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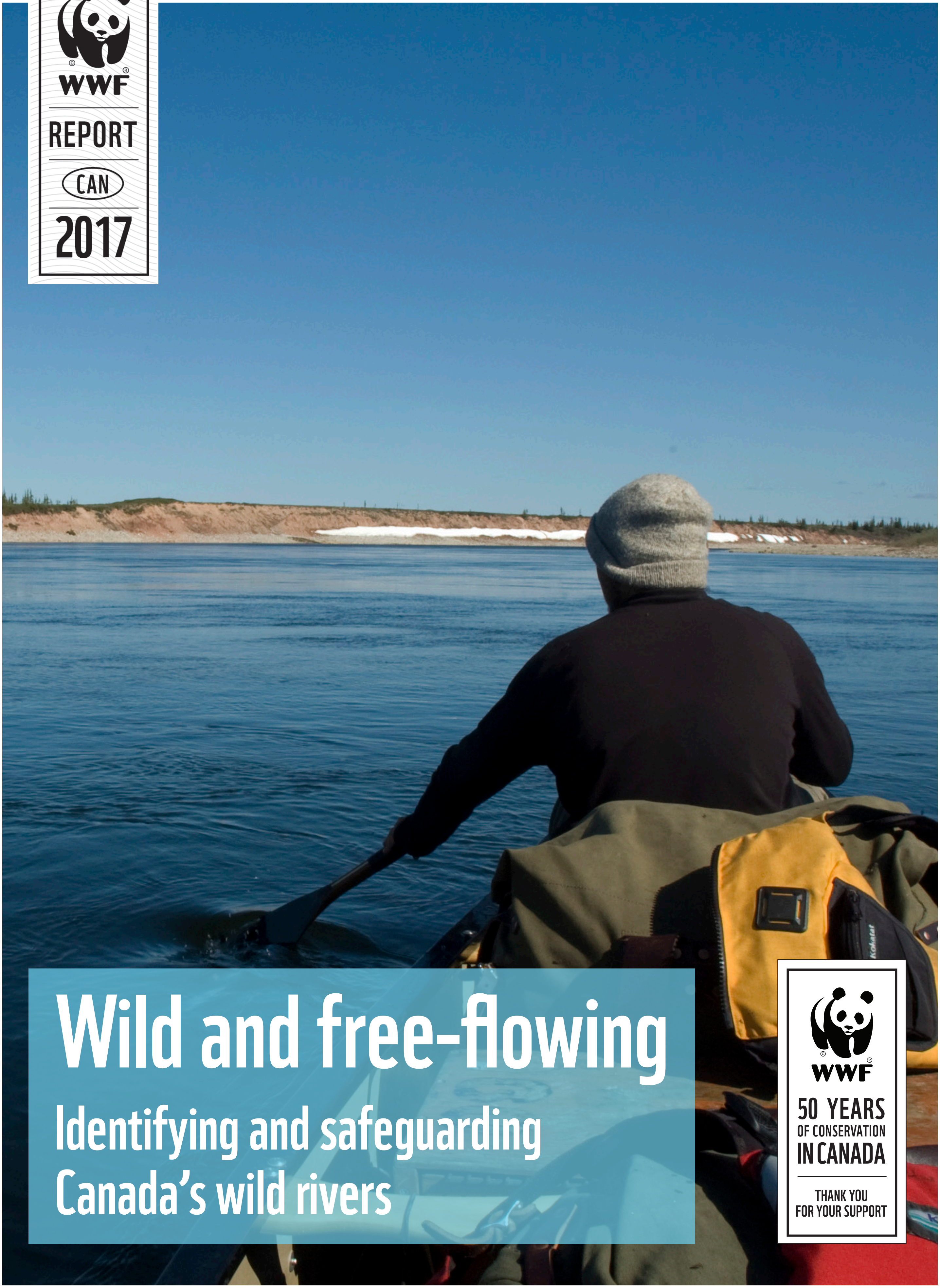

# Wild and free-flowing

## Identifying and safeguarding Canada's wild rivers

WWF

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THANK YOU FOR YOUR SUPPORT

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Cover photo: Paddler on the Thelon River, N.W.T, Canada © JEREMY HARRISON / WWF-Canada

# WILD AND FREE-FLOWING RIVERS

Historically, Canada has been a land of wild, large and free-flowing rivers teeming with abundant fish and other wildlife. These rivers have nourished Indigenous peoples for thousands of years and, over the past 150 years, have provided sustenance and supported a wide array of economic activities for Canadians in communities of all sizes throughout the country.

WWF-Canada undertook a comprehensive and systematic assessment to identify which rivers in Canada can truly be recognized as wild based on a set of criteria including pollution, habitat loss, habitat fragmentation, overuse of water, invasive species, climate change and alteration of flows.

Our goals for this work were to:

- identify Canada's remaining wild rivers,
- understand the potential threats to those rivers,
- bring awareness of the biological, cultural and economic benefits of these rivers,
- identify where regulatory regimes and/or community stewardship are already ensuring healthy and sustainable management of wild rivers and may serve as models for other regions, and
- identify where action is needed to support healthy wild rivers.

In doing this work, WWF-Canada reviewed data for millions of river reaches across the country, applied a quantitative approach and used a clearly defined set of criteria to determine which rivers were both free-flowing and wild. This report identifies the top 10 longest wild rivers in Canada. They include:

- the Liard River
- the Kazan River
- the Dubawnt River
- the Thelon River
- the Horton River
- the Anderson River
- the Taltson River
- the Stikine River
- the Ekwan River
- the Birch River

## What is a wild river?

A wild river and a free-flowing river are not one and the same. A free-flowing river is any river, or section of a river, that is not impacted by a dam.

A wild river is a free-flowing river that is not negatively impacted by pollution, habitat loss, habitat fragmentation, overuse of water, invasive species, climate change or alteration of flows. A wild river, then, is as close to its natural state as a river can be, unaltered by mankind and modern development.

## Threats to wild rivers

### POLICY GAPS

This analysis has found that there are still many wild and large free-flowing rivers remaining in Canada.  Unfortunately, there is no comprehensive legislation to protect and conserve rivers in this state. Despite some examples of local protections (see safeguarding our wild rivers section later in this report), nationally these rivers could be at risk and vulnerable to threats.

### ON-GOING DEVELOPMENT

Societies have gone to extraordinary lengths to harness the power and advantages of river systems. Dams, dykes, levees, channels, diversions and other alterations have facilitated incredible benefits: drinking water, electricity, irrigation for agricultural crops, water supply for industrial production, control of floods for land development, reduction in water-borne diseases, and finally transportation and navigation to remote corners of the Earth. Unfortunately, these efforts have had negative impacts on the freshwater ecosystems and human communities that the rivers support. In the 1930s, North America entered the “big dam” era, which lasted until the 1960s and altered the state of many North American rivers (McGrath, 2009).  Globally, only a small fraction of the world’s rivers remains unaffected by human activities. These rivers are generally in the high north (Vörösmarty et al., 2010; Pearce, 2006).

In Canada, rivers have significantly shaped the country we live in today. Canada can be called a “country of rivers” (Noel, 1995). Almost all of Canada’s freshwater eventually flows through and down rivers into just five salt water bodies: the Atlantic, Pacific and Arctic oceans, Hudson Bay and the Gulf of Mexico.

Many rivers in Canada face anthropogenic pressures in addition to dams. WWF-Canada’s Watershed Reports (2017a) found that watersheds are polluted by various activities including agricultural runoff, mining, pipeline incidents, and oil and gas development. Fragmentation occurs through the construction of roads and rail. Urbanization and forestry have resulted in the loss of habitat within watersheds across the country. Invasive species have significantly altered ecosystems. In many cases, water use for human activities is exceeding the amount of water needed to keep a river system healthy. Finally, all of Canada’s rivers are facing at least some impact of climate change. Fortunately, there are still rivers in Canada that are not significantly impacted by these stressors; however, increasing development pressures, including oil and gas exploration, mining, and hydropower development, may put these rivers at risk.

### RENEWABLE ENERGY TO ADDRESS CLIMATE CHANGE

While the era of intense dam building has slowed since the 1960s, recent demand for hydropower as an alternative low-carbon energy option has led to many proposals for new dam construction in Canada (WWF-Canada, 2009). At present, hydroelectricity provides the largest proportion of energy generation across Canada making up 59 per cent in 2014 (National Energy Board, 2016). Under various scenarios proposed in Canada’s Mid-century Long-term Low-Greenhouse Gas Development Strategy produced by Environment and Climate Change Canada (2016), a minimum of 36,000 MW of hydro capacity is required to reach Canada's greenhouse gas reduction targets. Without proper protections in place, free-flowing rivers could be at risk. It is critical that we balance our ability to generate power with our ability to preserve the many benefits provided by free-flowing rivers.

## Protecting wild rivers

The Living Planet Report produced by WWF in 2016 shows an alarming global trend within freshwater ecosystems. The Living Planet Index for freshwater found that on average, the abundance of populations monitored in global freshwater systems has declined by 81 per cent between 1970 and 2012, with habitat loss and degradation the biggest cause of decline (WWF, 2016b). Our Living Planet Report Canada found a stable trend in Canadian freshwater species populations; however, it also identified that freshwater systems were the least well-studied of all realms in Canada, suggesting that this stable trend may not be an accurate representation of Canada's freshwater systems (WWF-Canada, 2017b). Such results underscore the need to protect and monitor the remaining wild rivers that host abundant freshwater species diversity. Globally, the world is on track to double hydro power capacity by 2040, which could put free-flowing rivers across the world at risk (Moir et al., 2016). Canada has a responsibility to consider the fate of our wild rivers when making development decisions.

***WWF-Canada's analysis is the first step in safeguarding Canada's wild rivers.***

## Benefits of wild rivers

Wild rivers are like wilderness areas for freshwater, providing numerous ecological and community benefits (WWF, 2016a). Benefits include:

### ECOLOGICAL BENEFITS

#### Biodiversity

The natural flow of water within a river is pivotal to sustaining native biodiversity and ecosystem health. Healthy ecosystems are essential to the long-term viability of wildlife and human communities. Freshwater systems support ecosystem viability for both land and terrestrial based species.

