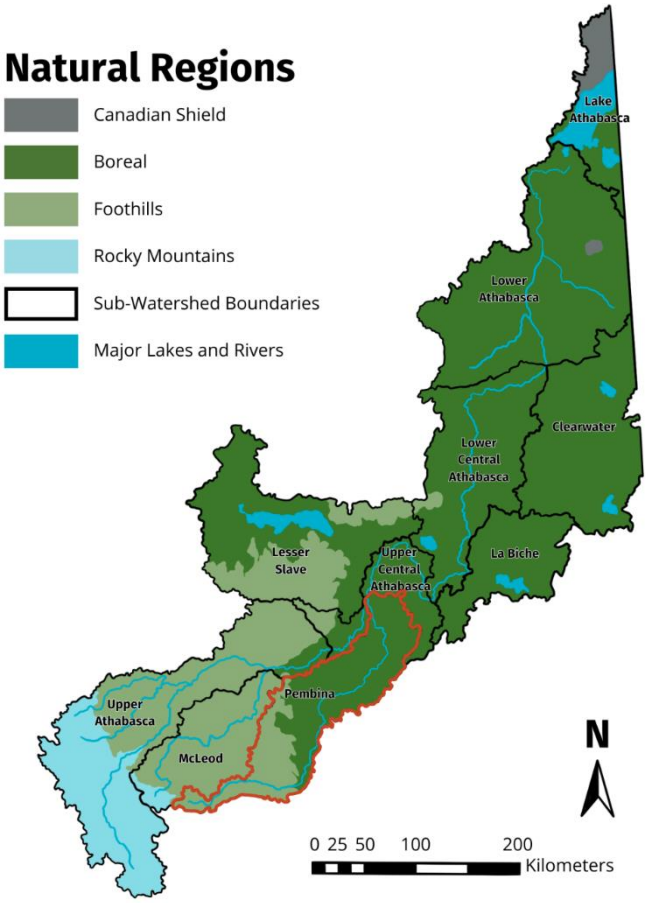
Athabasca
WATERSHED COUNCIL

Sub-Basins of the Athabasca Watershed

The Pembina River Sub-basin

Introduction

The Athabasca watershed can be broken down into ten smaller units (or sub-basins). This document focuses on the **Pembina sub-basin**.



PART I – GENERAL DESCRIPTION

Sub-basin Description

The Pembina River is one of five major tributaries to the Athabasca River. It originates at Red Cap Mountain in the eastern slopes of Alberta's Rocky Mountains. It then flows about 547 km through Foothills and Boreal Forest before joining the Athabasca River just northwest of the hamlet of Flatbush.

The Pembina River accounts for about 6% of the Athabasca River's mean annual discharge, with a flow of about 50.6 cubic metres per second (m^3/s) and an annual volume of about 1,595,924,000 cubic metres per year (m^3/y). The lands that drain into the Pembina River make up the Pembina watershed, an area of 14,296 km^2 - about 9.5% of the Athabasca watershed's total area (and a little more than 2% of Alberta). The Pembina sub-basin is often divided into Upper, Mid and Lower portions.

As it flows across the landscape, the Pembina River is joined by a number of smaller tributaries. Near its headwaters, at an elevation of around 2000 metres (m), it is fed by Rat 1, Bailey, Hanson, Crooked and Elk creeks. As it flows through Brazeau County, it is joined by Zeta, Dismal, Rat 2, and Paddy creeks. It is then met by the Bigoray River at an elevation of just under 800 m - a rather steep drop of about

1200 m over about 270 km. The drainage area associated with this upper portion of the Pembina river spans an area of nearly 4140 km^2 and is mostly covered by the coniferous and deciduous forest of Alberta's Foothills with wetlands and human modified land cover making up the rest of the region. Large parts of the Brazeau and Yellowhead counties intersect over the Upper Pembina area, along with a small portion of Parkland county in the most northeastern corner.

Fun Fact!

