Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Nooksack Dace (*Rhinichthys cataractae*) in Canada

Nooksack Dace


Photo by: Mike Pearson

March 2008

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003 and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the Web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/).

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Additional copies:

You can download additional copies from the SARA Public Registry (http://www.sararegistry.gc.ca/)

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DECLARATION

This final recovery strategy for Nooksack dace has been prepared by Fisheries and Oceans Canada and the British Columbia Ministry of Environment. Fisheries and Oceans Canada has reviewed and accepts this document as its recovery strategy for Nooksack dace as required by the *Species at Risk Act*. The British Columbia Ministry of Environment has reviewed and accepts this document as scientific advice.

This document identifies the recovery strategies that are deemed necessary, based on the best available scientific and biological information, to recover Nooksack dace populations in Canada. Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of the Nooksack dace and Canadian society as a whole. Fisheries and Oceans Canada and the BC Ministry of Environment will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk conservation. The Minister will report on progress within five years.

This strategy will be complemented by one or more action plans that will provide details on specific recovery measures to be taken to support conservation of the species. The Minister will take steps to ensure that, to the extent possible, Canadians interested in or affected by these measures will be consulted.

RESPONSIBLE JURISDICTIONS

The responsible jurisdiction for Nooksack dace under the *Species at Risk Act* is Fisheries and Oceans Canada. The Province of British Columbia co-led development of this recovery strategy.

AUTHORS

DFO and the Province of British Columbia cooperated in the development of this recovery strategy. A recovery team was assembled to provide science-based recommendations to government with respect to the recovery of Nooksack dace. Members of the Recovery Team for Nooksack Dace are listed below:

Todd Hatfield, Solander Ecological Research (Coordinator)
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Eric Taylor, University of British Columbia
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ACKNOWLEDGMENTS

Fisheries and Oceans Canada and the Province of BC are grateful to the technical experts involved in drafting this strategy, for their time and effort in attending meetings and reviewing the document. Financial support for the development of the recovery strategy was provided by the Habitat Conservation Trust Fund and the Province of British Columbia.

STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

In accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*, the purpose of a Strategic Environmental Assessment (SEA) is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally-sound decision making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats.

While this recovery strategy will clearly benefit the environment by promoting the recovery of Nooksack dace, some potentially adverse effects on other species were also considered. The strategy calls for the protection, creation, and enhancement of riffle habitat, which could require control of beavers and their dams, and which might eliminate some of the deep pool and marsh habitat of Salish sucker, another species listed as Endangered under SARA. The strategy recommends cooperation with local stewardship groups and agency staff on beaver management, and proposes to address potential conflicts with recovery of Salish sucker by coordinating recovery activities for both species in watersheds where they coexist through the development of a joint Action Plan. The recovery strategy also calls for minimization of impacts of introduced predators, through documenting their occurrence and educating the public on their impacts. Further information on potential interactions with other species is presented in the Recovery section of the document, in particular under the headings *Broad Strategies to Reduce Threats* and *Effects on Other Species*. Taking these approaches into account, it was concluded that the benefits of this recovery strategy far outweigh any adverse effects that may result.

RESIDENCE

SARA defines residence as: "*a dwelling -place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*" [SARA S2 (1)].

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry: http://www.sararegistry.gc.ca/plans/residence_e.cfm

PREFACE

The Nooksack dace is a freshwater fish, under the jurisdiction of the federal government. The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed Extirpated, Endangered or Threatened species. The Nooksack dace was listed as Endangered under SARA in June 2003. Fisheries and Oceans Canada - Pacific Region co-led the development of this recovery strategy with the British Columbia Ministry of Environment. The final strategy meets SARA requirements in terms of content and process (Sections 39-41). It was developed in cooperation or consultation with:

- The University of British Columbia
- The Township Of Langley

EXECUTIVE SUMMARY

Background
The Nooksack dace is a small (<15 cm) stream-dwelling cyprinid (minnow). It is considered a subspecies of the widespread and common longnose dace *Rhinichthys cataractae*. Within Canada it is known from four lowland streams in British Columbia's Fraser Valley. The global distribution includes approximately 20 additional streams in north-west Washington (McPhail 1997). The Nooksack dace is extirpated from some tributaries in Canadian watersheds where it was abundant in the 1960s (McPhail 1997). Its current status in Washington State is unknown.

Nooksack dace are strongly associated with riffle habitats (McPhail 1997) and the proportion of riffle in a reach is the strongest predictor of their presence (Pearson 2004a). Young-of-the-year fish require shallow pool habitats in close proximity to the riffles inhabited by adults (McPhail 1997). Home range size is typically very small (<50 m of channel) although a few individuals venture for at least hundreds of metres (Pearson 2004a). This suggests that clusters of riffles may contain semi-isolated subpopulations and that metapopulation dynamics may be important at the watershed scale (Pearson 2004a).

Threats
Nooksack dace populations appear to be most vulnerable to seasonal lack of water, habitat loss to drainage activities, sediment deposition, and riffle loss to beaver ponds. Introduced predators are widespread in the range but probably have minimal impacts on Nooksack dace because of lack of habitat overlap. Hypoxia and toxicity are significant threats in some sections of at least one watershed, but do not threaten the species throughout its range.

Critical Habitat
Critical Habitat for Nooksack dace consists of reaches in their native creeks and that consist of (or are known to have previously consisted of) more than 10% riffle by length. It includes all aquatic habitats and riparian reserve strips of native vegetation on both banks for the entire length of the reach. Reserve strips are continuous and extend laterally from the top of bank to a width equal to the widest zone of sensitivity (ZOS) calculated for each of five riparian features, functions and conditions. The ZOS values are calculated using methods consistent with those used under the British Columbia Riparian Areas Regulation (Reg. 837) under the Fish Protection Act (S.B.C. 1997, c. 21). The combined length of critical habitat for Nooksack dace is 33.1 km (of 93.9 km of surveyed stream channel).

Recovery
Recovery of Nooksack dace populations is both technically and biologically feasible. It will involve the establishment and/or maintenance of sufficient high quality riffle habitat in each creek to maintain a population. Specific requirements will vary, but will generally include in-stream flow protection, restoration of riffle habitat and, in some

circumstances, restriction of beaver impoundment. Some management will be required in all watersheds.

The goal of recovery is:

To ensure long-term viability of Nooksack dace populations throughout their natural distribution in Canada.

The recovery strategy has three objectives, each of which is discussed in detail in the text.

1. For all currently and historically suitable habitats in native streams to be occupied by 2015.
2. To increase Nooksack dace abundance to target levels in all watersheds by 2015.
3. To ensure that at least one reach in each watershed supports a high density of Nooksack dace.

Eight broad strategies have been identified in support of these objectives:

1. Protect[1], create and enhance riffle habitat in habitat reaches with high potential productivity.
2. Establish or maintain adequate baseflow in all habitats with high potential productivity.
3. Reduce sediment entry to creeks.
4. Ensure the integrity and proper functioning of riparian zones throughout watersheds.
5. Reduce habitat fragmentation.
6. Encourage stewardship amongst private landowners and the general public.
7. Minimize toxic contamination of creeks.
8. Minimize impacts of introduced predators.

[1] *Protection can be achieved through a variety of mechanisms including: voluntary stewardship agreements, conservation covenants, sale by willing vendors on private lands, land use designations , and protected areas.*

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1. BACKGROUND

1.1. Species Information

The status report and assessment summary for Nooksack Dace is available from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Secretariat (www.cosewic.gc.ca).

Common Name:	Nooksack Dace
Scientific Name:	*Rhinichthys cataractae*
Assessment Summary:	May 2000
COSEWIC Status:	Endangered, April 1996
SARA Status:	Endangered, June 2003
Reason for Designation:	This species has a restricted range in Canada, and is in significant decline due to habitat loss and degradation.
Range in Canada:	British Columbia
Status History:	Designated Endangered in April 1996. Status re-examined and confirmed in May 2000. Last assessment based on an existing status report.

1.2. Species Description

The Nooksack dace is a small (<15 cm) stream dwelling cyprinid (minnow). The body is streamlined, with large pectoral fins and a snout that overhangs the mouth. Body colouration is grey-green above a dull, brassy lateral stripe and dirty white below it. There is often a distinct black stripe on the head in front of the eyes, which in juveniles continues down the flanks to the tail (McPhail 1997). The Nooksack dace is considered a subspecies of the widespread and common longnose dace *Rhinichthys cataractae* (J.D. McPhail, University of British Columbia, pers. comm.). It evolved through geographic isolation in Washington State's Chehalis River valley sometime during the Pleistocene glaciations (McPhail 1997). Adults are generalized insectivores while juveniles feed on zooplankton (McPhail 1997).

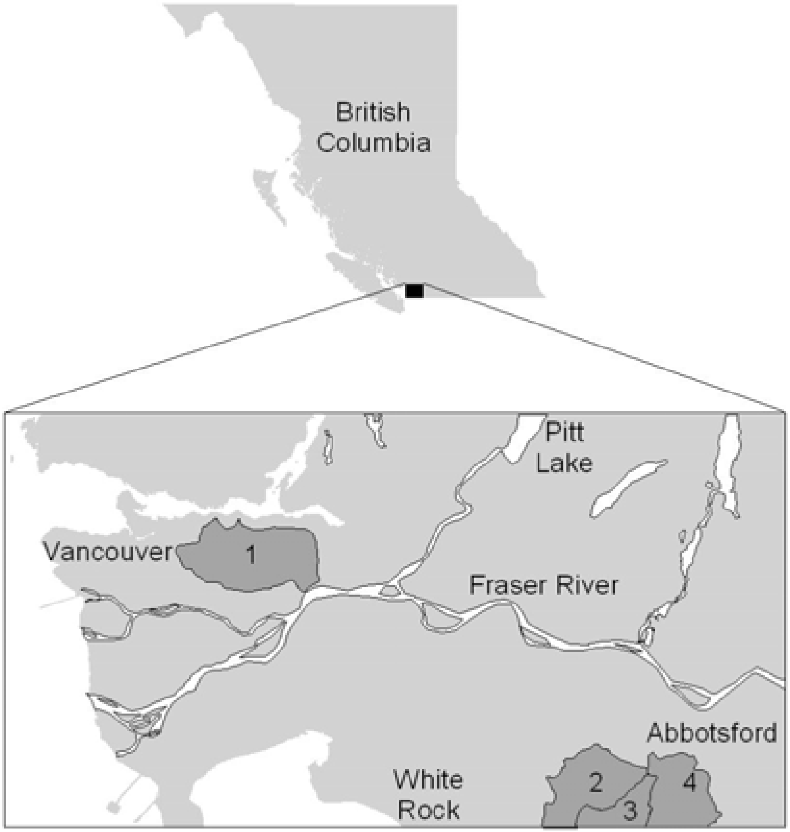
1.3. Populations and Distribution

Populations are documented from four lowland streams in British Columbia's Fraser Valley (Figure 1). The global distribution consists of approximately 20 additional streams in north-west Washington State. The species is extirpated from some tributaries within Canadian watersheds where it was abundant in the 1960s (McPhail 1997). The current status of Washington State populations is unknown. Based on available information, Canada contains approximately 10% of the global range and 20% of all populations (Figure 1).

1.4. Description of the Species Needs

1.4.1. Biological Needs, Ecological Role and Limiting Factors

The major factor limiting population abundance and distribution is the availability of high quality habitat (see below). Given adequate habitat Nooksack dace populations should recover rapidly as their life history characteristics promote rapid population growth. They are small-bodied, mature early (2 years, McPhail 1997), have an extended spawning period and may spawn more than once each year (April - July, Pearson 2004a), a trait that increases fecundity in species otherwise limited by small female body size (Blueweiss et al. 1978; Burt et al. 1988).



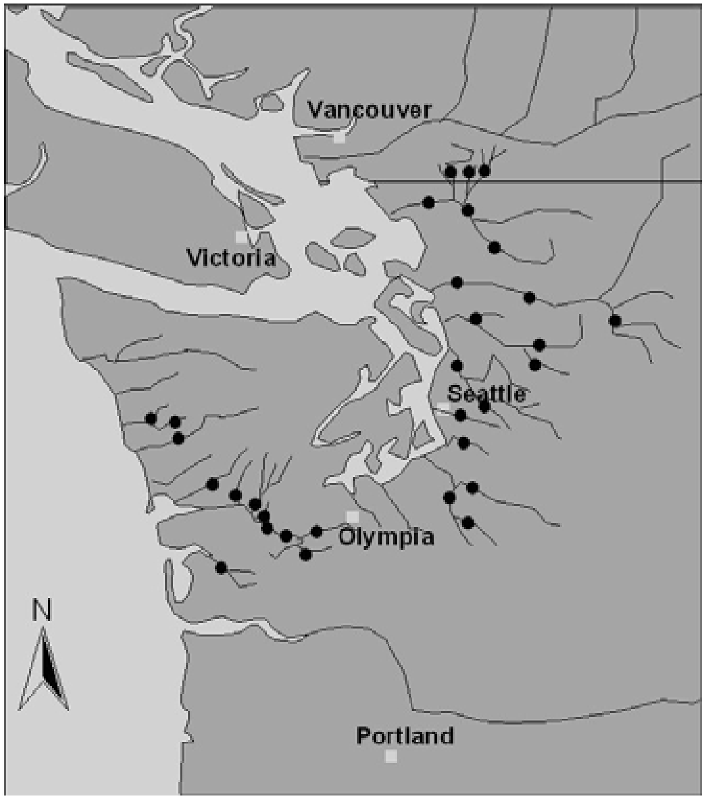


Figure 1: Canadian and global distribution of Nooksack dace. In Canada the Nooksack dace is known to inhabit four watersheds (left panel; 1- Brunette River, 2 – Bertrand Creek, 3 – Pepin Brook, 4 – Fishtrap Creek). Globally, it is also found in a number of other streams in northwestern Washington (right panel, adapted from McPhail 1997).

