APPENDIX xiii

NICHE SEGREGATION OF DOLLY VARDEN IN THE UPPER FINLAY RIVER WATERSHED

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1.0 Introduction

This document has been prepared to provide support for the proposed fish habitat compensation plans and fish salvage for the Kemess North mine expansion in north-central British Columbia. The goal of the report is to summarize some of the pertinent literature that will be utilized in the development of higher-level planning should the proposed compensation plan be accepted by the regulatory agencies. The information presented here largely comes from existing research, although site-specific studies for the mine expansion have been initiated and the results are included here where available.

Dolly Varden (*Salvelinus malma*) are highlighted as a key species in the proposed compensation plans. Existing information on the life-history characteristics of Dolly Varden is presented with special reference to the upper Finlay River population where possible. Notes on life-history aspects of other species, such as bull trout (*Salvelinus confluentus*), rainbow trout (*Oncorhynchus mykiss*), and mountain whitefish (*Prosopium williamsoni*), are presented in conjunction with Dolly Varden where relevant.

2.0 Dolly Varden in the Upper Finlay River Watershed

2.1 Distribution

Dolly Varden are found throughout British Columbia in drainages of the Pacific Basin. Dolly Varden have also colonized headwater portions of some Arctic drainages, including the headwaters of the Finlay River (tributary to the Peace River → Slave River → Mackenzie River) and Liard River (tributary to the Mackenzie River). Dolly Varden are suspected to be relative newcomers to these Arctic drainages, arriving post-glaciation via low gradient, headwater connections (McPhail and Baxter 1996), possibly a result of temporary diversions from avalanches, beaver dams, or flood-induced avulsions. The distribution of Dolly Varden in the Finlay River reflects this dispersal pattern, as Dolly Varden are known only from the headwater areas around Thutade Lake, and are currently absent from the Williston Reservoir and its tributaries, except for the Ingenika River (B.C. Ministry of Environment 2006). Dolly Varden in the Ingenika River are mostly confined to its headwaters and exist above a series of barriers to upstream fish migration (B.C. Ministry of Environment 2006; Triton 2006). A few scattered records from the mouth of the Ingenika River, and the mouths of Pesika Creek and the Akie River just upstream from the Reservoir are also noted. The upper Ingenika River fish are also expected to have arrived via headwater crossovers, either from the Attichika Creek drainage (tributary to Thutade Lake), or from the Moosevale Creek or Johanson Creek drainages (tributaries to the Sustut River → Skeena River; Pacific drainage).

Dolly Varden are often displaced from lower gradient, larger mainstem, and lacustrine habitat by rainbow trout (Hindar et al 1988) and adult bull trout. Both Dolly Varden and bull trout are known to utilize higher gradient and elevation stream reaches than any other species in British Columbia (Province of British Columbia 2000), except perhaps cutthroat trout, which are absent from the Arctic drainages of B.C. (except for introduced lake populations in the lower Peace River; McPhail and Carveth 1993). In the upper Finlay River watershed, both Dolly Varden and bull trout appear to be more widely distributed than any other salmonid species. Dolly Varden and bull trout were consistently captured in greater numbers than rainbow trout during field sampling events throughout the Toodoggone River watershed in 2006 (Triton 2006). The highest rainbow trout densities occurred where char were absent, such as the Jock Creek and Lawyers Creek drainages in the Toodoggone River watershed and an unnamed tributary (watershed code: 230-991300-89300) to the Ingenika River. Rainbow trout densities are also higher in most lakes where they occur in sympatry with char (Hatfield Consultants Ltd. 2004; R.L.& L. Environmental Services Ltd. 2002).

