Riparian Area Assessment for the Medicine-Blindman Rivers Watershed

FINAL REPORT

Project #2011
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Prepared for:

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Prepared by:

FIERA Biological Consulting

Front Cover Photo:
Aerial view of a riparian area captured from a unmanned aerial vehicle. Credit: Fiera Biological Consulting Ltd.

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Report Prepared by: Shari Clare and Shantel Koenig

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We would also like to acknowledge the financial assistance of the Government of Alberta, without which this project would not have been possible. The Government of Alberta contributed to the delivery of this project through the Watershed Resiliency and Restoration Program (WRRP), which aims to restore or enhance previously degraded priority areas within Alberta's watersheds, including riparian areas. Additionally, the Government of Alberta provided spatial data that was essential for the successful completion of this project.

Red Deer River Watershed Alliance

Alberta Government

Executive Summary

Riparian lands have substantial ecological, economic, and social value, and as such, the effective management of these habitats is a critical component to the maintenance of watershed health. In an effort to better manage riparian habitats within the Red Deer River watershed, the Red Deer River Watershed Alliance (RDRWA) retained Fiera Biological Consulting to assess riparian habitat along approximately 1,782 km of shoreline within the Medicine-Blindman Rivers watershed.

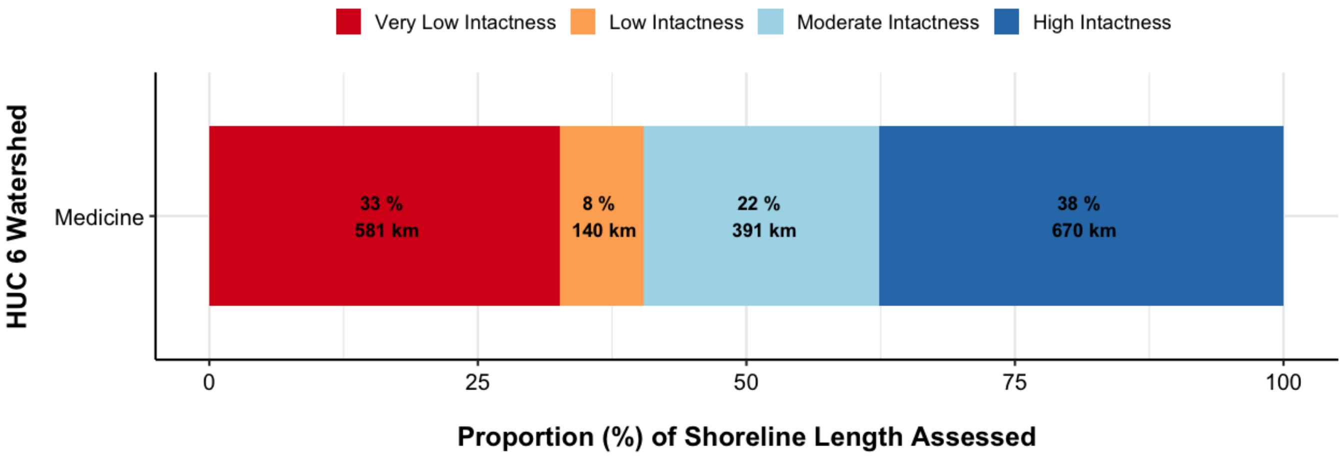
The Medicine-Blindman Rivers watershed covers an area of approximately 5,800 km^2 and is located in the west central portion of the Red Deer River watershed. This HUC 6 watershed is made up of three smaller HUC 8 subwatersheds, including the Medicine River, Blindman River, and the Red Deer River/Sylvan Lake subwatersheds. The Medicine-Blindman Rivers watershed was selected as the focus for this study because it is part of both the Lower Headwaters and Central Urbanizing Zones of the Red Deer River watershed, and these areas have been identified by the RDRWA as an important source water protection zone for the City of Red Deer. Additionally, the Medicine-Blindman Rivers watershed was identified as high priority for flood and drought mitigation by the provincial Watershed Resiliency and Restoration Program (WRRP).

Riparian management areas (RMAs) located along shorelines of interest were evaluated using a desktop-based approach that utilizes a current land cover layer. An RMA is defined as an area adjacent the shoreline that typically includes the near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone. For the purpose of this study, RMAs had a fixed width of 50 m and a variable length that was determined based upon major breaks in the cover of natural vegetation.

Intactness was used as the measure of riparian condition because the relationship between an intact riparian zone and the health or function of the aquatic environment is well established. Intact riparian zones play a vital role in the exchange of inorganic and organic material between the terrestrial and aquatic ecosystems via the interception of sediments and nutrients that runoff from adjacent upland habitats, and through the supply of leaf litter and woody debris. Intact riparian vegetation also regulates water temperature and the instream light environment, thereby ensuring suitable habitat for a range of aquatic species. Further, riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby improving water quality and protecting surrounding lands from flooding. Given the significant role that an intact riparian zone has on providing ecosystem services and supporting healthy and functional aquatic ecosystems, there is a need to effectively manage riparian areas. Thus, understanding the distribution of intact riparian habitat across the landscape and identifying areas where riparian intactness has been degraded is essential to improving conservation and management outcomes.

In addition to assessing riparian intactness, natural and anthropogenic pressure within local catchments was evaluated to identify riparian areas that may be functionally impaired due to surrounding land use. As a result, each RMA was assigned an intactness and pressure score, and these scores were combined using a prioritization matrix that assigns a conservation or restoration priority to each RMA. This in turn allows land managers to more precisely target areas for management, as well as prioritize areas for conservation and restoration within the watershed. It also allows land managers to target areas were more detailed, site-specific field assessments of riparian health or condition may be required.

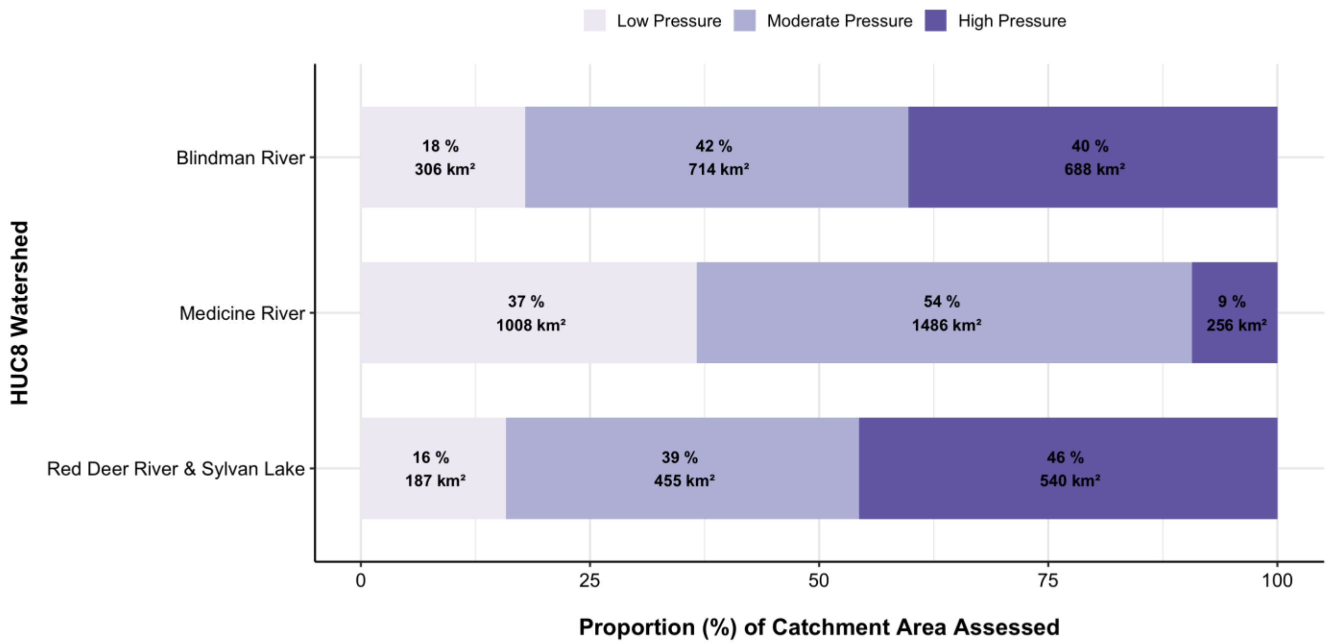
In total, 35 waterbodies within the watershed were assessed and 38% of the shoreline (670 km) was classified as High Intactness, with an additional 22% of the shoreline (391 km) classified as Moderate Intactness. Just over a third of the shoreline was classified as Very Low Intactness (33%; 581 km), with the remaining 8% (140 km) classified as Low Intactness.



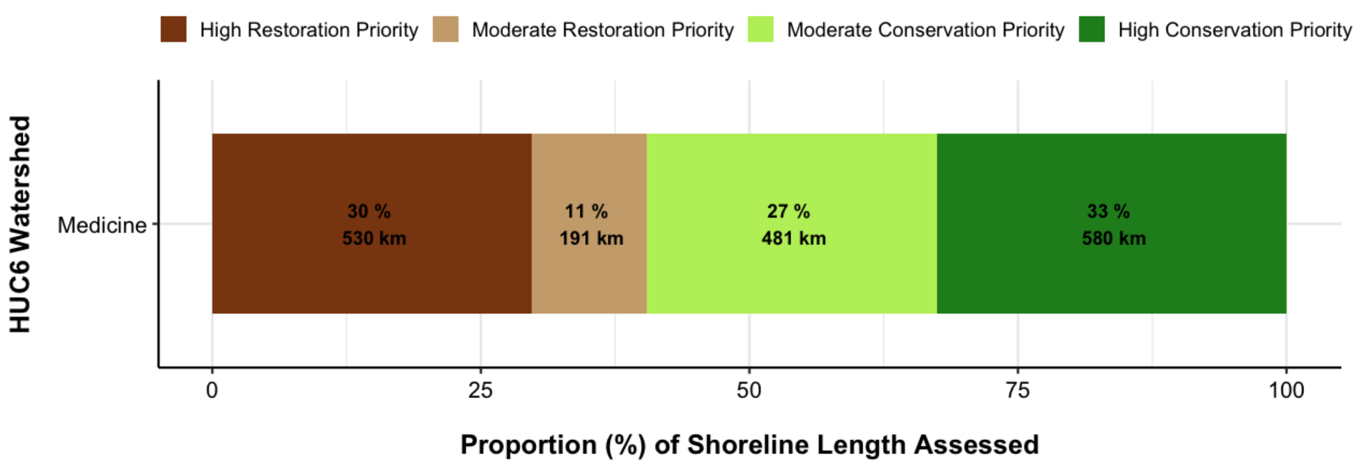
When intactness is compared by subwatershed, the Blindman River subwatershed had the greatest proportion (41%) of shoreline rated as High Intactness, followed by the Medicine River subwatershed (39%). The Red Deer & Sylvan Lake subwatershed had the greatest proportion of shoreline assessed as Very Low (43%) Intactness. When intactness was evaluated for each major municipality, the County of Wetaskiwin and Clearwater County had >50% of their shorelines assessed as High Intactness. In contrast, Lacombe, Ponoka, Red Deer Counties, as well as Penhold and Innisfail all had >30% of their shorelines classified as Very Low Intactness. When intactness was summarised and compared for each of the 35 waterbodies assessed in this study, 31% had more than half of their shorelines characterized as Very Low or Low Intactness.

Spatial Extent	Proportion (%) of Shoreline within Intactness Category					
	Very Low	**Low**	**Moderate**	**High**	**Very Low + Low**	**Moderate + High**
Medicine-Blindman Rivers Watershed	33	8	22	38	41	60
Blindman River Subwatershed	37	6	17	41	43	58
Medicine River Subwatershed	29	9	24	39	38	63
Red Deer & Sylvan Lake Subwatershed	43	6	22	29	49	51
Clearwater County	20	4	12	64	24	76
County of Wetaskiwin	0	1	0	99	1	99
Lacombe County	33	15	36	16	48	52
Ponoka County	38	5	13	44	43	57
Red Deer County	38	10	33	19	48	52
City of Red Deer	12	7	44	37	19	81
Penhold	100	0	0	0	100	0
Innisfail	35	3	18	44	38	62

Pressure on riparian system function was assessed for 632 local catchment areas within the watershed, covering an area of just over 5,600 km^2. The Red Deer River & Sylvan Lake subwatershed had the greatest proportion of its area classified as High Pressure (46%), with the Medicine River subwatershed having the largest proportion of land classified as Low and Moderate Pressure.

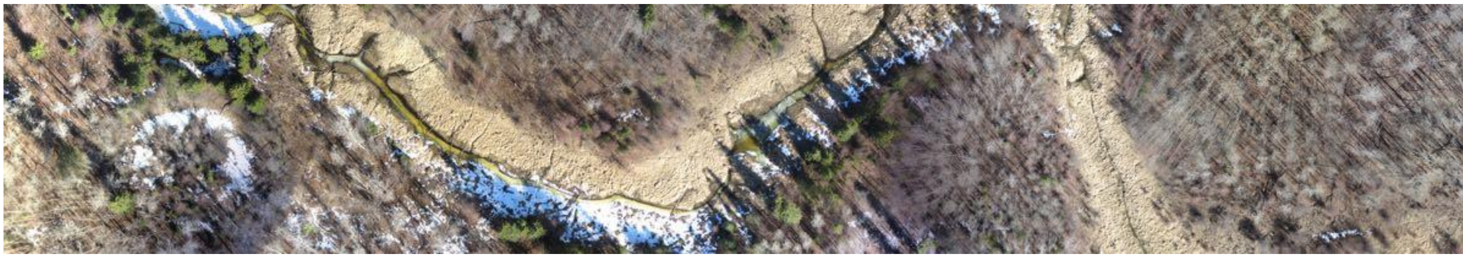


Within the Medicine-Blindman Rivers watershed, 60% of the shoreline length that was assessed was classified as either High (33%; 580 km) or Moderate (27%; 481 km) priority for conservation, representing approximately 1,061 km of shoreline. Conversely, 41% of the shoreline was classified as either High (30%; 530 km) or Moderate (11%; 191 km) priority for restoration, representing approximately 721 km of shoreline. For the majority of the unnamed creeks, shoreline restoration was identified as being the priority, whereas for the majority of the named creeks, conservation of was identified as being the priority.



Spatial Extent	Proportion (%) of Shoreline within Prioritization Category					
	High Restoration	Moderate Restoration	Moderate Conservation	High Conservation	Restoration Priority	Conservation Priority
Medicine-Blindman Rivers Watershed	30	11	27	33	41	60
Blindman River Subwatershed	38	4	27	31	42	58
Medicine River Subwatershed	23	14	24	38	37	62
Red Deer & Sylvan Lake Subwatershed	44	5	38	13	49	51
Clearwater County	19	5	21	54	24	75
County of Wetaskiwin	0	1	0	99	1	99
Lacombe County	34	14	40	12	48	52
Ponoka County	32	12	16	40	44	56
Red Deer County	36	13	32	19	49	51
City of Red Deer	20	0	80	0	20	80
Penhold	71	29	0	0	100	0
Innisfail	37	<1	39	23	38	62

This project has generated scientific information that can be used as the basis for the development and implementation of an evidence-based framework for adaptively managing riparian areas within the Medicine-Blindman Rivers watershed. Through the commissioning of this study, the RDRWA and its stakeholders now have an important foundation of scientific evidence upon which to target restoration and conservation activities that will improve drought and flood resilience in the watershed. The next step in the advancement of meaningful riparian management and conservation in the watershed will be to formalize a framework for action that includes a consideration of the current conditions and defining achievable outcomes and measurable targets, which can then be used to inform relevant collective action by key stakeholders. These actions can then be monitored on a regular basis to provide an evaluation of outcomes that feed into an adaptive and reflexive approach to riparian management through time.



List of Terms

Abbreviations

AAFC: Agriculture and Agri-food Canada

ABMI: Alberta Biodiversity Monitoring Institute

AGS: Alberta Geological Survey

ARHMS: Alberta Riparian Habitat Management Society (Cows & Fish)

BMP: Best Management Practice

DEM: Digital Elevation Model

HUC: Hydrologic Unit Code

RDRWA: Red Deer River Watershed Alliance

RMA: Riparian Management Area

Glossary

Aerial Videography: Video captured from a low flying aerial platform, such as helicopter or ultra light aircraft.

Catchment: Small local drainage areas ranging in size from 1.0 to 72 km^2 that were acquired as part of this study to assess pressure on riparian system function. The catchment data used in this study are freely available from the provincial government as part of Alberta ArcHydro Phase 2 spatial dataset (Government of Alberta 2018).

Conservation Priority: A riparian management area that has been assessed as being moderately to highly intact and is associated with a catchment assessed as moderately to low pressure. Because these areas are largely in a natural state, they are considered to be targets for conservation and/or protection to maintain their current state of function and ecological value.

Hydrologic Unit Code: The Hydrologic Unit Code Watersheds of Alberta (HUC) represent a collection of nested hierarchically structured drainage basin feature classes that have been created using the Hydrologic Unit Code system of classification developed by the United States Geological Survey (USGS), with accommodation to reflect the pre-existing Canadian classification system. The HUC Watersheds of

Alberta consist of successively smaller hydrologic units that nest within larger hydrologic units, resulting in a hierarchal grouping of alphanumerically-coded watershed feature classes. The hydrological unit codes include HUC 2, HUC 4, HUC 6, HUC 8, and HUC 10 with HUC 2 being the coarsest level of classification and HUC 10 being the finest level of classification.

Indicator: A measurable or descriptive characteristic that can be used to observe, evaluate, or describe trends in ecological systems over time.

Intactness: In reference to the condition of natural habitat, intactness refers to the extent to which habitat has been altered or impaired by human activity, with areas where there is no human development being classified as high intactness.

Left Bank: The bank of a river, stream, or creek that is on the left when facing downstream.

Metric: A qualitative or quantitative aspect of an *indicator*; a variable which can be measured (quantified) or described (qualitatively) and demonstrates either a trend in an indicator or whether or not a specific threshold was met.

Resilience: The capacity of an ecosystem to resist, absorb, and recover from the effects of natural and human-caused disturbance to preserve ecological and hydrological services and functions.

Restoration Priority: A riparian management area that has been assessed as being of low or very low intactness and that is associated with a catchment assessed as high pressure. Because these areas are largely in a modified or disturbed state, they should be targets of restoration to improve their current state of function and ecological value.

Right Bank: The bank of a river, stream, or creek that is on the right when facing downstream.

Riparian Area, Riparian Habitat, Riparian Land, or Riparian Zone: Riparian lands are transitional areas between upland and aquatic ecosystems. They have variable width and extent both above and below ground. These lands are influenced by and/or exert an influence on associated waterbodies, which includes alluvial aquifers and floodplains, when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes (Clare and Sass 2012).

Riparian Management Area: As per Teichreb and Walker (2008), and for the purpose of this report, a riparian management area is defined as an area along the shoreline of a waterbody that includes near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone.

Waterbody: Any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood. This includes, but is not limited to lakes, wetlands, aquifers, streams, creeks, and rivers.

Watercourse: A natural or artificial channel through which water flows, such as in creeks, streams, or rivers.

Watershed: An area that, on the basis of topography, contributes all water to a common outlet or drainage point. Watersheds can be defined and delineated at multiple scales, from very large (e.g., thousands of square kilometers, such as the Red Deer River watershed) to very small local watersheds (e.g., square metres, such as a small prairie wetland).

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1.0 Introduction

1.1. Background

Riparian areas are highly complex and dynamic "transitional habitats" that are found along the edge of waterbodies, including rivers, streams, lakes, wetlands, and springs. Riparian areas show steep hydrological and environmental gradients from the water's edge to the adjacent uplands, and are critical for facilitating the transfer of energy and materials between terrestrial and aquatic ecosystems (NRC 2002). Hydrology (both groundwater and surface water) is the driving force behind the physical, chemical, and biological processes that characterize riparian habitats, and because riparian lands are under the influence of both terrestrial and aquatic processes (e.g. nutrient and sediment transfer), these areas tend to be more biologically productive and have higher levels of biodiversity than other habitats that are of comparable size (Ibid).

From the perspective of human communities, riparian areas provide a multitude of beneficial ecosystem functions and services, and the relationship between an intact riparian zone and the integrity of the aquatic environment is well established (Pusey and Arthington 2003); for example, intact riparian zones play a vital role in the exchange of inorganic and organic material between the terrestrial and aquatic ecosystems, via the interception of sediments and nutrients that runoff from adjacent upland habitats, and through the supply of leaf litter and woody debris. Furthermore, intact riparian vegetation can modulate the transfer of solar energy to the aquatic ecosystem, regulating water temperatures and the instream light environment, ensuring suitable habitat for a range of aquatic species (Pusey and Arthington 2003). Riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby improving water quality and protecting surrounding lands from flooding (Orewole et al. 2015; Olokeogun et al. 2020). Riparian vegetation also slows floodwater and increases floodplain residence times, which increases recharge to groundwater aquifers (Swanson et al. 2017). In turn, this allows water to seep back into streams during low water or drought periods (Blackport et al. 1995), thereby stabilizing base water flows (Caissie 1991; Blackport et al. 1995).

Despite the importance of these habitats, the loss and impairment of riparian lands in Alberta over the last century has been significant (Clare and Sass 2012), and as a result, recent watershed management efforts throughout the province have been focused on identifying priority areas for riparian restoration and habitat management. In order to efficiently target habitat restoration efforts and resources across large spatial extents, however, there first needs to be reliable information about the location, condition, and function of riparian habitats.

1.2. Methods for Assessing Riparian Areas

The finest scale and most detailed evaluations of riparian condition come from “boots-on-the-ground” site-specific field assessments and/or inventories of riparian areas. In this type of assessment, such as the Alberta Riparian Habitat Management Society (ARHMS, also known as “Cows & Fish”) Riparian Health Assessment, detailed and local-scale traits of riparian areas are evaluated by trained practitioners, and a comprehensive and thorough assessment of riparian condition is made. Metrics evaluate a wide range of riparian attributes including: vegetation type, structure, and composition; bank characteristics; soil attributes; and land use and disturbance. The final compiled score provides a snapshot of whether a riparian area is “Healthy”, “Healthy, but with problems”, or “Unhealthy”, and gives a land-owner or other interested stakeholders an idea of where to focus management activities. To date, there have been many riparian assessments completed by Cows and Fish (O2 Planning + Design Inc. 2003) within the Red Deer River watershed, and while the site-specific detail offered by this approach cannot be matched, these assessments are limited in their ability to provide information for planning and management at municipal, regional, or larger scales.

As an alternative to the highly detailed information required and the substantial time and cost investment associated with field assessments, alternative approaches that utilize recorded video have been applied to assess riparian areas across larger extents. Aerial videography is a tool for assessing riparian habitat where a trained analyst uses spatially referenced continuous video to evaluate a hydrologic system. Instead of walking around and observing the site, the observation takes place through the video images that have been acquired at altitudes of 60 m or less from an oblique angle. Riparian condition is assessed within a “riparian management area” (RMA) polygon, and like the field-based Alberta Riparian Habitat Management Society Riparian Health Assessment, the evaluator answers a series of questions regarding different functional attributes of the riparian lands in question and converts it into a score that is classified according to three health categories akin to the field-based approach.

Videography has been applied by various organizations across Alberta using a variety of airborne video platforms (e.g., Mills and Scrimgeour 2004, AENV 2010, NSWA 2015). The benefit of videography is that the entire riparian area of a lake or river can be assessed at one time, while providing a permanent geo-referenced video record of the current status of shoreline. It provides a relatively rapid method to produce a “coarse filter” assessment of riparian health. This approach is not intended to replace field-based assessments, but rather, complement them by allowing larger areas to be evaluated in an approximate fashion, to be followed by more detailed checks on the ground. The goal is to provide low cost information of large areas so that management at larger scales (i.e. entire lake or river system) can be directed by standardized measurements, and in some cases, videography can be very cost-effective per kilometer of shoreline observed. At a certain scale, however, the size of the study area and the width of the river make assessments by videography cost prohibitive. Notably, several waterbodies have been assessed using areal videography in the Red Deer River watershed, including Red Deer, Medicine, Blindman and Little Red Deer Rivers, and Sylvan, Gull, and Buffalo Lakes (O2 Planning + Design Inc. 2013; Fiera Biological 2018d).

Although existing ground-based assessment methods are useful for gathering information about the general condition of riparian habitat at small spatial extents, the site-specific delineation employed for these assessments cannot be scaled up to provide information about riparian condition across larger geographic areas. Further, the results of these assessments are typically not available publicly due to confidentiality agreements with landowners (O2 Planning + Design Inc. 2013). Compared to ground-based methods, aerial videography offers a broader scale and relatively coarse assessment of riparian condition; however, at larger scales, such as for entire watersheds, this method becomes limited in practicality and efficiency (i.e., time and cost). As a result, a new method for assessing riparian habitats at large spatial extents was needed for Alberta (Clare and Creed 2012; O2 Planning + Design Inc. 2013).

In response to this need, Fiera Biological developed a Geographic Information System (GIS) method that can be used to assess thousands of kilometers of shoreline in a reliable and cost-effective way. This method was developed using metrics comparable to existing ground-based and aerial videography methods, and the results have been validated using both aerial videography (Fiera Biological 2018a) and field data (Fiera Biological 2019). The assessment method uses automated and semi-automated GIS techniques to quantify the intactness of riparian management areas and pressure on riparian system function using freely available or low cost spatial data. As such, this GIS method allows for the assessment of riparian condition over large spatial extents, and to date, this method has been used to assess over 6,000 km of shoreline across central Alberta (Fiera Biological 2018a-e). This includes previous riparian assessments in the Medicine-Blindman Rivers watershed, including Gull and Sylvan Lakes and their major tributaries (Fiera Biological 2018d), and the portion of the Blindman River extending from Bluffton to the confluence with the Red Deer River (Fiera Biological 2018e). An additional 20,000 km of shoreline is currently being assessed in the North Saskatchewan, Battle, and Athabasca River watersheds, and this work is expected to be complete in 2021.

1.3. Study Objectives

The overall goal of this project is to contribute to the improvement of flood and drought resilience in the Medicine-Blindman Rivers watershed by identifying riparian areas that can be targeted for habitat restoration and/or conservation. Specifically, in order to contribute to this goal, this study had the following primary objectives:

1) Create a recent land cover for the Medicine-Blindman Rivers watershed and use this layer to assess the intactness of riparian areas along major waterbodies.
2) Quantify both natural and anthropogenic pressures that exist upslope of riparian areas to generally assess pressures that may result in impairment of riparian system function.
3) Provide guidance on how the results from the intactness and pressure assessments can be used in combination to prioritize conservation and restoration efforts within the watershed.

The results of this study provide stakeholders with an overview of the status of riparian management areas within the watershed. This in turn allows organizations throughout the watershed to focus restoration, management efforts, and/or resources in areas of greatest need. Further, this approach has been adapted and applied in other watersheds throughout the province, thereby allowing for a standardization of the methods used to conduct large-scale riparian assessments in Alberta.

1.4. Purpose and Intended Use

This assessment synthesizes data from various sources to generally characterize the current condition of riparian management areas within the Medicine-Blindman Rivers watershed, and this report presents the methods, results, and applications of our analyses. Readers are asked to consider the following points regarding the scope of this assessment as they review the methods and interpret the results of this study:

- Assessments characterize relative intactness or pressure using collections of indicators and associated metrics that focus on natural attributes of a riparian area that are measurable in a GIS environment at a pixel resolution of 6 m. No statement on the absolute condition of any riparian area or catchment area is made and the results do not reflect the influence of factors that were not included or considered for analysis. For example, this analysis cannot assess the occurrence or abundance of weeds within a riparian area, nor does not consider the location or density of stormwater outfalls on riparian intactness or water quality.
- Intactness and pressure ratings are intended to support a screening-level assessment of management and/or conservation priorities across broad geographic areas (e.g., HUC 8 subwatershed, municipality, stream reach). *The tool assessments are not meant to replace more detailed, site-specific field assessments of riparian health or condition*. Instead, intactness and pressure ratings should be used to highlight smaller, more localized areas where field assessments and further validation may be required.
- The provincial hydrography data for streams, creeks, rivers, and lakes was used to delineate the shoreline of the waterbodies included in this assessment. Because waterbodies are dynamic and their boundaries change seasonally and annually, the boundaries for the waterbodies included in this study had to be manually adjusted to ensure that the boundary was reflective of the current location of the shoreline, as well as consistent with the imagery that was used to complete the riparian assessment. Notably, the location of the boundaries used in this assessment may not be representative of the location of these same waterbodies in the future. Further, boundaries for waterbodies that were not assessed as part of this study have not been updated.

2.0 Study Area

The Medicine-Blindman Rivers watershed is a large (~5,800 km^2) HUC 6 watershed located in central Alberta (Map 1) with an extensive hydrological network that flows through the Foothills, Boreal Forest, and Parkland Natural Regions (Map 2). The HUC 6 watershed is composed of three smaller (HUC 8) watershed, including the Medicine River, Blindman River, and Red Deer & Sylvan Lake subwatersheds (Map 3). The Medicine-Blindman Rivers watershed was selected as the focus for this study because it is part of both the Lower Headwaters and Central Urbanizing Zones of the Red Deer River watershed, and these areas have been identified by the RDRWA as an important source water protection zone for the City of Red Deer. Additionally, the Medicine-Blindman Rivers watershed was identified as high priority for flood and drought mitigation by the provincial Watershed Resiliency and Restoration Program (WRRP).

Human activity is prevalent within this watershed, with 65% of the lands classified into anthropogenic land cover types (Map 4). Agriculture (cropland and pasture) make up the largest proportion of lands modified by human activity (59%), with the remaining human land cover being composed of Built Up/Exposed (5%) and Disturbed Vegetation (2%). Approximately 35% of the watershed consists of natural land cover types, such as wetlands, forests, open water, and other low and open natural vegetative cover. Areas of natural cover are generally concentrated, with notable areas of treed wetland cover in the northwestern portion of the watershed, patches of forest and wetland cover in the central portion of the watershed and north of Gull Lake, and remnant patches of forest cover and wetland cover along the major rivers (Red Deer River, Blindman River). The predominant wetland classes include fen (8%) and marsh (4%), with swamp (1%) and bog (0.5%) cover being relatively rare. Open water accounts for roughly 3% of the land cover in the watershed.

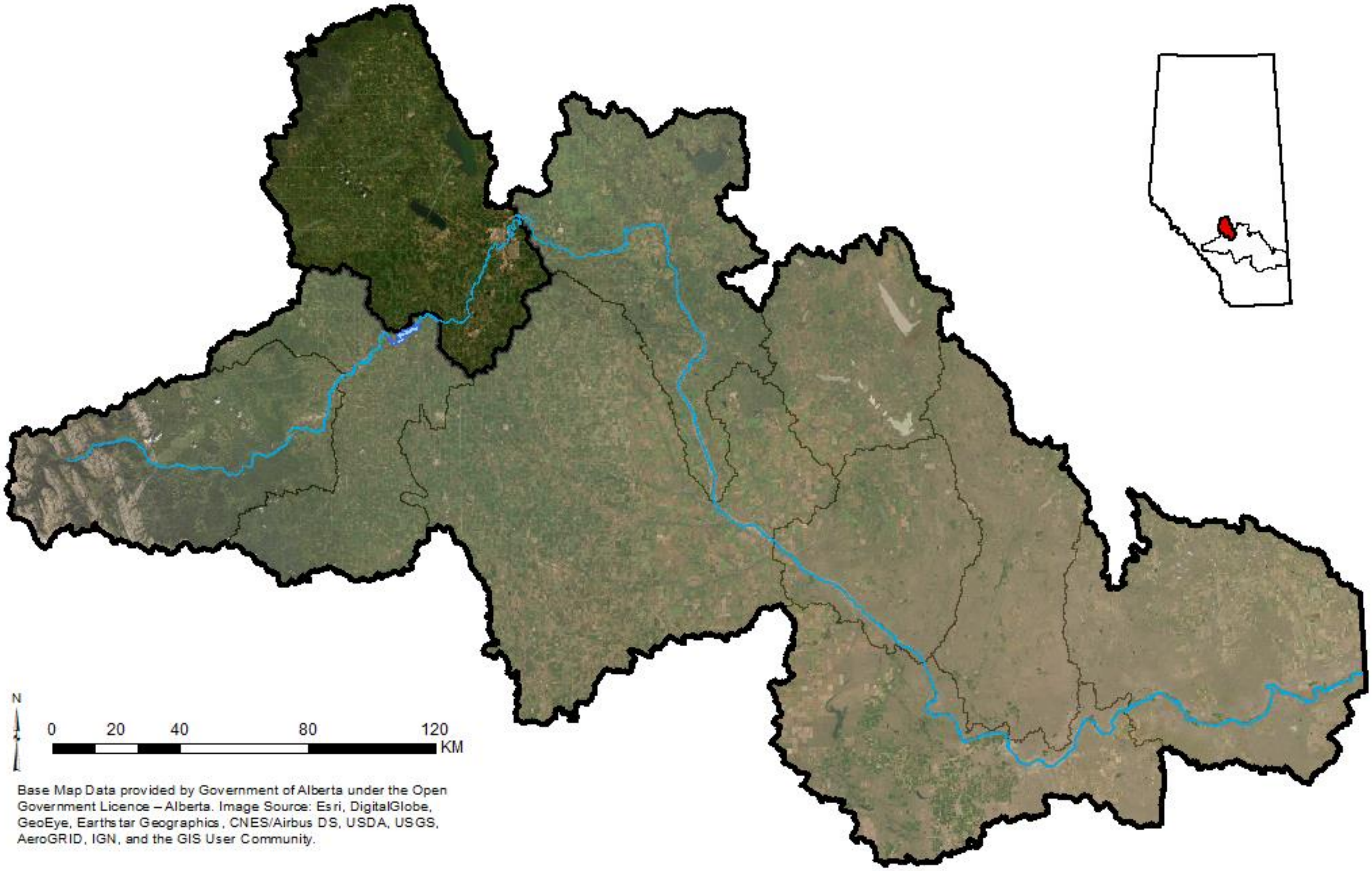
Five rural counties intersect the Medicine-Blindman Rivers watershed, as well as the urban municipality of the City of Red Deer and the larger Towns of Penhold and Innisfail (Map 5). In addition to these more built up areas, there are several smaller towns throughout the watershed, including Sylvan Lake, Rimbey, Bentley, Eckville, and portions of Blackfalds and Bowden.

The riparian management areas that were assessed as part of this study were associated with left and right banks of watercourses classified as Strahler Order 3 or greater. This included Medicine Creek and its major tributaries (Dickson Creek, Horseguard Creek, Open Creek, Tindastoll Creek, Welch Creek, and Wilson Creek), as well as the northern reach of the Blindman River upstream of Bluffton. Major tributaries to the Blindman River, including Anderson Creek, Boyd Creek, Lloyd Creek, and Rainy Creek, were also assessed, in addition to a number of other named creeks throughout the watershed (Table 1; Map 6).