Large infrastructure projects within rivers, like dams, often lead to changes in flow-regime – the dynamic patterns of all water flows – which is widely considered the "master variable" in rivers, and a significant influence in lakes, wetlands and estuaries (Walker et al, 1995). Wild rivers provide intact habitats, which support native species diversity (Reidy Liermann et al, 2012).

#### Climate change adaptation

Compared to rivers in degraded ecosystems, intact river systems are better able to adapt to changes in temperature and flow levels, which will likely occur due to climate change (Palmer et al., 2009). Additionally, when rivers are barrier free, they work as natural corridors for fish and other species, allowing them to relocate to conditions more suitable for their survival. When rivers have been dammed or diverted, it impedes the ability of species to adapt to a changing climate and may result in population loss (WWF, 2006).

#### Pollution control

Rivers transport and remove pollutants that can build up in a watershed. When the river flow is altered, pollutants can become trapped in the sediments behind dams leading to areas of high pollutant concentration. Furthermore, these pollutants can become a hazard when the lifecycle of the dam is over (WWF, 2006). Additionally, dams can negatively impact populations of species that improve water quality such as freshwater mussels (Auerbach et al., 2014).

### Unhindered transportation of nutrients

As sediments and nutrients are carried along the river's course, some are deposited along the banks and some are carried out to sea where they contribute to the health of coastal ecosystems (WWF, 2006). This movement is hindered when dams are constructed (Vorosmarty et al., 2003). Rivers with intact longitudinal connectivity can also facilitate the transportation of nutrients upstream in the bodies of anadromous fish, such as salmon, when they migrate upstream to spawn (Nilsson & Svedmark, 2002).

## COMMUNITY BENEFITS

### Healthy food supply

The physical barriers and the changes in river chemistry caused by dams can cause a decline in fish abundance and, in turn, freshwater fisheries. This decline in fish can impact communities that rely on those fish as a food source along the entire river reach (Garcia et al., 2010) as well as to water and land-based wildlife (e.g brown and grizzly bears) reliant on the fish as a food source.

### Vibrant industries

Wild rivers support tourism opportunities such as recreational fisheries, wildlife viewing and paddling industries. (Auerbach et al., 2014; Municipality of Baker Lake et al., 1989b). Additionally, these rivers can support high value commercial fisheries, providing livelihoods for the people who live around them. These fisheries and tourism outfits may be negatively impacted by dam construction (Hoeinghaus et al., 2009).

### Cultural values

Rivers play an important role in Canadian national identity, having created a sense of place and "deeply seated symbolic connections that set out the defining characteristics" of the country (Noel, 1995). The religious, spiritual, aesthetic and poetic values of rivers are best maintained when they remain wild and unthreatened by human activities.

Many of the wild rivers we identified through this analysis play significant roles in the heritage and culture of Indigenous peoples. For Inuit, for example, these rivers have spiritual importance (Nunavut Parks and Special Places and the Government of Nunavut, n.d.a.).

Given the significant ecological, cultural and economic benefits provided by wild rivers, it is critical that these unique ecosystems are safeguarded now and into the future.

# METHODOLOGY USED FOR ANALYSIS

## Identifying Canada's free-flowing rivers

This analysis focuses on free-flowing rivers remaining in continental Canada; the Arctic Archipelago was excluded due to data limitations. Seven indicators are used as the basis for analysis including pollution, habitat loss, habitat fragmentation, overuse of water, invasive species, climate change and alteration of flows.

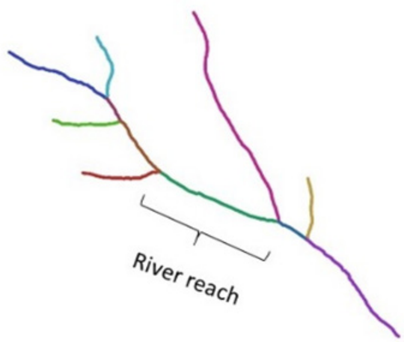



*Figure 1: Example river made up of multiple river reaches. Each colour represents one river reach.*

The analysis was conducted at the river reach level (Figure 1). A river reach is a section of a river network between two junctions of river confluences.

An analysis of river network connectivity was completed for each of Canada's 11 Water Survey of Canada major drainage basins (Figure 2) with the Geometric Network tools in ArcInfo for ArcGIS Desktop from ESRI. This analysis built upon attribute information on the direction of flow within the National Hydro Network (NHN) river networks to build an interconnected network of river flow at the basin scale. The NHN provides digital geospatial data on Canadian surface waters including: lakes, reservoirs, rivers,

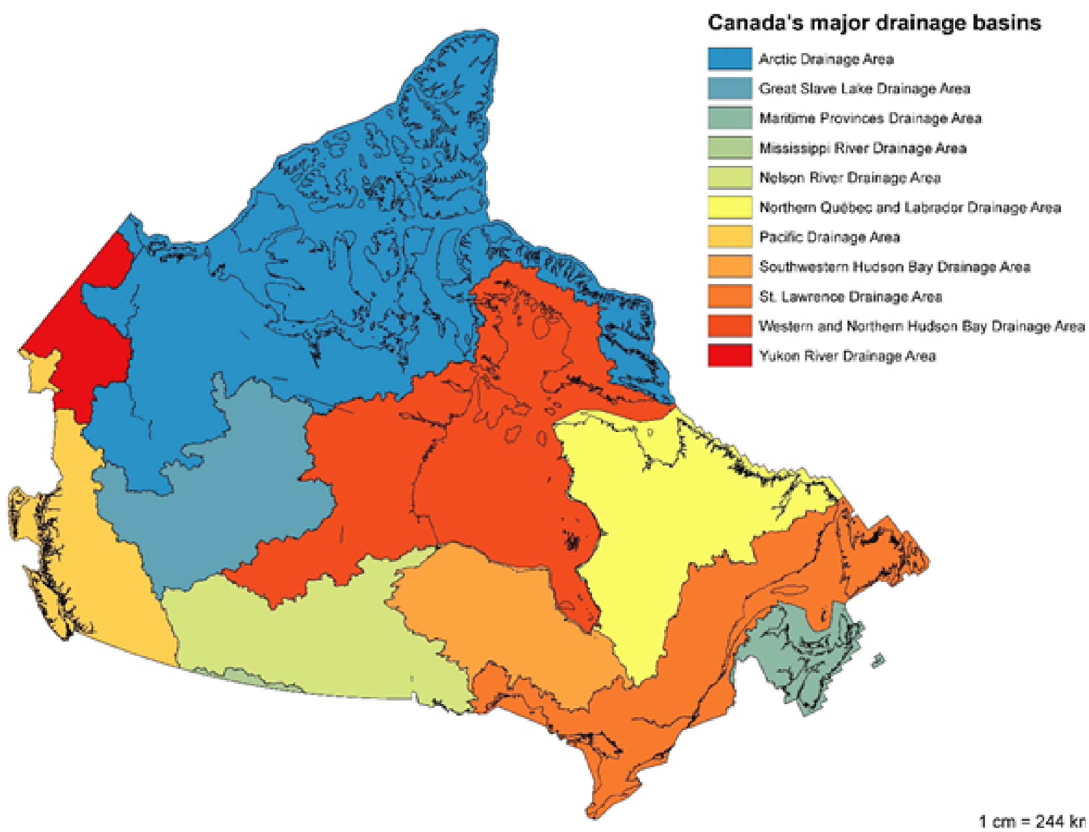



*Figure 2: Water Survey of Canada's major drainage basins.*

streams, canals, islands, drainage linear networks, toponyms or geographical names, constructions and obstacles to surface water, using the best available provincial and federal data (Natural Resources Canada, 2017). Dam data were derived from the NHN dataset MANMADE point, line and polygon layers.

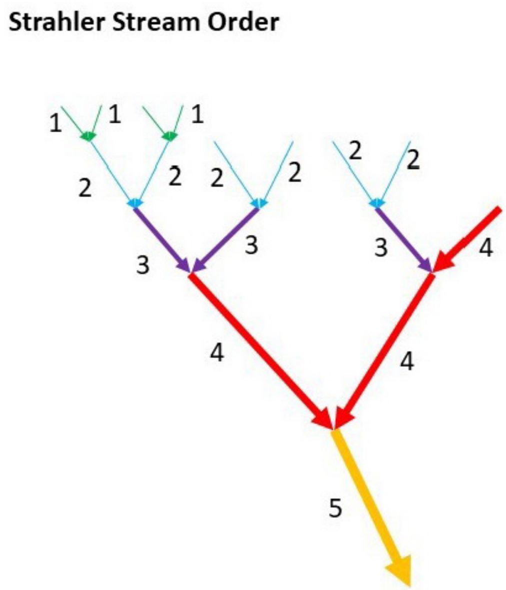


*Figure 3: Diagram depicting Strahler stream order.*

Stream order is a method used to provide a relative measure of river size, based on the hierarchical structure of river tributaries. In this analysis, Strahler stream order was calculated using either the RivEX tool in ESRI ArcMap 9.1 or running an iterative algorithm developed by WWF-Canada throughout the river networks. When calculating Strahler stream order, all headwater tributaries are assigned order one. When two upstream segments of the same order meet at a junction, the downstream segment increases by one order. When two upstream segments of different order meet at a junction, the downstream segment takes the higher order or the two incoming upstream links (Tarboton, 1991) (Figure 3).

The relative location of dams within the river networks were used to identify river sections where upstream and downstream river flows could be influenced by in-stream infrastructure. These segments were assigned a classification of "upstream," "downstream" or "upstream and downstream." Conversely, this analysis identified river networks where no dams were located and hence were considered "free-flowing" (Figure 4).

