Provincial Fisheries Management: Drought Response Plan

April 2024

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Prepared by

Ministry of Water, Lands and Resource Stewardship
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Victoria BC

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Executive Summary

The Province of British Columbia has developed a general criterion for the implementation of fish protection measures on streams and rivers in BC. The role of the provincial fisheries management group is to coordinate drought response throughout the province and support the region-specific actions on drought impacted watersheds. The guideline offers consistency in its approach by recognizing many of the most sensitive species in the stream ecosystems in BC. The provincial fisheries management response plan recognizes that drought has variable effects on streams within the province of BC; the plan encompasses all regions but recognizes that the framework is intended to for specific systems identified as priorities within regions.

Drought conditions can have adverse effects upon fish and fish habitat in streams and rivers in BC. Periodicity, duration, and frequency of drought conditions can invoke substantial impacts to fish populations thus reducing their future productivity and capacity. Increased temperature and reduced flows can be potential factors that reduce fish populations resulting from drought conditions. The ability to mitigate or offset effects of drought is crucial for the conservation and sustainability to fish populations and is considered a management priority in BC.

Based on the drought level assessment developed in BC Drought Response and Water Scarcity Plan, it is recommended that fish protection measures be invoked prior to reaching critical levels. Based on extensive review, depending on monitoring, it is recommended that trout specific streams and watersheds be closed to recreational angling where mean weekly maximum temperature (MWMT) exceed 20^{o}C and/or maximum daily temperatures exceed 23^{o}C. Similarly, it is recommended that char specific streams and watersheds be closed to recreational angling where MWMT exceed 16^{o}C and/or maximum daily temperatures exceed 20^{o}C. In addition, flows equating to percent long-term (% LT) mean annual discharge (MAD) are a convenient check on the ecological meaning of a particular stream discharge. Flows that drop to or below 10% LT MAD are of acute fisheries concern as key rearing habitats begin to severely dewater. Stream flows below 5% LT MAD represent “critical environmental flows” and can have severe impacts on fish populations. Combined with temperature thresholds, it is recommended that streams and watersheds be closed to recreational angling where the flows are reduced below 5% LT MAD.

Early and frequent communication about water supply conditions and responses to stakeholders is key to successful drought management, a priority action developed in BC Drought and Water Scarcity Response Plan. Such information requires agencies and local authorities to use a combination of communication tools, water supply and demand data,

regulatory instruments, and other tools to advocate for water conservation across communities. Likewise, early communication will be necessary and critical in the ability for fisheries management to implement fish protection measures on streams and rivers in BC. Provincial, regional and local drought response plans provide the necessary communication tools for updating and assessing the status of drought in BC. Such tools will be utilized by fisheries management agencies to communicate the implementation of fish protection measures on streams and rivers in BC.

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Acronyms and Abbreviations used

WLRS: BC Ministry of Water, Lands and Resource Stewardship
IADWG: Interagency Drought Working Group
% LT MAD: Percent long-term mean annual discharge MAD): The long term mean annual discharge is equivalent to the mean annual flow rate that would occur naturally in the absence of storage reservoirs and water extractions.
MWMT: Mean weekly maximum temperature: Defined as the average of the warmest daily maximum temperatures for seven consecutive days.

Overview

Drought conditions have occurred with an increasing frequency in the last decade within BC. Many of BC streams and rivers are experiencing increased effects of drought conditions, primarily increasing water temperatures and reduced seasonal flows. Factors associated with changes in climate, increased water demand, reduced accumulated snowpack plus earlier melt and seasonal precipitation have left many streams and rivers within BC in an undesirable state.

Drought conditions can have adverse effects upon fish and fish habitat in streams and rivers in BC. Periodicity, duration, and frequency of drought conditions can invoke substantial impacts to fish populations thus reducing their future productivity and capacity. Increased temperature and reduced flows resulting from drought conditions can be potential factors that reduce fish populations. The ability to mitigate or offset effects of drought is crucial for the conservation and sustainability of fish populations and is considered a management priority in BC.

Provincial and regional fisheries management teams recognize the need for a coordinated response to drought conditions and their effects upon fish populations in BC. There is a substantial diversity of fisheries on streams and rivers within BC which are managed by regional operations within Ministry of Water, Lands and Resource Stewardship (WLRS). The provincial management plan provides a framework for the development of regional based operational plans that invoke fish protection measures during drought conditions in BC. This fisheries management plan supplements guidance provided by the Drought Response and Water Scarcity Response Plan (WLRS 2023)[1] developed by the Inter-Agency Drought Working Group (IADWG).

Rationale of Plan

To develop criteria that provides provincial direction for fisheries management and guides the implementation of regional management actions during drought conditions in BC.

Objectives of Plan

1. Develop universal framework drought response for fisheries management in BC,
2. Identify drought criteria by managed fish species in BC,
3. Assist regional operations with implementation of fish protection measures,

[1] Drought Response and Water Scarcity Response Plan (WLRS, 2023) This plan is reviewed annually by the IADWG and updated as required to reflect emerging research, broader standards and agency mandates, The 2023 version is available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/drought-info/drought_response_plan_final.pdf.

4. Communicate and outline public fishing regulation response to drought at various levels, including an updated table of likely impacted waterbodies, and
5. Coordinate with Inter-Agency Drought Working Group to outline potential impacts and mitigation measures related to decreased flow availability due to water conservation identified by drought levels.

Background

What is Drought?

Drought is a recurrent feature of climate involving a deficiency of precipitation over an extended period, resulting in a water shortage for activities, communities or aquatic ecosystems. In British Columbia, drought may be caused by combinations of insufficient snow accumulation and/or advanced melt, hot and dry weather, or a delay in rainfall. Droughts can be defined as meteorological, hydrological, agricultural, or socioeconomic, each of which implies different impacts. Further details on drought conditions and the provincial response can be found in the Drought Response and Water Scarcity Response Plan (WLRS 2023).

Drought Response Levels

The Drought Response and Water Scarcity Response Plan (WLRS 2023) is organized around five successive levels of drought targeted at the water basin and watershed/stream levels. The different levels and their corresponding objectives and suggested water use targets are summarized in Table 1. In early season (January to May) the levels represent a forecast of potential and actual drought conditions. Only in late June can the likelihood, magnitude, and extent of drought be assessed based on, among other indicators, stream-flows, percentage of mean annual discharge, and precipitation.

At Level 0 (Green), conditions are average or wetter than average, and there is sufficient water to support ecosystem needs and human water uses. 30-day precipitation and 7-day average streamflows are both above the 30th percentile when compared with historic precipitation and streamflow records. Emphasis is on preparedness and acting in advance of droughts in order to increase readiness of water users and communities when they inevitably occur. This level is only addressed at a summary level in this plan in Section 3, above.