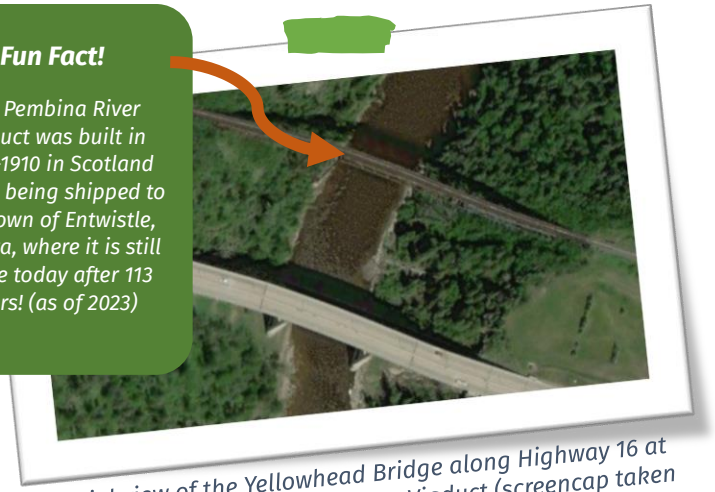
The site at Matthew Crossing was originally called Jack's Crossing and was travelled by early Indigenous peoples, and later traders and packers. In 1913, a post office was established on the east side of the river and the crossing renamed for the office's first post master, M.H. Matthews. Around 1920, a ferry was put in at Matthew where it operated for a number of years until it was moved down river to Sangudo.

The middle portion begins near the Pembina River-Moon Lake Natural Area with an elevation of about 736 m (about 17 km south of Entwistle) and leaves the Foothills to enter the Boreal Forest Natural Region. Near here, the Pembina River is met by the Lobstick River between Entwistle and Evansburg. Between Matthew's Crossing in Yellowhead County and Sangudo in Lac Ste. Anne County, the Pembina is joined by Deep Creek 1, fed from Brock Lake. As the Pembina continues flowing north along the border of Barrhead and Lac Ste. Anne counties it is fed by Coyote Creek, MacDonald (via Lac La Nonne) and Newton creeks (via Newton and George Lake) once it crosses over into Barrhead proper. Eventually the Pembina River meets its main tributary, Paddle Creek, near the margin of where the Mid- and Lower Pembina portions of the basin merge. The Mid-Pembina ends at around 623 m of elevation, for a total decline of about 113 m, at a more gradual gradient than the Upper portion of the Pembina.

The Mid-Pembina region encompasses an area of around 6220 km^2 making it the largest of the three portions of the Pembina sub-basin. The Mid-Pembina is a transitional zone between the Foothills and the Boreal Forest Natural Area of Alberta with wetlands and forested areas predominating the southern portion of the area, moving into the more agriculture dominated areas of central Alberta. The Mid-Pembina is ringed by the counties of Yellowhead, Woodlands, Barrhead, and Westlock, with the county of Lac Ste. Anne taking up the middle portion of the area.

Fun Fact!

The Pembina River Viaduct was built in 1909-1910 in Scotland before being shipped to the Town of Entwistle, Alberta, where it is still in use today after 113 years! (as of 2023)



Aerial view of the Yellowhead Bridge along Highway 16 at Entwistle and the Pembina River Viaduct (screencap taken from www.bing.com/maps)

The Lower Pembina begins 25 km south of where the river crosses the border of Barrhead and Westlock counties at an elevation of about 623 m just 10 km east of the Town of Barrhead. On its way through Westlock County the Pembina is met by Wabash, Dapp 1 (via Muskeg Lake, Bolloque Creek, and Bolloque Lake), Dapp 2, Shoal (via Shoal Lake), and French Creeks. Finally crossing over into the Municipal District of Lesser Slave River, it is met by Flatbush Creek before finally emptying into the Athabasca River northwest of Flatbush at an elevation of around 569 m. The elevation drop of the Lower portion is much more gradual than the Upper and Mid-portions, with a decline of only 54 m.

The Lower portion of the Pembina River incorporates around 3935 km². Most of the Lower Pembina is covered by agricultural land, winnowing to wetlands and more forested areas in its northern reaches. The Lower Pembina is mostly covered by Westlock County, with the County of Barrhead in the southwest portion and the north rimmed by the M.D. of Lesser Slave River and Athabasca counties.

Pembina River Provincial Park

The Pembina gorge was formed during the Wisconsin Glaciation and is composed of the Paskapoo Formation sandstone, underlaid by the Edmonton Formation siltstone and shales.