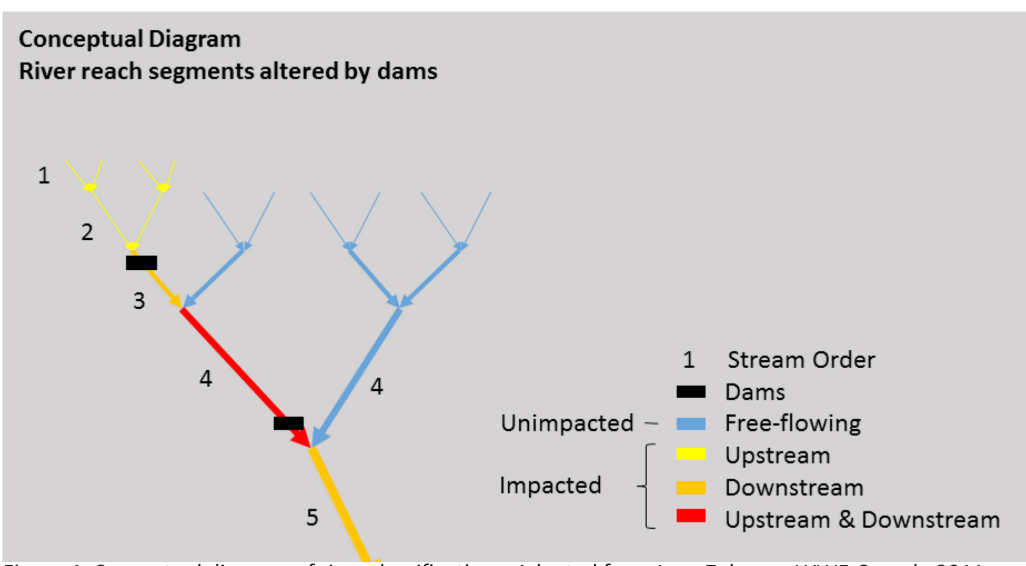


*Figure 4: Conceptual diagram of river classifications. Adapted from Juan Zuloaga, WWF-Canada 2011.*

In instances where river segments of different Strahler orders converged, the classification of the larger stream segment was carried downstream (Figure 5). In cases where segments had the same Strahler order and different classifications, the non-free-flowing classification was carried forward. As a result, it is possible for upstream sections of a river system to receive "free-flowing" status but, due to a convergence with a dammed tributary of equal or greater size, the downstream section of that river network is not considered to meet this standard. River reaches that are classified as "free-flowing" are thought of as being not impacted by dams, whereas river reaches classified as "upstream," "downstream" or "upstream and downstream" are thought to be impacted in some way by dams.

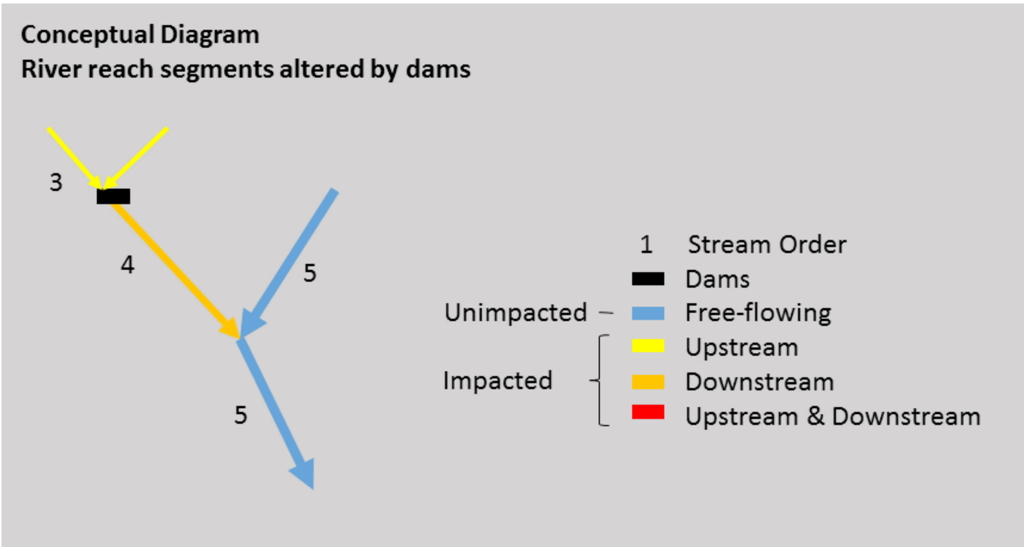



*Figure 5: Conceptual diagram demonstrating impact of Strahler order on downstream tributaries.*

Once all river segments were classified, a visual inspection was completed. The visual inspection is critical to ground-truth the analysis and to ensure accuracy. The dataset was then dissolved by river name to identify the longest remaining free-flowing rivers. River segments of Strahler order less than 4 were omitted to reduce processing burden. A limitation of this analysis is that many river segments do not have names; however, given the vast number of rivers in Canada (over 27 million river reaches were analyzed) this was the best option available.

The completed list of rivers was sorted by length and the longest rivers were identified. Again, a visual inspection was completed, and in instances where there were gaps due to unnamed segments, they were manually corrected.

## Identifying Canada's longest wild rivers

To classify rivers as wild, we then looked at the subwatersheds, or subdrainage areas (SDA) of the longest free-flowing rivers to determine if they were free from impact based on seven major indicators identified in WWF-Canada's Watershed Reports: pollution, habitat loss, habitat fragmentation, overuse of water, invasive species, climate change and alteration of flows.

Water use data was obtained from analysis completed by Statistics Canada.

The invasive species indicator was based on species richness and known impact level.

The alteration of flows indicator was classified by the total storage capacity area (in square kilometres) created by dams per sub-drainage area.

## SUB-INDICATORS

Selected indicators included sub-indicators. Sub-indicators were used for:

- **Pollution** - assessed based on four sub-indicators: 1) point source pollution; 2) pipeline incidents; 3) transportation incidents of dangerous goods; and 4) agricultural run-off.
- **Habitat loss** - in each watershed was quantified through two sub-indicators: 1) per cent of the total watershed that has been converted to agricultural lands and artificial surfaces (urban and industrial areas); and 2) per cent of the total watershed that has experienced forest loss.
- **Fragmentation** -The fragmentation indicator was developed with two sub-indicators: 1) fragmentation by dams and; 2) fragmentation by roads and rail.
- **Climate change** - was assessed through four sub-indicators: 1) summer maximum temperature anomaly; 2) winter mean temperature anomaly; 3) spring precipitation anomaly; and 4) summer precipitation anomaly.

Water use, invasive species and alteration of flow did not have any sub-indicators.

In each case, for both indicator or sub-indicator, data was mapped and class thresholds were determined based on equal intervals, percentiles or natural breaks. In cases where sub-indicators were used, results were standardized and either mean or max values across sub-indicators were used to determine an indicator score.

From there, we determined an overall score for each SDA. Individual indicator scores were standardized, and the median value across all seven indicators was used to determine final overall SDA value. These values were reclassified using equal intervals to give final indicator class thresholds (see Appendix). (For a more detailed methodology, please see WWF-Canada's Freshwater Threats Assessment.)

For this analysis, we are highlighting only the top 10 longest Wild Rivers in Canada (Figure 7). To ensure that no point source threats were present on the top 10 wild rivers, a visual inspection was completed using the National Pollution Release Inventory (Environment Canada, 2014) and the Natural Resources Canada map of producing mines (Natural Resources Canada, 2015). No significant point source threats were identified.

# RESULTS

## Free-flowing rivers

Figure 6 shows the distribution of free-flowing rivers across Canada. Unsurprisingly, the majority of free-flowing rivers in Canada fall in the North, where populations are smaller.