At Level 1 (Yellow), conditions are dry, and first indications of potential water supply shortages are recognized. 30-day precipitation and 7-day average streamflows are both between the 21st and 30th percentile. Emphasis is on stewardship and voluntary conservation through education, communication and planning.

Level 2 (Peach), conditions are becoming very dry, although potential adverse ecosystem or socio-economic are unlikely. 30-day precipitation and 7-day average streamflows are between the 11th and 20th percentile. Emphasis continues to be on voluntary conservation but increasing use of watering restrictions may be imposed by water-service providers.

At Level 3 (Orange), conditions are becoming severely dry. Potentially serious ecosystem or socio-economic impacts are possible or imminent and impacts may already be occurring. 30-day precipitation and 7-day average streamflows are between the 6th and 10th percentile. All unauthorized use should be curtailed, water suppliers may impose watering restrictions and provincial data collection to support regulatory action may be initiated.

At Level 4 (Red), conditions are extremely dry and there is likelihood that there is insufficient supply to meet community or ecosystem needs. 30-day precipitation and 7-day average streamflows are between the 2nd and 5th percentile. Progressively more severe and widespread socio-economic and ecosystem impacts are expected. Voluntary measures and increasing use of restrictions will continue but may be augmented by regulatory responses by the provincial government including use of authorities provided under the *Water Sustainability Act,* the *Fisheries Act* and other legislation (Appendix 1).

At level 5 (Maroon) conditions are exceptionally dry and adverse environmental and socio-economic impacts are almost certain. 30-day precipitation and 7-day average streamflows are below the 2nd percentile relative to historic records. All efforts should be made to conserve water and protect critical environmental flows.

Table 1: Drought Response Levels Summary (WLRS 2023)

Level	Impacts	General Response Measures
0	There is sufficient water to meet socio-economic and ecosystem needs	Preparedness
1	Adverse impacts to socio-economic or ecosystem values are **rare**	Conservation
2	Adverse impacts to socio-economic or ecosystem values are **unlikely**	Conservation Local water restrictions where appropriate
3	Adverse impacts to socio-economic or ecosystem values are **possible**	Conservation Local water restrictions likely
4	Adverse impacts to socio-economic or ecosystem values are **likely**	Conservation and local water restrictions Regulatory action possible
5	Adverse impacts to socio-economic or ecosystem values are **almost certain**	Conservation and local water restrictions Regulatory action likely Possible emergency response

Drought Response Specific to Fish

While the Drought Response and Water Scarcity Response Plan (WLRS 2023) focuses on addressing water needs for people and aquatic ecosystems during times of water scarcity, the Provincial Fisheries Management Drought Response Plan (PFMDRP) focuses directly on specific fish protection measures during drought conditions. Increased water temperature, reduced oxygen concentration, degraded water quality, and reduced fish food supply/delivery through reduced flows are key factors that impact fish populations during drought conditions.

Focal species within this plan include trout (*Oncorhynchus mykiss.*), Bull Trout and Dolly Varden char (*Salvelinus spp.*), and White Sturgeon (*Acipenser transmontanus*) which are often associated with recreational fisheries and primarily affected by drought. For example, Bull Trout, a species of concern in BC, are highly adapted to cold water environments and are very sensitive to temperature increases beyond the optimal of 13^{o}C (Selong et al. 2001). In comparison, Rainbow Trout (*Oncorhynchus mykiss*) and Cutthroat Trout (*Oncorhynchus clarki spp.*) are more resilient to higher temperatures that cover a range between 8 to 20^{o}C and optimal temperatures near 13^{o}C (Bear et al. 2007). In general, Rainbow Trout are the dominant salmonid in British Columbia streams where maximum temperatures are greater than 14^{o}C, whereas Bull Trout are dominant where maximum temperatures are less than 13^{o}C (Benjamin et al. 2016).

Preliminary results from research on White Sturgeon in the lower Fraser River suggest that that angling stress from catch and release fisheries appear to cause an acute stress response (McLean et al. 2014). Similar to salmonids, increased water temperatures in conjunction with handling stress from the recreational fishery may invoke unintended post release mortality and/or sub-lethal alterations.

Flow Criteria

Fish flow needs vary across the year by species and life-stage and are dictated by seasonal high- and low-flow timing and duration. Despite the biases associated with methodologies used to assess impacts of lower flows (Rosenfeld et al. 2016), it is well understood that seasonal flow reductions can create severe resource and habitat limitations for juvenile salmonids leading to increased density dependent effects on growth and survival (Grantham et al. 2012). Flow needs during summer droughts will range from rearing flows near 20% long-term (LT) (preferred) mean annual discharge (MAD) to adult salmon/char passage flows (>20% LT MAD) required prior to spawning. Sub-standard flows (<10% LT MAD) can affect fish by reducing the area and quality of riffle habitats that generate fish food and aeration. Flows nearing 5% LT MAD on highly flow-regulated streams due to excessive diversions may trigger emergency measures to highly restrict water use. The

intended benefit of restricting water diversions is the critical survival of fish in habitats that are otherwise warming too much, experiencing decreased water quality due to poor dilution of pollutants, and/or failing to address sufficient food delivery to sustain stock.

Temperature Criteria

Thermal tolerance associated with increasing water temperatures (McCullough 1999; McCullough et al. 2001) and associated impacts of recreational fisheries have been identified as a critical factor impacting salmonid (Bear et al. 2007, Boyd et al. 2010) and White Sturgeon populations (McLean et al. 2014). Temperature sensitivity and tolerance can vary by species and increased stress associated with fish handling in recreational fisheries can substantially increase mortality under drought conditions (Wilkie et al. 1997; Meka and McCormick 2005). However, given the range of temperatures for specific life history stages among fish species encountered in BC, the selection of a single criterion to meet the temperature requirements of all species is considered exceedingly difficult (Appendix 2).

Physiological effects of temperature on fish can vary based species and life history stage (McCullough et al. 2001). During incubation, water temperature affects the rate of embryo and alevin development, the amount of dissolved oxygen in the water, and, to a significant extent, the survival of early fry (McCullough et al. 2001). Similarly, water temperature can also have a substantial influence on growth and survival at the older juvenile and adult life stages. The effects of temperature on fish growth and survival depend on the magnitude and duration of temperature exposure and can be separated into three categories (Sullivan et al. 2000): zone of preference, zone of resistance, and zone of tolerance (Figure 1).