David Bustard and Associates Ltd. (2004a) speculated that rainbow trout distributions are strongly tied to lake-headed systems in the Thutade Lake watershed, citing the Duncan, El Condor, Bicknell, Thorne, and McConnell Lake tributaries, while char are characteristic of systems without lakes. This trend was observed at some locations while sampling near lakes in 2006 by Triton. Examples include higher trout than char captures in Frederikson Creek (1.5:1 ratio) below Frederikson Lake, an unnamed tributary lake to the Chukachida River[1] (waterbody identifier 00589CHUK, 9.5:1 ratio), and in the Toodoggone River below Toodoggone Lake (2:1 ratio), although in the latter case, mountain whitefish were the most numerous species. At one location in the Ingenika watershed (unnamed tributary, watershed code 230-991300-92800), Dolly Varden captures were more common than rainbow trout by a 3:1 ratio, despite the low stream gradient and presence of two moderately sized fish-accessible lakes in the headwaters.

Although bull trout have been shown to use the lacustrine habitat in Thutade Lake to the relative exclusion of Dolly Varden (Hagen and Taylor 2001), Dolly Varden do occur in lakes in the upper Finlay River watershed. A survey of Duncan Lake in 2004 by Hatfield Consultants Ltd. (2004) estimated 2131 ± 1241 rainbow trout, 779 ± 453 Dolly Varden (excluding fry), and 372 ± 216 mountain whitefish. Interestingly, no bull trout have been recorded from Duncan Lake, despite a lack of definite barriers to fish migration on Duncan Creek or its mainstem, Attycelley Creek. A reconnaissance inventory in 2001 revealed the presence of Dolly Varden in a nearby lake that is tributary to the upper Finlay River (00625FIRE; R.L.& L. Environmental Services Ltd. 2002). Similar to Duncan Lake, rainbow trout were the most abundant species (66 gillnet captures), while Dolly Varden were second (12 gillnet captures). No other species were captured (R.L.& L. Environmental Services Ltd. 2002). Dolly Varden were the only species captured in another unnamed lake (waterbody identifier 00492FIRE) which is now isolated by a landslide (R.L.& L. Environmental Services Ltd. 2002). Both Dolly Varden and bull trout were captured downstream in the mainstem of this lake. Dolly Varden (suspected) were also noted in two other small lakes (waterbody identifiers 00349FIRE and 00356FIRE), along with rainbow trout (R.L.& L. Environmental Services Ltd. 2002). A single bull trout was captured in an unnamed tributary lake (waterbody identifier 00269FIRE) to Delta Creek during a gillnet set in 2006, as well as 18 longnose suckers (Triton 2006).

[1] The Chukachida River forms part of the Stikine River watershed (Pacific drainage), though it is located immediately north of the Toodoggone River watershed and fish habitat conditions are similar

In the Toodoggone River watershed, Dolly Varden were captured in mainstem side channels and moderately sized tributaries (2 to 5 m channel widths) in the lower portion of the watershed, below Toodoggone Lake by Triton (2006). Some Dolly Varden were also captured in the upper portion of the watershed, though captures were more sporadic. Bull trout were found extensively throughout the watershed, but were notably absent above most major barriers. Rainbow trout were found above barriers on Jock Creek and Lawyers Creek, though the Jock Creek system has been artificially stocked (FISS 2006). Lawyers Creek may also have been artificially stocked, or may have been colonized from a previous connection to the Sturdee River watershed (via Chapelle Creek or Jellicoe Creek) over a low pass in the headwaters. An isolated population of mountain whitefish exists in Belle Creek, a tributary to McClair Creek. No other species are known from Belle Creek, and the origin of these mountain whitefish is unknown. Genetic samples were taken from these fish in 2006 for comparison with the mountain whitefish population in the mainstem Toodoggone River, though a lack of a suitable reference library of mountain whitefish alleles may limit the effectiveness of any genetic results. Although the proximity to the Metsantan Creek (Stikine River watershed) drainage and the low topographic relief in the headwaters of the Toodoggone River suggests the possibility of a drainage crossover, the lack of fish above barriers in the Toodoggone River drainage, especially in systems with ample fish habitat (Jock Creek prior to fish introductions, Mulvaney Creek, Bronlund Creek, lack of bull trout in Lawyers Creek and Belle Creek), suggests that the fish colonizing this watershed have migrated upstream from the Finlay River. This is further supported by the distribution of Dolly Varden in the lower portion of the river only, despite suitable habitats upstream. Dolly Varden are thought to have begun colonizing the upper Finlay River watershed much later than bull trout, and may still be increasing their range.

