Amended Recovery Strategy for the

Plains Minnow (*Hybognathus placitus*)

2026

Species at Risk Act
Recovery Strategy Series

Canada

Recommended citation:

Fisheries and Oceans Canada. 2026. Amended Recovery Strategy for the Plains Minnow (*Hybognathus placitus*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vi + 41 pp.

For copies of the recovery strategy, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports and other related documents, please visit the Species at Risk Public Registry.

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Également disponible en français sous le titre
« Programme de rétablissement modifié du méné des plaines (*Hybognathus placitus*) au Canada »

ISBN 978-0-660-98709-5

Catalogue no. En3-4/380-2026E-PDF

Amended recovery strategy for the Plains Minnow

The recovery strategy for the Plains Minnow, was originally posted on the Species at Risk Public Registry in September 2025. Under sections 45 of the Species at Risk Act (SARA), the competent Minister may amend a recovery strategy at any time. This “Amended Recovery Strategy for the Plains Minnow in Canada” (hereafter, “amended recovery strategy”) is for the purposes of:

- correcting the previous statement that the Minister responsible for Parks Canada is a competent minister for the Plains Minnow and clarifying that the Minister of Fisheries is the sole competent minister under SARA for this species;
- making minor corrections to associated competent minister authorities and responsibilities; and
- making minor edits to improve internal consistency within the document.

Once this amended document is posted on the Species at Risk Public Registry as final, it will replace the 2025 Recovery Strategy for Plains Minnow in Canada.

Preface

Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a recovery strategy for species listed as extirpated, endangered, or threatened and are required to report on progress 5 years after the publication of the final document on the Species at Risk Public Registry, and every subsequent 5 years, until the recovery strategy is no longer required under SARA or the species' recovery is no longer feasible.

The Minister of Fisheries is the competent minister under SARA for the Plains Minnow and has prepared this strategy, as per section 37 of SARA. In preparing this recovery strategy, the competent minister has considered, as per section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, this recovery strategy has been prepared in cooperation with Parks Canada, Government of Saskatchewan, and Saskatchewan Water Security Agency, as per section 39(1) of SARA.

As stated in the preamble to SARA, 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. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Plains Minnow and Canadian society as a whole.

This recovery strategy will be followed by 1 or more action plans. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

This recovery strategy was prepared by Pooi-Leng Wong, Ashley Gillespie, Robyn Kutz, Kristy Pagura, Nilo Sinnatamby, and Derek Crompton on behalf of Fisheries and Oceans Canada (DFO). DFO would like to thank the following organizations for their support in the development of the Plains Minnow recovery strategy: Government of Saskatchewan, Saskatchewan Water Security Agency, and Parks Canada. Mapping was produced by Andrew Geraghty (DFO).

Executive summary

The Plains Minnow (*Hybognathus placitus*) was listed as threatened under the *Species at Risk Act* (SARA) in 2019. This "Recovery Strategy for the Plains Minnow (*Hybognathus placitus*) in Canada" is part of a series of documents for this species that are linked and should be considered together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (COSEWIC 2012), science advisory report from the recovery potential assessment (RPA) (DFO 2013a), and 1 or more action plan(s) (to come). For a list of current documents published for the species, refer to the Species at Risk Public Registry. Recovery of the Plains Minnow has been determined to be biologically and technically feasible (DFO 2013a).

The Plains Minnow is considered to be at risk due to its limited distribution within Canada, occurring in only 1 small stream in southern Saskatchewan that is subject to drought. The Plains Minnow is tolerant to a broad range of water quality conditions, including high turbidity, low oxygen, and high temperatures, and requires long stretches of flowing water to complete its life cycle.

The main threats facing the species are described in section 5 and include habitat removal and alteration; alteration of natural flow regime, particularly from large impoundments; exotic piscivores; contaminants and toxic substances resulting from pipeline fractures; and climate change.

The population and distribution objective (section 6) for the Plains Minnow is:

- to protect and maintain populations of the Plains Minnow within its current range in Canada

A description of the broad strategies to be taken to address threats to the species' survival and recovery, as well as research and management approaches needed to meet the population and distribution objectives are included in section 7. These strategies and approaches will help inform the development of specific recovery measures in 1 or more action plans.

For the Plains Minnow, critical habitat is identified to the extent possible, using the best available information, and provides the functions, features, and attributes necessary to support the species' lifecycle processes. This recovery strategy identifies critical habitat for the Plains Minnow as the 26.5 river kilometers (rkm) of barrier-free river length within Rock Creek in Saskatchewan, beginning at the United States border and extending upstream (section 8). It is anticipated that the protection of the species' critical habitat will be accomplished through a SARA critical habitat order made under subsections 58(4) and 58(5(a)), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

Recovery feasibility summary

Recovery of the Plains Minnow is considered to be both biologically and technically feasible.

1. Are individuals of the wildlife species that are capable of reproduction available now or in the foreseeable future to sustain the population or improve its abundance?

   Unknown. The presence of the Plains Minnow population in Canada was discovered in Rock Creek in 2003, estimated to contain 41,800 adults in 2007, and assigned a high relative abundance designation. There is no known impediment to the reproduction potential of the Plains Minnow in Canada. The 2006 and 2007 surveys were thought to contain mainly adult individuals, but samples from 2003, 2006, and 2020 contained the Plains Minnow within the young of the year size range, which suggests that reproduction may be occurring within the Canadian distribution. Nevertheless, owing to the Plains Minnow's requirement for long, unimpeded stretches of stream (which may be greater than 115 river kilometers (rkm)) for larval development, reproductive success for the Canadian population likely relies on continuous distribution south of the international border in Montana. The Rock Creek Diversion Dam is located approximately 170 rkm south of the Canada-United States border. Therefore, there is the potential for interchange between Saskatchewan and Montana populations and it is important that this connectivity be maintained and taken into account in recovery planning. The Plains Minnow in Montana is currently ranked S4 (apparently secure) (NatureServe 2012) and considered a potential species of concern, which is defined as a species that may be quite rare in parts of its range or suspected of declining, despite being apparently secure. The population trajectory in Canada is unknown since there is limited historical data available for comparison. It is likely that the population fluctuates naturally in abundance and distribution, as the area of occupancy is prone to summer droughts and severe winter conditions.

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

   Unknown. Knowledge of the Plains Minnow habitat use in Canada is limited and much of the information used in the recovery potential assessment (RPA) and this recovery strategy is from areas outside of its Canadian range. A relative abundance rating of high was assigned to the population based on limited sampling in 2007, which suggests that sufficient suitable habitat exists to support the species. A standardized fish survey in 2020, however, suggested that the relative abundance of the Plains Minnow is low and that distribution is variable or may be contracting within its known range. There were no known significant habitat changes between those sampling events; it is instead likely that the population abundance and distribution fluctuate naturally in this drought-prone area. Given that the known Canadian range of the species consists of just 26.5 rkm, the Canadian population is likely reliant on continued connection to the population south of the international border.

3. Can significant threats to the species or its habitat be avoided or mitigated?

   Yes. The known distribution of the Plains Minnow in Canada occurs in Rock Creek adjacent to land that is managed by Parks Canada; existing land management practices and regulatory processes are thought to be sufficient to avoid or mitigate threats to a large extent. The primary threats to the Plains Minnow are the alteration of natural flow regimes from large impoundments, habitat removal and alteration, exotic piscivores, and contaminants from pipeline fractures. These threats can have a high impact on the Plains

Minnow but were considered unlikely to occur in the known Canadian range since a significant portion of the habitat is adjacent toa national park. Barriers to movement were identified as a high impact threat since the Plains Minnow may need greater than 115 rkm of flowing water to complete its life cycle; however, the likelihood of this threat was unknown. Collaboration with United States agencies to develop a shared monitoring protocol to predict changes in distribution of exotic species, to evaluate the risks, and to assess the impacts of water projects and dam construction, will help provide information to decision makers to decide if they want to make changes that will mitigate threats. The effect of climate change on the Plains Minnow is highly speculative and difficult to quantify and it's unknown what impact this might have on the species.

4. Do recovery techniques exist to achieve the population and distribution objectives or can they be developed within a reasonable timeframe?

   Yes. The techniques likely to be considered for conservation of the Plains Minnow populations are well founded in current science and management practices. Given the relative abundance of the species within its limited distribution, the focus should be on mitigating habitat impacts and removing non-native species. The technical knowledge for addressing potential habitat impacts is well documented and applied globally. The avoidance of species introductions is best accomplished through public education and management programs, both of which are entirely within the competency of the responsible jurisdictions. Based on available information, no impediments to the maintenance of self-sustaining populations of the Plains Minnow have been identified in the known Canadian range..

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1 Introduction

The Plains Minnow (*Hybognathus placitus*) was listed as threatened under the *Species at Risk Act* (SARA) in 2019. This “Recovery Strategy for the Plains Minnow (*Hybognathus placitus*) in Canada” (recovery strategy) is part of a series of documents for this species that should be considered together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Report (COSEWIC 2012), the science advisory report from the recovery potential assessment (RPA) (DFO 2013a), the “Multi-species Action Plan for Grasslands National Park of Canada” (Parks Canada 2016), and the subsequent action plan(s). 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 objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the subsequent action plan stage.

The RPA is a process undertaken by Fisheries and Oceans Canada (DFO) to provide the information and scientific advice required to implement SARA, relying on the best available scientific information, data analyses and modeling, and expert opinions. The outcome of this process informs many sections of the recovery strategy.

2 COSEWIC species assessment information

Assessment summary: May 2012

Common name: Plains Minnow

Scientific name: *Hybognathus placitus*

Status: Threatened

Reason for designation: This small fish has a very limited distribution in Canada at only one or two locations, both of which are small streams subject to drought. The species requires long stretches of flowing water to complete its life cycle. Further threats to water supply from additional irrigation dams and drought would increase risks to this species.

Occurrence: Saskatchewan

Status history: Designated threatened in May 2012.

3 Species status information

Table 1. Summary of existing protection or other status designations assigned to the Plains Minnow.

Jurisdiction	Authority/ organization	Year(s) assessed and/or listed	Status/description	Designation level
Canada	*Species at Risk Act* (SARA)	2019	Threatened	Species
Saskatchewan	Saskatchewan Conservation Data Centre	2017	Regional: S2 – Imperiled/Very rare	Species
International	NatureServe	2012	Global: G4 - Apparently Secure	Species

Upon listing as a threatened species, the Plains Minnow became protected wherever it is found by section 32 of SARA:

> "No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species." [subsection 32(1)]
>
> "No person shall possess, collect, buy, sell or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual." [subsection 32(2)]

Under section 73 of SARA, the competent minister may enter into an agreement or issue a permit authorizing a person to engage in an activity affecting a listed wildlife species, any part of its critical habitat, or its residences.

The *Fisheries Act* also provides for the protection of aquatic species at risk. The *Fisheries Act* provides a framework for (a) the proper management and control of fisheries; and (b) the conservation and protection of fish and fish habitat, including the prevention of pollution.