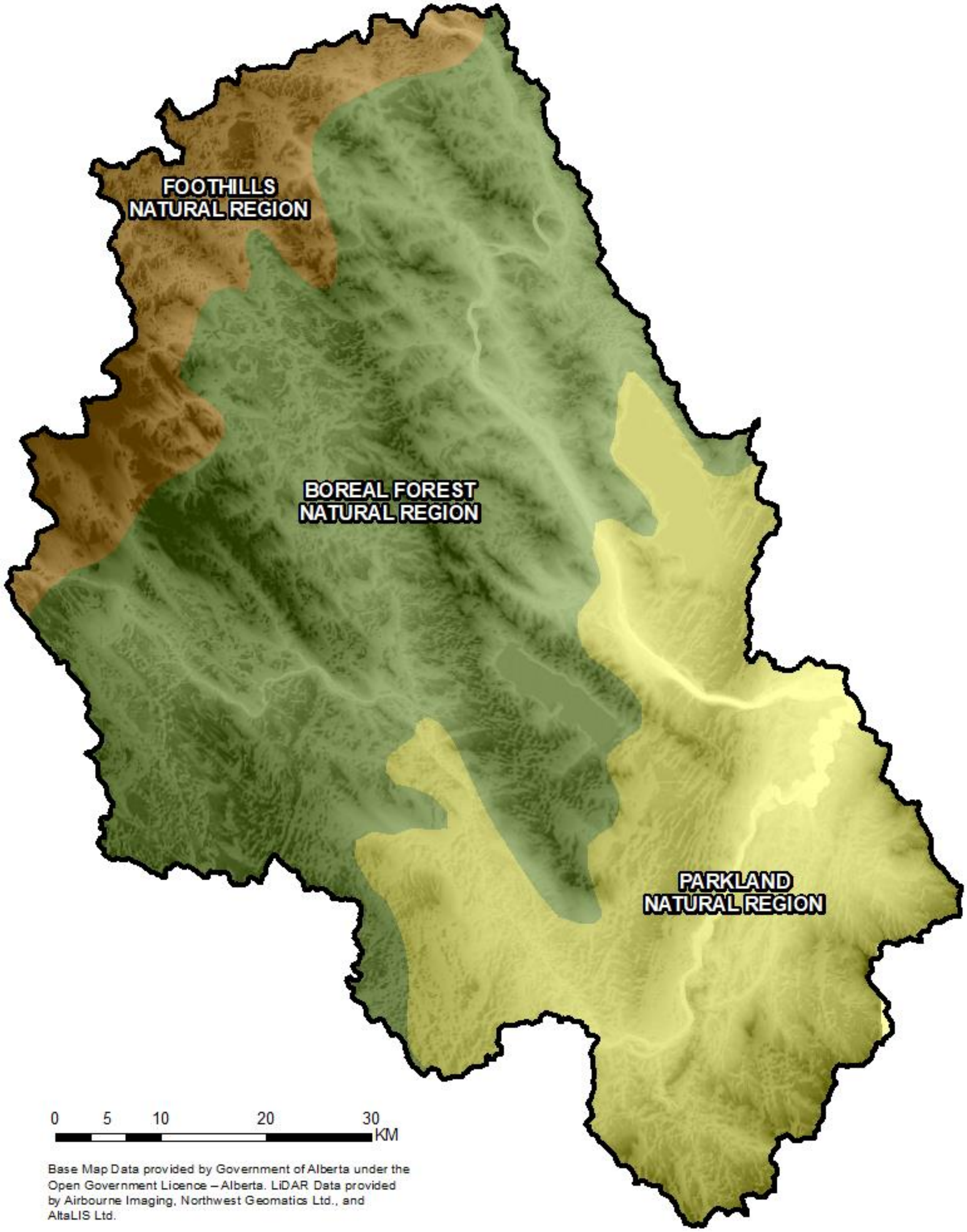
The study also included 11 creeks that flow into the major named creeks and are unnamed in the provincial government stream data; however, some of these creeks may have local names that were not used in this study. In addition, the Open Creek Reservoir was included in the assessment. While Gull and Sylvan Lakes are major waterbodies in the Medicine-Blindman Rivers watershed, these lakes were not included in this study because they were recently assessed using the same GIS method (Fiera Biological 2018d), as was the portion of the Blindman River extending from Bluffton to the confluence with the Red Deer River (Fiera Biological 2018e).

Table 1. Waterbodies in the Medicine-Blindman Rivers watershed that were assessed as part of this project. The shoreline length listed for each creek represents the total length of the stream that was assessed on both the left and right banks.

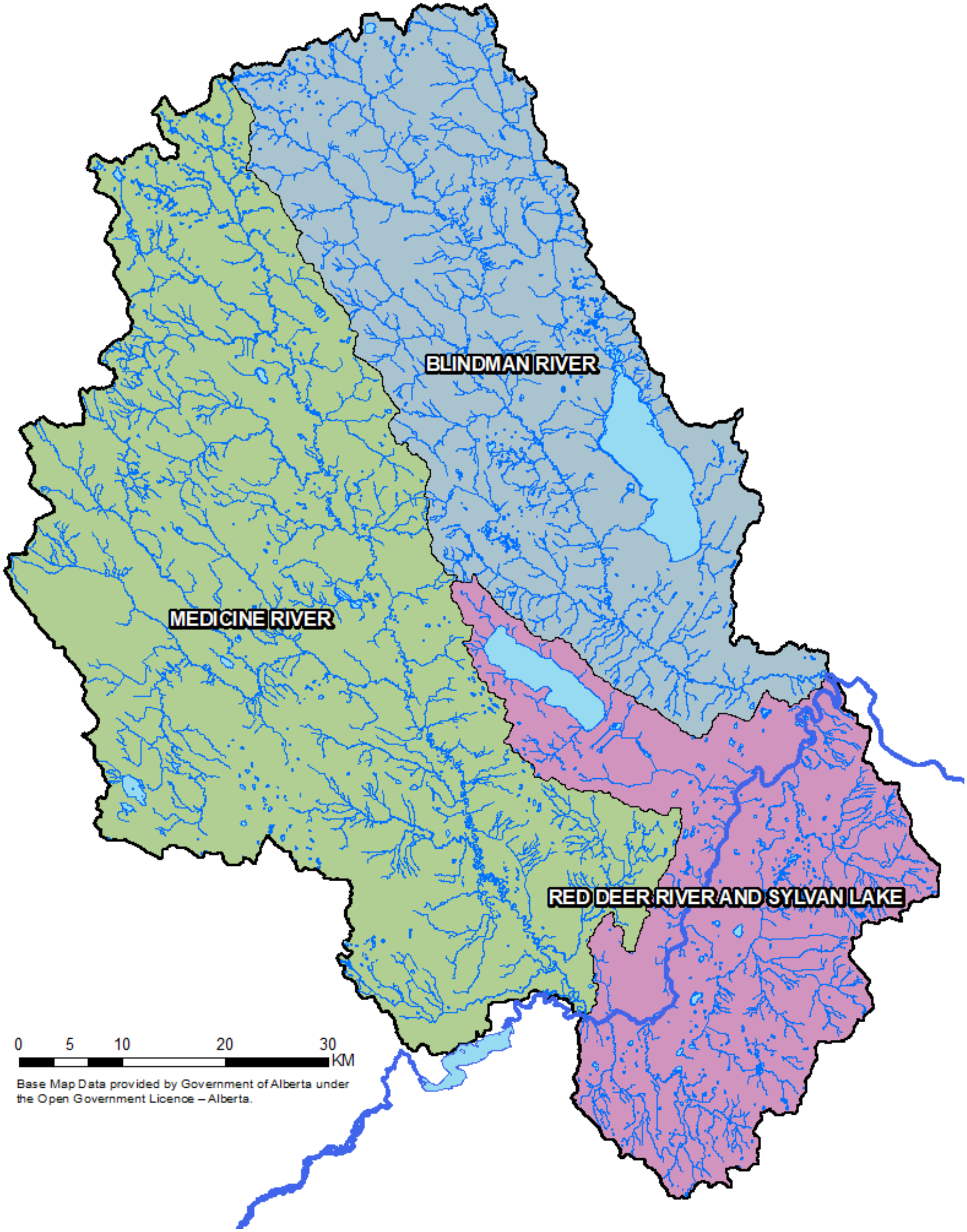
Waterbody Name	Length of Shoreline Assessed (km)
Creeks	
Anderson Creek	60.1
Blindman River	60.2
Block Creek	31.5
Blueberry Creek	30.8
Boyd Creek	44.5
Dickson Creek	40.4
East Lobstick Creek	24.8
Gilpatrick Creek	6.1
Horseguard Creek	147.9
Lasthill Creek	41.2
Lloyd Creek	108.7
Lobstick Creek	77
Medicine Creek	374.8
Nuorison Creek	5.9
Open Creek	48.3
Piper Creek	52.9
Rainy Creek	47.8
Sylvan Creek	30.9
Tindastoll Creek	60.4
Waskasoo Creek	105.7
Welch Creek	85.3
West Lobstick Creek	17.4
Wilson Creek	82.3
Unnamed Tributaries (11)	193.7
Lake/Reservoir	
Open Creek Reservoir	3.3
TOTAL	**1,781.9**



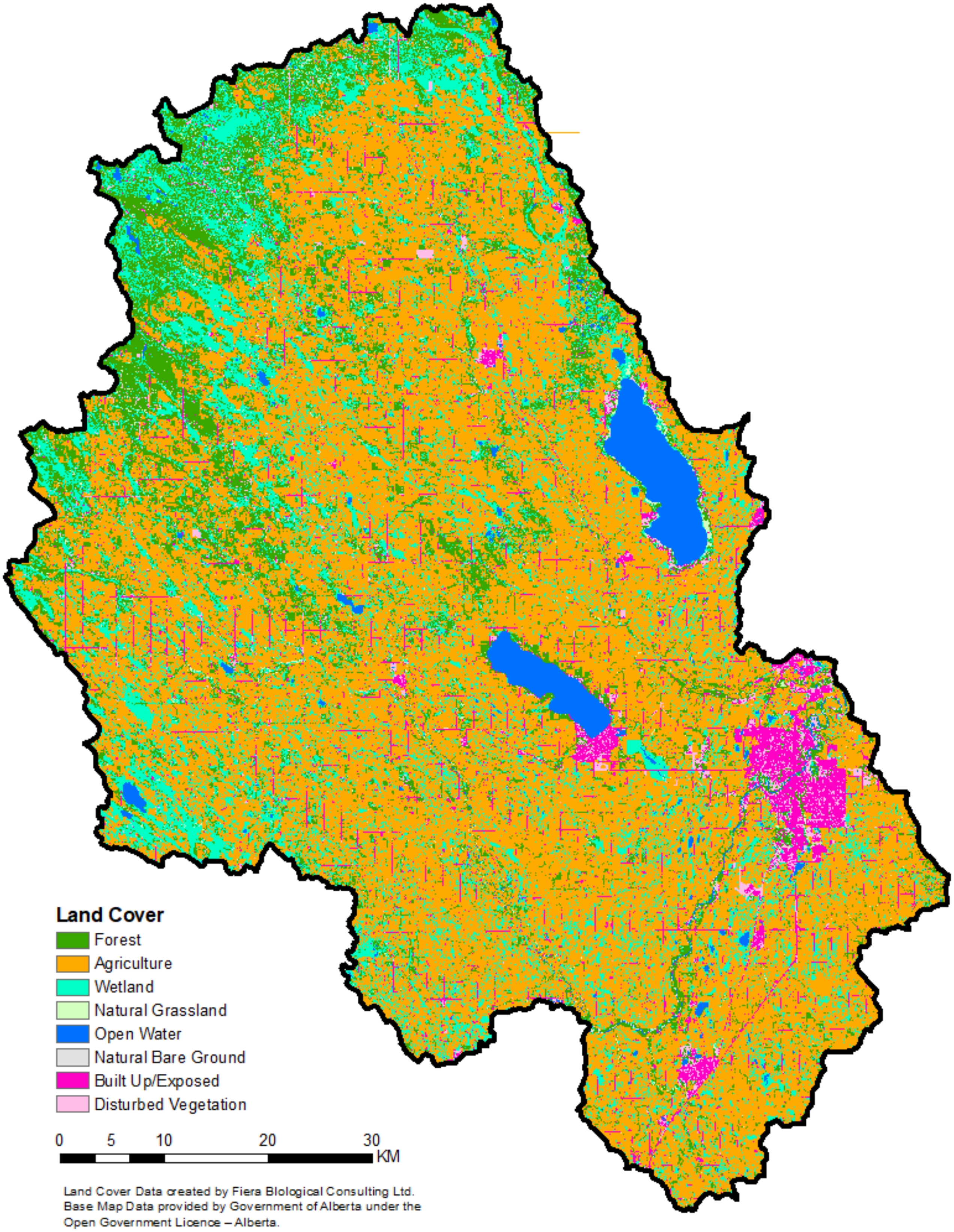
Map 1. The Medicine-Blindman Rivers HUC 6 watershed located within in the Red Deer River watershed.



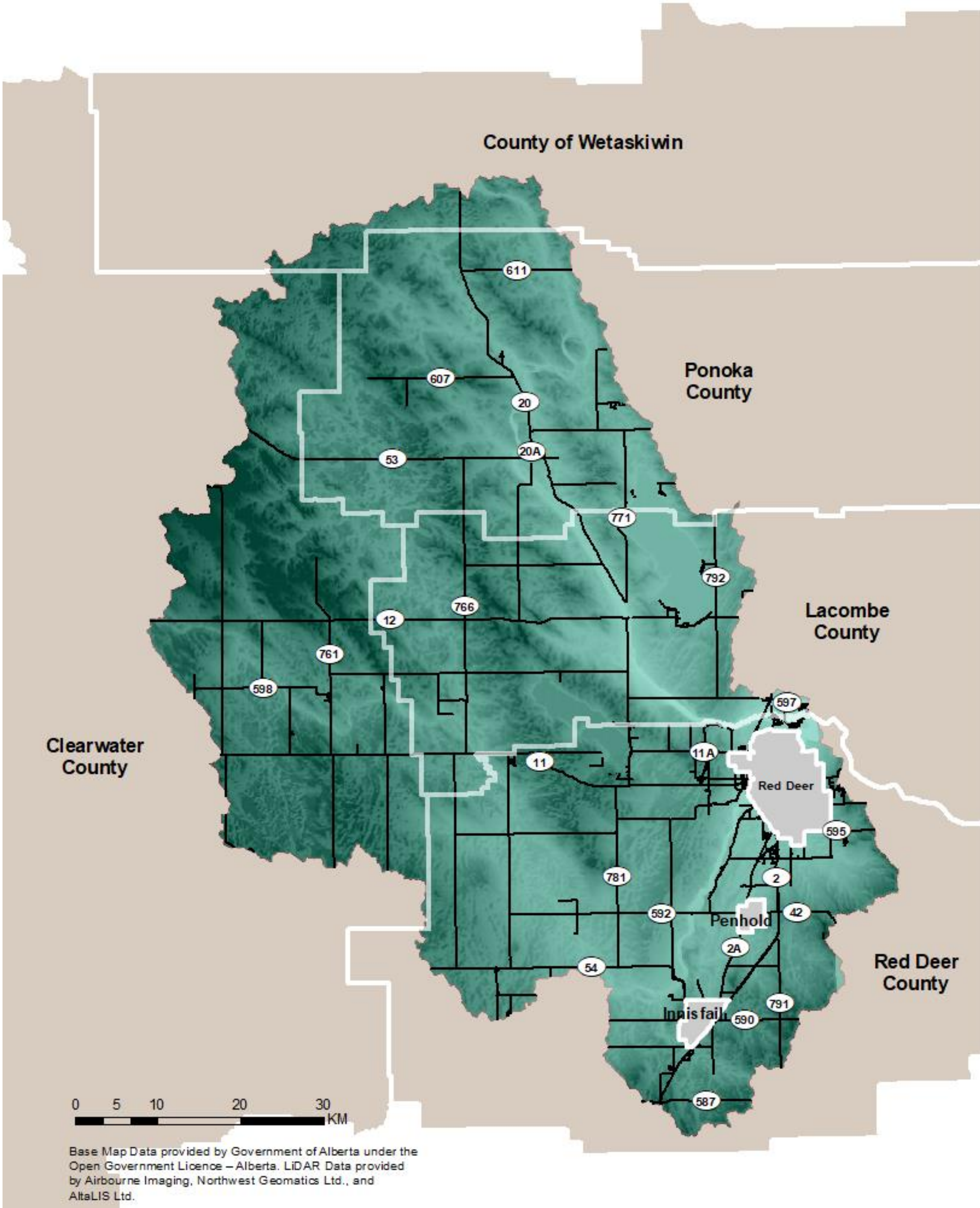
Map 2. The Medicine-Blindman Rivers watershed in central Alberta includes areas that fall within the Foothills, Boreal Forest , and Parkland Natural Regions.



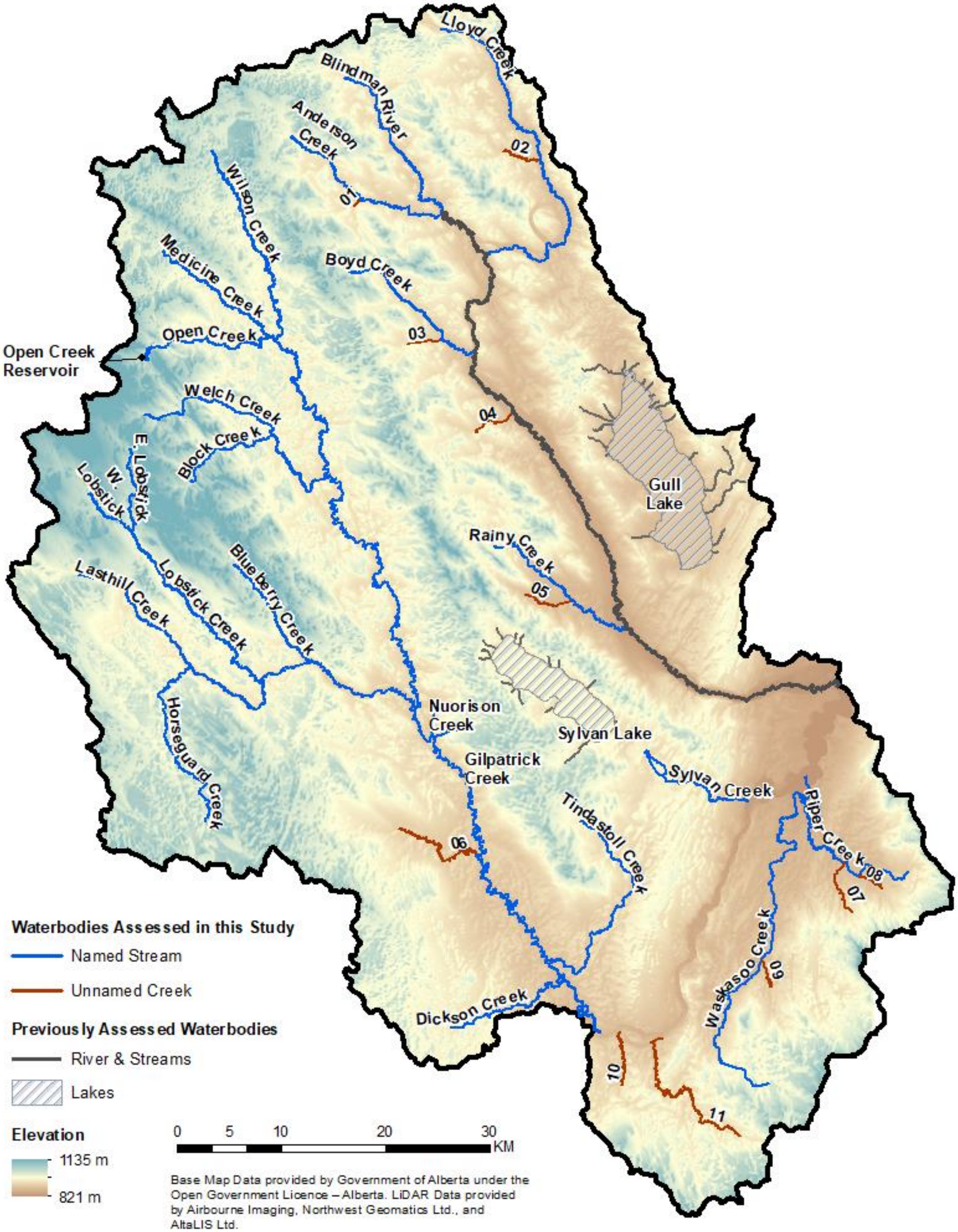
Map 3. The Medicine-Blindman Rivers HUC 6 watershed consists of three smaller HUC 8 subwatersheds: Medicine River, Blindman River, and the Red Deer River and Sylvan Lake subwatersheds.



Map 4. Land cover in the Medicine-Blindman Rivers watershed, created using imagery from 2017 and 2018.



Map 5. Major highways and major rural and urban communities located within the watershed.



Map 6. Location of the waterbodies assessed in this study. A portion of the Blindman River, as well as Sylvan and Gull Lakes and their tributaries, were previously assessed and were not included in this study.

3.0 Methods

3.1. Assessing Riparian Intactness

3.1.1. Land Cover Classification

To quantify riparian intactness in a GIS environment, several data sets were required, including a current land cover layer. While a freely available and current land cover layer was available from Agriculture and Agri-Food Canada (AAFC), the resolution of this data (30 m pixel size) is too coarse to accurately assess vegetation within riparian management areas. Consequently, we created a 6 m pixel resolution land cover using SPOT 6 satellite imagery from 2017 and 2018, which was obtained by the RDRWA free of charge from the Government of Alberta.

The high-resolution land cover classification was created for the entire watershed, and consisted of four separate SPOT 6 image scenes. Because of differences in date of acquisition and image quality, each scene was classified individually, but using the same classification methodology. Each satellite image scene was cloud masked, and the four SPOT 6 bands were combined with a set of ancillary raster data products generated for use in the classification (Table 2). The SPOT 6 imagery was used to generate layers for Normalized Difference Vegetation Index (NDVI), Blue Normalized Difference Vegetation Index (BNDVI), Green Ratio Vegetation Index (GRVI), and Iron Oxide Index (IOI), and a 15 m LiDAR DEM was used to derive terrain layers including Probability of Depression, Cost Distance to Water, and Deviation from Mean Elevation. As well, historic image analysis was performed in Google Earth Engine to generate mean summer temperature maps from Landsat 8 imagery and mean and standard deviation maps of NDVI from Sentinel 2 imagery (Table 2). Land cover classes were chosen and organized hierarchically into nested levels to facilitate training data selection and modelling (Table 3). Training data for the following classes were manually selected for each scene using the SPOT 6 RGB imagery and high resolution orthophotos: Coniferous; Deciduous; Shrub; Bog; Fen; Marsh; Swamp; Cultivated Depression; Open Water; Agriculture Pasture; Cropland; Human Built; Bare Ground. A random forest classification was performed on the four SPOT 6 bands and additional ancillary layers. Random forest is a classification algorithm that is based on a set of decision trees derived by a repeated selection of random subsets of training data, and by creating multiple models of decision trees, better prediction performance is obtained (Ho 1995). For this classification 70% of the training data was used to train the classifier and the remaining 30% of the data was held back to validate the preliminary results.

Following the first stage of the classification, decision rules and manual editing were used to fix general classification errors. During this stage, the Natural Grassland class was added to account for areas of natural, non-woody low cover vegetation, and the Disturbed Vegetation class was added to account for non-agricultural human impacted low vegetation cover and areas with managed or manicured vegetation. Once the quality control and editing for each scene were completed, the four scenes were mosaicked to create a complete classified land cover layer for the entire watershed, and the Alberta Base features Roads layer was used to add in a Roads class to complete the 17-class “Level 2” land cover classification (Table 3).

Table 2. Description of the spatial data obtained or derived for use in the assessment of riparian management area Intactness.

Data Layer	Year	Source	Usage
SPOT 6 Satellite Imagery	2017/2018	Government of Alberta	Derivation of land cover classification
15 m LiDAR DEM	n/d	Government of Alberta	Derivation of data products for classification
Normalized Difference Vegetation Index (NDVI)	2017/2018	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Blue Normalized Difference Vegetation Index (BNDVI)	2017/2018	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Green Ratio Vegetation Index (GRVI)	2017/2018	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Iron Oxide Index (IOI)	2017/18	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Probability of Depression	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Cost Distance to Water	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Deviation from Mean Elevation	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Roads	2014	Alberta Base Features	Derivation of land cover classification
Mean Summer Temperature	2013-2018	Fiera Biological. Layers created using Landsat 8 imagery	Derivation of land cover classification
Mean and Standard Deviation of NDVI	2013-2018	Fiera Biological. Layers created using Sentinel 2 imagery	Derivation of land cover classification
ABMI Human Footprint	2016/2017	Alberta Biodiversity Monitoring Institute	Semi-automated clean up of classification
6 m Land Cover	2017/2018	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta and derived layers	Derivation of RMAs and quantification of intactness metrics

Table 3. Land cover classes that were used to derive the land cover classification for the Medicine-Blindman Rivers watershed.

Level 1	Level 2	Description
Forest	Coniferous	Coniferous trees (needle-leaf) cover greater than 75% of treed area.
	Deciduous	Broadleaf trees covering greater than 75% of treed area.
	Shrub	Vegetation cover that is at least 1/3 shrub (low/short woody plants), with little or no presence of tress (<10% tree crown closure). Includes upland shrub and riparian shrub (e.g. shrub on gravel bars, shrub around marshes).
Natural Grassland	Natural Grassland	Naturally grassy areas with <1/3 shrub cover and <10% tree cover. Includes alpine meadows.
Open Water	Open Water	Any open water (lakes, permanent wetlands, standing water) and flowing water. Includes artificial waterbodies (e.g., dugouts and reservoirs).
Wetland*	Marsh	Low lying areas dominated by emergent or graminiod vegetation and depressional areas adjacent to streams/creeks and lakes.
	Swamp	Depressional areas dominated by deciduous tree or shrub cover.
	Bog	Areas that appear to be dominated by black spruce cover where no water flow is apparent.
	Treed/Shrubby Fen	Depressional areas dominated by woody vegetation cover where surface water flow is apparent.
	Graminoid Fen	Depressional areas dominated by graminoid vegetation cover where surface water flow is apparent.
	Agricultural Depression	Human impacted/altered basins in agricultural areas lacking intact emergent vegetation. In croplands these depressions are typically cultivated and/or drained, and in pasture these low lying areas may be drained and/or utilized for agricultural purposes such as providing water for cattle.
Natural Bare Ground	Natural Bare Ground	Naturally occurring bare soil, sand, sediment, banks, and beaches.
Agriculture	Pasture	Agricultural areas used primarily as pasture or hayland.
	Cropland	Agricultural areas used primarily as cereal crop. Tilled most years.
Disturbed Vegetation	Disturbed Vegetation	Non-agricultural human-impacted or managed non-woody vegetation.
Built Up/Exposed	Human Built	Human built features and human-caused exposed/bare areas.
	Roads	Paved and unpaved roads.

*NOTE: The wetland class names included in this land cover classification are similar to those used in the Alberta Wetland Classification System; however, this land cover classification should not be considered to be a wetland inventory.

3.1.2. Land Cover Classification Accuracy Assessment

Accuracy of the land cover was assessed using traditional remote sensing techniques, which provide a measure of accuracy for each land cover class, as well as an overall accuracy for all classes combined. Accuracy of the land cover layer was assessed at Level 1 using a stratified validation dataset that was a combination of held back training data points (samples collected at the same time as training data was selected, but were not used to train the random forest model) and randomly selected polygons that were validated by a trained photo interpreters. A total of 314 samples were used to assess accuracy with a minimum number of 10 samples validated for each class.

Overall accuracy at Level 1 for the classification was 89.5% with a Kappa statistic of 0.85 (Table 4). Class accuracies were high for nearly all classes except for Natural Grassland and Natural Bare Ground, which are rare classes that cover less than 0.7% (Natural Grassland) and 0.5% (Natural Bare Ground) of the watershed. Natural Grassland samples were typically confused with human impacted low vegetation classes, while Natural Bare Ground samples were primarily confused with Open Water (Table 4). A post-accuracy clean-up was performed on the Natural Grassland class, which reassigned areas of cleared vegetation along linear disturbances to the Disturbed Vegetation class. Inspection of the Natural Bare Ground class revealed that the samples confused with Open Water were at the margin of waterbodies where the water is very shallow. This class also received a minor additional round of clean-up to address this issue. A qualitative review of the land cover classification was also performed. Users of this land cover classification may want to consider that many riparian areas next to streams and rivers are classified as wetland cover classes (e.g., marsh, graminoid fen, treed/shrubby fen) throughout many parts of the watershed.

While the land cover and riparian assessment results for the Medicine-Blindaman Rivers watershed were not validated using field data, pervious riparian assessments completing using this GIS method have been validated using aerial videography data (Fiera Biological 2018), as well as high resolution imagery and data collected in the field (Fiera Biological 2019). In each case, the riparian assessment results were considered to be very robust when compared against the validation data.

Table 4. Accuracy assessment results for the Level 1 land cover classes.

	Agriculture	Built Up / Exposed	Disturbed Vegetation	Forest	Natural Grassland	Open Water	Natural Bare Ground	Wetland	Users Accuracy
Agriculture	142	0	2	5	1	1	0	1	93%
Built Up/ Exposed	0	12	0	0	0	0	1	0	92%
Disturbed Vegetation	1	0	12	1	0	0	0	0	86%
Forest	0	0	0	35	0	0	0	3	92%
Natural Grassland	2	0	1	1	6	0	0	0	60%
Open Water	0	0	0	0	0	10	2	0	83%
Natural Bare Ground	0	1	1	0	1	3	2	0	25%
Wetland	0	0	0	5	0	0	0	62	93%
Producers Accuracy	98%	92%	75%	74%	75%	71%	40%	94%	89%

NOTE: Producer's accuracy measures errors of omission, which is a measure of how well real-world land cover types can be classified. User's accuracy measures errors of commission, which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location.

3.1.3. Editing Water Boundary Data

The provincial hydrography data for the waterbodies of interest were used to delineate the shorelines included in this assessment. Due to the dynamic nature of waterbodies and the vintage of the provincial data, the location of the hydrography data does not always correspond well with shorelines in current imagery. Thus, in order to ensure the generation of RMAs and quantification of the intactness metrics were accurate, the hydrography data was manually edited where necessary to ensure that the boundaries corresponded with the SPOT imagery and the land cover classification. For streams, the edited water boundary represents the approximate centreline of the watercourse. Where the width of a stream or creek was greater than 20 m for a distance of more than 50 m in the SPOT imagery, or the stream passed through an area of open water greater than 1.0 ha, the stream was split and edited to have a unique left and right bank. Lake and open water shorelines were edited to approximate the location of the boundary between the upland and riparian zone. The edited water boundaries for assessed features have an approximate mean accuracy of +/- 5 m relative to their location in the SPOT imagery used in this project.

Figure 1. Example of the spatial inaccuracies associated with stream boundaries, where the location of the stream centre line does not match the actual location of the stream and exceeds the 5 m accuracy tolerance. In this example, the yellow lines represent the location of the streamline from the provincial data, and the blue line represents the manually edited location of the new stream centre line.

3.1.4. Delineating Riparian Management Area Width and Length

In order to allow for comparisons between watersheds, the GIS methods that were developed to assess riparian areas in the Modeste watershed (Fiera Biological 2018a) were applied in this watershed. As per the GIS method, which was developed to closely match previously developed aerial videography methods (Teichreb and Walker 2008), riparian intactness was assessed within a “riparian management area” (RMA).

An RMA is defined as an area along the shoreline of a waterbody that includes near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone (Figure 2). An RMA has two spatial components: width and length. For this assessment, riparian intactness was evaluated within RMAs that had a static 50 m wide buffer that was applied to the left and right banks of each watercourse. In the case of lakes, a single 50 m wide buffer was applied to the shoreline. When assessing riparian condition using aerial videography, RMA length is determined by a change in the score of any single metric, and is thus variable. In order to replicate this approach, we chose to delineate the upstream and downstream extents of each RMA based upon major changes in the proportion of natural cover along the shoreline.

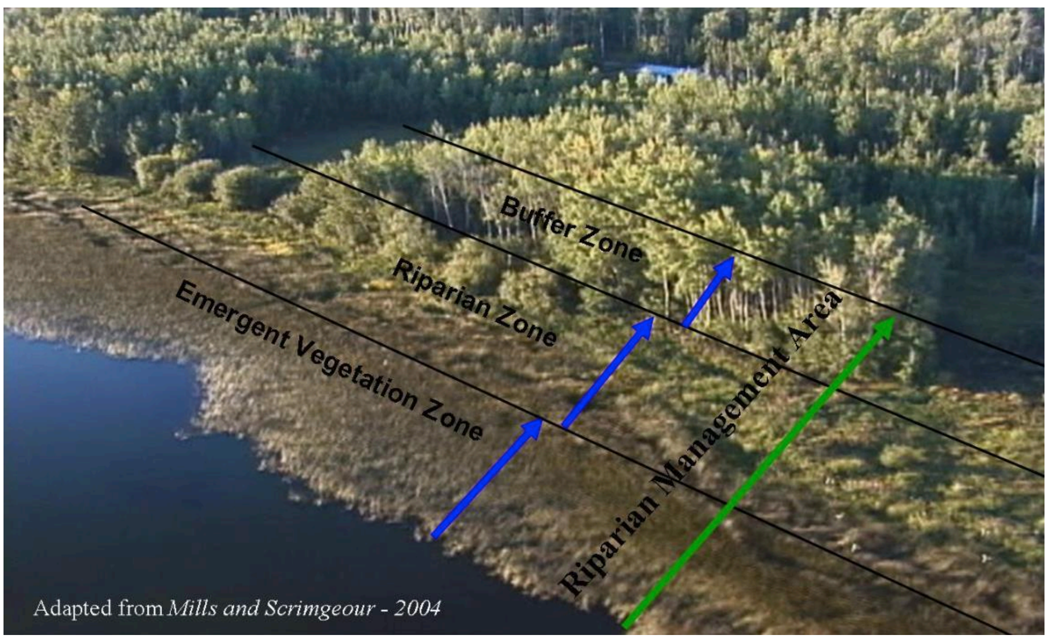


Figure 2. Schematic showing the different shoreline components included in a “riparian management area” (image taken from Teichreb and Walker 2008).

In order to determine the longitudinal extent of each RMA, the proportion of all natural cover types along the shoreline was evaluated, with the start and end points of each RMA corresponding with locations where there were major changes in the proportion of natural cover. To calculate the proportion of natural cover, all natural cover classes (i.e., Forest, Bog, Fen, Marsh, Swamp, Open Water, Natural Grassland, Bare Ground) were selected and exported as a single layer. The stream layer was then divided into 10-meter segments on the left and right banks, and the proportion of natural cover within a 25 m moving window was calculated for each segment. A threshold was used to identify locations along the shoreline where there was greater than or less than 55% natural cover. All adjoining homogeneous segments of less than or more than 55% natural cover were then merged to became a single RMA. This threshold value was selected based upon an iterative threshold testing procedure to determine the percent of natural vegetative cover that best approximated the videography RMA boundaries (Fiera Biological 2018a). To reduce error associated with misclassification in the 6 m land cover, we merged and dissolved very small RMAs (≤10 m) with neighbouring segments.

All municipal data summaries were generated by using a spatial intersect rule in ArcGIS, where the results from each analysis (i.e., intactness, pressure, priority) were intersected with the municipal boundary layer. Summarizing the data in this way reflects the assessed areas that touch the boundary of the municipality, and therefore, assessed features may extend outside the municipal boundaries (e.g., RMAs, catchment areas). It should also be noted that there are spatial discrepancies between the municipal boundary data and the provincial hydrography data that is freely available from AltaLIS. For example, in many instances, municipal boundaries follow the boundary of a waterbody (e.g., the boundary between two Counties follows a creek or river); however, the boundary topology of these two features do not match. In these instances, minor edits were made to correct the intersection outputs and reassign results from one municipality to another, but in most cases, municipal boundary layers were not extensively edited to correct topological errors. As a result, the municipal summaries of shoreline length for intactness and priority are approximate and should be considered estimates that reflect relative differences between municipalities.

3.1.5. Indicator Quantification and Riparian Intactness Scoring

Intactness with riparian management areas was quantified using the following metrics:

Metric 1: Percent cover of natural vegetation;
Metric 2: Percent cover of woody species;
Metric 3: Percent cover of all human impact and development (human footprint).

To quantify Metric 1, all natural cover classes were selected from the land cover layer and the proportion of the RMA covered by those cover classes was calculated. The natural classes used to quantify this metric included: Treed Wetland, Marsh, Forest, and Natural Grassland. To quantify Metric 2, the percent cover of Forest and Treed Wetland land cover classes was quantified for each RMA. For Metric 3, the percent cover of the following land cover classes were used to calculate human footprint within each RMA: Cropland, Pasture, Agricultural Depression, Disturbed Vegetation, and Built Up/Exposed.

Once each metric was quantified, the values were range standardized and were aggregated using a weighting comparable to the aerial videography methods. The metrics were weighted as follows: Metric 1: 0.15; Metric 2: 0.25; Metric 3: 0.60. The weighted scores were aggregated to derive a final RMA score that ranged between 0 and 100, and these scores were converted into intactness categories using the following categorical breaks:

- High Intactness (>75-100): Vegetation within the RMA is present with little or no human footprint.
- Moderate Intactness (>50-75): Vegetation within the RMA is present with some human footprint.
- Low Intactness (0-50): Vegetation cover within the RMA is limited and human footprint is prevalent.
- Very Low Intactness (0-25): Vegetation cover within the RMA is mostly cleared and human footprint is the most dominant land cover.

3.2. Assessing Pressure on Riparian System Function

We adapted the Watershed Integrity scoring methodology (Flotemersch et al. 2016) to assess Pressure on Riparian System Function in the Medicine-Blindman Rivers watershed. In this method, Watershed Integrity, *WI*, is the product of different watershed functions, with the underlying premise being that *"A high level of integrity exists when all functions are operating at levels that support and maintain the full range of ecological processes and functions essential to the long-term sustainability of biodiversity and ecosystem services" (*Flotemersch et al. 2016, pg. 1660).

With this approach, when any one of the functional components are compromised, the integrity of the watershed is also compromised, and as more functions are compromised, the integrity is compromised in a multiplicative way. We applied this watershed integrity approach to define and calculate Catchment Pressure, *CP*, with the objective of measuring the factors that increase or decrease the ecological and hydrological function of riparian habitats.