The Pembina River Provincial Park lies between the hamlets of Entwistle and Evansburg and is a well-known destination for canoeing/kayaking/tubing, swimming, fishing, hiking, and camping.

Raisingedmonton.com

Brief Human History

The Pembina sub-basin is located on Treaty 6 Territory, historically home to the Cree, Nakota Sioux, Blackfoot, Dene, Saulteaux and other First Nations. Today's Indigenous communities include Alexander First Nation and Alexis Nakota Sioux First Nation, as well as several Métis communities. The Alexis Elk River and Cardinal River reserves are located in Yellowhead County, near Pembina Forks. These Nations have a longstanding presence and continued practice of cultural traditions tied to land and water.

Like many areas of northern Alberta, the Pembina watershed was visited by early European explorers, became a part of the fur trade. Eventually, it was settled by farmers and ranchers. Commercial fishing, logging, and trapping added to the local economy at different times throughout the past century.

Fun Fact!

Discovery of the Pembina oil field actually helped to persuade geologists that non-Devonian reef formations could also be oil bearing units.

There are several early explorer's accounts of a '10-foot thick' Pembina Coal seam which drove an economic interest in the Pembina for extraction and advancement of the coal industry. Today, the Coal Valley Mine resides largely in the McLeod sub-basin, but the very south-eastern tip reaches into the upper portion of the Pembina watershed.

The Pembina oil field was discovered in 1953 in the Drayton Valley area southwest of Edmonton. In three years time, the Pembina oil field was producing about 100,000 barrels of oil a day. The discovery of this reserve was pivotal in perpetuating the oil and gas boom in Alberta and boasts

being one of the biggest, most productive conventional oil fields in the province, leaving a lasting impact in the Pembina.

Today, the Pembina sub-basin sits within several Alberta counties/municipal districts including the county of Barrhead No. 11, Westlock County, Lac Ste. Anne County, Brazeau County. Woodlands and Parkland County cover a small area in the central portion with Athabasca County and M.D. of Lesser Slave Lake just covering the northeastern edge of the sub-basin.

PART 2 WHAT WE KNOW ABOUT ...

Drinking Water

Today there are 13 municipalities in the Pembina sub-basin with a population of about 13,000. Six of these communities, plus 3 communities just outside the basin (Busby, Clyde and Vimy), for a total of about 6185 people, get their drinking water from the Westlock Treatment Plant which draws its source waters from the Pembina River. Another 3 communities (Barrhead, Manola, Neerlandia or 4440 people), get their water from the Barrhead Treatment Plant which draws from the Paddle River, a tributary of the Pembina. Five communities (2531 people), including Cynthia, Sangudo, Mayerthorpe, Evansburg and Wildwood, rely on groundwater wells. And finally, the community of Entwistle (pop. 429) gets its drinking water through an approved inter-basin transfer that connects it to the West Inter-Lake District (WILD) Regional Water Commission with source waters from the North Saskatchewan River.

Communities supplied by the Westlock Treatment Plant (Pembina River):
Busby*
Clyde*
Dapp
Fawcett
Jarvie
Pibroch
Pickardville
Vimy*
Westlock

Community Resiliency

The AWC is working towards a healthy Athabasca watershed that supports resilient communities. Communities that are resilient are knowledgeable about what climate variability and climate change might look like in their area. The are also proactive in protecting their source drinking water and in mitigating risk from fires, floods, droughts and other climatic events.

The Pembina sub-basin is rated by the Government of Alberta's Watershed Resiliency and Restoration program as a high priority for water quality, drought and flood mitigation. Overbank flooding has occurred in the past and is largely associated with ice breakup, ice jamming and snow melt. The province has undertaken Flood Hazard mapping at Sangudo and Barrhead.

Water Quality

Generally, water quality in the Pembina River is affected by both point and non-point sources of pollution. Major point sources in the Pembina are largely municipal wastewater discharge points. Non-point source pollution comes from diffuse run-off and varies depending on upland cover and land use.

There are multiple land uses in this sub-basin, starting with coal mining and logging in the upper sub-basin (which is largely public lands), with a transition to agriculture in the mid and lower sub-basin (predominately private lands), as well as oil and gas activities throughout. Relatively speaking, the Pembina has a larger human footprint in the Athabasca watershed than other sub-basins.