4 Species information

4.1 Species description

The Plains Minnow is a minnow with a blunt, triangular head, small subterminal mouth, and relatively small eyes, averaging 50 to 90 millimetres (mm) total length (TL) (Robison and Buchanan 1988; Sublette et al. 1990; Scheurer et al. 2003). Colouration is tan to olive dorsally, with a mid-dorsal stripe, silvery sides, a whitish abdomen, and black peritoneum (COSEWIC 2012). The Plains Minnow is morphologically similar to Mississippi Silvery Minnow (*Hybognathus nuchalis*), Western Silvery Minnow (*Hybognathus argyritis*), and Brassy Minnow (*Hybognathus hankinsoni)*, but may be differentiated in the field by slight differences in the dorsal fins, scales, eyes, and snout (COSEWIC 2012). The Plains Minnow is a herbivorous and benthivorous species, and has an important role in the ecosystem, transferring energy and nutrients up the food chain (COSEWIC 2012). The Plains Minnow is a pelagic, broadcast spawner and its reproductive success relies on periods of increased water flow and long

stretches of flowing water to complete its life cycle (Sawatzky and Watkinson 2013; Durham and Wilde 2014). The Plains Minnow is tolerant of a broad range of water quality conditions, including high turbidity, low oxygen, and high temperatures (COSEWIC 2012).

4.2 Population abundance and distribution

Population abundance

Little information is available on the abundance and trends of the Plains Minnow in Canada. A crude estimate obtained in 2007 indicated 41,800 adults (ranging from 2,400 to 55,400 with 80% confidence intervals for the 26.5 rkm, approximately 1,600 fish per kilometre where the Plains Minnow is expected to occur (COSEWIC 2012)), which generated a relative abundance index rank of high (DFO 2013a). Recent standardized sampling suggested low abundance (0.04 fish/m^2) and a variable or contracting distribution (Macnaughton et al. 2019; Teillet et al. 2021). Due to limited historical data and differing sampling methods, population trends for the Plains Minnow in the Canadian portion of their range are not available. Natural fluctuations in abundance are likely, given the species' short generation time and the varying flow rates of Rock Creek (COSEWIC 2012). Within the United States, the Plains Minnow is generally declining in distribution and abundance throughout its range due to anthropogenic impacts on habitat, particularly impoundments and water diversions (Winston 2002; Rees et al. 2005; Hoagstrom et al. 2007; Hoagstrom et al. 2010). Stable populations do exist in some areas (for example, the Missouri River along the Kansas border) (Cross and Moss 1987; Chadwick et al. 1997; Rees et al. 2005). The combined estimated high relative population abundance and the unknown population trajectory resulted in an overall population status of fair (DFO 2013a).

Distribution

The Plains Minnow occurs only in North America and is widely distributed across the Great Plains east of the Rocky Mountains and west of the Mississippi River, from Texas and New Mexico north to North Dakota, Montana, and Saskatchewan (COSEWIC 2012) (figure 1). The Canadian distribution of the Plains Minnow is highly restricted and has only been documented in Rock Creek, Saskatchewan from the United States border to 26.5 rkm upstream (figure 2). Previous documents also noted occupancy in Morgan Creek, Saskatchewan, a tributary of Rock Creek (COSEWIC 2012; DFO 2013a). This notation resulted from the use of an old name for a portion of Rock Creek that was changed in 1984 (Arthur 1984). All further references to the Plains Minnow distribution in this document use only Rock Creek, even when referencing an old document or earlier sampling where Morgan Creek was used. The Plains Minnow has not been identified in the Milk River (Alberta), Frenchman River, Caton, Conglomerate, Fairwell, Battle, Middle, Sucker, Belanger, Davis, and Nine-Mile creeks (Saskatchewan), despite extensive sampling efforts in 2003, 2007, 2017, and 2020 (Alberta Fish and Wildlife Management Information System; COSEWIC 2012; DFO fish inventories unpublished data; Teillet et al. 2021).

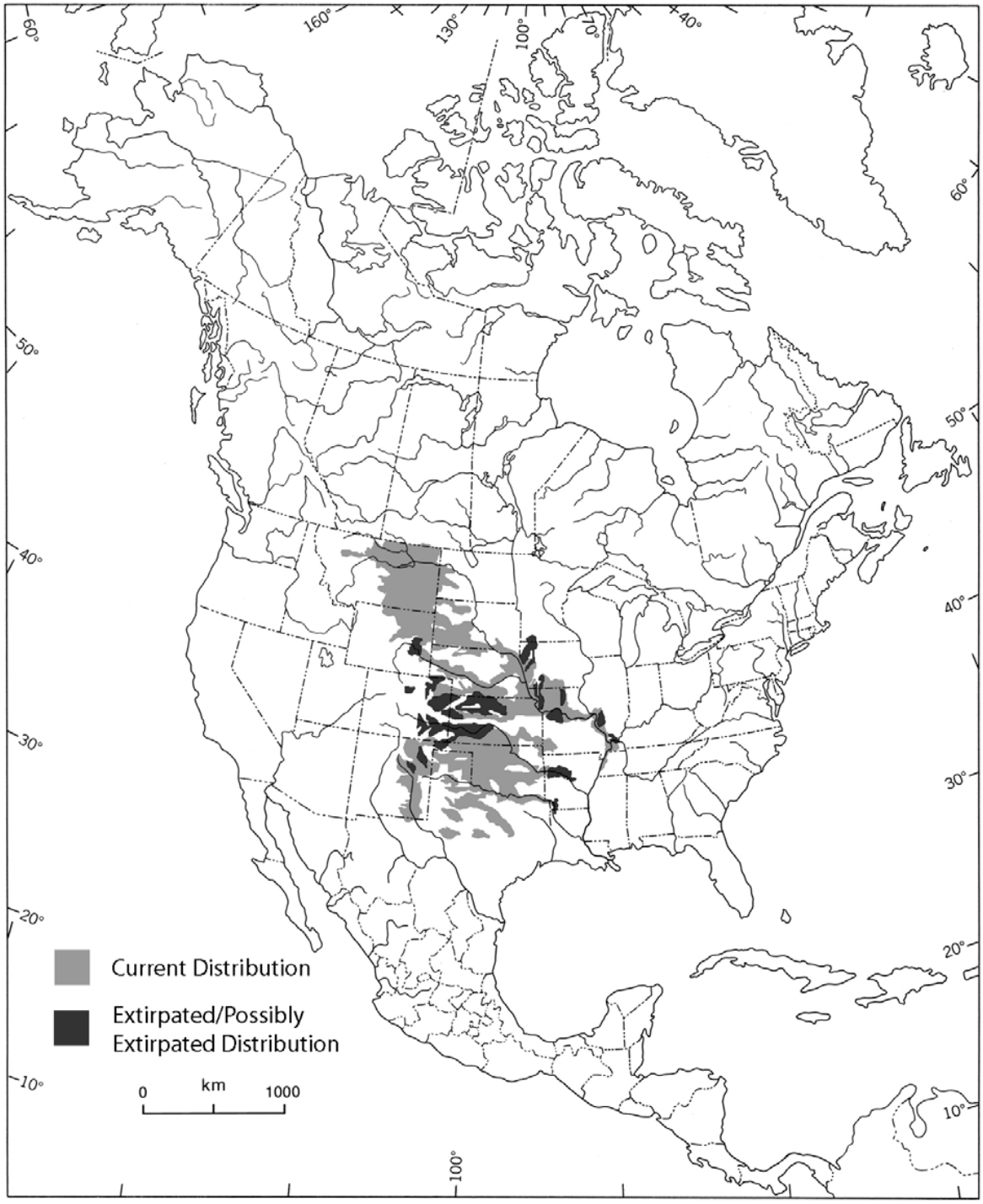

Figure 1. Global distribution of the Plains Minnow. Modified from NatureServe (2010). In COSEWIC 2012.

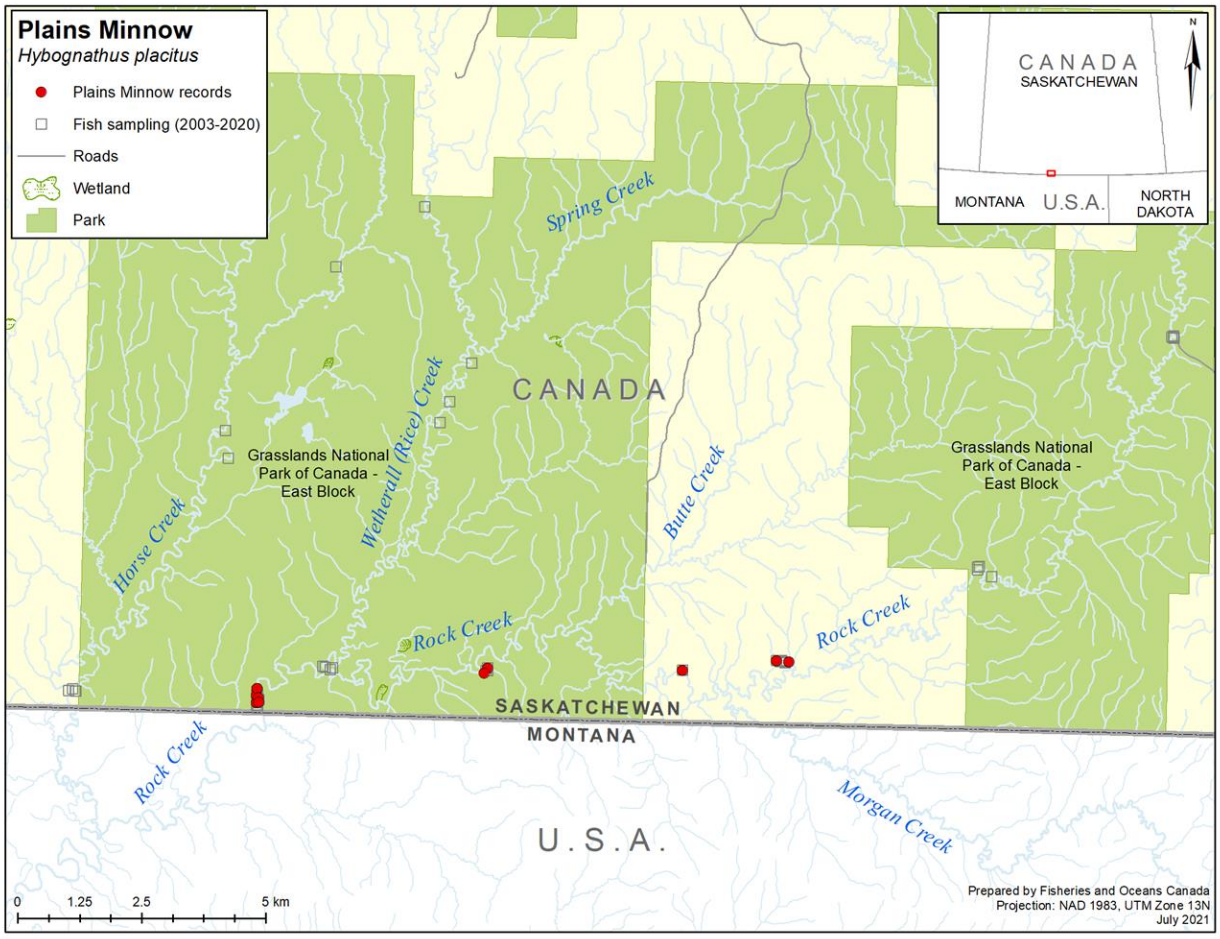

Figure 2. Canadian point distribution of the Plains Minnow in Rock Creek, Saskatchewan represented by red dots and location of sample sites where the Plains Minnow were not found represented by open squares.

4.3 Needs of the species

Biology and life history

Limited information on the biology and life history of the Plains Minnow in Canada is available because it was only discovered in 2003. Most of the information presented here comes from studies in the United States distribution.

