracted. Important components appear as a 'cliff face' and trivial components appear as the 'scree' at the bottom of the cliff.

5.6 QUALITY ASSURANCE / QUALITY CONTROL

In order to ensure consistently accurate data collection, a Quality Assurance (QA) and Quality Control (QC) program was established at the onset of the field program. The program involved a practice session held in the field prior to any crew conducting stream, lake and wetland assessments to review data collection procedures. Throughout the course of the field program, a qualified and experienced Quality Assurance Biologist reviewed each completed data card daily. A QA checklist was also completed for each site. Whenever clarification was required on specific points, the card was returned to the crew leader for editing and was accepted only after the necessary changes were made. Data entry, into FDIS and other databases, subsequent to the field program provided another opportunity to ensure data consistency through application of the built-in quality assurance routine which generated a QA report for review. Comments were provided to address deficiencies and conflicts identified in the quality assurance report generated by FDIS. Data transcription quality was also verified by comparing a sub-sample of randomly selected site cards with the corresponding data entered into FDIS and into project maps. The standard for QC under the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Protocol* is to verify 5% of all site cards (RISC 2001).

For lake and wetland fish and fish habitat assessments, field notes were transcribed onto electronic spreadsheets in the office and all transcriptions were checked visually against the field forms and any errors corrected. The biological data were plotted to identify any outliers that may have resulted from transcription errors that occurred in the field.

6. Results

6.1 ACCESS ROADS

6.1.1 Stream Fish Habitat

6.1.1.1 Site Classification of Access Roads

There are three proposed access roads for the proposed KSM Project: Teigen Access and Plant Site Road, Tunnel Divide Portal Spur Road and Coulter Creek Access Road. Detailed site cards, fish cards and photos for all sites on the roads are located in Appendix 6.1-1. Fish-bearing stream crossing locations are shown in Figure 6.1-1 for the Teigen/plant site and tunnel access roads. Fish-bearing stream crossing sites are shown in Figure 6.1-2 for the Coulter Creek Access Road.

Of the 170 sites that were assessed, 106 (or 63%) conformed to the definition of “stream” according to the *Fish Forest Practices Code Fish-Stream Identification Guidebook* (MOF 1998) (Figure 6.1-3). The remaining sites were classified as either NCDs (57 sites or 34%) or fish-bearing fisheries sensitive zones (FSZ) (7 sites or 4%).

Stream classifications were determined using various habitat criteria including: channel width, gradient and fish presence. Of the 106 sites classified as streams, the majority of sites (92 sites or 54%) were considered non-fish bearing due to habitat limiting conditions such as high channel gradient (>30%), natural barriers and poor quality fish habitat. The Teigen Access and Plant Site Road and Tunnel Divide Portal Spur Road cross numerous ephemeral drainages that were not defined as streams. The majority of streams that are present along these access roads are subject to continuous avalanches and landslides, as a result channel formation and fish habitat is continuously disturbed. The Coulter Creek Access Road is located within the Coulter Creek and Sulphurets Creek watersheds. Fish migration barriers present in the lower reaches of these creeks resulted in non-fish bearing classification of stream crossings upstream of these fish migration barriers.

6.1.1.2 Individual Stream Crossing Characteristics

Table 6.1-1 presents a summary of each fish bearing stream crossing. Details regarding stream classification, location, channel measurements, bed substrate, channel morphology, cover type, riparian habitat and habitat quality are presented in this table. Channel characteristics and fish habitat cover are site specific, and habitat quality varies between sites.

6.1.2 Stream Fish Community

6.1.2.1 Species Presence and Community

Appendix 6.1-2 shows all species biological data for each site. Appendix 6.1-3 shows all electrofishing effort and catch data for each site. Table 6.1-2 summarizes fish species captured and historical fish presence information at stream sites along the proposed access roads. Dolly Varden was present along all access roads. Coho salmon were present along the Teigen and Plant Site Access Roads and Coulter Creek Access Road. Larger stream sites (e.g., Teigen Creek, South Teigen Creek, Unuk River) possessed the most diverse fish communities.

Presence of a species, either sampled in 2009, 2008 (Rescan 2009) or previously known, was used to determine the fish bearing status of a stream. If fish were observed or caught in 2008 or 2009, the

stream classification was listed as confirmed fish bearing. If fish were not observed or caught at a site, and fish presence is known downstream (from historical data), and no barriers to fish passage were present, then the stream classification was listed as default fish bearing. In total, 24 sites were recorded as fish-bearing, 16 were confirmed, and 8 listed as default fish bearing. The Teigen Access and Plant Site Road had the most numerous fish bearing streams (9 sites), although two of them were default fish bearing. Along the Tunnel Divide portal Spur Road two of the four fish bearing streams were default, while along the Coulter Creek Access Road four of the eight streams were default.

Catch, effort and CPUE for all fish sampling locations along the access roads are presented in Table 6.1-3. A total of 14,147 seconds of electrofishing effort was expended over 19 sites. A total of 63 fish were caught along the proposed access roads, the majority of these fish were caught in South Teigen and Coulter creeks. Dolly Varden was the dominant catch, found along all access roads. Rainbow trout were caught along the Teigen Access and Plant Site Road, while coastal cutthroat trout were only caught at one stream along the Coulter Creek Access Road.

6.2 TAILINGS MANAGEMENT FACILITY AND PLANT SITE

6.2.1 Watershed Setting

The proposed TMF is situated within the headwaters of two watersheds: South Teigen and North Treaty creeks. The proposed plant site is situated within South Teigen Creek. South Teigen and North Treaty possess a watershed area of 61 and 33 km², respectively. Within South Teigen and North Treaty watersheds, the proposed TMF encompasses 12.6% (7.7 km²) and 14.5% (4.8 km²) of the total surface area, respectively.

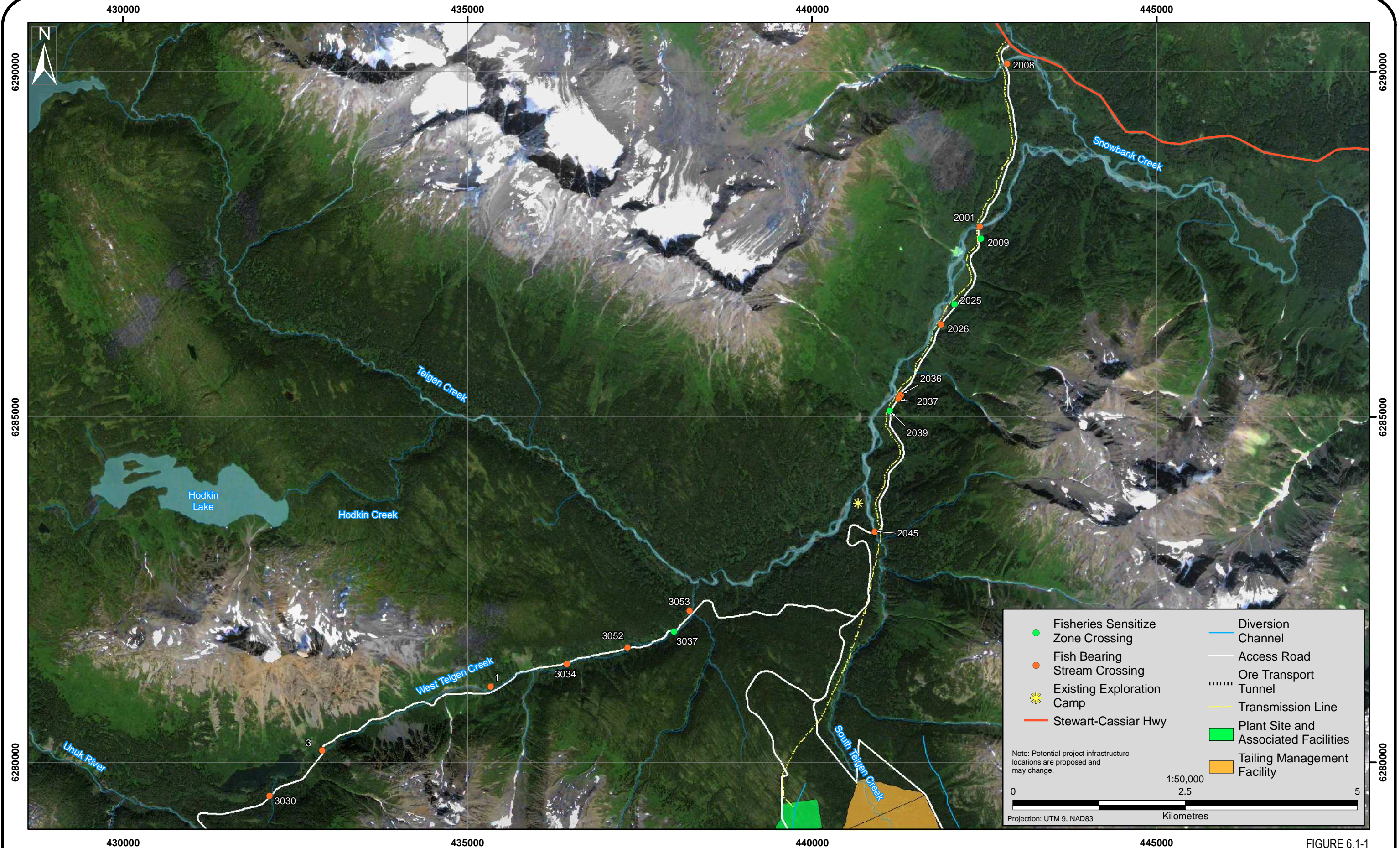
South Teigen Creek originates from glaciers on the eastern hillslope and flows into a broad, flat valley surrounded by wetland fen habitat (Plates 6.2-1 and 6.2-2). The creek then increases in gradient flowing through a confined valley with a 2.5 m-high falls (Plates 6.2-3 and 6.2-4). Downstream of the falls, the creek flows through an unconfined valley and discharges into Teigen Creek (Plate 6.2-5).

North Treaty Creek originates from two sources: the eastern hillslope and wetland complexes on the valley floor. The eastern hillslope provides a significant water source during the freshet and early summer, after which the flow is reduced (Plate 6.2-6). The wetland complex provides continuous water sources throughout the duration of the year (Plate 6.2-7). Both water sources merge to form North Treaty Creek. The creek flows in a low gradient valley surrounded by shrub riparian habitat (Plate 6.2-8). The creek then increases in gradient flowing through a confined valley (Plate 6.2-9) and discharges into a larger tributary. The larger tributary originates from the eastern hillslope and eventually discharges into Treaty Creek (Plate 6.2-10).

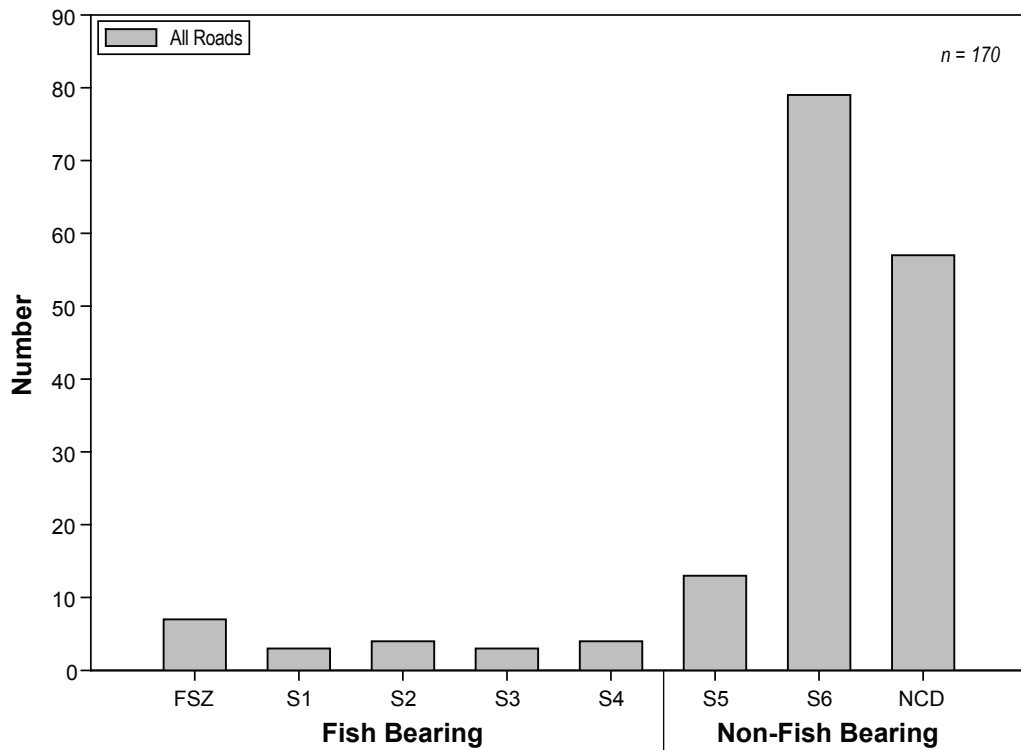
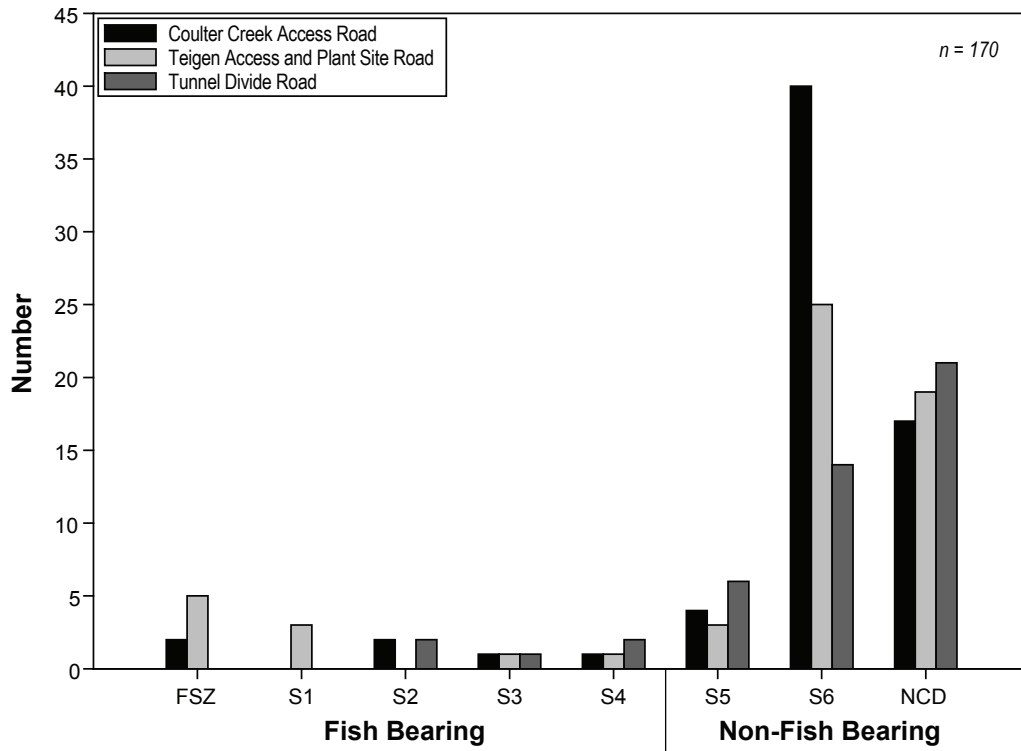
6.2.2 Stream Habitat

6.2.2.1 Summary

SHIM was used to characterize fish habitat within the TMF and within South Teigen and North Treaty mainstems downstream of the TMF between July 6 and 18. Appendix 6.2-1 presents SHIM data for each ILP. Appendix 6.2-2 presents FHAP data for each ILP site. Within South Teigen Watershed, a total of 15.4 km of stream fish habitat was mapped and assessed within the TMF, of which 7.6 km was the mainstem and 7.8 km was tributaries. A total of 5.0 km of South Teigen Creek was mapped and assessed downstream of the TMF to the confluence with Teigen Creek.







Site Classifications of
Access Road Streams, 2009

Table 6.1-1. Individual Fish Bearing Stream Crossing Details, 2009

Road	ILP	Stream Class	Location		Channel Measurements			
			Easting	Northing	Mean Channel Width (m)	Mean Gradient (%)	Mean Residual Pool Depth (m)	Mean Bankfull Depth (m)
Teigen Access and Plant Site Roads	2001	S1	442433	6287758	83.0	1.0	-	0.9
	(Teigen Creek)							
	2008	S1	442832	6290119	25.6	5.0	-	0.9
	2009	FSZ*	442450	6287586	3.6	0.0	-	0.7
	2025	FSZ*	442064	6286636	-	-	-	-
	2026	S2	441871	6286342	6.3	21.0	-	0.5
	2036	S4	441285	6285316	1.4	1.0	-	0.3
	2037	S3	441259	6285265	2.6	1.0	-	0.3
	2039	FSZ**	441125	6285089	-	-	-	-
	2045	S1	440912	6283335	23.8	2.5	-	0.9
Tunnel Divide Portal Spurs Road	(South Teigen Creek)							
	3030	S3	432126	6279512	3.0	4.0	0.2	0.2
	3052	S2	437324	6281660	11.5	4.3	-	0.4
	(West Teigen Creek)							
	3053	S2	438222	6282191	12.5	3.8	0.3	0.5
	(West Teigen Creek)							
	1	S2	435338	6281095	12.0	4.0	0.2	0.4
	(West Teigen Creek)							
	3	S2	432891	6280175	12.0	2.0	-	-
	(West Teigen Creek)							
Coulter Creek Access Road	3034	S4	436442	6281426	1.2	1.5	-	0.1
	3037	FSZ**	437997	6281895	1.4	1.5	0.1	0.1
	(Coulter Creek)							
	2060	S3	407703	6266547	1.9	0.5	-	0.3
	2061	S2	407561	6266553	16.0	1.5	0.6	-
	(Coulter Creek)							
	2062	FSZ**	-	-	-	-	-	-
	2063	S2	407277	6265832	12.7	3.5	0.3	-
	2064	S4	407274	6265770	1.4	14.0	0.2	0.3
	2076	FSZ**	407807	6262859	-	-	-	-
Unuk River	2077	FSZ**	408143	6262745	-	-	-	-
	2	S1	408020	6262770	145.0	1.0	-	-
	(Unuk River)							

Riparian Vegetation Type:

D = deciduous

C = coniferous

S = shrubs

G = grass

M = mixed

Dominant Substrate:

F = fines

C = cobble

B = boulder

G = gravel

Morphology:

CP = cascade pool

RP = riffle pool

SP = step pool

LC = large channel

Habitat

G = good

P = poor

F = fair

N = none

* FSZ = wetland

** FSZ = side channel

Dashes indicate not applicable or no data available

(continued)

Table 6.1-1. Individual Fish Bearing Stream Crossing Details, 2009 (completed)

Road	ILP	Stream Class	Location		Channel Characteristics		Stream Habitat		Habitat Quality		
			Easting	Northing	Dominant Substrate	Morphology	Dominant Cover Type	Riparian Vegetation Type	Overwintering	Rearing	Spawning
Teigen Access and Plant Site Roads	2001	S1	442433	6287758	G	RP	OV	M	G	G	G
	(Teigen Creek)										
	2008	S1	442832	6290119	B	CP	B	M	P	P	P
	2009	FSZ*	442450	6287586	F	LC	IV	M	G	G	N
	2025	FSZ*	442064	6286636	-	-	OV	-	-	-	-
	2026	S2	441871	6286342	C	CP	OV	S	N	P	N
	2036	S4	441285	6285316	G	RP	SWD	S	N	F	N
	2037	S3	441259	6285265	F	RP	SWD	S	P	P	N
	2039	FSZ**	441125	6285089	-	-	LWD	S	-	-	-
	2045	S1	440912	6283335	B	SP	B	D	P	P	P
Tunnel Divide Portal Spurs Road	(South Teigen Creek)										
	3030	S3	432126	6279512	G	RP	OV	S	P	G	G
	3052	S2	437324	6281660	C	CP	OV	S	P	G	G
	(West Teigen Creek)										
	3053	S2	438222	6282191	C	RP	OV	S	P	G	G
	(West Teigen Creek)										
	1	S2	435338	6281095	C	RP	OV	S	P	G	G
	(West Teigen Creek)										
	3	S2	432891	6280175	C	RP	OV	S	P	G	G
	(West Teigen Creek)										
Coulter Creek Access Road	3034	S4	436442	6281426	F	RP	OV	S	N	P	N
	3037	FSZ**	437997	6281895	F	-	OV	C	N	G	N
	(Coulter Creek)										
	2060	S3	407703	6266547	F	RP	OV	C	F	G	N
	2061	S2	407561	6266553	G	RP	LWD	C	G	G	G
	(Coulter Creek)										
	2062	FSZ**	-	-	F	-	LWD	C	-	-	-
	2063	S2	407277	6265832	G	RP	LWD	C	P	F	N
	2064	S4	407274	6265770	C	SP	OV	C	P	F	N
	2076	FSZ**	407807	6262859	-	-	-	-	-	-	-
Unuk River	2077	FSZ**	408143	6262745	-	-	-	-	-	-	-
	2	S1	408020	6262770	C	RP	DP	C	G	G	P
	(Unuk River)										