In our model, catchment pressure is the product of two functions that describe pressures that may occur within a local catchment area: Natural Resilience (*NR*) and Human Impacts (*HI*). Catchment pressure was calculated using the following equation, with higher scores indicating areas where there may be heightened pressure on riparian system function:

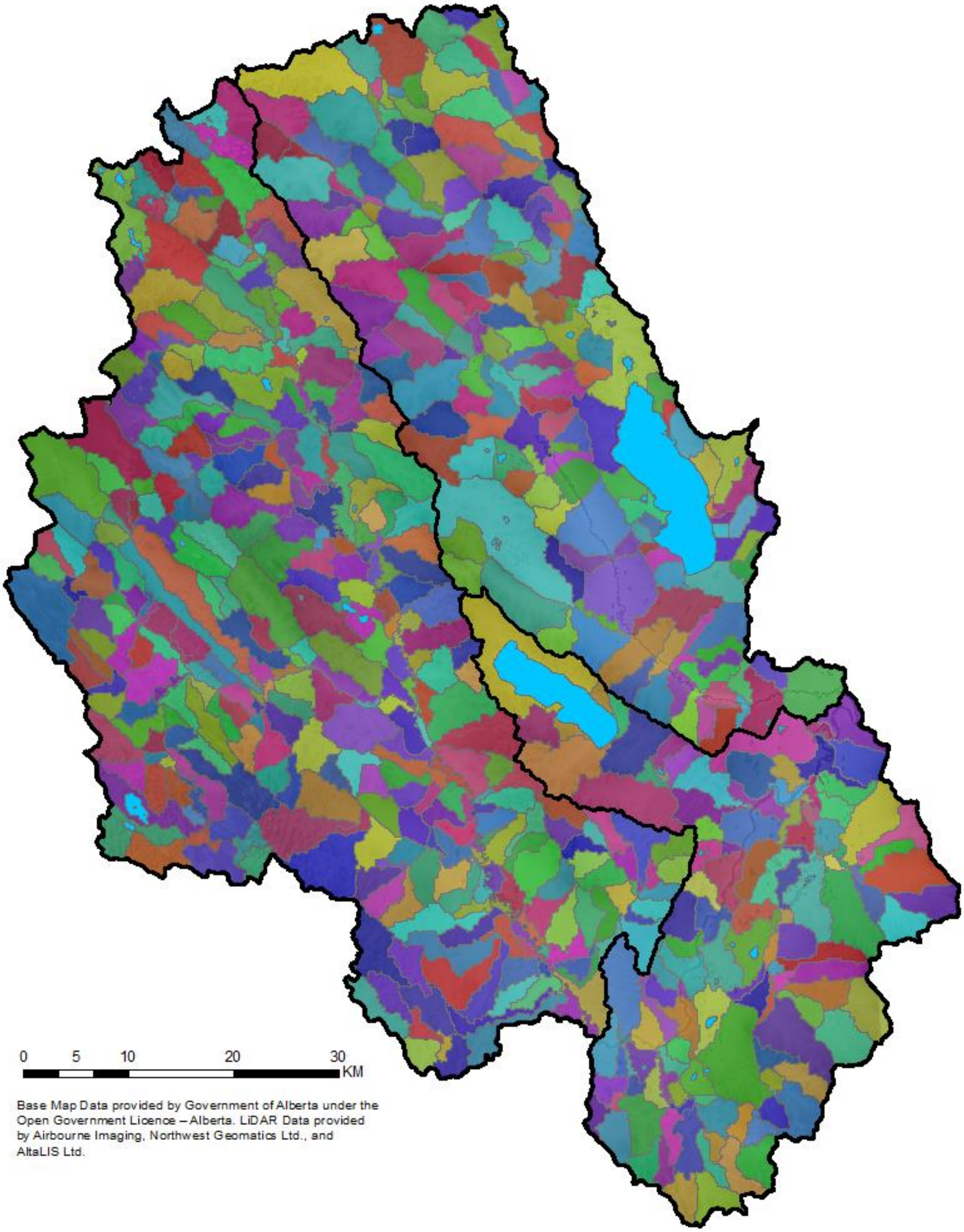
$$CP = CP_{NR} \times CP_{HI}$$

Natural Resilience (*NR*) and Human Impact (*HI*) function scores were calculated from a set of associated stressor metrics (S_i) that are known to affect riparian function and are measurable in a GIS environment. A list of the stressor metrics associated with each function, along with a description of how each stressor was quantified, and the data used for the quantification is provided in Table 3.

Variables that exert pressure on riparian system function range spatially from large-scale to site-specific. We conducted a pressure assessment at a local "catchment" scale, which we considered to be a scale that was meaningful both from the perspective of ecological and hydrological processes, as well as from the perspective of land management. Local catchment areas were identified using the Government of Alberta ArcHydro Phase 2 dataset (GOA 2018; Map 7). Local catchment areas that intersected the RMAs of the waterbodies included in this study were used as the unit of analysis for the pressure assessment.

Table 5. List of metrics used to assess pressure on riparian system function, along with a description of the methods used to assess each metric and the source and vintage of the data used for metric quantification. Each metric was quantified within local catchment areas that were derived specifically for this assessment using LiDAR 15 m data provided by the Government of Alberta.

Function	Stressor Metric	Metric Quantification	Data Source & Date
Natural Resilience (*NR*)	Natural Cover	Percent cover by natural vegetation cover classes	Fiera Biological Medicine-Blindman Rivers watershed Land Cover (2017/2018)
	Slope	Mean cover of steep slopes (>5%)	Fiera Biological, derived from Government of Alberta 15 m DEM
	Landslide Susceptibility	Area weighted average	Alberta Geological Survey (2016)
Human Impacts (*HI*)	Land Use Intensity	Zonal average of land use intensity values	Fiera Biological Medicine-Blindman Rivers watershed Land Cover (2017/2018) and ABMI Human Footprint (2016)
	Stream Crossing Density	Area weighted average of linear features that intersect major streams	Government of Alberta base features (2000)
	Road Density	Area weighted average of roads	Government of Alberta base features (2018)
	Density of Other Linear Disturbance Types	Area weighted average of non-road linear features	Government of Alberta base features (2018)



Map 7. Local catchment areas in the Medicine-Blindman Rivers watershed.

3.2.1. Quantifying Stressor Metrics & Calculating Function Scores

In order to quantify the Land Use Intensity stressor metric, we had to first assign a land use intensity value to land cover types and human footprint present in the watershed. To quantify this metric, the SPOT land cover and ABMI human footprint layers were used together, which allowed for intensity characterization by human use type. High intensity of use values were assigned to land cover types that are known to be more impactful on riparian system function, and all values were assigned using best professional judgment informed by a literature review (Donahue 2013). We tested several different schemes for assigning intensity of land use values, and an appropriate range of values and magnitudes was selected by iteratively inspecting output maps and intensity values and ranges. Where the SPOT land cover and ABMI human footprint overlapped, the maximum Intensity of Use Value was applied. The final intensity value assignments for land cover in the Medicine are provided in Table 6.

Table 6. Intensity of Use values assigned to the various land cover classes present in the Medicine-Blindman Rivers watershed.

Land Cover Class	Intensity of Use Value
Agriculture – Crop	50
Agriculture – Pasture/Forage	50
Airport	1000
Canals	10
Cultivation (Crop/Pasture/Bare Ground)	50
Cut Block	50
Dugout/Burrow-Pit/Sump	10
Exposed/Barren	1000
High-Density Livestock Operation	1000
Industrial Site (Urban/Heavy Industry)	1000
Industrial Site (Rural)	500
Mine Site	1000
Municipal Water/Sewage	50
Disturbed Vegetation (Other)	25
Peat Mine	100
Pipeline	50
Rail – Hard Surface	100
Rail – Vegetated Verge	50
Reservoir	10
Road – Hard surface	100
Road Vegetated Verge	50
Road/Trail – Vegetated	100
Rural Residential	50
Seismic Line	50
Transmission Line	25
Urban/Developed	1000
Well Site	100

Scores for each of the GIS stressor metrics were calculated using ArcGIS 10.7 in one of two ways. For stressors that have a known measurable biological response, literature-derived thresholds were used to define the maximum feasible value (Table 7). This threshold is the value above which the stressor impairs function beyond a repairable or reversible state. For example, forest cover of at least 25% is required to improve water quantity/quality (Adams and Taratoot 2001), so any catchment with ≤25% cover of forest cover is under maximum pressure for this stressor. For stressors with a known threshold, scores were calculated as:

$$S_i = 1 - \left(\frac{S_{observed}}{S_{threshold}}\right)$$

For stressors that are physical variables (e.g., slope), or for variables for which the biological response threshold value is not known (e.g., intensity of land use), the catchment stressor values were scored against the maximum value from the stressor's range of values within the Medicine-Blindman Rivers watershed (i.e., a range standardized score was calculated). For these stressors, scores were calculated as:

$$S_i = 1 - \left(\frac{S_{observed}}{S_{maximum}}\right)$$

A description of the stressor threshold values used in this assessment, and the method used to derive each threshold, is provided in Table 7.

Once stressors were quantified, the values were compiled within their associated pressure function (CP_{NR} and CP_{HI}) and were combined mathematically to calculate a final catchment pressure score, as follows:

$$CP = CP_{NR} \times CP_{HI}$$

for which,

$$NR = (\%Natural\ Cover) + \min(Slope, Landslide\ Susceptibility))$$

and,

$$HI = (Intensity\ of\ Use + average(Stream\ Crossing\ Density, Road\ Density, Linear\ Density))$$

Once calculated, the raw catchment pressure scores were scaled to allow for better interpretation of the values. Scaling can be performed and applied in different ways, and for this study, a percentage score was calculated by taking the ratio of the raw catchment pressure score to the theoretical maximum possible score. For the Medicine-Blindman Rivers watershed, there are two stressor scores for each function, and all stressors have a maximum score of 1, so the maximum possible score is (1+1) x (1+1) = 4. Dividing the raw catchment pressure score by the theoretical maximum (4) and multiplying by 100 gives a percent score. In order to have high scores represent areas of High Pressure and low scores represent areas of Low Pressure, values were reversed by subtracting the percentage score from 100.

3.2.2. Assigning Pressure Categories

Catchment integrity was translated into catchment pressure by taking the percent scores and grouping the scores into three pressure categories (Low, Moderate, High) based on the quartile percentile breaks for the distribution of scores. Catchments in the Low Pressure group correspond to the catchments with the top 25% of scores, catchments in the High Pressure group correspond to the catchments with the bottom 25% of scores, and Moderate Pressure catchments correspond to the remaining 50% of scores (i.e., scores between the 25th and 75th percentiles).

Table 7. Thresholds and scoring types used to calculate stressor scores for pressure metrics.

Function	Stressor Metric	Threshold	Scoring Type	References
Natural Resilience *(NR)*	Natural Cover	Minimum 25% cover	Literature review	Target forest cover of 25% for water quantity/quality (Adams and Taratoot 2001)
				30% cover at watershed scale supports less than one half of the potential species richness and marginally healthy aquatic systems (Environment Canada 2014)
				Target cover of at least 35% for subbasins to prevent moderate extirpation of bull trout (Ripley et al. 2005)
				Threshold of 30% natural cover correlated with riverine ecological condition (Deegan et al. 2010)
				6% loss of aquatic species for every 10% loss of natural land cover (Weijters et al. 2009)
	Slope	Maximum value	Range of values	N/A
	Landslide Susceptibility	Maximum value	Range of values	N/A
Human Impact *(HI)*	Land Use Intensity	Maximum value	Range of values	N/A
	Stream Crossing Density	0.6/km^2	Literature review	Stream crossings impede fish passage, affect water flow, and water quality - adapted thresholds from bull trout and general fish road density thresholds of 0.6km/km^2 and 0.7km/km^2 (Tchir et al. 2004)
	Road Density	1.0 km/km^2	Literature review	Extirpation of bull trout at 1.0 km/km^2 (AESRD 2012)
				Large mammals affected at various thresholds:0.4 km/km^2 for grizzly bear; 1.25 km/km^2 for black bear (AESRD 2012); 0.62 km/km^2 for elk (AESRD 2012)
	Density of Other Linear Disturbance Types	3.0 km/km^2	Literature review	Adapted general density threshold for watershed health, where >3 km/km^2 is used as an indicator for poor health (AESRD 2012)

3.3. Management Prioritization

While riparian intactness and catchment pressure scores on their own provide land managers with important information about riparian condition, combining these scores together to create a prioritization matrix that identifies high priority areas for both conservation and restoration allows land managers to more precisely target areas for management.

Combining intactness and pressure scores results in prioritization matrix with 12 scoring categories, and we assigned a unique score ranging between 1 and 12 to each category using best professional judgement (Table 8). The numeric scores were then combined and assigned to one of four prioritization categories, as follows:

- **High Conservation Priority (Category 1-3):** High/Moderate Intactness and Low/Moderate Pressure
- **Moderate Conservation Priority (4-6):** High/Moderate Intactness and Moderate/High Pressure
- **Moderate Restoration Priority (7-9):** Low/Very Low Intactness and Low/Moderate Pressure
- **High Restoration Priority (10-12):** Low/Very Low Intactness and Moderate/High Pressure

For each riparian management area, the pressure score was determined by intersecting the RMA polygons with the catchment polygons. This ensured that the pressure scores, which were calculated as polygons, could be accurately assigned to the RMA polygons. The resulting prioritization polygons were then scored, and the length of each RMA assigned to each priority category was calculated.

Table 8. Riparian prioritization matrix for RMAs in the Medicine-Blindman Rivers watershed.

		RIPARIAN INTACTNESS			
		High	**Moderate**	**Low**	**Very Low**
CATCHMENT PRESSURE	**Low**	1	3	7	9
	Moderate	2	5	8	11
	High	4	6	10	12

High Conservation Priority
Moderate Conservation Priority
High Restoration Priority
Moderate Restoration Priority

4.0 Results

4.1. Riparian Management Area Intactness Results

Riparian intactness was calculated for approximately 1,782 km of shoreline in the Medicine-Blindman Rivers watershed (Map 8 and Map 9). Overall, 38% of the shoreline that was assessed was classified as High Intactness, with a further 22% classified as Moderate Intactness (Figure 3; Table 9). Approximately 41% of the shoreline was classified as either Low (8%) or Very Low (33%) Intactness.

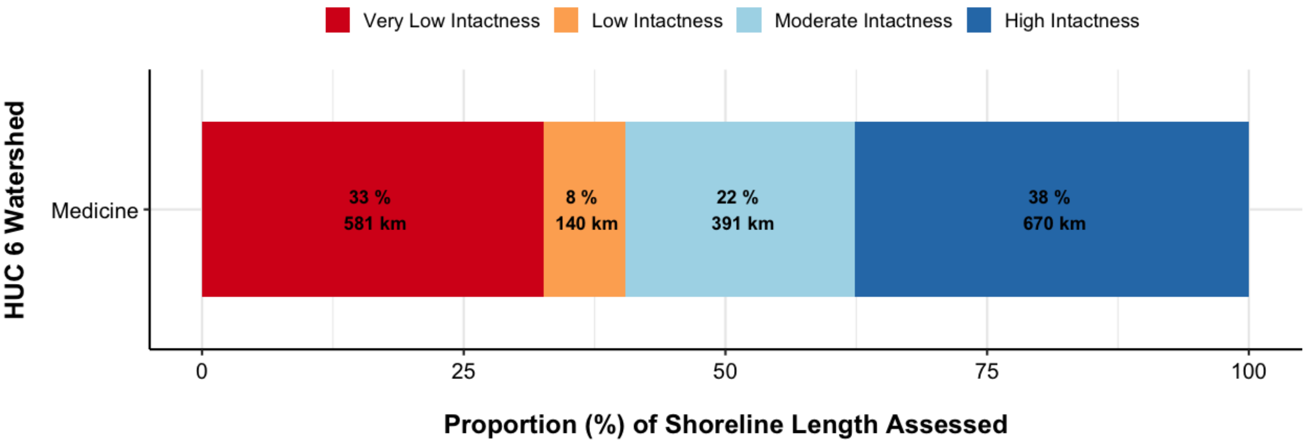
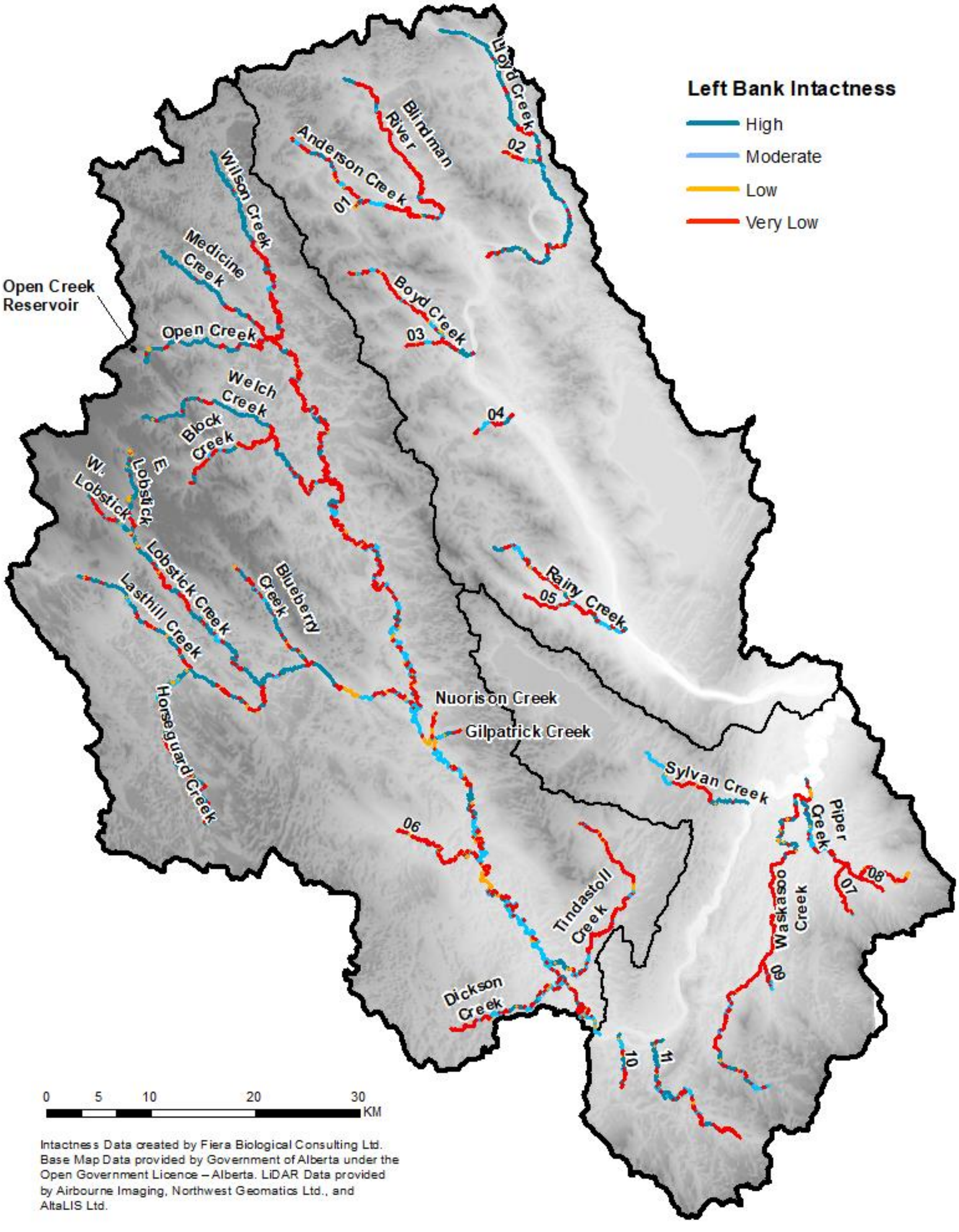
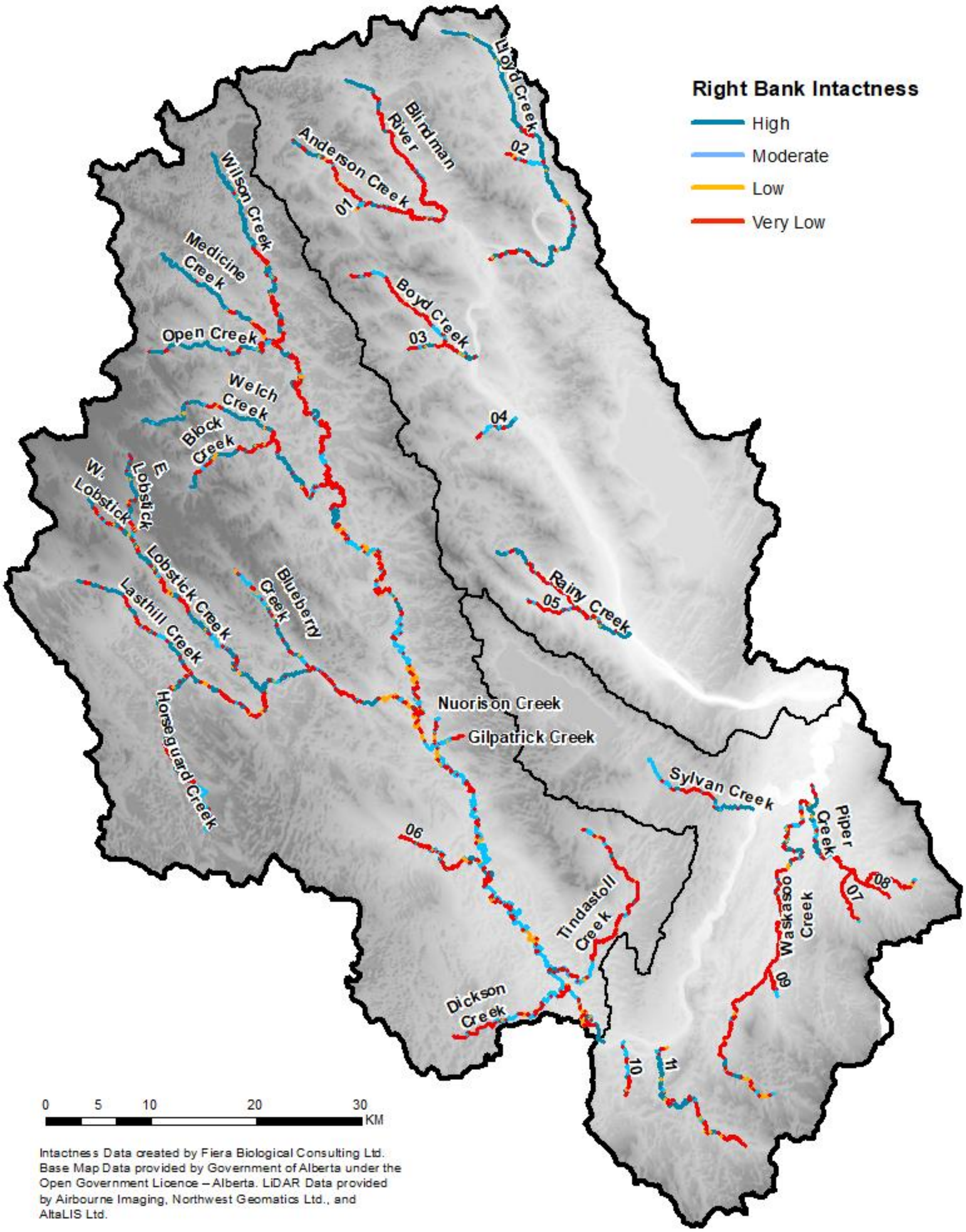


Figure 3. The total proportion of shoreline within the Medicine-Blindman Rivers watershed assigned to each riparian intactness category. Numbers indicate the total length (km) of shoreline associated with each category.



Map 8. Intactness for Open Creek Reservoir and the left bank of creeks that were included in this study.



Map 9. Intactness for the right bank of creeks that were included in this study.

When the length of shoreline assessed was calculated by HUC 8 subwatershed, the Medicine River subwatershed contained 1,121 km (63%) of the shoreline that was assessed (Table 9; Figure 4). Overall, the Medicine subwatershed had the greatest proportion (63%) and length (699 km) of shoreline classified as either High or Moderate Intactness, with the Red Deer/Sylvan subwatershed having the greatest proportion (49%) of its shoreline assessed as Very Low and Low Intactness (Figure 5).

Table 9. Total length of shoreline assessed within each HUC 8 subwatershed, along with a summary of the length of shoreline assigned to each riparian intactness category. The proportion of the total shoreline length assigned to each intactness category at the watershed scale is provided in brackets.

		Length (km) of RMA By Intactness Category			
HUC 8 Subwatershed	**Total Length Assessed (km)**	**Very Low Intactness**	**Low Intactness**	**Moderate Intactness**	**High Intactness**
Blindman River	366	134 (37%)	21 (6%)	62 (17%)	149 (41%)
Medicine River	1,121	321 (29%)	101 (9%)	265 (24%)	434 (39%)
Red Deer River & Sylvan Lake	294	126 (43%)	18 (6%)	64 (22%)	87 (29%)
Watershed Total	**1,781**	**581 (32%)**	**140 (8%)**	**391 (22%)**	**670 (38%)**

Fifteen out of the 24 named waterbodies in the watershed had more than 25% of their shorelines assessed as Very Low Intactness (Figure 6). The portion of the Blindman River that was assessed in this study had the greatest proportion of its shoreline assessed as Very Low intactness (71%), while Medicine Creek had the greatest length (115 km) of shoreline assessed as Very Low Intactness. When the two lowest intactness categories are considered together, Anderson Creek, Blindman River, Boyd Creek, Nuorison Creek, Tindastoll Creek and Waskasoo Creek all had 50% or more of their shorelines classified as either Very Low or Low Intactness. Conversely, Blueberry Creek, East Lobstick Creek, Lasthill Creek, Llyod Creek, Lobstick Creek, Open Creek, Open Creek Reservoir, Welch Creek, and Wilson Creek all had more than 50% of their shorelines assessed as High Intactness (Figure 6).

Of the 11 Unnamed Creeks that were assessed, six had 50% or more of their shoreline classified as Low or Very Low Intactness (Figure 7). Only one unnamed creek (#11) had more than 50% of its shoreline assessed as High Intactness. When High and Moderate Intactness categories are considered together, five of the 11 unnamed creeks had more than 50% of their shorelines classified in one of these two categories.

Notably, there have been other riparian intactness assessments completed in the Medicine-Blindman Rivers watershed, including Gull Lake, Sylvan Lake, and their tributaries (Fiera Biological 2018d), and the Blindman River extending from Bluffton to the confluence with the Red Deer River (Fiera Biological 2018e).

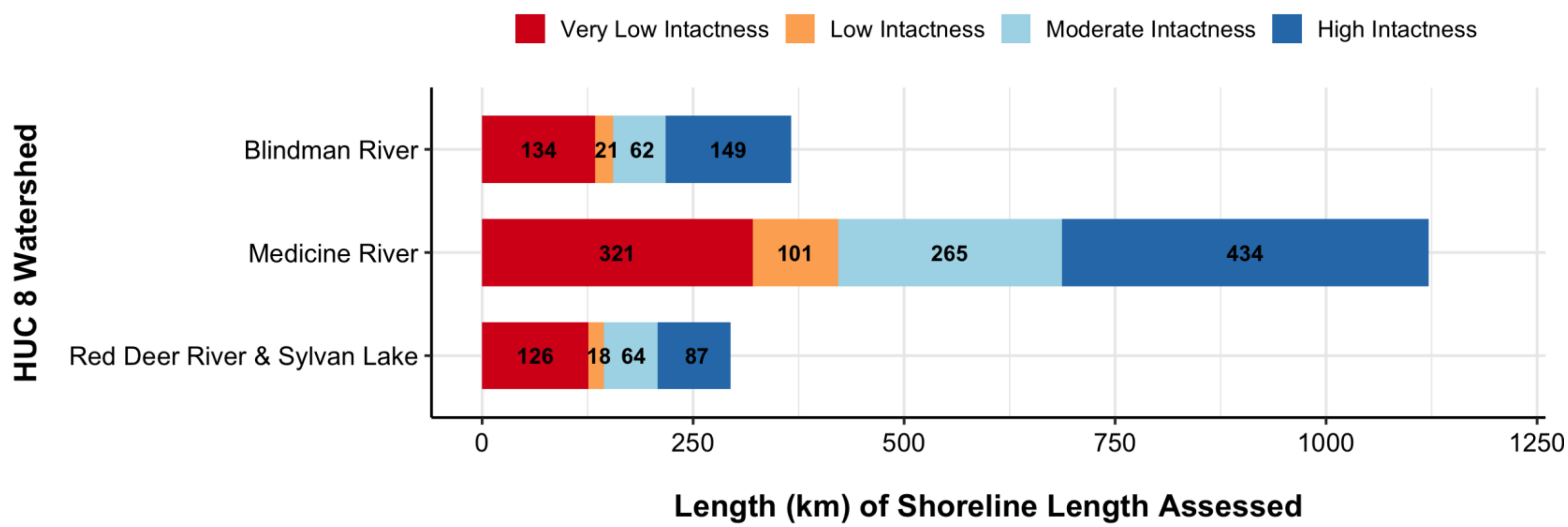


Figure 4. The total length of shoreline within the Medicine-Blindman Rivers watershed assigned to each riparian intactness category, summarized by HUC 8 subwatershed. Numbers indicate the total length (km) of shoreline associated with each intactness category.

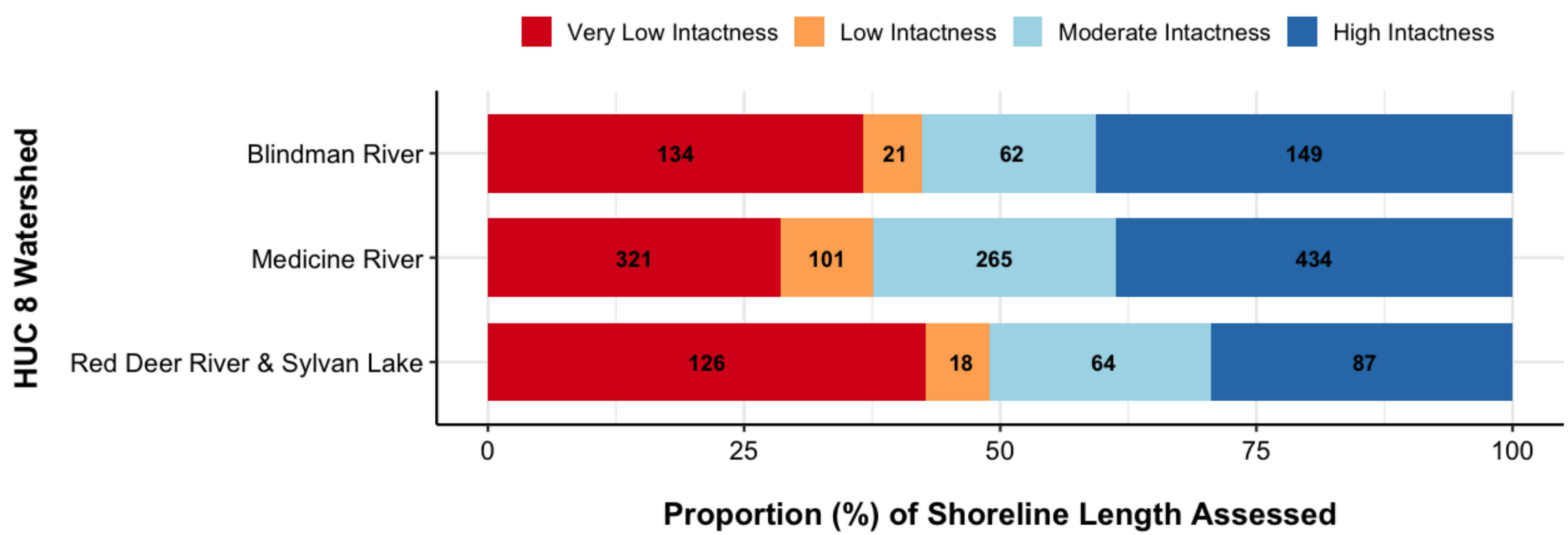


Figure 5. The total proportion of shoreline within the Medicine-Blindman Rivers watershed assigned to each riparian intactness category, summarized by HUC 8 subwatershed. Numbers indicate the total length (km) of shoreline associated with each intactness category.

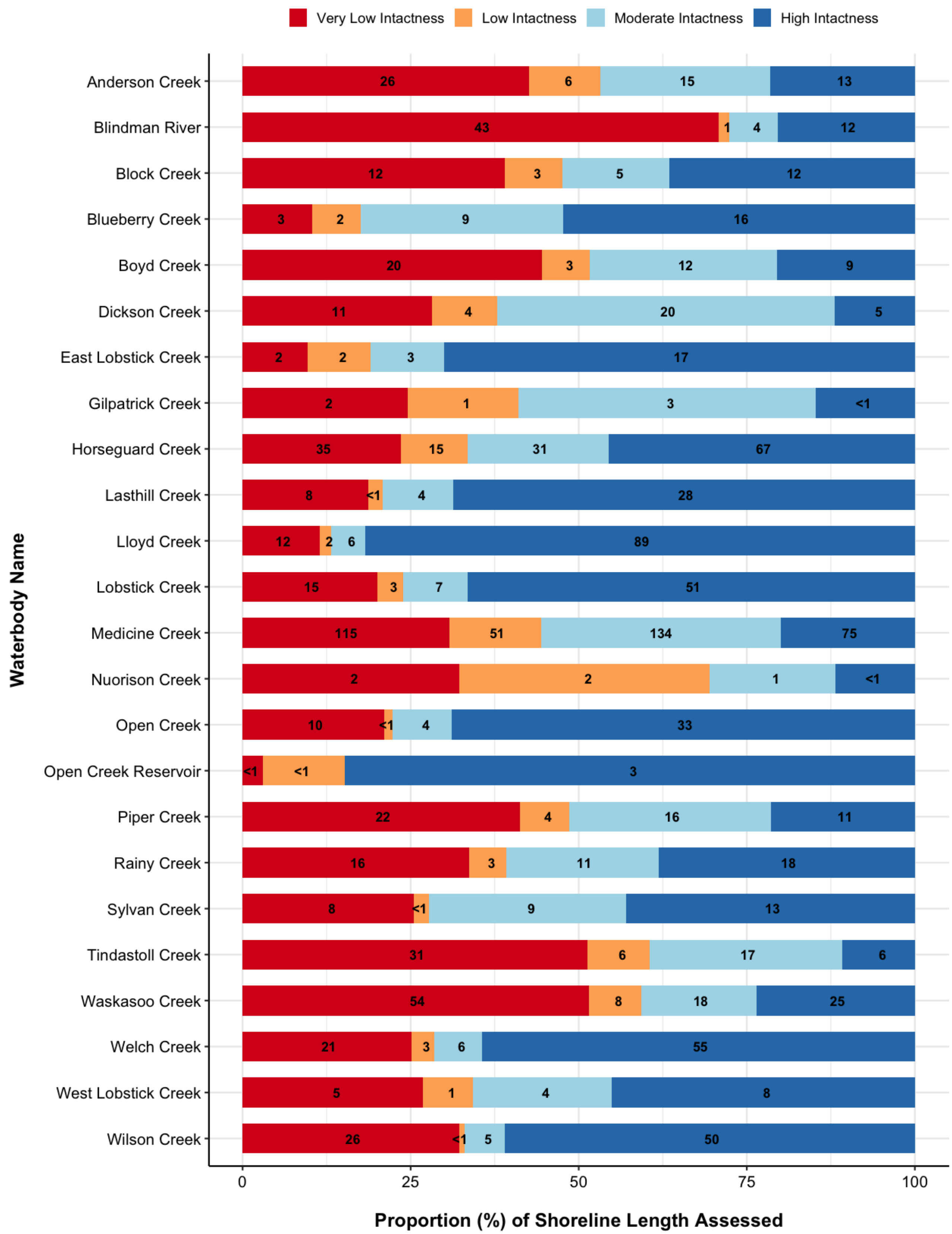


Figure 6. The total proportion of shoreline assigned to each riparian intactness category for named waterbodies in the Medicine-Blindman Rivers watershed. Numbers indicate the total length (km) of shoreline associated with each category.