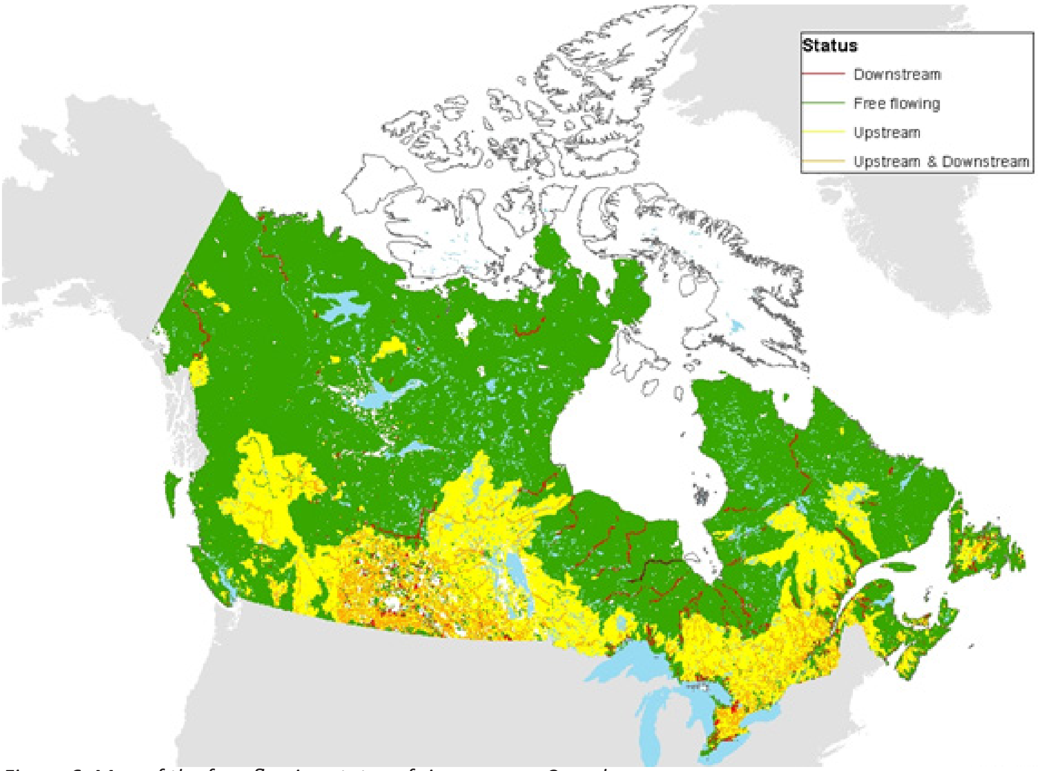
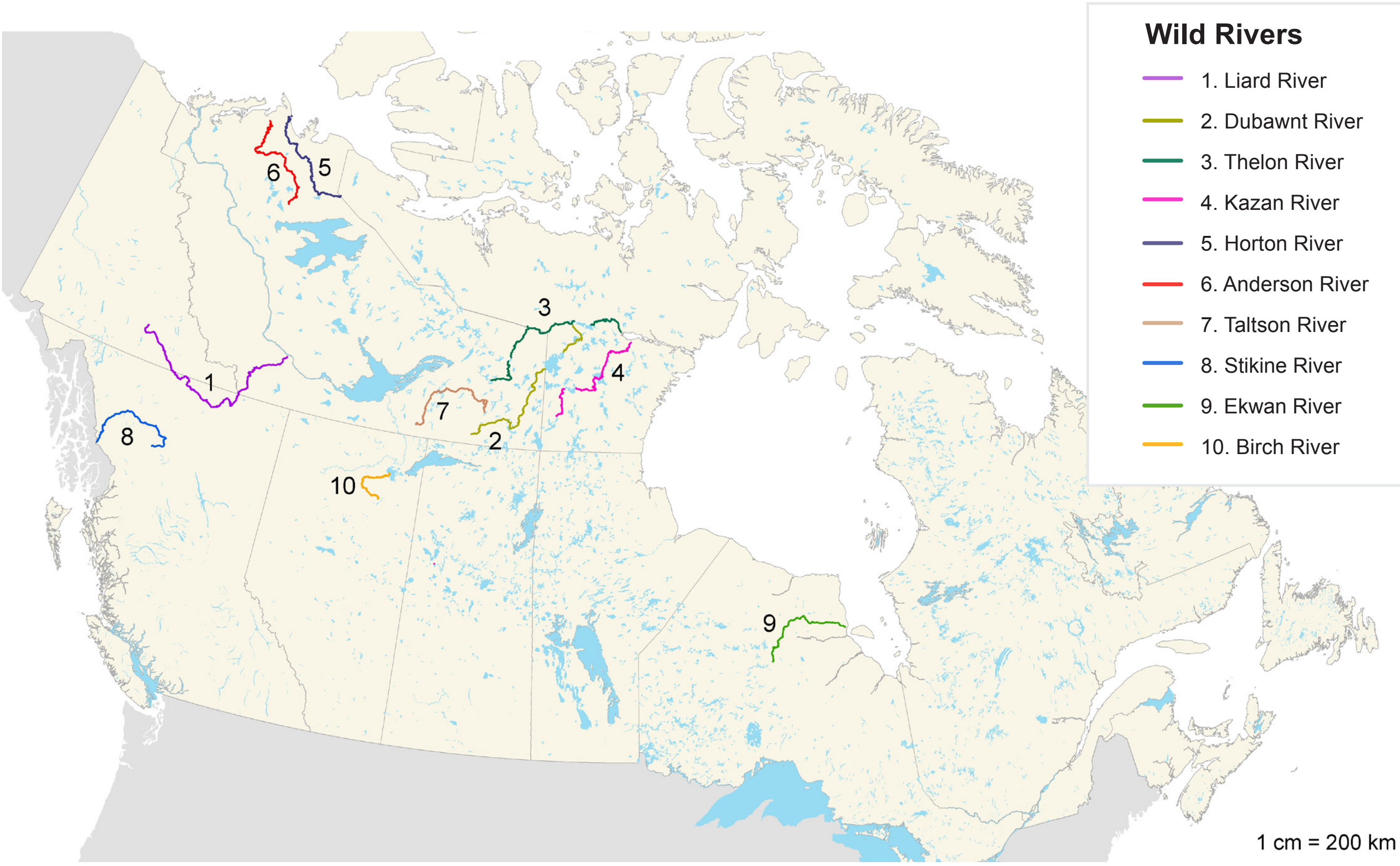



*Figure 6: Map of the free-flowing status of rivers across Canada.*

# The top 10 longest wild rivers in Canada




| River Name | Location | Wildlife that benefit | Free-flowing length in km |
|---|---|---|---|
| 1. Liard | Yukon Territory, British Columbia (B.C.), Northwest Territories (NWT) | Grizzly bear (Special Concern†); Moose; Wood bison (Special Concern†; Threatened*); Caribou (Northern Mountain Population) (Special Concern†); Bull trout (Special Concern†); Chum salmon; Muskrat | 1,210 |
| 2. Dubawnt | Nunavut, NWT | Barren-ground caribou (Threatened†); Lake trout; Muskrat | 916 |
| 3. Thelon | Nunavut, NWT | Barren-ground caribou (Threatened†); Arctic grayling; Grizzly bear (Special Concern†*) | 902 |
| 4. Kazan | Nunavut | Barren-ground caribou (Threatened†); Muskox; Arctic char | 733 |
| 5. Horton | NWT | Lake trout; Muskox; Arctic char | 733 |
| 6. Anderson | NWT | Grizzly bear (Special Concern†*); Barren-ground caribou (Threatened†); Green-winged teal | 703 |
| 7. Taltson | NWT | Wood bison (Special Concern†; Threatened*); Tundra swan; Muskrat | 632 |
| 8. Stikine | B.C. | Black bear; Chinook salmon | 580 |
| 9. Ekwan | Ontario | Lake sturgeon (Special Concern†) | 560 |
| 10. Birch | Alberta | Northern pike; Wood bison (Special Concern†; Threatened*); Mountain whitefish | 552 |

*Species at Risk Act 2002

†Committee on the Status of Endangered Wildlife in Canada

While WWF-Canada's wild rivers face the fewest stressors, their remoteness makes them more difficult to monitor. According to WWF-Canada's Watershed Reports, many of the wild river watersheds are currently data deficient for four health indicators that are key for understanding river health: flow, water quality, benthic invertebrates and fish. A lack of health data makes it difficult to know how human actions are impacting the health of these wild rivers.

## SPECIES PROFILES

Many species at risk, such as lake sturgeon and barren-ground caribou, benefit from the intact river ecosystems wild rivers provide.

**Lake sturgeon** – considered "living fossils" because they are remarkably unchanged after hundreds of millions of years – require different habitats for different life stages (Golder Associates Ltd., 2011) in order to grow to their full three-metre length and 180-kilogram weight. Their numbers have plummeted due to commercial fishing, habitat loss, fragmentation and degradation from dams in Canada; those remaining have been identified as endangered, threatened or of special concern by the Committee on the Status of Endangered Wildlife in Canada. Wild rivers, like the Ekwan, are critical to their survival.

**Barren-ground caribou**, one of Canada's most iconic species, are found across the North, including in the watersheds of wild rivers such as the Thelon, Kazan and Dubawnt rivers. During their migration, barren-ground caribou cross the rivers at consistent spots to reach calving grounds. Caribou continue to play a significant role in the cultural life of Indigenous communities of the North. The caribou river crossings are bountiful hunting grounds, providing food and clothing, and have long been advocated by Indigenous communities to be designated as protected areas to safeguard barren-ground caribou for generations to come. The draft Nunavut Land Use Plan currently proposes protections for caribou freshwater crossings and caribou calving areas. Once widely abundant, caribou herds are facing significant decline, in some herds by over 90 per cent, from threats such as habitat loss and climate change.

# THE WILD RIVERS

Each of these rivers supports a rich diversity of species, often including species designated under the *Species at Risk Act (2002)* such as barren-ground caribou and grizzly bears. Communities up and down these rivers develop their own cultures and identities based on the river. These rivers often support industries and the communities who live along them. They are worth celebrating and protecting. In some cases, the significance of these rivers has already been recognized, and protected areas, parks or legislation already exist to protect them. In other cases, no such protections exist.

## Liard River

The Liard River, the longest of our Wild Rivers, spans the Yukon Territory, northern British Columbia and Northwest Territories, and is a tributary of the Mackenzie River. Due to the long and cold winters in the region, the river is covered with ice for nearly half the year. The ice break-up on the Liard is significant and known to trigger the ice break-up of the Mackenzie River (Francis, 2014). The region was central in the fur trade in Canada, specifically the confluence of the Liard and the MacKenzie rivers, which is where the town of Fort Simpson is found (Wonders et al., 2015).

The Liard River watershed is home to many important species, such as grizzly bear, moose, wolverine, ptarmigan, snowy owl and Rocky Mountain elk (Francis, 2014). It also supports the Nahinni population of wood bison, which were successfully reintroduced in the 1980s (Larter and Allaire, 2007).

The river also sustains a high value fishing industry, with populations of chum salmon, Arctic grayling, bull trout, inconnu, mountain whitefish, lake whitefish, northern pike and burbot. Other species of fish found in the Liard River include lake chub, slimy sculpin, the long nose sucker, the white sucker and the long nose dace (BC Parks, 2016). The area around the river is productive for forestry and has potential for mining interest and oil and gas exploration (Fort Nelson Land and Resource Management Plan, 2007).

Traditionally the Upper Liard is the territory of the Kaska people, and the Lower Liard is the territory of the South Slavey, a major group of Dene (Francis, 2014). Both were nomadic people, relying on the watershed for hunting, trapping and fishing (Francis, 2014).

Several protected areas and parks are currently found along the Liard River, including the Liard River Corridor Provincial Park, Liard River Corridor Protected Area, Liard River Hot Springs Park and Scatter River Old Growth Provincial Park (B.C. Parks, n.d.a)

In the past, B.C. Hydro indicated interest in constructing a large 4,000 MW project on the Liard River, consisting of three dams and power plants (BC Hydro, 2008). However, this project is no longer being considered due to new legislation, including the creation of protected areas (BC Hydro, 2013). While the proposed hydro project has been abandoned, and some protections are in place, there is significant interest in oil and gas development in the watershed, which could threaten the wild status of this magnificent river.

## Dubawnt River

The Dubawnt River crosses the border between the Northwest Territories and Nunavut, beginning in a series of lakes (including Wholdaia, Boyd, Barlow, Nicholson, Dubawnt, Wharton and Marjorie lakes) before it joins the Thelon River at Beverly Lake (Marsh, 2006). A portion of the river flows through the Thelon Wildlife Sanctuary. Established in 1927, the sanctuary covers an area of 52,000 square kilometres in Canada's central tundra natural region (Nunavut Tourism n.d.a.).