Riparian Vegetation Type:

D = deciduous

C = coniferous

S = shrubs

G = grass

M = mixed

Dominant Substrate:

F = fines

C = cobble

B = boulder

G = gravel

Morphology:

CP = cascade pool

RP = riffle pool

SP = step pool

LC = large channel

Habitat

G = good

P = poor

F = fair

N = none

Table 6.1-2. Summary of Known Fish Species by Access Road and Stream, 2009

Road	ILP	Stream Class	Fish Bearing Status	Sample Method	Species Present
Teigen Access and Plant Site Roads	2008	S1	Confirmed	EF	DV, RB
	2001	S1	Confirmed	EF	DV, RB, BT, CO, CH, SK, MW
	(Teigen Creek)				
	2009	FSZ*	Confirmed	VO	DV
	2025	FSZ*	Confirmed	VO	CO
	2026	S2	Confirmed	EF	DV
	2036	S4	Default	NS	-
	2037	S3	Confirmed	VO	CO
	2039	FSZ**	Default	NS	-
	2045	S1	Confirmed	EF	DV, BT, RB, MW
	(South Teigen Creek)				
Tunnel Divide Portal Spurs Road	3030	S3	Confirmed	EF	DV
	3052, 3053	S2	Confirmed	EF	DV
	(West Teigen Creek)				
	3034	S4	Default	NS	-
	3037	FSZ**	Default	NS	-
Coulter Creek Access Road	2060	S3	Default	NS	-
	(Coulter Creek - side channel)				
	2061	S2	Confirmed	EF	CO, DV
	(Coulter Creek)				
	2062	FSZ**	Default	NS	-
	2063	S2	Confirmed	EF	DV, CO, CCT
	2064	S4	Default	NS	-
	2076	FSZ**	Default	NS	-
	2077	FSZ**	Confirmed	VO	UNK
	Unuk River	S1	Confirmed	EF	CO, CH, SK, DV, CCT

DV = Dolly Varden, RB = rainbow trout, CO = coho salmon, CCT = coastal cutthroat trout, BT = bull trout, CH = chinook salmon, SK = sockeye,

MW = mountain whitefish, UNK = unknown species

EF = electrofishing, VO = visual observation, NS = not sampled

* FSZ is wetland

** FSZ is side channel

Dashes indicate no data available

Table 6.1-3. Electrofishing Effort, Catch and CPUE of Fish Bearing Streams along the Proposed Access Roads, 2009

Road	ILP	Site	Effort (s)	Dolly Varden		Rainbow Trout		Coho Salmon		Coastal Cutthroat Trout	
				No. of Fish	CPUE	No. of Fish	CPUE	No. of Fish	Mean CPUE	No. of Fish	CPUE
Teigen Access and Plant Site Roads	2006	1	157	0	-	0	-	0	-	0	-
	2008	1	495	1	0.20	1	0.20	0	-	0	-
	2008	2	503	0	-	0	-	0	-	0	-
	2026	1	295	2	0.68	0	-	0	-	0	-
	2045	1	1,144	15	1.31	0	-	0	-	0	-
(South Teigen Creek)											
Tunnel Divide Portal Spurs Road	3000	1	1,006	NFC	-	NFC	-	NFC	-	NFC	-
	3001	1	1,036	NFC	-	NFC	-	NFC	-	NFC	-
	3002	1	1,004	NFC	-	NFC	-	NFC	-	NFC	-
	3003	1	1,004	NFC	-	NFC	-	NFC	-	NFC	-
	3004	1	1,014	NFC	-	NFC	-	NFC	-	NFC	-
	3005	1	1,038	NFC	-	NFC	-	NFC	-	NFC	-
	3009	1	502	NFC	-	NFC	-	NFC	-	NFC	-
	3031	1	122	NFC	-	NFC	-	NFC	-	NFC	-
	3048	1	583	NFC	-	NFC	-	NFC	-	NFC	-
	3051	1	1,023	NFC	-	NFC	-	NFC	-	NFC	-
	3052	1	1,056	1	0.09	0	-	0	-	0	-
	3053	1	503	NFC	-	NFC	-	NFC	-	NFC	-
Coulter Creek Access Road	2061	1	1,012	2	0.79	0	-	22	2.17	0	-
	(Coulter Creek)										
	2063	1	650	11	1.69	0	-	4	0.62	4	0.62

CPUE = catch-per-unit-effort, fish/100 s

NFC = no fish caught

Dashes indicate not applicable



Plate 6.2-1. South Teigen Creek along Eastern Hillslope.



Plate 6.2-2. South Teigen Creek within Flat Valley.



Plate 6.2-3. South Teigen Creek within Confined Valley.



Plate 6.2-4. South Teigen Creek Falls.



Plate 6.2-5. South Teigen Creek Downstream of Falls.

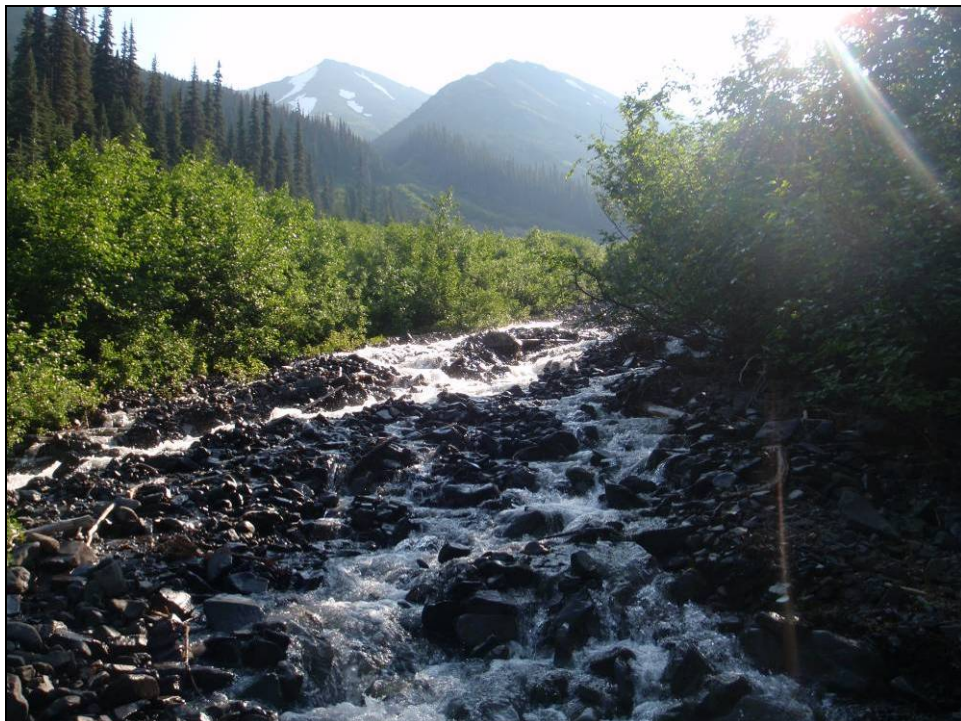


Plate 6.2-6. North Treaty Creek along Eastern Hillslope.



Plate 6.2-7. North Treaty Creek Wetland Complex.



Plate 6.2-8. North Treaty Creek within Low Gradient Valley.



Plate 6.2-9. North Treaty Creek within Confined Valley.



Plate 6.2-10. Large Tributary Downstream of North Treaty Creek Confluence.

Within North Treaty Watershed, a total of 8.3 km of stream fish habitat was mapped and assessed within the TMF, of which 2.8 km was the mainstem and 5.5 km was tributaries. A total of 1.2 km of

North Treaty Creek was mapped and assessed downstream of the TMF to the confluence with a large tributary from the eastern hillslope.

For the purposes of this report, streams were grouped according watershed location and habitat type: South Teigen Creek (mainstem within TMF and downstream of TMF), South Teigen tributaries (within TMF), North Treaty Creek (mainstem within TMF and downstream of TMF) and North Treaty tributaries (within TMF). Results were then grouped into three categories:

- channel characteristics - length assessed, area assessed, bankfull width, wetted width, bankfull depth, wetted depth, residual pool depth and gradient;
- instream and riparian habitat characteristics - habitat unit ratio, habitat weighted substrate composition, habitat weighted cover composition, riparian vegetation type, riparian structural stage, riparian crown closure, channel morphology, bank stability and dominant bank substrate; and
- habitat quality characteristics - spawning habitat, rearing habitat, over-wintering habitat, overall habitat and potential spawning habitat.

6.2.2.2 *Channel Characteristics*

Tables 6.2-1 to 6.2-4 summarize channel characteristics for South Teigen and North Treaty watersheds. Within South Teigen Watershed, a total of 6.8 ha of stream fish habitat were present within the TMF, of which 4.9 ha were the mainstem and 1.9 ha was tributaries. A total of 6.0 ha of South Teigen Creek fish habitat was present downstream of the TMF to the confluence with Teigen Creek. Within North Treaty Watershed, a total of 2.4 ha of stream fish habitat were present within the TMF, of which 1.7 ha were the mainstem and 0.7 ha was tributaries. A total of 0.9 ha of North Treaty Creek fish habitat was present downstream of the TMF to the confluence with the large tributary.

Channel characteristics varied between mainstem reaches and tributaries. Generally, South Teigen Creek had a larger mean bankfull width and depth than North Treaty Creek. North Treaty Creek had a higher mean channel gradient than South Teigen Creek. South Teigen tributaries had a larger mean bankfull width (1.9 m) and depth (0.3 m) than North Treaty tributaries (1.2 and 0.3 m). South Teigen tributaries had a greater occurrence of residual pools compared to North Treaty tributaries. South Teigen tributaries had a higher average channel gradient than North Treaty tributaries.

6.2.2.3 *Channel Morphology and Instream Habitat*

Channel Morphology

Tables 6.2-5 to 6.2-8 summarize channel morphology for South Teigen and North Treaty watersheds. Figure 6.2-1 (located in the map pocket) presents the SHIM channel morphology mapping results for South Teigen and North Treaty watersheds within the TMF.

Cascade-pool streams often have larger substrate classes than riffle-pool streams due to steeper gradient. Of the three primary morphology types, riffle-pool channels have the highest likelihood for supporting stream resident salmonids. In gravel bed channels, riffle-pool morphology generally meets all the life history requirements for spawning, rearing, over-wintering and migration habitat. Cascade-pool reaches with cobble, gravel and boulder substrates provide rearing and over-wintering habitat for juvenile salmonids. Spawning habitat in cascade-pool reaches is generally not abundant due to the predominance of cobble substrates. In cascade-pool reaches, spawning habitat is primarily restricted to small patches of gravel and sand in pool tailout areas.

Table 6.2-1. South Teigen Mainstem: Channel Characteristics

		1	2	3	4	All	4	5	6	7	8	All
Stream Length (m)		1340.0	760.0	1407.0	1518.0	5025.0	2376.0	2964.0	1220.0	261.0	808.0	7629.0
Bankfull Width (m)												
	Mean	15.33	10.30	10.30	11.33	11.82	6.70	6.44	5.06	6.00	8	6.44
	SE	2.03	0.72	0.72	0.67	1.03	0.46	0.77	0.27	-	-	0.50
Stream Area (m ²)		20546.67	7828.00	14492.10	17204.00	60070.77	15922.17	19073.34	6167.10	1566.00	6464.00	49192.61
Wetted Width (m)												
	Mean	12.33	10.07	10.07	10.67	10.78	6.28	6.14	4.61	6.00	7.8	6.16
	SE	1.20	0.70	0.70	0.83	0.86	0.40	0.75	0.08	-	-	0.41
Bankfull Depth (m)												
	Mean	1.11	1.00	1.00	0.99	1.03	0.97	0.84	0.55	0.30	0.7	0.67
	SE	0.20	0.25	0.25	0.25	0.24	0.16	0.14	0.13	-	-	0.14
Wetted Depth (m)												
	Mean	0.56	0.57	0.57	0.55	0.56	0.56	0.51	0.28	0.30	0.5	0.43
	SE	0.07	0.17	0.17	0.21	0.15	0.11	0.09	0.02	-	-	0.07
Residual Pool Depth (m)												
	Mean	-	-	-	-	-	0.97	0.93	-	-	-	0.95
	SE	-	-	-	-	-	0.44	0.18	-	-	-	0.31
Gradient (%)												
	Mean	1.50	2.85	3.00	3.50	2.71	2.75	1.00	5.00	-	6.00	3.00
	SE	-	-	-	0.33	0.56	0.55	-	-	-	1.00	0.54

Dashes indicate not present or not applicable

Table 6.2-2. South Teigen Watershed Tributaries: Channel Characteristics

Attribute	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018
Stream Length (m)	42.00	87.00	455.00	105.00	161.00	169.00	176.00	39.00	371.00	182.00	279.00	14.00	55.00	75.00	520.00	70.00	24.00
Bankfull Width (m)																	
Mean	1.10	0.91	2.17	1.67	1.17	2.26	1.32	0.50	6.20	1.93	3.60	2.00	0.65	0.90	3.45	3.50	1.50
SE	0.11	0.08	0.57	0.09	0.08	0.31	0.08	-	0.25	0.30	0.06	-	-	-	0.54	-	0.50
Stream Area (m ²)	45.99	78.74	985.08	174.83	188.01	382.50	231.44	19.50	2300.20	350.35	1004.40	28.00	35.75	67.50	1794.00	245.00	36.00
Wetted Width (m)																	
Mean	1.38	1.10	2.60	1.64	1.00	1.26	0.98	0.46	6.21	1.90	3.40	1.10	0.63	0.70	2.69	3.50	1.50
SE	-	-	-	0.24	0.13	0.40	0.12	-	0.17	0.32	0.15	-	-	-	0.10	-	-
Bankfull Depth (m)																	
Mean	0.30	0.30	0.30	0.24	0.20	0.18	0.29	0.24	0.52	0.48	0.35	-	0.17	0.70	0.41	-	-
SE	-	-	-	0.05	0.02	0.03	0.01	-	0.06	0.14	0.08	-	-	-	0.10	-	-
Wetted Depth (m)																	
Mean	0.18	0.16	0.10	0.16	0.15	0.11	0.11	0.05	0.37	0.40	0.26	0.25	0.13	0.08	0.26	-	-
SE	-	-	0.00	0.02	0.04	0.01	0.02	0.00	0.06	0.04	0.05	0.05	0.02	0.01	0.02	-	-
Residual Pool Depth (m)																	
Mean	0.10	0.17	-	0.12	0.12	0.16	0.05	-	-	0.37	0.28	0.33	-	0.10	-	-	-
SE	-	0.02	-	0.01	0.01	0.07	0.01	-	-	0.07	0.07	0.09	-	0.00	-	-	-
Gradient (%)																	
Mean	1.0	2.0	3.5	1.0	14.0	17.0	18.0	1.0	10.0	12.0	11.8	1.0	1.0	3.0	15.5	2.0	0.0
SE	-	-	1.50	-	6.24	8.00	-	-	-	5.29	2.75	-	-	-	7.50	-	-

Dashes indicate not present or not applicable

(continued)

Table 6.2-2. South Teigen Watershed Tributaries: Channel Characteristics (completed)

Attribute		1019	1021	1022	1023	1025	1026	1027	1028	1029	1030	1110	1150	1151	1152	1205	1206	1207	All
Stream Length (m)		550.00	168.00	289.00	173.00	352.00	100.00	112.00	105.00	448.00	1743.00	125.00	575.00	51.00	24.00	62.00	39.00	24.00	7764.00
Bankfull Width (m)																			
	Mean	2.75	1.25	1.52	1.83	1.64	1.75	0.91	3.10	3.00	2.61	5.25	1.29	0.50	1.22	1.40	1.52	1.25	1.99
	SE	0.25	0.09	0.26	0.24	-	0.13	0.28	0.10	0.00	0.45	0.25	0.05	-	-	0.90	-	-	0.25
Stream Area (m ²)		1512.50	209.58	439.28	317.28	578.34	175.00	101.55	325.50	1344.00	4553.10	656.25	741.23	25.50	29.28	86.80	59.28	30.00	19151.75
Wetted Width (m)																			
	Mean	3.75	1.23	1.43	1.88	1.40	1.88	0.64	3.20	3.00	3.04	5.25	1.42	1.03	1.22	0.50	1.39	1.25	1.93
	SE	0.63	-	0.03	0.27	0.07	0.03	0.19	-	-	0.36	-	0.04	-	-	-	-	-	0.20
Bankfull Depth (m)																			
	Mean	0.45	-	0.13	0.22	0.47	0.21	0.19	0.20	0.40	0.52	-	0.31	0.17	0.15	0.10	0.30	-	0.30
	SE	0.16	-	0.03	0.06	0.17	0.04	0.01	-	-	0.14	-	0.05	-	-	-	-	-	0.07
Wetted Depth (m)																			
	Mean	0.30	0.13	0.09	0.17	0.34	0.16	0.14	0.14	0.29	0.35	-	0.21	0.13	0.05	0.05	0.06	0.08	0.18
	SE	0.06	0.03	0.00	0.01	0.17	0.01	0.00	0.00	0.02	0.04	-	0.01	0.02	0.00	0.00	0.01	-	0.03
Residual Pool Depth (m)																			
	Mean	0.19	0.18	0.12	0.18	0.14	-	0.07	0.33	0.16	-	-	-	-	-	-	-	-	0.18
	SE	0.05	0.04	0.02	0.05	0.02	-	0.01	0.07	0.07	-	-	-	-	-	-	-	-	0.04
Gradient (%)																			
	Mean	10.8	6.8	18.0	13.0	9.8	4.0	17.0	2.0	1.0	3.8	2.0	2.7	2.0	2.0	0.5	2.0	30.0	7.5
	SE	4.71	2.95	-	10.00	3.84	2.00	7.00	1.00	-	1.11	-	0.47	-	-	0.50	-	-	0.92

Dashes indicate not present or not applicable

Table 6.2-3. North Treaty Mainstem: Channel Characteristics

Attribute	Reach Downstream TMF		Reaches Within TMF		
		1	1	2	All
Stream Length (m)		1230	660.0	2150.0	2810.0
Bankfull Width (m)					
	Mean	6.12	5.50	6.07	5.78
	SE	0.40	0.50	0.53	0.51
Stream Area (m ²)		7527.60	3630.00	13043.33	16673.33
Wetted Width (m)					
	Mean	5.90	5.50	5.69	5.59
	SE	0.48	0.50	0.36	0.43
Bankfull Depth (m)					
	Mean	0.64	0.40	0.65	0.52
	SE	0.08	-	0.12	0.12
Wetted Depth (m)					
	Mean	0.39	-	0.42	0.42
	SE	0.03	-	0.08	0.08
Residual Pool Depth (m)					
	Mean	0.30	0.50	0.45	0.48
	SE	-	-	0.15	0.15
Gradient (%)					
	Mean	4.8	5.8	2.0	3.4
	SE	0.25	1.49	-	0.75

Dashes indicate not present or not applicable

Channel morphology varied between mainstem reaches and tributaries. There was a higher proportion of riffle-pool morphology in North Treaty Creek (83.7%) compared to South Teigen Creek (46.9%), which was dominated by cascade-pool morphology. There was a higher proportion of riffle-pool morphology in North Treaty tributaries (82.4%) compared to South Teigen tributaries (46.0%), which had high proportions of cascade-pool (24.3%) and step-pool (27.1%) morphology.