Diet and Feeding

The Plains Minnow is thought to be herbivorous or detritivorous with a diet consisting primarily of benthic algae, diatoms, and other microflora (Miller and Robison 1973; Cross and Moss 1987; Robison and Buchanan 1988; Sublette et al. 1990).

Growth

The Plains Minnow grow to an average of 50 to 90 mm TL, with a maximum size of approximately 130 mm TL (Scheurer et al. 2003). Growth may be rapid, with juveniles reaching a TL of 28 to 43 mm by September of their first year in Grand River, Missouri (Pflieger 1997).

Both sexes begin to mature at 45 to 50 mm TL (Taylor and Miller 1990). In Canada, the Plains Minnow has ranged from 44 to 107 mm fork length (FL) and may live up to 3 years (Sylvester et al. 2005; COSEWIC 2012; DFO 2013a; Teillet et al. 2021).

Reproduction

The Plains Minnow release semi-buoyant, non-adhesive eggs into flowing water during multiple spawning events over a protracted season (May through June) (Urbancyzk 2012; Wilde and Urbanczyk 2013; Sawatzky and Watkinson 2013). These events occur synchronously during periods of increased stream flow, intensifying the number of individuals spawning and eggs released, or asynchronously, when a small portion of the Plains Minnow spawn during periods of low current on a daily basis (Urbanczyk 2012; Durham and Wilde 2014). Eggs drift downstream and hatch 24 to 48 hours (h) later followed by an obligate drifting larval stage for another 2 to 3 days to finish development (Perkin and Gido 2011). The Plains Minnow's reproductive success relies on sufficient current greater than 0.01 metres per second (m/s) and long, barrier-free stretches of stream to support the eggs' suspension, preventing them from settling to the river bottom (Perkin and Gido 2011; Wilde and Urbanczyk 2013; Durham and Wilde 2014). Most females carrying less than 1,000 eggs and sexes become mature at age 1 (Lehtinen and Layzer 1988), though this may occur later in the Canadian population (COSEWIC 2012). Post-spawning mortality is high, with only a small proportion of the Plains Minnow living to age 2 (Taylor and Miller 1990).

Spawning

Spawning is triggered by periods of increasing current caused by snowmelt, summer rainstorms, or reservoir releases (Widmer et al. 2012) prompting adults to move upstream during moderate to high flows (Durham and Wilde 2008, 2009a, 2009b). Groups of the Plains Minnow have been seen during receding high flows, in quiet water along sand bars, and in backwaters (Taylor and Miller 1990) with schools observed preparing to spawn in shallow backwaters, suggesting these areas are used for staging (Cross and Collins 1995). Drifting eggs were collected under similar conditions (Sliger 1967). Spawning in Canada has not been documented likely due to turbid waters within the species' range.

Larvae and juveniles

Information on larval and juvenile habitat is sparse, but likely resembles that of adults, although not in the same location since adults migrate upstream during spawning season (COSEWIC 2012). Once the larval air bladder is fully developed, they seek low-flow nursery habitat 3 to 5 days post-spawning (Platania and Altenbach 1998). The estimated minimum river fragment length required for reproductive success is 115 rkm, but may be longer in cooler water temperatures where development is slower (Perkin and Gido 2011). Young of the year (YOY) Plains Minnows have been captured over a hard-silt substrate overlaid by loose sand in a narrow, deeply incised channel and over sand substrates in the wide, braided main channel of the river (Widmer et al. 2010). Plains Minnows within the YOY size range (established by Taylor and Miller 1990) were obtained in the 2003, 2006, and 2020 samples in the Canadian distribution; however, the 2006 individuals were aged as 1+ (Sylvester et al. 2005; COSEWIC 2012; Teillet et al. 2021).

Adults

Adults are typically found in large, often turbid, sandy, silty rivers and have been classified as habitat generalists with a preference for both backwaters and embayments, while avoiding

higher velocity mid-channel habitats (Miller and Robison 1973; Matthews and Hill 1980; Polivka 1999; Kehmeier et al. 2007). They are most abundant where sediments accumulate in shallow backwater areas, calm eddies, and along edges of shifting dunes in sand-bed rivers with current (Robison and Buchanan 1988; Cross and Collins 1995; Pflieger 1997). In Canada, adults (aged ≥ 1 year) have been captured in June in run and pool habitat with a mean wetted width of 2.3 to 3.24 m and at depths less than approximately 1.2 m. Plains Minnows were collected in September 2020 in Rock Creek at an average depth of 0.58 m (range: 0.34 to 1.2 m) and a mean velocity of 0.02 m/s (range: 0.00 to 0.11 m/s) (Teillet et al. 2021).

Habitat

Information on the Plains Minnow habitat in Canada is limited. Information presented below is mostly knowledge gained from its range in the United States.

The Plains Minnow is most often found over sand substrate (Cross and Moss 1987; Robison and Buchanan 1988; Taylor and Miller 1990; Cross and Collins 1995; Pflieger 1997) and only rarely occurs over rock or mud bottoms (Robison and Buchanan 1988; Cross and Collins 1995; Pfleger 1997; Quist et al. 2004). In Rock Creek, Saskatchewan, the Plains Minnow was captured at sites with silt, sand, and gravel substrate (DFO fish inventories unpublished data, Sylvester et al. 2005). Information on presence or absence of vegetation in habitats occupied by the Plains Minnow is limited but reports from the United States have varied (COSEWIC 2012). The site in Rock Creek, Saskatchewan where the Plains Minnow was first discovered was typical of the Plains Minnow habitat. The site contained mainly run and pool habitat with slow velocities, small substrate and turbid water, and riparian vegetation consisted of grasses, sedges, and shrubs (Sylvester et al. 2005).

The Plains Minnow occupy streams that tend to have fluctuating water levels and can often become dry and turn into intermittent lentic pools during times of low flow, such as dry summers or cold winters, but are also subject to flash floods of murky water during heavy rains (COSEWIC 2012). The species is capable of tolerating such naturally occurring conditions and has evolved a tolerance for a wide range of physicochemical conditions including high turbidity, low dissolved oxygen, and high water temperatures (COSEWIC 2012).

5 Threats

5.1 Threat assessment

An assessment and prioritization of threats to survival and recovery of the Plains Minnow is undertaken when a RPA is developed. “A 2 step process is used, which first characterizes threats at the population level and then at the wildlife species[1] level.” For more details on the threat assessment process, refer to the Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk. The specific assessment categories and associated rankings used in table 2, which have been adapted from the RPA (Sawatzky and Watkinson 2013), are provided in appendix B. Assessment category definitions are provided in the table description.

[1] Also referred to as a designatable unit by COSEWIC.

Table 2. Population-level threat assessment for the Plains Minnow in Canada.

Threats	Threat likelihood[2]	Threat impact	Threat level
Alteration of natural flow regimes from large impoundments	Unlikely	High	Medium (2)
Habitat removal and alteration	Unlikely	High	Medium (2)
Exotic piscivores	Likely	Medium	Medium (2)
Contaminants and toxic substances from pipeline fractures	Unlikely	High	Medium (3)
Turbidity and sediment loading (at very high levels over a long period of time)	Unlikely	Medium	Low (3)
Alteration of natural flow regimes from small impoundments and dugouts	Known	Low	Low (3)
Nutrient loading	Known	Low	Low (3)
Introduced species and diseases except exotic piscivores	Known	Low	Low (3)
Contaminants and toxic substances except from pipeline fractures	Known	Low	Low (3)
Scientific sampling	Known	Low	Low (3)
Barriers to movement	Unknown	High	Unknown (2)

5.2 Description of threats

The biggest limitation to the Plains Minnow's persistence in Canada is its extremely small and localized distribution situated within a naturally drought-prone stream, which increases its vulnerability to stochastic events (COSEWIC 2012; Sawatzky and Watkinson 2013). No anthropogenic threats were assigned a threat level of high; rather, the list of threats presented in table 2 represent medium, low, or unknown threats. These threats are discussed independently below, but it should be noted that they may occur simultaneously and/or interact with natural processes to result in cumulative effects that may exacerbate the impact on the Plains Minnow.

Alteration of natural flow regimes from large impoundments

The naturally variable hydrograph of Great Plains streams is integral to the long-term sustainability of obligate riverine species such as the Plains Minnow (Winston et al. 2002; COSEWIC 2012). An estimate of greater than 115 rkm of flowing river habitat is required for the successful development of larvae and thus for the recovery of the Plains Minnow populations (Platania and Altenbach 1998; Dudley and Platania 2007; Perkin and Gido 2011). Numerous

[2] Threat likelihood was assigned a known, likely, unlikely, or unknown and threat impact was assigned as high, medium, low, or unknown. The number in parentheses refers to the level of certainty associated with the threat impact assignment and has been classified as: 1 = causative studies; 2 = correlative studies; and 3 = expert opinion. Certainty associated with the threat level is reflective of the lowest level of certainty associated with either threat likelihood or threat impact (Sawatzky and Watkinson 2013).

studies have shown significant declines in the Plains Minnow and similar species following the construction of dams and other infrastructure projects that create barriers and modify natural water flows and habitats within watersheds. These studies encompass a range of systems, from larger ones like the Missouri River to numerous smaller water bodies. The alteration of the flow patterns resulting from dam construction has transformed these rivers from highly fluctuating, turbid systems with occasional out-of-bank flows and intermittent pools into consistent and smaller flow streams with clear water. These changed conditions are likely unsuitable for the Plains Minnow, which are presumably not adapted to such environments (COSEWIC 2012). There are 12 reservoirs on Rock Creek with a cumulative capacity of 309 cubic metres, which represents a small proportion (1.8%) of the total annual discharge (White 2007). Any future dam-building (a barrier constructed to hold back water and raise its level) in Rock Creek and it's tributaries could alter the natural flow regime in the Plains Minnow habitat and negatively impact on the Plains Minnow population; however, new impoundments in the Canadian range are thought to be unlikely, and any proposed dam construction projects would be reviewed by DFO and assessed for impacts to aquatic species prior to a decision being made as to whether or not such a project will be authorized. Any dams built in the United States range would be downstream of the Canadian distribution and would not impact the natural flow regime in that area, although they would contribute to barriers to movement.