The Dubawnt River watershed is habitat for the Beverly and Ahiak Barren-ground caribou herds (Government of Northwest Territories, 2015). It is also an important migratory bird nesting site, including for lesser snow geese, and is home to foxes, wolves, muskox and grizzly bears (McKelvey et al, 2010; Gault, 2003).

The name Dubawnt is from the Chipewyan word *tobotua*, which means "water shore," possibly referencing the water between the remaining ice and the shore in late spring (Marsh, 2006).

The Dubawnt River offers large fish and catch volumes for fisherman as well as opportunities for wildlife viewing. It is also a popular paddling destination (Nunavut Tourism, n.d.). Along the river, paddlers can find markers left by J.B. Tyrell who charted the Dubawnt in 1893 for the Geological Survey of Canada (Gault, 2003).

## Thelon River

The Thelon River has been designated a Canadian Heritage River (Canadian Heritage River System, 2016). Located in Nunavut, it is found within a transition ecosystem referred to as an "Arctic Oasis" because the river supports a healthy stand of boreal forest while being surrounded by Arctic tundra. As a result, the area is habitat to a unique blend of Arctic and boreal species and has incredible biological diversity (Municipality of Baker Lake et al., 1989b). For example, both moose and muskox populations are found along the Thelon River (Municipality of Baker Lake et al, 1989b). The muskox populations, once threatened, have recovered due to the creation of the Thelon Wildlife Sanctuary (Nunavut Parks and Special Places and Government of Nunavut n.d.b.). The river supports many other incredible species. The Beverly and Qamanirjuaq caribou herds, which consist of up to 500,000 individuals, follow the river to a calving area north of Beverly Lake (Nunavut Parks and Special Places and Government of Nunavut, n.d.b.). The Thelon river watershed is home to the largest flock of greater Canada geese, lesser snow geese, wolverine, Arctic fox and Arctic wolf. It provides nesting grounds for peregrine falcons, gyrfalcons and rough-legged hawks, and denning grounds for barren-ground grizzly (Nunavut Parks and Special Places and Government of Nunavut, n.d.b.). Within the river, a mix of Arctic and boreal fish species, such as Arctic char, grayling, cisco, humpback and round whitefish, slimy sculpin, spoonhead sculpin and lake trout, co-exist (Nunavut Tourism, n.d.a.).

Historically, the Thelon River was home to Dene and Inuit people (Municipality of Baker Lake et al., 1989b). Evidence demonstrates that the watershed has been used for centuries by 11 distinct groups of Caribou Inuit peoples. Inukshuk, significant markers of past and present Inuit culture, can be found throughout the watershed. The inukshuk marks significant aspects of Inuit life including fishing spots, caribou crossings, land and water routes, and lookouts (Nunavut Parks and Special Places and Government of Nunavut, n.d.b.).

The current Inuit residents of Baker Lake are Caribou Inuit people. They are the only inland, non-coastal Inuit community in Canada (Nunavut Tourism, n.d.b.). The Thelon has supported their way of life and provided great spiritual value for thousands of years. The Thelon River continues to play a crucial role in the lives of Inuit families residing in Baker Lake (Nunavut Tourism, n.d.b.).

The river also played a significant role in the exploration of Canada's North. It provided passage into large regions of Canada which had previously been undiscovered by European settlers (Municipality of Baker Lake et al., 1989b).

While the area does not have a large tourism industry, the primary activity along the Thelon River is wilderness canoeing (Municipality of Baker Lake et al., 1989b). The season is only 8-10 weeks, and the number of canoeists averages around 100 per year (Nunavut Parks and Special Places and Government of Nunavut, n.d.b.; Nunavut Tourism, n.d.b.). It is also a prime location for sport fishing, hiking and camping (Municipality of Baker Lake et al., 1989b).

The Thelon River management, or heritage, strategy was prepared in 1989 with consultation from community groups, First Nations communities, regional organizations, government departments and private sector representatives. The presence of the Thelon Wilderness Sanctuary offers substantial protection to the river. Aside from subsistence hunting, no hunting or mineral developments are permitted within the protected area (Nunavut Parks and Special Places and Government of Nunavut, 2008b).

## Kazan River

Also located in Nunavut, the Kazan River is another Canadian Heritage River. The area has an interesting geological history – during the Wisconsin Glaciation (85,000 to 11,000 years ago), the Keewatin Ice Divide was found in this region, meaning the ice was thickest and remained longer than anywhere else in mainland Canada. Now the land in the region, once compressed by the weight of the ice, is rising at one of the highest rates in the world (Nunavut Parks and Special Places and Government of Nunavut, n.d.a.).

The northern portion of the river passes through a transitional zone between boreal and Arctic tundra ranges, which contribute to significant species diversity (Department of Sustainable Development, 2000). Species found in this watershed include wolverine, four species of loon (including the yellow-billed loon), snow owls, tundra swans and peregrine falcons (Nunavut Parks and Special Places, and Government of Nunavut, n.d.a.). Muskox were almost extirpated from the area during the 19th century due to demand in Europe for muskox robes; however, successful conservation efforts have stabilized the population (Canadian Heritage River System, 2016). The river is also along the migration route of both the Qamanirjuaq and Beverly caribou herds (Nunavut Parks and Special Places and Government of Nunavut, n.d.a.).

Evidence indicates that Dene and Inuit communities lived along the river for more than 5,000 years. During the summer they stayed close to the river and then migrated to the tree line or the coast for the rest of the year (Canadian Heritage River System, 2016). In fact, the river gets its name from the Dene word for 'ptarmigan' (Nunavut Parks and Special Places and Government of Nunavut, n.d.a.). Eventually the Dene reduced their use, and the first generation of Caribou Inuit began inhabiting the river year-round. The river played a large role in their ability to remain in the area over the winter, and this area is considered the birthplace of the Caribou Inuit culture (Nunavut Parks and Special Places and Government of Nunavut, n.d.a.; Nunavut Parks and Special Places and Government of Nunavut, 2008; Municipality of Baker Lake et al., 1989a). Along the river is a 30 km stretch of caribou crossing which has been designated as the Fall Caribou Crossing National Historic Site. Here, generations of Caribou Inuit have hunted, allowing them to survive the long winters (Nunavut Parks and Special Places and Government of Nunavut, 2008). The local Caribou Inuit along the river still travel by canoe and kayak while hunting and fishing (Canadian Heritage River System, 2016).

Activities along the Kazan include wilderness paddling, camping, hiking and fishing. Canoe trips down the river take four to six weeks and can include a variety of different types of paddling in the same day (Nunavut Parks and Special Places and Government of Nunavut, n.d.a.). Birders who visit the region can see Arctic terns, tundra swans, snowy owls and, of course, ptarmigans (Canadian Heritage River System, 2016). The river also supports Arctic grayling and lake trout fisheries.

## Horton River

The Horton River is located in the north of the Northwest Territories. It is home of the Smoking Hills. The name comes from the spontaneous ignition of deposits of carbon-rich shale and sulphur-rich pyrite as they are exposed to the air through erosion (CBC, 2016).

The wilderness paddling industry along the river offers paddlers the opportunity to see wildlife such as caribou, muskox, wolves, grizzly bears, golden eagles, peregrine falcons and gyrfalcons. Recreational fisheries include lake trout, grayling and Arctic char (Northwest Territories Tourism, 2016).

## Anderson River

Located in the Northwest Territories, the Anderson River flows into the Arctic Ocean. The Inuvialuit name for the river is “Kuuk” which means river (Inuvialuit Pitqusiit Inuuniarutait, n.d.a.). The river got the name Anderson River after James Anderson, a Hudson’s Bay Company employee who was in charge of the area in the 1860s (Francis, 2014).

The Anderson River Delta Migratory Bird Sanctuary (MBS) is located at the mouth of the river. Within the sanctuary is a diversity of habitat from coastal beaches to tundra which provides important feeding nesting and feeding territory for waterfowl and shorebirds (Environment and Climate Change Canada, 2016b). A total of 104 bird species use the sanctuary for various activities. Key bird species include: black brant, lesser snow goose, tundra swan, greater white-fronted goose, Canada goose, king eider, long-tailed duck, northern pintail, green-winged teal, mallard, American wigeon, greater scaup and white-winged scoter (Environment and Climate Change Canada, 2016b). The migration route of the Bluenose caribou herd travels through the watershed (Inuvialuit Pitqusiit Inuuniarutait, n.d.b).

This river was also home to the Eskimo curlew, a bird which many now believe to be extinct. The last bird was sighted along the Anderson River in 1989 (Bird Studies Canada, n.d.). In fact, this region inspired the book *The Last of the Curlew* by Canadian author Fred Bodsworth, which was included in school reading lists for many years.

Historically this area was inhabited by Inuvialuit communities, which were divided into eight regional groups, collectively called the Siglit (University of Calgary, 2010). The Siglit who lived along the Anderson River are now called the Anderson River people. They dispersed from the area as a result of disease such as scarlet fever and measles, likely joining other regional groups (University of Calgary, 2010; Inuvialuit Pitqusiit Inuuniarutait, n.d.a.).

## Taltson River

Taltson River is in the Northwest Territories and flows into Great Slave Lake; however, the wild portion of the river stops short of Great Slave Lake due to the presence of the Taltson Hydro plant, which is located north of Fort Smith and has a capacity of 18MW.  (Northwest Territories Power Corporation, 2014).

The watershed is the traditional territory of the Tatsanottine Dene (Freeman, 2008). Throughout the 1920s the area supported a prosperous trapping industry, however after the Second World War, economic pressures caused trading posts to close (Freeman, 2008).

The watershed is important habitat for several species at risk. It is one of three rivers in the Northwest Territories to have northern leopard frogs (Special Concern). The occupied range in the NWT has drastically reduced since the 1980s, likely indicating that the population size has shrunk as well. Not much is known about the Northwest Territories population; however, a Northwest Territories Amphibian Management Plan is being developed to address the needs of all amphibians in NWT, including the northern leopard frog (Government of Northwest Territories, 2013).

The Taltson is also home to the shortjaw cisco, a deepwater member of the whitefish family, which is designated as threatened under COSEWIC. Over-exploitation and competition from introduced species resulted in populations significantly declining from their formerly abundant numbers in the 1930s. Very little information exists about the Northwest Territories population. (Government of Northwest Territories, 2013).