Instream Habitat

Tables 6.2-5 to 6.2-8 summarize instream habitat for South Teigen and North Treaty watersheds.

The habitat unit ratio was evenly distributed between three habitat types (riffle, pool and cascade) for North Treaty Creek. In comparison, habitat unit ratio favoured riffle and cascade habitat types in South Teigen Creek. There were a higher proportion of riffles in North Treaty tributaries (79.0%) compared to South Teigen tributaries (50.2%), which had a high proportion of cascades.

Substrate is a key component of fish habitat due to its physical properties and its biological functions (e.g., invertebrate habitat, cover for fish and incubator of fish embryos). The habitat-weighted substrate composition was evenly distributed between three substrate types for South Teigen Creek. In comparison, habitat weighted substrate composition favoured gravel substrates in North Treaty Creek (62.0%). South Teigen tributaries were dominated by gravel substrates and North Treaty tributaries were dominated by fine substrates.

Table 6.2-4. North Treaty Watershed Tributaries: Channel Characteristics

Attribute		1051	1052	1053	1054	1055	1056	1057	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070
Stream Length (m)		71.0	23.0	90.0	136.0	135.0	45.0	29.0	957.0	707.0	31.0	245.0	15.0	29.0	39.0	15.0	81.0	70.0	12.0	61.0
Bankfull Width (m)																				
	Mean	1.8	1.42	1.80	1.54	1.65	1.46	1.40	1.88	3.59	0.73	1.20	0.70	0.69	1.15	0.99	1.75	1.00	0.40	0.81
	SE	0.3	0.02	-	0.17	-	-	-	0.13	0.55	-	0.22	-	-	-	-	-	-	-	-
Stream Area (m ²)		124.7	32.66	162.00	209.44	222.75	65.70	40.60	1797.79	2535.10	22.63	293.18	10.50	20.01	44.85	14.85	141.75	70.00	4.80	49.41
Wetted Width (m)																				
	Mean	1.76	1.42	1.80	1.37	1.65	1.46	0.40	1.85	3.30	0.73	1.42	0.70	0.69	1.15	0.99	1.70	1.00	0.40	0.81
	SE	0.27	0.02	-	-	-	-	-	0.45	-	-	0.02	-	-	-	-	-	-	-	-
Bankfull Depth (m)																				
	Mean	0.3	0.21	0.20	0.27	0.16	-	0.20	0.33	0.60	0.06	0.65	-	-	-	-	0.20	-	-	-
	SE	0.1	0.01	-	-	-	-	-	0.18	-	-	0.25	-	-	-	-	-	-	-	-
Wetted Depth (m)																				
	Mean	0.2	0.15	0.05	0.21	0.11	0.08	0.07	0.24	0.17	0.04	0.30	-	-	-	-	0.10	-	-	-
	SE	0.0	0.01	0.00	0.01	0.01	0.03	0.02	0.00	0.02	0.00	0.11	-	-	-	-	0.00	-	-	-
Residual Pool Depth (m)																				
	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	-	-
	SE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-
Gradient (%)																				
	Mean	4.0	2.0	3.3	2.0	4.0	2.0	2.0	9.2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	SE	2.00	-	1.33	-	-	-	-	2.88	-	-	-	-	-	-	-	-	-	-	-

Dashes indicate not present or not applicable

(continued)

Table 6.2-4. North Treaty Watershed Tributaries: Channel Characteristics (completed)

Attribute		1071	1072	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1101	All
Stream Length (m)		16.0	467.0	64.0	1212.0	66.0	128.0	89.0	53.0	232.0	40.0	72.0	28.0	40.0	14.0	5456.0
Bankfull Width (m)																
	Mean	0.81	0.94	1.67	1.75	0.83	1.30	0.65	1.84	1.06	1.00	0.50	0.50	0.82	0.50	1.21
	SE	-	0.24	-	0.15	-	-	-	0.03	0.06	-	-	-	-	-	0.19
Stream Area (m ²)		12.96	436.65	106.88	2119.65	54.78	166.40	57.85	97.34	246.69	40.00	36.00	14.00	32.80	7.00	9291.75
Wetted Width (m)																
	Mean	0.81	0.94	1.67	2.17	0.83	1.30	0.65	1.85	1.06	1.00	0.50	0.50	0.82	0.50	1.19
	SE	-	-	-	0.03	-	-	-	0.05	-	-	-	-	-	-	0.14
Bankfull Depth (m)																
	Mean	-	-	-	0.42	-	-	-	0.45	-	-	-	0.15	-	0.05	0.28
	SE	-	-	-	0.08	-	-	-	0.05	-	-	-	-	-	-	0.10
Wetted Depth (m)																
	Mean	-	-	-	0.22	-	-	-	0.27	-	-	-	0.12	-	0.03	0.15
	SE	-	-	-	0.03	-	-	-	0.05	-	-	-	0.00	-	0.01	0.02
Residual Pool Depth (m)																
	Mean	-	-	-	0.16	-	-	-	-	-	-	-	-	-	-	0.18
	SE	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	0.01
Gradient (%)																
	Mean	2.0	2.0	2.6	3.0	1.0	2.0	2.0	10.0	1.0	0.0	2.0	10.0	25.0	5.0	3.9
	SE	-	-	0.18	-	-	-	-	7.51	-	0.00	-	-	-	-	0.65

Dashes indicate not present or not applicable

Table 6.2-5. South Teigen Mainstem: Instream and Riparian Habitat Characteristics

Attribute	Descriptor	Reaches Downstream TMF					Reaches Within TMF					
		1	2	3	4	All	4	5	6	7	8	All
Stream Length Mapped	m	1340.0	760.0	1407.0	1518.0	5025.0	2376.0	2964.0	1220.0	261.0	808.0	7629.0
Mean Channel Width	m	15.33	10.30	10.30	11.33	11.82	6.70	6.44	5.06	6.00	8.00	6.44
Stream Area Mapped	m ²	20546.7	7828.0	14492.1	17204.0	60070.8	15922.2	19073.3	6167.1	1566.0	6464.0	49192.6
Habitat Unit Ratio (%)	Riffle	10.0	10.0	10.0	34.0	16.0	60.0	35.0	90.0	100.0	0.0	57.0
	Cascade	85.0	75.0	75.0	44.0	69.8	13.0	0.0	10.0	0.0	100.0	24.6
	Pool	5.0	15.0	15.0	22.0	14.3	21.0	25.0	0.0	0.0	0.0	9.2
	Glide	0.0	0.0	0.0	0.0	0.0	6.0	40.0	0.0	0.0	0.0	9.2
Habitat Weighted Substrate Composition - % by unit area	Fines	0.0	0.0	0.0	0.0	0.0	7.9	25.3	52.1	100.0	0.0	37.1
	Gravel	13.3	13.7	13.7	16.5	14.3	35.2	63.5	47.9	0.0	0.0	29.3
	Cobble	52.0	74.2	74.2	77.1	69.4	52.2	7.8	0.0	0.0	80.0	28.0
	Boulder	34.8	12.1	12.1	6.5	16.4	4.7	3.4	0.0	0.0	20.0	5.6
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	36.7	29.3	29.3	28.2	30.9	10.3	19.4	0.0	0.0	10.0	7.9
	Boulder	31.5	6.3	6.3	6.5	12.7	2.5	1.3	0.0	0.0	20.0	4.8
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Overhanging Vegetation	5.0	3.2	3.2	3.2	3.6	6.4	5.0	12.1	100.0	0.0	24.7
	Undercut Bank	0.0	0.0	0.0	0.0	0.0	3.3	6.0	5.0	0.0	0.0	2.9
	Large Woody Debris	3.4	3.7	3.7	3.5	3.6		0.0	0.0	0.0	0.0	0.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0	0.0	58.3
	Shrubs	0.0	0.0	0.0	41.1	12.4	23.3	0.0	0.0	0.0	0.0	7.3
	Coniferous Forest	0.0	0.0	100.0	58.9	45.8	76.7	0.0	0.0	0.0	0.0	23.9
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	10.6
	Not Assessed	100.0	100.0	0.0	0.0	41.8	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 6.2-5. South Teigen Mainstem: Instream and Riparian Habitat Characteristics (completed)

Attribute	Descriptor	Reaches Downstream TMF					Reaches Within TMF					
		1	2	3	4	All	4	5	6	7	8	All
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	0.0	0.0	0.0	41.1	12.4	23.3	100.0	100.0	100.0	0.0	65.5
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	100.0	0.0	100.0	28.8	36.7	60.9	0.0	0.0	0.0	0.0	19.0
	Mature Forest	0.0	100.0	0.0	30.1	9.1	15.7	0.0	0.0	0.0	100.0	15.5
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	0.0	0.0	0.0	40.4	12.2	5.4	100.0	100.0	100.0	0.0	60.0
	1-20%	100.0	100.0	100.0	59.6	87.8	94.6	0.0	0.0	0.0	85.4	38.5
	21-40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	1.5
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	100.0	100.0	100.0	100.0	100.0	85.3	0.0	100.0	0.0	100.0	53.1
	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	0.0	0.0	0.0	0.0	0.0	14.7	100.0	0.0	100.0	0.0	46.9
	Step Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bank Stability - % by stream length	Stable - Undercut	0.0	0.0	0.0	0.0	0.0	25.2	100.0	100.0	0.0	0.0	62.7
	Stable - No Undercut	100.0	100.0	100.0	100.0	100.0	74.8	0.0	0.0	0.0	0.0	23.3
	Aggrading	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	1.5
	Eroding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	85.4	12.5
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fines	0.0	0.0	0.0	0.0	0.0	15.7	100.0	100.0	100.0	100.0	73.8
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cobble	100.0	100.0	100.0	95.1	98.5	79.1	0.0	0.0	0.0	0.0	24.6
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	4.9	1.5	5.1	0.0	0.0	0.0	0.0	1.6

Table 6.2-6. South Teigen Watershed Tributaries: Instream and Riparian Habitat Characteristics

Attribute	Descriptor	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018
Stream Length Mapped	m	42.0	87.0	455.0	105.0	161.0	169.0	176.0	39.0	371.0	182.0	279.0	14.0	55.0	75.0	520.0	70.0	24.0
Mean Channel Width	m	1.10	0.91	2.17	1.67	1.17	2.26	1.32	0.50	6.20	1.93	3.60	2.00	0.65	0.90	3.45	3.50	1.50
Stream Area Mapped	m ²	46.0	78.7	985.1	174.8	188.0	382.5	231.4	19.5	2300.2	350.4	1004.4	28.0	35.8	67.5	1794.0	245.0	36.0
Habitat Unit Ratio (%)	Riffle	0.0	0.0	100.0	40.0	37.5	30.0	25.0	100.0	10.0	50.0	10.0	0.0	0.0	100.0	40.0	-	-
	Cascade	100.0	100.0	0.0	50.0	55.0	70.0	70.0	0.0	53.3	30.0	60.0	0.0	0.0	0.0	50.0	-	-
	Pool	0.0	0.0	0.0	10.0	7.5	0.0	5.0	0.0	36.7	20.0	30.0	0.0	0.0	0.0	10.0	-	-
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	100.0	-
Habitat Weighted Substrate Composition - % by unit area	Fines	0.0	70.0	0.0	43.7	15.9	5.5	9.4	20.0	1.3	0.0	4.0	0.0	100.0	75.0	0.0	-	-
	Gravel	30.0	30.0	30.0	43.0	52.1	94.5	82.9	80.0	38.9	96.2	57.1	0.0	0.0	25.0	81.0	-	-
	Cobble	70.0	0.0	70.0	13.3	32.0	0.0	7.7	0.0	54.8	3.8	26.9	0.0	0.0	0.0	19.0	-	-
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	11.9	100.0	0.0	0.0	0.0	-	-
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Habitat Weighted Cover Composition - % by unit area	Pool	0.0	0.0	0.0	8.4	13.2	2.8	11.3	0.0	34.6	19.8	27.6	0.0	0.0	0.0	7.2	-	-
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	11.9	50.0	0.0	0.0	0.0	-	-
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	-	-
	Overhanging Vegetation	70.0	70.0	80.0	4.6	0.0	37.6	4.7	80.0	2.7	4.5	0.5	0.0	90.0	25.0	4.5	-	-
	Undercut Bank	0.0	0.0	0.0	0.0	2.1	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-
	Large Woody Debris	5.0	5.0	0.0	10.6	2.8	0.0	5.9	0.0	9.1	15.0	14.0	0.0	0.0	0.0	7.4	-	-
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	66.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
	Shrubs	100.0	0.0	0.0	0.0	0.0	16.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
	Coniferous Forest	0.0	100.0	0.0	100.0	100.0	84.0	100.0	0.0	100.0	100.0	100.0	0.0	0.0	100.0	100.0	100.0	0.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	33.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Tall Shrub (2-10m)	100.0	0.0	66.6	0.0	0.0	16.0	0.0	100.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	0.0	100.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
	Mature Forest	0.0	0.0	33.4	0.0	0.0	84.0	100.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	100.0	100.0	0.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	0.0	0.0	66.6	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
	1-20%	100.0	100.0	0.0	100.0	0.0	16.0	100.0	0.0	100.0	67.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0
	21-40%	0.0	0.0	33.4	0.0	100.0	84.0	0.0	0.0	0.0	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 6.2-6. South Teigen Watershed Tributaries: Instream and Riparian Habitat Characteristics (continued)

Attribute	Descriptor	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018
Channel Morphology - % by stream length	Cascade Pool	0.0	0.0	33.4	0.0	60.2	16.0	0.0	0.0	62.0	74.2	39.8	0.0	0.0	0.0	57.7	0.0	0.0
	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	100.0	100.0
	Riffle Pool	100.0	100.0	66.6	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
	Step Pool	0.0	0.0	0.0	0.0	39.8	84.0	100.0	0.0	38.0	25.8	60.2	0.0	0.0	0.0	42.3	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bank Stability - % by stream length	Stable - Undercut	0.0	100.0	0.0	0.0	60.2	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0
	Stable - No Undercut	100.0	0.0	66.6	100.0	39.8	100.0	100.0	100.0	100.0	33.0	0.0	0.0	0.0	100.0	0.0	100.0	100.0
	Aggrading	0.0	0.0	33.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.7	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.0	0.0	0.0	0.0	0.0	42.3	0.0	0.0
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fines	100.0	100.0	33.4	100.0	100.0	16.0	100.0	100.0	0.0	0.0	39.8	100.0	100.0	100.0	57.7	100.0	100.0
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cobble	0.0	0.0	66.6	0.0	0.0	84.0	0.0	0.0	100.0	25.8	0.0	0.0	0.0	0.0	42.3	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.2	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 6.2-6. South Teigen Watershed Tributaries: Instream and Riparian Habitat Characteristics (continued)

Attribute	Descriptor	1019	1021	1022	1023	1025	1026	1027	1028	1029	1030	1110	1150	1151	1152	1205	1206	1207	All
Stream Length Mapped	m	550.0	168.0	289.0	173.0	352.0	100.0	112.0	105.0	448.0	1743.0	125.0	575.0	51.0	24.0	62.0	39.0	24.0	7764.0
Mean Channel Width	m	2.75	1.25	1.52	1.83	1.64	1.75	0.91	3.10	3.00	2.61	5.25	1.29	0.50	1.22	1.40	1.52	1.25	2.0
Stream Area Mapped	m ²	1512.5	209.6	439.3	317.3	578.3	175.0	101.5	325.5	1344.0	4553.1	656.3	741.2	25.5	29.3	86.8	59.3	30.0	19151.7
Habitat Unit Ratio (%)	Riffle	75.0	100.0	0.0	40.0	45.0	60.0	70.0	100.0	100.0	81.7	-	41.7	0.0	100.0	100.0	100.0	0.0	50.2
	Cascade	15.0	0.0	90.0	52.5	50.0	40.0	30.0	0.0	0.0	0.0	-	30.0	0.0	0.0	0.0	0.0	100.0	33.7
	Pool	10.0	0.0	10.0	7.5	5.0	0.0	0.0	0.0	0.0	1.7	-	5.0	0.0	0.0	0.0	0.0	0.0	5.1
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	-	23.3	100.0	0.0	0.0	0.0	0.0	13.8
Habitat Weighted Substrate Composition - % by unit area	Fines	12.8	0.0	2.0	5.7	1.4	0.0	0.0	50.0	60.0	12.9	-	37.7	100.0	10.0	30.0	40.0	0.0	22.8
	Gravel	87.2	100.0	32.0	58.4	98.6	68.9	100.0	50.0	40.0	72.9	-	37.2	0.0	90.0	70.0	60.0	20.0	55.7
	Cobble	0.0	0.0	65.9	35.9	0.0	31.1	0.0	0.0	0.0	14.2	-	22.0	0.0	0.0	0.0	0.0	80.0	17.6
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	3.1	0.0	0.0	0.0	0.0	0.0	3.9
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	12.8	0.0	16.1	3.1	0.0	0.0	0.0	0.0	0.0	1.3	-	3.3	0.0	0.0	0.0	0.0	0.0	5.2
	Boulder	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	-	3.1	0.0	0.0	0.0	0.0	0.0	2.3
	Instream Vegetation	0.0	0.0	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	30.0	0.0	0.0	80.0	0.0	4.4
	Overhanging Vegetation	42.3	90.0	18.0	18.6	2.4	2.0	5.0	100.0	100.0	27.0	-	48.8	95.0	90.0	100.0	0.0	60.0	41.1
	Undercut Bank	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	1.8	0.0	0.0	0.0	0.0	0.0	0.8
	Large Woody Debris	10.1	0.0	20.5	14.0	10.0	14.1	0.0	0.0	0.0	0.0	-	6.8	0.0	0.0	0.0	0.0	0.0	4.8
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	18.2	13.1	0.0	20.2	7.4	83.0	0.0	75.2	100.0	68.3	0.0	14.1	100.0	100.0	100.0	100.0	0.0	33.8
	Shrubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
	Coniferous Forest	81.8	86.9	100.0	79.8	92.6	17.0	100.0	24.8	0.0	0.0	100.0	85.9	0.0	0.0	0.0	0.0	100.0	55.6
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	Tall Shrub (2-10m)	18.2	13.1	0.0	20.2	7.4	83.0	0.0	75.2	100.0	68.3	0.0	14.1	100.0	100.0	100.0	100.0	0.0	35.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	72.7	0.0	0.0	0.0	0.0	0.0	14.0
	Mature Forest	81.8	86.9	100.0	79.8	92.6	17.0	100.0	24.8	0.0	17.7	100.0	13.2	0.0	0.0	0.0	0.0	100.0	50.6
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	18.2	39.3	0.0	100.0	7.4	83.0	0.0	75.2	100.0	82.3	0.0	14.1	100.0	100.0	100.0	0.0	0.0	39.3
	1-20%	81.8	60.7	0.0	0.0	92.6	17.0	100.0	24.8	0.0	17.7	100.0	85.9	0.0	0.0	0.0	100.0	0.0	50.1
	21-40%	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	10.7
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 6.2-6. South Teigen Watershed Tributaries: Instream and Riparian Habitat Characteristics (completed)

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Table 6.2-7. North Treaty Mainstem: Instream and Riparian Habitat Characteristics