Habitat removal and alteration

Habitat removal and alteration may occur within the distribution of the Plains Minnow as a result of stream bank trampling associated with intense cattle grazing and watering, small impoundments and dugouts, water withdrawals, large impoundments, or water crossings (DFO 2013a). Cattle ranching is the main activity on land surrounding Rock Creek within the known distribution of the Plains Minnow, both inside and outside of Grasslands National Park. It has the potential to alter the Plains Minnow habitat, primarily through stream bank trampling when cattle directly access the streams for drinking water; however, cattle density is low and direct impacts to habitat are likely localized (COSEWIC 2012). Higher use areas where stream bank trampling may occur would be limited to sites where cattle can easily access Rock Creek for watering. Cattle exhibit habitual behaviour and prefer to access watering sites known to them (Keshavarzi et al. 2020). Before European settlement, the prairies were inhabited by freely roaming ungulates such as bison, elk, pronghorn and antelope, but over the last century ranching has become the dominant land use. These have contributed to maintaining the prairie ecosystem (Parks Canada 2022); however linkage between historic ungulate presence and the Plains Minnow are unknown. An experimental grazing study conducted in Grasslands National Park determined that the aquatic invertebrate community inhabiting this semi-arid environment are naturally-stressed due to seasonal flow conditions, and remained stressed, even at low grazing intensity (Wlasichuk 2014); thus indicating that additional stressing factor may be affecting the aquatic habitat (Wlasichuk 2014). Land adjacent to the Plains Minnow's distribution outside Grasslands National Park consists of Saskatchewan Crown land leased for ranching. Thus, land bordering the known distribution of the species is managed by either Parks Canada or the Saskatchewan Ministry of Agriculture, and is subject to livestock carrying capacity limits expressed as Animal Unit Months (AUMs). AUMs are a standard used in range management and can be used to determine the number of animals which can be grazed each season (stocking rate) by accounting for the type and average weight of the animals and duration of grazing in months; carrying capacity (AUM rating) does not fluctuate from year to year, whereas stocking rates may need to be adjusted based on fluctuations in growing conditions (for example, precipitation and soil moisture). This ensures the land is grazed in a manner to ensure the prolonged health and vigor of the landscape. The private rancher in this area, along with PC, places a high value on stewardship. As a result, most of the grazing land is well managed using

sustainable practices that prevent over-grazing. However, there may be local areas subject to heavy grazing over a series of years, such as livestock concentration areas associated with calving, water sources, and salt blocks. Tools are available to minimize the impact to streams, such as placing cattle attractants, such as salt or mineral blocks, away from streams.

Large impoundments (for example, dams) can alter habitat by stagnating flow and reducing sediment, providing clear, rocky habitat that may be preferred by non-native predators (Macnaughton et al. 2019); however, no large dams exist within the Canadian portion of the distribution. Small impoundments and dugouts can be used by ranchers for cattle watering and can alter habitat by decreasing water levels, where water is directed out of the stream to fill them; however, there are no known dugouts or man-made impoundments along Rock Creek in areas of the Plains Minnow distribution that are adjacent to Grasslands National Park. Since cattle typically use the stream as a water source directly (Sliwinski pers. comm 2021), it was estimated that <2% of flow was being held upstream for stock watering (DFO 2013b). Water withdrawals for other purposes can also have impacts on habitat by reducing water levels; these withdrawals would be managed and licensed by Saskatchewan's Water Security Agency and do not play a significant role in the area (Schweitzer pers. comm. 2001). Although this fact was not specifically addressed in the previous reports (COSEWIC 2012; DFO 2013a), all developments on Saskatchewan Crown land, including water developments (dugouts, wells, pipelines) require Saskatchewan Ministry of Agriculture approval prior to starting work. The Saskatchewan Ministry of Agriculture prohibits breaking or clearing of native prairie on all agricultural Crown lands. If critical habitat for certain species at risk is present, Saskatchewan Ministry of Environment approval is also required prior to starting work. The approval process ensures impacts to critical habitat and species at risk are eliminated or mitigated. In some cases, an Aquatic Habitat Protection Permit, issued by the Saskatchewan Water Security Agency, is also required.

A limited number of stream crossings exist within the Rock Creek drainage. New stream crossings or alterations to existing stream crossings may impact this threat level; however, these activities would be subject to fish and fish habitat provisions under the federal *Fisheries Act* and provisions of the *Species At Risk Act*.

Rock Creek Campground, a recreational campground, was built upstream of the known Plains Minnow distribution in Grasslands National Park, with preliminary rudimentary construction starting in 2009 and more permanent upgrades completed in 2017. This campground was not assessed or included in the RPA (DFO 2013a). Rock Creek Campground was built on a previously developed site following PC's park management plan. An impact assessment was conducted by PC prior to this development being approved and all identified threats were considered unlikely to have residual effects following mitigation.

In general, additional habitat removal and alteration was thought to be unlikely within the Canadian range of the Plains Minnow, but assigned a high threat impact ranking because of known declines in abundances in other areas of its range as a result of habitat alteration. These 2 rankings combined to result in an overall threat level of medium (Sawatzky and Watkinson 2013).

Exotic piscivores

This threat was reassessed, from a threat likelihood of unlikely and threat impact of high (DFO 2013b), to a threat likelihood of likely, and a threat impact of medium, resulting in an overall threat level of medium, based on a better understanding of exotic piscivores in the watershed and their likely impact if present in the Canadian portion of the system. In other parts of their

range, the Plains Minnow abundance declines have been associated with exotic piscivores (Quist et al. 2004; Hoagstrom et al. 2007; Sawatzky and Watkinson 2013). Black Bullhead (*Ameiurus melas*) is the only exotic piscivore that has been observed in the Canadian distribution of the Plains Minnow (COSEWIC 2012; Teillet et al. 2021). Impacts from any potential predation by Black Bullhead is not expected because of low abundance in Rock Creek. Northern Pike (*Esox lucius*), which are not considered native in the Missouri drainage, have not yet been observed in the Canadian portion of Rock Creek, but are present elsewhere in the watershed in Montana. Often, small-bodied fish are notably absent from streams containing Northern Pike (DFO 2013b; Watkinson pers. comm. 2021). If the watershed experienced a multi-year wet period, Northern Pike would likely migrate into the Canadian portion of Rock Creek from Montana and could establish a population. However, any effects would likely be short-lived since the hydrology of the system, characterized by low summer and winter flows, with negative implications for larger-bodied fish, are likely to limit their prolonged establishment (Watkinson pers. comm. 2021). Any game fish introduction into the area would likely require new dams and reservoirs to provide habitat that would allow reproducing populations to establish; the creation of new dams and reservoirs is an activity that would need to be evaluated by DFO to determine whether or not such a project would be authorized (COSEWIC 2012).

Contaminants and toxic substances from pipeline fractures

One pipeline occurs near Rock Creek and although unlikely, the threat impact from contaminants and toxic substances from a pipeline fracture would be high. The impact would be dependent on type (for example, natural gas or light or heavy crude) (DFO 2013b), resulting in a medium threat level. Additionally, pipeline integrity management requirements are stringent within the oil and gas industry, which enables proactive maintenance on existing pipelines prior to a spill or incident.

Climate change

The effects of climate change on the Plains Minnow are highly speculative and difficult to quantify and were not included in analysis of the threats in the RPA. Nonetheless, the RPA lists climate change as one of the greatest threats to the Plains Minnow (DFO 2013a). Predicted effects of climate change in the region include increases in water and air temperatures, changes in water levels, shortening of the duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases and drought, and shifts in predator-prey dynamics, all of which may impact native fishes (Lemmen and Warren 2004). The Plains Minnow in Canada may be most susceptible to decreases in discharge from drought or increased evapotranspiration, or increased winter freezing exacerbated by low water (COSEWIC 2012). Increased air temperatures are unlikely to directly impact the Plains Minnow in its Canadian range because of its high thermal tolerance (COSEWIC 2012). Annual flow in Rock Creek has declined since the 1970s, with a resulting decrease in the frequency and duration of flooding events, which was more likely attributable to climate change rather than water being retained in reservoirs, which only hold a small proportion of the annual discharge (1.8%) (White 2007).

Other low-level or unknown threats

During the RPA threats assessment, turbidity and sediment loading was assigned a threat level of low (derived from being an unlikely threat with a medium threat impact level). Elevated turbidity may occur as a result of a number of activities (for example, water crossings, trenchless crossing and pipeline remediation, well site remediation, and cattle grazing). It should be noted that the Plains Minnow has a high tolerance for turbid waters, but this threat was defined as turbidity at high levels over a long period of time, and indirect impacts through effects

on prey were also considered (Sawatzky and Watkinson 2013; DFO 2013a; DFO 2013b). Alteration of natural flow regimes from small impoundments and dugouts, introduced species (excluding piscivores) and diseases, and scientific sampling were all assigned threat levels of low, as a result of a known threat likelihood with a low threat impact (DFO 2013a). As previously stated, the lessee of provincial crown land surrounding Rock Creek does not use intensive grazing practices, resulting in a low threat level for nutrient loading from cattle grazing. Weed and alien or invasive species control is a Crown lessee requirement under the lease agreement and may include the use of herbicides, reviewed by Saskatchewan Ministry of Agriculture. These lease agreements are issued on agricultural Crown lands used for cultivation, hay and grazing. Currently there is no clause restricting the use of pesticides on agricultural Crown lands. Herbicides are commonly applied within cultivated leases and may be selectively applied on hay and grazing leases for targeted control of weed and alien or invasive species. The application of herbicides should pose a low level threat as long as they are applied according to the product label, and buffer zones are followed as specified on each herbicide label.

Alteration of the natural flow regime can also occur as a result of water withdrawals, which are managed through provincial water license and through domestic water use allowances to leaseholders, but are not present within or upstream of the distribution of the Plains Minnow. Given the Plains Minnow’s reliance on long stretches of unimpeded river to successfully reproduce, barriers to movement was assigned a threat impact level of high, but the likelihood of this threat is currently unknown. There are no known barriers to movement in the 26.5 rkm of river habitat within the Canadian distribution, but there are diversion dams on Rock Creek and Milk River in Montana, which may act as barriers (Sawatzky and Watkinson 2013).

Recovery

6 Population and distribution objectives

Limited historical sampling makes it difficult to determine whether the Plains Minnow in Canada has experienced a decline in the population, however sampling in September 2020 in comparison to previous sampling in 2006 and 2007 suggests that abundance remains low and its distribution is variable or contracting within the known range since (Teillet et al. 2021). This population appears to persist naturally in this watershed but may always be at some level of risk because of its limited distribution in Canada. The focus of recovery planning should be to maintain the population by reducing, eliminating, or managing existing or potential threats. Since it is unknown whether population abundances and habitat require recovery or restoration, a conservation approach based on protecting and maintaining the existing population and their habitats is recommended.

The population and distribution objective for the Plains Minnow is:

> "To protect and maintain populations of the Plains Minnow within its current range in Canada."