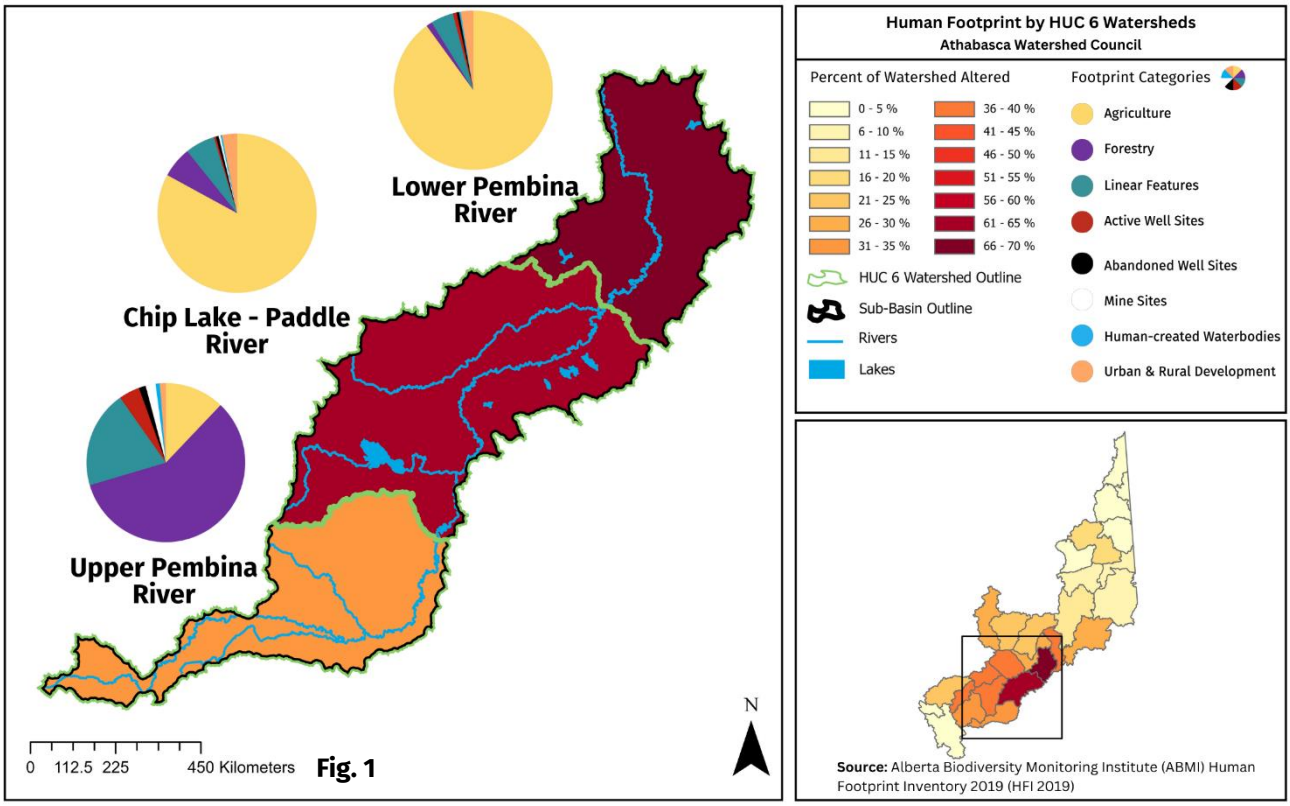


Fig. 1 Human Footprint by HUC 6 Watersheds (Pembina sub-basin) *A localised map of the Pembina sub-basin (tertiary watersheds 07BA, 07BB, and 07BC) showing the percentage of watershed altered by human activity.*

To manage land uses, there are several provincial and municipal planning documents and programs to guide activities in different areas. While there is no regional land use plan yet, there are several integrated resource plans (IRP) including:

- Big Bend Sub-regional IRP (including North Athabasca, Smith-Jarvie and plans)
- Whitecourt/Anselmo Public Land Use Strategy
- Cold Creek Regional Integrated Decision
- Brazeau-Pembina Sub-Regional IRP (Pembina-North Saskatchewan)
- Upper Brazeau-Dismal
- Edson South-Pembina
- Coal Branch Sub-Regional IRP (Robb Highlands)

Additionally, there are several municipal planning documents, forest management agreements and public land dispositions that guide land use activities in the Pembina watershed.