Attribute	Descriptor	Reach			
		Downstream TMF	Reaches Within TMF		
		1	1	2	All
Stream Length Mapped	m	1230	660.0	2150.0	2810.0
Mean Channel Width	m	6.12	5.50	6.07	5.78
Stream Area Mapped	m ²	7527.6	3630.0	13043.3	16673.3
Habitat Unit Ratio (%)	Riffle	30.0	0.0	58.9	29.4
	Cascade	56.0	60.0	8.3	34.2
	Pool	14.0	40.0	32.8	36.4
	Glide	0.0	0.0	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	0.0	7.7	13.8	10.8
	Gravel	29.5	55.5	68.6	62.0
	Cobble	57.8	27.7	16.0	21.9
	Boulder	12.8	9.1	1.6	5.3
	Bedrock	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	15.2	10.0	33.1	21.6
	Boulder	11.7	11.4	1.0	6.2
	Instream Vegetation	0.0	0.0	0.0	0.0
	Overhanging Vegetation	40.1	56.8	32.4	44.6
	Undercut Bank	0.8	0.0	0.0	0.0
	Large Woody Debris	9.0	10.0	8.9	9.5
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	0.0	0.0
	Shrubs	14.6	30.8	44.5	41.2
	Coniferous Forest	0.0	69.2	55.5	58.8
	Deciduous Forest	0.0	0.0	0.0	0.0
	Mixed Forest	85.4	0.0	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	37.8	30.8	44.5	41.2
	Sapling (>10m)	0.0	0.0	0.0	0.0
	Young Forest	0.0	0.0	0.0	0.0
	Mature Forest	62.2	69.2	55.5	58.8
	Old Growth Forest	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	100	30.8	24.9	26.3
	1-20%	0.0	69.2	75.1	73.7
	21-40%	0.0	0.0	0.0	0.0
	41-70%	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	100.0	13.8	0.0	3.2
	Large Channel	0.0	0.0	0.0	0.0
	Riffle Pool	0.0	30.8	100.0	83.7
	Step Pool	0.0	55.5	0.0	13.0
Bank Stability - % by stream length	Stable - Undercut	54.9	0.0	24.9	19.1
	Stable - No Undercut	45.1	100.0	75.1	80.9
	Aggrading	0.0	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0
	Fines	0.0	0.0	77.5	59.3
	Gravel	100.0	30.8	0.0	7.2
	Cobble	0.0	44.2	22.5	27.6
	Boulder	0.0	0.0	0.0	0.0
	Bedrock	0.0	25.0	0.0	5.9

Table 6.2-8. North Treaty Watershed Tributaries: Instream and Riparian Habitat Characteristics

Attribute	Descriptor	1051	1052	1053	1054	1055	1056	1057	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071
Stream Length Mapped	m	71.0	23.0	90.0	136.0	135.0	45.0	29.0	957.0	707.0	31.0	245.0	15.0	29.0	39.0	15.0	81.0	70.0	12.0	61.0	16.0
Mean Channel Width	m	1.8	1.42	1.80	1.54	1.65	1.46	1.40	1.88	3.59	0.73	1.20	0.70	0.69	1.15	0.99	1.75	1.00	0.40	0.81	0.81
Stream Area Mapped	m ²	124.7	32.7	162.0	209.4	222.8	65.7	40.6	1797.8	2535.1	22.6	293.2	10.5	20.0	44.9	14.9	141.8	70.0	4.8	49.4	13.0
Habitat Unit Ratio (%)	Riffle	86.7	75.0	100.0	100.0	100.0	0.0	100.0	100.0	0.0	100.0	60.0	100.0	100.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0
	Cascade	13.3	25.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted	Fines	40.5	82.7	20.0	90.0	20.0	75.0	80.0	74.2	0.0	80.0	20.0	100.0	60.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Substrate Composition - % by unit area	Gravel	59.5	17.3	80.0	10.0	80.0	25.0	20.0	25.8	10.0	20.0	80.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Instream Vegetation	0.0	0.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Overhanging Vegetation	95.8	70.0	100.0	0.0	10.0	40.0	5.0	52.4	0.0	5.0	80.0	100.0	100.0	50.0	100.0	40.0	100.0	100.0	10.0	10.0
	Undercut Bank	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Large Woody Debris	8.4	36.3	0.0	10.0	10.0	10.0	0.0	1.8	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	50.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	0.0	21.3	0.0	0.0	0.0	5.3	27.7	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0
	Shrubs	100.0	100.0	100.0	47.8	0.0	0.0	0.0	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Coniferous Forest	0.0	0.0	0.0	30.9	100.0	100.0	100.0	82.2	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	100.0	100.0	100.0	69.1	0.0	0.0	0.0	17.8	27.7	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	0.0	0.0	0.0	0.0	0.0	0.0	100.0	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mature Forest	0.0	0.0	0.0	30.9	100.0	100.0	0.0	0.0	72.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	12.4	27.7	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0
	1-20%	0.0	0.0	0.0	100.0	0.0	100.0	100.0	87.6	41.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-40%	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	43.7	100.0	0.0	30.9	0.0	100.0	0.0	0.0	65.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	56.3	0.0	100.0	69.1	100.0	0.0	100.0	100.0	34.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Step Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bank Stability - % by stream length	Stable - Undercut	0.0	100.0	100.0	0.0	0.0	0.0	0.0	94.7	27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
	Stable - No Undercut	100.0	0.0	0.0	100.0	100.0	100.0	100.0	5.3	18.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0
	Aggrading	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fines	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	46.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 6.2-8. North Treaty Watershed Tributaries: Instream and Riparian Habitat Characteristics (completed)

Attribute	Descriptor	1072	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1101	All
Stream Length Mapped	m	467.0	64.0	1212.0	66.0	128.0	89.0	53.0	232.0	40.0	72.0	28.0	40.0	14.0	5456.0
Mean Channel Width	m	0.94	1.67	1.75	0.83	1.30	0.65	1.84	1.06	1.00	0.50	0.50	0.82	0.50	1.21
Stream Area Mapped	m ²	436.6	106.9	2119.7	54.8	166.4	57.9	97.3	246.7	40.0	36.0	14.0	32.8	7.0	9291.75
Habitat Unit Ratio (%)	Riffle	100.0	100.0	95.0	100.0	100.0	100.0	90.0	100.0	0.0	0.0	100.0	100.0	100.0	79.0
	Cascade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2
	Pool	0.0	0.0	5.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1
Habitat Weighted	Fines	90.0	100.0	51.3	100.0	90.0	10.0	31.0	30.0	0.0	0.0	10.0	10.0	10.0	59.8
Substrate Composition - % by unit area	Gravel	10.0	0.0	48.7	0.0	10.0	90.0	69.0	70.0	0.0	0.0	90.0	90.0	90.0	31.4
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8
	Overhanging Vegetation	10.0	100.0	71.7	100.0	100.0	50.0	10.0	100.0	0.0	0.0	80.0	80.0	10.0	53.9
	Undercut Bank	0.0	0.0	1.6	0.0	0.0	0.0	1.0	0.0	0.0	0.0	5.0	0.0	0.0	0.4
	Large Woody Debris	50.0	0.0	6.8	0.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	51.7	100.0	100.0	100.0	0.0	62.1	100.0	0.0	100.0	0.0	0.0	34.9
	Shrubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.9	0.0	0.0	0.0	0.0	100.0	11.3
	Coniferous Forest	100.0	100.0	22.1	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	0.0	37.4
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	26.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.3
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
	Tall Shrub (2-10m)	0.0	0.0	46.5	100.0	100.0	100.0	0.0	100.0	100.0	0.0	100.0	0.0	100.0	46.4
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	0.0	0.0	36.9	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1
	Mature Forest	100.0	100.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	27.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.3
Riparian Crown Closure - % by stream length	0	0.0	0.0	7.3	100.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	100.0	29.1
	1-20%	0.0	100.0	46.5	0.0	100.0	100.0	100.0	0.0	0.0	0.0	100.0	100.0	0.0	42.8
	21-40%	100.0	0.0	46.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.7
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.3
Channel Morphology - % by stream length	Cascade Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.9	0.0	0.0	0.0	0.0	100.0	12.9
	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.7
	Riffle Pool	100.0	100.0	100.0	100.0	100.0	100.0	100.0	62.1	0.0	0.0	100.0	100.0	0.0	82.4
	Step Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.3
Bank Stability - % by stream length	Stable - Undercut	0.0	0.0	11.5	0.0	100.0	0.0	100.0	62.1	0.0	0.0	100.0	0.0	0.0	32.7
	Stable - No Undercut	100.0	100.0	88.5	100.0	0.0	100.0	0.0	37.9	100.0	0.0	0.0	100.0	100.0	59.1
	Aggrading	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.3
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fines	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	0.0	88.9
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.3
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Not assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.3

The habitat-weighted cover composition was dominated by overhanging vegetation and pool habitat in both South Teigen and North Treaty creeks. However, the proportions of these habitat types were greater in North Treaty Creek. South Teigen and North Treaty tributaries were dominated by overhanging vegetation, 41.4% and 53.9%, respectively.

In general, the more pools within a reach, the better the rearing and over-wintering habitat quality (Johnston and Slaney 1996). A very low pool cover proportion in South Teigen Creek indicates less complex habitat, reduced rearing and over-wintering habitat capability (depending upon winter flows). A low occurrence of pools can be explained by several factors. First, the bed substrate has a high composition of cobble which is resistant to scour and movement at all but peak flows, hence the bed is very stable. Second, the riparian zone lacks trees that strengthen banks and enable large undercuts to develop. In addition, the channel lacks any LWD because riparian zones are dominated by shrubs. LWD causes horizontal stream energy and laminar flow to be interrupted and deflected into the banks and bed causing pools to be scoured while also providing cover for fish.

Functional LWD abundance, type, and distribution influence fish habitat quality for all life stages. LWD cover was more abundant in tributaries than mainstem reaches. LWD cover was absent from South Teigen Creek and more prevalent in North Treaty Creek (9.5%).

Instream vegetation was not present in any mainstem streams of tributaries, which reflects the cold nature of these streams.

6.2.2.4 Riparian Vegetation and Stream Bank Characteristics

Riparian Vegetation

Tables 6.2-5 to 6.2-8 summarize riparian vegetation for South Teigen and North Treaty watersheds. Riparian vegetation provides diverse physical and biological functions along a stream channel, including bank stability, erosion prevention, shade, physical and energy inputs as well as habitat for invertebrates, fish and wildlife.

South Teigen Creek riparian vegetation type and structural stage was dominated by natural wetland (58.3%) composed of tall shrubs (65.5%). North Treaty Creek was evenly distributed by upland tall shrubs (41.2%) and mature coniferous forest (58.8%). In addition, crown closure varied between 0 to 20% for the majority of South Teigen and North Treaty creeks. South Teigen tributaries were distributed by natural wetland composed of tall shrubs (35.0%) and mature coniferous forest (50.6%). North Treaty tributaries were dominated by a variety of riparian vegetation types and structural stages. In addition, crown closure varied between 0 and 40% for the majority of South Teigen and North Treaty tributaries.

Bank Substrate and Stability

Tables 6.2-5 to 6.2-8 summarize stream bank characteristics for South Teigen and North Treaty watersheds. The composition and shape of the stream banks as well as erosion and deposition processes affect the overall channel stability and complexity of fish habitat.

North Treaty Creek had stable banks (no undercut) composed of fines and cobble substrates. South Teigen Creek had stable undercut banks, for the majority of the mainstem, which was composed of fines and cobble substrates. North Treaty and South Teigen tributaries possessed a mixture of stable banks (undercut and no undercut) composed of fines and cobble substrates depending upon site specific conditions.

6.2.2.5 *Habitat Quality*

Since Dolly Varden are the only fish species identified within the TMF, field crews focused on the habitat requirements of juvenile and adult Dolly Varden. Professional expertise was used to rank habitat as either poor, fair, good or not present (none) based upon Dolly Varden habitat requirements (McPhail 2007; Roberge et al. 2002). Good quality habitat has most or all of the key physical and biological attributes for the life stage and species of interest. Fair quality habitat has some physical/biological features for the life stage but is missing one or two key attributes. Poor quality habitat has very few physical/biological features for the life history stage and is missing most of the key attributes. No habitat has none of the physical/biological features for the life history stage.

Rearing Habitat

Tables 6.2-9 to 6.2-12 summarize rearing habitat quality for South Teigen and North Treaty watersheds. Figure 6.2-2 (located in the map pocket) presents the SHIM rearing habitat mapping results for South Teigen and North Treaty watersheds within the TMF.

The subjective evaluation of rearing habitat took into account several factors:

- rearing habitat preferences of Dolly Varden;
- distribution and abundance of habitat features (e.g. pools, riffles, cover types, water depth); and
- fish location, abundance and preferences determined during rearing habitat and density electrofishing assessments.

The relative quality of rearing habitat was rated as good, fair, poor, or none present for each stream segment. Ratings were summarized by percent of stream length for comparison of the relative amount of each habitat quality. Good rearing habitat contains most of the habitat features to sustain populations of Dolly Varden like sufficient depth, suitable velocity, several habitat cover types, a mix of substrates, mix of habitat unit types, low gradient, etc. Fair quality rearing habitat contains similar attributes but several components are at less than ideal states (e.g., lower abundance, monotypic substrate, lower complexity and patchy cover, higher gradient, etc.). Poor rearing habitat lacks most of the features necessary to support fish with obvious features lacking (e.g., sparse cover, lack of suitable flow or ephemeral flows, no fish found in that habitat, high gradient, etc.). No fish habitat occurs in NCDs and confirmed non-fish bearing streams.

Fair or better rearing habitat quality was observed at 96.6% or better of South Teigen and North Treaty creeks (Figure 6.2-2). Generally, North Treaty Creek possessed higher quality rearing habitat because of greater habitat diversity and fish habitat cover compared to South Teigen Creek. Furthermore, the overall rearing habitat for juveniles was of higher quality in North Treaty Creek compared to South Teigen Creek based upon electrofishing sampling data. The fish population density results supported the assessment of fair or better rearing throughout these creeks. Summer rearing habitat is not likely a population bottleneck or limiting factor in these creeks because it was abundant, widely dispersed and supported moderate to high fish densities through the mainstems.

Table 6.2-9. South Teigen Mainstem: Habitat Quality Characteristics

Attribute	Descriptor	Reaches Downstream TMF					Reaches Within TMF					
		1	2	3	4	All	4	5	6	7	8	All
Stream Length Mapped	m	1340.0	760.0	1407.0	1518.0	5025.0	2376.0	2964.0	1220.0	261.0	808.0	7629.0
Mean Channel Width	m	15.33	10.30	10.30	11.33	11.82	6.70	6.44	5.06	6.00	8.00	6.44
Stream Area Mapped	m ²	20546.7	7828.0	14492.1	17204.0	60070.8	15922.2	19073.3	6167.1	1566.0	6464.0	49192.6
Spawning Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Good	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	96.6
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	3.4
OverWintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Good	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	96.6
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	3.4
	Poor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potential Spawning Habitat - % of stream length	Abundant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Micropatches	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moderate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	None	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	96.6
	Marginal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	3.4

Table 6.2-10. South Teigen Watershed Tributaries: Habitat Quality Characteristics

Attribute	Descriptor	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013
Stream Length Mapped	m	42.0	87.0	455.0	105.0	161.0	169.0	176.0	39.0	371.0	182.0	279.0	14.0
Mean Channel Width	m	1.10	0.91	2.17	1.67	1.17	2.26	1.32	0.50	6.20	1.93	3.60	2.00
Stream Area Mapped	m ²	46.0	78.7	985.1	174.8	188.0	382.5	231.4	19.5	2300.2	350.4	1004.4	28.0
Spawning Habitat Quality - % of stream length	Fair	0.0	28.7	0.0	8.6	47.2	0.0	0.0	61.5	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	91.4	13.0	16.0	0.0	0.0	100.0	33.0	92.8	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.5	0.0	0.0	7.2	100.0
	Poor	100.0	71.3	100.0	0.0	39.8	84.0	100.0	0.0	0.0	67.0	0.0	0.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	100.0
	Good	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	74.2	92.8	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	25.8	0.0	0.0
Overwintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	53.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.5	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	100.0	100.0	100.0	100.0	61.5	0.0	100.0	0.0	100.0
Potential Spawning Habitat - % of stream length	Abundant	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	100.0	0.0	92.8	0.0
	Micropatches	100.0	100.0	66.6	100.0	0.0	100.0	100.0	0.0	0.0	67.0	0.0	0.0
	Moderate	0.0	0.0	0.0	0.0	87.0	0.0	0.0	61.5	0.0	33.0	0.0	0.0
	None	0.0	0.0	33.4	0.0	0.0	0.0	0.0	38.5	0.0	0.0	7.2	100.0
	Not Assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	0.0	0.0	0.0	100.0	13.0	16.0	0.0	0.0	100.0	74.2	100.0	0.0
	Marginal	100.0	100.0	100.0	0.0	87.0	84.0	100.0	100.0	0.0	25.8	0.0	100.0

(continued)

Table 6.2-10. South Teigen Watershed Tributaries: Habitat Quality Characteristics (continued)

Attribute	Descriptor	1014	1015	1016	1017	1018	1019	1021	1022	1023	1025	1026	1027
Stream Length Mapped	m	55.0	75.0	520.0	70.0	24.0	550.0	168.0	289.0	173.0	352.0	100.0	112.0
Mean Channel Width	m	0.65	0.90	3.45	3.50	1.50	2.75	1.25	1.52	1.83	1.64	1.75	0.91
Stream Area Mapped	m ²	35.8	67.5	1794.0	245.0	36.0	1512.5	209.6	439.3	317.3	578.3	175.0	101.5
Spawning Habitat Quality - % of stream length	Fair	0.0	0.0	42.3	0.0	0.0	18.2	63.1	49.5	20.2	0.0	0.0	33.0
	Good	0.0	0.0	57.7	0.0	0.0	68.2	13.1	0.0	0.0	60.2	0.0	0.0
	None	100.0	100.0	0.0	100.0	100.0	13.6	0.0	0.0	0.0	0.0	0.0	67.0
	Poor	0.0	0.0	0.0	0.0	0.0	0.0	23.8	50.5	79.8	39.8	100.0	0.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	13.6	0.0	0.0	100.0	39.8	0.0	0.0
	Good	0.0	0.0	100.0	0.0	0.0	68.2	0.0	49.5	0.0	60.2	0.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	0.0	100.0	100.0	18.2	100.0	50.5	0.0	0.0	100.0	100.0
Overwintering Habitat Quality - % of stream length	Fair	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	79.8	0.0	0.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0	81.8	0.0	0.0	0.0	52.8	0.0	0.0
	None	100.0	100.0	0.0	100.0	0.0	18.2	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	0.0	0.0	100.0	0.0	100.0	100.0	20.2	47.2	100.0	100.0
Potential Spawning Habitat - % of stream length	Abundant	0.0	0.0	57.7	0.0	0.0	68.2	13.1	0.0	0.0	0.0	0.0	0.0
	Micropatches	0.0	100.0	0.0	0.0	0.0	13.6	60.7	100.0	100.0	39.8	0.0	67.0
	Moderate	0.0	0.0	42.3	0.0	0.0	0.0	26.2	0.0	0.0	60.2	100.0	33.0
	None	100.0	0.0	0.0	100.0	100.0	18.2	0.0	0.0	0.0	0.0	0.0	0.0
	Not Assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	0.0	0.0	100.0	0.0	0.0	81.8	39.3	49.5	20.2	60.2	0.0	0.0
	Marginal	100.0	100.0	0.0	100.0	100.0	18.2	60.7	50.5	79.8	39.8	100.0	100.0

(continued)

Table 6.2-10. South Teigen Watershed Tributaries: Habitat Quality Characteristics (completed)

Attribute	Descriptor	1028	1029	1030	1110	1150	1151	1152	1205	1206	1207	All
Stream Length Mapped	m	105.0	448.0	1743.0	125.0	575.0	51.0	24.0	62.0	39.0	24.0	7764.0
Mean Channel Width	m	3.10	3.00	2.61	5.25	1.29	0.50	1.22	1.40	1.52	1.25	2.0
Stream Area Mapped	m ²	325.5	1344.0	4553.1	656.3	741.2	25.5	29.3	86.8	59.3	30.0	19151.7
Spawning Habitat Quality - % of stream length	Fair	75.2	100.0	0.0	54.4	23.1	0.0	100.0	33.9	0.0	0.0	19.9
	Good	24.8	0.0	14.9	0.0	49.6	0.0	0.0	0.0	0.0	0.0	29.8
	None	0.0	0.0	0.0	0.0	0.0	100.0	0.0	66.1	0.0	0.0	6.6
	Poor	0.0	0.0	85.1	45.6	27.3	0.0	0.0	0.0	100.0	100.0	43.6
Rearing Habitat Quality - % of stream length	Fair	100.0	0.0	53.4	100.0	0.0	0.0	0.0	66.1	0.0	0.0	20.9
	Good	0.0	100.0	28.9	0.0	54.6	0.0	0.0	0.0	0.0	0.0	43.6
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	17.7	0.0	45.4	100.0	100.0	33.9	100.0	100.0	35.5
Overwintering Habitat Quality - % of stream length	Fair	75.2	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.4
	Good	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9
	None	0.0	0.0	0.0	0.0	0.0	100.0	0.0	33.9	100.0	100.0	5.8
	Poor	24.8	0.0	0.0	100.0	100.0	0.0	100.0	66.1	0.0	0.0	39.9
Potential Spawning Habitat - % of stream length	Abundant	0.0	0.0	14.9	0	5.0	0.0	0.0	0.0	0.0	0.0	21.1
	Micropatches	0.0	0.0	0.0	0	72.7	0.0	0.0	0.0	0.0	100.0	30.6
	Moderate	24.8	0.0	67.4	54.4	22.3	0.0	100.0	33.9	100.0	0.0	29.9
	None	75.2	100.0	17.7	45.6	0.0	100.0	0.0	66.1	0.0	0.0	18.5
	Not Assessed	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	100.0	100.0	100.0	100.0	88.3	0.0	0.0	0.0	0.0	0.0	68.2
	Marginal	0.0	0.0	0.0	0.0	11.7	100.0	100.0	100.0	100.0	100.0	31.8