1. Zone of Preference – This is the optimal temperature range for the species. In this temperature range, fish exhibit normal patterns of behaviour.
2. Zone of Tolerance – Temperatures in this range result in chronic, sub-lethal effects, after longer time periods of exposures (ranging from weeks to months). The sub-lethal effects of chronic temperatures can include changes in growth, competitive interactions, behaviour and/or disease prevalence. A common quantitative metric to delineate the lower threshold for this zone is the maximum growth temperature. This is the temperature at which daily growth rates decline after longer time periods of exposure (weeks to months).
3. Zone of Resistance – Temperatures in this range result in death within minutes to 96 hours after exposure. The most common quantitative metric used to define the lower boundary of this zone is the Ultimate Upper Incipient Lethal Temperature (UUILT). The UUILT is the temperature at which 50% of the population experiences mortality after a given time period.

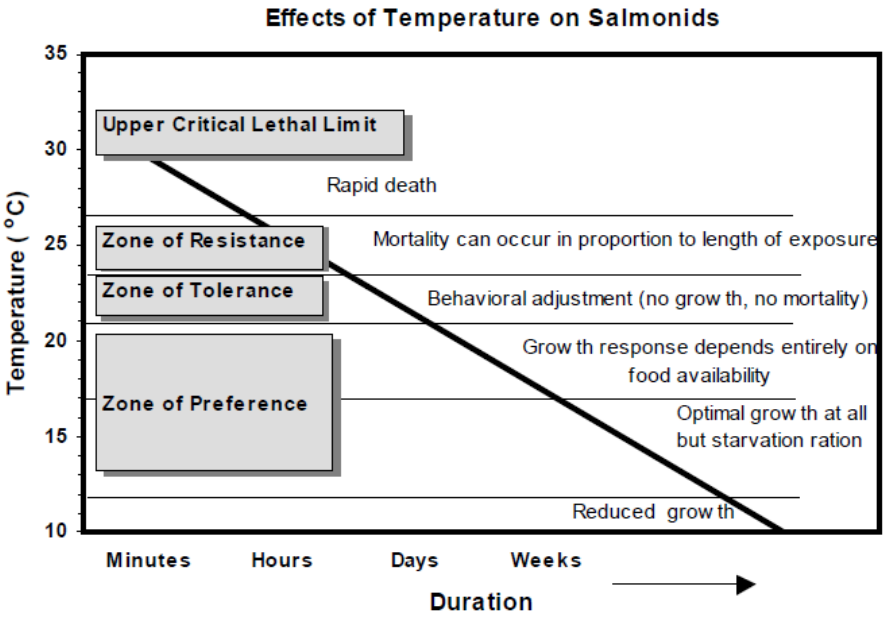

Figure 1. General biological effects of temperature on salmonids in relation to duration and magnitude of temperature from Sullivan et al. (2000)

Appendix 1. Fisheries Management Drought Legislation

Legislation	Agency	General Scope
Water Sustainability Act, 2016	Ministry of Water, Lands and Resource Stewardship, Land, and Natural Resource Operations	Provides for the allocation and management of surface water by authorizing issuance of water licences and approvals, creation of reserves, development of water management plans, and establishment of water user communities. The Minister may issue Fish Population Protection Orders where low water flow in a stream may impact fish survival. The Act also sets out protective measures for wells and groundwater, and identifies offences and penalties. Protects fish and fish habitat by prohibiting bank-to-bank dams on protected rivers and authorizing designation of "sensitive streams" for fish sustainability. It also provides authorities for provincial directives for streamside protection. The Act allows the Minister responsible to temporarily order regulation or reduction of the diversion, rate of diversion or time of diversion of water from a stream in order to ensure the survival of a fish population, provided that consideration has been given to the needs of agricultural users.
Riparian Areas Protection Act	Ministry of Water, Lands and Resource Stewardship	Riparian vegetation provides drought buffers for fish habitat around streams along with food sources, woody debris, and shade.

		The Act enables local governments to protect and enhance riparian habitat through the development permit process on residential, commercial, and industrial development. It uses a set methodology to determine an appropriate riparian setback to development from streams.
Fisheries Act	Department of Fisheries and Oceans Canada	Protection of fish and fish habitat

Appendix 2 outlines optimum temperature guidelines to protect specific life history stages of salmonids include juvenile and adult rearing, 18 to 19°C (maximum weekly average); maximum water temperatures between 22 and 24°C; adult spawning, 8 to 10°C (maximum weekly average); and egg incubation, 13 to 15°C (maximum). Similarly, Appendix 2 outlines optimum temperature guidelines for White Sturgeon for incubation and spawning. However, more updated temperature optima for specific life stage from more recent sturgeon research is provided in Table 2 (DFO 2012a).

Table 2. Updated temperature optima for White Sturgeon from DFO (2012a) and

Life History Stage	Optimal and Range
Incubation	9-19
Rearing	1-22
Migration	5-19
Spawning	9-18

Maximum water temperatures in the range of 22 to 24°C represent the upper thermal limits to salmonid and sturgeon distribution and represents threshold values at which individual species are at high risk of impairment or death. Based on the review of the literature to date, individual species will experience an impairment threshold (i.e. net zero growth or cumulative effects leading to death; (McCullough 1999) at a point between optimum temperature and incipient lethal level. Setting the guideline at the impairment threshold offers consistency in its approach by recognizing the most sensitive species in the stream ecosystem. Moreover, the guideline is highly amenable to regional adjustments in species-specific temperature optima owing to differences in latitude or elevation across the province that may influence a species' local adaptation to ambient temperature regimes.

In summary, recommended guideline changes for the protection of fish species in streams or rivers in BC include:

1. Temperature thresholds be described by the 7-day average maximum temperature or mean weekly maximum temperature (MWMT) where more intensive monitoring occurs (continuous temperature monitoring via loggers),

2. Alternatively, where temperature monitoring is limited or not readily available (daily temperature data), maximum daily temperature can be used as a proxy to the MWMT approach,

3. MWMT should not exceed 20°C, and maximum daily temperature should not exceed 23°C, and

4. Mean weekly maximum water temperatures should not exceed ±1 C° beyond the optimum temperature range for each life history phase of the most sensitive salmonid species present (Appendix 2)

Fisheries Management Responsibilities

A number of provincial and federal agencies are involved in drought management, summarized in Drought Response and Water Scarcity Response Plan (WLRS 2023) and detailed in Figure 2. As part of the drought response an Inter-Agency Drought Working Group (IADWG) coordinates provincial actions to effectively respond to drought and mitigate impacts to a broad range of concerns including agricultural, First Nations, domestic and environmental.