A number of approaches are proposed to meet the population and distribution objective. The approaches take into account the uncertainty associated with knowledge of the species' biology, life history, abundance, and habitat requirements, as well as impact and likelihood of identified threats to the survival of the Plains Minnow in the Rock Creek drainage. The recovery approaches are:

- to quantify and maintain population equal to, or greater than, estimated population size of the Plains Minnow in Rock Creek in Canada
- to increase knowledge of the life history, biology, and habitat requirements of the Plains Minnow to refine the identification and protection of critical habitat
- to increase understanding of how human activities affect the Plains Minnow survival, so that potential threats can be eliminated, or mitigated

7 Broad strategies and general approaches to meet objectives

7.1 Actions already completed or currently underway

A number of activities related to the protection and maintenance of the Plains Minnow have already been completed. They include:

- Grasslands National Park of Canada Management Plan, 2022, which replaces the 2010 management plan
    - key strategy #2, species at risk and resource management, aims to protect the park's treasured landscape with all its natural and cultural resource values
    - additional elements of this strategy include increasing partnerships and improving knowledge
- in 2020, DFO employed a standardized sampling protocol developed by DFO to monitor the relative abundance and distribution of the Plains Minnow in Rock Creek and adjacent watersheds at 17 access points (Teillet et al. 2021)

- in 2019, DFO developed a standardized sampling protocol to monitor occurrence and abundance of the Plains Minnow and to provide information on the changes to the distribution range and trends in the species abundance (Macnaughton et al. 2019)
- in 2018, DFO developed an action plan for the Milk and St. Mary river drainage basins in Canada
    - the action plan currently includes 2 threatened fishes, the Western Silvery Minnow (*Hybognathus argyritis*) and Rocky Mountain Sculpin, Eastslope populations (*Cottus* sp.)
    - the Plains Minnow may be included in future revisions of this action plan, as it is found within the Milk River drainage (Fisheries and Oceans Canada 2018)
- in 2016, a Multi-species Action Plan for Grasslands National Park was prepared by PC
    - it identified critical habitat for 7 species, including the Sprague's Pipit (*Anthus spragueii*), a threatened bird
    - the Sprague's Pipit's critical habitat includes park land within the Rock Creek drainage in the East Block of Grassland National Park, which overlaps with the distribution of the Plains Minnow
    - mitigation measures or recovery actions in the Rock Creek drainage to protect critical habitat of the Sprague's Pipit may indirectly benefit the Plains Minnow (Parks Canada 2016)
- in 2016, Environment and Climate Change Canada, prepared an action plan for multiple species at risk in southwestern Saskatchewan: South of the Divide (SoD)
    - this action plan included descriptions of critical and important habitat located within SoD, but outside of Grassland National Park for 11 terrestrial species
    - portions of critical habitat for 3 threatened species, Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*), Sprague's Pipit, and Swift Fox (*Vulpus velox*) and important habitat for 3 special concern species, Long-billed Curlew (*Numenius americanus*), McCown's Longspur (*Calcarius mccownii*), and Northern Leopard frog (*Rana pipiens*) are in the Rock Creek drainage and overlap with the Plains Minnow distribution
    - some measures taken to protect the habitats of these 6 species may indirectly benefit the Plains Minnow (Environment and Climate Change Canada 2017)
- in 2014, critical habitat for the Greater Sage-Grouse (*Centrocercus urophasianus*) was identified in the East Block of Grasslands National Park, adjacent to Rock Creek
- in 2013, an emergency protection order was published to protect Greater Sage-Grouse habitat in areas including those adjacent to Rock Creek
- in 2010, PC developed the Grasslands National Park of Canada Management Plan
    - 2 of the 4 key strategies of the management plan are to maintain the ecological integrity of the Park by ensuring the persistence and restoration of the prairie, collaborating with neighbors, stakeholders and other partners, and using outreach and education
    - implementation of these strategies will have indirect benefits to the Plains Minnow
- riparian health assessment of Rock Creek is part of Grasslands National Park's Ecological Integrity monitoring program, which is used to detect changes in
- representative parks' ecosystems and to inform management actions required to maintain or improve their health
    - these assessments are conducted every 2 years, following standardized protocols

7.2 Strategic direction for recovery

Descriptions of the broad strategies to address identified threats and of the research and management approaches needed to meet population and distribution objectives are presented in table 3. These will help to inform the development of specific recovery measures in 1 or more action plans.

Table 3 summarizes the identified threats to the recovery of the Plains Minnow, knowledge gaps, concerns, and the strategies to address them. The research and approaches are not independent of one another and, in some cases, it may be possible to address threats or concerns using a single recovery action. “Priority” reflects the degree to which the approach is expected to contribute directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species. A “high” priority approach is considered likely to have an immediate and/or direct influence on the recovery of the species. A “medium” priority approach is important but considered to have an indirect or less immediate influence on the recovery of the species. A “low” priority approach is considered to be an important contribution to the knowledge base about the species and mitigation of threats.

Table 3. Recovery planning table for the Plains Minnow.

General description of research and management approaches	Broad strategy	Priority	Level of influence	Threat or concern addressed
Monitor the Plains Minnow using a standardized approach for fish and habitat data collection to establish a baseline understanding of population abundance and distribution	Inventory and monitoring	High	Immediate and/or direct influence	Unknown or incomplete population status
Conduct periodic surveys using a standardized approach to determine population trends	Inventory and monitoring	High	Immediate and/or direct influence	Unknown or incomplete population status
Continue periodic monitoring using a standardized approach to evaluate whether population abundances respond to recovery measures or identify changes in abundance and distribution related to natural processes or changes in threats	Inventory and monitoring	High	Immediate and/or direct influence	Unknown or incomplete population status

General description of research and management approaches	Broad strategy	Priority	Level of influence	Threat or concern addressed
Identify existing barriers or activities that prevent or impede fish movement or alter flow (for example, impoundments, stream crossings, dams, water withdrawal projects, and other disturbances) Coordinate with Saskatchewan Ministry of Agriculture and Saskatchewan Water Security and lessee (if applicable) to assess barriers and determine whether mitigation or restoration activities are required	Inventory and monitoring	High	Immediate and/or direct influence	Unidentified or unquantified threats
Monitor for occurrence of new exotic species Monitor abundance and distribution of exotic species previously observed in the watershed to identify changes	Inventory and monitoring	Medium	Indirect or less immediate influence	Exotic piscivores
Identify human-caused sediment sources that may result in elevated sediment entering the watercourse for prolonged periods (for example, stream crossings and other disturbances) Coordinate with Saskatchewan Ministry of Agriculture and Saskatchewan Water Security and lessee (if applicable) to assess barriers and determine whether mitigation or restoration activities are required	Inventory and monitoring	Low	Important contribution to knowledge of species and mitigation of threats	Habitat removal and alteration

General description of research and management approaches	Broad strategy	Priority	Level of influence	Threat or concern addressed
Determine life history characteristics for all life stages of the Plains Minnow in Canada Targeted sampling, rather than the current standardized sampling protocol, may be required to address this measure, which may impact its feasibility	Research	Medium	Indirect or less immediate influence	Unknown life history
Determine how environmental variability relates to variation in population estimates Define causative relationships between threats and population abundances Targeted sampling, rather than the current standardized sampling protocol, may be required to address this measure, which may impact its feasibility	Research	Medium	Indirect or less immediate influence	Unknown drivers of annual abundance and distribution variability in Canada
Identify and determine effects of point sources contributing to water quality degradation and input of increased nutrients Determine Canada-specific Plains Minnow tolerance thresholds for a number of water quality measures These thresholds may be difficult to determine experimentally or observationally, which may impact the feasibility of this measure	Research	Low	Important contribution to knowledge of species and mitigation of threats	Nutrient loading; Habitat removal and alteration

General description of research and management approaches	Broad strategy	Priority	Level of influence	Threat or concern addressed
Maintain ongoing coordination with Parks Canada (PC), the Government of Saskatchewan, and landowners to articulate management strategies that prioritize high-level concerns, such as barriers to movement and changes in natural flow. Additionally, emphasize medium-level concerns, such as turbidity and sediment loading, as lower-priority threats.	Management and coordination	High	Immediate and/or direct influence	Alteration of natural flow regimes from large impoundments, habitat removal and alteration, alteration of natural flow regimes from small impoundments and dugouts, barriers to movement
Engage with Government of Saskatchewan to prevent invasive species and introduction of exotic piscivores	Management and coordination	Medium	Indirect or less immediate influence	Introduced species (non-piscivores) and diseases; introduction of exotic piscivores
Coordinate with PC, Government of Saskatchewan, and land users adjacent to Rock Creek, when planning and implementing programs for other species at risk	Management and coordination	Medium	Indirect or less immediate influence	Habitat removal and alteration
Engage landowners, stakeholders, and the public through presentations, distribution of informational material, and interpretive signage for the Plains Minnow	Stewardship and outreach	Medium	Indirect or less immediate influence	Species awareness
Work with United States agencies to maintain connectivity and ensure minimum stream length requirements are met	International collaboration	High	Immediate and/or direct influence	Barriers to movement
Collaborate with the United States to determine the current distribution and extent of suitable habitat in the United States portion of the Rock Creek watershed	International collaboration	High	Immediate and/or direct influence	Unknown suitable habitat outside of Canada

General description of research and management approaches	Broad strategy	Priority	Level of influence	Threat or concern addressed
Work with the United States agencies to monitor the possible invasion of exotic piscivores, other introduced species, and diseases Develop mitigation measures to address any of these threats	International collaboration	Medium	Indirect or less immediate influence	Exotic piscivores, introduced species and diseases

7.3 Descriptions of approaches in the recovery planning table

Strategies proposed to address identified or potential threats, and to guide appropriate research and management activities to meet the population and distribution objective, are presented for each of the broad approaches, namely inventory and monitoring, research, management and coordination, stewardship and outreach, and international coordination.

Some strategies have been discussed in supporting documents to this recovery strategy (see DFO 2013a) and they are designed to assess, mitigate, or address information deficiencies that might otherwise inhibit species recovery; or to contribute to the species' recovery in general. These strategies will help inform the development of specific recovery measures in subsequent action plan(s) and may benefit additional species.

Recovery approaches will help ensure that:

- research is conducted on the Plains Minnow population in Canada to fill knowledge gaps on biology, ecology, and the environment (including interactions with introduced species and exotic piscivores) to inform prioritization and implementation of recovery actions
- there is continuing efforts to monitor, assess, and protect the Plains Minnow populations and their habitat, and monitor human activities to assess, minimize, and mitigate ongoing and emerging threats
- there is awareness of the species and support for recovery of the Plains Minnow within the province and elsewhere

Inventory and Monitoring

Baseline information for the Plains Minnow abundance and distribution should be established by conducting multiple years of sampling using standardized methodology developed by Macnaughton et al. (2019). The need for continued abundance estimates is a high priority since existing estimates in Rock Creek are limited, sporadic (2006, 2007, 2020), and were conducted using different methods. Distribution based on more robust sampling can be used to refine critical habitat extents. Catch per unit effort (CPUE) data collected from sampling in 2006 and 2007 were slightly higher than the CPUE estimates in 2020, suggesting that the relative abundance of the Plains Minnow in Canada is low and that its distribution is variable or contracting within the known range (Teillet et al. 2021). Despite use of a standardized sampling method, Teillet et al. (2021) suggested that the sampling effort invested in 2020 may have been insufficient to properly assess the distribution of the Plains Minnow given that the species may

occur at low abundances and/or patchy distribution. Once a baseline is established, continued monitoring can be used to address the currently unknown population trend for the Plains Minnow in Canada. Adopting monitoring programs that use consistent survey protocols should provide more efficient, comparable, and powerful assessments of population trends over time (Macnaughton et al. 2019). Timing of surveys should consider annual flow conditions as well as inter-annual flow trends, to ensure that surveys are conducted for similar flow stages (Macnaughton et al. 2019).

Continued periodic monitoring should occur to evaluate how population abundances respond to recovery measures or to identify changes to abundance or distribution related to natural processes or changes in threats. Given the reliance of the Plains Minnow on its ability to access greater than 115 rkm to complete its life cycle, and that the RPA assigned a threat impact of high and a likelihood of unknown to barriers to movement (DFO 2013a), continued monitoring should identify specific locations of existing threats such as barriers or other activities that impede movement or flow (such as water withdrawals, small and large impoundments, stream crossings, and other disturbances), and quantify their impact. The current threat level for exotic piscivores is medium, since such species are already present within the Canadian distribution or within the larger watershed with no barriers to movement; as such, continued monitoring should occur to identify any changes to this threat. Habitat monitoring should also identify any human-caused sources of prolonged elevated sediment inputs; this action is a low priority since the Plains Minnow are tolerant of high turbidity, but there may be indirect impacts through the food chain.

An increase in suspended sediments, or turbidity, can limit light penetration in the water and reduce food sources for the Plains Minnow (Henley et. al 2000).