Table 6.2-11. North Treaty Mainstem: Habitat Quality

Attribute	Descriptor	Reach Downstream TMF	Reaches Within TMF		
		1	1	2	All
Stream Length Mapped	m	1230	660.0	2150.0	2810.0
Mean Channel Width	m	6.12	5.50	6.07	5.78
Stream Area Mapped	m ²	7527.6	3630.0	13043.3	16673.3
Spawning Habitat Quality - % of stream length	Fair	0.0	0.0	29.4	22.5
	Good	100.0	100.0	67.0	74.7
	None	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	3.6	2.8
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0
	Good	100.0	100.0	100.0	100.0
	None	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	0.0	0.0
Overwintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0
	Good	100.0	100.0	96.4	97.2
	None	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	3.6	2.8
Potential Spawning Habitat - % of stream length	Abundant	45.1	75.0	68.5	70.0
	Micropatches	0.0	0.0	3.6	2.8
	Moderate	54.9	25.0	27.9	27.2
	None	0.0	0.0	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0
	Important	100.0	100.0	100.0	100.0
	Marginal	0.0	0.0	0.0	0.0

Fair or better rearing habitat quality was similar between South Teigen and North Treaty tributaries, 64.5 and 63.8%, respectively. Generally, North Treaty tributaries possessed higher quality rearing habitat because of their lower gradient and abundant fish habitat cover compared to South Teigen tributaries. Furthermore, the overall rearing habitat for juveniles was of higher quality in North Treaty tributaries compared to South Teigen tributaries based upon electrofishing sampling data and fish population density results. Typically, as channel gradient increased the quality of rearing habitat decreased. In South Teigen tributaries along the western hillslopes, upstream reaches flowed subsurface during the summer months which isolated the upper reaches from the mainstem. Overall, summer rearing habitat is not likely a population bottleneck or limiting factor in these tributaries because it was abundant, widely dispersed and supported moderate to high fish densities.

Table 6.2-12. North Treaty Watershed Tributaries: Habitat Quality Characteristics

Attribute	Descriptor	1051	1052	1053	1054	1055	1056	1057	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068
Stream Length Mapped	m	71.0	23.0	90.0	136.0	135.0	45.0	29.0	957.0	707.0	31.0	245.0	15.0	29.0	39.0	15.0	81.0	70.0
Mean Channel Width	m	1.8	1.4	1.8	1.5	1.7	1.5	1.4	1.9	3.6	0.7	1.2	0.7	0.7	1.2	1.0	1.8	1.0
Stream Area Mapped	m ²	124.7	32.7	162.0	209.4	222.8	65.7	40.6	1797.8	2535.1	22.6	293.2	10.5	20.0	44.9	14.9	141.8	70.0
Spawning Habitat Quality - % of stream length	Fair	100.0	0.0	100.0	30.9	100.0	0.0	0.0	32.7	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	21.3	0.0	0.0	0.0	12.4	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	81.2	0.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0
	Poor	0.0	100.0	0.0	47.8	0.0	100.0	100.0	49.5	11.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	69.1	0.0	0.0	0.0	5.3	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.7	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	30.9	100.0	100.0	100.0	0.0	88.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Overwintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.2	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	100.0	100.0	100.0	100.0	17.8	72.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Potential Spawning Habitat - % of stream length	Abundant	56.3	0.0	0.0	52.2	100.0	0.0	0.0	12.4	6.9	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0
	Micropatches	0.0	100.0	0.0	47.8	0.0	100.0	0.0	49.5	0.0	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
	Moderate	43.7	0.0	100.0	0.0	0.0	0.0	0.0	32.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	100.0	5.3	93.1	0.0	0.0	0.0	0.0	100.0	0.0	100.0	100.0
	Not Assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	100.0	0.0	0.0	21.3	0.0	0.0	0.0	94.7	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
	Marginal	0.0	100.0	100.0	78.7	100.0	100.0	100.0	5.3	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

(continued)

Table 6.2-12. North Treaty Watershed Tributaries: Habitat Quality Characteristics (completed)

Attribute	Descriptor	1069	1070	1071	1072	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1101	All
Stream Length Mapped	m	12.0	61.0	16.0	467.0	64.0	1212.0	66.0	128.0	89.0	53.0	232.0	40.0	72.0	28.0	40.0	14.0	5456.0
Mean Channel Width	m	0.4	0.8	0.8	0.9	1.7	1.7	0.8	1.3	0.7	1.8	1.1	1.0	0.5	0.5	0.8	0.5	1.2
Stream Area Mapped	m ²	4.8	49.4	13.0	436.6	106.9	2119.7	54.8	166.4	57.9	97.3	246.7	40.0	36.0	14.0	32.8	7.0	9291.8
Spawning Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.2
	Good	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	23.3	0.0	0.0	100.0	100.0	0.0	12.8
	None	100.0	100.0	100.0	0.0	100.0	53.9	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	31.9
	Poor	0.0	0.0	0.0	100.0	0.0	8.4	0.0	100.0	0.0	0.0	76.7	0.0	100.0	0.0	0.0	100.0	34.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3	0.0	100.0	0.0	0.0	0.0	6.5
	Good	0.0	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	57.3
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.3
	Poor	100.0	100.0	100.0	0.0	0.0	0.0	100.0	100.0	100.0	0.0	76.7	100.0	0.0	100.0	100.0	0.0	35.9
Overwintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	Good	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.7
	None	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	6.0
	Poor	100.0	0.0	0.0	100.0	100.0	88.5	100.0	100.0	100.0	0.0	100.0	0.0	100.0	100.0	100.0	0.0	68.3
Potential Spawning Habitat - % of stream length	Abundant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	23.3	0.0	0.0	100.0	0.0	0.0	16.0
	Micropatches	0.0	0.0	0.0	100.0	0.0	15.8	0.0	100.0	0.0	0.0	76.7	0.0	0.0	0.0	0.0	100.0	32.5
	Moderate	0.0	0.0	0.0	0.0	0.0	37.7	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	0.0	18.0
	None	100.0	100.0	100.0	0.0	100.0	46.5	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	32.1
	Not Assessed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.3
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	0.0	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	59.4
	Marginal	100.0	100.0	100.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0	100.0	40.6

Spawning Habitat Quality and Frequency

Tables 6.2-9 to 6.2-12 summarize spawning habitat quality and frequency for South Teigen and North Treaty watersheds. Figure 6.2-3 (located in the map pocket) presents the SHIM spawning habitat mapping results for South Teigen and North Treaty watersheds within the TMF.

The subjective evaluation of spawning habitat took into account several factors:

- spawning habitat preferences of Dolly Varden;
- distribution and abundance of habitat features (e.g., pools, riffles, cover types and water depth); and
- fish presence and preferences determined during surveys for spawning adults and presence of fry (i.e., those 0+ years in age) from electrofishing assessments. Since fry have limited swimming ability and generally cannot actively migrate upstream past small chutes, their presence indicates the successful spawning within a stream segment in the previous year.

Spawning habitat consists of several elements: suitable-sized gravel patches in the proper hydraulic location, adequate water depth and flow, and suitable cover for adults. During the assessment, field crews undertook a subjective assessment of each stream segment for spawning habitat quality (i.e., poor, fair, good and none) and rated the relative amount of potential spawning habitat within a segment (i.e., abundant, moderate, trace or micro-patch). The percentage of a stream segment that was suitable for spawning was classified as abundant ($\geq 50\%$), moderate (30 to 50%) or micro-patch (i.e., gravel patch less than 1 m²). Micro-patches were very small features within stream segments and were typically a sand or small gravel patch deposited behind a boulder along the bank.

Field crews considered good spawning habitat for Dolly Varden to contain mainly sand and gravel substrate with minor cobble. Good spawning habitat was generally found in low gradient and velocity stream segments with abundant overhanging vegetation and instream cover. Poor spawning habitat typically only had one of these elements resulting in a low likelihood of being used for spawning since key features (cover and depth) were not present. Stream segments that did not have gravel patches and some form of cover was not considered spawning habitat.

The results for spawning habitat quality and distribution were the opposite of the rearing habitat findings. In contrast to rearing habitat, which was observed throughout the mainstems and tributaries, South Teigen Creek provided none to poor suitable spawning habitat. The high composition of glacial fine substrate and high flows during the spawning season do not provide suitable spawning habitat for Dolly Varden. Furthermore, the lack of adults observed spawning in the mainstem (Table 6.2-13) and absence to low abundance of fry in the mainstem support this assessment. The entire length of North Treaty Creek provides good and abundant Dolly Varden spawning habitat due to habitat characteristics, suitable flow, and good water quality.

Fair or better spawning habitat quality was observed at 49.7% of South Teigen tributaries. Typically, as channel gradient increased the quality of spawning habitat decreased. South Teigen tributaries possessed higher quality spawning habitat in the lower gradient tributary reaches near the mainstem because suitable spawning habitat was present, and the abundance of fry rearing in these reaches based upon electrofishing sampling data. Spawning habitat is not likely a population bottleneck or limiting factor in the South Teigen tributaries. However, the maintenance of winter baseflows to provide sufficient egg incubation along the western and eastern hillslope tributaries is not known since certain tributaries flow subsurface during the summer months.

Table 6.2-13. Summary of Spawning Habitat Assessments within South Teigen and North Treaty Watersheds, 2009

Watershed	Streams Surveyed	Spawning Observed	Redd Observed
South Teigen	1001 (South Teigen Creek)	-	-
	1007	-	-
	1008	-	-
	1009	-	-
	1010	Y	-
	1011	-	-
	1012	Y	-
	1014	-	-
	1015	-	-
	1016	-	-
	1017	-	-
	1018	-	-
	1021	-	-
	1022	-	-
	1030	Y	-
	1150	-	-
	1206	-	-
	1207	-	-
North Treaty	1050 (North Treaty Creek)	-	-
	1059	Y	-
	1060	-	-
	1062	-	-
	1063	-	-
	1064	-	-
	1065	-	-
	1066	-	-
	1067	-	-
	1068	-	-
	1072	Y	Y
	1082	Y	-
	1083	-	-
	1088	-	-

Y = yes

Dashes indicate "no"

Fair or better spawning habitat quality was observed at 34.0% of North Treaty tributaries. North Treaty tributaries possessed higher quality spawning habitat near the wetland complex because of suitable flow, cover, substrate, depth, observation of adults spawning in these tributaries, and the abundance of fry rearing in these streams based upon electrofishing sampling data. The wetland complex provides maintenance of baseflows to provide sufficient egg incubation during the winter months. Spawning habitat is not a population bottleneck or limiting factor in the North Treaty tributaries.

Over-Wintering Habitat

Tables 6.2-9 to 6.2-12 summarize over-wintering habitat quality for South Teigen and North Treaty watersheds. Figure 6.2-4 (located in the map pocket) presents the SHIM over-wintering habitat mapping results for South Teigen and North Treaty watersheds within the TMF.

Over-wintering habitat consists of refuge areas, typically pools or deep runs, that remain wetted and do not freeze to the bottom at base winter flows (November to May). Water depth and velocity, cover, as well as ice thickness and distribution, generally determine the suitability of an area as over-wintering habitat. Fish reduce their activity during winter but still forage. Over-wintering habitat potential was based mainly upon the presence of pools or deep runs and knowing the maximum fish size (approximately 25 cm).

All reaches of South Teigen and North Treaty creeks provide good over-wintering habitat for Dolly Varden. This assessment was based upon the presence, frequency and distribution of pools, adequate residual pool depths, instream cover, and maintenance of base flows throughout the winter months.

Fair or better over-wintering habitat quality was observed at 54.3% for South Teigen tributaries. A high percentage of these tributaries possessed no over-wintering habitat. The majority of tributaries had very few deep pools and deeper runs of less than 20 cm residual depth, with the exception of Streams 1010, 1016 and 1019. As noted previously, the channel morphology was shallow with mean water depths during the high-flow summer period less than 20 cm and even lower winter base flows are predicted. The channels were mostly cobble riffles and runs which are anticipated to provide very little space for over-wintering fish.

Fair or better over-wintering habitat quality was observed at 25.7% of the North Treaty tributaries. A high percentage of these tributaries possessed no over-wintering habitat. The majority of tributaries had no residual pools. As noted previously, the channel morphology was shallow with mean water depths during the high-flow summer period less than 15 cm and even lower winter base flows are predicted. The channels were mostly fines and gravel riffles and runs which are anticipated to provide very little space for overwintering fish. However, tributaries located downstream of the wetland complex may provide sufficient over-wintering habitat despite the lack of pools.

Overall Habitat

Tables 6.2-9 to 6.2-12 summarize overall habitat quality for South Teigen and North Treaty watersheds. Figure 6.2-5 (located in the map pocket) presents the SHIM overall habitat mapping results for South Teigen and North Treaty watersheds within the TMF.

Overall habitat quality is based upon all the life history stage rankings (i.e., spawning, rearing and over-wintering) previously discussed for each stream segment. The criteria of overall habitat are defined in Table 5.2-2.

All reaches of South Teigen and North Treaty creeks provided important fish habitat for Dolly Varden. Important habitat quality was observed at 68.2% for South Teigen tributaries and 59.4% for North Treaty tributaries. Critical habitat was not identified in either watershed.

6.2.2.6 *Spawning Habitat Assessment*

The Dolly Varden spawning period was anticipated to be the last two weeks of September and first week of October, based upon field observations in 2008 (Rescan 2009), literature reviews (McPhail 2007; Roberge *et al.* 2002; Bustard 2006). Dolly Varden spawning surveys were conducted in mapped streams within the TMF from September 17 to 19. Appendix 6.2-3 presents spawning survey data for each stream ground-truthed within the TMF.

Table 6.2-13 summarizes the results of the spawning survey by spawning activity or redds observed. Spawning activity and redds were observed in six tributaries, but not mainstem reaches of South Teigen and North Treaty creeks. All sites were low-gradient reaches, with abundant cover and small-sized gravels. Photographs of typical Dolly Varden spawning substrate are shown in Plates 6.2-11 and 6.2-12. Spot surveys were conducted at various locations along South Teigen and North Treaty creeks. Water clarity was poor in South Teigen Creek during the time of the assessment.

6.2.3 *Stream - Fish Community*

The locations of density sampling sites within the TMF are shown in Figure 6.2-2. Appendix 6.1-2 shows all species biological data for each density sampling site and rearing sampling site. Appendix 6.1-3 shows all electrofishing effort and catch data for each site.

6.2.3.1 *Length, Weight and Condition*

Table 6.2-14 summarizes length, weight and condition data for fish species captured in South Teigen and North Treaty watersheds. Dolly Varden in South Teigen Creek were longer and heavier compared to conspecifics in its tributaries, North Treaty Creek and its tributaries. Length-frequency distributions were plotted for all Dolly Varden caught in South Teigen and North Treaty watersheds (Figures 6.2-6 and 6.2-7). Dolly Varden were smaller in South Teigen tributaries compared to South Teigen Creek. These results support previous assessments that the tributaries provide the majority of fry (0+) and parr (1+) rearing habitat within South Teigen watershed (Section 6.2.2.5). Dolly Varden were shorter in North Treaty tributaries compared to North Treaty Creek. Although this shift was of a smaller magnitude than in South Teigen watershed, it supports previous assessments that North Treaty Creek provides suitable rearing habitat for Dolly Varden fry and parr. Length class modes were similar between watersheds, with approximate length ranges of 25 to 45 mm for fry, 45 to 70 mm for parr, 70 to 85 mm for 2+ fish, and 85 to 105 mm for 3+ fish.

Dolly Varden weight-length regressions were calculated by watershed (Figure 6.2-8). Regressions of fish weight-length data for South Teigen and North Treaty watersheds were all highly significant ($P < 0.001$) and explained between 98 and 99% of the variation in weight. The slope of regressions for Dolly Varden sampled from these sites was close to the expected value of 3.0, typical for the length-weight geometry of fish. Generally, Dolly Varden in North Treaty Creek were in better condition than its tributaries, South Teigen Creek and its tributaries (Table 6.2-14).

6.2.3.2 *Age and Growth*

Age data for all fish captured in South Teigen and North Treaty watersheds are summarized in Table 6.2-15. Generally, Dolly Varden from the mainstems were older than from the tributaries. Age-frequency distributions were constructed for all Dolly Varden aged from South Teigen and North Treaty watersheds (Figure 6.2-9). South Teigen Creek had the greatest age range of 1 to 5 years. North Treaty tributaries had the narrowest age range of 2 to 3 years. However, interpretation of this dataset should be applied with caution because of low sample size - many fish were too small to effectively take age structures from.



Plate 6.2-11. Typical Dolly Varden Spawning Habitat.