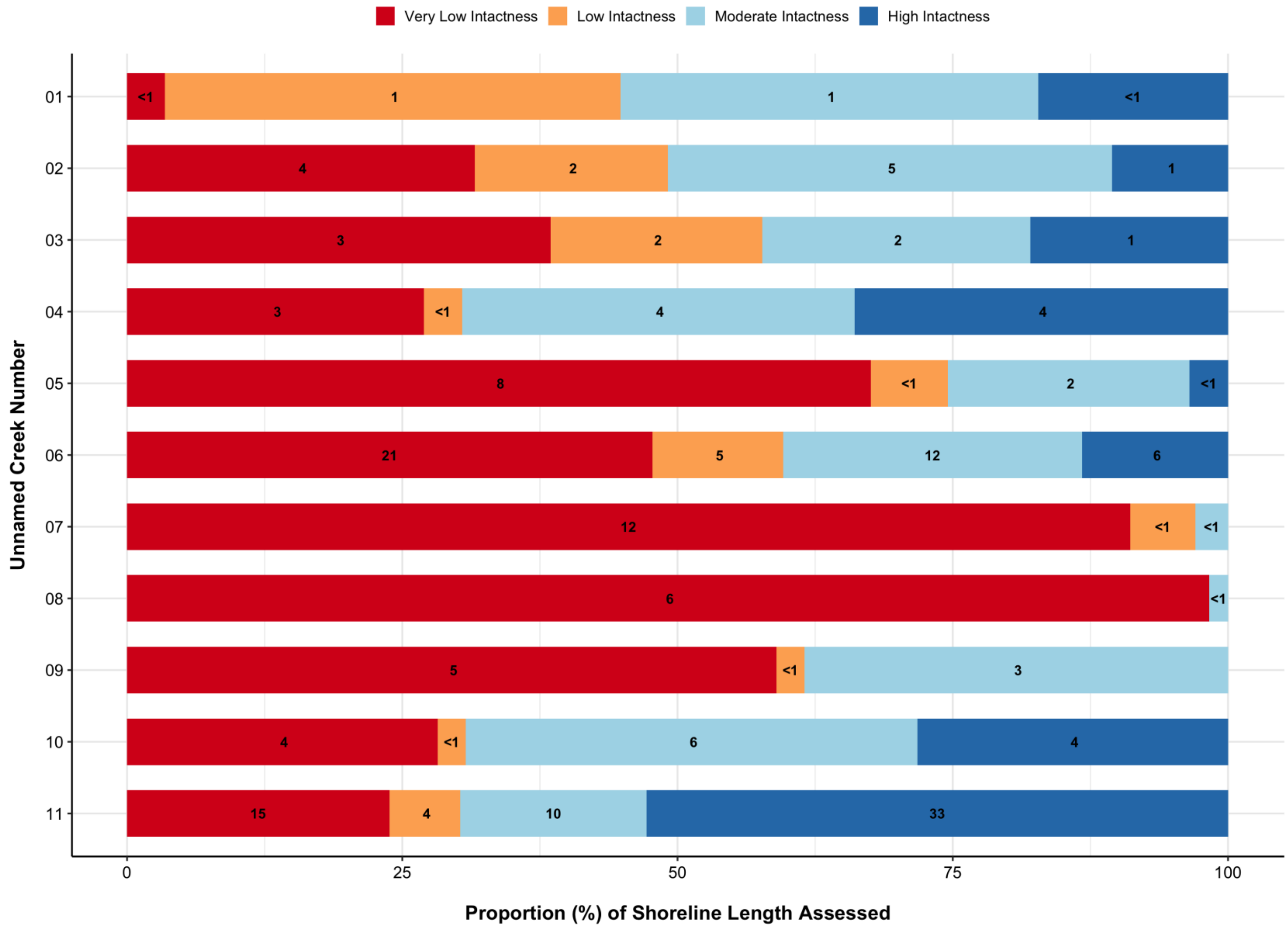


Figure 7. The total proportion of shoreline assigned to each riparian intactness category for Unnamed Creeks in the Medicine-Blindman Rivers watershed. Numbers indicate the total length (km) of shoreline associated with each category.

4.2. Pressure on Riparian System Function Results

Pressure on riparian system function was assessed for 632 local catchment areas within the Medicine-Blindman Rivers watershed, covering an area of just over 5,600 km^2 (Figure 8). Of that area, 26% was classified as High Pressure, with the majority (47%) of local catchments being classified as Moderate Pressure, and the remaining 27% being classified as Low Pressure.

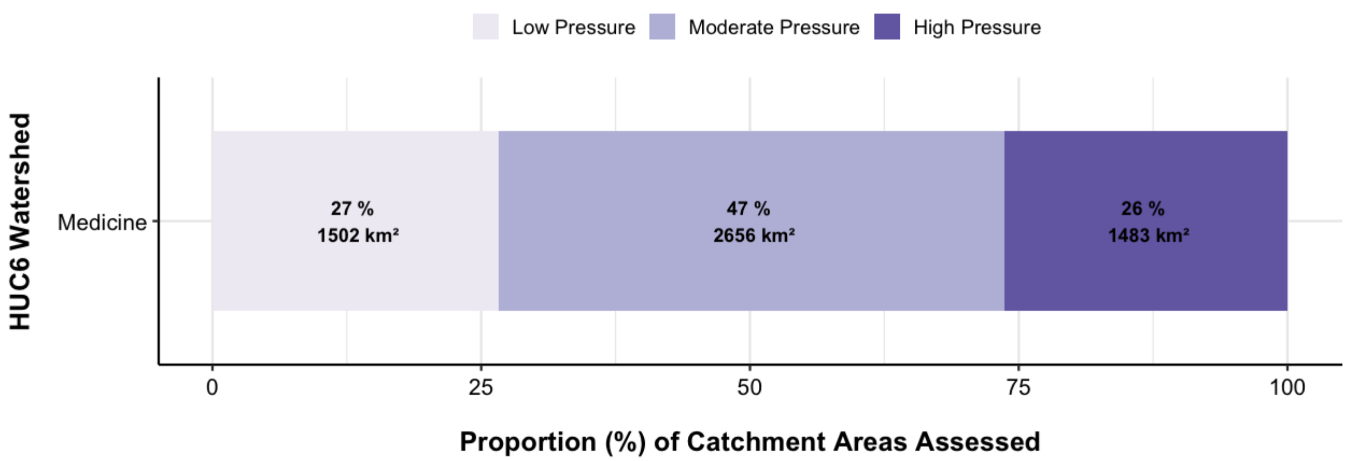


Figure 8. The proportion and area of local catchments within the Medicine-Blindman Rivers watershed assigned to each pressure category.

When pressure scores were compared between HUC 8 subwatersheds, the Red Deer River & Sylvan Lake subwatershed had the greatest proportion of local catchments classified as High Pressure; however, both Red Deer River & Sylvan Lake and the Blindman River subwatersheds had more than 80% of their local catchments classified as either Moderate or High Pressure (Figure 9). Spatially, areas of High Pressure were concentrated in the central and eastern portions of the watershed, primarily in association with intensively built-up areas like the City of Red Deer (Map 10 and Map 11).

For named waterbodies, pressure on riparian system function varies across the watershed, with 13 out of the 24 named waterbodies having more than 75% of adjacent lands classified as either Moderate or High Pressure (Figure 10). Blueberry Creek had the highest proportion of adjacent lands classified as High Pressure at 100%; conversely, Wilson Creek had the highest proportion of adjacent lands classified as Low Pressure, with Open Creek having the second highest proportion of adjacent lands classified as Low Pressure. Results differed for unnamed creeks, with 10 of the 11 unnamed streams (91%) having more than 90% of adjacent lands classified as Moderate or High Pressure (Figure 11) Only Unnamed Creek 10 had a substantial proportion (66%) of adjacent lands classified as Low Pressure.

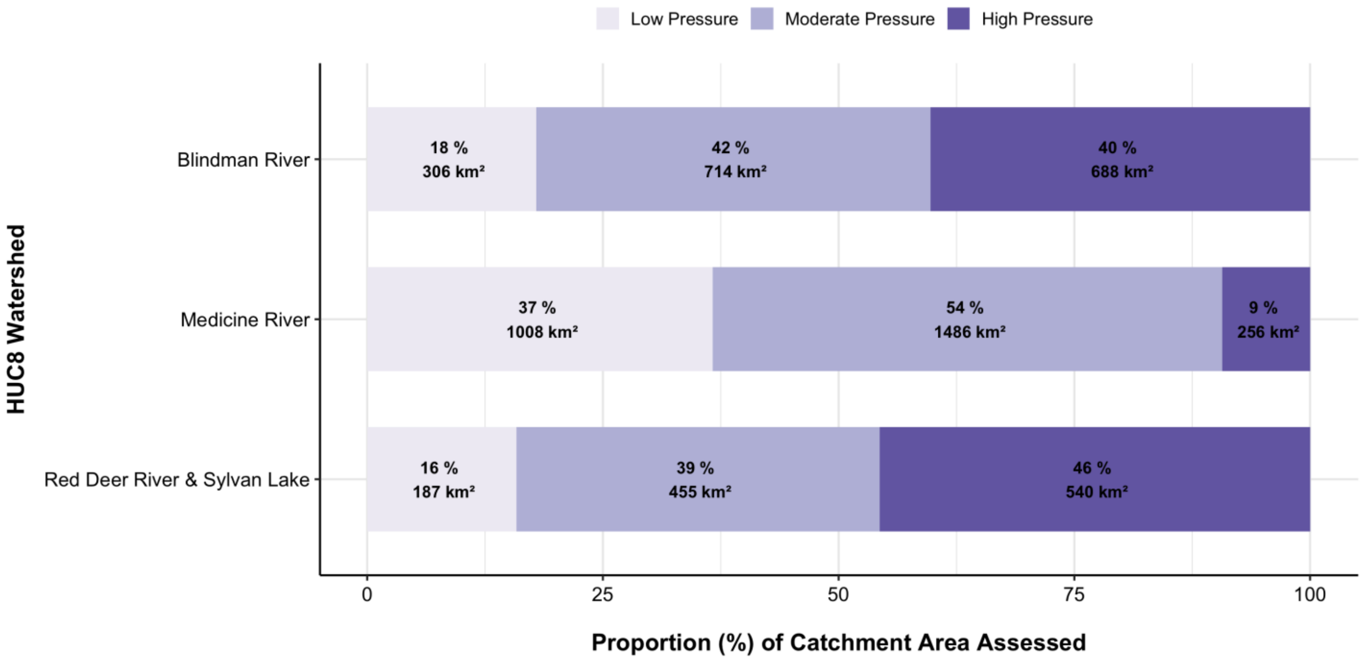
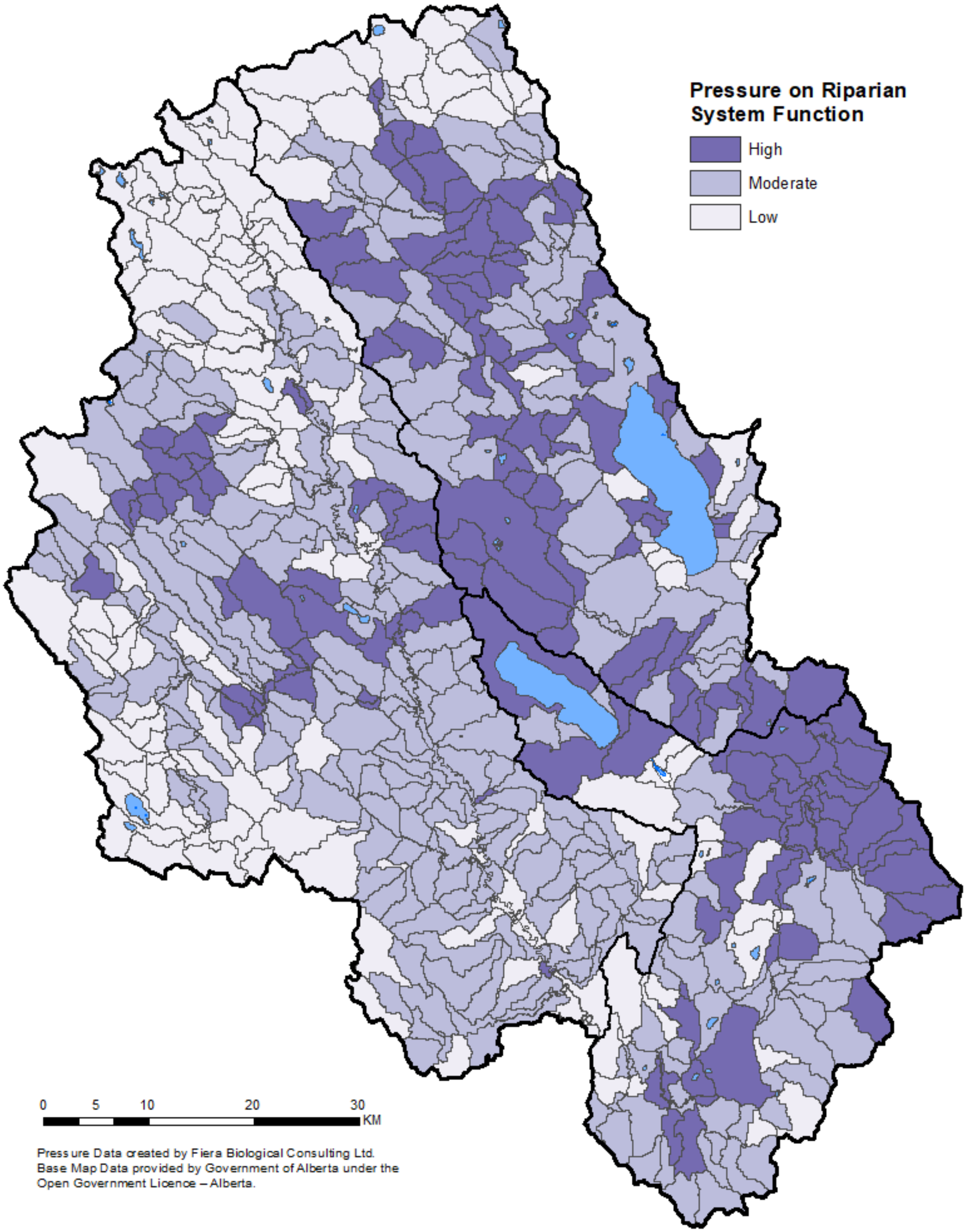
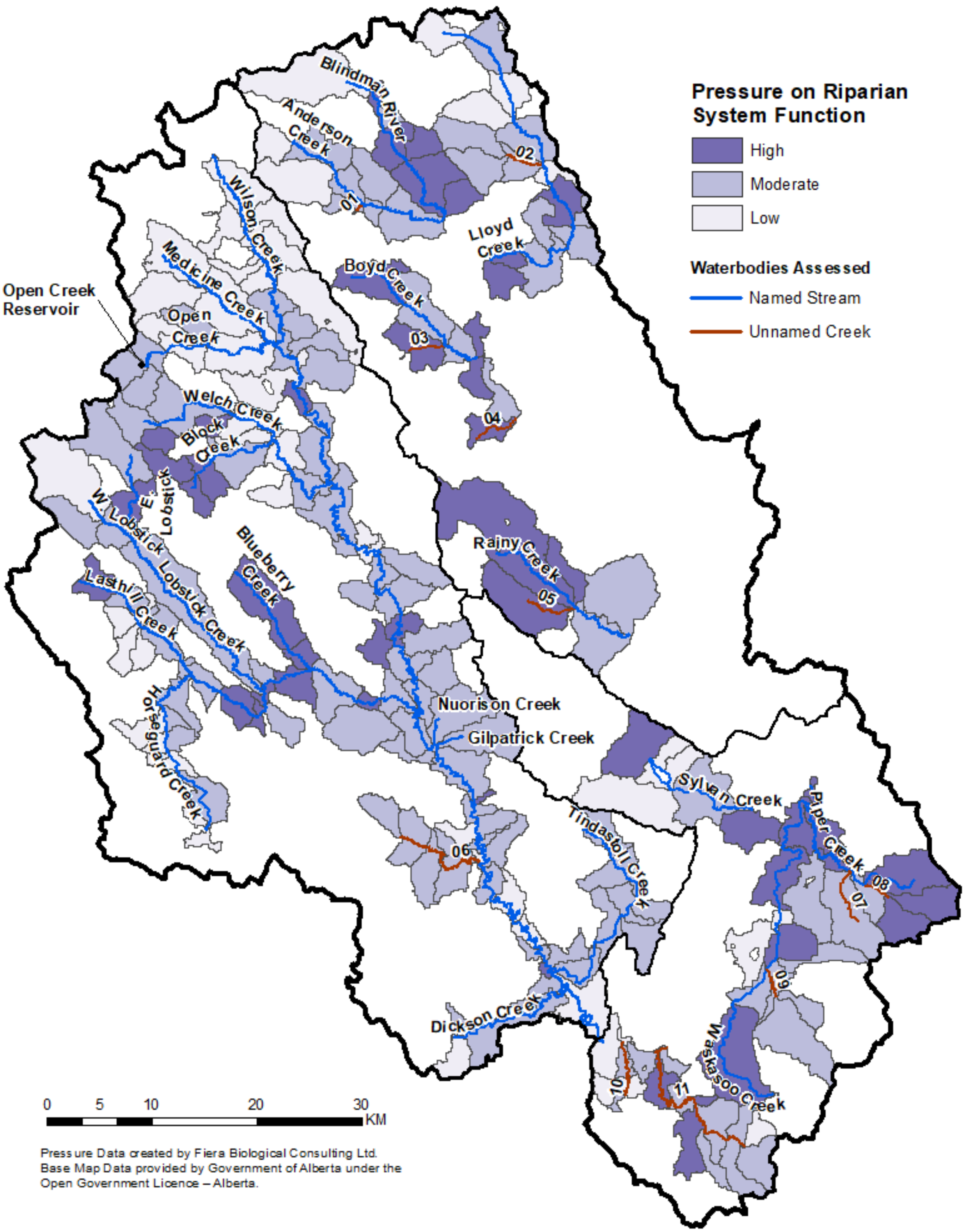


Figure 9. The proportion and area of local catchments assigned to each pressure category, summarized by HUC 8 subwatershed.



Map 10. Distribution of local catchments classified as High, Moderate, and Low Pressure within the Medicine-Blindman Rivers watershed.



Map 11. Pressure classification for local catchment areas that intersect the RMAs of waterbodies that were included in this study.

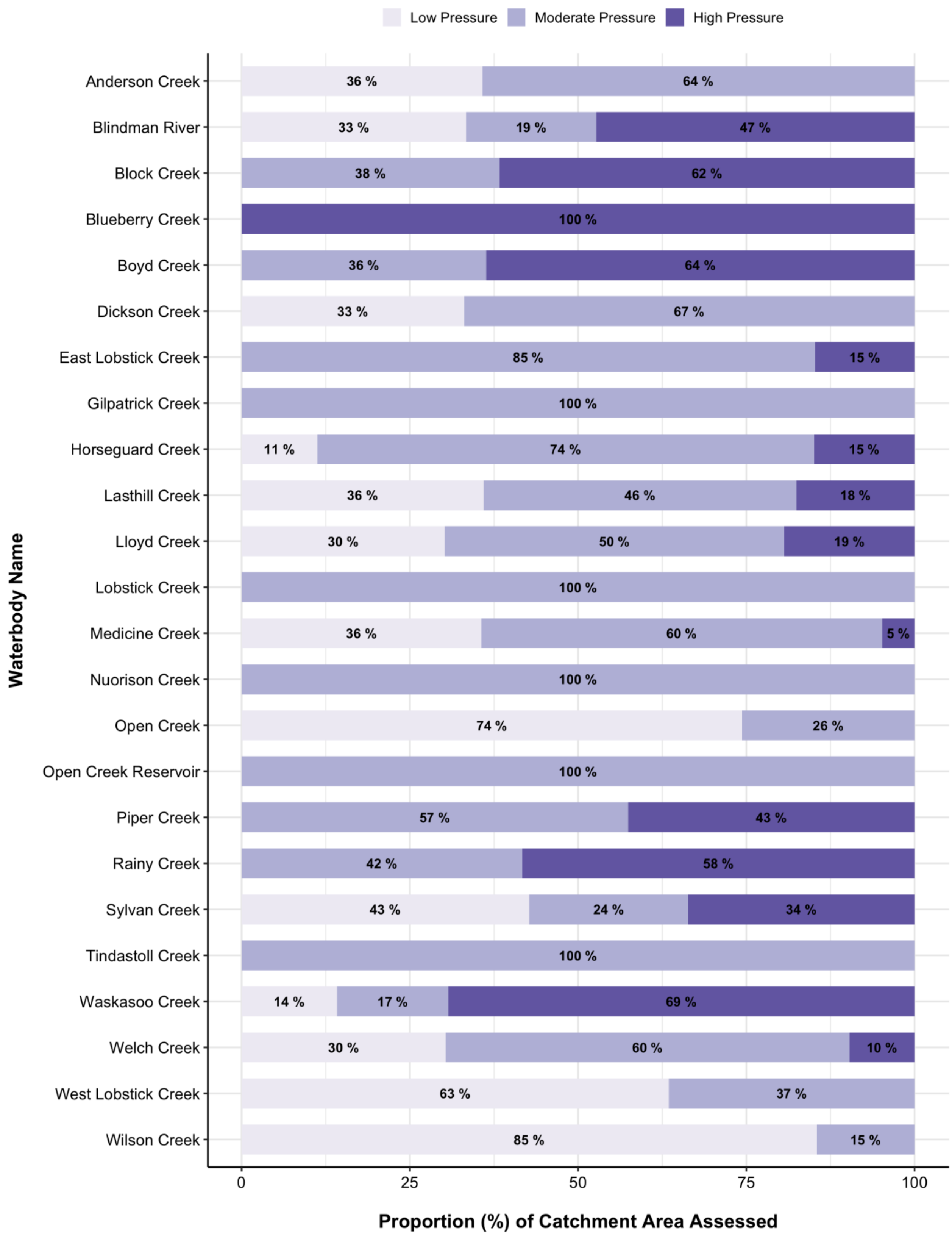


Figure 10. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of named waterbodies in the Medicine-Blindman Rivers watershed. Numbers indicate the proportion of area assigned to each category.

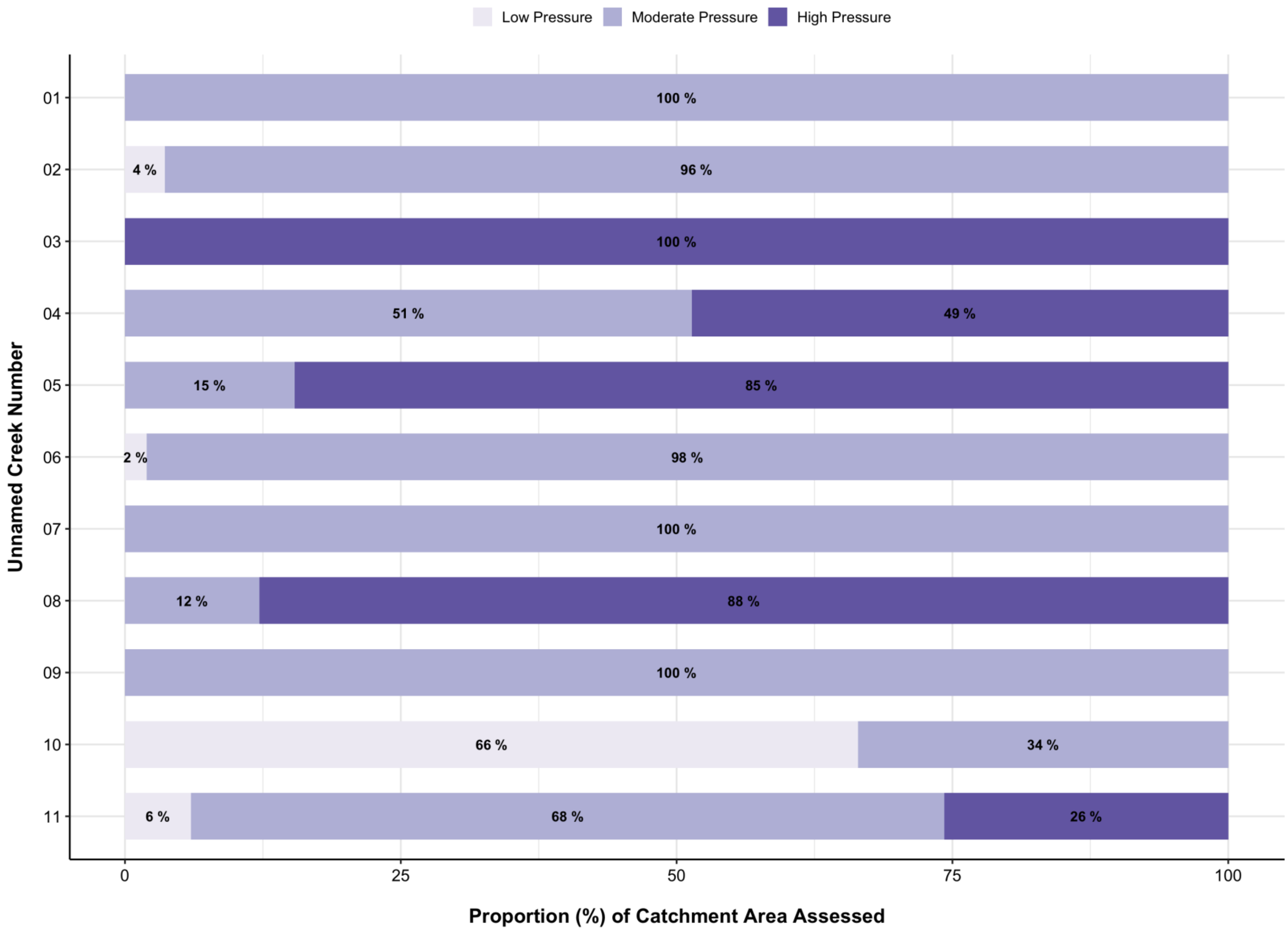


Figure 11. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of Unnamed Creeks. Numbers indicate the Numbers indicate the proportion of area assigned to each category.

4.3. Conservation & Restoration Prioritization Results

Conservation and restoration priority was assigned to the RMAs of all lakes and creeks that were included in this study (Map 12 and Map 13), and the results have been summarized as the total length of shoreline that has been assigned to each priority category. Within the Medicine-Blindman Rivers watershed, 60% of the shoreline length that was assessed was classified as either High Conservation (33%) or Moderate Conservation (27%) Priority, representing approximately 1,061 km of shoreline (Figure 12). Conversely, 41% of the shoreline was classified as either High Restoration (30%) or Moderate Restoration (11%) Priority, representing approximately 721 km of shoreline.

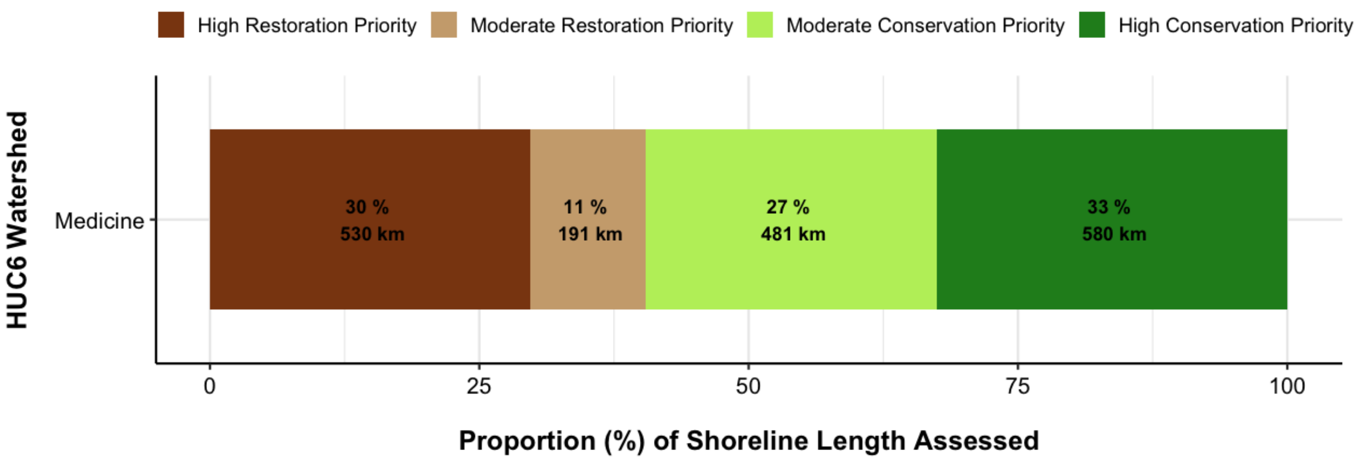


Figure 12. The total proportion of shoreline within the Medicine-Blindman Rivers watershed assigned to each priority category. Numbers indicate the total length (km) of shoreline associated with each category.

When summarized by HUC 8 subwatershed, the Red Deer River & Sylvan Lake subwatershed had the highest proportion (43%) of shoreline assessed as either High or Moderate Restoration Priority and the lowest proportion of shoreline assessed as High Conservation Priority (13%). Conversely, the Medicine River subwatershed had the highest proportion of shoreline prioritized for conservation, with nearly 40% of the shoreline being identified as High Conservation Priority (Figure 13); however, this subwatershed also had the highest proportion (14%) of shoreline identified as High Restoration Priority. For the Blindman River subwatershed, 69% of the shoreline was identified as High or Moderate Conservation Priority while only 4% of the shoreline was identified as High Restoration Priority.

Of the 24 named waterbodies assessed, six creeks, Anderson Creek, Blindman River, Boyd Creek, Nuorison Creek, Tindastoll Creek, and Waskasoo Creek, had more than 50% of their shorelines classified as either High or Moderate Restoration Priority. Conversely, 16 of the 24 named waterbodies assessed had at least 50% of their shorelines identified as either High or Moderate Conservation Priority (Figure 14). Of these, Lasthill Creek, Lloyd Creek, Lobstick Creek, Open Creek Reservoir, Sylvan Creek, Welch Creek, West Lobstick Creek, and Wilson Creek had more than 50% of their shorelines assessed as High Priority for Conservation. When unnamed creeks were considered, six of the 11 unnamed creeks had more than half of their shorelines prioritized for restoration, with five of these unnamed creeks (#3, #5, #7, #8, and #9) having more than 50% of its shoreline classified as High Restoration Priority. Conversely, five out of 11 creeks that were assessed had more than half of their shorelines classified as High or Moderate Conservation Priority; however, of these, only Unnamed Creek 10 had more than 25% of its shorelines classified as High Conservation Priority (Figure 15).

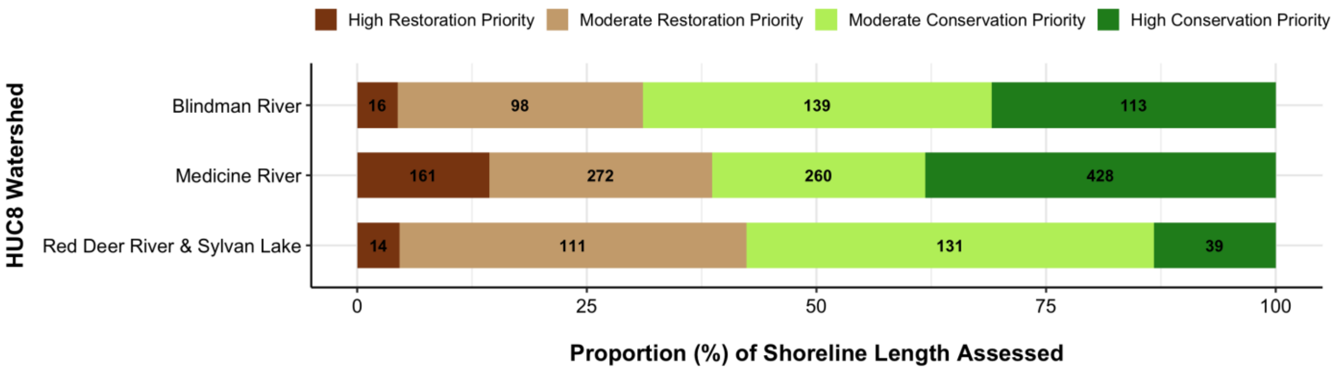
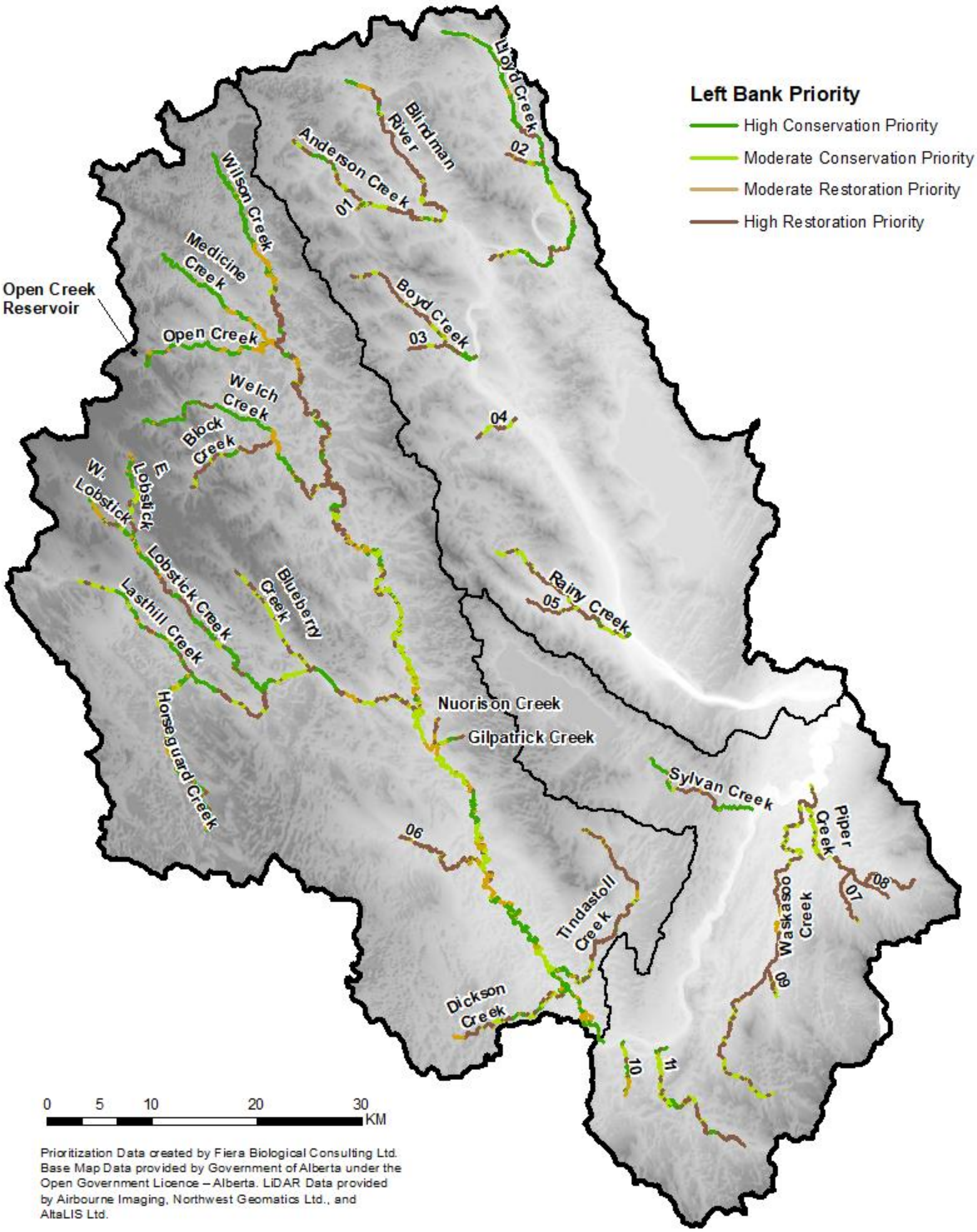
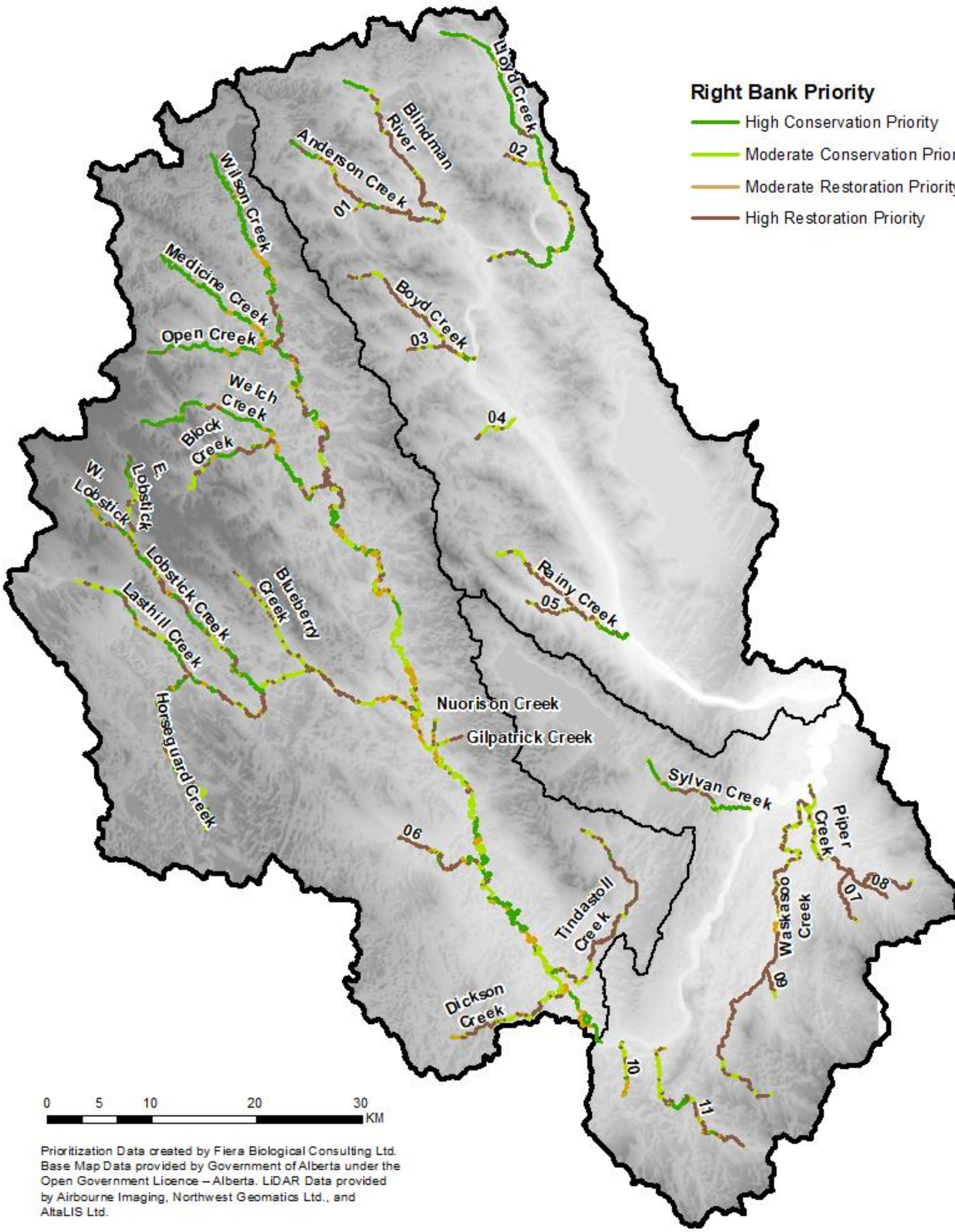


Figure 13. The total proportion of shoreline within the Medicine-Blindman Rivers watershed assigned to each priority category, summarized by HUC 8 subwatershed. Numbers indicate the total length (km) of shoreline associated with each category.