Instream Flow Needs and Reliable Supplies

The Pembina River has a mean annual discharge of about 50 m^3/s. Instream flow needs (IFN) include the quantity of water (usually as a measure of river flow, or discharge) needed by fish and other biodiversity, and for functions like scouring and maintaining river channels. Although there is currently no legislated amount set aside for IFN in the Pembina (via use of a Water Conservation Objective under the *Water Act*), the area does fall under the advisory Surface Water Allocation Directive which can include requirements on water allocation licences to protect IFN.

According to the Alberta Water Tool (using the AEPA Desktop Method; downloaded Sept. 24, 2023), the Pembina watershed has a sustainable withdrawal limit of 13.9% of its discharge. It currently has allocations of 1.69%. Additionally, licenced allocation amounts may not reflect actual water withdrawals and/or consumption. Hence it appears IFN is currently being met on the Pembina mainstem, with room for additional allocations. However, these amounts are based on desktop calculations and have not been ground truthed. Also, smaller tributaries, particularly during drought or low flow periods, may be more susceptible to the impact of allocations on IFN.

There are currently (Sept. 24, 2023) 1302 water allocation licences in this basin. The oil and gas sector holds the majority of allocations, largely from both surface and groundwater term licences (although temporary diversion licences increased substantially in 2023). Other allocations are for 'other' (e.g., lake stabilization), municipal, agriculture, commercial and power sectors.

Biodiversity

At its most western extent, the Pembina Sub-Basin briefly touches the Rocky Mountains, but it very quickly transitions into the Foothills, characterised by Lodgepole Pine, White Spruce, and Aspen dominating the upland canopy, Black Spruce and Larch the lowland. Labrador Tea and Low Bush Cranberry are characteristic of the underbrush. Further downstream, the foothills transition to Boreal Forest, often characterized by a mix of conifer and deciduous species. For a good description of these regions, see Natural Regions & Subregions of Alberta.)

Pembina Sub-basin Total Area: 14,296 km^2			
Natural Region	Natural Sub Region	Area (km^2)	Area (%)
Rocky Mountain	Alpine	0.7	0.01
	Subalpine	130	0.91
	Total	131	0.92
Foothills	Upper Foothills	1,068	7.5
	Lower Foothills	3,295	23.0
	Total	4,363	30.5
Boreal	Dry Mixedwood	6262	48.8
	Central Mixedwood	3531	24.7
	Total	9793	68.5

The Pembina is home to many Alberta Indicator Species such as Arctic Grayling, Bull Trout, Burbot, Northern Pike, and Walleye. The sensitivity of fish habitats along the Pembina River and its tributaries is rated as high.