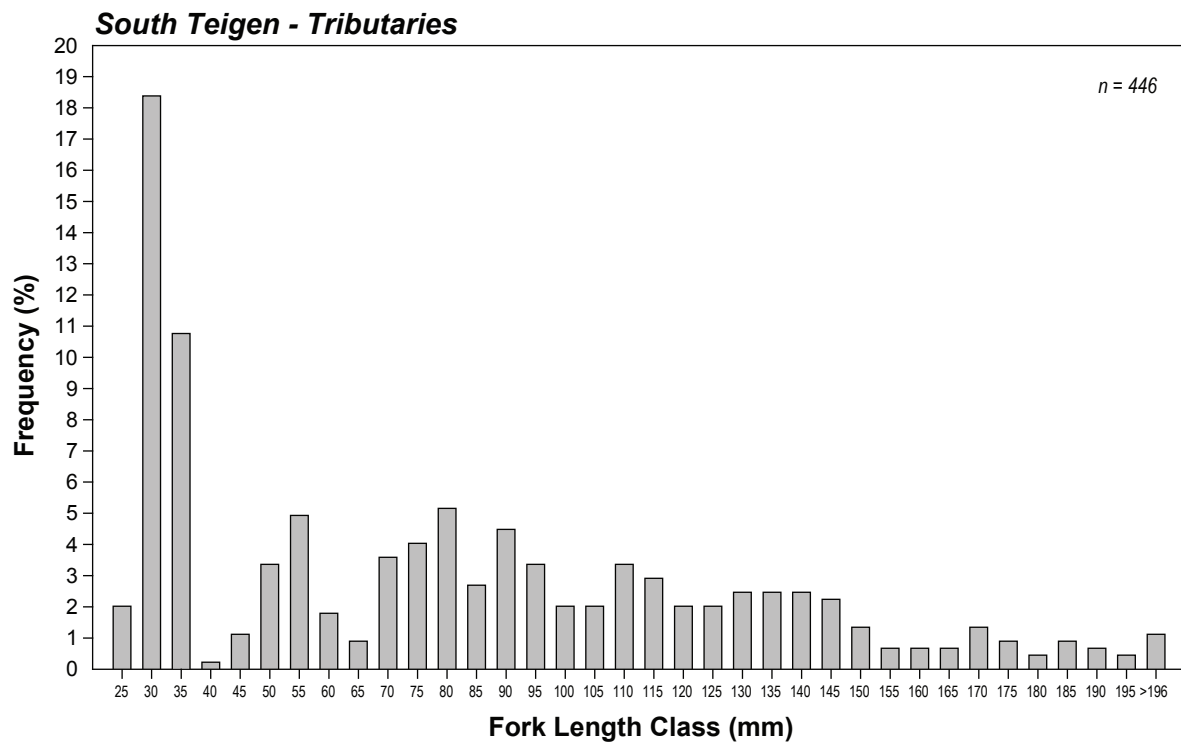
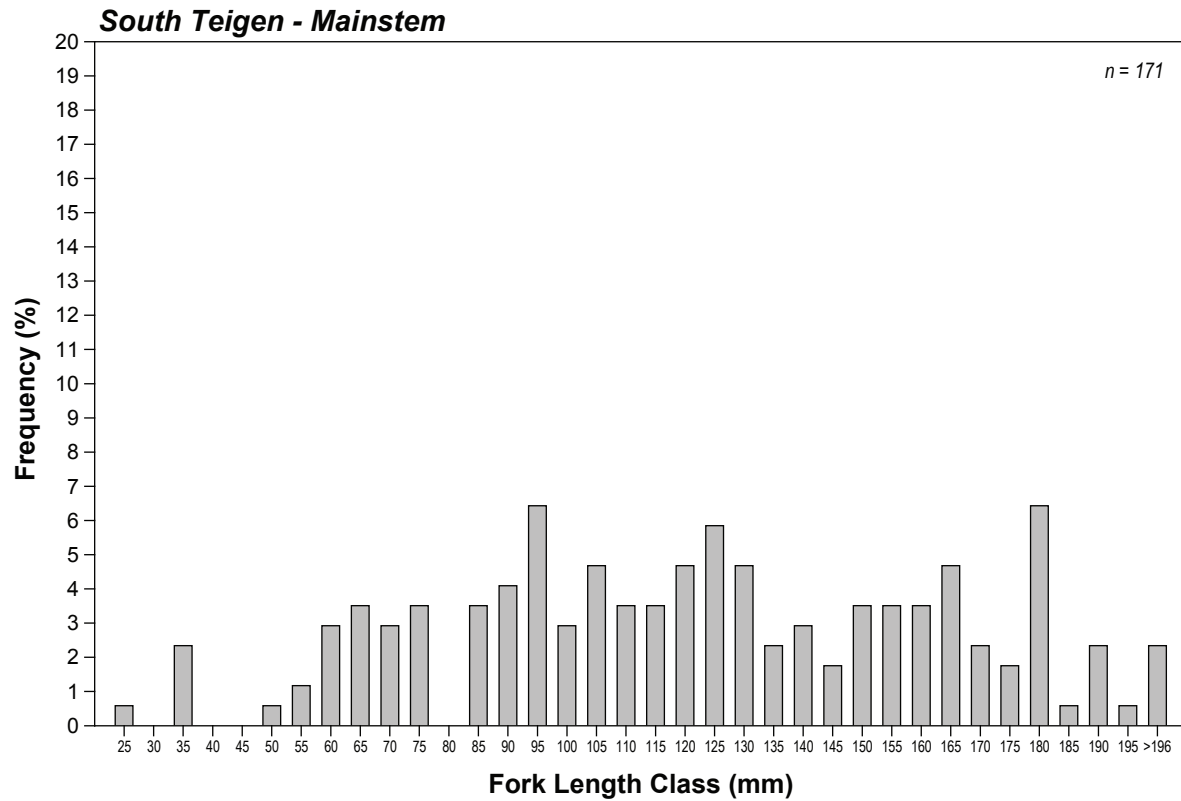


Plate 6.2-12. Dolly Varden within Cover near Spawning Habitat

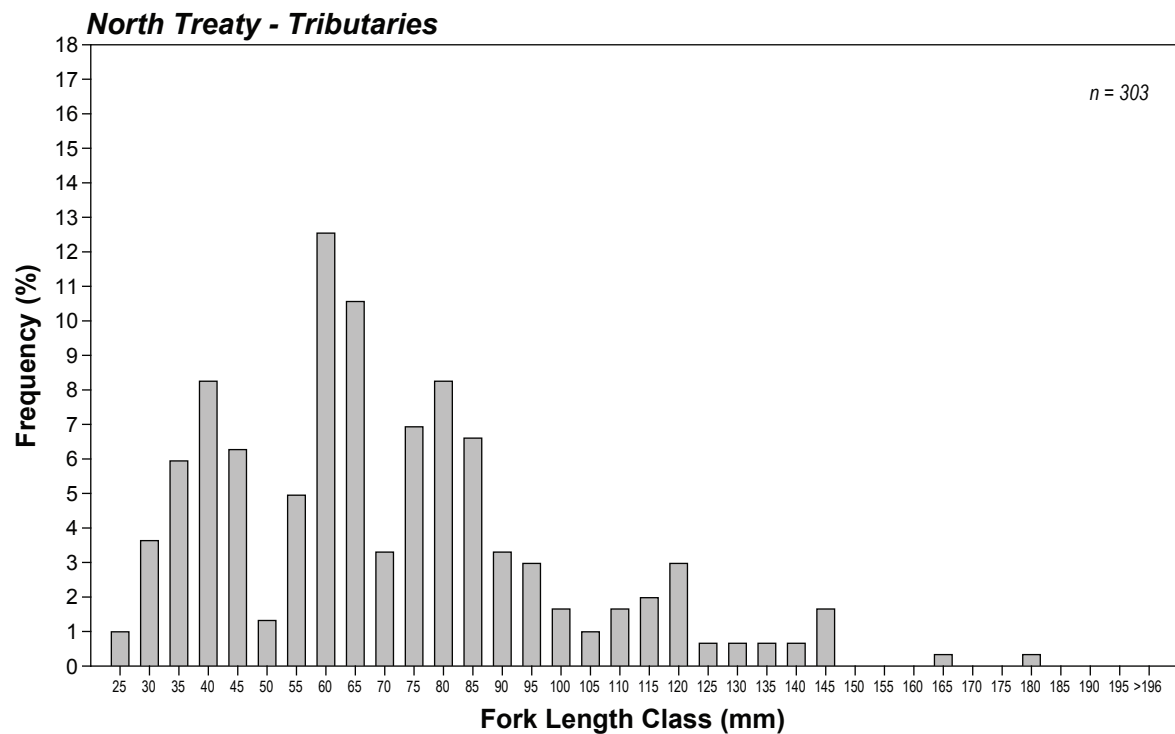
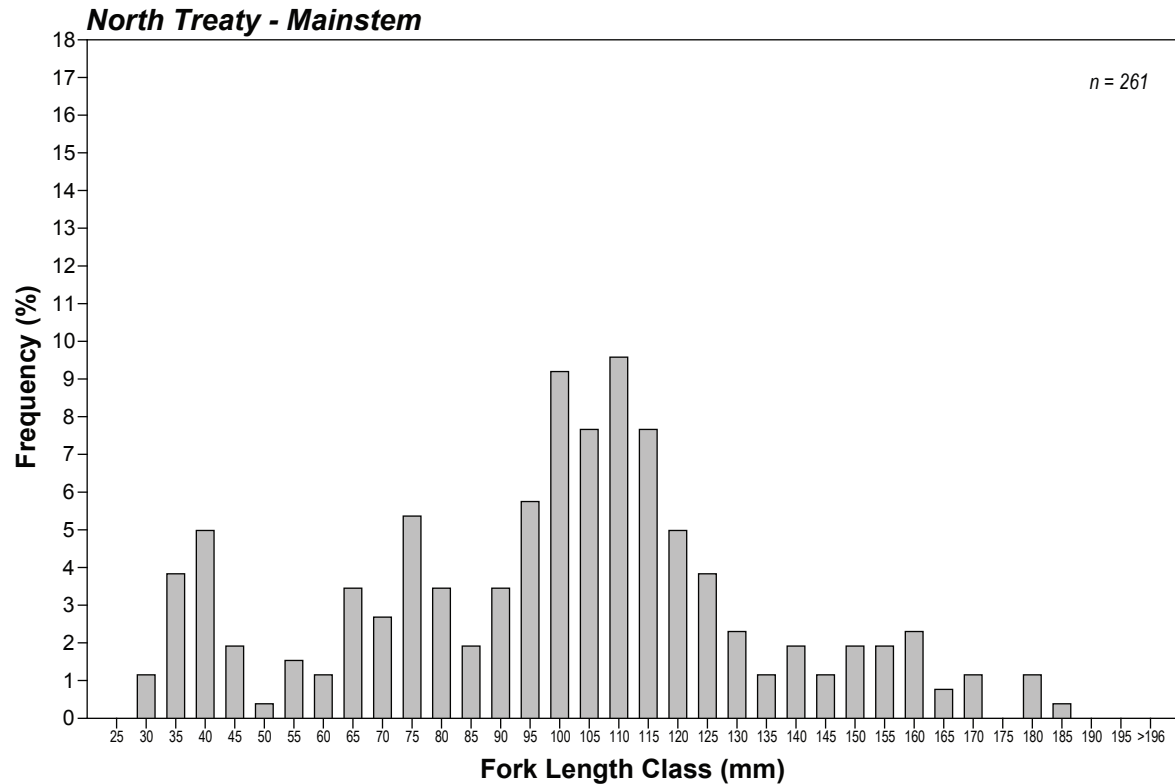
Table 6.2-14. Mean Length, Weight and Condition of Dolly Varden Captured in South Teigen and North Treaty Watersheds, 2009

Watershed	Length (mm)					Weight (g)					Condition (g/mm ³)		
	N	Mean	SE	Min	Max	N	Mean	SE	Min	Max	N	Mean	SE
North Treaty (Mainstem)	261	97	2.1	28	185	261	13.1	0.8	0.2	66.5	261	1.05	0.01
North Treaty (Tributaries)	303	68	1.6	22	180	258	4.8	0.4	0.2	59.6	303	0.90	0.12
South Teigen (Mainstem)	171	120	3.2	25	210	170	25.1	1.7	0.2	101.9	171	1.04	0.01
South Teigen (Tributaries)	398	71	2.0	23	179	293	9.4	0.7	0.1	61.0	398	0.81	0.03

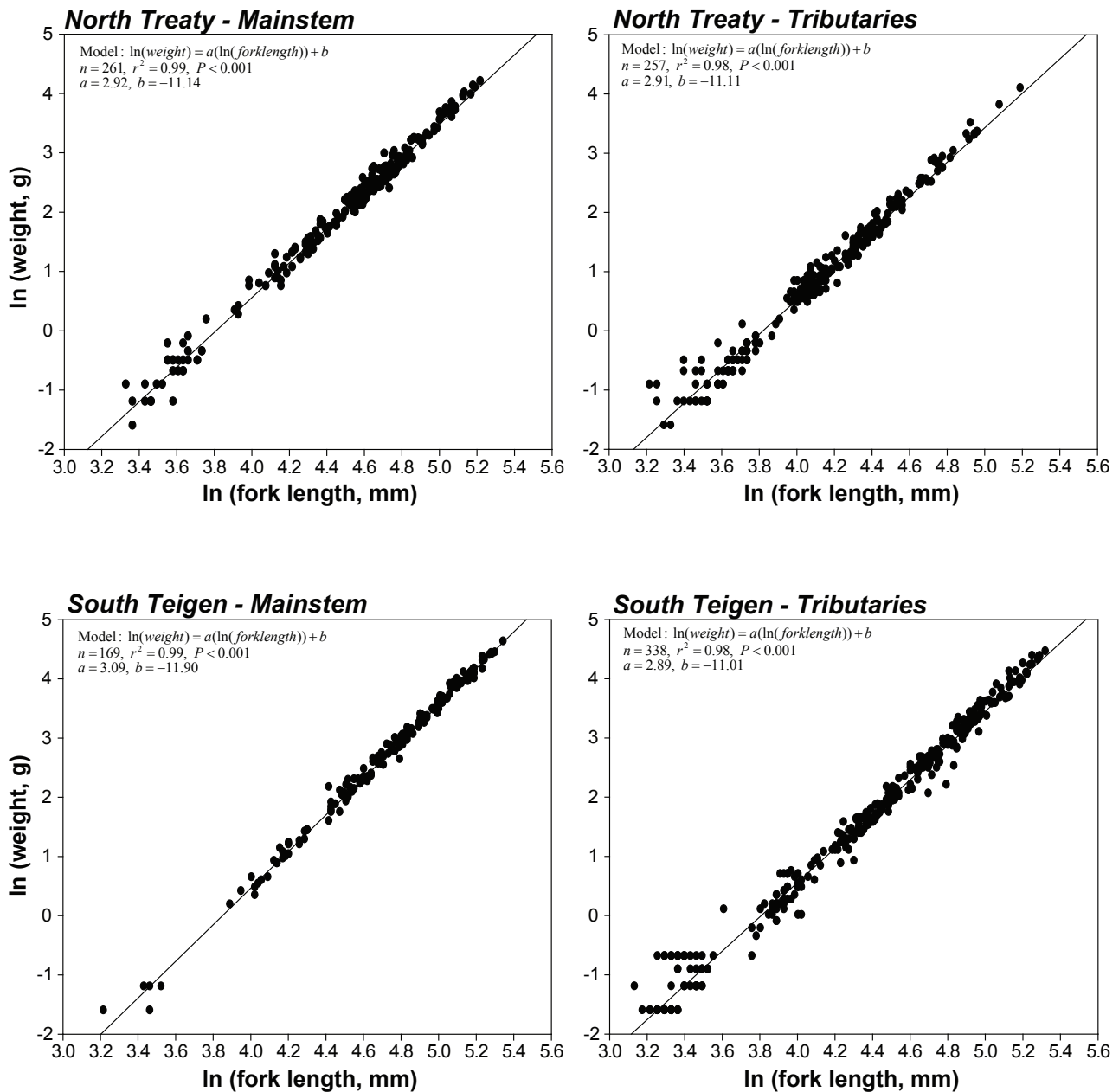
SE = standard error



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



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



**Weight-Length Regression of Dolly Varden within
South Teigen and North Treaty Watersheds, 2009**

FIGURE 6.2-8

Table 6.2-15. Mean Age of Dolly Varden Captured in South Teigen and North Treaty Watersheds, 2009

Watershed	n	Age (years)			
		Mean	SE	Min	Max
North Treaty (Mainstem)	16	3	0.2	2	5
North Treaty (Tributaries)	11	2	1.0	2	3
South Teigen (Mainstem)	36	3	0.2	1	5
South Teigen (Tributaries)	30	3	0.1	2	4

SE = standard error

Von Bertalanffy growth models were fit to the age and length data of fish from South Teigen and North Treaty creeks (Figure 6.2-10). Age explained between 64 and 84% of the variation in fish length. The maximum attainable length was estimated at 202 mm for North Treaty Creek and 610 mm for South Teigen Creek. However, interpretation of these growth curves should be applied with caution because of low sample size.

6.2.3.3 Population Density

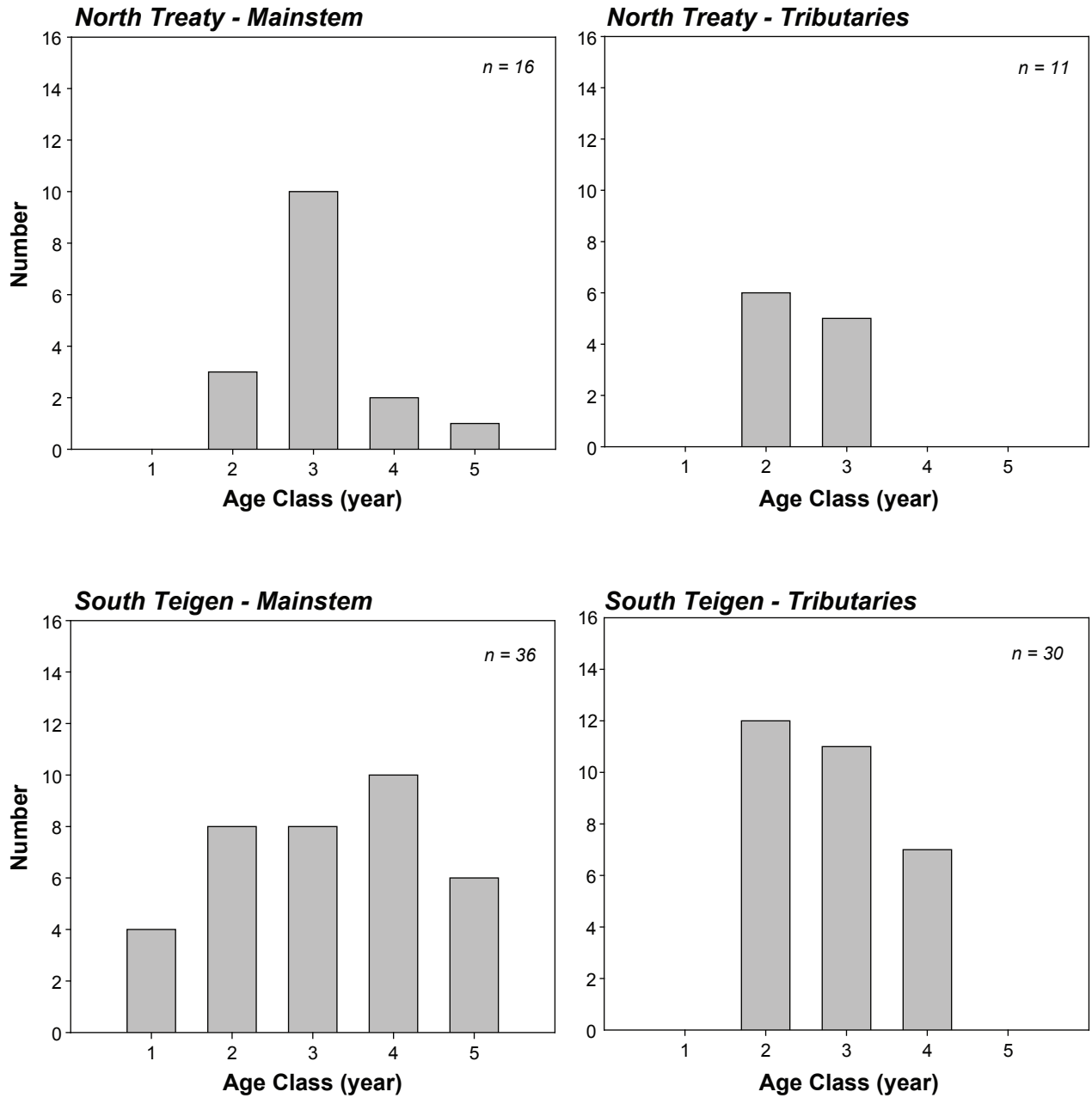
Appendix 6.1-3 shows all electrofishing effort and catch data for each density sampling site. Appendix 6.2-4 shows the results of density calculations with upper and lower confidence limits for each site.

Three-pass electrofishing surveys were completed in mid-August and early September (South Teigen Creek only) at 11 sites in South Teigen Creek, 16 sites in South Teigen tributaries, 7 sites in North Treaty Creek and 8 sites in North Treaty tributaries (Figure 6.2-2). Sites were randomly distributed among the mainstem reaches and tributaries throughout the TMF. Electrofishing sampling conditions were good across all sites with good water visibility, effective block nets preventing fish movement, low flows, and suitable water temperatures, except South Teigen Creek where water visibility and flow was moderate.