Research

Research will assist in filling information gaps that currently exist regarding population structure, life history requirements, habitat requirements, drivers of seasonal and annual variability, and water quality thresholds of the Plains Minnow in Canada that need to be addressed to refine the recovery strategy and to ensure that the population is adequately protected. Research is required to add to the knowledge on the life history of the Plains Minnow in Canada but may be limited by the feasibility of targeted sampling required to address this unknown. Key life history characteristics that are needed to inform the Plains Minnow population modelling efforts are unknown; they include fecundity, the relationship between flow rates and spawning, and survival at all stages. Other unknowns are growth rate, age at maturity, longevity, and frequency of catastrophic declines of the Plains Minnow in Canada. It is unknown if post spawning mortality is high for first time spawners, or if individuals survive to reproduce a second year. It is also unknown if the Plains Minnow can recruit from one life stage to the next in years of low or no flow (DFO 2013a). Preliminary age and size structure data from the Canadian population suggested that the Plains Minnow may live as long as 3 years, which is older than most United States reports (COSEWIC 2012). Further research is required to confirm this potentially longer lifespan and also to confirm that YOY are found within Canada using otolith aging techniques. Current size-structure comparisons with United States populations suggest that YOY occur in Canada.

Research is required to determine how environmental factors relate to annual variability in population abundances; this action was assigned a medium priority since most information about the species comes from populations in the United States. Understanding baseline natural variation will provide context for further research to determine causative relationships between

threats and population abundances. This goal may be challenging to address given the amount of targeted sampling required to address this unknown.

Understanding the relationships between threats and population abundances, and the Plains Minnow tolerance thresholds for various water quality measures would provide more certainty about the impact of each threat on the Plains Minnow and would facilitate estimating the cumulative effects of landscape changes, but may be difficult to determine experimentally or observationally. Several water quality parameters such as specific conductivity, clarity of water (measured by Secchi depth), salinity, total dissolved solids, and pH were determined at sites where the Plains Minnow were captured in the Rock Creek drainage in Canada. There is a need to determine upper and lower threshold levels of these parameters to have a better understanding of the habitat requirements for the Plains Minnow in Canada.

Management and Coordination

To achieve the population and distribution objective of the Plains Minnow, coordination is required with PC and the Government of Saskatchewan to manage water and land-use in the Rock Creek drainage. DFO should work with PC, the Government of Saskatchewan and those who use the land to mitigate and prevent possible negative effects of in-water work and future water crossing projects in the Rock Creek drainage.

Declines in the Plains Minnow abundance have been connected to exotic piscivores in the United States (Quist et al. 2004; Hoagstrom et al. 2007). Largemouth Bass (*Micropterus salmoides*) has been introduced into Saskatchewan outside the Rock Creek drainage. Northern Pike are present in the Milk River basin and may move into upper Rock Creek if the watershed experienced a multi-year wet period. Currently, Black Bullhead, which is not native to the Milk River basin, is present in the Canadian reaches of Rock Creek. Common Carp (*Cyprinus carpio*), which is not piscivorous, have been found in the Rock Creek drainage, indicating such invasions by exotic species, including piscivores, are possible. To prevent future invasions, it is important that a coordinated effort with the Government of Saskatchewan and PC is conducted to prevent invasions, to protect and maintain populations of the Plains Minnow in Canada.

Stewardship and Outreach

Stakeholders, municipalities, counties, schools, and the public should be engaged through presentations, distribution of informational material, and interpretive signage to raise species awareness and to encourage the public to assist in the protection of the Plains Minnow. DFO will collaborate with PC to develop interpretive signs and to display them near critical habitat or within interpretive areas and the visitors centre in Grasslands National Park.

International Collaboration

It is estimated that only 26.5 rkm of the 115 rkm minimum needed for larval development is in Canada. Thus, it is essential to collaborate with the United States to maintain connectivity with the United States' portion of Rock Creek. In addition, it is important to understand the current distribution and extent of suitable habitat in the United States portion of the watershed.

In addition to monitoring for exotic piscivores and introduced species within Canada, a protocol should be developed in collaboration with the United States to monitor, evaluate, and propose actions for any possible invasion of species and the potential spread of diseases to the Canadian portion of the Rock Creek drainage that could harm the survival of the Plains Minnow in the watershed.

8 Critical habitat

8.1 Identification of the species' critical habitat

8.1.1 General description of the specie's critical habitat

Critical habitat is defined in SARA as "…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species." [subsection 2(1)]

Also, SARA defines habitat for aquatic species as "… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [subsection 2(1)]

For the Plains Minnow, critical habitat is identified to the extent possible, using the best available information, and identifies the functions and features necessary to support the species' lifecycle processes. The schedule of studies (section 8.2) outlines additional research required to refine the critical habitat necessary to support the species' lifecycle processes.

This recovery strategy identifies the features of critical habitat for the Plains Minnow as barrier-free, turbid, sandy to silty waters, with a preference for backwaters and embayments. The area within which critical habitat can be found includes the 26.5 rkm of barrier-free river length of Rock Creek in Saskatchewan, beginning from the United States border and extending upstream.

8.1.2 Information and methods used to identify critical habitat

The critical habitat for the Plains Minnow was identified using the bounding for Rock Creek, Saskatchewan. The bounding box identifies the upstream and downstream extent of distribution of the species while the bankfull channel defines the sides of the bounding box. The bankfull channel width is the width of the stream at bankfull discharge, which is the flow at which water begins to leave the channel and move into the floodplain. This method for identifying critical habitat requires the use of essential features and attributes for each life function of the species to identify patches of critical habitat within the bounding box, which is defined by the distribution of the species. The bounding box is used when functions, features, and attributes can be described but their location varies or when knowledge of their specific location is unknown. Critical habitat does not include the entire area within the identified boundaries, but rather only those areas within the identified geographical boundaries where the described biophysical features occur as described in table 4. The downstream extent of critical habitat occurs at the Canada-United States border (P1 in figure 3). The upstream extent of critical habitat corresponds to the upstream extent of the species distribution in Canada (P2).

DFO determined the population size needed for the recovery of the Plains Minnow, which is based on the objective of achieving a sustainable population (demographic sustainability), as part of an RPA (DFO 2013a). Demographic sustainability was defined as the minimum adult population needed for the probability of survival of the species over 100 years (approximately 42 generations). The RPA modelling results showed that the estimated population size necessary for persistence of a stable Plains Minnow population over the long term could be 60,000 adults

(ages 1+), requiring 12 hectares (ha) of suitable habitat with at least 115 rkm of barrier-free river.

The analysis assumed a 50% probability of catastrophic decline in population size, defined as a probability of 0.15 decline per generation and an extinction threshold of 2 adults. Available habitat in Canada is estimated at 12 ha, including 26.5 rkm of barrier-free river. Estimated available rkm from the United States portion of Rock Creek is 170 rkm to Rock Creek Diversion Dam.

Given that its diet consists primarily of benthic algae, diatoms, and other microflora, the Plains Minnow is not likely to benefit directly from the addition of prey from terrestrial sources. The riparian zone of the Plains Minnow habitat consists of primarily grasses and short shrubs that are unlikely to shade or regulate stream temperature. Given these considerations, the riparian zone was not taken into consideration for the delineation of critical habitat for the Plains Minnow. However, an intact riparian habitat benefits the general ecosystem health and should consequently be maintained to ensure instream habitat quality.

8.1.3 Identification of critical habitat

Geographic information

For the Plains Minnow, critical habitat is identified as Rock Creek, Saskatchewan (figure 3).

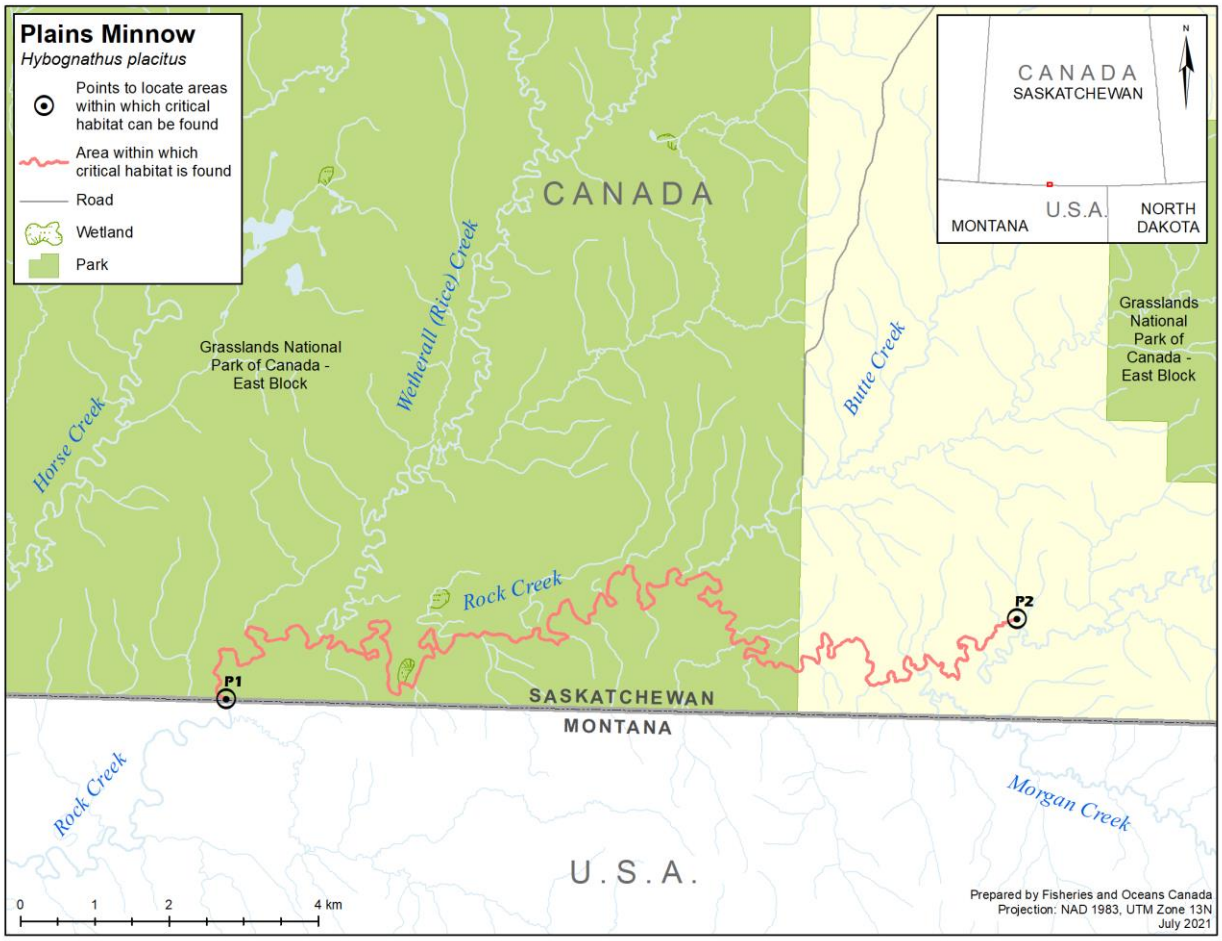

Figure 3. Area within which critical habitat is identified for the Plains Minnow, *Hybognathus placitus*, in Rock Creek, Saskatchewan.[3]

The critical habitat's functions, features, and attributes have been identified using the bounding box. This means that the critical habitat is not composed of the entire area within the identified boundaries but only those areas within the identified geographical boundaries where the described biophysical feature and the function it supports occur, as described in table 4. The geographic coordinates for the areas within which critical habitat is found for the Plains Minnow are indicated in table 5 and illustrated on figure 3.