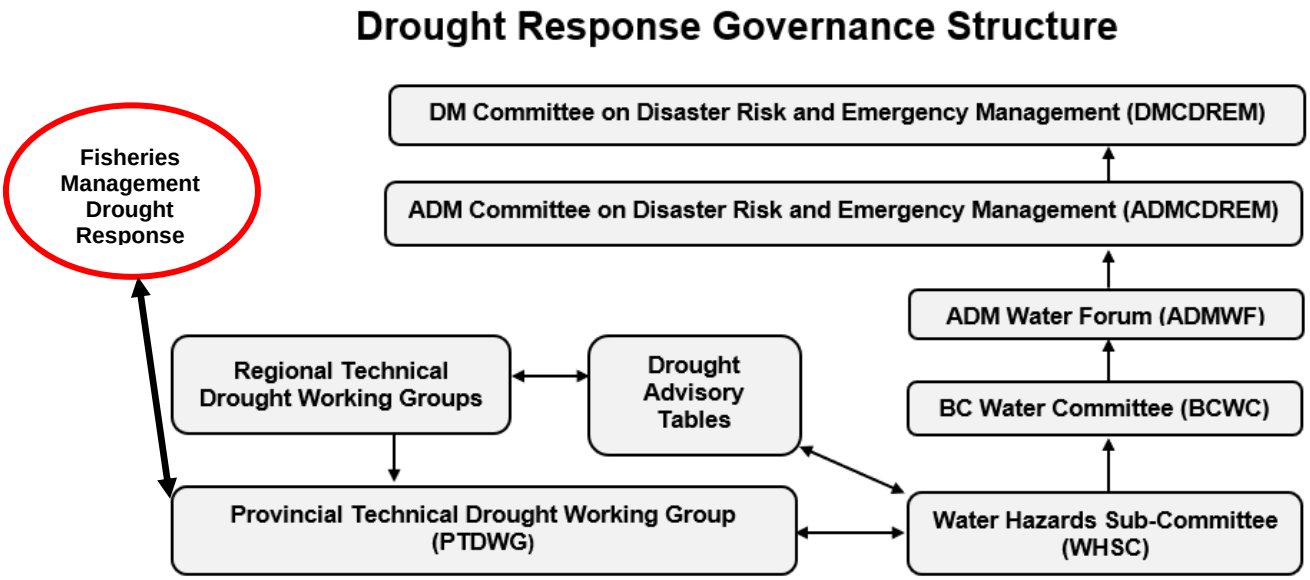

Figure 2. Key coordinating bodies and individuals Involved in BC Drought Response adapted for Fisheries Management Drought Response Plan (in color).

Provincial and Regional

Following the Drought Response and Water Scarcity Response Plan (WLRS 2023), the role of the provincial fisheries management group is to coordinate drought response throughout the province and support the region-specific actions on drought impacted

watersheds. The provincial fisheries management response plan recognizes that drought has variable effects on streams and rivers by region within the province of BC. Therefore, the plan encompasses all regions but recognizes that the framework is intended for specific systems identified as priorities within regions.

It is well understood that the cumulative impacts of above normal water temperatures and reduced stream flow states are anticipated to generate excessive stress in fish populations by reducing habitat and food availability, increasing competition in reduced habitat areas, disrupting patterns of movement into and out of sanctuary habitats and increasing metabolic stress particularly where fish are angled to exhaustion.

Two key objectives for implementing fish protection measures provincially include:

1. Conservation-ensure population persistence and maintenance during drought conditions, and
2. Sustainability-ensure the future sustainability of social and economic benefits associated with recreational fishery opportunity.

Drought Indicators and Actions

The BC drought response assessment levels, detailed in Table 1, will be used to inform and guide the provincial and regional fisheries management response to fish and fish habitat associated with drought conditions. Core indicators for the BC drought response plan are identified in Table 3 (WLRS 2023). For the fisheries management plan, key indicators such as flow and temperature criteria will provide fisheries management the necessary guideline of when to invoke fish protection measures within streams and rivers in BC.

Table 3: Core Indicators from Drought Response and Water Scarcity Response Plan (WLRS, 2023)

Indicator	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
30 Day Precipitation (Percentiles)	>30th	21st - 30th	11th - 20th	6th - 10th	2nd - 5th	< 2nd
7-Day Average Streamflow (Percentiles)	>30th	21st - 30th	11th - 20th	6th - 10th	2nd - 5th	< 2nd

Flow

Drought flows observed on a given day or hour or averaged over 7 days are as a rule below the lower Quartile. As part of Environment and Climate Change Canada Hydrometric Data, Water Survey of Canada (WSC) continuously tracks real-time flow information on selected locations within BC (https://wateroffice.ec.gc.ca/index_e.html). The map depicts

streamflow conditions as computed at WSC stream gages. The colours represent real-time streamflow compared to percentiles of historical daily streamflow for the day of the year. Mapping of flow state uses colour-coded spots by stream ranging from red indicating much below normal (<10 percentile) to dark blue indicating much above normal (>90 percentile). Flows that qualify as drought flows in April-May may still represent relatively high environmental flows in LT MAD. Flows that drop to or below 10% LT MAD are of acute fisheries concern as key rearing habitats (Riffles) begin to severely dewater. Flows equating to % LT MAD are a convenient check on the ecological meaning of a particular stream discharge. Actions to cease all significant water diversions in the summer by regulation can apply to over-subscribed streams. This occurs when flows approach 5% LT MAD in an emergency to avoid reaching zero flow.

Temperature

A review of temperature related closures for salmonid sport fishing revealed an average stream temperature of 18°C as the trigger for the closure for Atlantic salmon (*Salmo salar*) in New Brunswick (DFO 2012b). Montana uses a daily maximum water temperature of 23°C for 3 consecutive days as a closure threshold (Boyd et al. 2010). Within BC, Region 4 uses 18^{o}C as the trigger for a seasonal fishery closure on the Slocan River and Region 5 uses 18^{o}C as the trigger for the Horsefly River time and area closures. In addition, Region 8 provides an excellent example of the rationale for implementing fish protection measures under a variation order (VO) for the Kettle River watershed where summer temperatures are often >23^{o}C and numerous fish kills have been documented over the last decade.