2.2 Life History and Habitat Requirements

2.2.1 Temperature

Dolly Varden generally prefer small tributary streams and side channels, with cool temperatures (Scott and Crossman 1973; Meehan and Bjornn 1991). Fish in the genus *Salvelinus* are among the most thermally sensitive salmonid fishes. Selong et al (2001) found that 98% of bull trout juveniles survived longer than 60 days at 18˚C, but 100% mortality occurred within 60 days as temperature was increased to 22˚C. Predicted upper lethal temperature was found to be 20.9˚C, while peak growth occurred at 13.2˚C (Selong et al 2001). Similar temperature requirements can be expected for Dolly Varden. Much of the upper Finlay River watershed is fed by high elevation snowmelt and a few small glaciers, and as such, water temperatures generally remain cool throughout the year. Elevated summer temperatures may limit char use of shallow wetland and lake habitats at a few locations. Some evidence exists of temperature-mediated spatial distribution in sympatry with rainbow trout (Haas 1996).

2.2.2 Feeding

Dolly Varden feed primarily on aquatic invertebrates, including mayflies, chironomids, and small crustaceans (Meehan and Bjornn 1991). Although allopatric populations of trout and char often occupy similar niches, Dolly Varden are more often associated with benthic habitats than other salmonid species (e.g. rainbow and cutthroat trout) when in sympatry (Hindar et al 1988), though they share this niche with juvenile bull trout in the upper Finlay River watershed (Hagen and Taylor 2001). Adult Dolly Varden may feed more on insects taken from the surface, or from the drift (Meehan and Bjornn 1991), particularly in the absence of other species. Hagen and Taylor (2001) found only slight differences in feeding behaviour between Dolly Varden and juvenile bull trout, primarily that bull trout consumed larger, benthic prey items and Dolly Varden consumed winged insects from the drift, though significant overlap in feeding behaviour was evident.

2.2.3 Rearing

Juvenile bull trout and Dolly Varden appear to utilize similar habitats for feeding and rearing, even when they are the only two species within a system. This lack of niche separation may be a result of the relatively short period of time that the species have come into contact (Hagen and Taylor 2001). Alternative explanations include a lack of alternative niches in the high gradient, nutrient poor streams of the upper Finlay River watershed, or similarity in phenotypic ability for either species to utilize different niches effectively (Hagen and Taylor 2001).

While Dolly Varden and juvenile bull trout are often found together in tributary streams and occupy similar niches, the life-history strategy of bull trout and Dolly Varden deviate at the sub-adult stage, as bull trout in the upper Finlay River watershed are known to migrate to Thutade Lake and become piscivorous (Hagen and Taylor 2001). Adult bull trout in Thutade Lake attain sizes of 440 mm to 890 mm at maturity, while Dolly Varden, which appear to remain stream-resident throughout their life cycle, are considerably smaller at maturity (113 mm to 235 mm; Hagen and Taylor 2001). Dolly Varden with fork lengths of up to 368 mm were reported in one unnamed tributary lake (00625FIRE) to the Finlay River by R.L.& L. Environmental Services Ltd. (2002). Though voucher specimens were independently verified during this study by personnel from the B.C. Ministry of Environment, larger specimens may not have been submitted and may represent bull trout, though identification of larger specimens is usually easier. The lake may also have a unique population of large Dolly Varden.

Hagen and Taylor (2001) found that a negative relationship between the densities of bull trout and Dolly Varden existed in tributary streams of the Thutade Lake watershed, and that total densities among the streams examined were not significantly different between reaches with either one or other of the species, or both. This further indicates that neither species undergoes a shift in niche utilization in the presence of the other, and the presence of other niches suitable for other salmonids will not necessarily increase the carrying capacity of the stream for *Salvelinus* species in B.C.

2.2.4 Spawning

Dolly Varden and bull trout spawn in the fall, though slight differences in timing and site selection for each species has been well documented in several watersheds in B.C. Bull trout tend to spawn in large tributaries to main rivers, and often make long-distance migrations to suitable spawning grounds (Bahr 2003; Pillipow and Williamson 2004).