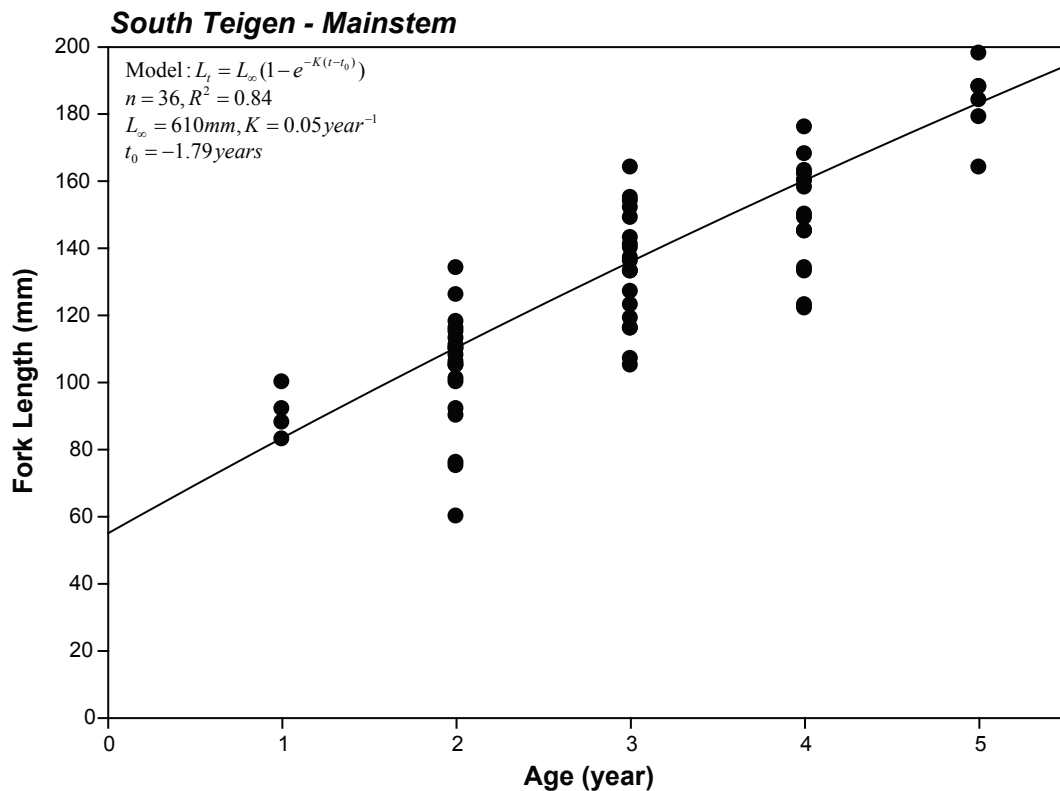
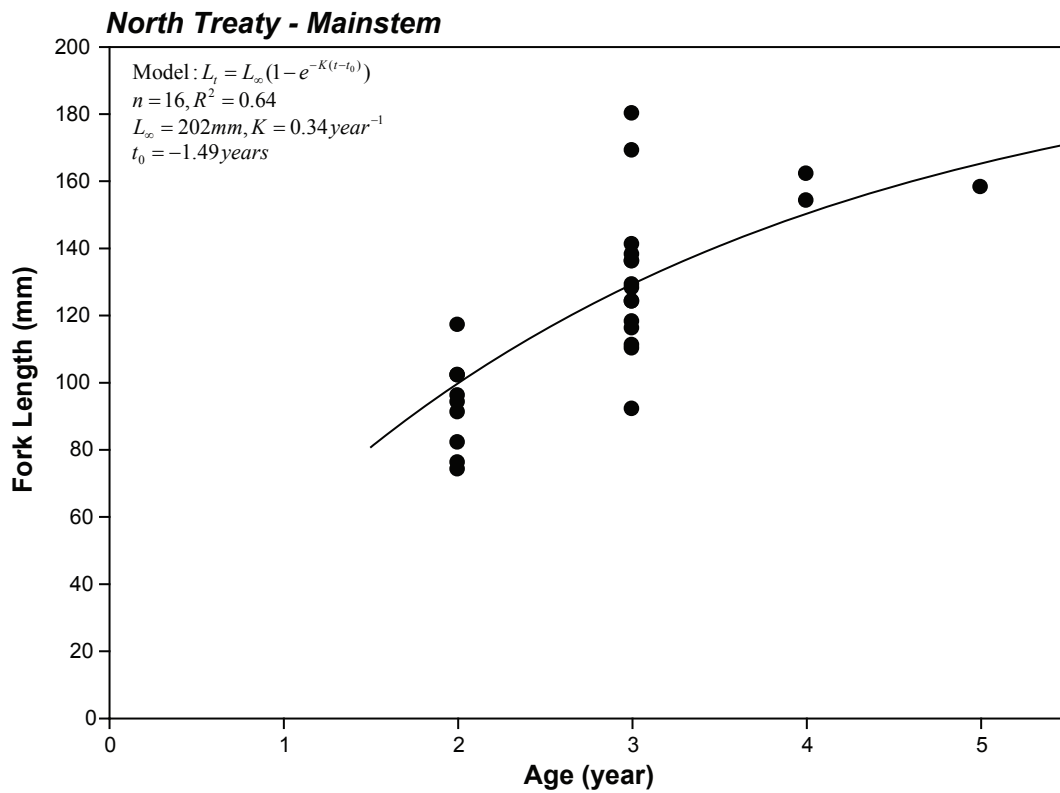
A total area of 5,856 m² was sampled for fish population density across the 42 sites (Appendix 6.2-4). The mean area sampled within South Teigen and North Treaty creeks was 159 m² with a range of 25 to 304 m². The mean area sampled within South Teigen and North Treaty tributaries was 82 m² with a range of 35 to 195 m².

Mean electrofishing effort was 2,057 s/site within South Teigen and North Treaty creeks. Mean electrofishing effort was 1,686 s/site within South Teigen and North Treaty tributaries. Crews were moderately successful in maintaining consistent effort between each pass. For South Teigen and North Treaty creeks, mean pass effort was 7.1, 6.9 and 6.7 s/m² for each pass. For South Teigen and North Treaty tributaries, mean pass effort was 8.5, 7.7 and 7.5 s/m² for each pass.

A total of 7 sites were excluded from the population density analysis because they failed to meet model assumptions (i.e., increasing catch probability with each successive pass) (Johnson et al. 2007). Dolly Varden population estimates were obtained with maximum likelihood methods for 30 sites with declining catch ratios. Population estimates were obtained with the Bayesian method for the other 5 sites that had catches that did not decline consistently with successive passes. Mean Dolly Varden population estimates for sites were 16 for South Teigen Creek, 63 for North Treaty Creek, 19 for South Teigen tributaries and 36 for North Treaty tributaries (Appendix 6.2-4).



**Age Class Distribution of Dolly Varden within
South Teigen and North Treaty Watersheds, 2009**



**Von Bertalanffy Growth Models of Dolly Varden within
South Teigen and North Treaty Watersheds, 2009**

FIGURE 6.2-10

Mean Dolly Varden population densities were higher in North Treaty Creek (99 fish/100 m²) compared to 9 fish/100 m² for South Teigen Creek (Table 6.2-16). The range of densities was 1.5 to 17.1 fish/100 m² in South Teigen Creek. The range of densities was 41.1 to 252 fish/100 m² in North Treaty Creek (Appendix 6.2-4). Mean Dolly Varden population densities were higher in North Treaty tributaries compared to South Teigen tributaries (Table 6.2-16). The range of densities was 0 to 54.5 fish/100 m² in South Teigen tributaries. The range of densities was 0 to 138 fish/100 m² in North Treaty tributaries (Appendix 6.2-4). Mean population densities and first-pass CPUE results were similar between watersheds.

Table 6.2-16. Mean CPUE and Density of Dolly Varden Captured in South Teigen and North Treaty Watersheds, 2009

Watershed	1st Pass CPUE (fish/100 s)			Population Density (fish/100m ²)		
	n	Mean	SE	n	Mean	SE
South Teigen (Mainstem)	11	1.2	0.6	11	8.8	1.2
South Teigen (Tributaries)	12	1.8	2.4	12	29.9	2.1
North Treaty (Mainstem)	4	3.8	1.9	4	99.3	17.2
North Treaty (Tributaries)	8	2.4	2.2	8	50.1	3.1

SE = standard error

n = sample size

Furthermore, electrofishing effort occurred on Stream 1010 upstream of a series of cascades (Plate 6.2-13) in the location of the proposed plant site (Figure 6.2-2). A total of 1,525 s electrofishing effort was exerted in Stream 1010 on two separate sampling events; however no fish were caught. Stream 1010, formally Stream 4009, was sampled in 2008 and no fish were caught despite 1,422 s of electrofishing effort (Rescan 2009). Therefore, streams above the series of cascades were classified as non-fish bearing.

6.2.3.4 Dolly Varden Genetics

A total of 164 Dolly Varden genetic tissue samples were collected from four areas within the Treaty and Teigen watersheds. The four areas were: upstream of South Teigen Creek falls (Teigen Watershed), downstream of South Teigen Creek falls (Teigen Watershed), North Treaty Creek within the TMF (Treaty Watershed) and Treaty Creek (Treaty Watershed). Appendix 6.2-5 presents a final report, conducted by UBC, of genetic variation within and between Dolly Varden from two localities within the Bell-Irving Watershed assessed using microsatellite DNA. A summary of the report results are provided below.

The genetic variation from Teigen Creek was slightly more variable (mean number of alleles per locus = 13.6, mean expected heterozygosity of 0.70) than that from Treaty Creek (11.7 and 0.65, respectively). These markers clearly provide considerable power to investigate genetic differentiation in these Dolly Varden populations.

The proportion of the total variation in allele frequencies that is attributable to differences among samples is known as F_{ST} and is estimated from sample data using Weir and Cockerham's (1984) θ statistic, which varies from 0 (no difference) to 1.0 (maximum difference among samples). There was clear separation between Dolly Varden collected from the two watersheds. This was evident in the ordination of each fish along the first three FCA axes (Figure 6.2-11). In Figure 6.2-11, the blue symbols represent individuals from Teigen Creek watershed and the yellow symbols represent individuals from Treaty Creek watershed.



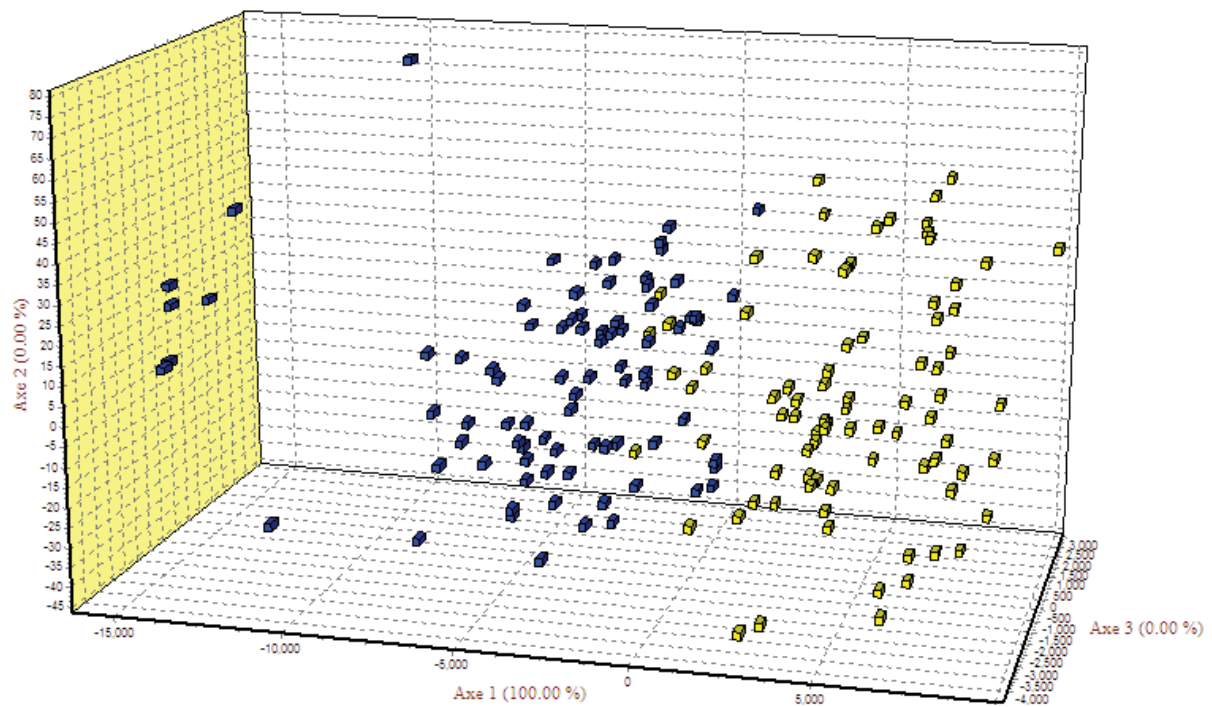
Plate 6.2-13. *Stream 1010 Cascades.*

Within Treaty Creek, there was a clear distinction between samples collected from the lower watershed and those from the upper watershed (Appendix 6.2-5, Figure 2). Within Teigen Creek, there was a clear separation between fish collected above and below the putative migration barrier (Appendix 6.2-5, Figure 3). There were also a number of individuals sampled below the putative migration barrier, in South Teigen Creek, that were homozygous for an allele at Sfo18 that is normally diagnostic for bull trout.

The F_{ST} resolved was consistent with values (0.02 to 0.09) across a similar spatial scale and reported in allozyme surveys of Dolly Varden populations within tributaries flowing to the Beaufort Sea on the North Slope of Alaska (Everett et al. 1997). For interconnected systems, such as examined in this study, the reported F_{ST} values are consistent with values reported for other salmonid populations (Taylor et al. 2003; Hendry et al. 2004). The analyses also indicate that there is significant population subdivision within each creek; F_{ST} values between above and below barrier localities both within Treaty and Teigen creeks were significant and slightly exceeded those between creeks. Such within-stream variation above and below migration barriers is a common phenomenon in fluvial-dwelling salmonid populations, including char. Although the presence of such within-stream variation in Treaty and Teigen creeks is not a unique situation, it is likely an important one to acknowledge for local management.

6.2.4 Wetland - Habitat

The locations of six assessed wetlands within South Teigen and North Treaty watersheds are shown in Figure 6.2-2. Each fish-bearing wetland was mapped according to the SHIM methodology and habitat was assessed in each wetland (Tables 6.2-17 and 6.2-18). All wetland substrates were dominated by sand and fines with gravels as sub-dominant. All wetlands were dominated by pool cover type with instream vegetation (*Carex spp.*) and overhanging vegetation as sub-dominant cover types. All wetlands had tall shrub riparian vegetation, except wetland ST-W1.



Note: Blue symbols represent individuals from Teigen Creek Watershed and the yellow symbols represent individuals from Treaty Creek Watershed.

Microsatellite DNA Allele Frequency Differences of Dolly Varden from Teigen and Treaty Watersheds

FIGURE 6.2-11

Table 6.2-17. Summary of Wetland Characteristics within South Teigen and North Treaty Watersheds, 2009

Watershed	Wetland Name	Pond No.	Survey Date (dd/mm/yy)	Open Water (%)	Max Water Depth (m)	Area (m ²)
North Treaty	NT-W3	3	13-Jul-09	-	0.7	624
	NT-W2	4	13-Jul-09	-	0.7	4,344
	NT-W1	2	13-Jul-09	-	1.5	4,421
South Teigen	ST-W1	5	13-Jul-09	-	0.8	1,544
	ST-W2	7	-	40	0.5	314
	ST-W3	1	8-Jul-09	80	-	309

Dashes indicate no data available

Table 6.2-18. Summary of Wetland Habitat within South Teigen and North Treaty Watersheds, 2009

Watershed	Wetland Name	Pond No.	Bed Composition (%)					Instream Cover Presence						Riparian Vegetation	Fish Habitat (Y/N)	Fish Present	Comments
			Sand	Gravel	Cobble	Boulder	Bedrock	Pool	Boulder	IV	OV	UB	LWD				
North Treaty	NT-W3	3	95	5	0	0	0	D	-	SD	SD	-	-	Tall Shrub	Y	N	Old beaver dam at outlet to larger beaver pond, no fish caught in pond
	NT-W2	4	100	0	0	0	0	D	-	SD	SD	-	-	Tall Shrub	Y	N	Old beaver dam at outlet, fish present on other side of dam, no fish caught in pond
	NT-W1	2	100	0	0	0	0	D	-	SD	T	-	-	Tall Shrub	Y	N	Old beaver dam at outlet to larger beaver pond, no fish caught in pond
South Teigen	ST-W1	5	100	0	0	0	0	D	-	SD	T	-	-	Grass	Y	Y	Direct connection to mainstem South Teigen, DV caught in pond
	ST-W2	7	70	30	0	0	0	D	-	SD	SD	-	-	Tall Shrub	Y	Y	Direct connection to stream 1152
	ST-W3	1	100	0	0	0	0	D	-	SD	SD	-	T	Tall Shrub	Y	Y	Old beaver pond and dam, connected by channels to mainstem

IV = instream vegetation

OV = overhanging vegetation

UB = undercut bank

LWD = large woody debris

D = dominant

SD = sub-dominant

T = trace

Dashes indicate not applicable

All wetlands possessed good rearing habitat. Wetland NT-W1 possessed abundant over-wintering habitat with water depths greater than 1.5 m present in some areas; however a beaver dam was present which restricts fish passage and use. All wetlands possessed no spawning habitat, due to the fine substrates.

6.2.5 Wetland - Fish Community

Appendix 6.2-6 shows the biological data on all species of fish sampled from each wetland. Appendix 6.2-7 shows all electrofishing and minnow trap effort and catch data for each wetland.

Two wetlands were sampled in 2009 (Table 6.2-19). Dolly Varden were captured in Wetland ST-W1. No fish were caught in Wetland NT-W2 despite 125 h of minnow trap effort. Wetland NT-W2 was sampled in 2008, formerly named Wetland 1, and no fish were caught despite 52 h of minnow trap effort and 850 s of electrofishing effort (Rescan 2009). The presence of a beaver dam likely restricts upstream fish movement into this wetland.

Mean length, weight, and condition of Dolly Varden sampled in Wetland ST-W1 are presented in Table 6.2-20.

6.3 RECEIVING ENVIRONMENT - STREAM AND WETLAND HABITAT

6.3.1 Watershed Setting

The fish and fish habitat study area encompasses a number of watersheds (Figure 4.1-1). For the purposes of data analysis and comparison, three watersheds were selected for detailed fish and fish habitat analysis: Teigen Creek, Treaty Creek and the Unuk River. A number of other watersheds within the study area were assessed for fish and fish habitat values, including: Bowser, South Unuk and Bell-Irving rivers, Oweegee, Snowbank, West Teigen, Sulphurets and Coulter creeks.

Stream reaches were identified and mapped for watersheds, within the study area, through air-photo interpretation, flight surveys, and ground-truthing according to RISC (2001). Characterization of each stream and reach within the study area is presented in Table 6.3-1 (Rescan 2009; SKR 1998). The location and reach boundaries for each watershed are presented in Figure 6.3-1.

6.3.2 Teigen, Treaty and Unuk Watersheds - Fish Habitat

Teigen Creek is a sixth order tributary of the Bell-Irving River and possesses a watershed area of 98.4 km² (Figure 6.3-2). Teigen Creek originates from a large headwater lake, Teigen Lake, and glaciers on the eastern hillslope. The creek is frequently confined, with a gradient of 4% and cobble channel substrates in the upper watershed (Plate 6.3-1). The creek then decreases in gradient, is unconfined with side channels and substrate size decreases in the middle watershed (Hodkin Creek to Snowbank Creek confluences) (Plate 6.3-2). In the lower watershed, downstream of Snowbank Creek confluence, the creek is braided with frequent side channels and wetlands, and discharges into the Bell-Irving River (Plate 6.3-3).

Treaty Creek is a fourth order tributary of the Bell-Irving River and possesses a watershed area of 180.6 km² (Figure 6.3-3). Treaty Creek is turbid and originates from glaciers. The creek is unconfined with braided channels near the glacial headwaters then the channel becomes confined with increased channel substrate size (Plate 6.3-4). The middle watershed is unconfined and heavily braided with numerous side channels (Plate 6.3-5). In the lower watershed, the creek is partially entrenched with few side channels, and discharges into the Bell-Irving River (Plate 6.3-6).