Based on the review of information and literature from within BC and outside, it is recommended that 7-day average maximum temperature or mean weekly maximum temperature (MWMT) be used to assess temperature criteria for drought conditions. For streams or rivers that are inhabited by trout species, the summer water temperature conditions should not exceed a mean weekly maximum temperature (MWMT) of 20^{o}C and maximum daily temperatures of 23^{o}C. For streams or rivers inhabited by char species, the summer water temperature conditions indicate that a mean weekly maximum temperature (MWMT) of 14^{o}C and maximum daily temperatures of 16^{o}C should not be exceeded. However, adult Bull Trout can often be found in systems that exceed the recommended temperature thresholds previously mentioned (Selong et al. 2001; Parkinson et al. 2012). Therefore, increasing the threshold to mean weekly maximum temperature (MWMT) of 16^{o}C and maximum daily temperatures of 20^{o}C is more appropriate for this species. Although, it should be recognized that daily maximum temperatures are likely not the best trigger for implementing fish protection measures since there is substantial fluctuation in daily temperatures during the summer. Temperature thresholds and definitions include:

- Stress Induced Threshold-stress induced temperature thresholds developed for recreational fisheries in BC,
- Optimal-selected growth optima (McCullough et al. 2001),
- Ultimate Upper Incipient Lethal Limit (UUILT) – the temperature at which 50% of the population experiences mortality after a given time period (usually 7 days) (Selong et al. 2001), and
- Critical Thermal Maximum (CTM) – the temperature at which fish lose equilibrium after changing water temperature at a rapid rate from a series of acclimation temperatures (Selong et al. 2001).

Table 4. Relative temperature thresholds for fish handling in recreational fisheries by species affected by drought conditions in BC.

Species	Stress Induced Threshold (°C)	Optimal and Range	Upper Limit (°C)	CTM (°C)
Rainbow Trout	20.0	13.1 (8-20)	25.6	28.0
Cutthroat Trout	18.0	13.6 (8-20)	25.0	28.0
Sturgeon*	20.0	13.1 (8-20)	24.0	28.0
Bull Trout	16.0	<13 (6-13)	20.0	24.0

*Note-due to the overlap, salmonid optimum temperatures were used as surrogates for sturgeon based on expert opinion.

Fish Protection Measures

Various tools can be used to implement fish protection measures on recreational fisheries during drought conditions. Tools include angling regulations, implementation of water use plans for the allocation of water, and complete closures that mitigate the effects of environmental variables (i.e. climate) that are not readily controlled. Legislation and regulatory tools by the provincial government include use of authority provided under the *Water Sustainability Act,* the *Fisheries Act* and other legislation detailed in Appendix 1.

1. Angling Regulations

Changes or variation in angling regulations can provide an immediate effect for the conservation and status of various stocks of fish within recreational fisheries during drought conditions. Implementation of various types of gear restrictions, time area closures, implementation of catch and release are all intended to minimize mortality effects associated with angling.

For example, implementing gear restrictions (i.e. natural bait ban, single barbless) would be considered the first step in addressing chronic drought conditions on specific streams and rivers within BC. It is acknowledged that a single barbless hook restriction on streams has been already adopted throughout the province. Reduction in harvest quotas and or replacement of harvest fisheries with catch-and-release fisheries would also be considered a viable tool in reducing unnecessary mortality on fish during drought conditions. Lastly, seasonal time and area closures provide another useful tool in

minimizing mortality in fish stocks under stressful conditions. There are numerous variations of time (i.e. time of day) and area (proportion of stream closed) closures specific to certain fisheries throughout regions that are already implemented during low flow and high temperature conditions. However, implementation of such closures should be mindful of the how variation orders (VOs) are applied, ensuring consistency and simplifications of such measures consider proper stakeholder engagement (public, First Nations), compliance and enforcement factors. In all, such measures attempt to reduce handling stress associated with angling during stressful conditions associated with reduced flow and high temperatures.

In general, VO procedures rely on regional operations (WLRS) to provide defensible scientific rationale for specific stream closures. Regional management initiates a VO, with Section Head and Regional Manager signature, VO which is then forwarded to the Fish and Wildlife Management Headquarters to be approved by the Provincial Fisheries Manager and/or the Director of Fish and Wildlife (Appendix 3).

2. Water-Use Planning

When it comes to water planning and management on streams with a long history of allocations with little to no regard for fish, a wide variety of human uses, societal values and instream environmental needs must be considered and balanced. Water-use planning (WUP) is one approach to achieving this balance for a specified watershed and/or water facility such as a reservoir. A watershed-based approach is particularly relevant because it includes all water uses, including instream environmental flows. The water-use planning process has provided valuable information about environmental flow requirements in many of BC's water systems. Many drought affected watersheds are developing water use plans that address multi-stakeholder water use within regions. An example of this is the WUP developed for the Kettle River watershed in Region 8.

3. Recreational Angling Closures

Complete angling closure on recreational fisheries for specific watersheds is one of the last steps available to fisheries management teams during drought conditions. Complete closure provides the best strategy for mitigating impacts to fish populations from induced stress associated with recreational fisheries under drought conditions.

Such action could be viewed as a proactive and responsive plan to protect fisheries resources over a broad geographic area during obviously stressful conditions. It will also add support for related water conservation measures imposed on all water users detailed in Drought Response and Water Scarcity Response Plan (WLRS 2023). In contrast, such actions will affect a large number of watersheds and recreational opportunity which may be perceived as unnecessary despite the supporting science-based decision. While loss

of opportunity is a factor it is likely that angling effort may redistribute to other fisheries unaffected by drought conditions.

Stream Watch List

Based on the drought conditions experienced in 2015 and mapped flow-sensitive landscape units from provincial hydrometric analyses (Figure 3), a provincial priority list of flow sensitive streams by Eco-region has been developed to guide monitoring activities during the drought season (July through September) (Appendix 4). This group of prioritized streams is the "Stream Watch List." As geography, human population distribution, and water management activities are specific to individual basins and ecoregions, the response to drought conditions will vary between streams and ecoregions. Summer drought conditions are more severe in the yellow-coded eco-sections of Figure 3; this is because the natural 1-in-2-year-frequency base flows are less than or equal to 20% LT MAD. Water management response options appropriate to each drought level will be identified for each stream on the list which will be developed by each region.

The two main categories of streams on the Watch List include streams with Water Survey Canada (WSC) automated real-time data and streams where manual streamflow measurements will be required (Appendix 4). A set of hydrological descriptors for each stream on the list will be developed to help place the reported discharge measurement from any given date into context. Streams requiring manual flow monitoring include those that have been monitored on previous drought circuits (e.g., Doyle 2004 and Nyhof 1988), those identified as having water demand levels that can pose a high risk to environmental values, reference streams, and those that have been identified by water officers as flow sensitive streams with high demand. For each stream requiring manual flow monitoring, the Regional Specialists will pre-determine the specific locations for measuring stream flow, water level, water temperature, and fish habitat condition (e.g., riffle depth).

Regional Drought Response Plans

Currently, three regions have developed action plans for responding to drought conditions which identify priority streams and rivers for their area region, including; Region 3- Thompson Okanagan Region (MFLNRO 2016), Region 5- Cariboo Drought Implementation Plan (MFLNRO 2015) and Region 8- Thompson Okanagan Region (MFLNRORD 2016). Other regions are currently developing regional based plans in response to drought and will rely on the general guidelines within the provincial response plan to manage their fisheries.