1.4.2. Habitat Needs

Physical Habitat

Nooksack dace are riffle specialists. The proportion of riffle habitat in a reach is the strongest predictor of their presence and they are rarely found in reaches with less than 10 percent riffle by length (Figure 2) or in reaches where long stretches of deep pool habitat separate riffles (Pearson 2004a). Young-of-the-year fish require shallow, calm pool habitats in close proximity to riffles. Most individuals appear to have small home ranges (tens of metres of channel) although a small number of individuals venture hundreds of metres. Clusters of riffles may contain semi-isolated subpopulations. Distances and barriers between clusters may influence long-term population persistence by altering watershed scale population dynamics.

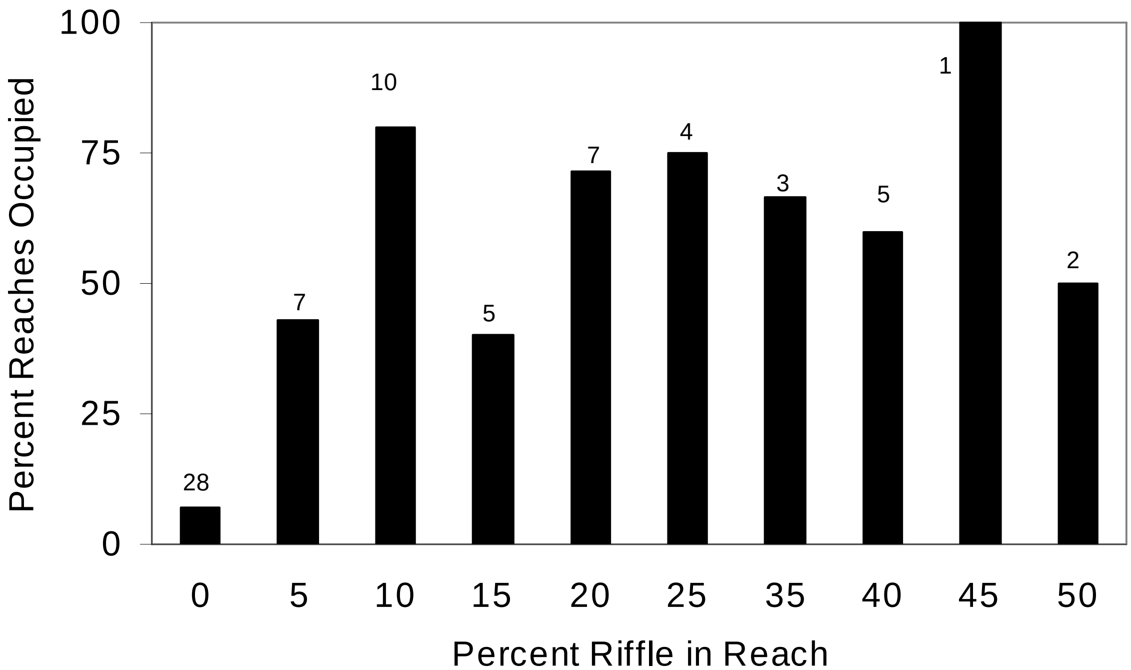


Figure 2: Nooksack dace are found in fewer than half of reaches that contain less than 10 percent riffle by length. Numbers over bars indicate sample size (adapted from Pearson 2004a).

Water Quantity

Riffles are among the shallowest of stream habitats and consequently among the first to shrink when flow declines. When surface flow ceases, riffle habitat is entirely eliminated and Nooksack dace may be forced into pools, a non-preferred habitat where foraging success and security from predation may be compromised.

Water Quality

Little information exists on tolerances or preferences of Nooksack dace for parameters such as dissolved oxygen, pH, and temperature. Activity appears minimal at temperatures below 11 ^{o}C, and fish forage normally at temperatures in excess of 20 ^{o}C

(Pearson 2004a). Nooksack dace are likely poorly adapted to hypoxia, as their riffle habitats are typically well oxygenated. The federal water quality guideline for dissolved oxygen to support aquatic life (5 mg/l, CCREM 1987) is an appropriate benchmark for habitat assessment.

2. THREATS

2.1. Identification of the threats to the survival of the species

The prospects for recovery of a species at risk depend upon its vulnerability to the threats facing it, their severity and ubiquity across the range. In the following sections we summarize detailed analyses of each of these factors, taken from (Pearson 2004a, b).

Eight factors (Table 1) are considered threats based on knowledge of species biology and habitat conditions across the Canadian range. All are proximate, in that they act directly upon the fish or their habitats. The vulnerability of Nooksack dace to each threat, and the severity of each threat in each watershed are rated and summarized graphically in Table 2. The ratings are based on analyses of a suite of factors that cause, exacerbate, or mitigate threats (Figure 3), and are briefly summarized in the text. A summary by watershed is presented in Table 3. For details of assessment methods and rationales for ratings see Pearson (2004a; 2004b).

Table 1: Potential threats to Nooksack dace in Canada in descending order of concern.

Threat	Management Concern
1. Physical Destruction of Habitat:	Drainage, dyking, channelization and infilling of water bodies destroying habitat.
2. Seasonal Lack of Water:	Low flows in late summer eliminate habitat, reducing fitness or survival.
3. Sediment Deposition:	Deposited sediment degrading habitat.
4. Riffle Loss to Beaver Ponds:	Beaver ponds flooding riffle habitat.
5. Habitat Fragmentation:	Permanent or temporary barriers preventing or inhibiting fish from traversing some stream reaches. This restricts access to usable habitats and/or alters metapopulation dynamics to increase extinction risk.
6. Toxicity:	Toxic discharges from point or non-point sources significantly reducing survival or fitness.
7. Hypoxia:	Episodes of extreme hypoxia causing acute mortality or reduced fitness.
8. Increased Predation:	Introduced predators consuming individuals or reducing their fitness by inducing behavioural changes.

Table 2: Summary of threats assessment for Nooksack dace (see text for basis of assessment).

Threat	Vulnerability of Nooksack Dace	Severity Across Range
Physical Destruction of Habitat	***	***
Seasonal Lack of Water	***	***
Sediment Deposition	***	***
Riffle Loss to Beaver Ponds	***	**
Habitat Fragmentation	**	***
Toxicity	**	**
Hypoxia	*	**
Increased Predation	*	***

***	major concern	**	moderate concern	*	minor concern

Table 3: Assessment of threat severity in each of the four watersheds from which Nooksack dace are known in Canada. Background data and details of assessment methods for Bertrand, Pepin and Fishtrap Creeks are provided by Pearson (2004a). The Brunette River population was discovered in 2004 and a threats analysis has not been completed for it.

Threat	Bertrand Creek	Pepin Brook	Fishtrap Creek	Brunette River
Hypoxia	**	***	**	?
Physical Destruction of Habitat	**	***	***	?
Habitat Fragmentation	***	**	**	?
Toxicity	**	*	***	?
Sediment Deposition	**	***	**	?
Seasonal Lack of water	***	*	**	?
Increased Predation	**	**	**	?
Riffle Loss to Beaver Ponds	*	***	*	?

Threat 1: Physical Destruction of Habitat

Description

Channelization, dredging and infilling directly destroying or degrading stream habitats.

Vulnerability (major concern)

The riffle habitats required by Nooksack dace are the ‘high spots’ in a stream, and tend to be targeted for removal or alteration in drainage projects. Channelization and drainage work also typically eliminates the shallow marginal pools preferred by young-of-the-year.

Severity (major concern)

Approximately 77% of pre-settlement wetland areas in the Fraser Valley have been drained or infilled (Boyle et al. 1997). Fifteen percent of the area’s streams no longer exist, having been paved over or piped (Fisheries and Oceans Canada 1998). A large, but unknown, proportion of those that remain have been channelized and/or repeatedly dredged in agricultural drainage or urban development projects. It is

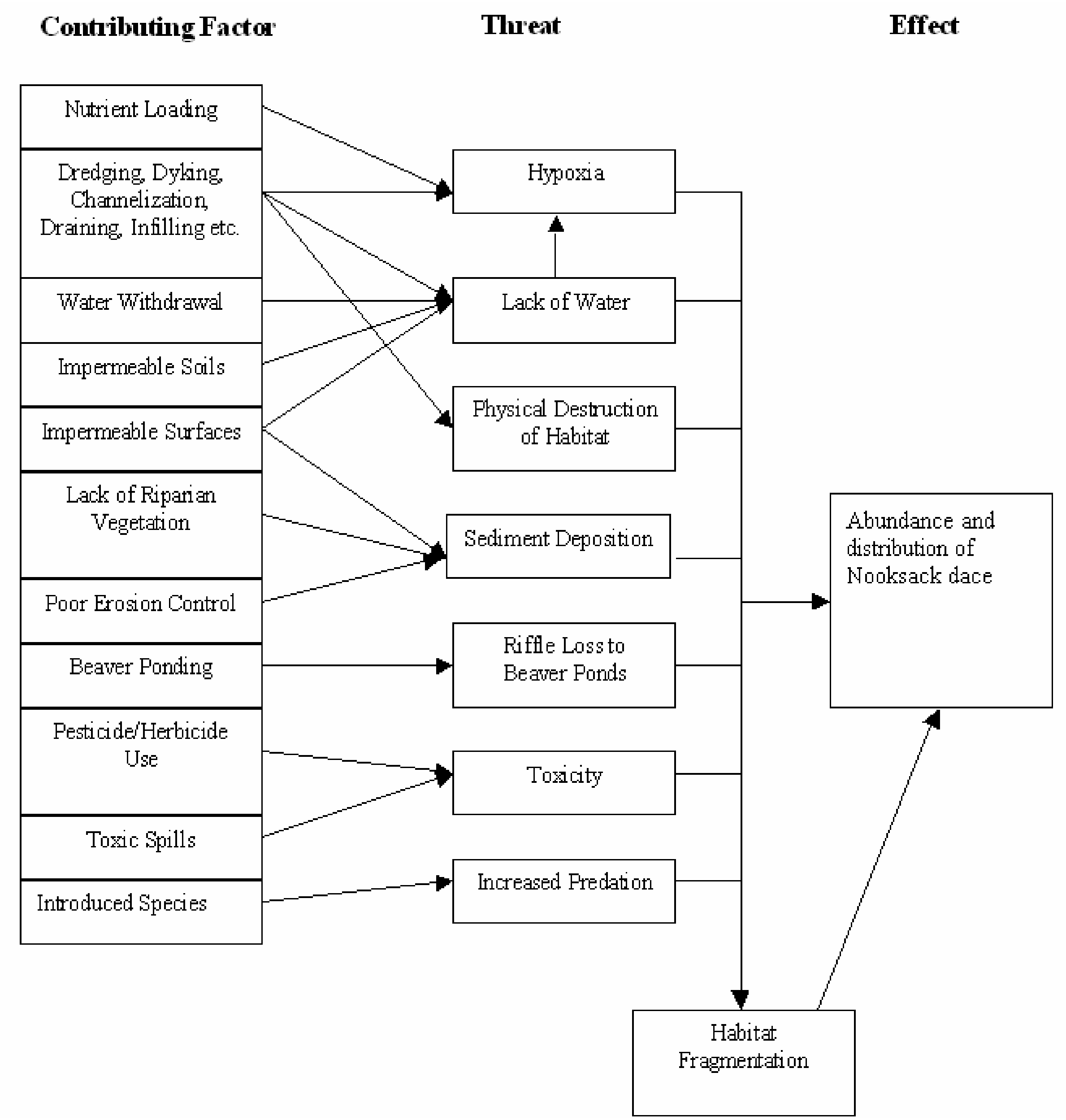


Figure 3: Factors known or suspected to drive or trigger threats to Nooksack dace (from Pearson 2004b).

difficult to overstate the historical extent of fish habitat loss to these activities. Both permitted and un-permitted dredging of ditches and stream channels for flood control and agricultural drainage still occur annually in all watersheds included in this strategy. In recent years, Fishtrap Creek has been most affected. The lower 5 km of the mainstem were dredged by the City of Abbotsford in 1990-1991 (Pearson 2004a), eliminating riffle from what was previously a densely populated reach (J.D. McPhail, UBC pers. comm.).

Threat 2: Seasonal Lack of Water

Description

During late summer, when rainfall is sparse, Fraser Valley stream flows are maintained almost solely by groundwater. Stream hydrographs vary widely depending on surface soil permeability and water use. Watersheds with large unconfined aquifers maintain steady flows of cold water throughout this critical period, while surface flows may cease completely in watersheds with impermeable surface soils. Unfortunately the late summer low-flow period coincides with peak demand for water withdrawal from wells and streams for irrigation and domestic use. Common land use changes in the Fraser Valley also tend to exacerbate problems with water availability. Gravel mining reduces the size of the aquifer contributing to baseflow, urban development increases the area of impermeable surfaces (reducing infiltration to the aquifer), and agricultural drainage lowers water tables, further reducing flows.

Vulnerability (major concern)

Nooksack dace are highly vulnerable to lack of water. Adults inhabit riffles and young-of-the-year school in nearby shallow pools (McPhail 1997). These habitats are the first to be affected by lack of water. Adults also spawn in riffles, but during spring and early summer when water is more plentiful.