Table 6.2-19. Wetland Sampling Effort, CPUE and Catch Statistics in South Teigen and North Treaty Watersheds, 2009

Watershed	Site	MT Effort (hrs)	Species	No. Caught	CPUE (fish/trap/24h)
South Teigen	ST-W1	125.2	Dolly Varden	14	2.7
North Treaty	NT-W2	125.0	NFC	0	-

CPUE = catch-per-unit-effort

NFC = no fish caught

MT = minnow trap

Dashes indicate not applicable

Table 6.2-20. Mean Length, Weight and Condition of Dolly Varden Captured in South Teigen and North Treaty Wetlands, 2009

Watershed	Site	Length (mm)					Weight (g)					Condition (g/mm ³)	
		N	Mean	SE	Min	Max	N	Mean	SE	Min	Max	Mean	SE
South Teigen	ST-W1	14	118	5.3	80	142	14	17.0	2.1	4.7	26.8	0.96	0.01
North Treaty	NT-W2	-	-	-	-	-	-	-	-	-	-	-	-

Dashes indicate no data available

SE = standard error

N = sample size

Table 6.3-1. Summary of Stream Reaches within the Receiving Environment Watersheds, 2009

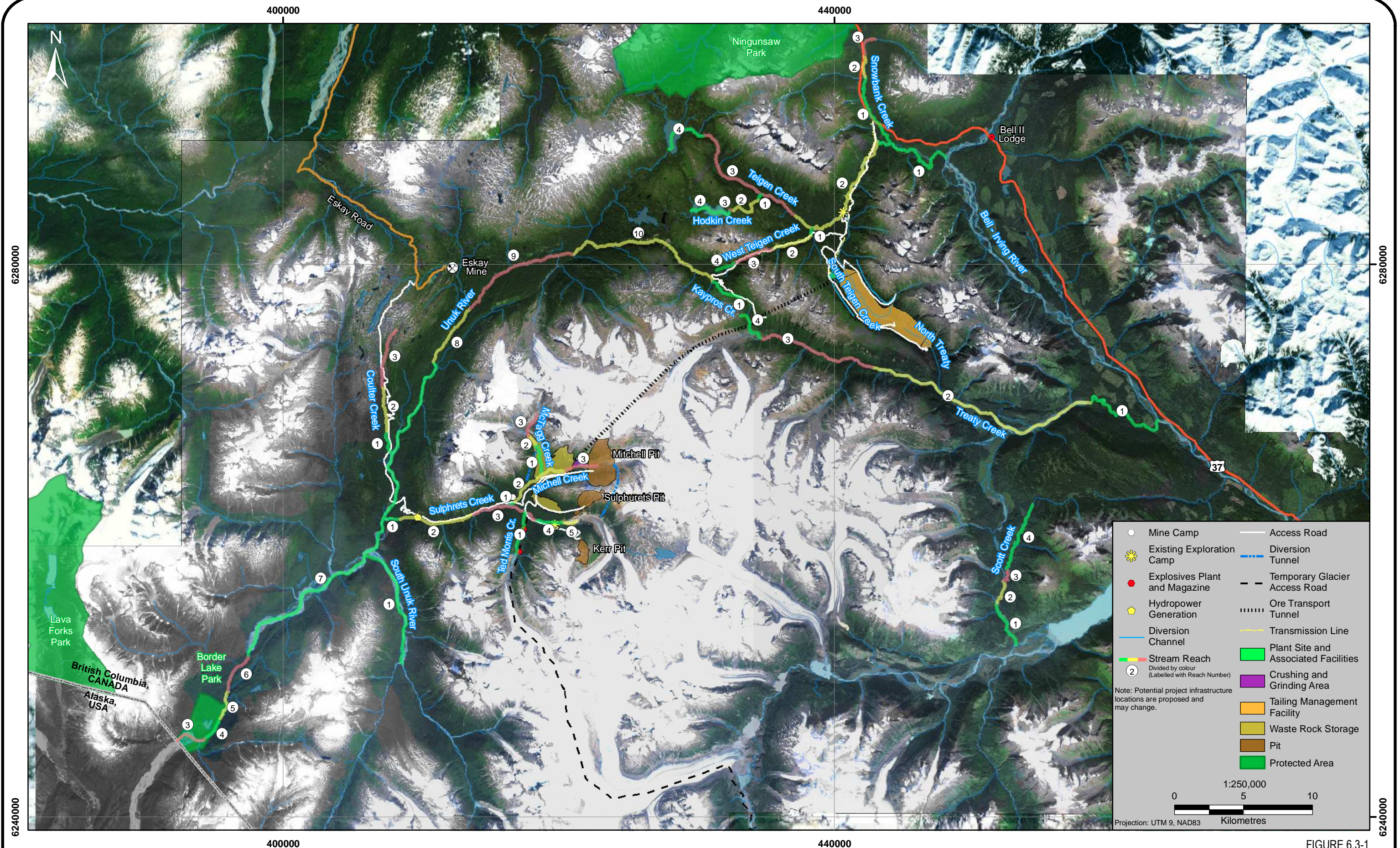
Watershed	Sub-Watershed	Watershed Description	Reach	Stream Length (km)	Reach Description
Bell-Irving					
Treaty Creek	-	4th order tributary of Bell-Irving River	1	7.9	Channel partially entrenched with few side channels, gradient 1%
			2	18.4	Channel heavily braided and unconfined, numerous side channels, gradient 1%
			3	9.2	Channel confined, increased channel substrate size, gradient 1%
			4	2.8	Channel unconfined, channels braided
Teigen Creek	-	6th order tributary of Bell-Irving River	1	7.9	Channel unconfined, frequent side channels, low gradient 1%
			2	11.4	Channel unconfined and braided, low gradient 1%
			3	11.0	Channel frequently confined, increased gradient to 4%, decreased channel width, increased channel substrate size
Teigen Creek	West Teigen Creek	Tributary of Bell-Irving River that discharges into Teigen Creek	4	-	Teigen Lake
			1	0.5	Channel unconfined, braided, occasional gravel bars, gradient 1%
			2	3.3	Channel occasionally confined, seldom braided, no side channels
Teigen Creek	Hodkin Creek	Tributary of Bell-Irving River that discharges into Teigen Creek	3	3.0	Channel confined, channel not well defined in sections due to avalanche activity
			4	-	West Teigen Lake
			1	0.6	Low gradient, riffle-pool morphology channel
Snowbank Creek	-	Tributary of Bell-Irving River that discharges into Teigen Creek	2	2.9	Channel entrenched with high banks
			3	0.4	Steep gradient channel with cascades and falls
			4	-	Hodkin Lake
			1	6.1	Channel infrequently confined and braided, gradient 3%
Snowbank Creek	-	Tributary of Bell-Irving River that discharges into Teigen Creek	2	1.8	Flooded wetland with no well defined channel, beaver dams present throughout reach, substrates consisted of fines
			3	1.8	Defined channel, low gradient, gravel substrates, wetlands present
			Bowser		
Scott Creek	-	4th order tributary of Bowser River	1	3.8	Channel partially confined, gradient 2-2.5%
			2	2.0	Channel confined with occasional side channels, infrequent gravel-cobble bars
			3	1.5	Channel partially confined, gradient 1.5%
			4	6.4	Heavily braided with extensive beaver dam activity, sections lack well defined channel

(continued)

Table 6.3-1. Summary of Stream Reaches within the Receiving Environment Watersheds, 2009

Watershed	Sub-Watershed	Watershed Description	Reach	Stream Length (km)	Reach Description
Unuk					
Unuk River	Kaypros Creek	Headwater Tributary of Unuk River	1	2.8	Channel confined, low gradient, riffle-pool morphology, gravel channel substrates
Unuk River	-	-	1-3	2.5	The first three reaches are located in Alaska. Reach 3 channel unconfined and braided
			4	1.7	Entrenched channel, second canyon
			5	2.4	Unconfined channel, multiple channel braids
			6	3.2	Entrenched channel, third canyon
			7	29.4	Unconfined channel, multiple channel braids and side channels, gradient 1%
			8	4.9	Confined and entrenched channel, bedrock banks and substrates
			9	9.5	Unconfined channel, braided with gravel/cobble bars
			10	12.6	Occasionally confined channel smaller channel width
			1	9.5	Unconfined channel, braided with gravel/cobble bars
			1	1.8	Unconfined channel, channel banks not defined due to high velocity flood event, low gradient
South Unuk River	-	Tributary of Unuk River	2	3.4	Entrenched channel, multiple falls and cascades, high gradient
Coulter Creek	-	Tributary of Unuk River	3	4.7	Confined channel, low gradient
Sulphurets Creek	-	Tributary of Unuk River	1	1.3	Unconfined channel, gradient 1%, braided channel
			2	5.7	Entrenched channel, long cascades and falls, bedrock banks
			3	5.3	Unconfined channel, gradient 3%, braided channel
			4	2.0	Confined channel, cobble and boulder channel substrates, gradient 4%
			5	-	Sulphurets Lake
Sulphurets Creek	Ted Morris Creek	Tributary of Unuk River that discharges into Sulphurets Creek	1	9.5	Confined channel, cobble and boulder channel substrates, gradient 5%
Mitchell Creek	-	Tributary of Unuk River that discharges into Sulphurets Creek	1	0.6	Unconfined channel, braided channel, low gradient
			2	5.1	Confined channel and entrenched in sections, cobble and boulder channel substrates, high gradient,
			3	2.4	Broad glacial fan, multiple braided channels, gradient 1%
McTagg Creek	-	Tributary of Unuk River that discharges into Mitchell Creek	1	2.5	Confined channel and entrenched in sections, cobble and boulder channel substrates, high gradient,
			2	0.8	Unconfined channel, braided channel, low gradient
			3	1.9	Confined channel, cobble and boulder channel substrates, gradient 5%

Dashes indicates not applicable



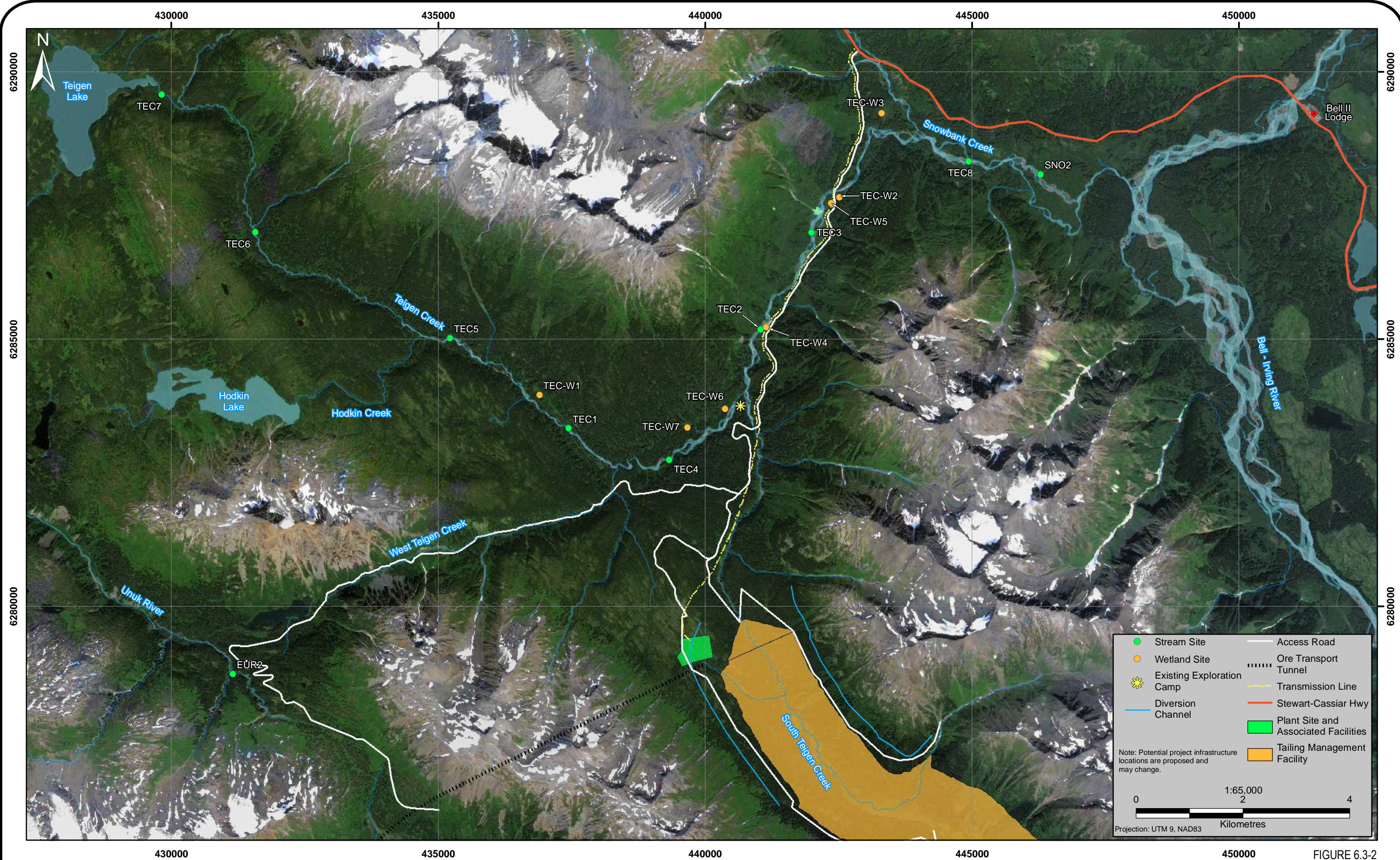




Plate 6.3-1. Teigen Creek Upper Reaches.



Plate 6.3-2. Teigen Creek Middle Reaches.



Plate 6.3-3. Teigen Creek Lower Reaches.

The Unuk River is a large river that originates from glaciers in British Columbia, flows through Alaska and discharges into the Pacific Ocean (Figure 6.3-4). There are ten reaches within the Unuk River. The majority of these reaches are low gradient, unconfined and braided (Plates 6.3-7 and 6.3-8). However, sections of the river are entrenched (Plate 6.3-9).

Channel Characteristics

Appendix 6.1-1 shows site and stream habitat details presented in the form of completed site cards. Detailed fish habitat data for receiving environment streams are presented in Appendix 6.3-1. Tables 6.3-2 and 6.3-3 present a summary of channel statistics and characteristics for Teigen Creek, Treaty Creek and the Unuk River, from the headwaters to lower reaches. Figures 6.3-5, 6.3-6 and 6.3-7 show a summary of weighted mean bed substrate composition for Teigen Creek, Treaty Creek and the Unuk River, from the headwaters to lower reaches.

The majority of Treaty Creek possessed riffle-pool morphology with meandering and sinuous, unconfined, braided channels of 1 to 2% gradient. Bankfull widths ranged from 21.2 to 218.2 m from the headwaters to lower reaches. Wetted depths were deep and defined pools were not present throughout the creek. Bed substrate composition varied throughout the creek, however the dominant bed substrates were cobble and gravel.

The Unuk River possessed cascade-pool morphology in the upper reaches then changes to riffle-pool morphology downstream of Storie Creek confluence. The reaches downstream of Storie Creek confluence are sinuous, unconfined with braided channels of 1 to 2% gradient. Bankfull widths range from 14.3 to 106.9 m from the headwaters to lower reaches. Wetted depths are deep and un-wadeable due to stream velocity. Bed substrate composition varies throughout the creek, however the dominant bed substrates are cobble and boulders in the headwater reaches and cobble in the lower reaches.

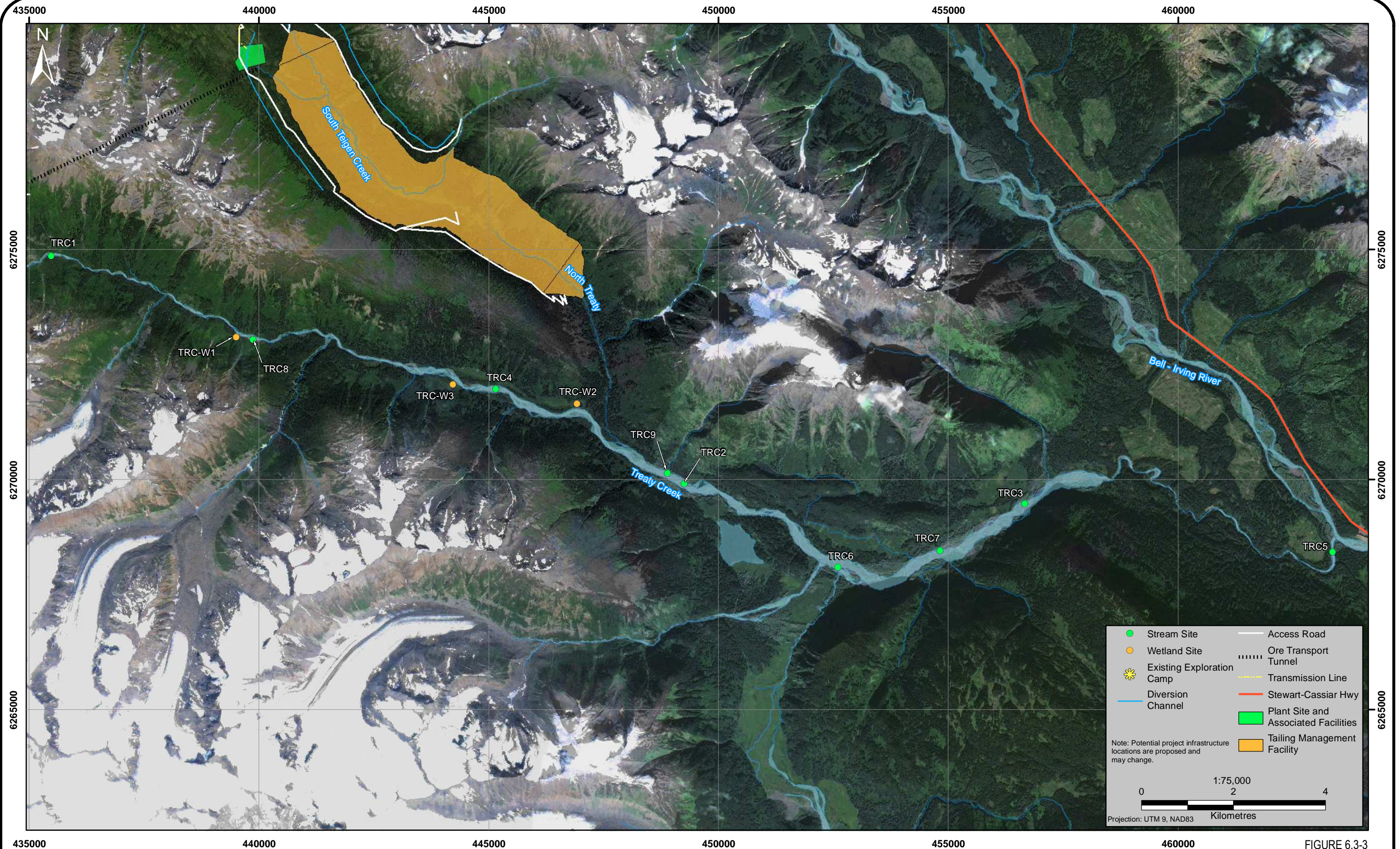




Plate 6.3-4. Treaty Creek Upper Reaches.



Plate 6.3-5. Treaty Creek Middle Reaches.



Plate 6.3-6. Treaty Creek Lower Reaches.

Habitat

Figures 6.3-8, 6.3-9 and 6.3-10 show a summary of weighted mean habitat unit composition for Teigen Creek, Treaty Creek and the Unuk River, from the headwaters to lower reaches. Figures 6.3-11, 6.3-12 and 6.3-13 show a summary of weighted mean habitat cover composition for Teigen Creek, Treaty Creek and the Unuk River, from the headwaters to lower reaches. Table 6.3-4 present a summary of LWD abundance, distribution and riparian habitat.

For Teigen Creek, dominant habitat unit composition was riffles and cascades in the upper reaches, with a higher proportion of riffles and glides in the middle and lower reaches. Pool and boulder habitat cover were present and dominant throughout the creek. LWD was abundant throughout the creek, and was distributed both evenly and in clumps. Riparian habitat types were mixed along the creek channel.

For Treaty Creek, dominant habitat unit composition was riffles in all reaches, except the reach near the confluence with the Bell-Irving River. Pool, overhanging vegetation, and LWD habitat cover were present and dominant throughout the creek. LWD was scattered throughout the creek, which was clumped in distribution. Riparian habitat types were dominated by shrubs along the creek channel.

For the Unuk River, dominant habitat unit composition was riffles in all reaches, except the confined upper reach (ECM9). All habitat cover types were present throughout the creek, except instream vegetation. LWD was scattered throughout the river, which was clumped in distribution.