Figure 3. Example of Eco-regions derived flow-sensitive streams or rivers in BC. The levels shown are for illustrative purposes only.

Summary

Droughts can be defined as meteorological, hydrological, agricultural, or socioeconomic, each of which implies different impacts (WLRS 2023). The cumulative effects of low flow and increased water temperature during drought and associated impacts with recreational fisheries have been well documented for various salmonid species. Reduced flow and high temperatures can invoke stress and mortality which can be intensified by catch and handling of fish during drought conditions.

Native fish stocks within BC, particularly trout and char species, are closely tied to their natal streams and have evolved with natural fluctuations in stream temperatures and other environmental variables and is best characterised by:

> *"British Columbia is a landscape of diverse geography, geology, vegetation, and climate that together define the physical and chemical characteristics of the streams and rivers draining the land. These stream characteristics in turn can*

> *define the fish species assemblages that have colonized and adapted to them. Salmonids exhibit various natural adaptations to the range of local stream conditions that reflect this diverse landscape."-(MacIsaac 2009)*

Many species of char are often considered as a stenothermal species because they require a narrow range of cold temperatures to rear and reproduce and may thrive in waters too cold for other salmonid species. These cold-water adapted species often have temperature thresholds well below the optimal range for the other salmonids native to the Pacific Northwest. Some of the observed effects of increased temperature on salmonids include decreased oxygen supply, disrupted metabolism, increased vulnerability to disease, and reduced ability to avoid predators.

Early and frequent communication about water supply conditions and responses to stakeholders is key to successful drought management, a priority action developed in Drought Response and Water Scarcity Response Plan (WLRS 2023). Such information requires agencies and local authorities to use a combination of communication tools, water supply and demand data, regulatory instruments, and other tools to advocate for water conservation across communities. Likewise, early communication will be necessary and critical in the ability for fisheries management to implement fish protection measures on streams and rivers in BC. Provincial, regional, and local drought response plans provide the necessary communication tools for updating and assessing the status of drought in BC. Such tools will be utilized by fisheries management agencies to communicate the implementation of fish protection measures on streams and rivers in BC.

The Province of British Columbia has developed a general criterion for the implementation of fish protection measures on streams and rivers in BC. The role of the provincial fisheries management group is to coordinate drought response throughout the province and support the region-specific actions on drought impacted watersheds. The guideline offers consistency in its approach by recognizing many of the most sensitive species in the stream ecosystems in BC. The provincial fisheries management response plan recognizes that drought has variable effects on streams within the province of BC and the plan encompasses all regions but recognizes that the framework is intended to for specific systems identified as priorities within regions.

Based on the drought level assessment developed in Drought Response and Water Scarcity Response Plan (WLRS 2023), it is recommended that fish protection measures be invoked prior to reaching drought level 4 restrictions. At level 3 drought conditions, provincial and regional fisheries management groups need to be prepared for the implementation of fish protection measures. Flow and temperature monitoring data should be used for making informed decisions on watershed and stream specific cases and regional priority. Based on an extensive review, depending on monitoring it is

recommended that trout specific streams and watersheds be closed to recreational angling where MWMT exceed 20 ^{o}C and/or maximum daily temperatures exceed 23 ^{o}C (Table 5). Similarly, it is recommended that char specific streams and watersheds be closed to recreational angling where MWMT exceed 16 ^{o}C and/or maximum daily temperatures exceed 20 ^{o}C (Table 5). In addition, flows equating to %LT MAD are a convenient check on the ecological meaning of a particular stream discharge. Flows that drop to or below 10%LT MAD are of acute fisheries concern as key rearing habitats begin to severely dewater. Stream flows below 5% LT MAD represent "critical environmental flows" and can have severe impacts on fish populations. Combined with temperature thresholds, it is recommended that streams and watersheds be closed to recreational angling where the flows are reduced below 5% LT MAD (Table 5).

Table 5. Stress induced temperature (MWMT) and flow criteria (%MAD) for implementing fish protection measures (angling closures).

Species	MWMT Threshold (^{o}C)	Maximum Daily Threshold (^{o}C)	Flow (%LT MAD)
Trout	>20.0	>23.0	<5%
Sturgeon	>20.0	>24.0	NA
Char	>16	>20	<5%

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Appendix 1. Fisheries Management Drought Legislation

Legislation	Agency	General Scope
Water Sustainability Act, 2016	Ministry of Water, Lands and Resource Stewardship, Land, and Natural Resource Operations	Provides for the allocation and management of surface water by authorizing issuance of water licences and approvals, creation of reserves, development of water management plans, and establishment of water user communities. The Minister may issue Fish Population Protection Orders where low water flow in a stream may impact fish survival. The Act also sets out protective measures for wells and groundwater, and identifies offences and penalties. Protects fish and fish habitat by prohibiting bank-to-bank dams on protected rivers and authorizing designation of "sensitive streams" for fish sustainability. It also provides authorities for provincial directives for streamside protection. The Act allows the Minister responsible to temporarily order regulation or reduction of the diversion, rate of diversion or time of diversion of water from a stream in order to ensure the survival of a fish population, provided that consideration has been given to the needs of agricultural users.
Riparian Areas Protection Act	Ministry of Water, Lands and Resource Stewardship	Riparian vegetation provides drought buffers for fish habitat around streams along with food sources, woody debris, and shade. The Act enables local governments to protect and enhance riparian habitat through the development permit process on residential, commercial, and industrial development. It uses a set methodology to determine an appropriate riparian setback to development from streams.
Fisheries Act	Department of Fisheries and Oceans Canada	Protection of fish and fish habitat

Appendix 2. Optimal Temperature Ranges Salmonids and Other Species

Species	Incubation	Rearing	Migration	Spawning
Salmon				
Chinook	5.0-14.0	10.0-15.5	3.3-19.0	5.6-13.9
Chum	4.0-13.0	12.0-14.0	8.3-15.6	7.2-12.8
Coho	4.0-13.0	9.0-16.0	7.2-15.6	4.4-12.8
Pink	4.0-13.0	9.3-15.5	7.2-15.6	7.2-12.8
Sockeye	4.0-13.0	10.0-15.0	7.2-15.6	10.6-12.8
Trout				
Brown	1.0-10.0	6.0-17.6		7.2-12.8
Cutthroat	9.0-12.0	7.0-16.0		9.0-12.0
Rainbow	10.0-12.0	16.0-18.0		10.0-15.5
Char				
Arctic char	1.5-5.0	5.0-16.0		4.0
Brook trout	1.5-9.0	12.0-18.0		7.1-12.8
Bull trout	2.0-6.0	6.0-14.0		5.0-9.0
Dolly Varden		8.0-16.0		
Lake trout	5.0	6.0-17.0		10.0
Grayling				
Arctic grayling	7.0-11.0	10.0-12.0		4.0-9.0
Whitefish				
Lake whitefish	4.0-6.0	12.0-16.0		>8.0
Mountain whitefish	<6.0	9.0-12.0		<6.0
Other species				
Burbot	4.0-7.0	15.6-18.3		0.6-1.7
White sturgeon	14.0-17.0			14.0