Severity (major concern)

Low surface flows have reduced the availability of suitable habitat in Bertrand and Fishtrap creeks for several weeks during very dry years (Pearson, pers. obs.). Nooksack dace are especially vulnerable to further wetland drainage, increases in impermeable surfaces and/or water withdrawal. Extensive gravel mining is underway in two watersheds and will reduce baseflow in these systems by an unknown amount in future.

Threat 3: Sediment Deposition

Description

Sediment deposition is controlled by the balance between the rate of sediment delivery to the channel and capacity of the stream to mobilize and carry it downstream. Sediment delivery may be increased by direct discharges, storm drain runoff, or bank erosion accelerated by lack of riparian vegetation and/or increased peak flows (Waters 1995). All of these sources are likely to increase with urban, agricultural and mining development in a watershed.

Vulnerability (major concern)
Adult dace spawn, forage and rest in the crevasses between and under coarse riffle substrate (McPhail 1997). Sedimentation clogs these spaces and inhibits the flow of oxygenated water through the substrate. It is less likely to be a problem for young-of-the-year dace, which inhabit the water column in shallow pools (McPhail 1997).

Severity (major concern)
Significant sediment deposition occurs in portions of all watersheds (Pearson 2004a).

Threat 4: Riffle Loss to Beaver Ponds
Description
Beaver ponds have been shown to influence fish populations both positively and negatively (Hanson & Campbell 1963; Keast & Fox 1990; Lavkulich et al. 1999; Schlosser 1995). The impacts of riffle loss through ponding have received scant attention, but may be significant for species like Nooksack dace, which depend on these habitats.

Vulnerability (major concern)
Nooksack dace are riffle specialists. The proportion of riffle habitat a reach contains is the best predictor of their presence, and dace are absent from long sections of continuous deep pool, like beaver ponds, even when riffles are present (Pearson 2004a).

Severity (moderate concern)
Riffle loss to beaver ponding is a major concern in at least one watershed, Pepin Brook. In 1999, beavers had impounded 47% of its 6.4 km mainstem. By 2001 an additional 690 m of channel was impounded, eliminating 10% of the 938 m of riffle recorded in the 1999 survey (Pearson 2004a). Impounded area did not change in two other watersheds monitored over the same period (Bertrand and Fishtrap creeks) as higher winter flows washed out dams regularly and narrower riparian forest strips probably limit the food supply of beavers (Pearson 2004a).

Threat 5: Habitat Fragmentation
Description
Physical barriers such as perched culverts, beaver dams, and agricultural weirs commonly prevent movement between habitats for all or part of the year in Fraser Valley streams. In addition, any of the other threats discussed may fragment habitat by preventing or curtailing movement of fish through affected reaches. On a larger scale, connections between watersheds during floods were undoubtedly more common prior to the extensive dyking and drainage works of the past century.

Vulnerability (moderate concern)
Most Nooksack dace have very small home ranges, covering less than 50 m of channel, although a few individuals appear to venture further (Pearson 2004a). The distribution of populations is also very clumped within streams. In combination, these data suggest that each watershed is inhabited by loosely connected subpopulations. Most barriers

and habitat fragmentation in Nooksack dace watersheds date from 50 to 130 years ago, and surviving populations have shown some resilience (Pearson 2004a). The effects of less movement between subpopulations and reduced ability to colonize new habitat, however, may occur over longer time frames. The extent and importance of this to the long-term persistence of individual subpopulations and to recolonization following local extinctions of subpopulations is unclear.

Severity (major concern)
The extensive destruction of aquatic habitat that has occurred within the Fraser Valley over the past 150 years (see *Physical Destruction of Habitat* above) has fragmented habitat badly. Within watersheds, physical barriers and degraded habitat have likely affected movement patterns between subpopulations. Bertrand, Pepin and Fishtrap Creeks are all tributaries of the Nooksack River, but are isolated from one another by poor habitat conditions in the Washington State portion of their watersheds (McPhail 1997). Fish and habitat distributions within the Brunette system have yet to be surveyed.

Threat 6: Toxicity
Description
Toxic compounds enter Fraser Valley streams through urban storm runoff, contaminated groundwater (e.g. agricultural pesticides and herbicides), direct industrial discharges, sewage treatment plant effluents, aerial deposition, and accidental spills (Hall et al. 1991). Concentrations in the water column are widely variable over time because dilution varies with stream discharge and inputs are often pulsed (e.g. first flush of stormwater following a long dry spell, Hall et al. 1991). Some contaminants, particularly heavy metals, bind to sediments where they may be taken up and bioaccumulated by aquatic invertebrates and subsequently fish.

Vulnerability (moderate concern)
Data on threshold concentrations for lethal and sublethal effects of toxic compounds on Nooksack dace are lacking. As a bottom-dwelling species, they may be sensitive to contaminants bound to sediment as well as those in food items and the water column.

Severity (moderate concern)
Toxicity is likely to impact some Nooksack dace populations. Large portions of the Fishtrap Creek, Bertrand Creek, and the Brunette River watersheds are urbanized, which generally causes elevated levels of copper, lead and zinc in stream sediments (Hall et al. 1991). Row crop agriculture with intensive pesticide/herbicide use is also common in the Fishtrap Creek watershed (Pearson 2004a). The range of compounds that could enter creeks from spraying, poor waste management, and accidental spills is enormous.

Threat 7: Hypoxia
Description
Hypoxia is ultimately caused by the cumulative effects of local and watershed-scale impacts. Increased nutrients result in algal blooms and high densities of macrophytes

that strip the water of oxygen at night. Decomposition of dead algae and vegetation exacerbates the problem and may severely depress daytime oxygen levels as well. Nutrients in Fraser Valley groundwater and streams are elevated, primarily a consequence of over-application of manure and fertilizers to agriculture lands (Lavkulich et al. 1999; Schreier et al. 2003), but also of urban stormwater runoff and septic systems (Lavkulich et al. 1999). Lack of shade from riparian vegetation permits water temperatures to rise. Warmer water has less capacity for dissolved oxygen and increases the metabolic demands of fish and other organisms. Reduced water movement impairs reoxygenation of water and may be caused by channelization, (Schreier et al. 2003), beaver ponds (Fox & Keast 1990; Schlosser & Kallemyn 2000), or low flows.

Vulnerability (minor concern)
Lethally low levels of hypoxia are unknown for Nooksack dace, but riffles are generally well-oxygenated habitats and species that are specialized to inhabit them are unlikely to be well adapted to hypoxia. Even moderate levels of chronic hypoxia may reduce growth, condition, and fecundity. In the absence of better information, the federal guideline for the protection of aquatic life ($5 mg \cdot l^{-1}$, CCREM 1987) is a useful target.

Severity (moderate concern)
Hypoxia is a major concern in at least one stream, Pepin Brook, and a moderate concern in Bertrand and Fishtrap Creeks. Fish inhabiting riffles and shallow pools immediately below hypoxic reaches may be affected, although this comprises a small proportion of total habitat.

Threat 8: Increased Predation
Description
Increased predation is most likely to arise from the introduction of new species to Nooksack dace habitats. Such introductions are implicated in the extinction of numerous native fishes across North America (Gido & Brown 1999; Miller et al. 1989; Richter 1997).

Vulnerability (minor concern)
The impacts of introduced predators on Nooksack dace populations are unknown. Populations have coexisted with bullheads (*Ameiurus nebulosis*), bullfrogs (*Rana catesbeiana*), smallmouth bass (*Micropterus dolomieu*), or largemouth bass (*M. salmoides*) for at least ten years in these watersheds (Pearson, unpubl.). All of these species would undoubtedly prey upon Nooksack dace given the opportunity, but there is little habitat overlap. These predators thrive in warm water littoral zones (Corkran & Thoms 1996; Scott & Crossman 1973) and are very rarely found in riffles. Lack of water could, however, force Nooksack dace out of riffles and into pools where predation risk is likely to be much higher. The possibility of a new, effective predator being introduced to Nooksack dace habitat is also ever present.

Severity (major concern)
Introduced predators inhabit every stream known to contain Nooksack dace.

2.2. Summary of Threats Analysis

Nooksack dace populations appear to be most vulnerable to seasonal lack of water, habitat loss to drainage activities, sediment deposition, and riffle loss to beaver ponds. Habitat fragmentation is likely having some impacts in all watersheds and is considered a moderate concern. Introduced predators are widespread in the range but probably have minimal impacts on Nooksack dace because of lack of habitat overlap. Hypoxia and toxicity are significant threats in some sections of at least one watershed, but do not threaten the species throughout its range.

3. CRITICAL HABITAT

3.1. Definition

Critical habitat was defined using in-stream habitat characteristics at the scale of the reach, a natural unit of stream habitat that ranges from hundreds to thousands of metres in length (Frissell et al. 1986). There are three reasons for adopting this scale. First, the reach scale corresponds to the distribution of subpopulations of both species within watersheds and usually contains all habitat types used during the life history cycle (Pearson 2004a). Second, the ‘channel units’ of critical habitat (riffles and pools) are dynamic and frequently move during flood events in these streams. Effective protection and management of critical habitat in these circumstances must allow for normal channel processes and must, therefore, occur at a spatial scale larger than the channel unit. The reach scale is the next largest in accepted stream habitat classifications (Frissell et al. 1986; Imhof et al. 1996) and by definition represents relatively homogenous segments of stream demarcated by distinct geomorphic or land use transitions. Third, the reach scale corresponds most closely to that of land ownership in these watersheds and, consequently, to most recovery actions.

Critical habitat includes riparian reserve areas. Reserve widths are assessed using a GIS based methodology adapted directly from and consistent with that of the British Columbia Riparian Area Regulation (RAR, Reg. 837 under the Fish Protection Act (S.B.C. 1997, c. 21) Anonymous 2005). The width of existing riparian vegetation and areas where riparian reserve width is restricted by permanent structures (roads, buildings, yards etc.) are also mapped.

3.2. Identification of Critical Habitat

Critical habitat includes all habitats within occupied watersheds that the Recovery Team considers of high quality or potentially high quality for Nooksack dace, and constitutes the habitat that the Recovery Team deems necessary for species persistence, and to achieve recovery objectives. Critical Habitat for Nooksack dace consists of reaches in their native creeks and that consist of (or are known to have previously consisted of) more than 10% riffle by length. It includes all aquatic habitats and riparian reserve strips of native vegetation on both banks for the entire length of the reach. Reserve strips are continuous and extend laterally from the top of bank to a width equal to the widest zone of sensitivity (ZOS) calculated for each of five riparian features, functions and conditions: large woody debris supply for fish habitat and maintenance of channel morphology, localized bank stability, channel movement, shade, and insect and debris fall. The ZOS values are calculated using methods consistent with those used under the British Columbia Riparian Areas Regulation (Reg. 837) under the Fish Protection Act (S.B.C. 1997, c. 21).

The combined length of critical habitat for Nooksack dace is 33.1 km (of 93.9 km of surveyed stream channel). Maps showing the extent of critical habitat for the watersheds known to contain Nooksack dace are provided in Appendix 2.

3.3. Rationale

Riffle Habitat

Available information overwhelmingly indicates that Nooksack dace require riffle habitats and that reaches with a high percentage of riffle habitats support most of the population. Nooksack dace typically occur in riffles with loose gravel and cobble substrates where water velocity exceeds 0.25 m.s-1. They spawn near the upstream end of riffles (McPhail 1997) between late April and early July (Pearson 2004a) and forage nocturnally for riffle dwelling insects (McPhail 1997). Logistic regression relating Nooksack dace presence to habitat type (riffle, shallow pool etc.), cover availability and riparian land use showed that reach occupancy was most strongly predicted by the amount of riffle habitat present, and that riffles isolated by long stretches of deep pool are seldom inhabited (Pearson 2004a). The proposed threshold of 10% riffle by length is intended to exclude reaches with very small amounts of riffle habitat that contribute minimally to Nooksack dace production and population size.

A number of reaches containing less than 10% riffle by length when surveyed are included in critical habitat (Table 4) because of evidence that they previously contained more riffle habitat and supported Nooksack dace populations. Most of these reaches are known to have been channelized and dredged or were temporarily impounded by beaver at the time of survey. All currently contain Nooksack dace except four reaches in Fishtrap Creek. These are known to have contained abundant riffle and Nooksack dace prior to dredging (J.D. McPhail pers. comm.). The remaining (non-critical habitat) reaches in all watersheds contain a total of 490 m2 of riffle habitat, or 1.9% of the total riffle habitat present.

Shallow Pool Habitat

Young-of-the-year Nooksack dace inhabit shallow (10-20 cm) pools adjacent to riffles where they swim above sand, mud, or leaf litter substrates and feed upon chironomid pupae and ostracods (McPhail 1997). Insofar as these habitats are exclusively used for larval rearing before juveniles move in to riffle habitat, the loss of these habitats would likely cause population declines.

Riparian Habitat
Riparian vegetation is included in critical habitat to the extent necessary to protect the integrity of in-stream critical habitat. Loss of riparian vegetation will result in bank erosion, siltation, water temperature elevation, and nutrient inputs that will directly degrade instream critical habitat. Required widths will vary among sites and are defined in reach scale assessments. Reserves must be sufficient to control sediment entry to the stream from overland flow, to prevent excessive bank erosion and to buffer stream temperatures. Reserve areas will also remove significant amounts of nitrate and phosphorous from groundwater, although their efficiency depends strongly on hydrogeologic conditions (Martin et al. 1999; Puckett 2004; Wigington et al. 2003). The effectiveness of a riparian reserve in preventing materials (sediment, nutrients, toxins, etc.) from entering a stream depends upon on its continuity in addition to its width, particularly when it is narrow (Weller et al. 1998). Consequently, riparian reserves in critical habitat reaches should be continuous. In open landscapes, such as agricultural fields, vegetation from reserve areas will collect windblown insects (Whitaker et al. 2000). Such insects, falling from riparian vegetation into the water constitute an important food source in headwater streams (Allan et al. 2003; Schlosser 1991). More than 30 m of riparian vegetation may be required for full mitigation of warming (Brown & Krygier 1970; Castelle et al. 1994; Lynch et al. 1984), and siltation (Davies & Nelson 1994; Kiffney et al. 2003; Moring 1982), and for long-term maintenance of channel morphology (Murphy et al. 1986; Murphy & Koski 1989). At least 10 m are required to maintain levels of terrestrial food inputs similar to those of forested landscapes (Culp & Davies 1983). Reserves as narrow as 5 m provide significant protection from bank erosion and sediment deposition from overland flow (Lee et al. 2003; McKergow et al. 2003).