Bull trout in the above studies were most often found spawning in areas with good instream LWD habitat or overhead cover, and stream reaches had low gradients and an abundance of medium sized gravels. Bull trout in the upper Finlay River watershed spawn in late August to early September (D. Bustard and Associates 2006) which is similar to other populations of bull trout such as the Morice River (Aug. 23 to Sept. 15; Bahr 2003) and Goat River (late Aug. to early Sept.; Pillipow and Williamson 2004).

Dolly Varden spawning occurs in late September to early October (D. Bustard and Associates 2004b, 2006; Hagen and Taylor 2001) in the upper Finlay watershed, concurrent with what is reported in the literature (Scott and Crossman 1973; Meehan and Bjornn 1991). The majority of known Dolly Varden spawning habitat in the Thutade Lake watershed occurs in small, groundwater seepage fed tributary streams with relatively constant discharge and small gravels (D. Bustard and Associates 2004b). Some spawning has also been noted on shoals in Duncan Lake at the confluence of small, seepage tributaries (D. Bustard and Associates 2004b). Shoreline spawning has not been recorded in the primary literature for Dolly Varden, although it is suspected to occur in other lakes outside of the Finlay River watershed (e.g. Silvern Lake in the Zymoetz River drainage near Smithers and Zeballos Lake on Vancouver Island; D. Bustard and Associates Ltd. 2004b)

Natural hybrids between bull trout and Dolly Varden were discovered by Baxter et al (1997) in the upper Finlay River watershed, and the presence of post- F1 generation hybrids (fish with a hybrid mother or father, or both) confirmed their reproductive viability. Despite this apparent gene flow between the species, mixing of genetic material was not found to be widespread, and pre-zygotic barriers to hybridization appear to be maintaining the genetic integrity of the species in the area (Baxter et al 1997). Specifically, the slight difference in the timing of spawning, spawning site selection (larger tributaries and deeper water for bull trout, small seepages and smaller gravels for Dolly Varden), and size of mature spawners appears to limit cross-mating opportunities (Hagen and Taylor 2001).

3.0 Considerations for Translocation of Dolly Varden

Dolly Varden are highlighted as a key species in the proposed compensation plans. Although rainbow trout and mountain whitefish are present within the Duncan Lake watershed, the Dolly Varden in Duncan Lake do not appear to mix with the population downstream in the mainstem (Attycelley Creek, tributary to the Finlay River at the outlet of Thutade Lake) and exhibit some unique characteristics that indicate they may be genetically distinct from other Dolly Varden populations in the upper Finlay River watershed (D. Bustard and Associates Ltd. 2004b). Moving the fish downstream into Attycelley Creek and/or Thutade Lake may result in the loss of unique alleles from this population (Minckley 1995; Stockwell and Leberg 2002).

While the fish salvage of Duncan Lake is a mitigative measure and does not form part of the compensation plan *per se*, translocation of Dolly Varden salvaged from Duncan Lake to nearby watersheds features prominently in the compensation plans. The conservation of this genetic strain is highlighted as a goal of the translocation program. Consideration is also given to the potential impact Dolly Varden transplants may have on systems that already have fish present. In particular, rainbow trout are already present in the Jock Creek drainage, and the potential addition of Dolly Varden from Duncan Lake to this drainage is briefly discussed.

3.1 Characteristics of Introduction Sites

Desirable characteristics for selecting suitable introduction sites were presented in Williams et al (1988). Their suggested guidelines are listed here and each addressed separately in the following sections:

a) Restrict introductions to within the native or historic habitat whenever possible.
b) Restrict introductions to a protected site.
c) Restrict introductions to sites where the potential for dispersal has been determined and is acceptable.
d) Restrict introductions to sites that fulfill life history requirements of the species.
e) Restrict introductions to sites that contain sufficient habitat to support a viable population.
f) Prohibit introductions into areas where the endangered and threatened fish could hybridize with other species or subspecies.
g) Prohibit introductions into areas where other rare or endemic taxa could be adversely affected.