Appendix 3. Variation Order Template

BRITISH COLUMBIA

VARIATION ORDER REQUEST FORM

HQ Use Only			
Fisheries Mgr Approval	☐	Map	☐
Variation Drafted	☐	Synopsis	☐
Website	☐	AHTE	☐

Contact:	**Phone:**	**Date of Submission:**

Subject:

Water Body:	**Watershed Code:**
Region:	**Management Unit:**

Species:

Proposed effective date if different from the regular posting of the synopsis:

For In-Season Regulation Changes only, please indicate if proposal is:

☐ Permanent ☐ Temporary If temporary, period of regulation:

Note: A **minimum** of 3 days is required to co-ordinate with Government Communications and Public Engagement (GCPE) should a news release be required.

Who is the regional contact for communications issues?

(someone with authority to deal with media requests if requested by Communications and Public Engagement)

Name: Phone:

PART A: PURPOSE

1. Nature of the change:

☐ New regulation ☐ Amending Existing Regulation ☐ Deletion of an existing regulation

(e.g., method/gear/bait, quota, no fishing)

2. What is currently in the synopsis? *(exact wording preferred)*

Copy the exact wording from the synopsis (not the regulation) as it presently exists. Victoria staff will translate what is requested in the synopsis to regulation.

3. Briefly describe the proposed wording in the synopsis:

You may be able to copy #2 and add new wording.

4. Is there, or will there be, an associated map in the synopsis (page and map# if applicable)?

☐ Yes ☐ No ☐ N/A

- This map may be used to form the regulation or for a news release, therefore it should be digital and professional. Ensure that all maps are sent via post and email.

5. Brief Description of variation order (Are tributaries included?)

6. Rationale for variation order:

What is the problem or issue that the regulation change is intended to address or resolve?
Why is government action required at this time?
Write at a professional level. This document may be part of the OIC/MO package and is subject to FOI requests.

7. Is a DFO Mirror Order required?

☐ Yes ☐ No ☐ N/A

PART B: ANALYSIS

1. Describe surveys used for conservation issues and their results as they relate to this submission:

What were the results of scientific surveys? For example, what population monitoring techniques were used? Anecdotal (hunter comments) and/or scientific information can be used. Be brief and write at layman's level. Doesn't require a lot of technical detail. (Reports, technical data can be sent as an attachment.)

2. Alternatives to regulation considered:

If no alternatives were considered, explain why.
What other methods of regulation were considered and rejected and why? (e.g., voluntary codes, self-management, partnerships, etc.)
Could other bodies outside of government ensure standards are met?(e.g., accreditation, certification, auditing, etc.)

3. Pros/Cons analysis undertaken & results:

Explain how the benefits outweigh the costs. An example of a pro would be an increase in recreational opportunity or reduced costs. An example of a con would be impact on species population or increased regulatory complexity.
Can the costs or benefits for proposed regulation be quantified? What factors were evaluated to determine this impact?

4. Identify risks of NOT implementing the new provision:

'Risk' is the potential of loss or damage resulting from a decision. Risks would include conservation issues and relationships with stakeholders. Describe the "worst case scenario". (A risk in the broadest sense is the potential for loss. Risk may be represented by any unintentional event or situation that leads to harm for an organization, group, habitat, species, or individual. The loss might be as simple as the pain of a twisted ankle or as complex as a liability claim ending in a law suit.)

8. Comments by Reviewers: *(if relevant)*

Use separate page, as comments may not be included in the final OIC/MO Package. Copies of email correspondence may be attached.

PART D: STAKEHOLDER CONSULTATION & FIRST NATIONS ENGAGEMENT

ADEQUATE CONSULTATION AND ENGAGEMENT MUST BE RECORDED, OR THE FORM WILL BE RETURNED TO THE ORIGINATOR.

Please attach supporting documentation, such as letters, meeting minutes, etc.
Identify who was consulted and when consultations took place.

Who raised concerns and what was the nature of their concerns?
Has the regulation been changed to respond to the First Nations' or Stakeholders' Concerns?

Organization	Contact Name	Date and type of Consultation & Engagement	Support? (If no, attach an explanation)
CO Service			☐Yes ☐No ☐N/A
Fish & Wildlife Branch **Consultation is required BEFORE submission is sent to Victoria. Consultation for: Greg.Andrusak@gov.bc.ca**			☐Yes ☐No ☐N/A
Other Regions			☐Yes ☐No ☐N/A
DFO Field Staff			☐Yes ☐No ☐N/A
DFO Management			☐Yes ☐No ☐N/A
Local fisheries advisory committee (*if relevant*)			☐Yes ☐No ☐N/A
BC Parks			☐Yes ☐No ☐N/A
First Nations: If incomplete, this form will be returned.*			☐Yes ☐No (No is not an option without full explanation why)

List attachments:
List number of attachments and their nature (e.g., letter from local rod and gun club, minutes from public meeting)

***First Nations**
We require the name of each FN group engaged and individuals within the group. When did the engagement take place and in what forum (letter, fax, meeting, etc.)? What was the response or outcome of engagement (band by band or tribal association)? What might be the anticipated impact of this proposal on the First Nation's ability to practice their Aboriginal Interests?

CHECKLIST – Variation requests should not be submitted without the following:

☐ Map showing subject area

☐ Effective dates and date Variation Order needed

☐ Rationale clearly indicated

☐ Consultation with DFO is salmon involved

☐ Consultation completed and itemized

☐ Consultation feedback summarized

☐ Your response to negative feedback

☐ Regional Management sign-off

PART E: APPROVAL

1. Section Head, Originating Office (GIVE LOCATION)	2. Regional Manager

Reviewed by: _____ Date: _____ Signature: _____ ☐ Supported ☐ Not Supported	Reviewed by: _____ Date: _____ Signature: _____ ☐ Supported ☐ Not Supported

Appendix 4. Waters Potentially Affected Low-Flow or High-Temperature Conditions (By Region)