Failure to maintain an adequate riparian reserve as part of critical habitat is likely to cause population-level impacts. In habitats lacking sufficient flow or groundwater, absence of shade may increase water temperatures to harmful levels, especially under climate warming scenarios. Increased erosion due to poor bank stability will cause direct sediment deposition in riffles, impairing spawning and incubation, reducing food availability, and eliminating the interstitial spaces in coarse substrate that Nooksack dace and their prey occupy. Nutrient loading will be higher in reaches without adequate riparian vegetation (Dhondt et al. 2002; Lee et al. 2003; Martin et al. 1999) and is likely to contribute to hypoxia through eutrophication. Increased solar radiation in nutrient rich reaches lacking adequate riparian shading (Kiffney et al. 2003) will also contribute to eutrophication and hypoxia.

Width of riparian reserves required to protect key habitat attributes for Nooksack dace have not been quantified. R. cataractae is certainly less dependant upon deep pool habitats than salmonids are, suggesting somewhat lesser requirements for large woody debris. They also favour benthic over drifting invertebrates (Scott & Crossman 1973) suggesting they are less dependant on insects of terrestrial origin. R. cataractae appear tolerant of slightly higher water temperatures than salmonids (Wehrly et al. 2003), suggesting a reduced need for shading, but this may not be true under future climate warming scenarios. However, Nooksack dace are likely to be equally or more vulnerable than salmonids to habitat degradation caused by sedimentation, loss of scope for natural channel movement, and invasive plant overgrowth of riffles fuelled by nutrient loading and riparian loss. Benthic insectivores and fluvial specialists, like Nooksack dace, are among the most sensitive fish species to loss of wooded riparian areas (Stauffer et al. 2000), probably due to the impacts of siltation and alterations to macroinvertebrate community structure (Allan 2004; Kiffney et al. 2003). Overall, there is little reason to believe that Nooksack dace require narrower buffers than salmonids.

BC MOE and DFO have developed and implemented a methodology for determining riparian reserve widths required to protect fish habitat in streams that they deem to be minimally sufficient in maintaining riparian function to protect fish habitat. The Riparian Area Regulation (RAR) was developed under the Fish Protection Act to protect "salmonids, game fish, and regionally significant fish" from the impacts of land development. In the absence of definitive data for a SARA listed species, this seem to be a reasonable standard to apply in the identification of critical habitat, as it represents a benchmark and standard methodology to which both federal and provincial agencies responsible for management of species at risk have already agreed, and it forms the basis of the methodology employed (see below). The width of riparian buffers sufficient to protect fish habitat is a scientific discipline in itself, and it is neither practical nor within the mandate of the Recovery Team to develop an independent assessment methodology and regulatory framework.

Finally, it should be noted that unidirectional transport of sediment in flowing waters means that riparian reserve strips upstream of critical habitat reaches are important in minimizing sedimentation and other impacts within critical habitat. For this reason stewardship programs should promote the establishment of continuous riparian reserve strips of native vegetation throughout the watershed, not just along critical habitat reaches.

Table 4: Reaches included in critical habitat for Nooksack dace that contained less than 10% riffle by length at the time of survey (1999).

Watershed	Reach	Length	Riffle Length	Riffle Area	% Riffle by Length	Dace Present	Condition
Bertrand	BTD5	652	40	112	6.1	Y	Channelized and dredged
	BTD7	449	29	58	6.5	Y	Partially impounded by beaver
	BTD8	1139	44	176	3.9	Y	Partially impounded by beaver
	BTD9	1104	57	200	5.2	Y	Channelized
	BTD18	637	35	88	5.5	Y	Channelized
Fishtrap	FTP1	1984	170	459	8.6	N	Dredged 1990-1991
	FTP2	1239	72	144	5.8	Y	Dredged 1990-1991
	FTP3	962	15	33	1.6	N	Dredged 1990-1991
	FTP6	926	66	198	7.1	N	Dredged 1990-1991
	FTP12	476	32	19	6.7	N	Channelized
Pepin	PEP1	263	5	13	1.9	Y	Channelized and dredged

3.4. Activities Likely to Result in Destruction of Critical Habitat

Many of the threats that face Nooksack dace are habitat-related, and this is of particular concern. Threats to critical habitat for Nooksack dace are identified, and the reader is also referred to the Threats section for a more thorough discussion of threats identified below. It is also important to note that there are many gaps in our understanding of critical habitat features and their threats, and that this will be a focus for research in one or more action plans.

Activity	Description
Excessive water withdrawal	Water extraction (surface or ground) during dry periods reduces flows, which may contribute to hypoxia and drying of riffles needed for spawning.
Excessive sediment releases	Sediment deposition in spawning substrate and inhibition of the flow of oxygen-rich water to eggs and larvae during incubation.
Drainage projects	Dredging, dyking, and channelization works directly destroy habitat, cause sediment deposition in riffles, and reduce base flow,
Impoundment	Ponding caused by either human or beaver activities eliminated riffle habitat.
Urban storm drainage	Storm drain systems that discharge directly to creeks are major sources of toxic contamination and sediment. They also reduce baseflow by inhibiting water infiltration to aquifers.
Riparian vegetation removal	Riparian vegetation removal exposes a stream to increased erosion and sediment deposition, elevated water temperatures, reduced supplies of terrestrially derived food, and increased nutrient loading
Livestock access to creeks	Livestock damage habitat by trampling or causing erosion that clogs riffles with sediment. Access also contributes to nutrient loading.

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Activity	Bertrand Creek	Pepin Brook	Fishtrap Creek	Brunette River
Excessive water withdrawal	+++	+	++	?
Excessive sediment releases	+	+++	++	?
Drainage projects	++	+	+++	?
Impoundment	+	+++	++	?
Urban storm drainage	+++	-	+++	+++
Riparian vegetation removal	++	+	+++	?
Livestock access to creeks	+	+	+	?

+++	major concern	+	minor concern
++	moderate concern	-/?	not a concern/unknown

3.5. Schedule of Studies to Identify Critical Habitat

Information exists to assist in the definition of critical habitat for Nooksack dace throughout its presently known range. Further surveys are required to identify other potential populations and characterize their critical habitats, as summarized below:

Study	Description	Timeframe	Status
Population Identification	The Coquitlam and Alouette Rivers are suspected of containing Nooksack dace based on a preliminary genetic and morphometric study of their *R. cataractae* populations (J.D. McPhail, UBC, unpubl. data). Additional samples are required for confirmation.	2005-2006	Underway
Critical Habitat Surveys	Habitat in the Brunette River has not been surveyed as its populations were unknown prior to 2004. Surveys will also be required in the Coquitlam and Alouette Rivers if the presence of Nooksack dace is confirmed there.	2006-2007	Planned

3.6. Knowledge Gaps in Nooksack Dace Biology

Additional studies should be conducted to address the following data needs related to specific threats to Nooksack dace. This information will contribute to the protection of Nooksack dace and their critical habitats.

Study	Description	Timeframe	Status
Impacts of Riffle Drying	The fate of dace in reaches that dewater during late summer is uncertain. Sampling during this period will resolve whether fish leave the reach, move into pools, burrow into substrate, or die.	2004-2005	Underway
Impacts of Sediment Deposition in Riffles	The extent to which sediment deposited in riffles affects their ability to support healthy dace populations is uncertain and needs to be quantified.	2007-2008	Need Identified

4. RECOVERY

4.1. Recovery Feasibility

Feasibility Criteria[2]

1. *Are individuals capable of reproduction currently available to improve the population growth or population abundance?*

   Yes. Breeding adults have been captured recently from all populations.

2. *Is sufficient habitat available to support the species or could it be made available through habitat management or restoration?*

[2] Draft Policy on the Feasibility of Recovery, Species at Risk Act Policy. January 2005.

Yes. Sufficient physical habitat exists to support the three populations that have been surveyed (Bertrand, Pepin and Fishtrap creeks), although up to 70% of it is seriously degraded by sediment deposits or low water levels in late summer. The severity and extent of these problems could be mitigated by reducing ground and surface water withdrawals during sensitive periods, by reducing sediment entry to streams and by managing beaver activity in sensitive habitats. The quantity and condition of available habitat in the Brunette River population is unknown at present.

3. *Can significant threats to the species or its habitats be avoided or mitigated through recovery actions?*

   Yes. Riffle degradation through seasonal drying can be avoided by reducing water withdrawals or flow supplementation. Sedimentation can be reduced through riparian planting, improved agricultural practices, the installation of sediment traps in storm sewer systems, and proper sediment control at mine and construction sites. Riffle loss can be mitigated through habitat restoration and (when necessary) beaver control.

4. *Do the necessary recovery techniques exist and are they demonstrated to be effective?*

   Yes. Techniques to reduce problems of low base flow, sediment deposition and beaver ponding are well known. Monitoring of created riffle habitat has demonstrated that restored habitats are quickly colonized.

Feasibility Assessment

Recovery of Nooksack dace populations to levels ensuring long-term survival is both technically and biologically feasible. However, it is highly likely the species will remain at some risk due to the continued pressure on its habitats from a rapidly growing human population in the Fraser Valley.

Recovery will involve the establishment and/or maintenance of riffle habitat sufficient to maintain a population in each creek. Some management will be required in all three watersheds. It should focus on in-stream flow protection in Bertrand Creek, restriction of beaver impoundment in Pepin Brook, and the restoration of riffle habitat in Fishtrap Creek. Appropriate recovery actions in the Brunette River are unknown pending population and habitat status surveys.

4.2. Recovery Goal, Objectives and Corresponding Approaches

4.2.1. Recovery Goal

To ensure the long-term viability of Nooksack dace populations throughout their natural distribution in Canada.

4.2.2. Recovery Objectives

1. *For all currently and historically suitable habitats in native streams to be occupied by 2015.*

Watershed	Habitat with High Potential Productivity Occupied in 2004 (km)	Total Habitat with High Potential Productivity (km)
Bertrand Creek	<6.5	10.0
Pepin Brook	<2	2.8
Fishtrap Creek	unknown	8.5
Brunette River	unknown	unknown

Rationale:
A significant portion of habitat with high potential productivity is not currently occupied, primarily due to riffle degradation or loss to drying, sediment deposition and beaver impoundment. Achievement of interim population recovery targets in the three surveyed watersheds will require that all habitat with high potential productivity be occupied (see objective 2 below). In most cases unoccupied areas could be rendered habitable quickly by increasing water flow, controlling beaver, and/or implementing fish-sensitive drainage maintenance practices.

2. *To increase Nooksack dace abundance to target levels in all watersheds by 2015.*

Watershed	Area of Riffle in Potential Habitat Reaches (m^2)	Population Target (excludes young of year)
Bertrand Creek	3000	5700*
Pepin Brook	2300**	4400*
Fishtrap Creek	2030	3900*
Brunette River	unknown	unknown pending habitat survey

*Assumes an average density of 1.9 Nooksack dace per m^2 riffle in suitable habitat (Inglis et al. 1994). Rounded to nearest hundred.
** Based on 1999 survey. By 2001 approximately 200 m^2 of riffle was lost to beaver ponding (Pearson 2004a).

Rationale
Ideally population targets would be based on robust population viability analyses. Unfortunately the necessary demographic data is lacking for Nooksack dace. An appropriate guideline for minimum viable population (MVP) size in vertebrate species, based on an extensive review of the scientific literature (Reed et al. 2003; Thomas 1990), is 7000 breeding adults (median value; range 2000-10000). This abundance is considered adequate to maintain genetic diversity and to buffer the population from random variations in survival, and thus to maintain long-term viability in the absence of deterministic factors causing the population to decline.

Populations of Nooksack dace in each of the four watersheds are essentially independent of one another, with extremely low probability of natural exchange of individuals between watersheds because of the very large distances of unsuitable habitat that separate populations. Natural recolonization of habitat from which a population has been extirpated (rescue effect) is therefore highly unlikely. Each watershed, consequently, warrants a separate recovery target in the low to mid thousands.

High quality habitat in Bertrand Creek supported an average of 1.9 dace/m^{-2} (n=20, SE = 0.35) in the single available direct estimate of density (Inglis et al. 1994). If all riffle areas in all reaches with habitat with high potential productivity supported this density, total adult abundance would be in the low thousands for each watershed. This suggests that for Nooksack dace in the three surveyed watersheds, the maximum achievable population size is close to the minimum viable population size and that all suitable habitats should be designated critical.

3. To ensure that at least one reach in each watershed supports a high density of Nooksack dace.

Rationale
Within each watershed, individual populations may be structured as metapopulations, with different subpopulations separated by poor quality habitat, and some level of exchange of individuals between sub-populations. Population persistence in such systems is dependent upon the existence of one or more source areas where population growth is positive and densities are high.

4.2.3. Broad Strategies to be Taken to Address Threats

Eight broad strategies have been identified in support of the recovery objectives.