A Introduce Within the Species' Native Habitat

Proposed translocation sites for Dolly Varden from Duncan Lake include Jock Creek and Mulvaney Lake, both of which flow into the Toodoggone River, which subsequently flows into the upper Finlay River, and Whudzi Lake, which drains into the Finlay River just upstream from the confluence of the Toodoggone River. All of these potential locations are within the range of Dolly Varden in the Finlay River watershed, and therefore satisfy condition (a).

B Introduce Into a Protected Site

Williams et al (1988) suggest that introduction sites should be secure from future habitat destruction for transplants. Although their paper was primarily aimed at transplants of endangered species, rather than salvage of relatively secure species such as Dolly Varden, the criteria is nevertheless met as the upper Finlay River is remote. No road access exists in the Whudzi and Mulvaney Creek Drainages, and although much of the upper portions of Jock Creek is road accessible, proposed development at this time is limited to small mining operations.

C Introduce to Sites Where Dispersal Potential is Limited

Although barriers exist on all potential recipient systems, downstream dispersal will still be possible. Although the rate of fish dispersal downstream past large barriers is poorly known, it is unlikely to be high. Dolly Varden in the donor system (Duncan Lake) were not isolated and could disperse into the upper Finlay River via Attycelley Creek. Fish dispersing downstream from potential recipient systems will also end up in the upper Finlay River.

D Introduce To Sites That Fulfill Life-History Requirements

Habitat assessments of all potential donor systems have been conducted and preliminary results are presented in the individual compensation plans. Rearing, spawning, and overwintering habitats have been documented in each system, and in most cases, limiting habitat factors have been estimated. Habitat enhancements have been proposed for systems where spawning and/or rearing conditions could limit the productivity of recipient systems.

E Introduce to Sites That Can Support a Viable Population

Recipient systems must contain enough habitat to support a large enough population of fish to avoid the effects of inbreeding and genetic drift (Williams et al 1988). Traditionally, resource managers have used the 50 / 500 rule when determining appropriate population sizes during introductions (Rieman and Allendorf 2001). The rule very generally estimates that at least 50 individuals are required to reduce the vulnerability of the population to the immediate effects of inbreeding, and 500 individuals are required in order to ensure that a population will retain enough genetic variation to survive longer time periods (that is, enough genetic variation to remain adaptable to changing environmental conditions). Rieman and Allendorf (2001) point out that a determination of effective population size (the number of individuals which contribute to the recruitment of the next generation) is complicated by the fact that not all individuals in a population are mature fish capable of reproduction, and that age of maturation occurs at different ages across, and often within species. They found that even bull trout populations of 500 or more may lose up to 10% of original heterozygosity in 200 years, and this rate climbs dramatically as population size is reduced. They suggest 100 individuals would be required to minimize inbreeding and 1000 adults spawning annually would be required to maintain variation indefinitely.

Achieving a suitably sized effective population of Dolly Varden should be achievable given that Dolly Varden require less spawning habitat and overall stream productivity to maintain a given number of individuals, owing to their much smaller size at maturity and tendency to group spawn at appropriate sites (D. Bustard and associated Ltd. 2004b). The entire population of Dolly Varden in Duncan Lake was estimated at only 779 ±453 individuals (Hatfield Consultants Ltd. 2004), thus it should be possible to move the entire population to a larger recipient system (i.e., Jock Creek). Investigations into the carrying capacity of recipient systems would be undertaken prior to the translocation of Dolly Varden, and the largest number of individuals possible would be moved into the system (while safeguarding against over-stocking), to ensure a large enough effective population is established to prevent degradation of the Duncan Lake genetic strain.

F Do Not Introduce Fish into Areas where Hybridization Could Occur

Barriers to upstream fish migration occur on all potential recipient systems, and all are barren of fish above the barriers, with the exception of Jock Creek, which has an introduced population of rainbow trout. This will ensure that Dolly Varden from the upper Finlay River watershed will not be able to breed with the translocated Duncan Lake population, and the genetic integrity of this population will be maintained. Although a potential watershed crossover feature is proposed within the Jock Creek system which would allow Dolly Varden from the Finlay River to colonize the Jock Creek watershed, this feature could be removed from the compensation plan if (a) Dolly Varden from Duncan Lake are found to be genetically distinct from the Finlay River population at large, and (b) Jock Creek is chosen as the primary recipient for the Duncan Lake Dolly Varden fish salvage.