The Taltson River watershed also supports the Slave River Lowlands population of the threatened wood bison. Wood bison populations have been declining in NWT for the past three generations, and threats include changes in flow regimes, thus underscoring the need for protections for this wild river (Species at Risk Committee, 2016).

## Stikine River

The Stikine River is located in Northwestern British Columbia. The name “Stikine” means “the great river” in Tlingit. The Tlingit people lived along the West Coast and often travelled upriver to dry salmon and harvest berries (Fox, 2006). The Stikine River is the traditional territory of the Tahltan native communities (Fox, 2006). Trade between the Tlingit and Tahltan was important to their economies (Fox, 2006; Kennedy, 2007). Tahltan communities still live along the Stikine River today (BC Parks, n.d.b). Historically, the river was used as a route by non-native peoples to reach inland; many used it to reach the Klondike Goldfields in the late 1800s (Fox, 2006).

Separating the upper and lower reaches of the river, near Telegraph Creek, is the Grand Canyon of the Stikine River (Fox, 2006). It is a steep-walled canyon, 80 kilometres long. While the canyon is considered unnavigable by watercraft, extreme paddlers successfully complete the run (Kayak Session, 2013).

The Stikine River Provincial Park was established in 1987 to protect the beautiful Stikine River, including the Grand Canyon portion (BC Parks, n.d.a.). Today it is home to mountain goats, grizzly bears, black bears, moose, stone sheep, salmon, wolves, coyotes and caribou. Fish species found within the river include Dolly Varden, Arctic grayling and rainbow trout, Chinook salmon and steelhead.  Within the park, activities such as canoeing, fishing, hiking, horseback riding and hunting are permitted (BC Parks, n.d.b).

Designated under the B.C. Fish Protection Act (1997), and upheld in the Water Sustainability Act (2016), the Stikine is a “protected river” which means that new dams are prohibited on the mainstem (Fish Protection Act, 1997). This Act was the first of its kind in Canada, and will ensure that the Stikine remains wild for generations to come (British Columbia Ministry of Environment, n.d.). Other provinces can look to the Fish Protection Act as a potential model for protecting wild rivers within their own jurisdictions.

## Ekwan River

The Ekwan River is in the Kenora district of Northern Ontario and is the southernmost of our wild rivers. The region is governed by the Mushkegowuk Council, which represents seven First Nations in Western James Bay and Hudson’s Bay: Attawapiskat First Nation, Taykwa Tagamou First Nation, Kashechewan First Nation, Fort Albany First Nation, Moose Cree First Nation, Chapleau Cree First Nation, and Missanabie Cree First Nation (Mushkegowuk Council, 2012).

The Ekwan River is home to several species at risk including caribou (Boreal population) (Government of Ontario, 2016) and the Southern Hudson Bay/James Bay population of lake sturgeon, which is considered of Special Concern by COSEWIC (Government of Ontario, 2015).

While current threats are low, the Ekwan may be at risk from mining development, as the Ring of Fire is located in the headwaters of this watershed (Mushkegowuk Council, 2012). The Ring of Fire is a proposed chromite mining development approximately 400 kilometres north of Thunder Bay (Tencer, 2013). The project has faced significant challenges, including lack of access to necessary infrastructure, declining commodity prices, significant environmental concerns and lack of support from First Nations communities, leading to declining support from the federal government (Younglai, 2016). The future of this project remains unknown; however, if it were to proceed, it would likely have significant impacts on the Ekwan River.

## Birch River

The Birch River in northern Alberta flows into Lake Claire and the Peace-Athabasca Delta. The Peace-Athabasca Delta is one of the world’s largest freshwater deltas and is significant habitat for migratory waterfowl from across North America (Parks Canada, 2016).

The delta is sensitive to changes in flow level, therefore any development on Birch River could have negative downstream impacts on this ecological treasure (Struzik, 2013). Fortunately, a large portion of the river flows through Wood Buffalo National Park, which was created in 1922. It is

Canada's largest national park, one of the largest national parks in the world, and a UNESCO World Heritage Site (Parks Canada, 2016). Birch River runs through the southern portion of this park. This extraordinary region is home to one of the biggest free-roaming buffalo herds in the world (Parks Canada, 2016). Additionally, under the Lower Athabasca Regional Plan 2012-2022, there is a proposed Birch River Conservation Area, south of Wood Buffalo National Park, and expansion of the Birch Mountain Provincial Wildland Park. The plan includes a list of permitted activities within these areas (Alberta Government, 2012). Activities such as petroleum and natural gas exploration and development, and mining, will not be permitted within these proposed new and expanded areas (Alberta Government, 2012).

Historically, this region has been inhabited by Beaver, Slavey and Chipewyan communities, however the Beaver and Slavey people moved away from the area as the fur trade in the region, which started in the 1700s, moved further west. Today the region is populated by Chipewyan, Cree, Metis and non-aboriginal communities. Within the park today, subsistence hunting, trapping and fishing are still permitted for certain Indigenous groups (Parks Canada, 2016).

The river supports a recreational and commercial fishery, with species including goldeye, lake whitefish, mountain whitefish, northern pike and walleye (Alberta Fishing Guide.com, 2016; Struzik, 2013).

This wild river is incredibly significant to an area of extraordinary biodiversity and cultural value. The protections put in place through the creation of the national park, and the creation/expansion of conservation areas will safeguard the river within those boundaries; however, the headwaters remain unprotected, meaning developments that alter water levels in the Birch River could have significant impacts to the Peace-Athabasca Delta (Stuzik, 2013).

# SAFEGUARDING OUR WILD RIVERS

Canada is fortunate to have a wealth of wild rivers. These rivers played a significant role in our history, and still today are the veins of Canada, pumping life-giving water across the country. Each of the wild rivers supports vibrant communities of people and species.

Internationally, there are some examples of legal frameworks that protect free-flowing rivers.

In the United States, for example, the National Wild and Scenic Rivers Act (established in 1968) allows for the identification and designation of rivers as wild, scenic or recreational, each bringing a different level of protection to the river and surrounding area. Currently this system – which protects rivers with outstanding natural, cultural and recreational values in a free-flowing condition – protects over 12,000 miles of rivers across the country (Moir et al., 2016). In Canada, on the other hand, legal tools to protect free-flowing rivers are limited and those we do have are underutilized.

Each province and territory has laws and/or strategies related to river conservation, either directly or indirectly. These include: British Columbia's Water Sustainability Act (2016); Alberta's Water Act (2000); Saskatchewan's Water Security Agency Act (2005); Manitoba's Water Resources Conservation Act (2006) and Water Protection Act (2005); Ontario's Clean Water Act (2006), Provincial Parks and Conservation Reserves Act (2006), Lakes and Rivers Improvement Act (1990) and Conservation Authorities Act (1990); Quebec's Natural Heritage Conservation Act (2013); New Brunswick's Clean Water Act (1989); Nova Scotia's Environment Act (2011); Newfoundland and Labrador's Lands Act (1991); Prince Edward Island's draft Water Act (now entering the second round of public consultation); Yukon's Waters Act (2003); Northwest Territories' "Northern Voices, Northern Waters: NWT Water Stewardship Strategy" (2010); and Nunavut's Water Regulations (2013).

Each province also has other management plans, strategies and legislation that can have implications for rivers (such as the Agricultural Operations Act in Saskatchewan). And in some cases, trans-boundary agreements govern how water resources are managed, such as the Mackenzie River Basin Transboundary Waters Master Agreement. Dozens of pieces of legislation impact water in some way, shape or form across Canada.

None of these various laws and agreements, however, offer comprehensive protection to wild rivers.

Nor does the Canadian Heritage Rivers System. This voluntary system was established in 1984 by federal, provincial and territorial governments to conserve rivers with outstanding natural, cultural and recreational heritage. Currently there are 42 Canadian Heritage Rivers (38 designated, and another four nominated) across Canada. Designation does not result in legal protections, however. Any protective activities on the Heritage Rivers rely on pre-existing laws and regulations, and respect the rights of all stakeholders, including Indigenous peoples, communities and private landowners. Throughout the nomination and designation process, governments retain their jurisdictional powers and management responsibilities of the river. While this system is successful at highlighting rivers in Canada with high heritage value (not necessarily free-flowing), it does not offer any legal protections against development pressures. For this reason, WWF-Canada does not see this as a viable strategy for real protection of wild rivers in Canada.

Without awareness and protection, the remaining wild rivers are vulnerable to development pressures. As we work to meet energy needs with low-carbon technologies, we must consider the impact to these places of vital ecological and economic importance, or risk destroying this natural wealth of rivers upon which many communities and wildlife depend.

## Recommendations

At present, there are no national and comprehensive protections for these important wild rivers. We recommend that:

1. No dams be built on the 10 wild rivers identified in this report. These rivers must be kept free-flowing;
2. Any other development proposal on one of Canada's 10 longest wild rivers should automatically trigger an environmental assessment;
3. Adequate monitoring programs must be established along Canada's 10 longest wild rivers to ensure that development decisions are informed by science.

On a broader scale, it is problematic that the free-flowing status of a river is not factored into development decisions in Canada. While this report focused on the 10 longest wild rivers, there are many other wild and free-flowing rivers in Canada that are important to the wildlife and people that depend on them. To that end, when reviewing hydropower development proposals on free-flowing rivers, governments should strive to keep that status by requiring (a) that operation plans account for environmental flow, and (b) that proponents consider cumulative effects and impacts on habitat at the watershed level.

## Ways to use this report

### COMMUNITIES

Communities along wild rivers can use this information to inform local development and management plans. Knowledge about the value of wild rivers may impact decision-making at a local scale, particularly during basin management planning.

### GOVERNMENTS

At all levels, governments can use the results of this analysis to determine if rivers in their jurisdiction are wild. If so, this should be factored into all development and planning decisions.

### CONSERVATIONISTS

Conservationists can use this report to identify priority rivers and watersheds to which they can direct resources. Due to the high value of these ecosystems, efforts to protect them will provide significant positive impacts to biodiversity and communities. Conservationists can also use examples of pre-existing protection options identified in this report to inform their strategies.