Region 1

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 1	Aggregate	All 1-1 to 1-6	**EVI**	
Region 1	4	Cowichan	**EVI**	
Region 1	5	Nanaimo	**EVI**	
Region 1	3	San Juan	**EVI**	
Region 1	3	Gordon	**WVI**	
Region 1	2	Sooke	**EVI**	
Region 1	6	Oyster	**EVI**	
Region 1	5	Englishman	**EVI**	
Region 1	6	Little Qualicum	**EVI**	
Region 1	3	Caycuse	**WVI**	
Region 1	5	Chemainus	**EVI**	
Region 1	3	Nitinat	**WVI**	
Region 1	6	Trent	**EVI**	
Region 1	6	Tsable	**EVI**	
Region 1	6	Big Qualicum	**EVI**	Exception*DFO
Region 1	6	Puntledge	**EVI**	Exception*DFO

Region 2

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 2	Aggregate	All Rivers Streams and Sloughs, MU 2-2 to 2-12 inclusive and MU 2-16 to 2-19 inclusive	**LOM+PAC**	
Region 2	8	Alouette	**PAC**	
Region 2	6	Ashlu	**PAC**	
Region 2	4	Bear (Mahood) Cr.	**LOM**	
Region 2	18	Big Silver Cr.	**PAC**	
Region 2	11	Birkenhead	**PAC**	
Region 2	8	Brunette	**LOM**	
Region 2	4	Campbell	**LOM**	
Region 2	8	Capilano	**PAC**	
Region 2	5	Chapman Cr.	**PAC**	
Region 2	7	Cheakamus	**PAC**	
Region 2	19	Chehalis	**PAC**	
Region 2	4	Chillawack (Vedder)	**PAC**	
Region 2	18	Cogburn Cr.	**LOM**	
Region 2	17	Coquihalla	**PAC**	
Region 2	8	Coquitlam	**PAC**	
Region 2	8	Corbold Cr.	**PAC**	
Region 2	6	Elaho	**PAC**	
Region 2	2	Fraser River	Multiple	Sturgeon concerns
Region 2	3	Frost Cr.	**LOM**	
Region 2	18	Harrison	**PAC**	
Region 2	4	Hyland Cr.	**PAC**	
Region 2	8	Indian	**PAC**	
Region 2	8	Kanaka Cr.	**LOM**	
Region 2	9	Lillooet	**PAC**	
Region 2	4	Lonzo (Marshal) Cr.	**LOM**	
Region 2	8	Lynn Cr.	**PAC**	
Region 2	7	Mamquam	**PAC**	Downstream of CN Bridge
Region 2	19	Miami Cr.	**LOM**	
Region 2	19	Morris Cr.	**PAC**	
Region 2	4	Nicomeki	**LOM**	
Region 2	8	Noons Cr.	**LOM**	
Region 2	8	Norrish Cr.	**PAC**	
Region 2	8	North Alouette	**PAC**	
Region 2	8	Upper Pitt	**PAC**	
Region 2	8	Lower Pitt	**PAC**	
Region 2	5	Ruby Cr.	**LOM**	
Region 2	4	Salmon	**LOM**	
Region 2	4	Serpentine	**LOM**	
Region 2	4	Seymour	**PAC**	
Region 2	2	Silverhope Cr.	**PAC**	
Region 2	2	Skagit	**PAC**	
Region 2	6	Squamish Powerhouse Channel	**PAC**	
Region 2	6	Squamish River	**PAC**	
Region 2	8	Stave	**PAC**	
Region 2	9	Stawamus	**PAC**	
Region 2	4	Sumas	**LOM**	
Region 2	2	Sumallo	**PAC**	
Region 2	2	Tamihi Cr.	**PAC**	

Region 3

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 3	13	Nicola River below outlet of Nicola Lake	**TOP**	
Region 3	13	Spius	**NCR**	
Region 3	13	Coldwater	**NCR**	
Region 3	29	Deadman Cr.	**TOP**	
Region 3	30	Bonaparte River Below Bonaparte Lake	**FAP**	
Region 3	38	Barrier	**COH**	
Region 3	40	Raft	**COH**	

Region 4

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 4	Aggregate	MU 4-3 to-4-9 inclusive	**NCM**	
Region 4	6	Goat	**NCM**	
Region 4	8	Salmo	**NCM**	
Region 4	17	Slocan	**NCM**	
Region 4	17	Bonanza Cr.	**NCM**	
Region 4	20 CW	Lower St. Mary	**NCM**	
Region 4	2	Upper Wigwam	**SRM**	
Region 4	21	Ram Cr.	**NCD**	
Region 4	23 CW	Michel Cr.	**NCD**	

Region 5

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 5	Aggregate	Horsefly	**COH**	Rainbow trout

Region 6

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 6	30	Kispiox River	NRA	BT/DV/ST
Region 6	10	Lakelse River	NRA	BT/DV/ST/CT
Region 6	08/09	Morice/Bulkley Rivers	FAP/EHN	BT/DV/ST
Region 6	04/09	Nadina River	FAP/EHN	RB/BT/DV
Region 6	16	Meziadin River	NRA	ST/BT
Region 6	15	Cranberry River	NRA	ST/BT
Region 6	30	Kitwanga River	NRA	ST/BT/DV/CT
Region 6	9	Zymoetz River	NRA	ST/BT/DV
Region 6	8	Suskwa River	NRA	ST/BT

Region 7A and 7B

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 7A	12 CW	Stellako	**FAP**	Rainbow trout
Region 7A	7	Bowron	**COH**	Rainbow trout Bull trout
Region 7A	30	Nation	**FAB**	Rainbow trout, Arctic Grayling
Region 7A	23	Parsnip and tribs	**FAB**	Bull trout, Arctic grayling
Region 7A	5	Goat	**FAB**	Bull trout
Region 7A	3	Walker	**FAB**	Bull trout
Region 7A	3	McKale	**FAB**	Bull trout
Region 7A	17	Torpy	**FAB**	Rainbow trout Bull trout
Region 7A	5	Haggen	**FAB**	Bull trout
Region 7A	11	Chilako	**FAB**	Rainbow trout
Region 7A	3	Chalko	**FAB**	Bull trout
Region 7B		Confirmed Low Risk		

Region 8

Region	Management Unit (MU)	Watershed	Eco-Region	Species
Region 8	Aggregate	All streams, WU 8-2 through 8-7 inclusive and 8-12 through 8-14 inclusive includes all Similkameen and Kettle drainage and all tributaries, all streams of MU 8-15 with the exception of the Grandby river	**TOP+NCR**	Rainbow Trout, Whitefish
Region 8	15	Grandby	**SBF**	
Region 8	14	Kettle	**TOP**	
Region 8	2	Similkameen	**NCR**	
Region 8	24	Duteau	**TOP**	
Region 8	24	Creighten	**TOP**	
Region 8	24	Bessette	**TOP**	
Region 8	23	Mid-Shuswap	**COH**	