Hybridization between translocated Duncan Lake individuals and the Finlay River population could occur downstream from the barriers, although there are currently no natural mechanisms preventing this from happening as Duncan Lake fish can move downstream into Thutade Lake during high flow events.

Hybridization of Dolly Varden and bull trout has been recorded in the upper Finlay River watershed (Baxter et al 1997), though it does not appear to be widespread and natural, prezygotic barriers to Dolly Varden / bull trout mating appear to be maintaing the genetic identity of each species (Hagen and Taylor 2001)

G Do Not Introduce Fish into Areas with rare or Endangered Taxa

The Williston Lake population of Arctic grayling (*Thymallus arcticus*) is the only red-listed fish species present in the upper Finlay River watershed. No arctic grayling are present within the proposed recipient systems. (B.C. Conservation data Centre 2006). Bull trout are provincially blue listed, and are present immediately downstream of the barriers on each potential recipient system. No adverse impacts are expected on bull trout populations, although hybridization with Dolly Varden which disperse downstream over the barrier could occur (see above).

Rocky Mountain capshell (*Acroloxus coloradensis*) is a blue-listed mollusc that occurs rarely in alpine and sub-alpine lakes in the Rocky Mountains and has been recorded from the Mackenzie Forest District (B.C. Conservation Data Centre 2006). Dolly Varden introductions are not expected to have a negative impact on Rocky Mountain capshell populations, although their presence should be determined.

Several blue-listed aquatic plants have been recorded from the Mackenzie Forest District (B.C. Conservation Data Centre 2006), but Dolly Varden introductions and potential habitat enhancements are not expected to have any negligible impact on native flora.

3.2 Interactions with Rainbow Trout

While translocation of Dolly Varden from Duncan Lake to systems without fish was a preferred option, the Jock Creek system appears to provide the most suitable habitat and appropriate conditions of the systems examined. Black Lake, at the head of Jock Creek, was stocked with 5000 rainbow trout fry (Dragon strain) in 1991 (FISS 2006). Rainbow trout have since migrated downstream and are found throughout the Jock Creek watershed. Rainbow trout densities appear highest in and around Black Lake and at two smaller, unnamed lakes (waterbody identifiers 01507TOOD and 01516TOOD) in the middle portion of the watershed. Rainbow trout densities were low in most tributaries (Triton 2006). It is unclear whether the low densities are a result of unfavourable conditions for rainbow trout in these tributaries, or insufficient time has elapsed since the initial introduction for all habitats to be colonized. Other factors may also be involved, and the dynamics of rainbow trout distribution in Jock Creek may be quite complex.

Rainbow trout usually displace Dolly Varden from lower gradient, larger, warmer, reaches. Haas (1996) suggested a temperature-mediated interaction with Dolly Varden. The upper incipient lethal temperature for Dolly Varden is reported to be 24.5˚C and rainbow trout between 25.6˚C and 26.2˚C (Selong et al 2001). Maximum growth temperature for rainbow trout is reported as 17.2˚C, but is not reported for Dolly Varden (Selong et al 2001). Maximum growth temperature for bull trout was found to be 13.2˚C, and 13.8˚C for arctic char (*Salvelinus alpinus*) (Selong et al 2001), and similar, perhaps slightly higher maximum growth temperature can be expected for Dolly Varden.

Water temperatures in the Jock Creek system ranged from approximately 5.0˚C to 10.5˚C (Triton 2006). Tributaries to the Jock Creek mainstem had lower temperatures overall. Temperature data was collected throughout the watershed on different days, at different times of day, precluding any in-depth analysis (Triton 2006). However, tributary streams had temperatures ranging from 5.0˚C to 9.5˚C. An unnamed tributary to Galen Creek (alias name; watershed code: 239-667500-19200-90700) had a temperature of 9.5˚C, if this stream is excluded, the next highest tributary temperature was 5.8˚C. The average temperature in the tributaries was 5.6˚C (5.2˚C if the unnamed tributary to Galen Creek is excluded). Aspect appeared to have little effect on stream temperatures, though some difference would likely be noted if more detailed temperature data were available. Triton (2006) recorded temperatures ranging from 5.2˚C to 10.5˚C in the Jock Creek mainstem, and the average recorded temperature was 7.8˚C.