Map 12. Restoration and conservation priority for Open Creek Reservoir and the left bank of creeks that were included in this study.



Map 13. Restoration and conservation priority for the right bank of creeks that were included in this study.

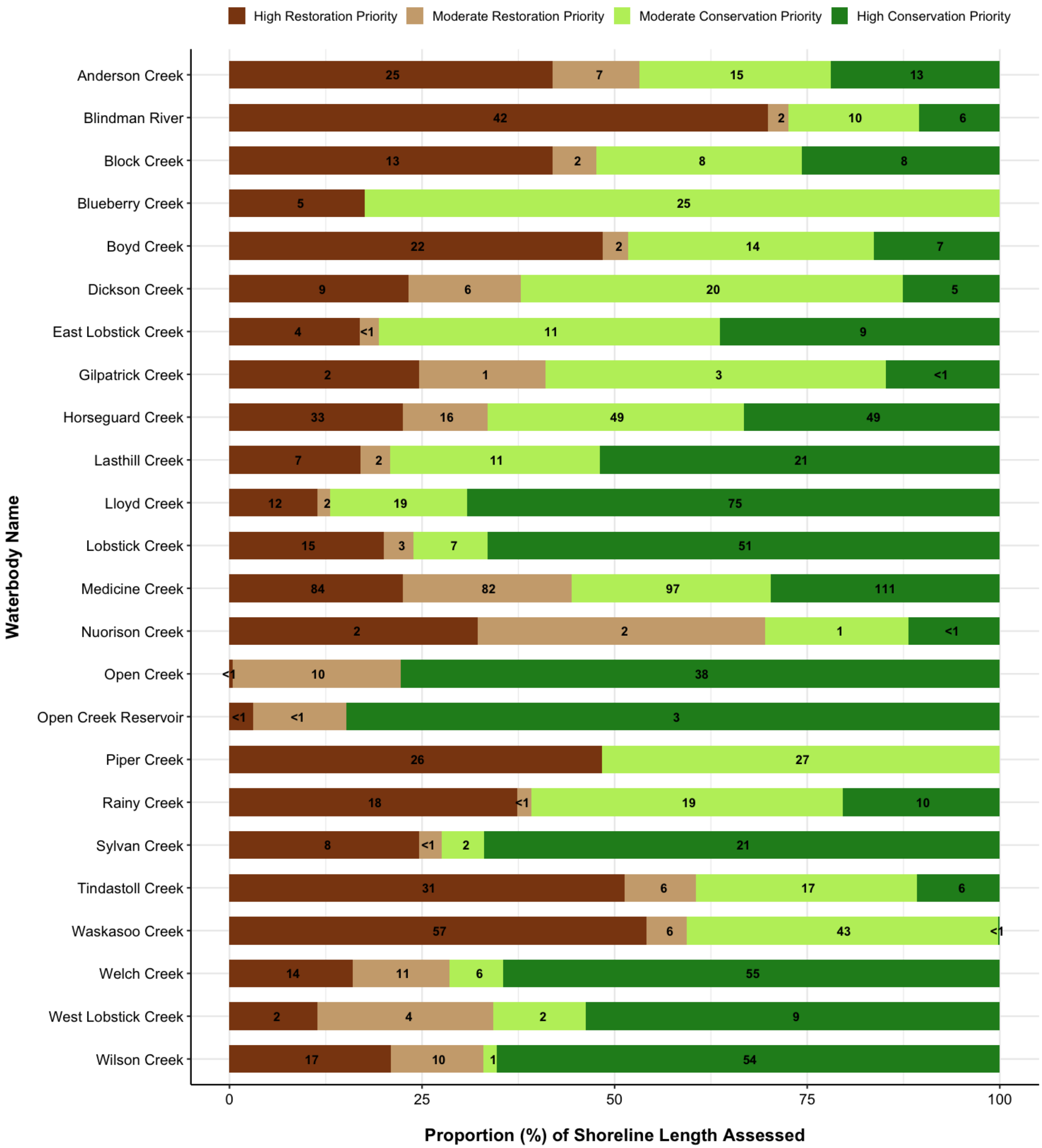


Figure 14. The total proportion of shoreline for named waterbodies assigned to each priority category. Numbers indicate the total length (km) of shoreline associated with each category.

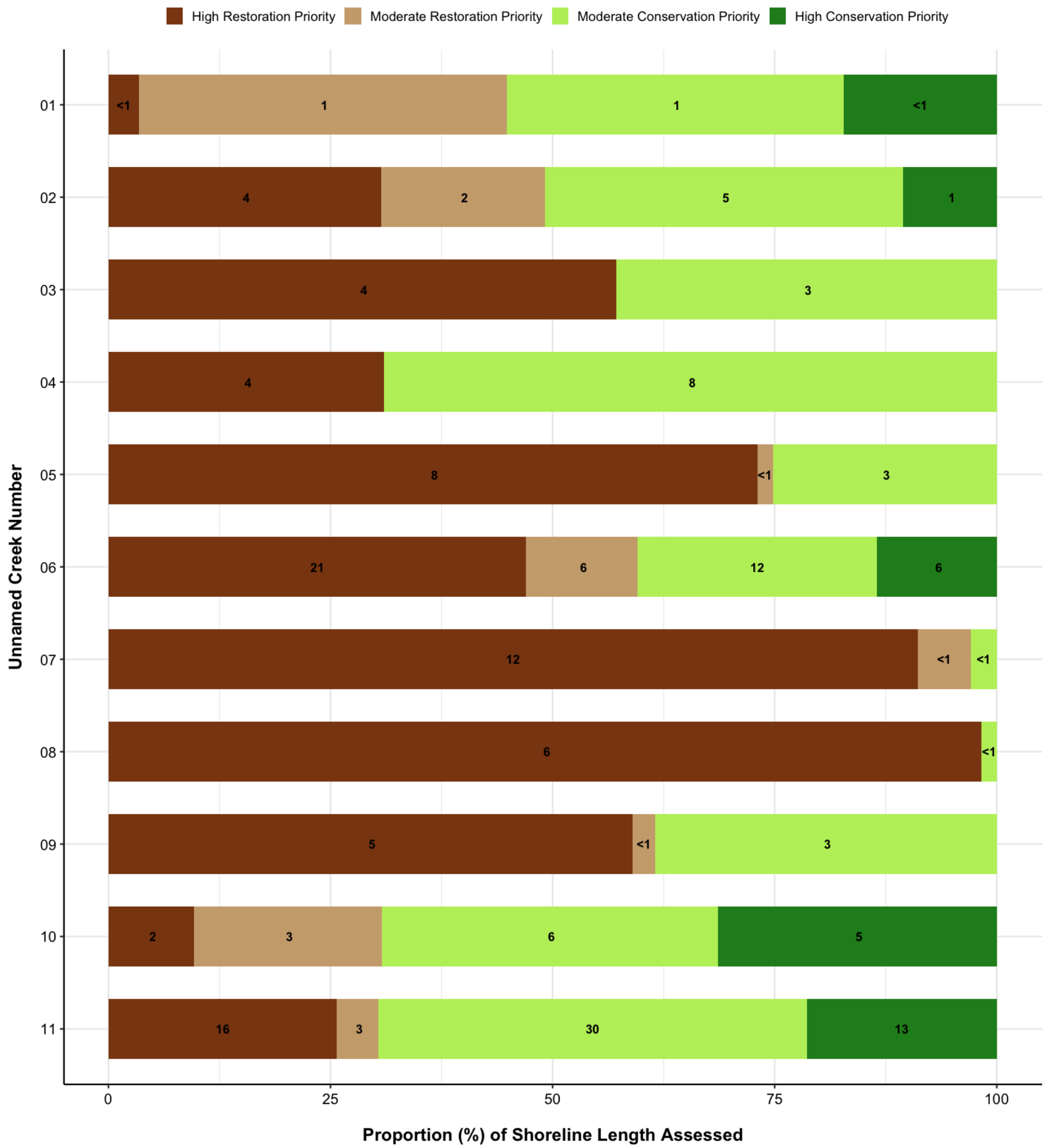


Figure 15. The total proportion of shoreline for Unnamed Creeks assigned to each priority category. Numbers indicate the total length (km) of shoreline associated with each category.

5.0 Municipal Summary

5.1. Comparison of Intactness, Pressure & Priority

In order to provide riparian assessment information that is relevant from a municipal planning and policy perspective, this section summarizes riparian intactness, pressure on riparian system function, and management prioritization within the Medicine-Blindman Rivers watershed by municipality. Specifically, the results of this study were summarized for the City of Red Deer, Penhold, and Innisfail, as well as for the rural municipalities of Clearwater, Wetaskiwin, Lacombe, and Ponoka (Map 5). Clearwater, Ponoka, and Red Deer County all had more than 500 km of shoreline assessed in this study, while County of Wetaskiwin, the City of Red Deer, Penhold, and Innisfail all had less than 50 km assessed (Figure 16).

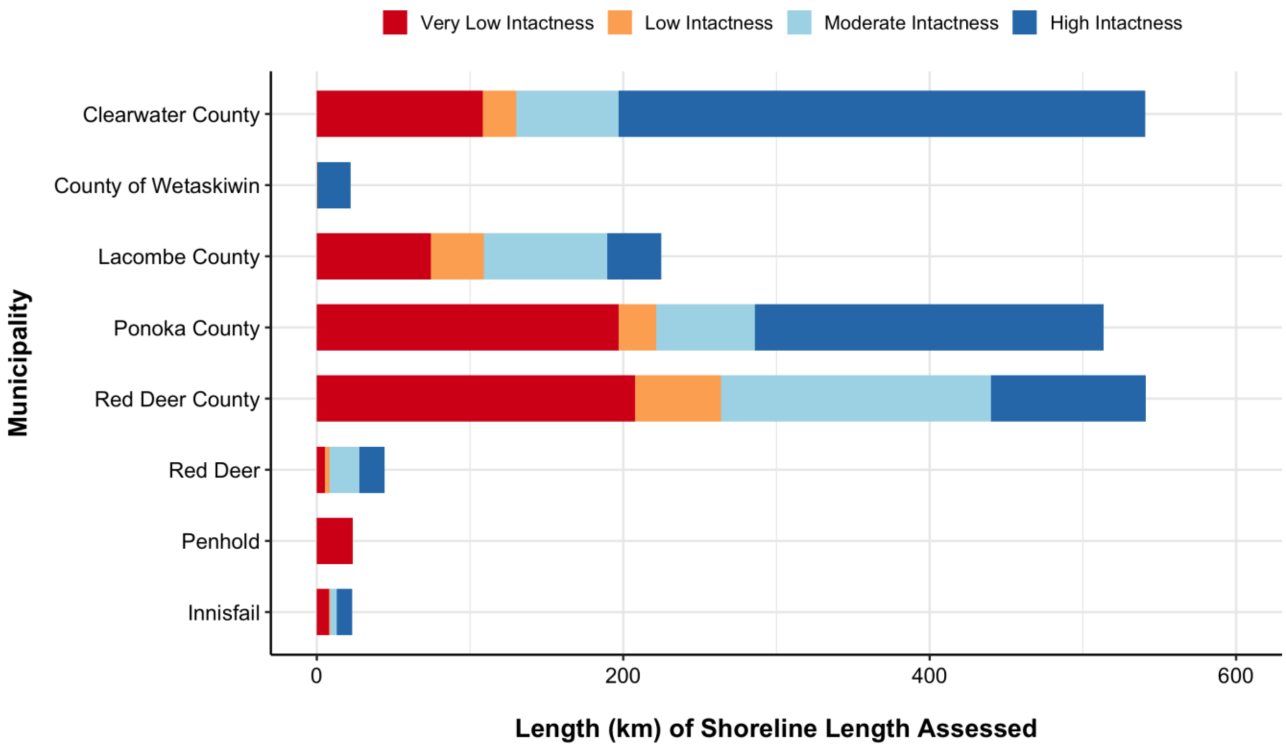


Figure 16. The total length of shoreline assigned to each riparian intactness category, summarized by municipality.

When the proportion of shoreline length assigned to each intactness category was evaluated for each municipality, the County of Wetaskiwin and Clearwater County both had >50% of their shorelines assessed as High Intactness (Figure 17). In contrast, Lacombe, Ponoka, Red Deer Counties, as well as Penhold and Innisfail all had >25% of their shorelines classified as Very Low Intactness. Notably, nearly 100% of the ~23 km of shoreline riparian habitat associated with Penhold was assessed as Very Low Intactness.

When pressure was compared between municipalities, Innisfail had a much greater proportion of local catchment areas classified as High Pressure, as compared to other municipalities (Figure 18; Map 16). When High and Moderate Pressure categories are considered together, Innisfail had the highest proportion of area classified into these two categories, followed by the City of Red Deer and Lacombe County. Generally, catchments dominated by built-up areas (e.g., towns and cities) and agricultural land use (particularly cultivation) receive higher pressure scores than catchments with a higher proportion of natural cover. The County of Wetaskiwin had the greatest proportion of local catchment areas adjacent to assessed shorelines classified as Low Pressure.

When conservation and restoration priority is considered, five of the eight municipalities had more than 25% of their shorelines classified as High Restoration Priority (Figure 19; Map 17). In total, this represents 450 km of shoreline, with Red Deer County and Ponoka County accounting for 78% of this total. For all municipalities other than Penhold, more than half of the shorelines falling within their jurisdiction were classified as either Moderate or High Conservation Priority, with Clearwater County having 289 km and Ponoka County having 205 km classified as High Conservation Priority.

Note that all municipal data summaries were generated by using a spatial intersect rule in ArcGIS. Summarizing the data in this way assigns the entire length of an RMA that intersects a municipal boundary to a given municipality, even if the RMA extends beyond the municipal boundaries. Consequently, the sum of the shoreline length assessed for each intactness and prioritization category is greater than the values summarized by individual waterbody, HUC 8 and HUC 6. A more detailed breakdown of results by municipality is provided in sections 5.2 through 5.7.

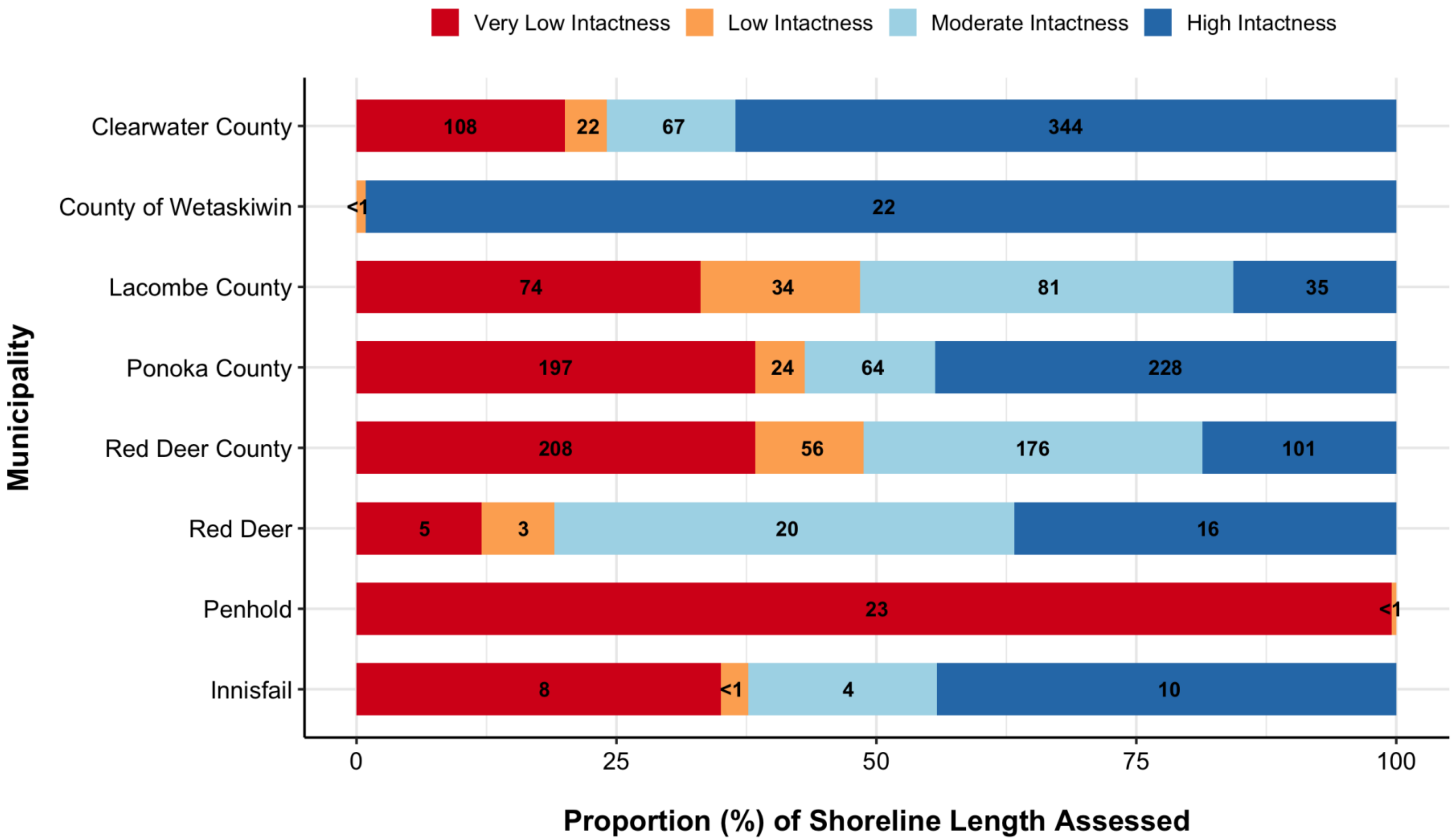


Figure 17. The proportion of shoreline length assigned to each riparian intactness category, summarized by municipality. Numbers indicate the approximate length (km) of shoreline associated with each intactness category.

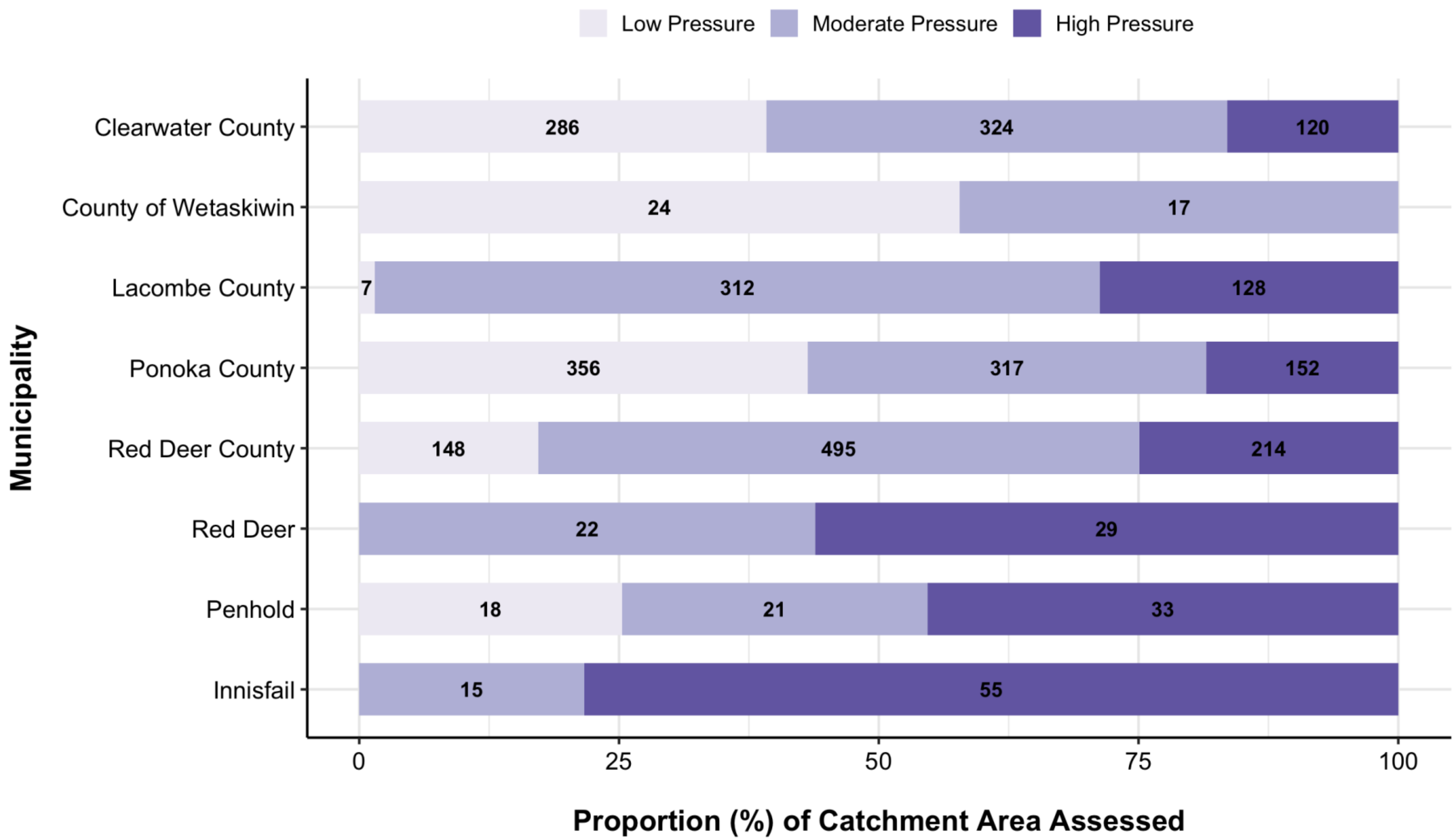


Figure 18. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies contained within each municipality. Numbers indicate the total area (km^2) assigned to each pressure category.

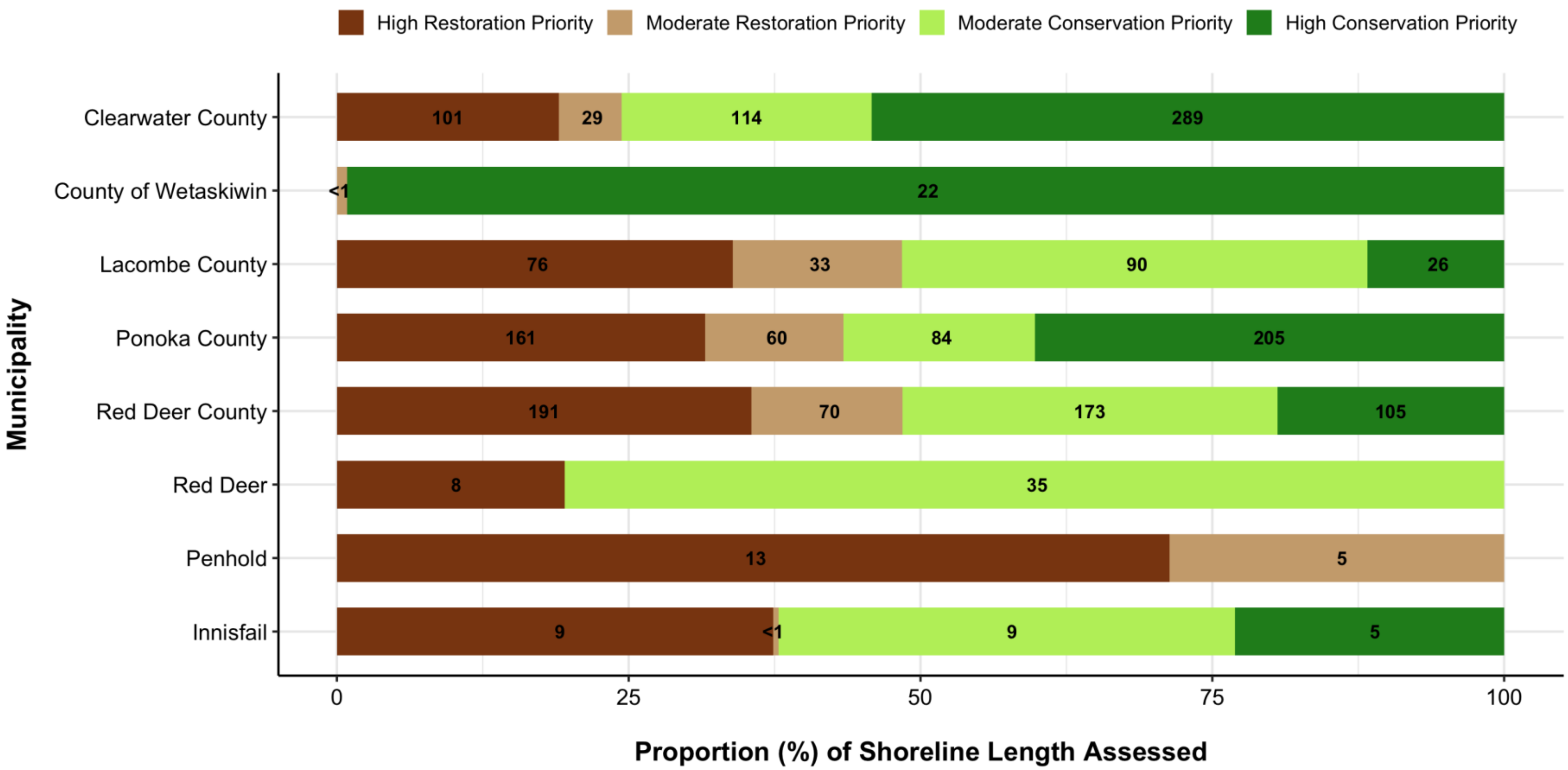
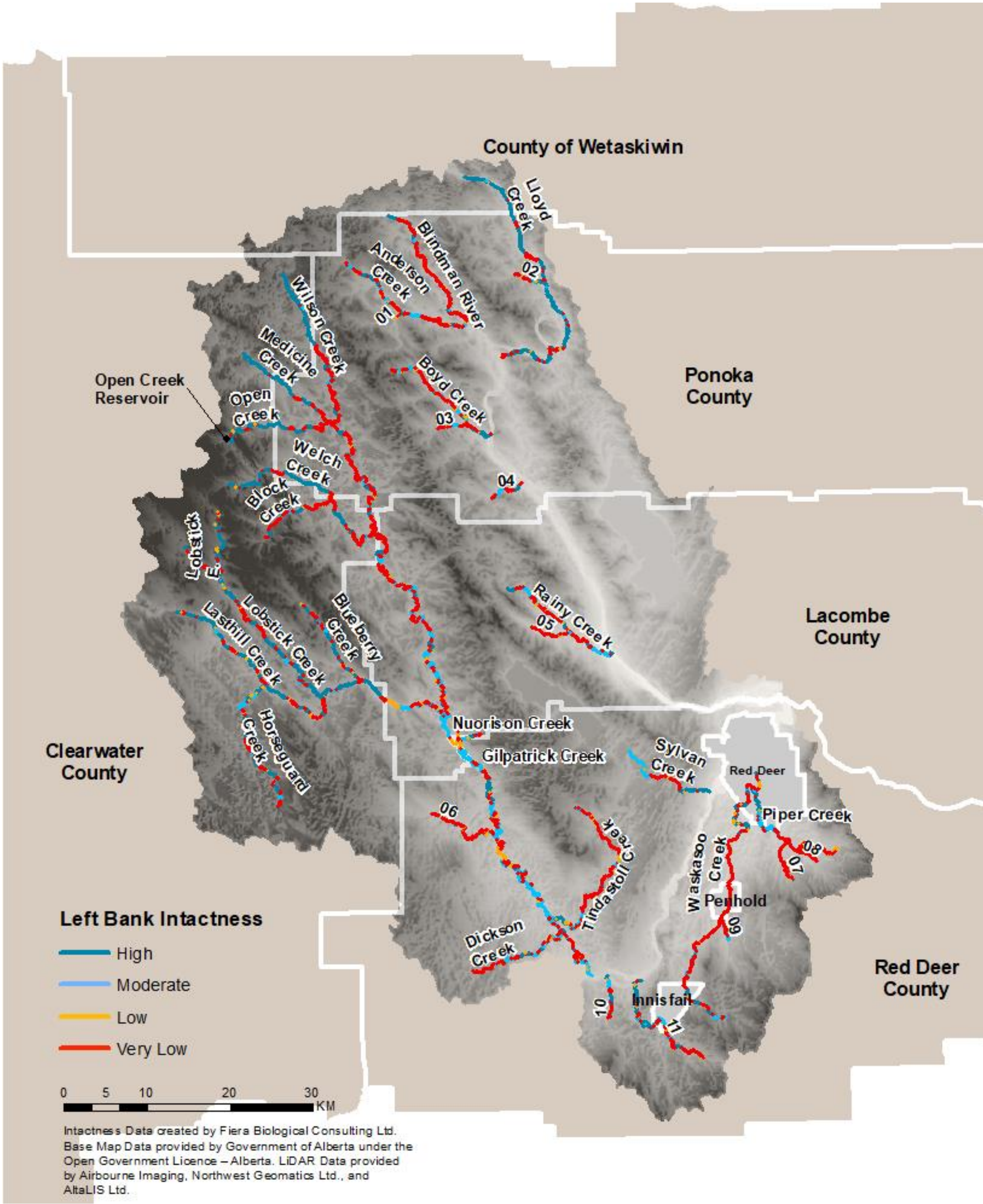
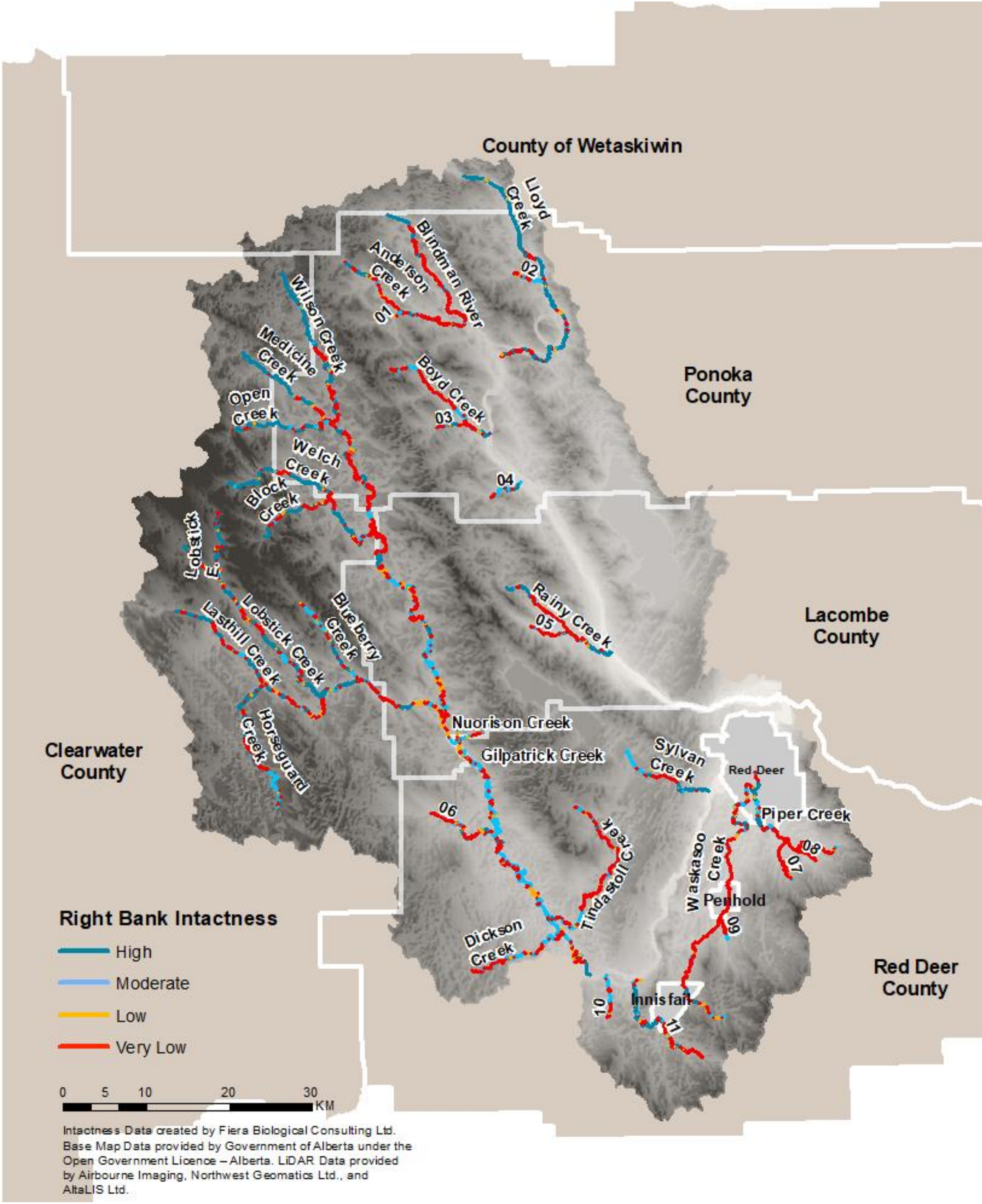


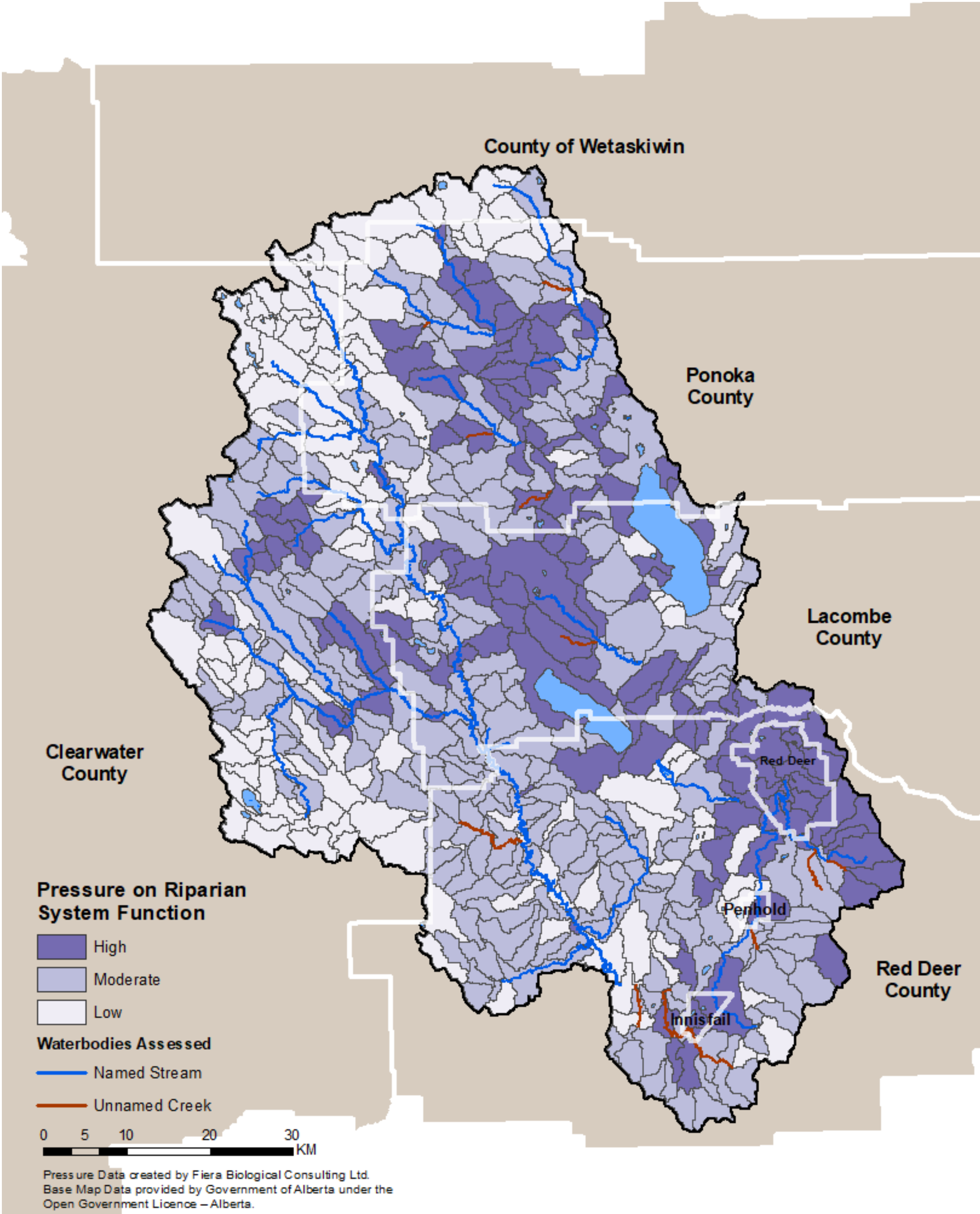
Figure 19. The proportion of shoreline length assigned to each priority category, summarized by municipality. Numbers indicate the approximate length (km) of shoreline associated to each priority category.