### GENERAL PUBLIC

Canadians treasure rivers, especially their role in our shared heritage, but many may not realize their true value. Canadians can insist governments of all levels consider these rivers in development decisions and ensure they remain wild.

## Conclusion

WWF-Canada is committed to helping communities prosper within their watersheds while maintaining the wild river status of these rivers.

Wild rivers provide habitat for wildlife in the river itself, are a source of water and food for terrestrial mammals, and, when healthy, allow for the unhindered transportation of nutrients and the movement of freshwater wildlife. As the climate changes, this will only increase in importance. At the same time, because Canada's wild rivers are largely in fragile northern temperate-zone ecosystems, they themselves face pending disruption as the climate changes. Wild rivers also have cultural and subsistence importance to Indigenous peoples and provide economic benefits for local communities.

As Canada shifts to a low-carbon economy, the potential exists for large free-flowing rivers to be tapped for hydropower, reducing the health of ecosystems and blocking migration routes for wildlife attempting to adjust to habitat range shift caused by climate change. Now that Canada's wild rivers have been identified, and their value clearly stated, we can ensure they receive robust monitoring and are protected by a suite of measures at the local, provincial and national levels so they can remain resilient and undisturbed.

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# Appendix – Freshwater Threats Assessment

## INTRODUCTION

WWF-Canada's Freshwater Threats Assessment provides a set of key indicators that identify the current stressors across all of Canada's freshwater systems. Using metrics and a scientifically credible methodology, the framework provides a broad scale analysis and classification of current threats and stresses to freshwater systems.

There are seven threat indicators identified in this framework: pollution, habitat loss, fragmentation, water use, invasive species, alterations to water flow, and climate change (Table 1). These indicators were developed in accordance with current literature on threats to freshwater systems, including Environment Canada's report on Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada (Environment Canada, 2001). Other examples of identifying and mapping threats to freshwater habitats include work on cumulative stress in the Great Lakes (Allan, et al., 2012), mapping threats to Florida's freshwater habitats (Rickets & Stys, 2008), threats to imperiled freshwater fauna (Richter, Braun, Medelson, & Master, 1997) and a global assessment to human water security and river biodiversity (Vorosmarty, et al., 2010). The framework was also reviewed and vetted by several leading experts and academics, who aided in the process of refining our methodology in accordance with current analysis techniques in freshwater hydrology, ecology, and geomorphology.

Of the seven indicators, four are comprised of sub-indicators which quantitatively measure the level of a given component of a threat. The quantitative analysis was based on the data available, the quality of the data, and scientific rationale based on previous literature. The sub-indicators were then "rolled-up" to a final indicator score, and eventually to a final threat score. The analysis for each sub-indicator and indicator was conducted at the sub-watershed level, based on the Water Survey of Canada (WSC) "Sub-Drainage Area" (Natural Resources Canada, 2009). Eventually, the scores of the sub-drainage areas were amalgamated to the "Pearse" watershed level (Pearse, Bertrand and Maclaren, 1985). The current version of the Freshwater Threats Assessment focuses on river systems, but has relevance to all freshwater ecosystems, including lakes and wetlands. Additionally, the Freshwater Threats Assessment is national in scope and is intended to provide a consistent framework across the entire country at a broad scale. Therefore, national datasets were used in the analysis. Variations in geology, and local or hyper local data and threats were not used in the analysis. Finally, the analysis was conducted as a relative ranking of threats across the country. For instance, a watershed with a low score indicates that the watershed ranks relatively low compared to all the watersheds in Canada. Absolute thresholds to quantify threat levels have not yet been defined.

## Table 1: Indicators and sub-indicators used in WWF-Canada's Freshwater Threats Assessment

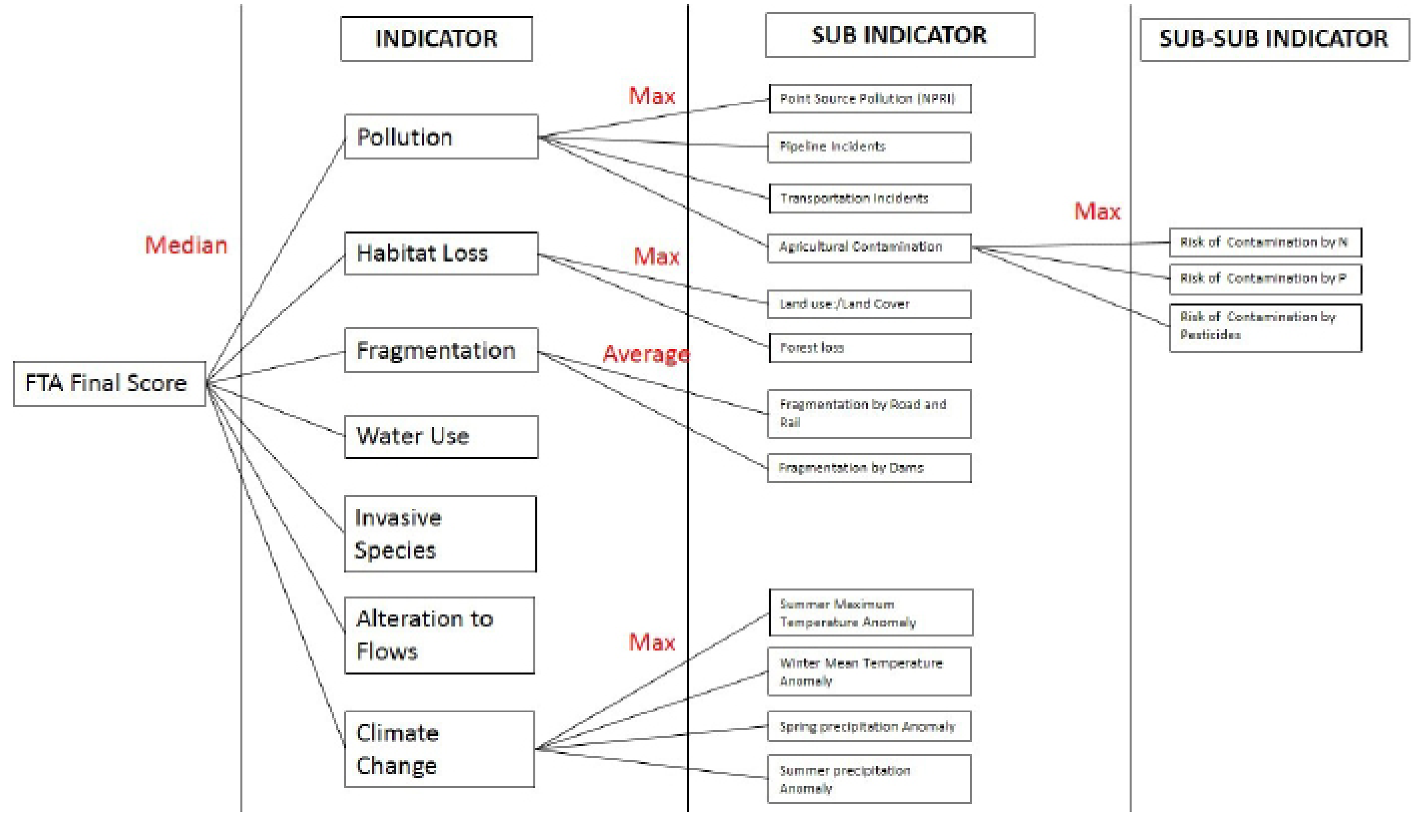
| INDICATOR | DESCRIPTION | SUB-INDICATOR |
|---|---|---|
| POLLUTION | The presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects. Includes pollution from industry (factories, mines, oil & gas), wastewater treatment, pulp and paper mills, agricultural production, etc. | Point-source pollution<br>Pipeline incidents<br>Transportation incidents<br>Risk of water contamination from agricultural by nitrogen phosphorous, and pesticides |
| HABITAT LOSS | Loss of freshwater habitat (wetlands, bogs, fens, etc.) due to land conversion to agriculture, urban areas, and industry. | Land use/Land Cover<br>Forest loss |
| FRAGMENTATION | Loss of connectedness between freshwater habitats due to intersection of roads, rail, and dams. | Fragmentation by dams<br>Fragmentation by road and rail |
| WATER USE | Total amount of water removed from freshwater systems for urban, agricultural, and industrial uses. | Ratio of water intake to water yield |
| INVASIVE SPECIES | Species introduced intentionally or accidentally outside of their natural range, often resulting in loss of native species | Presence of invasive species |
| ALTERATION TO WATER FLOWS | The presence of large dams and reservoirs can cause ecological damage, degradation, harm natural habitats, and alter the natural flow of a river system. | Reservoirs/dam size |
| CLIMATE CHANGE | Change in amounts and temperature of water due to changing climate, affecting water availability and the natural history of the species living within the system. | Summer maximum temperature anomaly<br>Winter mean temperature anomaly<br>Spring precipitation anomaly<br>Summer precipitation anomaly |

For more information on the detailed methodology for each indicator, visit http://watershedreports.wwf.ca/#canada/by/threat-overall/profile

## ROLLING UP TO OVERALL SUB-DRAINAGE AREA SCORES

Once all the analysis was complete for each indicator and sub-indicator, it was essential to our study to create an overall score for each sub-drainage area (SDA) as well as an overall score for each Pearse Drainage basin. First, a decision tree was created to evaluate how best to roll up sub-indicators into indicator scores. Either an average or maximum of the sub-indicators threat score was taken to create a final indicator score (see figure 1).

*Figure 1: Decision tree for rolling up sub-indicators to indicator scores, and to a final sub-drainage area score.*




Since some indicators did not have the same number of classes, it was first necessary to standardize all the indicator scores. While most indicators had a total of 5 classes, Water Use and Climate Change had 4 classes and 3 classes, respectively. For each indicator, the class score was divided by the total number of classes and given a percentage score. For instance, if a SDA received a class score of 4, with a total of 5 classes, the standardized score was 80%. The following formula was used:

$$SDAi = (\text{Class Score}_i/\text{Total Number of Classes}_i) \times 100$$

*Equation 9*

where i is the indicator. The scores were then reclassified per indicator at the SDA level using equal intervals (Table 9). Once the score for each indicator was standardized, a median score was taken across the 7 indicators per SDA. The medians were then reclassified using equal intervals (see Table 9 for break values).