Fish densities in Jock Creek were generally higher in the Jock Creek mainstem, particularly closer to lacustrine habitats near Black Lake and the two smaller, unnamed lakes in the middle part of the drainage. Densities in the tributary streams were generally low, except in an unnamed tributary to Black Lake (WSC: 239-667500-19200-95200), where young-of-the-year rainbow trout fry were captured, and in Galen Creek immediately below a barrier to upstream fish migration. The average fish density of Jock Creek tributaries was 0.08 fish/m^2, but if these two sites are excluded, the average density drops to 0.02 fish/m^2. No fish were captured in some tributary streams, despite an absence of barriers or significant obstructions. The average fish density in the Jock Creek mainstem was 0.06 fish/m^2. Although other factors are likely involved, rainbow trout may be avoiding tributary habitats due to the colder temperatures. This may provide abundant suitable habitat for Dolly Varden, which are usually displaced by or occur in smaller numbers when in sympatry with rainbow trout.

Competition for spawning habitat does not occur between Dolly Varden and rainbow trout. Rainbow trout spawn in the spring from mid-April to June at temperatures between 10˚C and 15.5˚C (Scott and Crossman 1973), with fry emerging in the early summer. Spawning likely occurs at temperatures below what is reported here, as temperatures above 10˚C were only recorded once in the Jock Creek watershed in late July / August (Triton 2006). Dolly Varden are fall spawners, with spawning occurring in late September / early October in the nearby Attycelley Creek drainage (D. Bustard and Associates Ltd. 2004b). Spawning is reported to occur at water temperatures of around 7.8˚C (Scott and Crossman 1973). Dolly Varden eggs take considerably longer to hatch than rainbow trout, and usually emerge from the gravel in late April to mid May (Scott and Crossman 1973).

When they occur in sympatry, Dolly Varden are usually more associated with the stream bottom than trout (Hindar et al 1988; Scott and Crossman 1973), and consume more benthic organisms than trout, which tend to feed more at the surface and from the drift (Hagen and Taylor 2001; Scott and Crossman 1973; Meehan and Bjornn 1991). Typical Dolly Varden prey items include chironomids, nymphal mayflies, small crustaceans, and other insects (Meehan and Bjornn 1991). Rainbow trout in Duncan Lake consumed mostly insects from the surface of the lake, with only 6% of the diet being comprised of benthic organisms (insect larvae and crustaceans) (Hatfield Consultants Ltd. 2004). Rainbow trout in Duncan Lake used shallow areas (<10 m) almost exclusively (Hatfield Consultants Ltd. 2004). The diet of Duncan Lake Dolly Varden consisted almost entirely of benthic bivalves and amphipods, and the fish were more often found in deeper waters of the lake than rainbow trout, moving to shallower near-shore areas at night to feed (but remaining close to the bottom) (Hatfield Consultants Ltd. 2004).

The differences in life-history strategies between rainbow trout and Dolly Varden in the upper Finlay River suggest that viable populations of both species could be maintained in the Jock Creek watershed. Dolly Varden are likely to utilize the cooler, steeper tributaries to a greater extent than rainbow trout, which currently occupy the lacustrine habitats and larger mainstem habitats throughout the Jock Creek system. Although shallower than Duncan Lake, rainbow trout in Black Lake likely utilize similar littoral and near-surface resources. Depending on summer water temperatures and dissolved oxygen levels, Dolly Varden may be able to occupy deep water habitats and utilize benthic food resources. The utilization of these separate niches may help prevent competition for food resources, and actually increase the overall productivity of the lake by cycling nutrients from the bottom to the water column above, increasing the total biomass of the lake (Havens 1993).

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