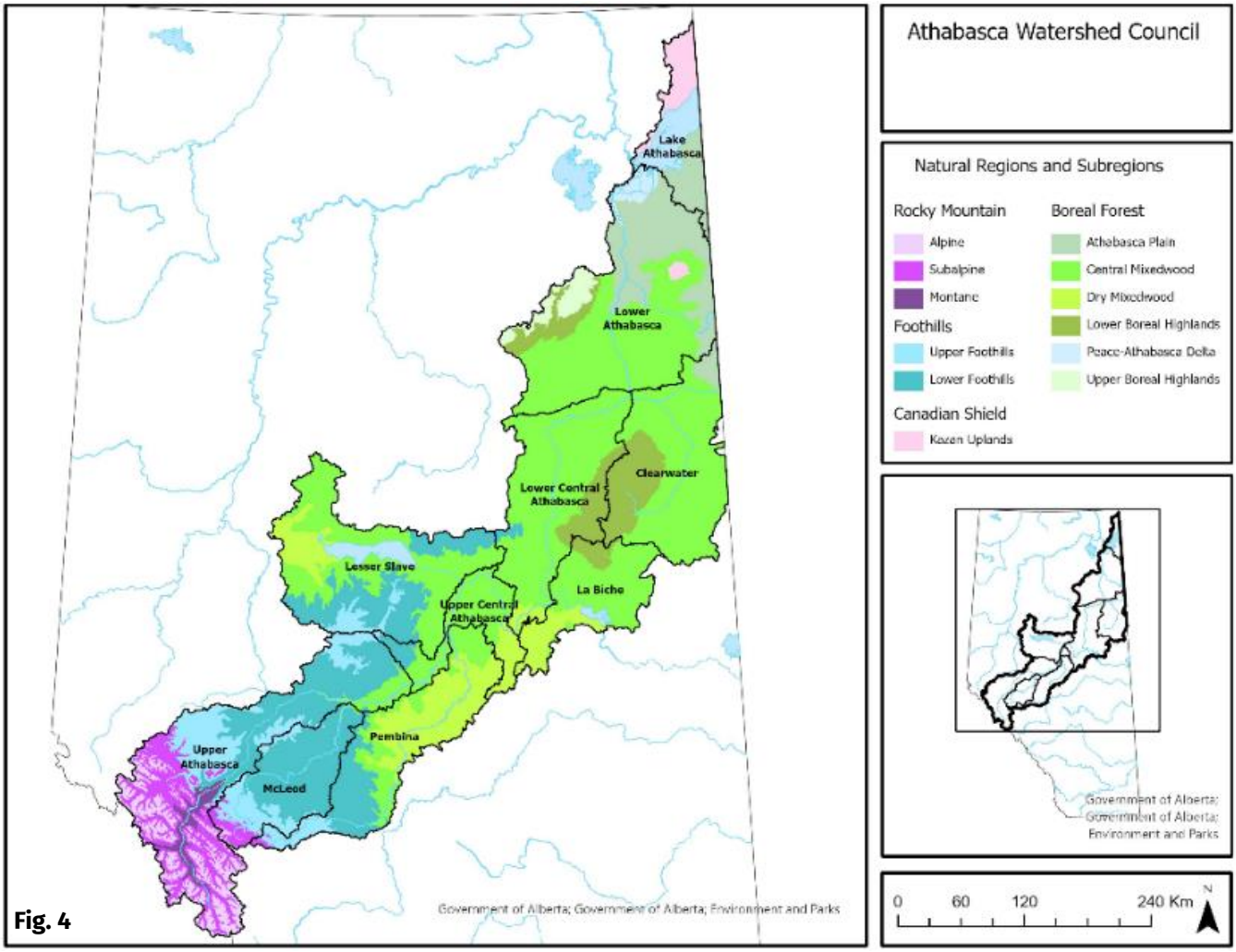


Fig. 4

Fig. 4 Map of the Natural Sub-Regions in the Athabasca Watershed. *The Pembina sub-basin is located in the central southern portion of the watershed and includes subregions upper and lower foothills, as well as dry and central mixed wood forest.*

Pembina Sub-Basin Species Highlight

Arctic Grayling (photo credit: R. Blanchard)

Fun Fact!
The genus name *Thymallus* comes from the slight odour of thyme that can be smelt from the fish's flesh.

Freshpoint.com

Arctic Grayling

Thymallus arcticus

Family: Salmonidae	
Description	This small, grey fish, distinguished by a large, rounded, sail-like dorsal fin, is closely related to whitefish, salmon, and trout.
Distribution & Habitat	Arctic Grayling are a keystone species in the Pembina watershed. In Alberta, it is native to the Athabasca, Hay, and Peace rivers. The Arctic Grayling is found most commonly in the Mid- and Upper portions of the Pembina - the southern most distribution for this species in Alberta.
Conservation Status	Decades of harvest pressure and habitat loss has contributed to shrinking Arctic Grayling populations, which have essentially collapsed. In 2016, the upper Pembina River watershed was closed to all angling for a five-year period to help recover the grayling population. In 2017, the upper Pembina was included in the North Central Native Trout recovery program, a larger provincial program to recover native salmonids along Alberta's eastern slopes.
What's Being Done?	The Northern Lights Fly Fishers (a branch of Freshwater Conservation Canada [formerly Trout Unlimited Canada]), in partnership with Alberta Environment and Parks and Alberta Conservation Association have given many hours and resources towards the recovery of Arctic Grayling populations in the Pembina River. Activities include angling surveys, fish movement studies, stream temperature monitoring, and habitat assessments. In 2018, this group undertook the Dismal Creek Restoration, planting willow stakes along the bank to restore riparian health. Today, grayling populations remain very low in the Pembina, as well as most other river systems in Northern Alberta. Lower water quality and increasing temperatures may be influencing the decline in Arctic Grayling distribution as Salmonids are heavily influenced by temperature and prefer cooler environments. For more about this species, read this AWC blog post Upper Pembina River Fisheries Update | Athabasca Watershed Council (awc-wpac.ca).