1. Protect[3], create and enhance riffle habitat in habitat reaches with high potential productivity.
2. Establish or maintain adequate baseflow in all habitats with high potential productivity.
3. Reduce sediment entry to creeks.
4. Ensure the integrity and proper functioning of riparian zones throughout watersheds.
5. Reduce habitat fragmentation
6. Encourage stewardship amongst private landowners and the general public.
7. Minimize toxic contamination of creeks.
8. Minimize impacts of introduced predators.

In Table 5 these are prioritized, detailed and related to the relevant recovery goals and objectives.

4.3. Evaluation

Monitoring and evaluation of a subset of populations will occur each year with the status of each population and watershed being evaluated every five years at minimum.

[3] *Protection can be achieved through a variety of mechanisms including: voluntary stewardship agreements, conservation covenants, sale by willing vendors on private lands, land use designations , and protected areas*

Performance measures for each objective and broad strategy are listed in Tables 6 and 7. Details and priorities of strategy implementation will be provided in one or more Action Plans.

4.4. Effects on Other Species

Most recovery efforts will benefit co-occurring native species including steelhead, cutthroat trout, and coho salmon. All three Nooksack dace streams in Canada also contain the Salish sucker (*Catostomus* sp.), which is also listed as Endangered under SARA. Most of the strategies for Nooksack dace recovery should also benefit Salish sucker, although there is potential for conflict over beaver management. In some cases beaver control and dam removal may benefit a Nooksack dace population by restoring riffle habitat, but harm Salish sucker population by eliminating deep pool and marsh habitat. Recovery activities for the two species will be coordinated in watersheds where they co-occur through the development of one or more multi-species Action Plans. Beaver management will be intended to restore that species' natural balance in these watersheds. Specific measures of controlling beavers and their dams will be determined in one or more Action Plans.

4.5. Approaches to Recovery

An active adaptive management approach (Walters & Holling 1990) should be used in planning and implementing recovery. Whenever possible management actions should be conducted as controlled experiments designed to inform ongoing recovery and action planning. Recovery planning and implementation should occur at the scale of individual watersheds as their populations are isolated from one another and face differing suites of threats in each watershed.

4.6. Actions Already Complete or Underway

Landowner Contact and Public Education Programs

A Recovery Implementation Group (RIG) has been formed. The RIG, in cooperation with local stewardship groups, has developed programs to contact landowners in three Nooksack dace watersheds. A public meeting to exchange information was held in each watershed. In addition, colour display posters on Nooksack dace have been given to stewardship groups in Langley for use in public events.

Table 5: Broad strategies for Nooksack dace recovery and details of associated research and management activities. Underlined points should not be postponed despite lack of full scientific certainty.

Broad Strategy	Obj. No.	Threats Addressed	Priority	Specific Steps	Outcomes or Deliverables
1. Protect, create and enhance riffle habitat in reaches with high potential productivity.	1,2,3	Physical destruction of habitat Riffle loss to beaver ponds Habitat fragmentation	High	Identify high priority sites for protection, restoration or habitat creation. Assess benefits of riffle creation and enhancement to Nooksack dace populations. Estimate current extent of riffle loss to authorized and unauthorized stream and ditch dredging and to beaver activity. Work with stewardship groups and landowners to identify and implement habitat creation and restoration projects. Develop best management practices and work plans for habitat reaches with high potential productivity that require drainage maintenance or beaver management.	Protection of habitats with high potential productivity through stewardship agreements, conservation covenants or acquisition of lands containing habitats with high potential productivity. Riffle creation/enhancement projects identified and developed. Public education materials on importance of riffle habitat to fish developed and distributed to landowners. Advice on Nooksack dace habitat requirements and beaver management available to local stewardship groups and agency staff involved in habitat work.
2. Establish and maintain adequate baseflow in all habitats with high potential productivity.	1,2	Seasonal Lack of Water Habitat fragmentation	High	Identify watersheds vulnerable to inadequate baseflow for Nooksack dace. Develop water balance models for watersheds. Establish biologically-based minimum in-stream flows for habitats with high potential productivity. Develop wetland restoration projects in vulnerable watersheds. Investigate need and feasibility of supplementing baseflow with well water. Develop and distribute public education materials on impacts of water use on fish and wildlife to landowners and public.	Water balance model showing relative influences of groundwater extraction, surface water extraction, and gravel removal on baseflow for each vulnerable watershed. Objectives for present and future water management in vulnerable watersheds (baseflow and water withdrawal). Adequate water rights for conservation purposes in established and vulnerable watersheds.
3. Reduce	1,2	Sediment	High	Estimate levels of sediment in riffles that	Maximum recommended levels of sediment

sediment entry to creeks.		deposition		are harmful to Nooksack dace. Map, assess and prioritize mitigation for riffle sedimentation in all watersheds. Work with landowners, municipal governments, and stewardship groups to prevent, mitigate and restore sediment degradation of riffles from urban, agricultural and industrial sources. Develop and distribute public education materials on sediment impacts on fish and wildlife to landowners.	content established for habitat riffles with high potential productivity. Restoration of degraded riffles completed at high priority sites. Mitigation projects to reduce sediment entry completed (e.g. riparian planting, stormsewer retrofits, improved settling ponds).
4. Ensure the integrity and proper functioning of riparian zones throughout watersheds.	1,2,3	Sediment deposition Physical destruction of habitat Toxicity Hypoxia	High	Conduct riparian assessments of habitat reaches with high potential productivity as the basis of proposed riparian buffer widths. Identify, prioritize and develop riparian planting or other projects in cooperation with landowners, stewardship groups and government agencies. Develop and distribute public education materials on riparian reserve strips to landowners	Riparian planting projects completed in high priority areas. Educational materials developed and included in landowner contact programs and other public education applications.
5. Reduce habitat fragmentation.	1,2	Habitat Fragmentation	Med.	Assess the ability of different life history stages to cross different types of barriers. Identify permanent/seasonal barriers and prioritize for mitigation.	Use of strategically located restoration projects to eliminate barriers and provide 'stepping stones' for dispersal to other riffle-rich reaches. Advice on prioritizing restoration projects available to local stewardship groups and agency staff involved in habitat work.
6. Encourage stewardship amongst private landowners, local governments and the general public.			Med.	Give presentations and field tours on Nooksack dace and watershed ecology to local stewardship groups, schools and others. Advise stewardship groups, agency staff, and consultants involved in habitat work on Nooksack dace habitat requirements.	Increased awareness of Nooksack dace and local stream ecology among public. Nooksack dace habitat features incorporated into in-stream works undertaken for other purposes.

7. Minimize toxic contamination of creeks.	1,2,3	Toxicity	Med.	Estimate extent and severity of toxic contamination of creeks. Work with municipalities to identify, prioritize and develop projects to improve storm water treatment. Increase width and continuity of riparian reserve areas on agricultural lands (see strategy 3). Develop and distribute public education materials on pesticide/herbicide impacts on fish and wildlife to landowners.	Stormwater treatment projects completed at high priority sites. Riparian planting projects completed in high priority areas. Educational materials developed and included in landowner contact programs and other public education applications.
8. Minimize impacts of introduced predators.	1,2,3	Increased predation	Low	Document distribution and densities of introduced predators in each watershed. Assess impact of riffle loss to drying on predation risk. Develop and distribute public education materials on potential impacts of introduced predators on native species to landowners and recreational fishers.	Introduced predator distributions mapped in each watershed. Educational materials developed and included in landowner contact programs and other public education applications.

Table 6: Performance measures for evaluating the achievement of objectives.

Objectives	Process Performance Measure	Biological Performance Measure
1. For all currently and historically utilized habitats in native streams to be occupied by 2015.	Habitat with high potential productivity identified and occupancy evaluated in all watersheds.	Proportion of habitat with high potential productivity occupied.
2. To increase Nooksack dace abundance to target levels in all watersheds by 2015.	Development of a monitoring protocol for population abundance. Abundance surveys completed in all watersheds.	Estimated population size relative to target population.
3. To ensure that at least one reach in each watershed supports a high density of Nooksack dace.	Abundance surveys completed in all watersheds.	Number of reaches where catch-per-unit-effort exceeds 0.8 Nooksack dace per standard Gee-trap (24 h set, n≥10)

Table 7: Performance measures for evaluating the success of broad recovery strategies.

Broad Strategies	Process Performance Measure	Biological Performance Measure
Protect, create and enhance riffle habitat in habitat reaches with high potential productivity.	Area of riffle habitat restored, created or protected. Number of landowners and others reached in public education and consultation programs.	Area of riffle protected, restored or created in habitat reaches with high potential productivity. Establishment or significant growth of populations in habitat reaches with high potential productivity containing protected, created or enhanced riffles.
Establish and maintain adequate baseflow in all habitats with high potential productivity.	Minimum discharges for maintenance of Nooksack dace habitat established in vulnerable watersheds. Discharge monitored in vulnerable watersheds.	Minimum discharges exceeded in vulnerable watersheds.
Reduce sediment entry to creeks.	Major sources of sediment entry to each watershed identified. Major sources of sediment entry addressed.	Area and proportion of habitat with high potential productivity affected by sediment deposition. Establishment or growth of Nooksack dace populations in habitat reaches with high potential productivity where sediment deposition has been addressed.
Ensure the integrity and proper functioning of riparian zones throughout watersheds.	Length and area of riparian habitat restored in each watershed. Proportion of habitat with high potential productivity for which a riparian assessment has been completed. Proportion of habitat with high potential productivity for which the results of a riparian assessment have been adopted.	Length and proportion of habitat with high potential productivity with greater than 5, 10, and 30 m of riparian reserve. Establishment or significant growth of Nooksack dace populations in habitat reaches with high potential productivity with restored riparian reserve strips.
Reduce habitat fragmentation.	Permanent and seasonal barriers to movement mapped in each watershed.	Quantity of habitat reconnected by removal of barriers. Establishment or growth of Nooksack dace populations in habitat reaches with high potential productivity where habitat fragmentation has been addressed.
Encourage stewardship amongst private landowners and the general public.	Number of non-government organizations /individuals involved in recovery activities. Number of stewardship agreements/conservation covenants signed to protect habitat with high potential productivity. Number of landowners and others reached in public education and consultation programs. Length of habitat with high potential productivity protected or restored on private	Establishment or growth of Nooksack dace populations in habitat reaches with high potential productivity on stewarded lands.

	land or with public involvement.	
Minimize toxic contamination of creeks.	Sources of toxic contamination identified. Sources of toxic contamination addressed.	Area and proportion of habitat with high potential productivity affected by contamination. Establishment or growth of Nooksack dace populations in habitat reaches with high potential productivity where toxic contamination has been addressed.
Minimize impacts of introduced predators.	Extent of habitat with high potential productivity occupied by introduced predators mapped.	Proportion of habitat with high potential productivity containing introduced predators. Correlation of establishment or growth of Nooksack dace population with introduced predator absence.

4.7. Statement of When an Action Plan Will Be Completed

Within two years of posting the final recovery strategy, one or more Action Plans will be developed, including one or more multi-species Actions Plan for Nooksack dace and Salish sucker. The plans will include descriptions of programs, plus a timeline of programs with estimated budgets, and will encompass a timeframe of at least five years. More detailed plans are being prepared for each of the inhabited watersheds as resources and partnership opportunities become available.

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APPENDIX 1 - RECORD OF COOPERATION AND CONSULTATION

Nooksack dace are listed on Schedule 1 of the Species at Risk Act (SARA), and as an aquatic species are under federal jurisdiction and managed by Fisheries and Oceans Canada (DFO): 200 - 401 Burrard Street, Vancouver, BC.

To assist in the development of an initial draft of this Recovery Strategy, as well as those for other listed freshwater fishes in British Columbia, DFO in cooperation with the Province of BC assembled a group of experts from various levels of government, academia, consultants, and non-governmental organizations to form the Pacific Region Non-Game Freshwater Fish Recovery Team. This team, co-chaired by DFO and the Province of BC, is responsible for drafting recovery strategies for Pacific Region freshwater fish species listed under SARA, including Nooksack dace. In addition, local stakeholders have subsequently established a Recovery Implementation Group for Nooksack dace which has contacted landowners and held public information meetings on the recovery of the species.

Consultation on the draft Recovery Strategy was provided through a series of multi-stakeholder Community Dialogue Sessions and First Nations information exchanges in BC communities, as part of DFO Pacific Region's Fall Consultation Program. A consultation weblink was sent to 198 First Nations, Tribal Councils and Aboriginal Fisheries Commissions, as well as other stakeholders. Notices announcing the Community Dialogue Sessions were placed in 74 newspapers, and announcements specific to Nooksack dace were placed in an additional six newspapers. A specific presentation and discussion session on the proposed Recovery Strategy for Nooksack dace was held in Abbotsford in November 2005, with four attendees. Comments from the session were recorded and archived.

Additional input on the draft Recovery Strategy was sought through a discussion guide and feedback form available on the internet (October – December 2005). No responses were received. Input from the Province of BC and the Township of Langley was received through recovery team participation. An external peer review was requested from several outside experts but no reviews were provided. All feedback received was considered in the finalization of the Recovery Strategy.

An assessment of potential critical habitat for Nooksack Dace was reviewed by the Canadian Science Advisory Secretariat Consultation (DFO 2007) in October, 2007. Consultations on critical habitat were undertaken in February, 2008 and included letters to First Nations, landowners, and other interested parties followed by presentations and discussion sessions with local First Nations, the municipalities of Abbotsford, Langley, Burnaby and New Westminster, and the Province of BC. Public meetings, including presentations and discussions were held in Burnaby, Langley and Abbotsford. Meetings with regional agriculture committees also occurred.