## ROLLING UP TO PEARSE DRAINAGE BASIN SCORES

Once standardized scores were determined for each SDA, a Pearse drainage basin score was also calculated. For each indicator, the following formula was used to create an overall Pearse score based on the scores of the SDA:

$$PDB_i = \Sigma (A_{SDA}/A_{PDB}) \times SDA_i$$

*Equation 10*

where $A_{SDA}$ is the area of the sub-drainage area, $A_{PDB}$ is the area of the Pearse drainage basin, and

$SDA_i$ is the indicator score at the SDA level. The sum of all the area weighted scores within that Pearse drainage basin was taken to find the indicator score. If more than 50% of the total Pearse basin area had a "Null" score for an indicator, the Pearse basin also received a "Null" score for that indicator. The indicator scores were then reclassified using the same breaks used at the SDA level.

The final the overall score of the Pearse drainage basin, the median value was taken of all the indicator scores. The median scores were then reclassified using the same breaks used at the SDA level.

***Tables 2 through 9 indicate the thresholds that were used for each indicator***

## Table 2: Classification for Water Pollution sub-indicators

| INDICATOR | SUB-INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES | | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|---|
| | | | MIN. | MAX. | | |
| Water Pollution | Point Source Pollution | Percentiles | 0 | 0 | 0 | No Threat |
| | | | 0.01 | 95.37 | 1 | Very Low |
| | | | >95.37 | 1,375.53 | 2 | Low |
| | | | >1,375.53 | 4,978.74 | 3 | Moderate |
| | | | >4,978.74 | 24,068.78 | 4 | High |
| | | | >24,068.78 | 671,981.19 | 5 | Very High |
| | Pipeline Incidents | Percentiles | - | - | Unknown | Unknown |
| | | | 0 | 0 | 0 | No Threat |
| | | | 200 | 11,000 | 1 | Very Low |
| | | | >11,000 | 129,100 | 2 | Low |
| | | | >129,100 | 2,932,733 | 3 | Moderate |
| | | | >2,932,733 | 57,817,264 | 4 | High |
| | | | >57,817,264 | 1,513,562,880 | 5 | Very High |
| | Transportation Incidents | Jenks Natural Breaks | 0 | 0 | 0 | No Threat |
| | | | 2 | 9 | 1 | Very Low |
| | | | 10 | 22 | 2 | Low |
| | | | 23 | 45 | 3 | Moderate |
| | | | 46 | 66 | 4 | High |
| | | | 67 | 107 | 5 | Very High |
| | Agricultural Contamination | Percentiles | 0.00 | 0.00 | 0 | No Threat |
| | | | 0.01 | 0.10 | 1 | Very Low |
| | | | >0.10 | 0.34 | 2 | Low |
| | | | >0.34 | 0.80 | 3 | Moderate |
| | | | >0.80 | 1.73 | 4 | High |
| | | | >1.73 | 4.82 | 5 | Very High |

## Table 3: Classification for Habitat Loss sub-indicators

| INDICATOR | SUB-INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES | | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|---|
| | | | MIN. | MAX. | | |
| Habitat Loss | Land Use/Land Cover | Jenks Natural Breaks | 0% | 0% | 0 | No Threat |
| | | | 0.01% | 1.96% | 1 | Very Low |
| | | | >1.96% | 10.37% | 2 | Low |
| | | | >10.37 | 30.78% | 3 | Moderate |
| | | | >30.78% | 59.22% | 4 | High |
| | | | >59.22% | 85.18% | 5 | Very High |
| | Forest Loss | Jenks Natural Breaks | <0 % | 0 % | 0 | No Threat |
| | | | >0% | 1.51% | 1 | Very Low |
| | | | >1.51% | 4.15% | 2 | Low |
| | | | >4.15% | 8.34% | 3 | Moderate |
| | | | >8.34% | 16.76% | 4 | High |
| | | | >16.76 | 60.82% | 5 | Very High |

## Table 4: Classification for Fragmentation sub-indicators

| INDICATOR | SUB-INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES | | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|---|
| | | | MIN. | MAX. | | |
| Fragmentation | Fragmentation By Dams | Percentiles | 0 | 0 | 0 | No Threat |
| | | | 200 | 11,000 | 1 | Very Low |
| | | | >11,000 | 129,000 | 2 | Low |
| | | | >129,100 | 2,932,733 | 3 | Moderate |
| | | | >2,932,733 | 57,817,264 | 4 | High |
| | | | >57,817,264 | 1,513,562,880 | 5 | Very High |
| | Fragmentation By Roads and Rail | Percentiles | 0 | 0 | 0 | No Threat |
| | | | 1 | 9 | 1 | Very Low |
| | | | >9 | 22 | 2 | Low |
| | | | >22 | 47 | 3 | Moderate |
| | | | >47 | 71 | 4 | High |

## Table 5: Classification for Water Use sub-indicators

| INDICATOR | SUB-INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES | | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|---|
| | | | MIN. | MAX. | | |
| Water Use | Ratio of water intake to water yield | Pre-classified | Data not available | | N/A | Unknown |
| | | | 0% | <10% | 1 | Low |
| | | | 10% | <20% | 2 | Moderate |
| | | | 20% | <40% | 3 | High |
| | | | ≥40% | | 4 | Very High |

## Table 6: Classification for Invasive Species sub-indicators

| INDICATOR | SUB-INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES | | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|---|
| | | | MIN. | MAX. | | |
| Invasive Species | Presence of invasive species | Percentiles | Known invasives in province, but no sightings in watershed | | N/A | Unknown |
| | | | No known invasives in province, no sightings in watershed | | 0 | No Threat |
| | | | >0 | 8 | 1 | Very Low |
| | | | >8 | 19 | 2 | Low |
| | | | >19 | 37 | 3 | Moderate |
| | | | >37 | 57 | 4 | High |
| | | | >57 | | 5 | Very High |

## Table 7: Classification for Alteration to Water Flows sub-indicators

| INDICATOR | SUB-INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES | | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|---|
| | | | MIN. | MAX. | | |
| Alteration to Water Flows | Area of reservoirs/dam | Jenks Natural Breaks | 0 | 0 | 0 | No Threat |
| | | | 0.01 | 14.4 | 1 | Very Low |
| | | | 14.5 | 105.7 | 2 | Low |
| | | | 105.8 | 616.5 | 3 | Moderate |
| | | | 616.6 | 1,991.2 | 4 | High |
| | | | 1,991.3 | 19,518.8 | 5 | Very High |

## Table 8: Classification for Climate Change sub-indicators

| INDICATOR | SUB-INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES | | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|---|
| | | | MIN. | MAX. | | |
| Climate Change | 1) Summer maximum temperature anomaly; 2) winter mean temperature anomaly; 3) spring precipitation anomaly and 4) summer precipitation anomaly | Standard Deviations | < 1SD or > -1SD | | 1 | Low |
| | | | > 1SD or < -1SD | | 2 | Moderate |
| | | | > 2SD or < -2SD | | 3 | High |

## Table 9: Final indicator classification for sub-drainage area indicators and Pearse Drainage Area

| INDICATOR | CLASSIFICATION SCHEME | VALUE RANGES MIN. | VALUE RANGES MAX. | CLASS | THREAT CATEGORY |
|---|---|---|---|---|---|
| Habitat Loss | Equal Interval | 0 | | 0 | No Threat |
| | | >0 | 20 | 1 | Very Low |
| | | >20 | 40 | 2 | Low |
| | | >40 | 60 | 3 | Moderate |
| | | >60 | 80 | 4 | High |
| | | >80 | 100 | 5 | Very High |
| Pollution | Equal Interval | Unknown | | N/A | Unknown |
| | | 0 | | 0 | No Threat |
| | | >0 | 20 | 1 | Very Low |
| | | >20 | 40 | 2 | Low |
| | | >40 | 60 | 3 | Moderate |
| | | >60 | 80 | 4 | High |
| | | >80 | 100 | 5 | Very High |
| Fragmentation | Equal Interval | 0 | | 0 | No Threat |
| | | >0 | 20 | 1 | Very Low |
| | | >20 | 40 | 2 | Low |
| | | >40 | 60 | 3 | Moderate |
| | | >60 | 80 | 4 | High |
| | | >80 | 100 | 5 | Very High |
| Water Use | Equal Interval | Unknown | | 0 | No Threat |
| | | 0 | | 1 | Very Low |
| | | >0 | 25 | 2 | Low |
| | | >25 | 50 | 3 | Moderate |
| | | >50 | 75 | 4 | High |
| | | >75 | 100 | 5 | Very High |
| Alteration to Water Flow | Equal Interval | 0 | | 0 | No Threat |
| | | >0 | 20 | 1 | Very Low |
| | | >20 | 40 | 2 | Low |
| | | >40 | 60 | 3 | Moderate |
| | | >60 | 80 | 4 | High |
| | | >80 | 100 | 5 | Very High |
| Invasive Species | Equal Interval | Unknown | | N/A | Unknown |
| | | 0 | | 0 | No Threat |
| | | >0 | 20 | 1 | Very Low |
| | | >20 | 40 | 2 | Low |
| | | >40 | 60 | 3 | Moderate |
| | | >60 | 80 | 4 | High |
| | | >80 | 100 | 5 | Very High |

| | | | | | |
|---|---|---|---|---|---|
| **Climate Change** | Equal Interval | 0 | | 0 | None |
| | | 33.33 | | 1 | Low |
| | | 66.67 | | 2 | Moderate |
| | | 100 | | 3 | High |
| **Overall Score** | Equal Interval | 0 | | 0 | No Threat |
| | | 0 | <20 | 1 | Very Low |
| | | 20 | <40 | 2 | Low |
| | | 40 | <60 | 3 | Moderate |
| | | 60 | <80 | 4 | High |
| | | 80 | <100 | 5 | Very High |

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature by:

- Conserving the world's biological diversity
- Ensuring that the use of renewable natural resources is sustainable
- Promoting the reduction of pollution and wasteful consumption

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