Biophysical functions, features and attributes

Table 4 summarizes the best available knowledge of the functions, features, and attributes for each life stage of the Plains Minnow (refer to section 4.3 "Needs of the species" for full references). Not all attributes in table 4 must be present for a feature to be identified as critical habitat. If the features as described in table 4 are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table. Note, information on the functions, features, and attributes for the Plains Minnow is limited, in part due

[3] While Rock Creek passes through Grasslands National Park, administration and control of the watercourse is currently under the Province of Saskatchewan and not Parks Canada.

to their preference for turbid waters, making observation difficult. Also, research in Canada is limited as the species was only discovered in 2003. Much of the information presented below is from its range in the United States.

Table 4. General summary of the biophysical functions, features, and attributes of critical habitat in Rock Creek Saskatchewan, necessary for survival or recovery of the Plains Minnow.

Life stage	Functions[4]	Features[5]	Attributes[6]
Adult (spawning)	• Spawning (spring to summer) • Staging	• Flowing water of rivers or streams • Shallow backwaters • Sandbars	• Moderate to high flow • Flowing water • Unimpeded access to upstream areas
Eggs to exogenous feeding	• Nursery • Cover • Feeding	• Flowing water of rivers or streams • Backwaters	• Moderate to high flows • Unimpeded river length (minimum of 115 rkm) • Food availability
Juvenile	• Feeding • Cover	• Flowing water of rivers or streams, • Backwaters • Intermittent pools	• Likely similar to adults (see below) • Hard silt-sand substrate, loose sand substrate • Food availability
Adult	• Feeding • Cover	• Backwater and embayment areas of river • Shallow backwaters • Eddies and along edges of shifting dunes in sand-bed rivers with current • Unimpounded river reaches	• Low to mid-velocity flows • Substrate dominated by sand • Unimpounded river • Turbid water • Low abundance of exotic piscivores • Food availability

[4] Functions: functions are life-cycle processes of the listed species taking place in critical habitat (for example, spawning, nursery, rearing, feeding, and migration).

[5] Features: features are the essential structural component that provides the requisite function(s) to meet the species' needs. Features may change over time and usually consist of more than one part or attribute. A change or disruption to the feature or any of its attributes may affect the function and its ability to meet the biological needs of the species.

[6] Attributes: attributes are measurable properties or characteristics of a feature. Attributes describe how the identified features support the identified functions necessary for the species' life processes.

		• Main channels of large turbid silt-laden rivers	

Existing anthropogenic structures, such as bridges, culverts (regardless of size), roads, pipelines, water intakes that are within the areas delineated as critical habitat, are excluded and not considered to be critical habitat for the Plains Minnow. Activities including installation, maintenance, repair or replacement of any anthropogenic structures, located within critical habitat (table 5) must be reviewed by DFO to determine whether a *Species at Risk Act* permit and/or *Fisheries Act* authorization is required.

Table 5. Coordinates locating the boundaries within which critical habitat is found for the Plains Minnow were calculated using the WGS 1984 datum, in decimal degrees.

Point	Location	Latitude	Longitude
P1	Rock Creek	48.99999	-106.77938
P2	Rock Creek	49.01184	-106.63452

Summary of critical habitat relative to population and distribution objectives

The biophysical functions, features, attributes, and locations described in table 4 are the areas that the Minister of Fisheries considers necessary to achieve the species' population and distribution objective required for the recovery of the Plains Minnow.

8.2 Schedule of studies to identify critical habitat

Further research is required to refine the current boundaries of the critical habitat necessary to support the species' population and distribution objective and to protect the critical habitat. This additional work includes the following studies (table 6):

Table 6. Schedule of studies to refine critical habitat for the Plains Minnow.

Description of study	Rationale	Timeline
Long-term monitoring of thermal trends	Temperature drives species' distribution via cumulative impacts with water flow, dissolved oxygen concentration, and other variables This work will help better understand population trends over time	5+ years
Habitat data to help explain future presence/absence or changes in abundance of the Plains Minnow at any location (water velocity, depth, substrate complexity, plant cover, as well as multiple other environmental/habitat descriptors)	This data will capture the variability, conditions and features of habitat within the Plains Minnow range in Rock Creek This will provide important information about habitat changes through time	5+ years

Description of study	Rationale	Timeline
Monitoring occurrence and abundance of the Plains Minnow using a standardized approach for fish and habitat collection. Reducing environmental variability by using the same sampling sites and timing	Rock Creek has a highly variable hydrograph and the flow becomes intermittent, limiting movement of fishes Ensuring similar flow conditions and temperature at time of sampling will reduce uncertainty in the population estimates related to environmental variability; this will allow fish density and biomass estimates to be compared across sites and between years	5+ years
Conducting studies to identify and characterize habitat use by the Plains Minnow in Canada	There is limited information on the habitat use of each life stage of the Plains Minnow in the Rock Creek drainage in Canada This work will help refine critical habitat and will specifically link habitat use to life stage	5+ years
Determining habitat requirements for spawning, development of eggs, proto-larval stage, and juveniles	There has not been any work done targeting habitat requirements for spawning adults, development of eggs, proto-larva, and juvenile life stages in Canada This work will help define critical habitat for these specific life stages in Canada	5+ years

8.3 Activities likely to result in the destruction of critical habitat

The following examples of activities likely to result in the destruction[7] of a part of critical habitat (table 7) are based on known human activities that are likely to occur in and around critical habitat and would result in the destruction of a part of critical habitat if unmitigated. The list of activities is neither exhaustive nor exclusive and its development has been guided by the threats described in section 5. The absence of a specific human activity from this table does not preclude or restrict the Department's ability to regulate that activity under SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition, and does not mean that the activity will inevitably result in destruction of a part of critical habitat. Every proposed activity

[7] Destruction occurs when there is a temporary or permanent loss of a function of critical habitat at a time when it is required by the species.

must be assessed on a case-by-case basis, and site-specific mitigation will be applied where it is reliable and available. Where information is available, thresholds and limits have been developed for critical habitat attributes to better inform management and regulatory decision-making. However, in many cases knowledge of a species and its critical habitat's thresholds of tolerance to disturbance from human activities is lacking and must be acquired.

Table 7. Activities likely to result in the destruction of critical habitat for the Plains Minnow.

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Alteration of natural flow regimes from large impoundments	• Large impound-ments (for example, dams)	• Change in habitat structure and cover • Change in food supply • Change in access to habitat	• Feeding • Cover • Spawning • Staging • Nursery	• Flowing waters	• Depth • Velocity • Substrate • Temperature • Unimpeded access to upstream areas
Habitat removal and alteration	• Impoundments (for example, dams, and large irrigation projects) • Water crossings (for example, bridges, culverts, and open cut or ford crossings) • Stream bank trampling associated with intense cattle grazing and watering • Water withdrawals	• Change in habitat structure and cover • Change in food supply	• Feeding • Cover • Spawning	• Backwaters and embay-ments • Flowing waters	• Depth • Velocity • Substrate • Temperature • Unimpeded access to upstream areas
Contaminants and toxic substances from pipeline fractures[8]	• Trenchless crossing and pipeline remediation	• Change in contamin ant concentra tion	• Feeding • Spawning	• Backwaters and embayments • Flowing waters	• Food availability

[8] Water quality attributes were not identified for these functions; however, the presence of contaminants and toxic chemicals could impact functions in a way that would threaten species' survival.

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Barriers to movement	• Impoundments • Water withdrawal	• Change in access to habitat • Change in food supply	• Feeding • Cover • Spawning • Staging • Nursery	• Backwaters and embayments • Flowing waters • Connectivity	• Depth • Velocity • Substrate • Temperature • Unimpeded access to upstream areas • Unimpeded river length

8.4 Measures to protect critical habitat

Under SARA, critical habitat must be legally protected within 180 days of being identified in a final recovery strategy or action plan that is included in the Species at Risk Public Registry. Once the final recovery strategy is included in the Species at Risk Public Registry, the critical habitat for the Plains Minnow will be protected through a SARA critical habitat order made under subsections 58(4) and 58(5(a)), which will invoke the prohibition in subsection 58(1) against the destruction of a part of the identified critical habitat.

9 Measuring progress

The performance indicators presented below provide a way to define and measure progress towards achieving the population and distribution objective. A successful recovery program will achieve the overall aim to protect and maintain a self-sustaining population of the Plains Minnow within its current range in Rock Creek, Saskatchewan, Canada. Progress towards meeting this objective will be assessed using standardized sampling protocols developed by Macnaughton et al. (2019). Progress towards meeting this objective will be reported in the report on the progress of recovery strategy implementation, completed 5 years after the publication of the final document on the Species at Risk Public Registry, and every subsequent 5 years.

Performance indicators:

- population abundance has not declined or has increased
- current distribution is maintained or has increased

10 Statement on action plans

The federal government's approach to recovery planning is a 2 part approach, the first part being the recovery strategy and the second part being the action plan. An action plan contains specific recovery measures or activities required to meet the objectives outlined in the recovery strategy. An action plan for the Plains Minnow will be completed within 5 years of posting the final recovery strategy. The action plan may be included in the "Action Plan for the Milk River and St. Mary River Drainage Basins in Canada" (Fisheries and Oceans Canada 2018) or in its own action plan.

11 References

Alberta Fish and Wildlife Management Information System. Fish and Wildlife Internet Mapping Tool . Retrieved June 28, 2024 from https://geospatial.alberta.ca/FWIMT_Pub

Arthur, D. S. Saskatchewan Geographic Names Board. Letter to the Geographical Names Board Secretariat, Alan Rayburn. Regina, Canada. 28 February 1984. Government of Saskatchewan Collection.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2012. COSEWIC assessment and status report on the Plains Minnow *Hybognathus placitus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 41 pp.

Cross, F. B., and J. T. Collins. 1995. Fishes in Kansas. 2nd Revised Edition. 1995. University of Kansas Natural History Museum Public Education Series No. 14. University Press of Kansas, Lawrence KS. 315 pp.

Cross, F. B., and R. E. Moss. 1987. Historic changes in fish communities and aquatic habitats in plains streams of Kansas. *In:* Community and evolutionary ecology of North American stream fishes. Edited by W.J. Mathews and D.C. Heins. University of Oklahoma Press, Norman, OK. pp. 155 to 165.

DFO (Fisheries and Oceans Canada) fish inventories, unpublished survey data 2003 – 2017.

DFO 2013a. Recovery potential assessment of Plains Minnow (*Hybognathus placitus*) in Canada. Canadian Science Advisory Secretariat Science Advisory Report 2013/042.

DFO 2013b. Proceedings of the regional recovery potential assessment of Plains Minnow (*Hybognathus placitus*) in Canada; 12 December 2012. Canadian Science Advisory Secretariat Proceedings Series 2013/01.

Dudley, R. K., and S. P. Platania. 2007. Flow regulation and fragmentation imperil pelagic-spawning riverine fishes. Ecological Applications 17: 2074 to 2086.

Durham, B. W., and G. R. Wilde. 2008. Asynchronous and synchronous spawning by Smalleye Shiner *Notropis buccula* from the Brazos River, Texas. Ecology of Freshwater Fish: 17: 528541.