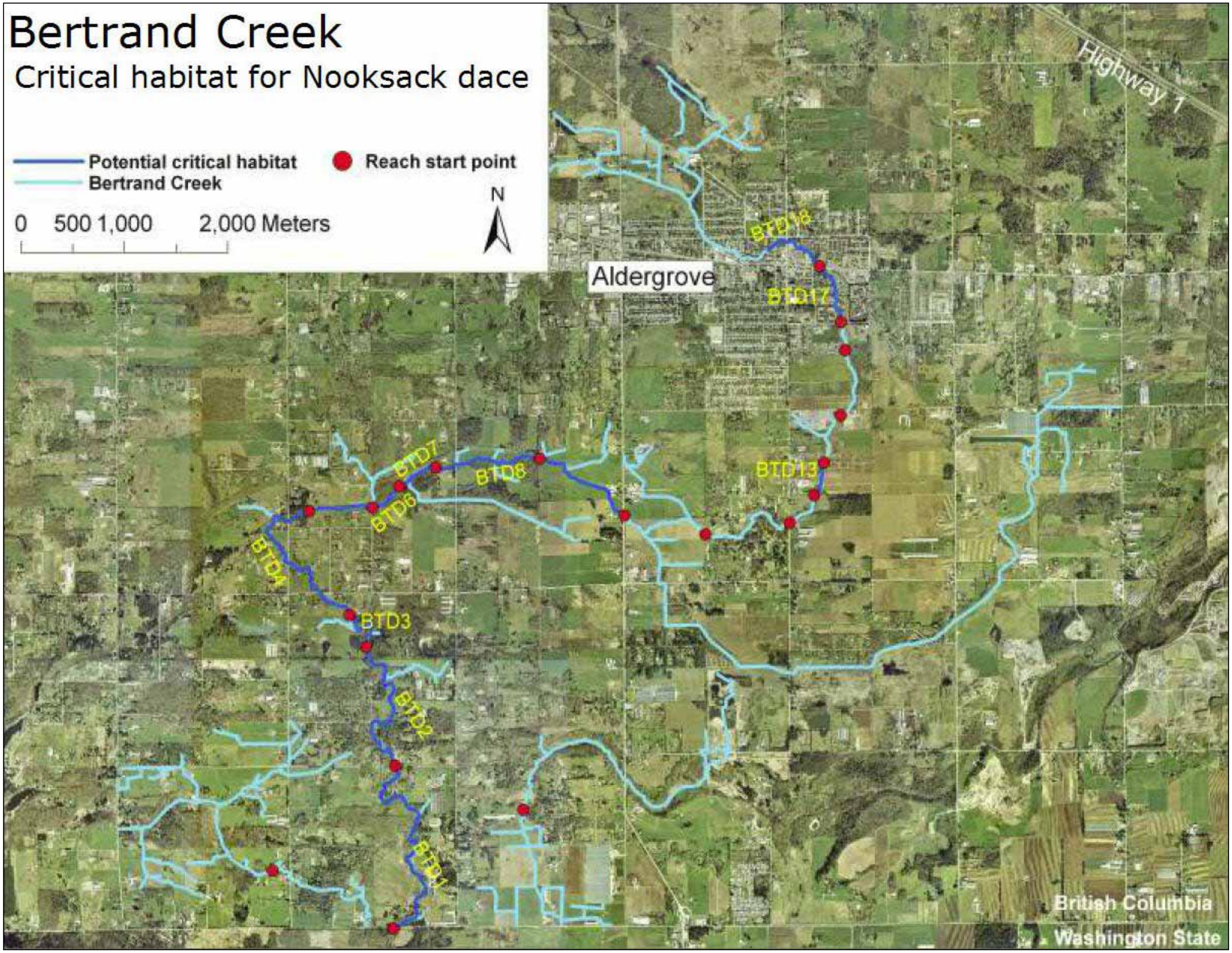
APPENDIX 2 - WATERSHED SCALE MAPS

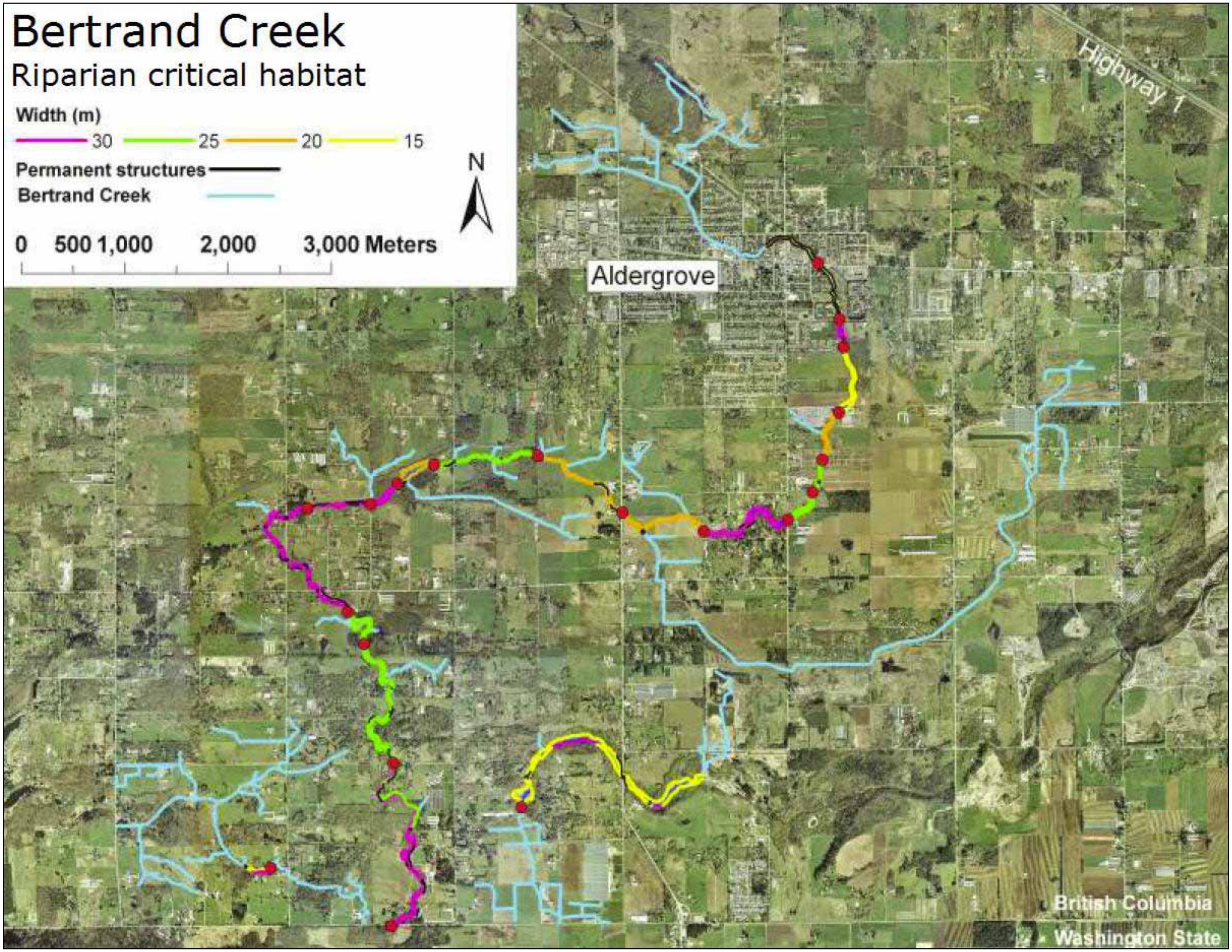
Introduction

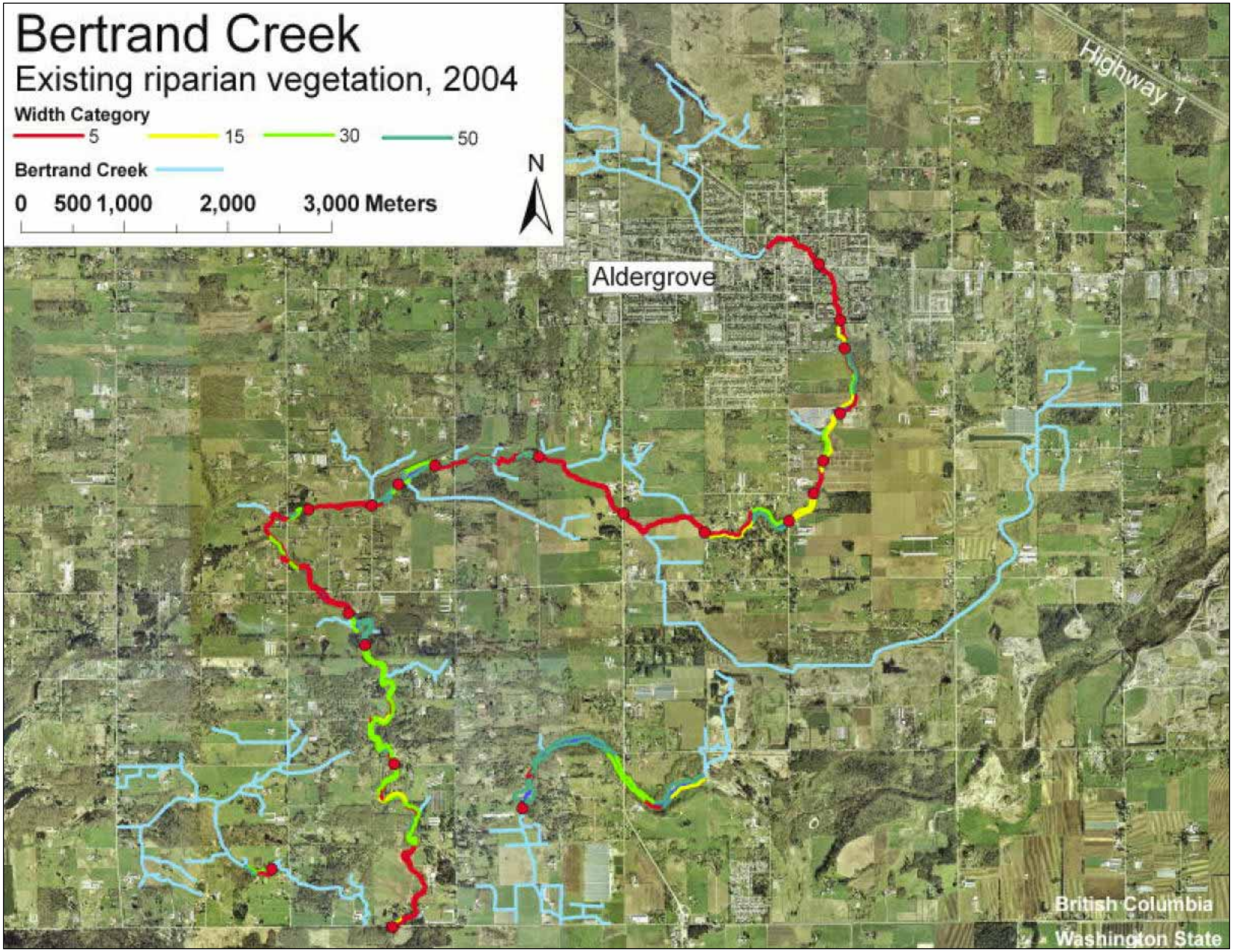
This appendix includes the GIS watershed maps from which most of the data assessing riparian critical habitat (RCH) were generated. Table 2.1 describes the three categories of maps provided for each of the watersheds included in the study.

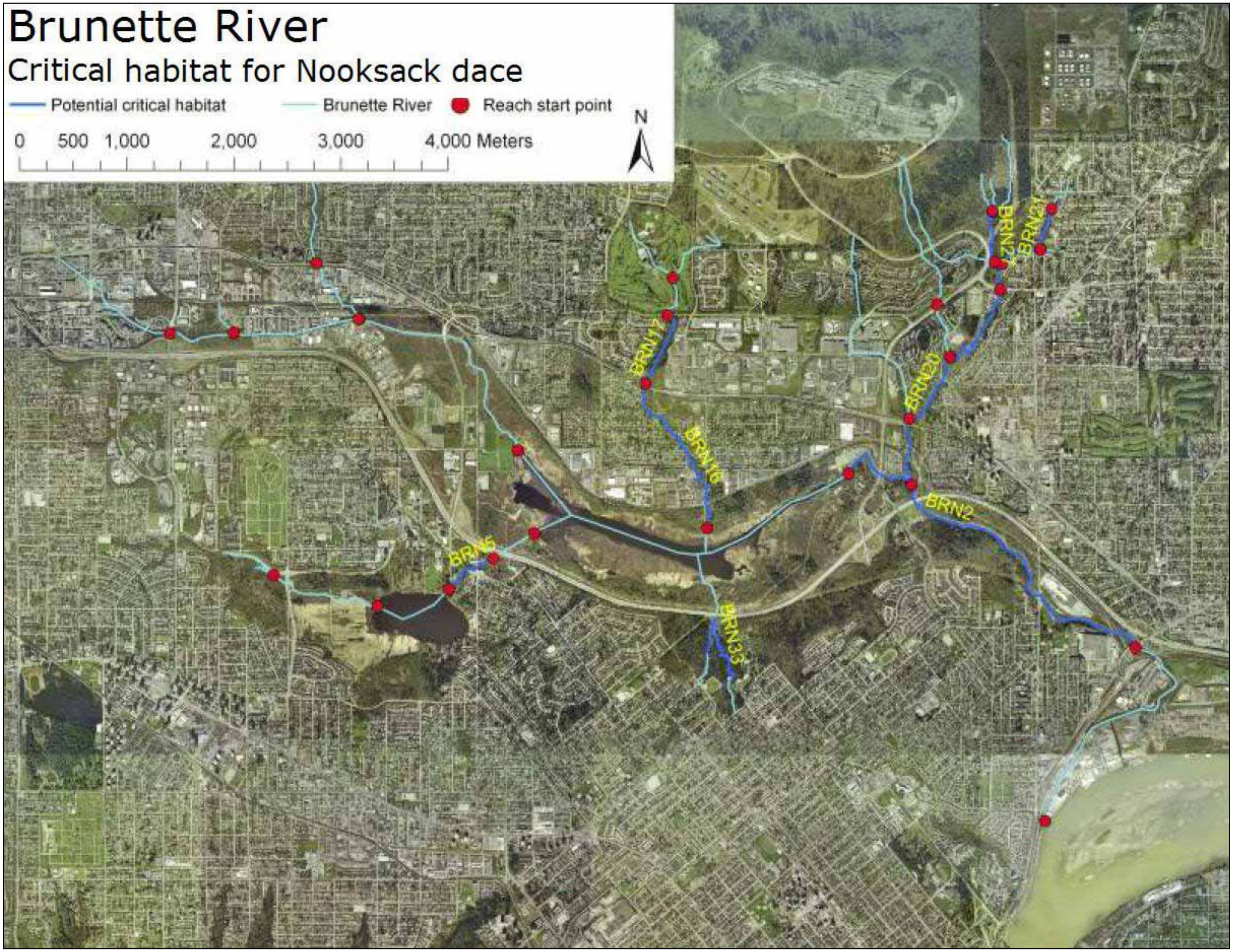
Table 2.1: Contents of the maps of each watershed included in this appendix.