Ecosystem Health

Wetlands

Wetlands are an important component of any watershed, providing services such as water storage, flood attenuation and groundwater recharge. About 10 percent of the Pembina watershed is made up of wetlands, predominately fens and open water, with a small number of swamps, marsh and bogs. For more information, see the Canadian Wetland Inventory (CWI) tool Canadian Wetland Inventory | Climate Change Data and Resources.

Wetland Class	Wetland Area (km^2)	% of Pembina watershed (14,296 km^2)
Fen	990	6.93
Open water	290	2.03
Swamp	110	0.77
Marsh	46	0.32
Bog	2.9	0.02
Total	1438.9	10.07

Riparian Areas

Riparian areas are transitional buffers between terrestrial and aquatic environments along the margins of waterbodies, such as rivers, streams, and lakes. Like wetlands, riparian areas also provide many important functions, such as reducing the amount of sediment discharge into the water to help maintain water quality, providing habitat for wildlife, and slowing flood waters. Riparian intactness has been assessed throughout much of the Pembina watershed. While riparian areas are largely intact in the Upper Pembina, the middle and lower Pembina sub-basins have large areas of poor intactness. For more information, see the AWC's Healthy Shorelines Initiative.

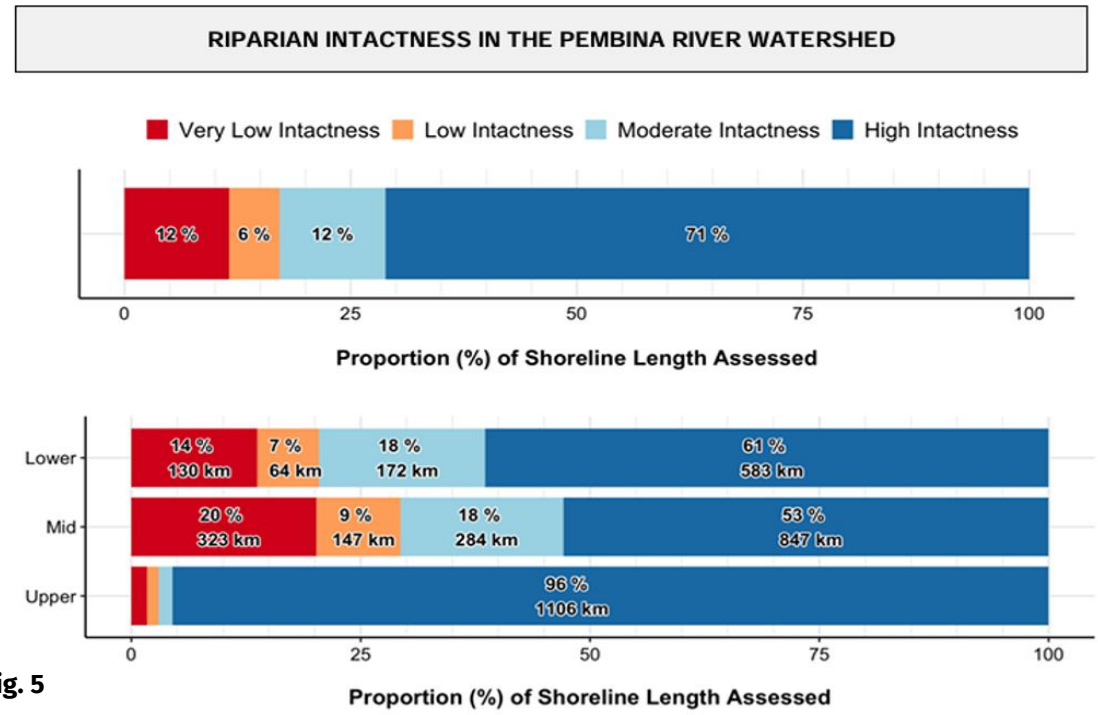


Fig. 5

Fig. 5 Riparian Intactness in the Pembina River Watershed. *Taken from the Athabasca Watershed Council's Pembina River Watershed Riparian Assessment Results Summary document 2012d_Pembina-Watersheds-Riparian-Assessments_Summary_FINAL-1.pdf*