Durham, B. W., and G. R. Wilde. 2009a. Effects of streamflow and intermittency on the reproductive success of two broadcast-spawning cyprinid fishes. Copeia 2009(1): 21 to 28.

Durham, B. W., and G. R. Wilde. 2009b. Population dynamics of the Smalleye Shiner, an imperiled cyprinid fish endemic to the Brazos River, Texas. Transactions of the American Fisheries Society 138: 666 to 674.

Durham, B. W., and G. R. Wilde. 2014. Understanding complex reproductive ecology in fishes: the importance of individual and population-scale information. Aquatic Ecology 48: 91 to 106.

Environment and Climate Change Canada. 2017. Action Plan for Multiple Species at Risk in Southwestern Saskatchewan: South of the Divide. *Species at Risk Act* Action Plan Series. Environment and Climate Change Canada, Ottawa. xi + 127 pp.

Fisheries and Oceans Canada. 2018. Action Plan for the Milk River and St. Mary River Drainage Basins in Canada. *Species at Risk Act* Action Plan Series. Fisheries and Oceans Canada, Ottawa. iii + 24 pp.

Henley, W.F., M.A., Patterson, R.J. Neves, and A.D. Lemly. 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. Reviews in Fisheries Science. 8: 125-139.

Hoagstrom, C. W., A. C. DeWitte, N. J. C. Gosch, and C. R. Berry, Jr. 2007. Historical fish assemblage flux in the Cheyenne River below Angostura Dam. Journal of Freshwater Ecology. 22: 219 to 229.

Hoagstrom, C. W., N. D. Zymonas, S. R. Davenport, D. L. Propst, and J. E. Brook. 2010. Rapid species replacements between fishes of the North American plains: a case history from the Pecos River. Aquatic Invasions 5: 141 to 153.

Keshavarzi H., C. Lee, J.M. Lea, and D.L.M. Campbell. 2020. Virtual fence responses are socially facilitated in beef cattle. Frontiers in Veterinary Science. 7:543158. doi: 10.3389/fvets.2020.543158

Kehmeier, J. W., R. A. Valdez, C. N. Medley, and O. B. Myers. 2007. Relationship of fish mesohabitat to flow in a sand-bed southwestern river. North American Journal of Fisheries Management 27: 750 to 764.

Lehtinen, S. F., and J. B. Layzer. 1988. Reproductive cycle of the Plains Minnow, *Hybognathus placitus* (Cyprinidae), in the Cimarron River, Oklahoma. Southwestern Naturalist 33: 27 to 33.

Lemmen, D., and F. Warren. 2004. Climate change impacts and adaptation: A Canadian perspective. Climate Change Impacts and Adaptation Directorate, Natural Resources Canada. Ottawa. ON.

Macnaughton, C. J., T. Rudolfsen, D. A. Watkinson, and E. C. Enders. 2019. Standardized field sampling method for monitoring the distribution and relative abundance of the Plains Minnow (*Hybognathus placitus*) population in Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 3317: vii + 24 p.

Matthews, W. J., and L. G. Hill. 1980. Habitat partitioning in the fish community of a southwestern river. Southwestern Naturalist 25: 51 to 66.

Miller, R. J., and H. W. Robison. 1973. The fishes of Oklahoma. Oklahoma. Oklahoma State University Press, Stillwater, OK. 450 p.

NatureServe. 2010 NatureServe Explorer: An online encyclopedia of life [Web application]. Version 7.1. NatureServe, Arlington, Virginia. Accessed: October 19, 2017.

Parks Canada. 2016. Multi-species Action Plan for Grasslands National Park of Canada. *Species at Risk Act* Action Plan Series. Parks Canada, Ottawa. iv + 57 pp.

Parks Canada. 2022. Grasslands National Park of Canada Management Plan 2022. Parks Canada, Ottawa. x + 21pp.

Perkin, J. S., and K. B. Gido. 2011. Stream fragmentation thresholds for a reproductive guild of Great Plains fishes. Fisheries 36: 371 to 383.

Pflieger, W. L. 1997. The Fishes of Missouri. Missouri Department of Conservation, Jefferson City, 372 pp.

Platania, S. P., and C. S. Altenbach. 1998. Reproductive strategies and egg types of seven Rio Grande basin Cyprinidae. Copeia 1998: 559 to 569.

Polivka, K. M. 1999. The microhabitat distribution of the Arkansas River Shiner, *Notropis girardi*: A habitat mosaic approach. Environmental Biology and Fisheries 55: 265 to 278.

Quist, M. C., W. A. Hubert, and F. J. Rahel. 2004. Relations among habitat characteristics, exotic species, and turbid-river cyprinids of Wyoming. Transactions of the American Fisheries Society 133: 727 to 742.

Rees, D. E., R. J. Carr, and W. J. Miller. 2005. Plains Minnow (*Hybognathus placitus*): A technical conservation assessment. USDA Forest Service. Rocky Mountain Region 25 p.

Robison, H. W., and T. M. Buchanan. 1988. Fishes of Arkansas. University of Arkansas Press, Fayetteville, AR, 536 pp.

Sawatzky, C. D., and D. A. Watkinson. 2013. Information in support of a recovery potential assessment of Plains Minnow (*Hybognathus placitus*) in Canada. DFO Canadian Science Advice Secretariat Research Document 2013/044. v + 35 p.

Scheurer, J. A., K. R. Bestgen, and K. D. Faust. 2003. Resolving taxonomy and historic distribution for conservation of rare Great Plains fishes: *Hybognathus* (Teleostei: Cyprinidae) in eastern Colorado basins. Copeia 2003: 1 to 12.

Schweitzer, Aaron, pers. comm. 2021. Email correspondence to N. Sinnatamby. September 2021. Manager, Water Rights, Approvals and Compliance, Water Security Agency, Moose Jaw, Saskatchewan.

Sliger, A. S. 1967. The embryology, egg structure, micropyle, and egg membranes of the Plains Minnow, *Hybognathus placitus* (Girard). M. Sc. Thesis, Oklahoma State University, Stillwater, OK. 55pp.

Sliwinski, M, pers. comm. 2021. Email correspondence to N. Sinnatamby. October 2021. Rangeland Ecologist, Grasslands National Park, Parks Canada, Val Marie Saskatchewan.

Sublette, J. E., M. D. Hatch, and M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque, NM.

Sylvester, R. M., S. E. Freeling, and C. R. Berry. 2005. First record of the Plains Minnow, *Hybognathus placitus*, in Canada. Canadian Field-Naturalist 119: 219 to 223.

Taylor, C. M., and R. J. Miller. 1990. Reproductive ecology and population structure of the plains minnow, *Hybognathus placitus* (Pisces: Cyprinidae), in central Oklahoma. American Midland Naturalist 123(1): 32 to 39.

Teillet, M., D. A. Watkinson, M. R. Tyree, R. Hlasny, and E. C. Enders. 2021. Plains Minnow (*Hybognathus placitus*) relative abundance and distribution in Canada. Canadian Data Report of Fisheries and Aquatic Sciences 1329: vi + 12 p.

Urbanczyk, A. C. 2012. Reproductive ecology of the Plains Minnow in the Brazos River, Texas. M.Sc. Thesis, Texas Tech University.

Watkinson, D., pers. comm. 2021. Email correspondence to N. Sinnatamby. October 2021. Research Biologist, Fisheries and Oceans Canada, Winnipeg, Manitoba.

White, C. L. 2007. Impacts of reservoir development and climate trends on hydrology in southwestern Saskatchewan: implications for Silver Sagebrush (*Artemesia cana*) habitat and Greater Sage-Grouse (*Centrocercus urophasianus*). Report submitted by Saskatchewan Watershed Authority to Environment Canada, Habitat Stewardship Program. 34 pp.

Widmer, A. M., L. L. Burckhardt, J. W. Kehmeier, E. J. Gonzales, C. N. Medley, and R. A. Valdez. 2010. Detection and population estimation for small-bodied fishes in a sand-bed river. North American Journal of Fisheries Management 30: 1553 to 1570.

Widmer, A. M., J. J. Fluder, III, J.W. Kehmeier, C.N. Medley, R.A. Valdez. 2012. Drift and retention of pelagic spawning minnow eggs in a regulated river. River Research and Applications 28: 192 to 203.

Wilde, G. R., and A. C. Urbanczyk. 2013. Relationship between river fragment length and persistence of two imperiled great plains cyprinids. Journal of Freshwater Ecology 28(3): 445 to 451.

Winston, M. R. 2002. Spatial and temporal species associations with the Topeka Shiner (*Notropis topeka*) in Missouri. Journal of Freshwater Ecology 22: 219 to 229.

Wlasichuk, C. A. 2014. The impacts of cattle grazing on stream ecosystems in Grasslands National Park of Canada, Saskatchewan. M.Sc. Thesis, University of Manitoba. 190 pp.

Appendix A: Record of cooperation and consultation

Recovery strategies are to be prepared in cooperation and consultation with other jurisdictions, organizations, affected parties, and others, as outlined in the *Species at Risk Act* section 39. Fisheries and Oceans Canada (DFO) has utilized a process of seeking input from species/subject matter expert reviewers for the development of this recovery strategy. Information on participation is included below.

Table 8. List of partners and stakeholder groups from whom DFO received input for the development of the recovery strategy for the Plains Minnow.

Member / attendee	Affiliation
Doug Watkinson	Fisheries and Oceans Canada
Eva Enders	Fisheries and Oceans Canada
Jeff Sereda	Water Security Agency
Matt Tyree	Government of Saskatchewan - Ministry of Environment
Ron Hlasny	Government of Saskatchewan - Ministry of Environment
Joanne Tuckwell	Parks Canada
Conrad Jaeger	Parks Canada
Dan Rafla	Parks Canada
Laura Gardiner	Parks Canada
Krista Cairns	Parks Canada
Stefano Liccioli	Parks Canada

In addition, DFO sought input from Indigenous groups in Saskatchewan during the development of the recovery strategy.

Additional Indigenous, stakeholder, and public input was sought through the publication of the proposed document on the *Species At Risk* Public Registry for a 60-day public comment period held from December 11 2024 to February 6 2024. All feedback received was considered in the finalization of the recovery strategy. Suggestions and concerns related to the implementation of recovery measures for the Plains Minnow will be considered in the action plan that will be developed.

Appendix B: Threat assessment categories and threat level matrix

Threat assessment categories

Threat occurrence	Definition
Known	Threat recorded to occur within Canadian portion of range
Likely	Greater than 50% chance of this threat occurring within Canadian portion of range
Unlikely	11 to 50% chance that this threat is or will be occurring
Unknown	No data or prior knowledge of this threat occurring within Canadian portion of range
Threat impact	**Definition**
High	If threat were to occur, it would jeopardize the survival or recovery of this population
Medium	If threat were to occur, it would likely jeopardize the survival or recovery of this population
Low	If threat were to occur, it would be unlikely to jeopardize the survival or recovery of this population
Unknown	No prior knowledge, literature or data to guide the assessment of the impact this were to occur
Causal	**Definition**
1	Causative study
2	Correlative study
3	Expert opinion

Threat level matrix

		Threat Impact			
		Low	Medium	High	Unknown
Threat Likelihood	Known	Low	Medium	High	Unknown
	Likely	Low	Medium	High	Unknown
	Unlikely	Low	Low	Medium	Unknown
	Unknown	Unknown	Unknown	Unknown	Unknown