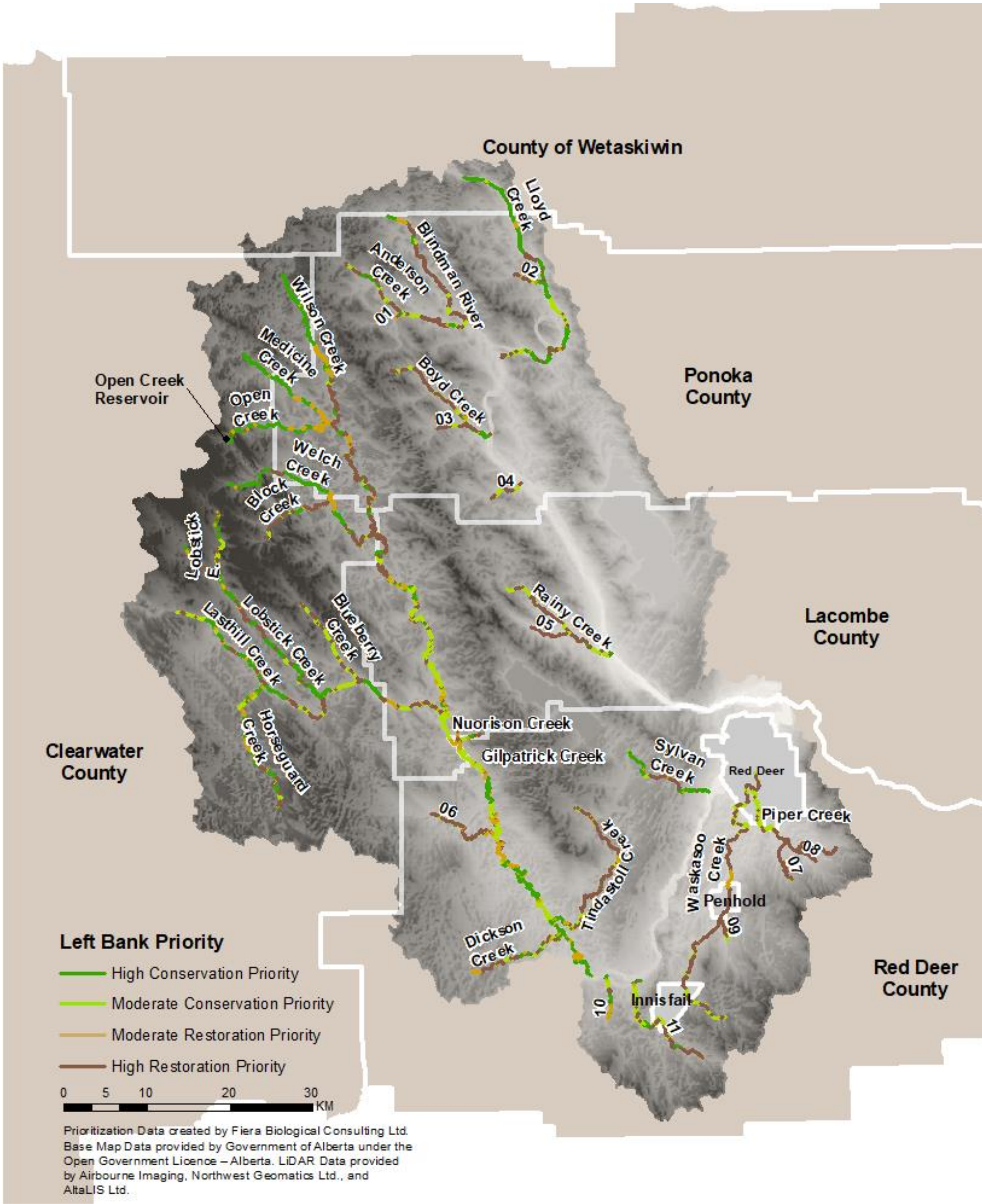
Map 14. Intactness for Open Creek Reservoir and the left bank of creeks that were included in this study, by municipality.



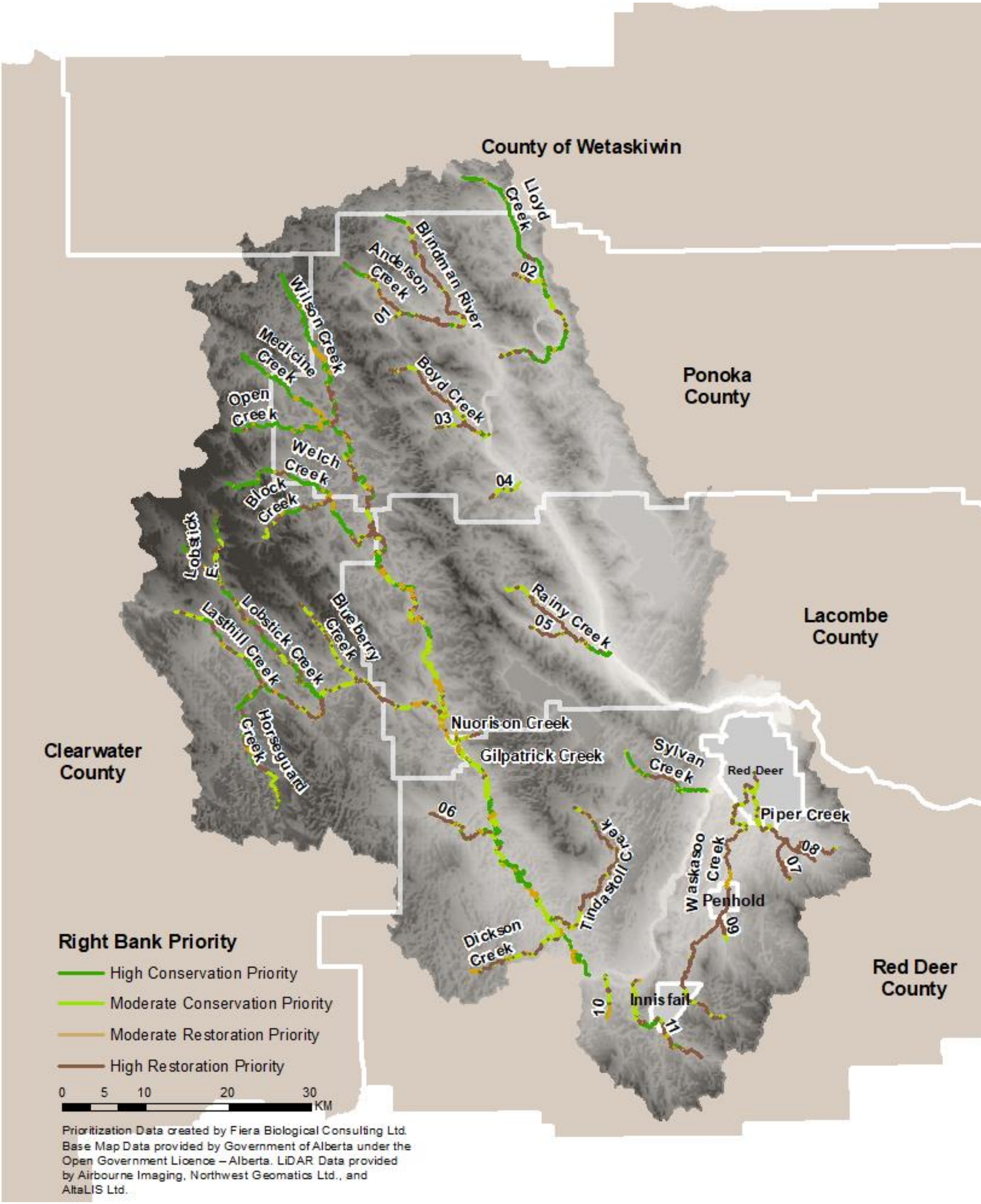
Map 15. Intactness for the right bank of creeks that were included in this study, by municipality.



Map 16. Distribution of local catchments classified as High, Moderate, and Low Pressure, by municipality.



Map 17. Restoration and conservation priority for Open Creek Reservoir and the left bank of creeks that were included in this study, by municipality.



Map 18. Restoration and conservation priority for the right bank of creeks that were included in this study, by municipality.

5.2. Clearwater County

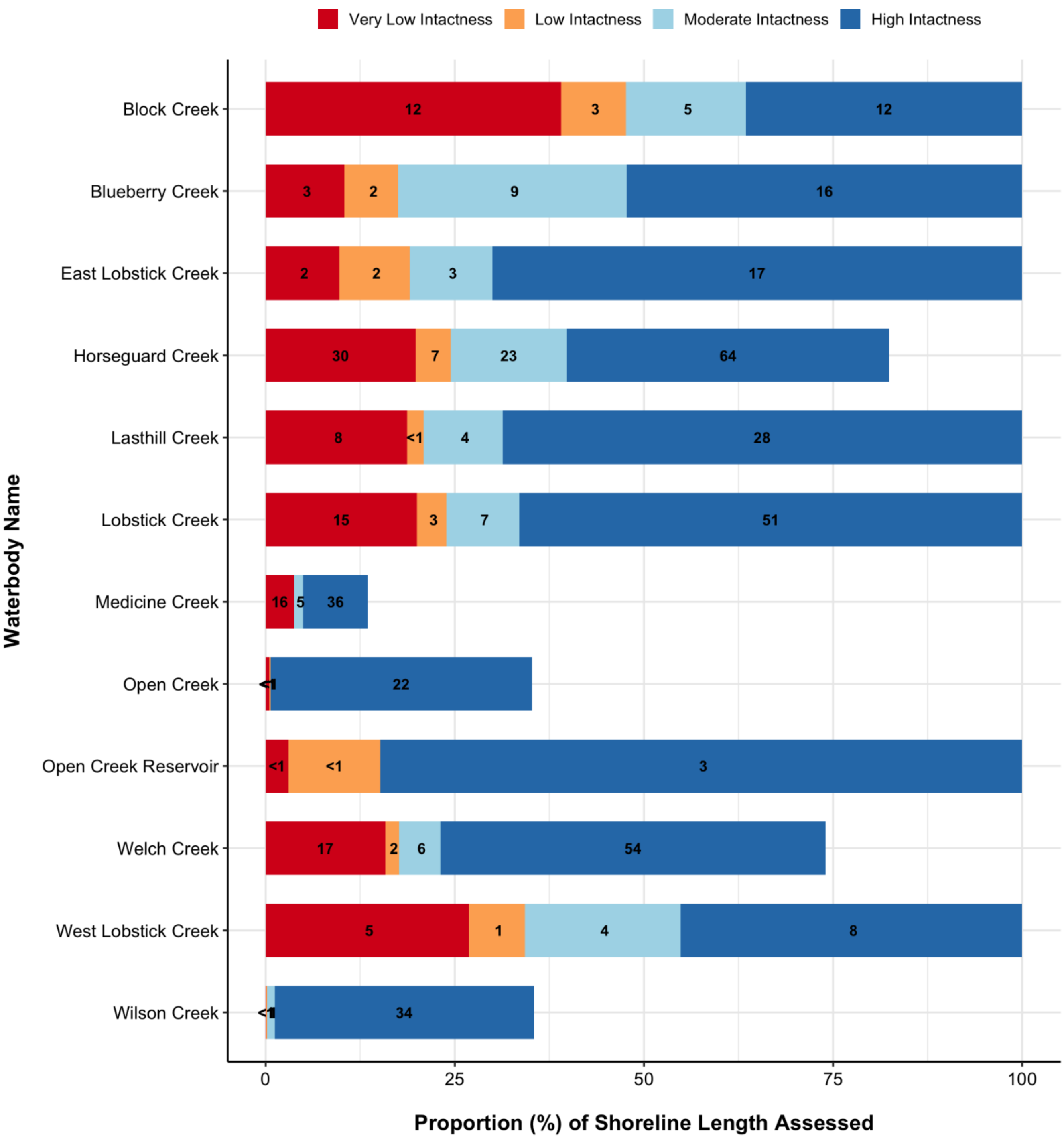


Figure 20. The proportion of shoreline length assigned to each riparian intactness category for waterbodies within Clearwater County. Numbers indicate the approximate length (km) of shoreline associated with each category.

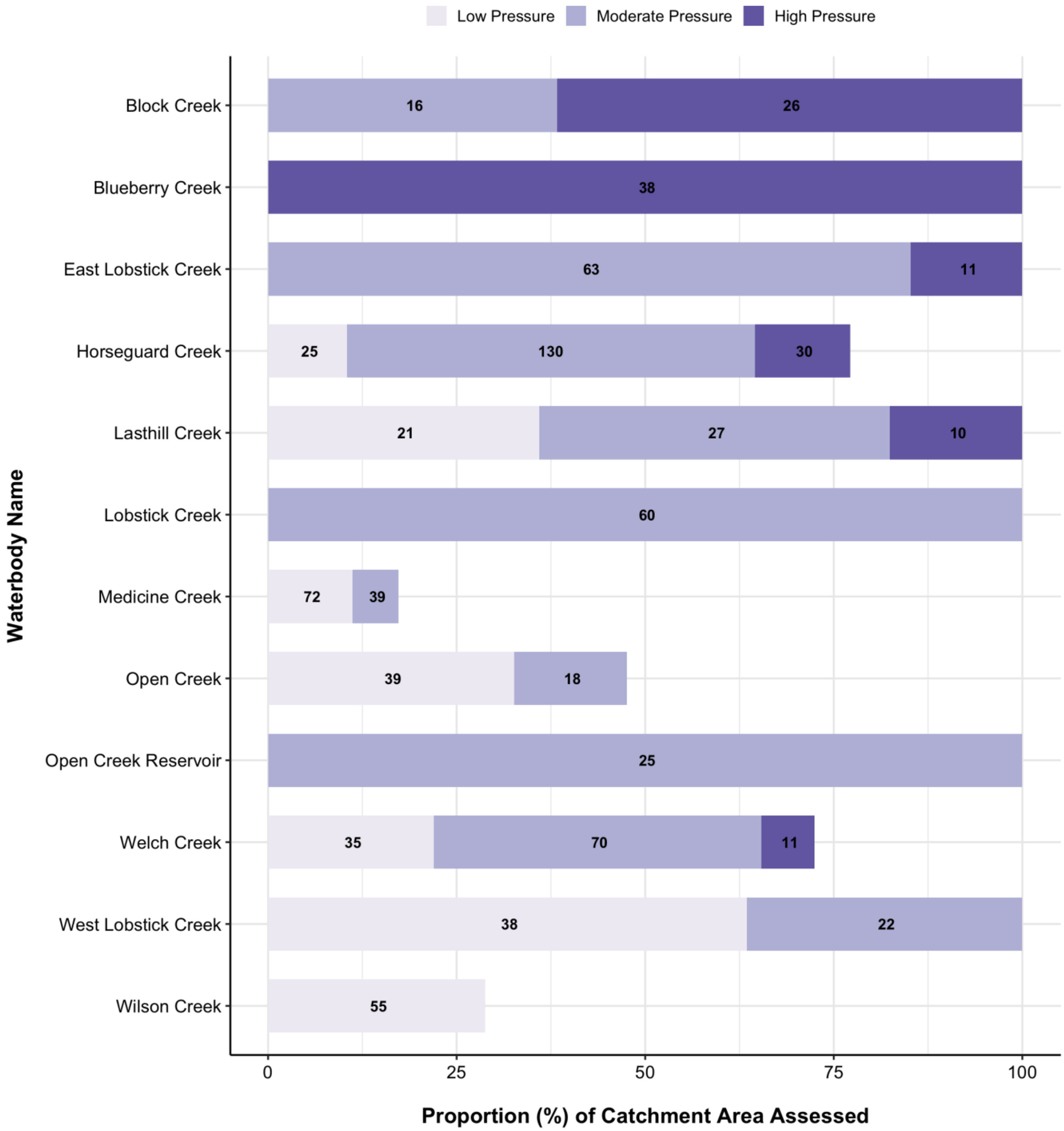


Figure 21. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies in Clearwater County. Numbers indicate the total area (km^2) assigned to each pressure category.

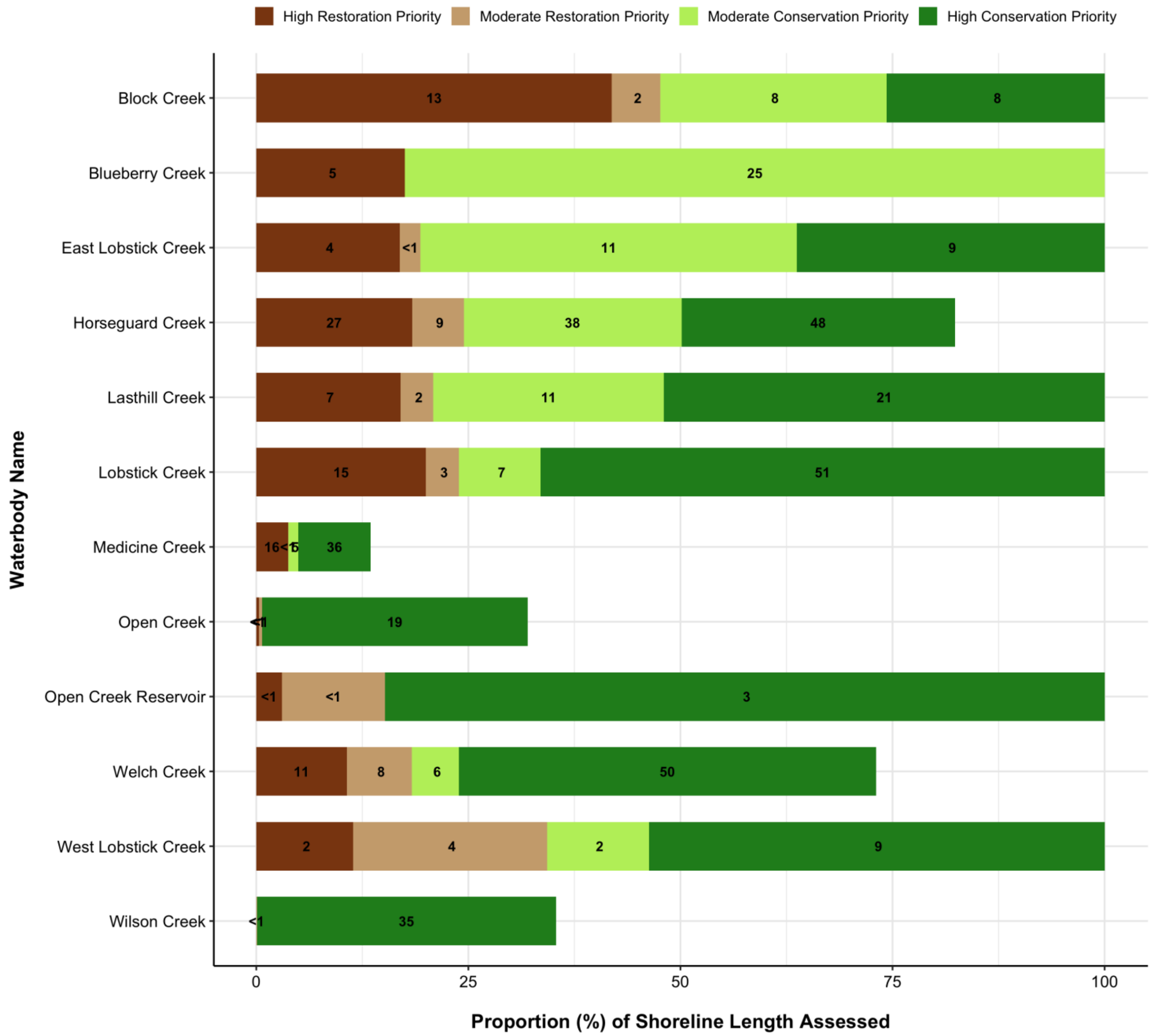
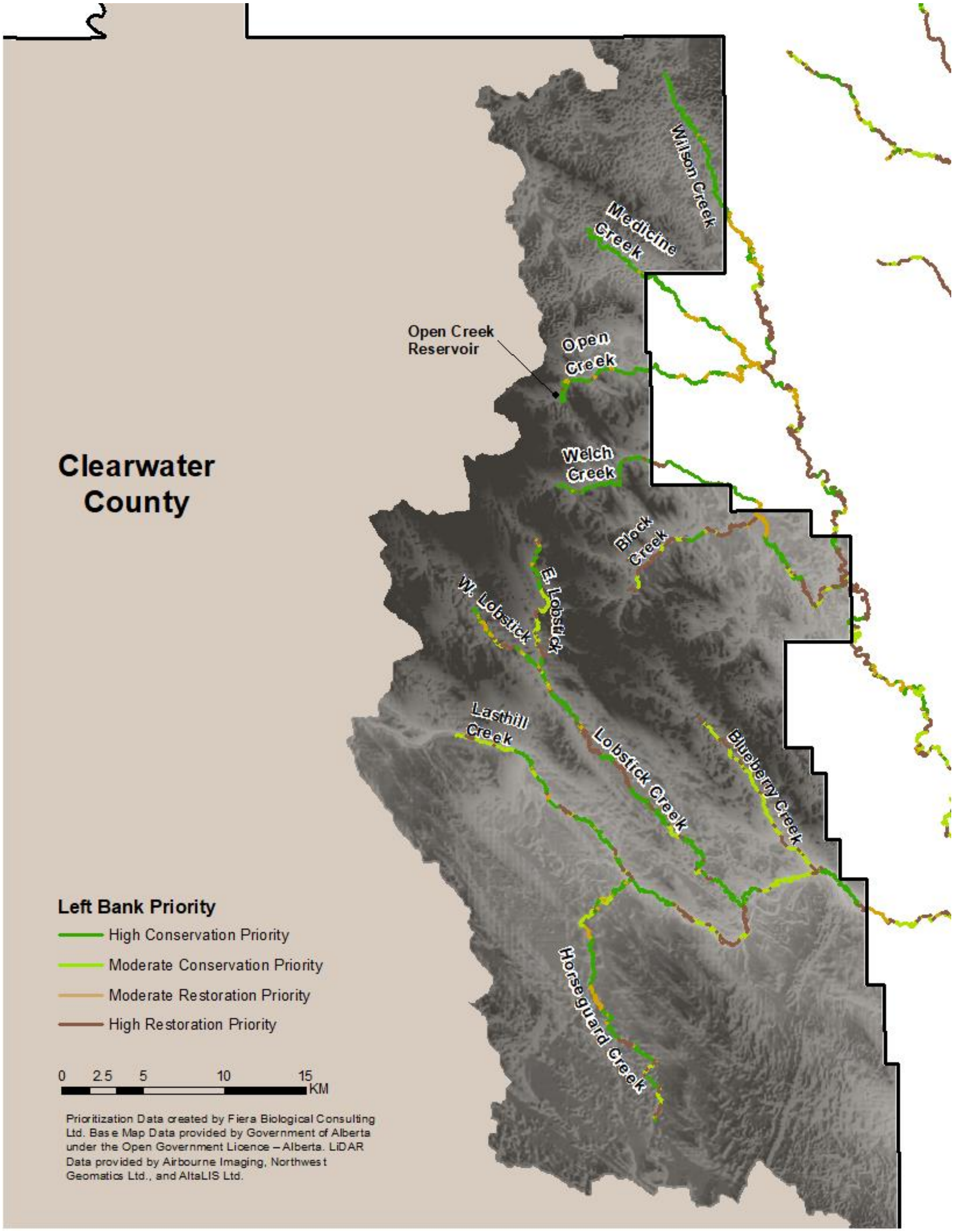
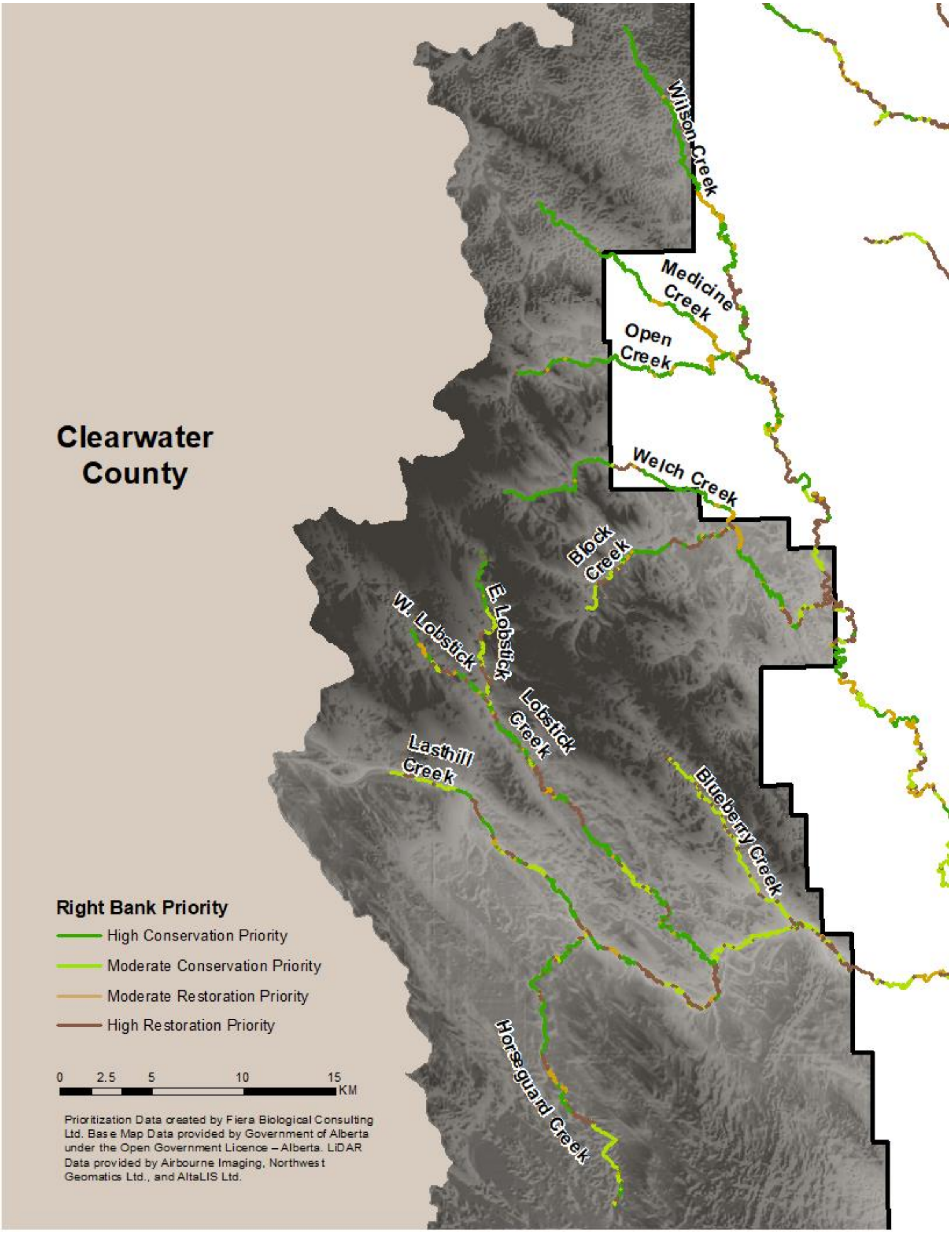


Figure 22. The proportion of shoreline length assigned to each priority category for waterbodies in Clearwater County. Numbers indicate the approximate length (km) of shoreline associated with each category.



Map 19. Restoration and conservation priority for Open Creek Reservoir and the left bank of creeks in Clearwater County.



Map 20. Restoration and conservation priority for the right bank of creeks in Clearwater County.

5.3. County of Wetaskiwin

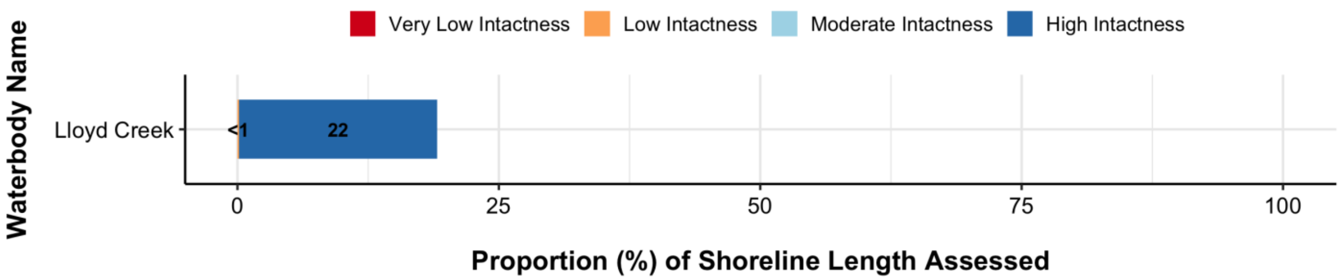


Figure 23. The proportion of shoreline length assigned to each riparian intactness category for waterbodies in the County of Wetaskiwin. Numbers indicate the approximate length (km) of shoreline associated with each category.

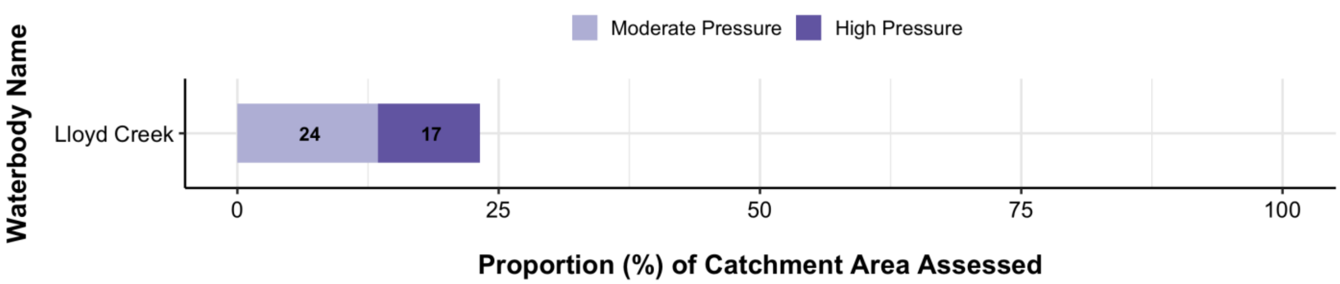


Figure 24. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies in the County of Wetaskiwin. Numbers indicate the total area (km^2) assigned to each pressure category.

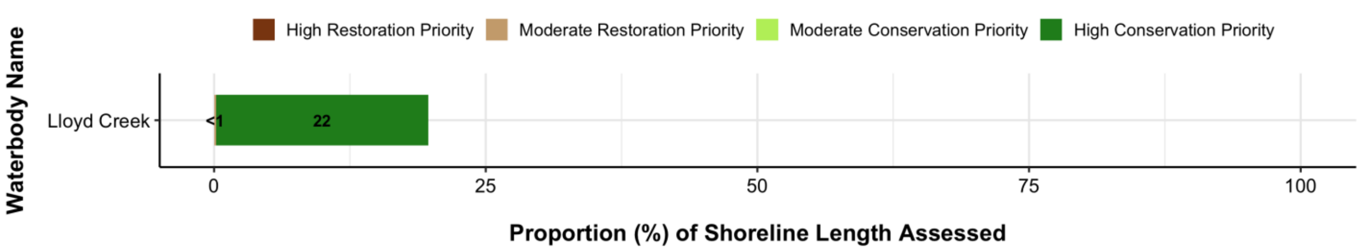


Figure 25. The proportion of shoreline length assigned to each priority category for waterbodies within the County of Wetaskiwin. Numbers indicate the approximate length (km) of shoreline associated with each category.

5.4. Lacombe County

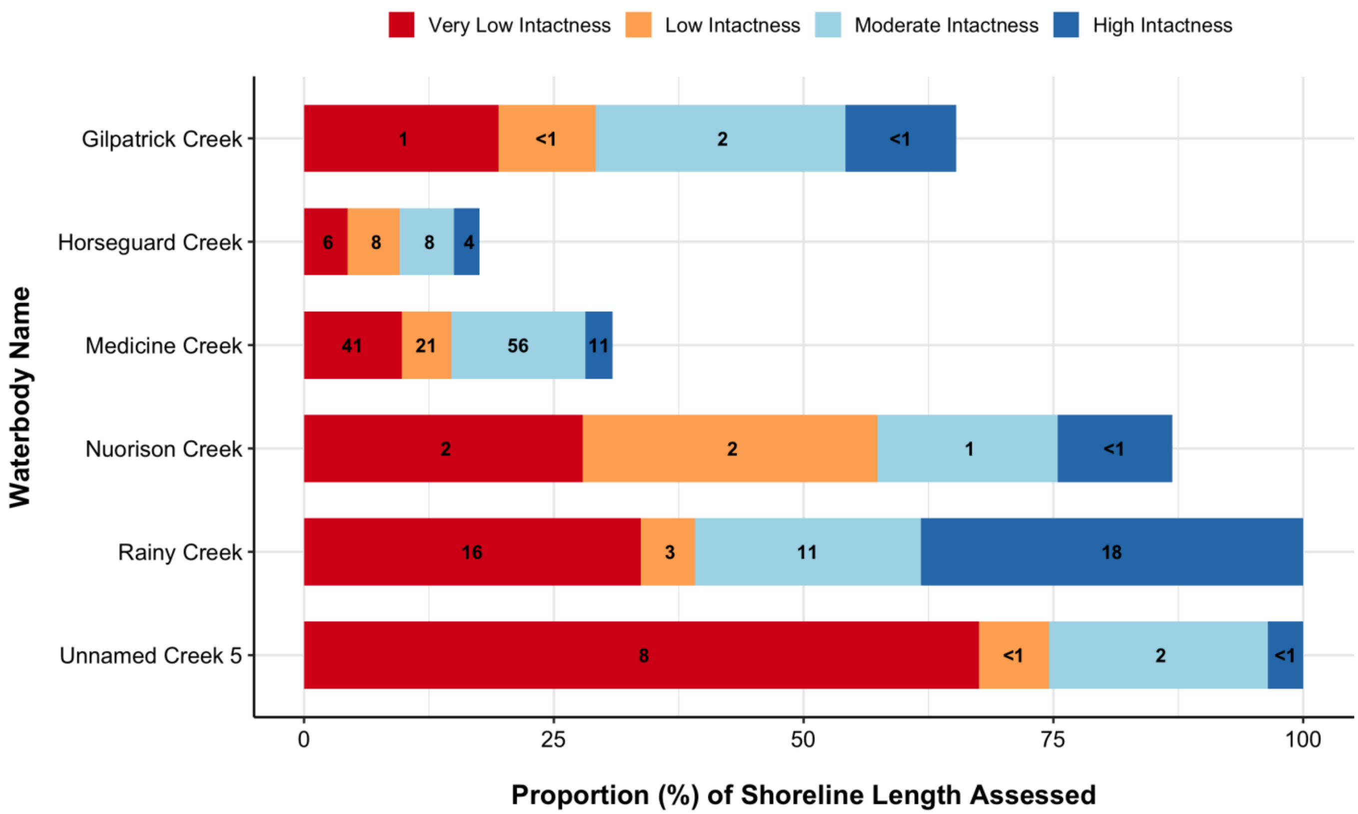


Figure 26. The proportion of shoreline length assigned to each riparian intactness category for waterbodies in Lacombe County. Numbers indicate the approximate length (km) of shoreline associated with each category.