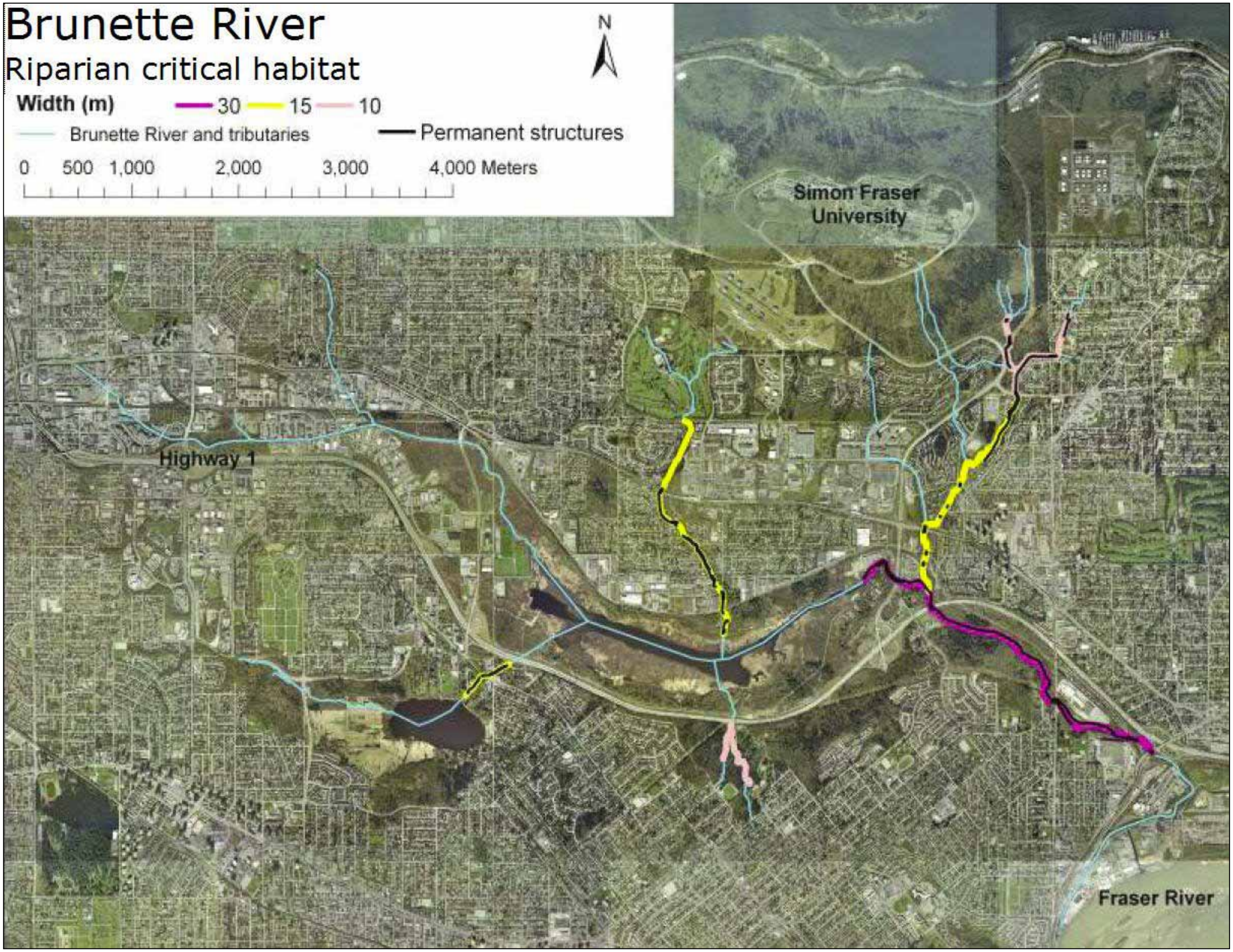
Map	Shows
Critical habitat reaches	• Critical habitat reaches for Nooksack dace.
Riparian critical habitat (RCH)	• Width categories of RCH: the calculated width of native vegetation necessary to maintain full riparian function in each reach. Categories are in 5 m increments ranging from 5 m to 30 m. • Portions of bank where RCH width is restricted by permanent structures.
Existing riparian vegetation	• Width categories of existing riparian vegetation as defined in the document.


Bertrand Creek
Critical habitat for Nooksack dace
Potential critical habitat
Bertrand Creek
Reach start point
0 500 1,000 2,000 Meters
N
Highway 1
Aldergrove
BTD18
BTD17
BTD13
BTD8
BTD7
BTD6
BTD4
BTD3
BTD2
BTD1
British Columbia
Washington State

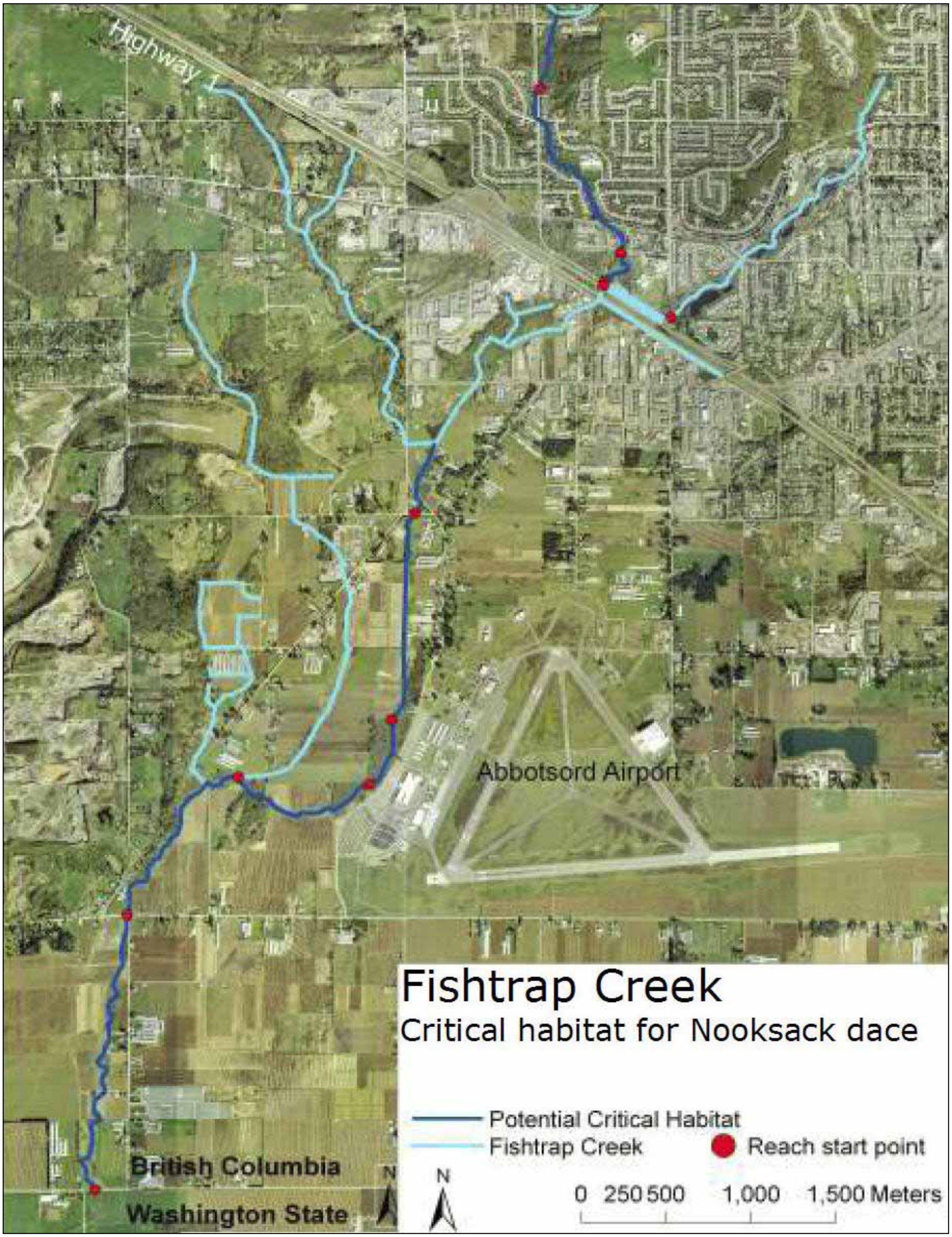

Bertrand Creek
Riparian critical habitat
Width (m)
30
25
20
15
Permanent structures
Bertrand Creek
N
0 500 1,000 2,000 3,000 Meters
Aldergrove
Highway 1
British Columbia
Washington State

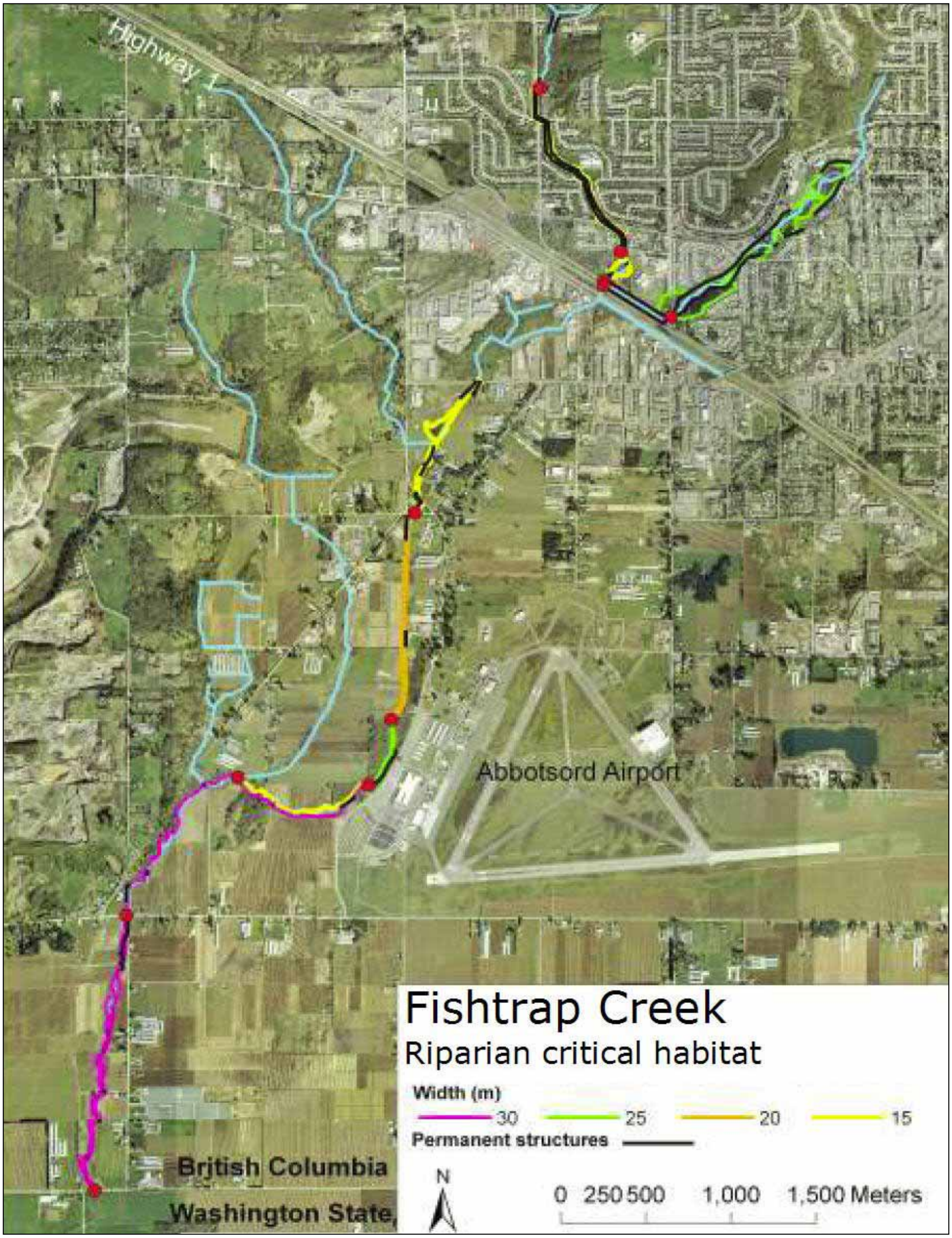

Bertrand Creek
Existing riparian vegetation, 2004
Width Category
5
15
30
50
Bertrand Creek
0 500 1,000 2,000 3,000 Meters
N
Aldergrove
Highway 1
British Columbia
Washington State