Major Lakes or Other Water/Ecological Features of Note

The Pembina watershed has a number of lakes, natural areas, campgrounds and other recreational areas to explore! Some key sites include:

- Pembina Forks Provincial Recreation Area
- Paddle Dam and Reservoir
- Pembina River Provincial Park
- Thunder Lake Provincial Park
- Herbert Lake Wildland Provincial Park
- Cross Lake Provincial Park
- Spruce Island Lake Natural Area

Knowledge (Research and Monitoring)

Alberta Environment monitors both flow and water quality in the Pembina watershed and this information supports the Upper Athabasca Surface Water Quality Monitoring Framework. Both government and non-government organizations have been involved in several decades of fish management in this sub-basin. Additionally, data on species biodiversity, wetlands and human footprint is available through the Alberta Biodiversity Monitoring Institute. Also mentioned, the AWC has completed a desktop GIS riparian assessment of the Pembina watershed and is currently undertaking a comprehensive water quality monitoring study.

The AWC has completed several State of the Watershed reports over four phases in accordance with the Government of Alberta's Water for Life strategy. These reports include information on the Pembina sub-basin. To read these reports and to learn more, see https://athabascawatershed.ca/state-of-the-watershed/.

Despite the above activities, data gaps still exist, and further work is needed to better understand pollutant run-off rates, sources /tributary loading of pollutants to the main stem, risks to source drinking water and the future impacts of climate change and cumulative effects in this region.

Partnerships & Other Initiatives in the Pembina Sub-basin

Today, there are a number of agencies working on water and related issues in the Pembina watershed. For more information on their activities, check out their websites:

- Alberta Conservation Association
- Alberta Environment and Protected Areas
- ALUS Barrhead-Westlock-Athabasca
- Cows and Fish
- Northern Fly Fishers (Trout Unlimited Canada)
- Farming Forward (previously West Central Forage Association)

Many of these agencies participate on the AWC's Pembina River Watershed Technical Advisory Committee. This group meets quarterly to better share information, coordinate activities, identify gaps and provide advice to the AWC and others on how to keep the Pembina watershed healthy.

IN CONCLUSION

The Pembina River sub-basin is an important sub-basin of the larger Athabasca watershed. Although it has a larger human footprint than other Athabasca sub-basins, it is relatively healthy, meeting the social, economic and environmental needs of the area. However, like most watersheds in Alberta and elsewhere, the Pembina is subject to several pressures. Continued research, monitoring, and collaboration between interested partners will ensure this watershed remains healthy, today and for future generations.

References and Resources

Literature

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Fiera Biological Consulting Ltd. 2020. Mid-Pembina Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2012. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 80.

Fiera Biological Consulting Ltd. 2021. Lower Pembina Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2012b. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 76.

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Web Links

Alberta topographic map, elevation, terrain

Alberta Water Tool (alberta-watertool.com)

Arctic Grayling (Thymallus arcticus) - Species Profile (usgs.gov)

Arctic Grayling FSI | Alberta.ca

Articles | Encyclopédie du patrimoine culturel de l'Amérique française – histoire, culture, religion, héritage

Athabasca Watershed Sub-Basins | Athabasca Watershed Council (awc-wpac.ca)

Canadian Wetland Inventory | Climate Change Data and Resources

Chapter 23 - Cretaceous Cardium Formation | Alberta Geological Survey (aer.ca)

Flood Hazard mapping

GeoDiscover Alberta

Lac La Nonne Enhancement Protection Association (lepa-ab.com)

Matthews Crossing, Alberta - Wikipedia

Pembina Oil Field - Conventional Oil - Alberta's Energy Heritage

Reports - ALMS

Riparian Management Resources Webpage – AWES | Agroforestry and Woodlot Extension Society of Alberta (awes-ab.ca)

Upper Pembina River Fisheries Update | Athabasca Watershed Council

Watershed Resiliency and Restoration program

Westlock County - Utilities