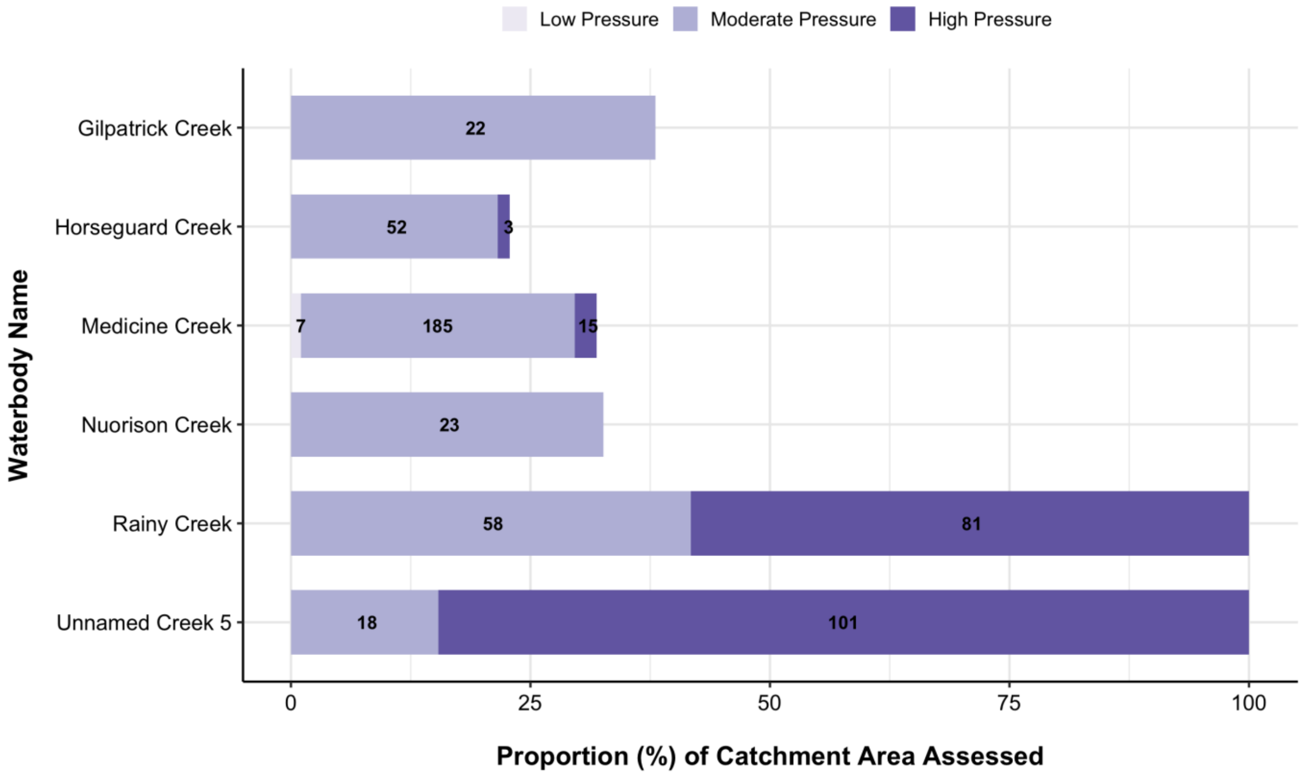


Figure 27. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies in Lacombe County. Numbers indicate the total area (km^2) assigned to each pressure category.

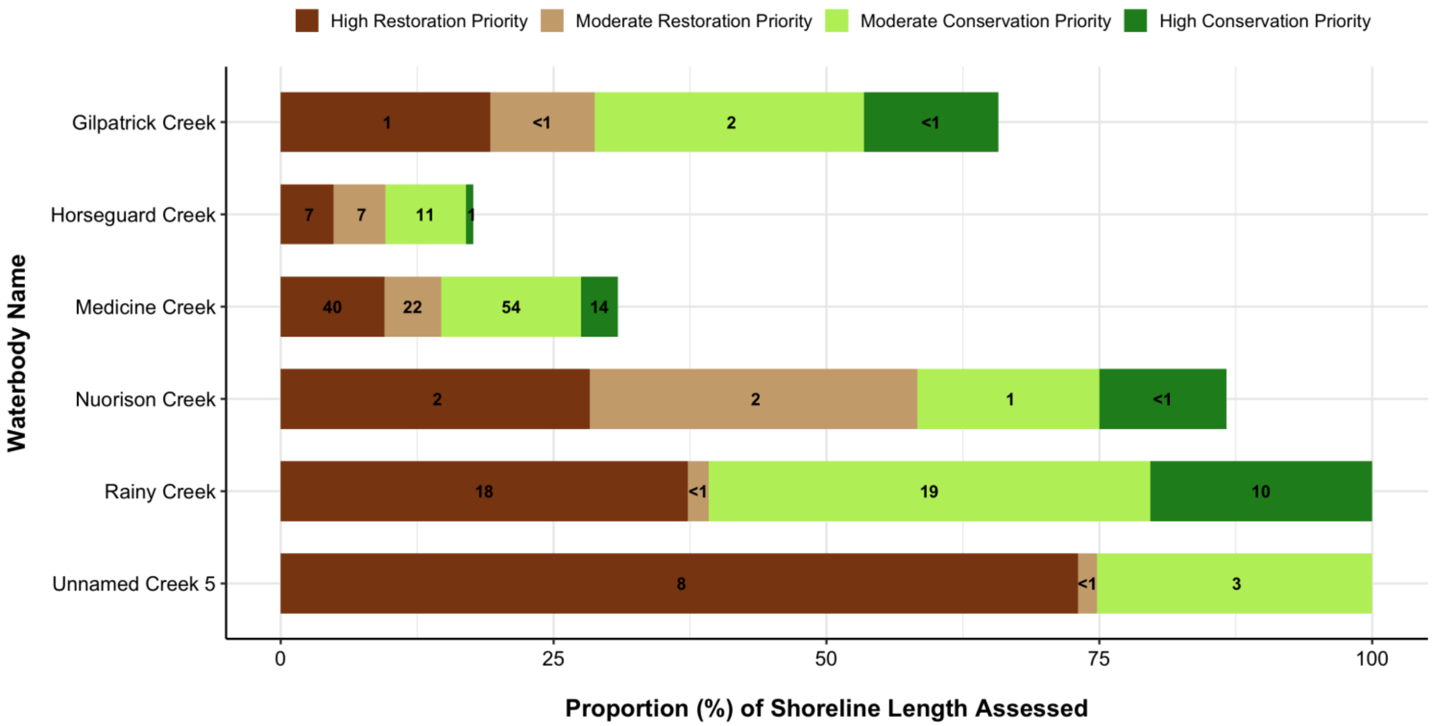
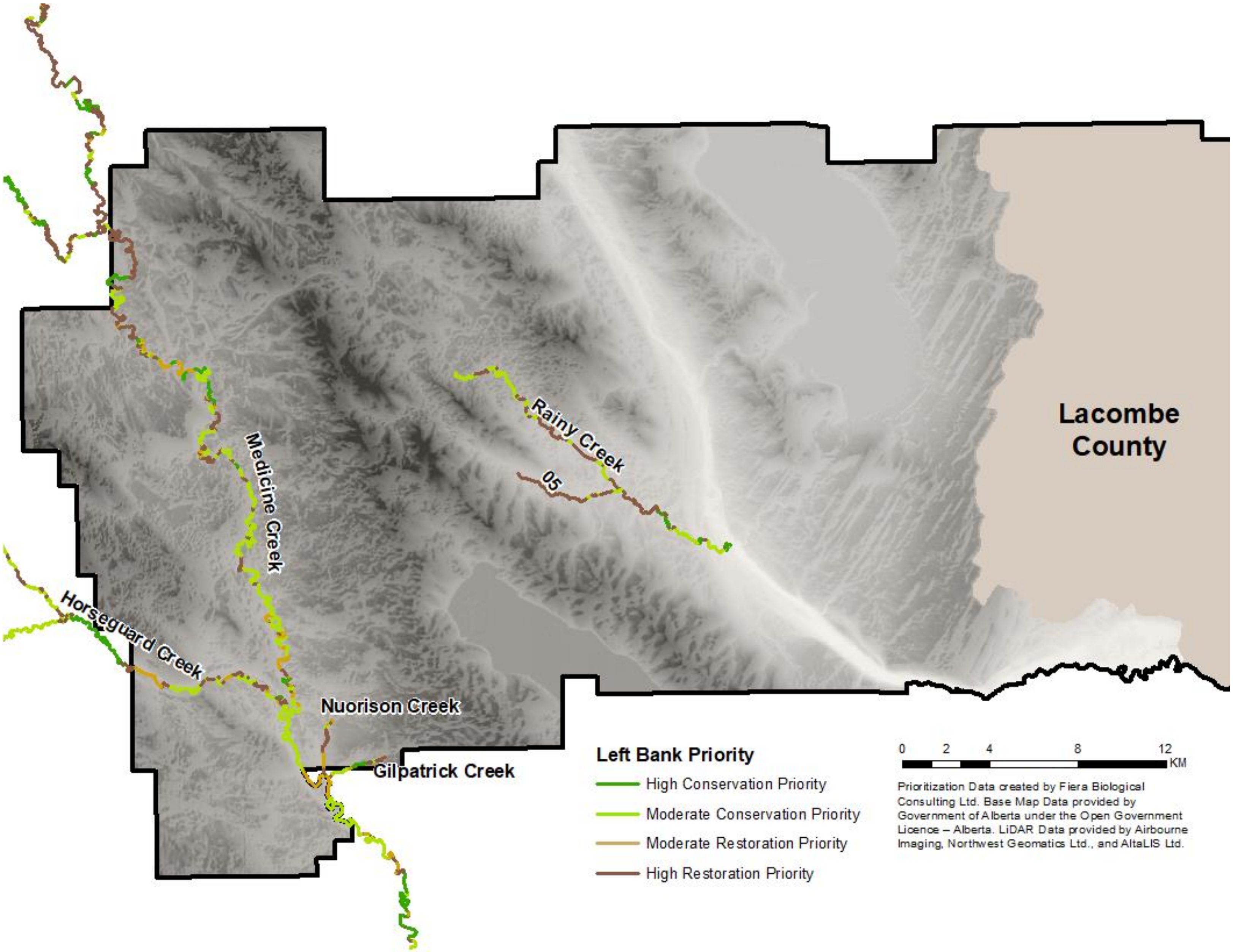
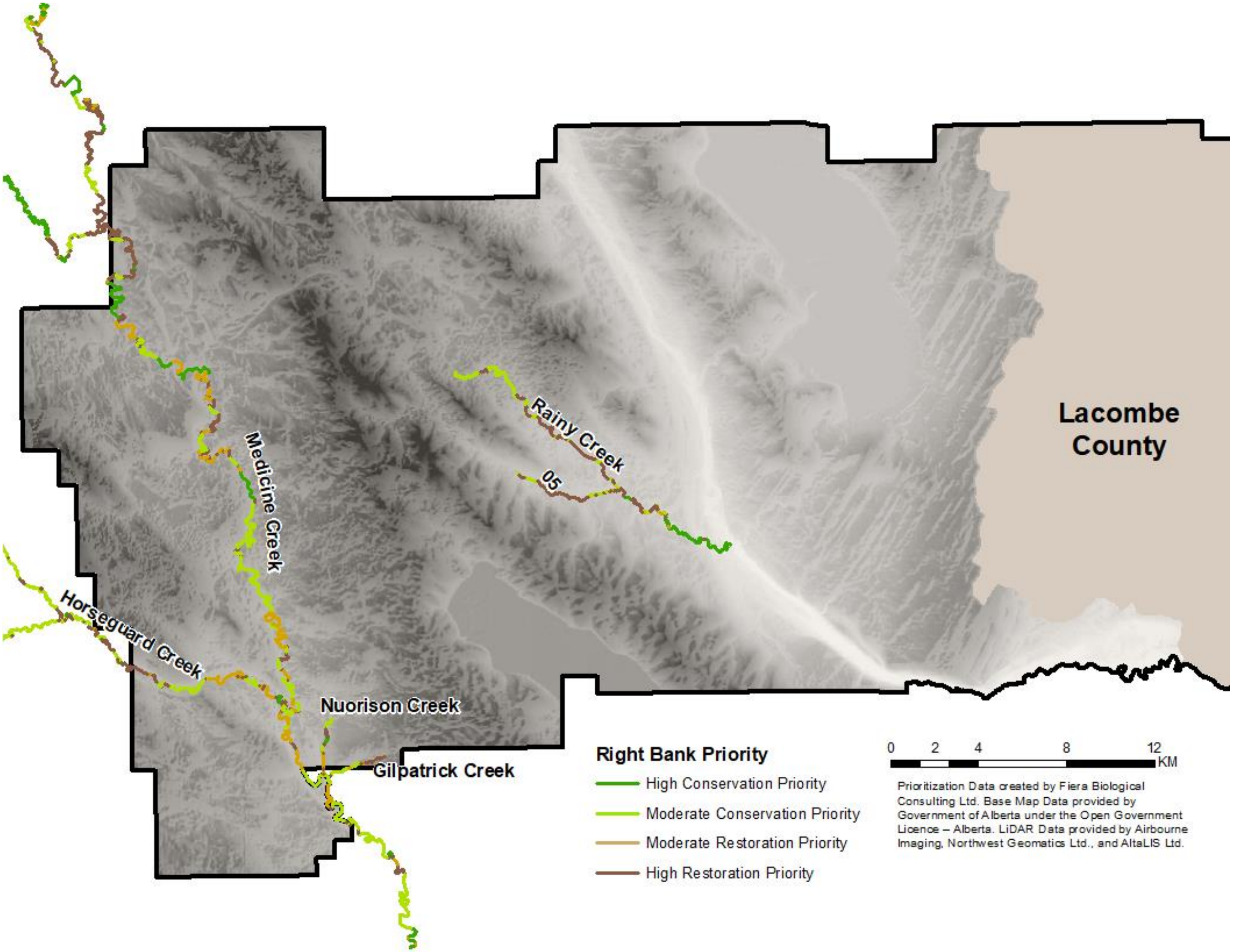


Figure 28. The proportion of shoreline length assigned to each priority category for waterbodies in Lacombe County. Numbers indicate the approximate length (km) assigned to each priority category.



Map 21. Restoration and conservation priority for the left bank of creeks in Lacombe County.



Map 22. Restoration and conservation priority for the right bank of creeks in Lacombe County.

5.5. Ponoka County

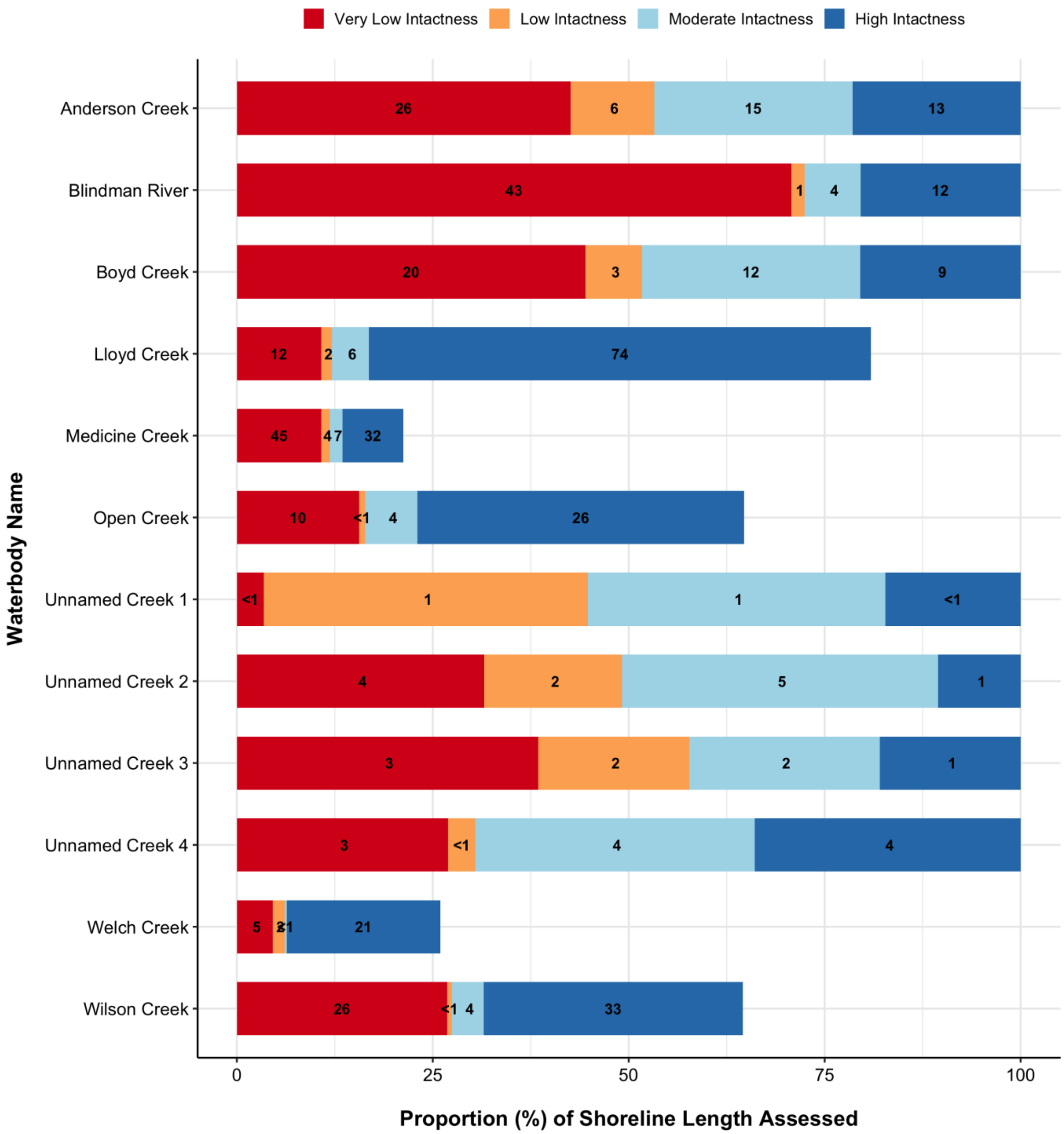


Figure 29. The proportion of shoreline length assigned to each riparian intactness category for waterbodies located within Ponoka County. Numbers indicate the approximate length (km) of shoreline associated with each category.

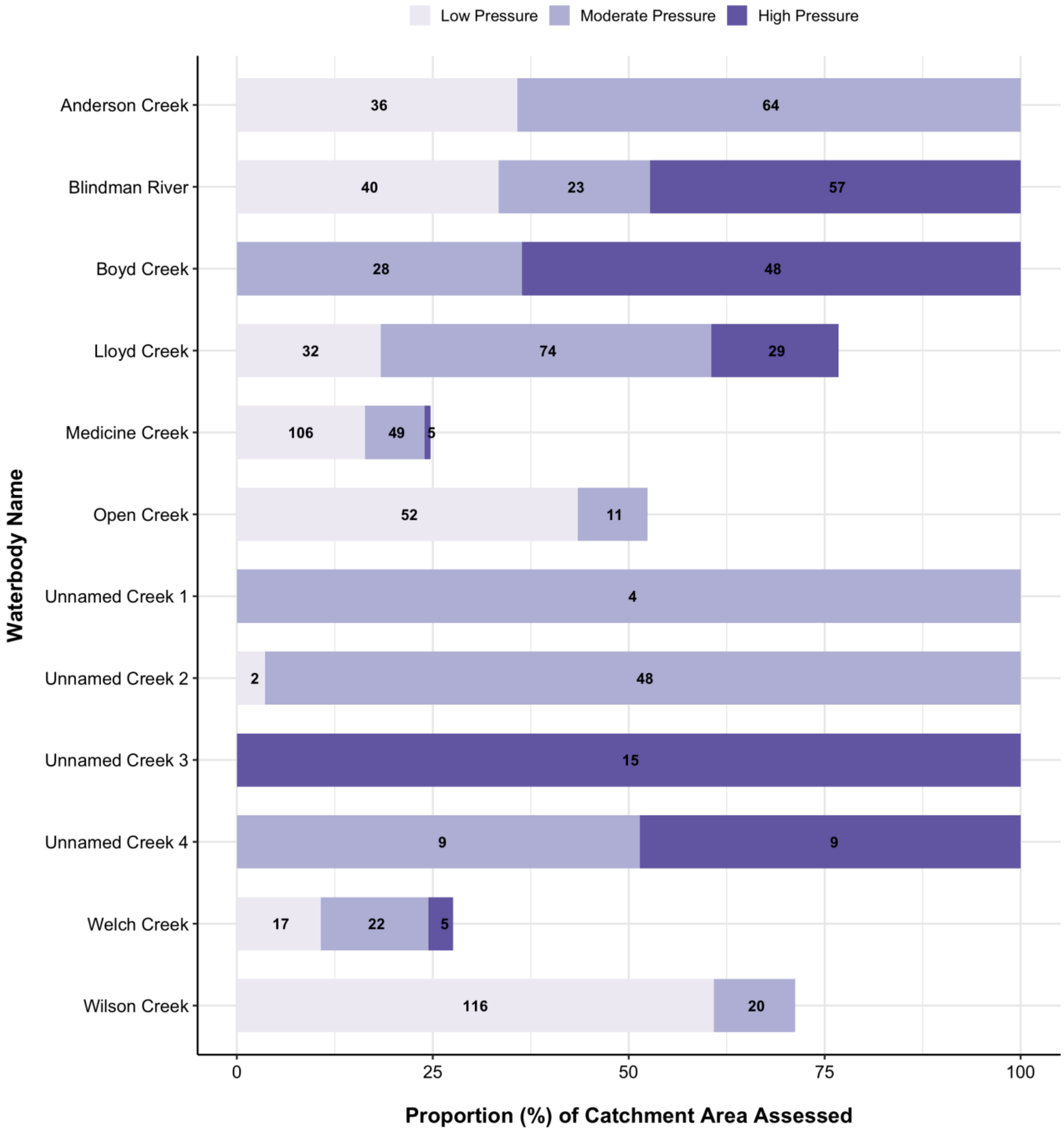


Figure 30. . The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of for waterbodies located within Ponoka County. Numbers indicate the total area (km^2) assigned to each pressure category.

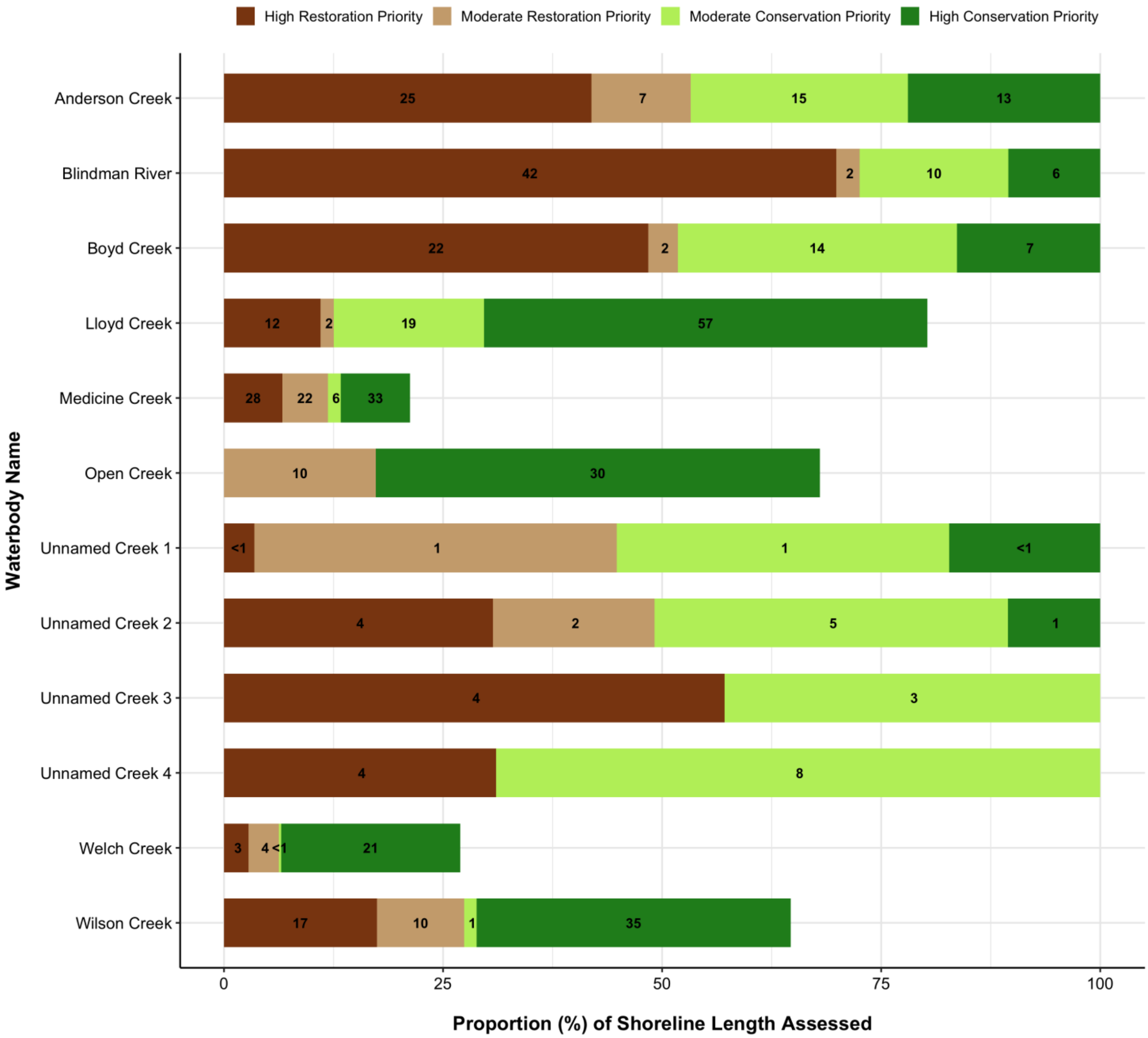
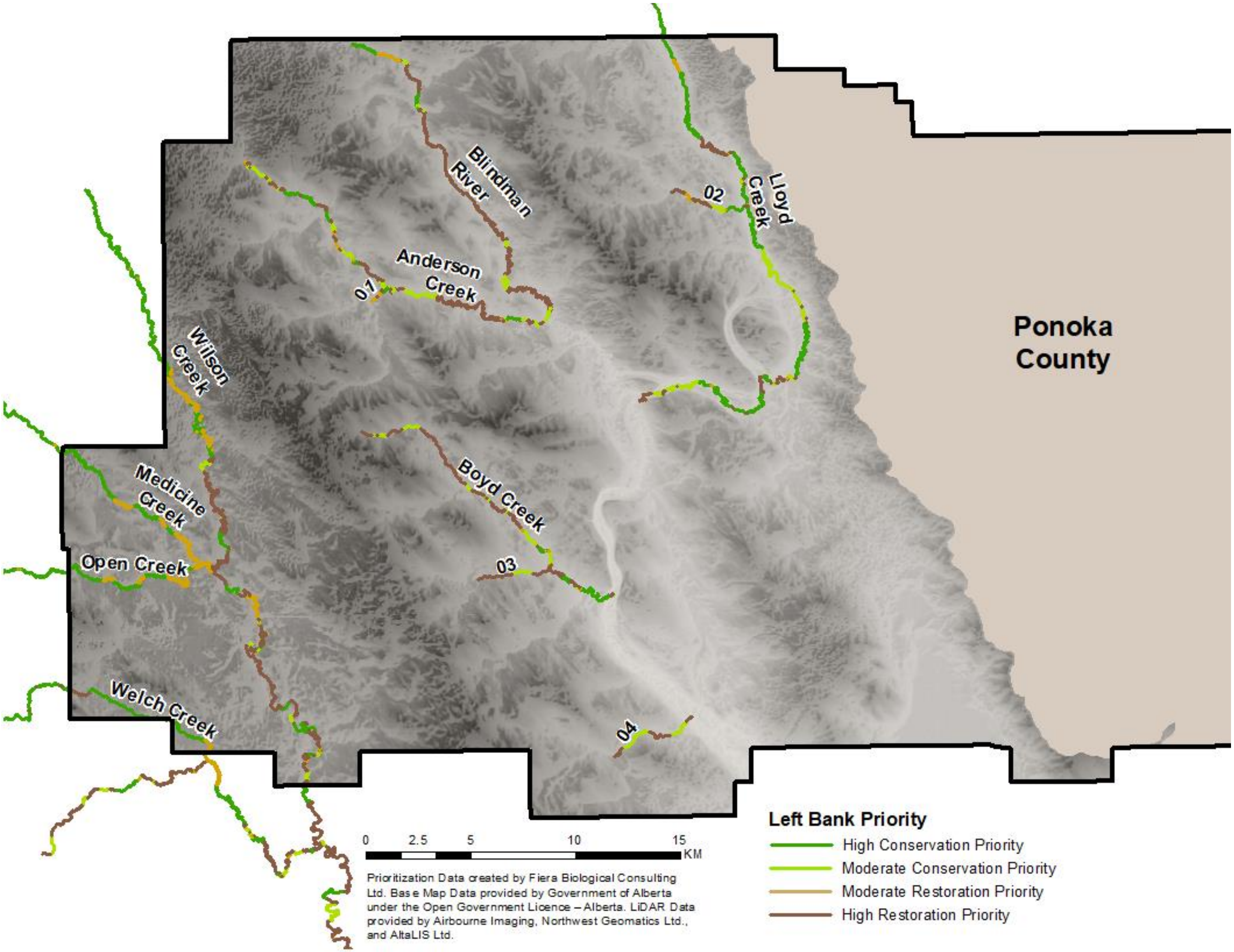
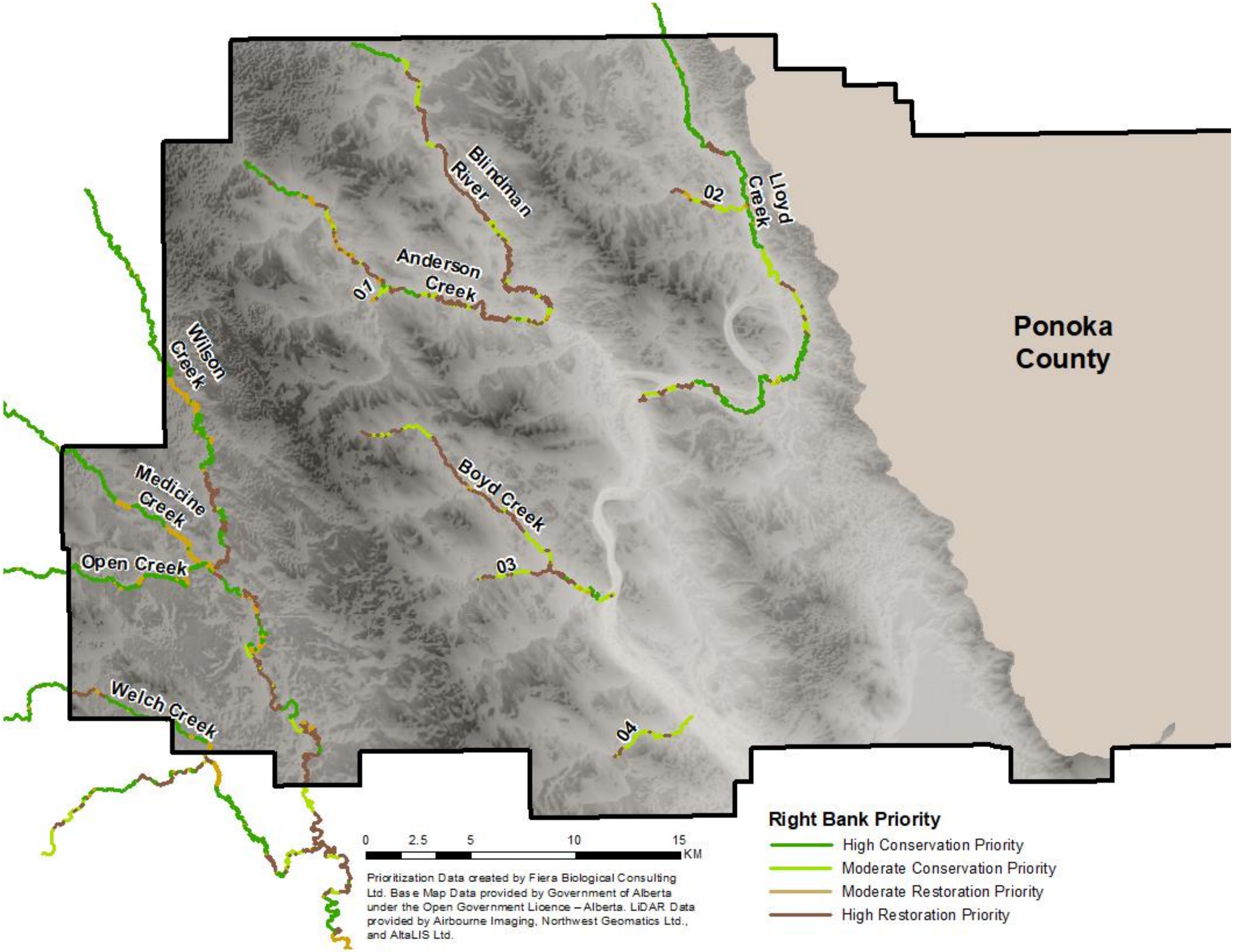


Figure 31. The proportion of shoreline length assigned to each priority category for waterbodies located within Ponoka County. Numbers indicate the total length (km) of shoreline associated with each category.



Map 23. Restoration and conservation priority for the left bank of creeks in Ponoka County.



Map 24. Restoration and conservation priority for the right bank of creeks in Ponoka County.

5.6. Red Deer County

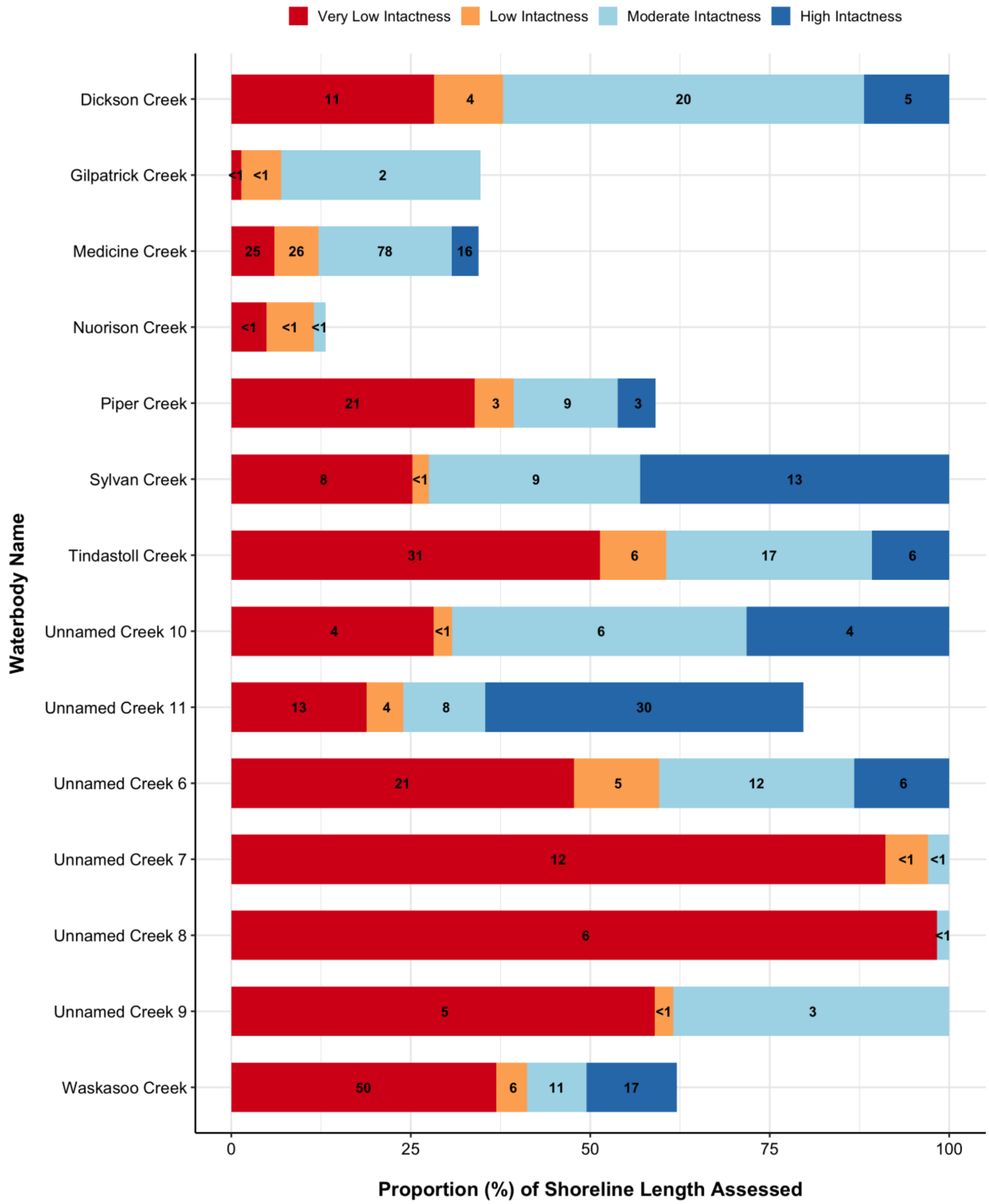


Figure 32. The proportion of shoreline length assigned to each riparian intactness category for waterbodies in Red Deer County. Numbers indicate the approximate length (km) of shoreline associated with each category.