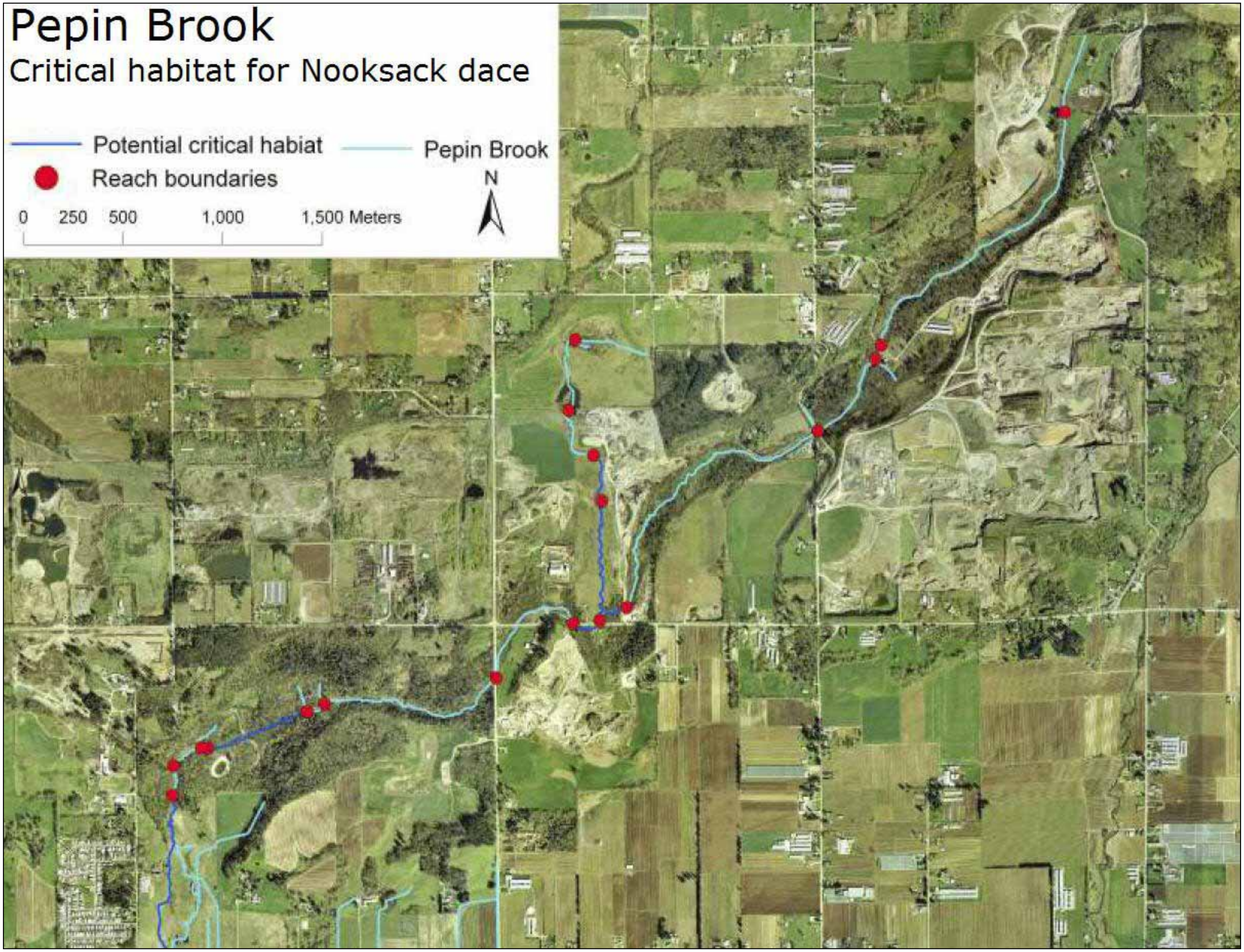

Brunette River
Critical habitat for Nooksack dace
Potential critical habitat
Brunette River
Reach start point
0 500 1,000 2,000 3,000 4,000 Meters
N
BRN24
BRN21
BRN17
BRN20
BRN16
BRN2
BRN5
BRN33

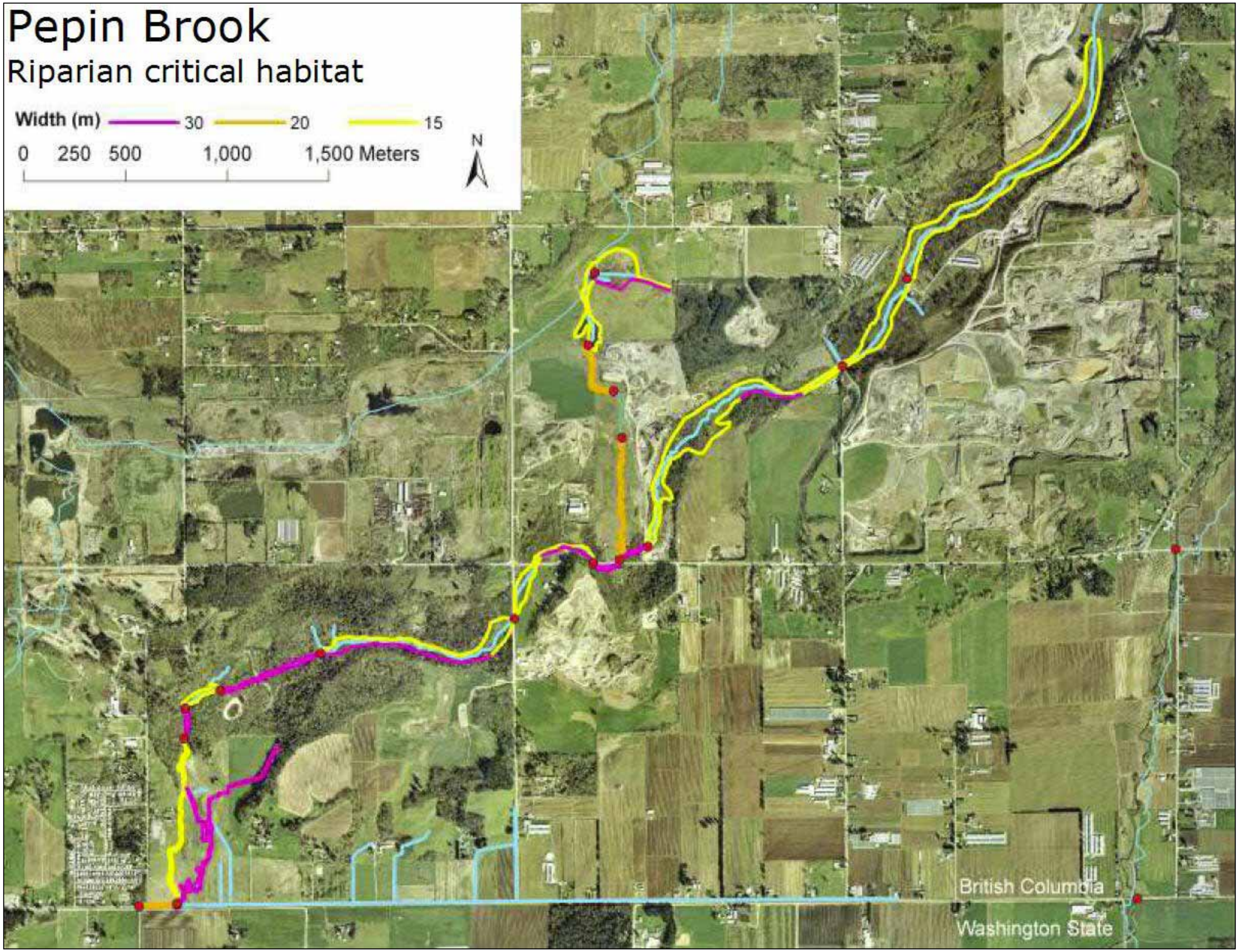

Brunette River
Riparian critical habitat
Width (m)
30
15
10
Brunette River and tributaries
Permanent structures
0
500
1,000
2,000
3,000
4,000 Meters
N
Simon Fraser University
Highway 1
Fraser River

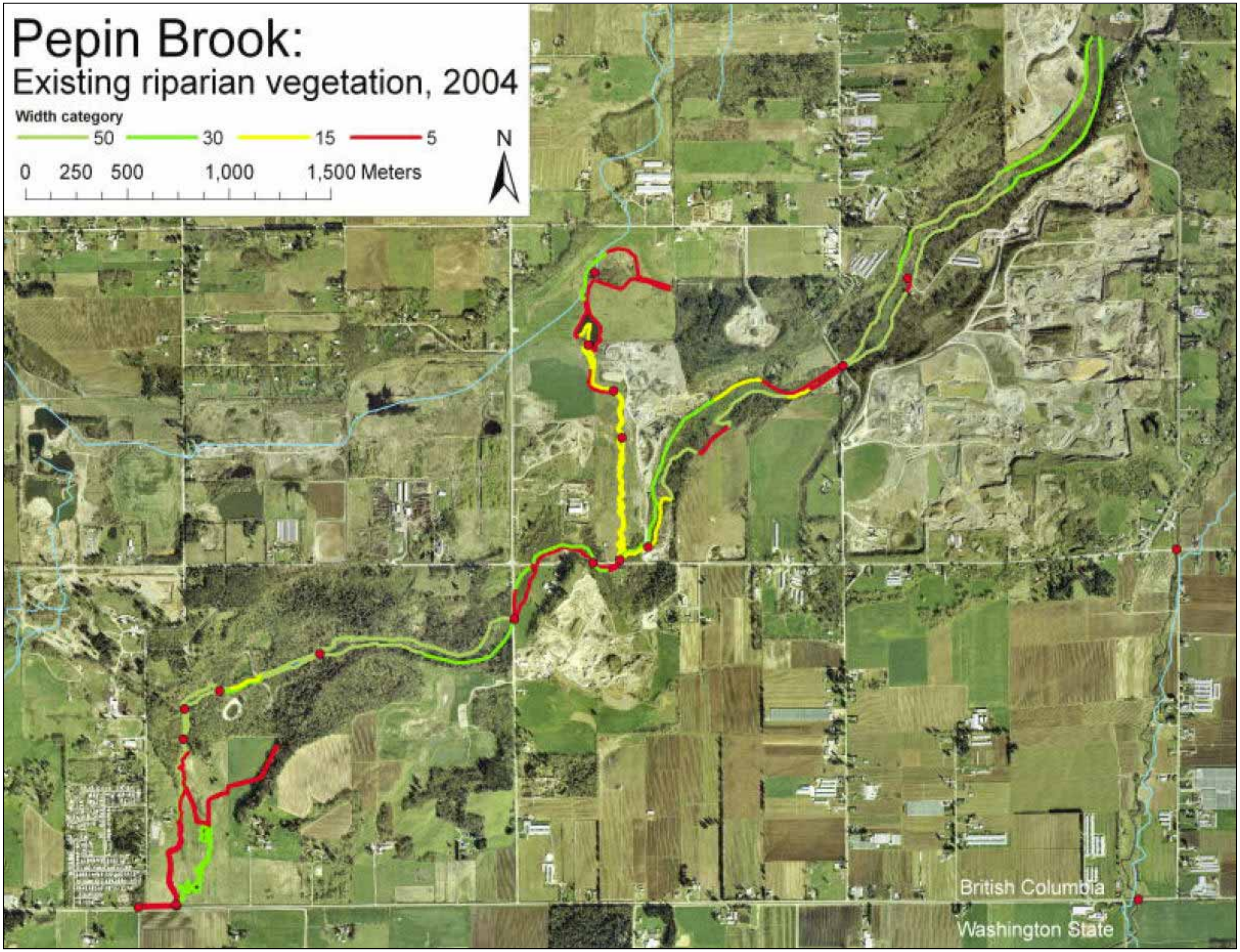

Brunette River
Existing riparian vegetation, 2004
Width Category: 50 30 15 5 Brunette River
0 500 1,000 2,000 3,000 4,000 Meters
N
Simon Fraser University
Highway 1
Fraser River


Highway 1
Abbotsord Airport
Fishtrap Creek
Critical habitat for Nooksack dace
Potential Critical Habitat
Fishtrap Creek
Reach start point
British Columbia
Washington State
N
N
0 250 500 1,000 1,500 Meters


Highway 1
Abbotsord Airport
Fishtrap Creek
Riparian critical habitat
Width (m)
30
25
20
15
Permanent structures
British Columbia
Washington State
N
0 250 500 1,000 1,500 Meters


Pepin Brook
Critical habitat for Nooksack dace
Potential critical habiat
Pepin Brook
Reach boundaries
N
0 250 500 1,000 1,500 Meters


Pepin Brook
Riparian critical habitat
Width (m) 30 20 15
0 250 500 1,000 1,500 Meters
N
British Columbia
Washington State


Pepin Brook:
Existing riparian vegetation, 2004
Width category
50
30
15
5
N
0 250 500 1,000 1,500 Meters
British Columbia
Washington State