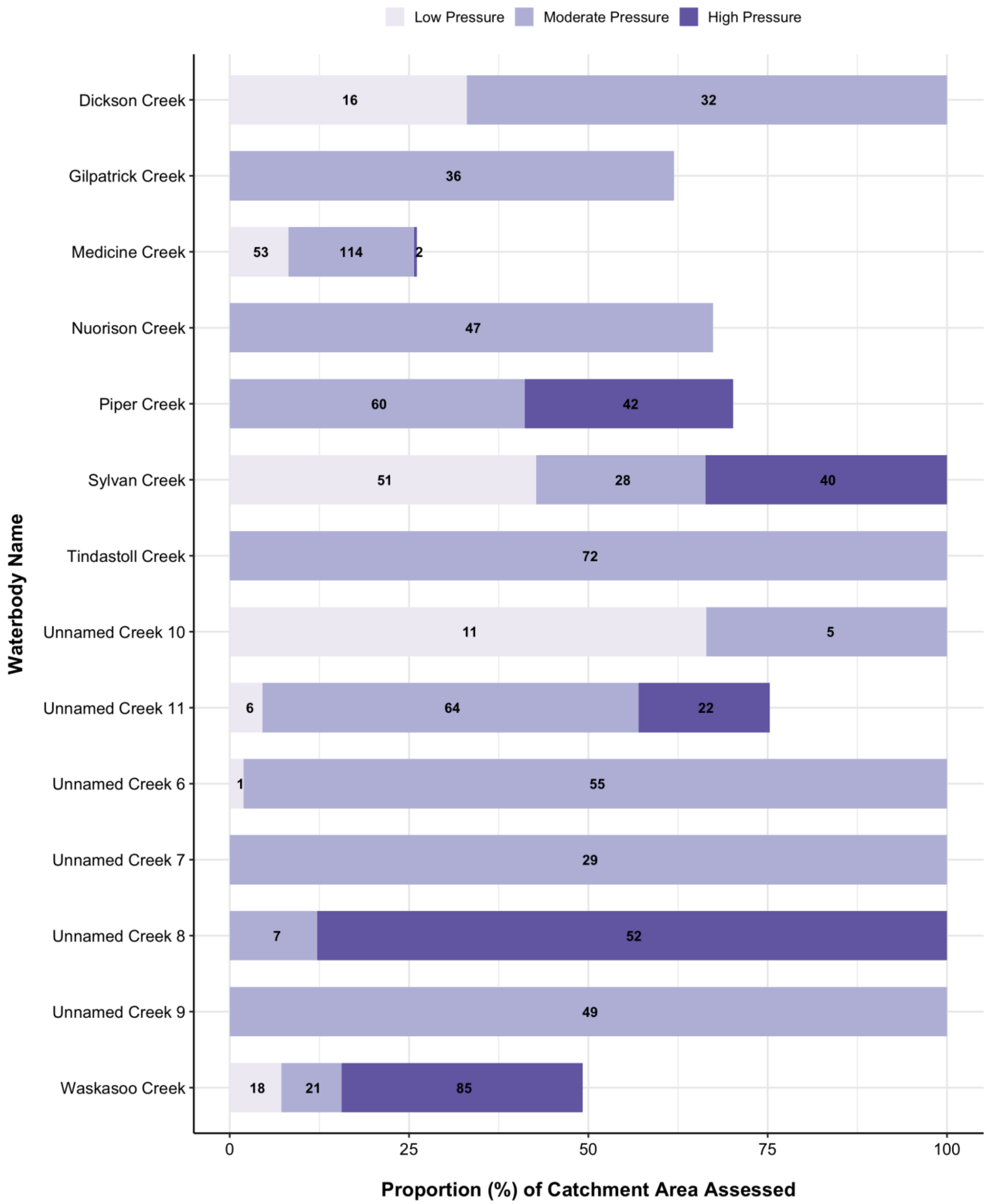


Figure 33. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies in Red Deer County. Numbers indicate the total area (km^2) assigned to each pressure category.

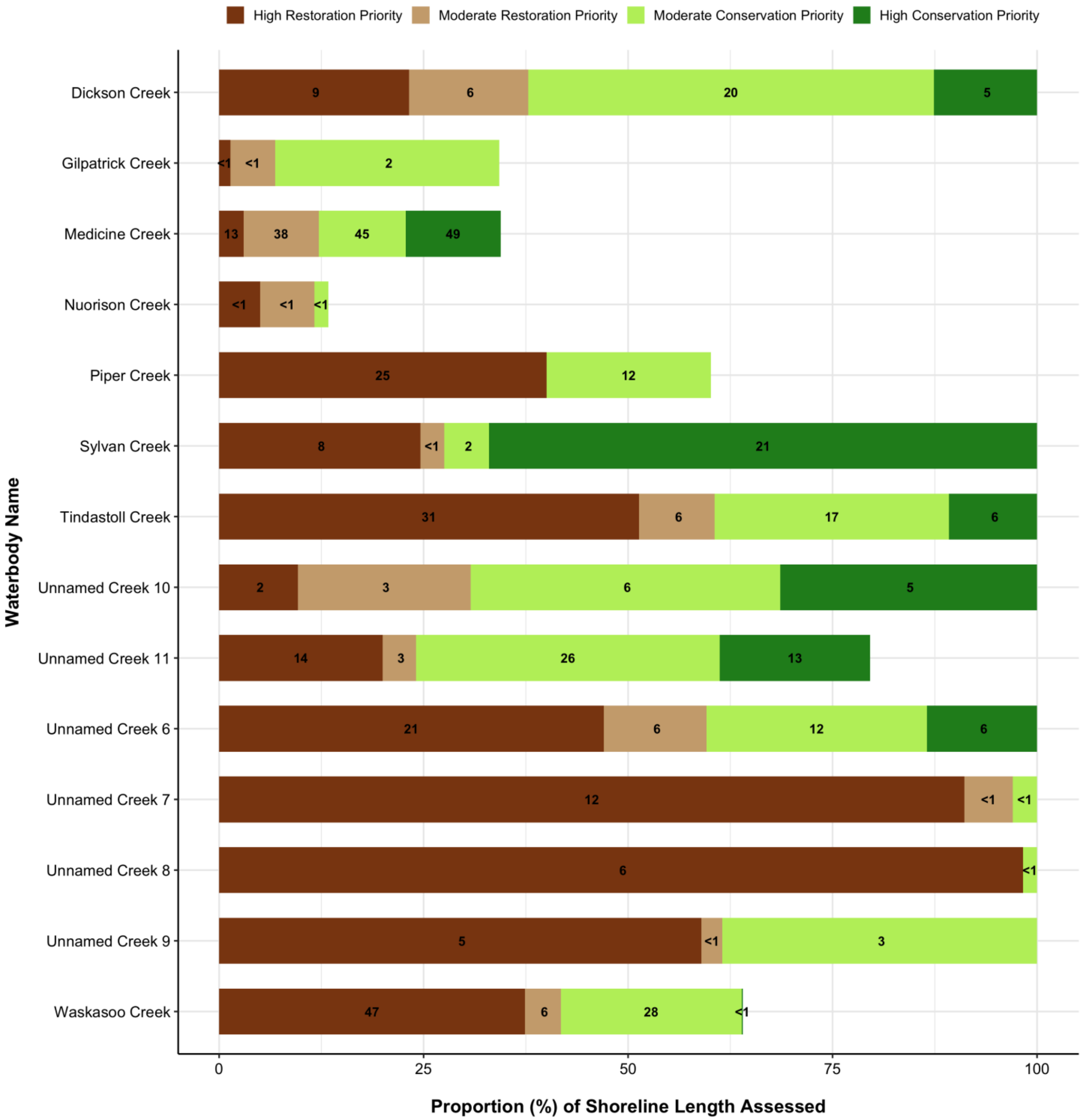
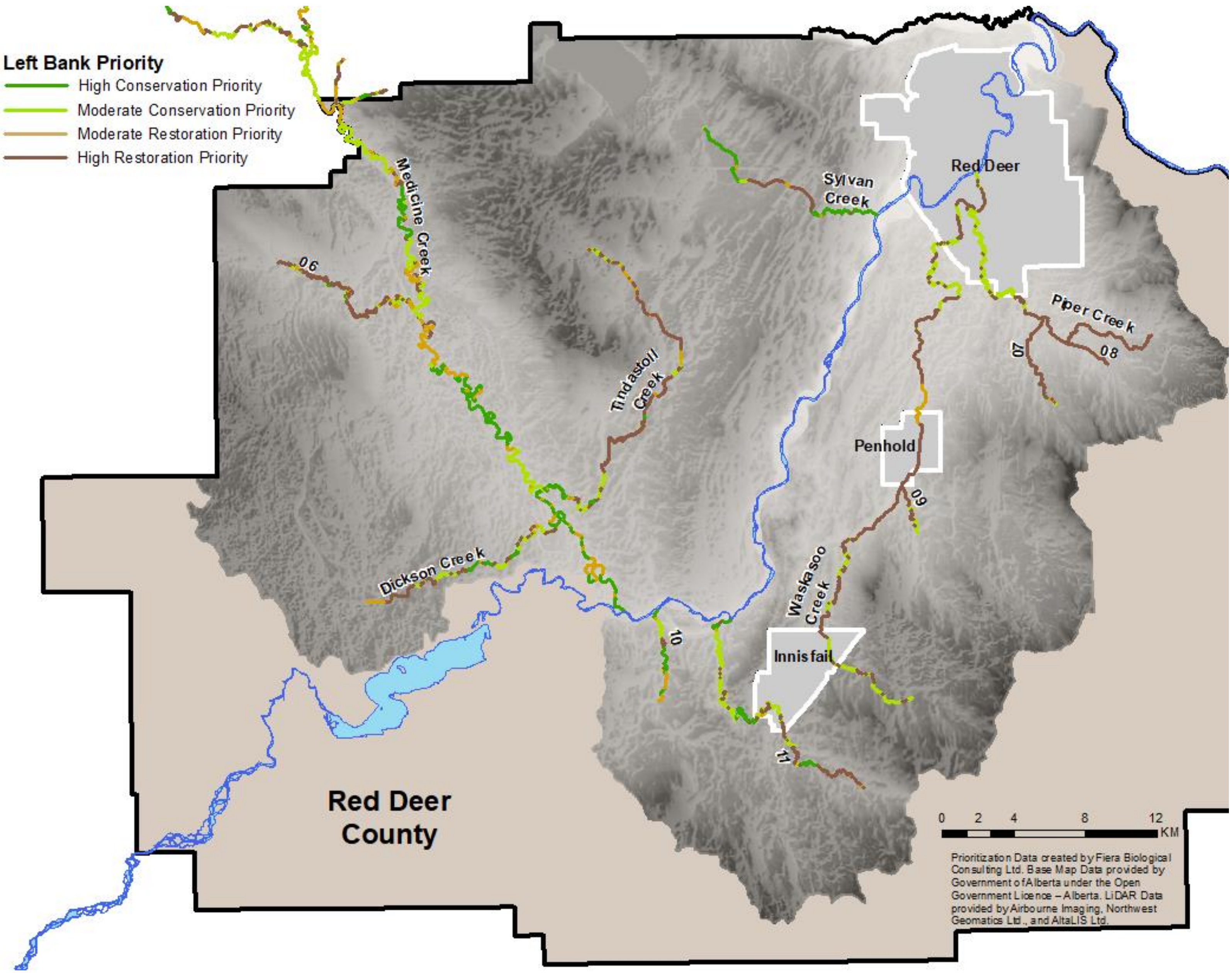
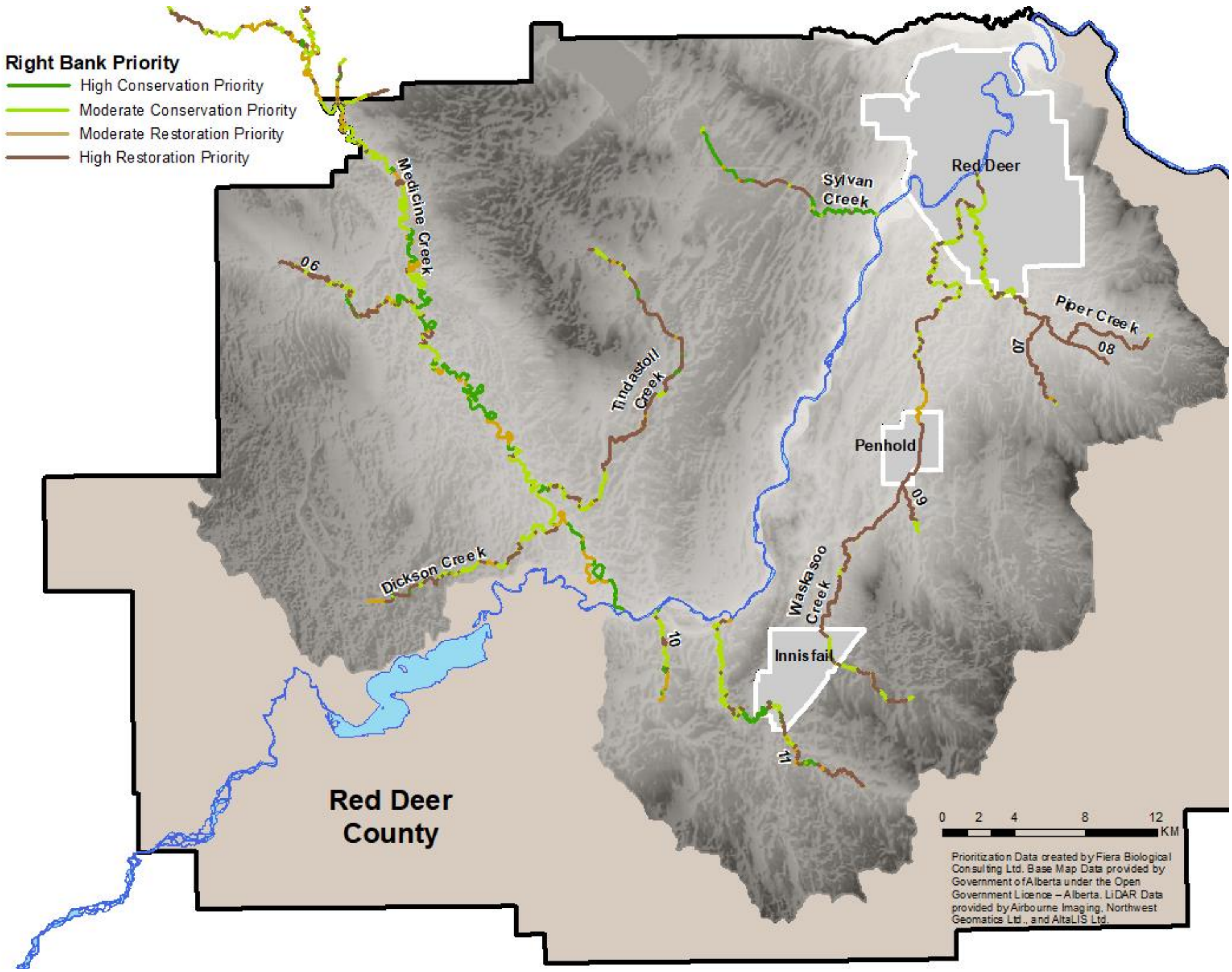


Figure 34. The proportion of shoreline length assigned to each priority category for waterbodies in Red Deer County. Numbers indicate the approximate length (km) of shoreline associated with each priority category.



Map 25. Restoration and conservation priority for the left bank of creeks in Red Deer County.



Map 26. Restoration and conservation priority for the right bank of creeks in Red Deer County.

5.7. City of Red Deer

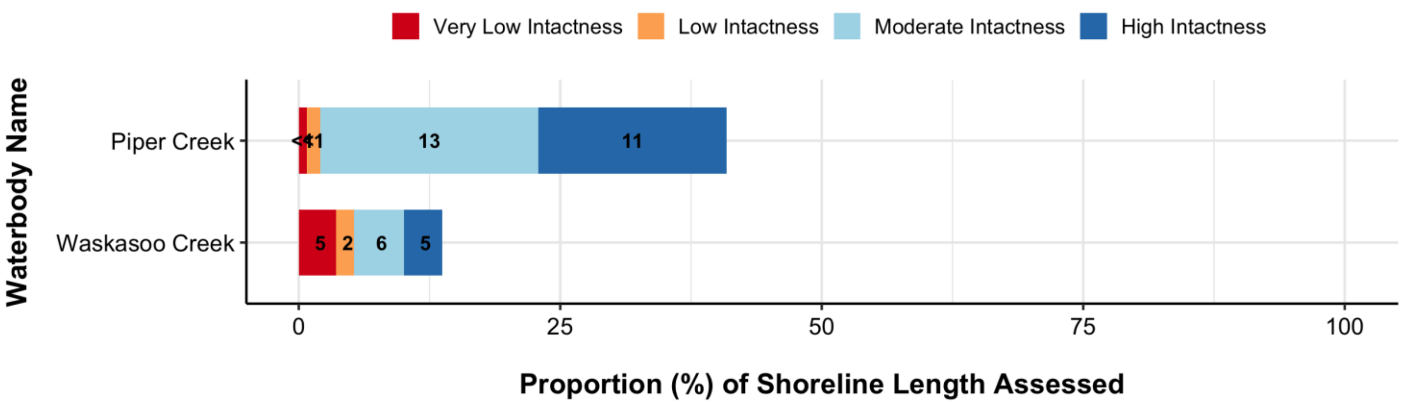


Figure 35. The proportion of shoreline length assigned to each riparian intactness category for waterbodies in the City of Red Deer. Numbers indicate the total length (km) of shoreline associated with each category.

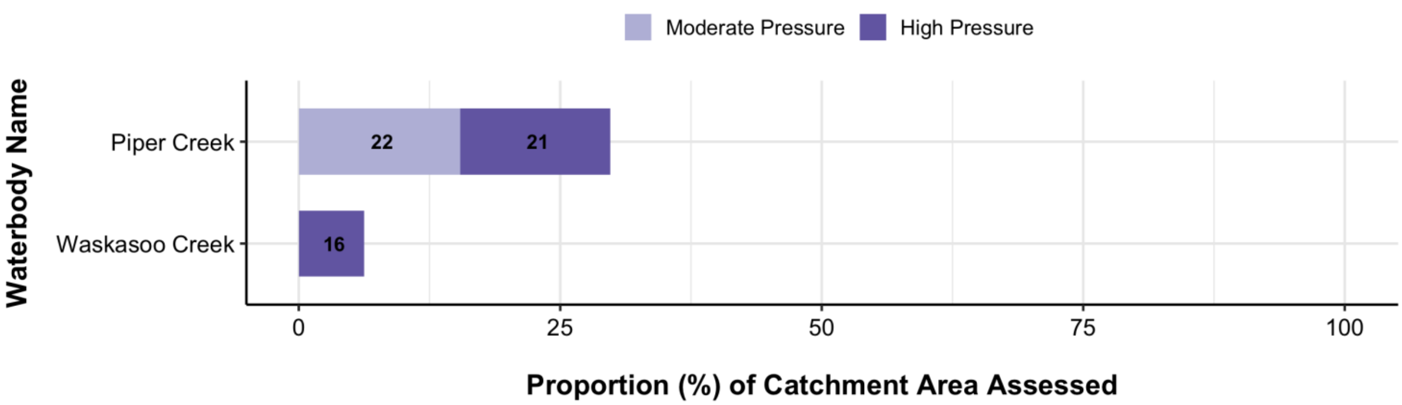


Figure 36. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies in the City of Red Deer. Numbers indicate the total area (km^2) assigned to each pressure category.

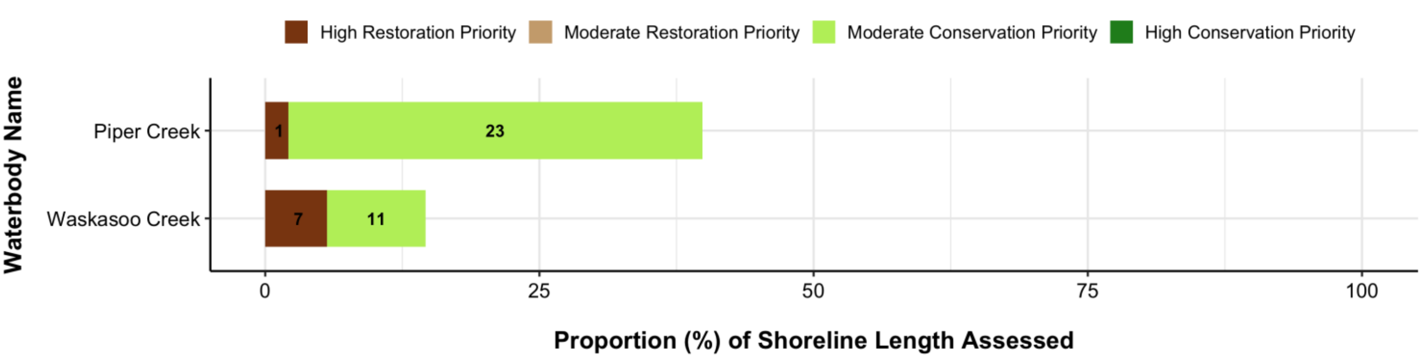


Figure 37. The proportion of shoreline length assigned to each priority category for waterbodies in the City of Red Deer. Numbers indicate the approximate length (km) of shoreline associated with each priority category.

5.8. Penhold

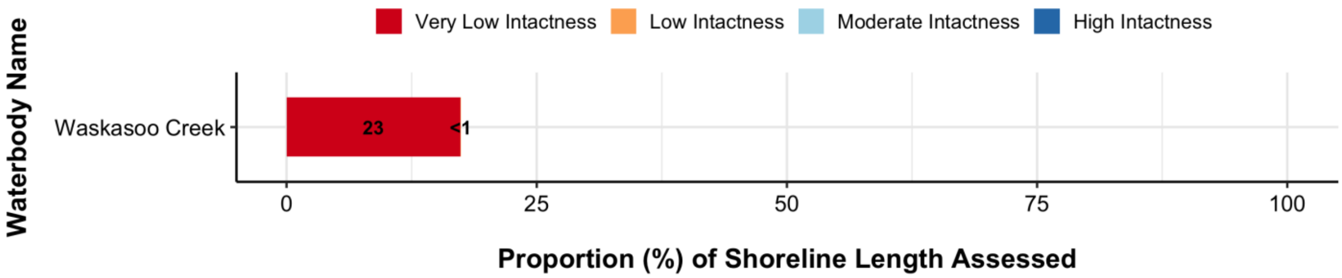


Figure 38. The proportion of shoreline length assigned to each riparian intactness category for waterbodies in Penhold. Numbers indicate the total length (km) of shoreline associated with each category.

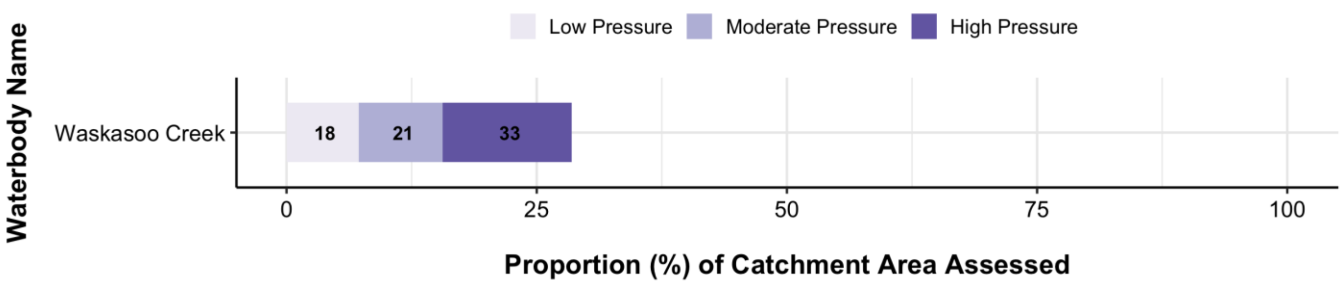


Figure 39. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies in Penhold. Numbers indicate the total area (km^2) assigned to each pressure category.

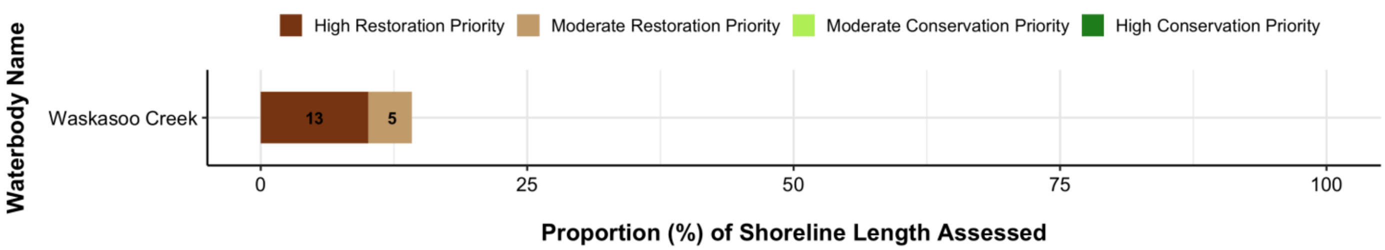


Figure 40. The proportion of shoreline length assigned to each priority category for waterbodies in Penhold. Numbers indicate the approximate length (km) of shoreline associated with each priority category.

5.9. Innisfail

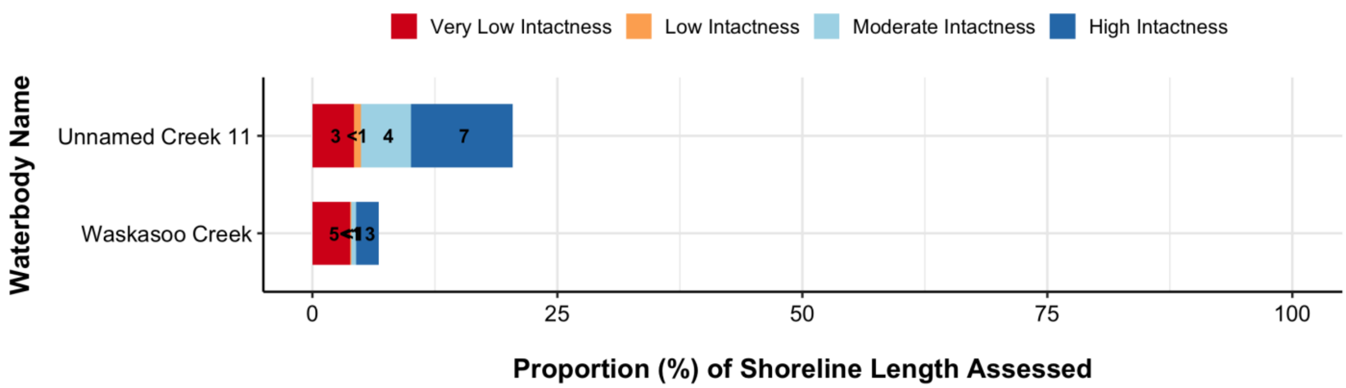


Figure 41. The proportion of shoreline length assigned to each riparian intactness category for waterbodies in Innisfail. Numbers indicate the total length (km) of shoreline associated with each category.

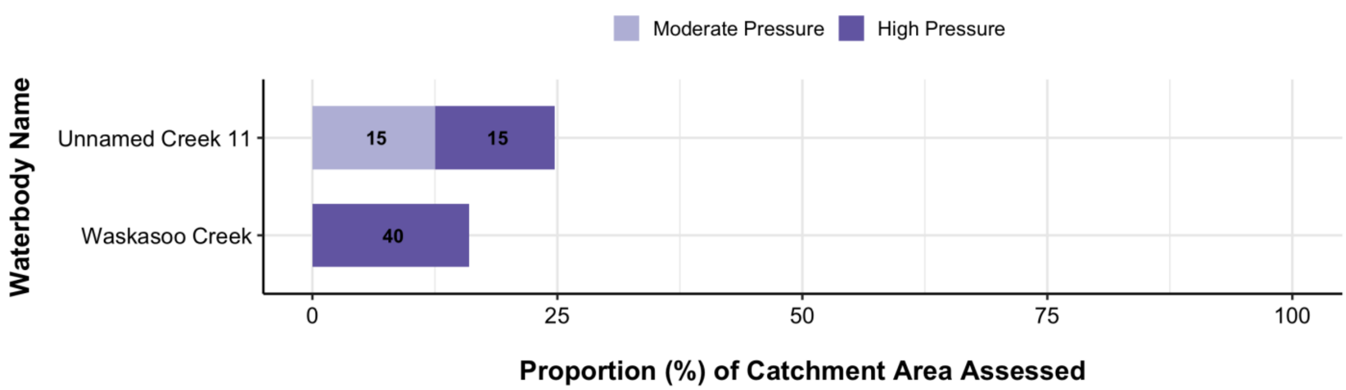


Figure 42. The proportion of catchment area by pressure category associated with RMAs that intersect the shorelines of waterbodies in Innisfail. Numbers indicate the total area (km^2) assigned to each pressure category.

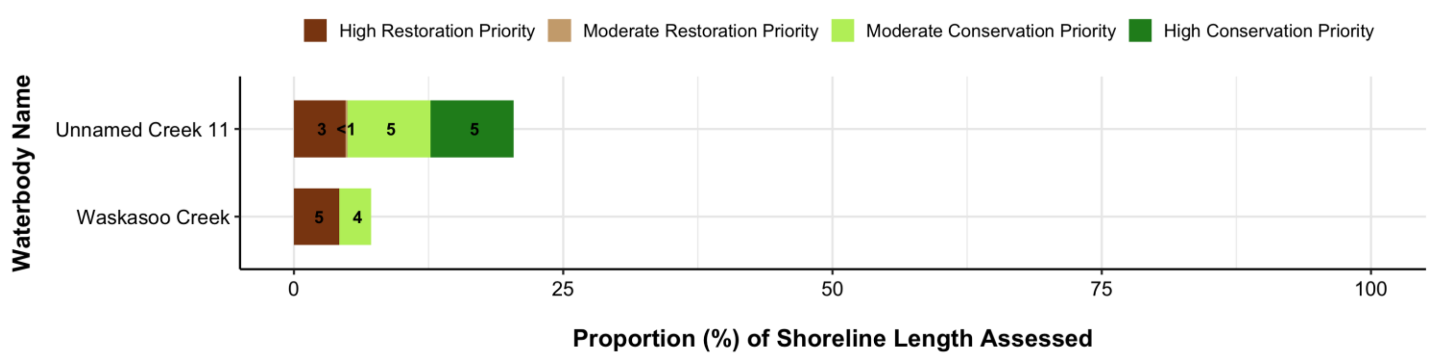


Figure 43. The proportion of shoreline length assigned to each priority category for waterbodies in Innisfail. Numbers indicate the approximate length (km) of shoreline associated with each priority category.

6.0 Creating a Riparian Habitat Management Framework

Foundational to any conservation planning exercise is the collection and generation of scientific information that can be used as the basis for the development and implementation of an evidence-based adaptive management framework. Through the commissioning of this study, the RDRWA and its stakeholders have an important foundation of scientific evidence upon which to build a systematic and adaptive framework for riparian habitat management in the Medicine-Blindman Rivers watershed.

Importantly, the next step in the advancement of meaningful riparian management and conservation in the watershed will be to formalize a framework for action that includes a consideration of the current conditions (baseline) and defining achievable outcomes and measurable targets, which can then be used to inform relevant collective action by key stakeholders. These actions can then be monitored on a regular basis to provide an evaluation of outcomes that feed into an adaptive and reflexive approach to riparian land management through time.

Central to the goal of improving riparian habitat management and conservation outcomes in the watershed is the development of a framework with specific objectives for riparian land management. Objectives may address different types of goals, such as environmental (e.g., targets for amount of intact riparian area), social (e.g., increase in awareness), and/or programmatic (e.g., development of municipal policy or application of BMPs). Each defined objective should have associated measures, targets, and actions that are developed to ensure that the associated objective is achievable, and success towards achieving each objective can be measured. A definition for each of the key building blocks for the development of a riparian management framework for the watershed is provided below:

Objective:	High-level statements of desired future conditions (outcomes).
Measure:	Specific metrics that can be quantified to assess the progress towards, and the degree to which, desired future conditions have been achieved.
Target:	Values of measurable items (metrics) that indicate the attainment of a desired condition. In the current context these may be expressed as a single value or as a range to acknowledge the inherent variability of ecosystems.
Action:	Management actions, plans, or policies for achieving stated objectives.

While the development of a riparian management framework and associated objectives should be undertaken collectively by key stakeholders, we provide a number of key recommendations below that should be considered in the development of any riparian management plan.

6.1. Key Recommendations

The development of management objectives must consider ecological, social, and economic factors, and must acknowledge that maintaining functional and resilient ecological and hydrological systems is fundamental to maintaining healthy and vibrant human communities and economies. Below we outline what we consider to be important riparian management objectives for the Medicine-Blindman Rivers watershed, and offer considerations and suggestions for the selection of measures and targets for each objective. We also offer a list of high-level actions for each objective; further discussion about potential actions that can be undertaken to improve riparian habitat management is provided in Section 7. Note that this list of management objectives is not exhaustive, and there may be other important riparian habitat management objectives defined by stakeholders in the watershed.

Objective 1:

- Maintain or improve watershed resilience by conserving high quality riparian habitat.

Measure:

- Proportion (%) of shoreline assessed as Moderate and/or High Intactness.
- Total area of High or Moderate Conservation Priority lands secured through conservation easements or other mechanisms.

This objective can include a measure of conservation at multiple and nested spatial extents. For example, a target for conservation of high quality riparian habitat can be developed for the Medicine-Blindman Rivers watershed watershed as a whole, and can also include measures and targets for riparian habitat conservation at the scale of the HUC 8 subwatershed, municipality, lake, and/or individual stream. Further, measures for riparian habitat conservation may also be specific to the type (order) and the location (e.g., headwaters) of the stream. For example, riparian vegetation provides proportionately greater benefits to stream aquatic habitat along the headwaters of streams specifically as it relates to the regulation of temperature, flow, and sediment regimes (Wipfli and Musslewhite 2004; Anonymous 2007). Thus, there may be a desire to preferentially target riparian habitat along headwater streams for conservation. Alternatively, retention of riparian habitats along higher order streams could be prioritized in areas where habitat connectivity is a primary objective to support biodiversity conservation.

Targets:

There is no universally accepted scientific target for the total amount of riparian habitat that should be maintained within a watershed; however, there is scientific consensus that the higher the quality and the greater the amount of riparian habitat that is maintained on the landscape, the better the outcomes for biodiversity, water quality, and water quantity. Further, there is no universal consensus on the width of vegetation along streams that should be maintained; however, there is general scientific agreement that factors such as the size (order) of the stream, the steepness of the banks, and the specific management concerns of the local system (e.g., soils, type of adjacent land use and land cover) should all be factors considered when determining the amount (width) of vegetation retained adjacent to a stream. For example, Environment and Climate Change Canada suggests as a riparian management guideline that 75% of a stream's length should be naturally vegetated, and that both sides of a stream should have a minimum 30-meter-wide naturally vegetated zone, while also acknowledging that wider buffers may be appropriate in some circumstances (Government of Alberta 2012; Environment Canada 2014).

Results from this study provide an important baseline that can be used to inform the selection of targets for this objective, as well as to measure improvement and progress towards achieving targets. For example, currently, 22% of the shoreline assessed within the Medicine-Blindman Rivers watershed watershed has been classified as Moderate Intactness, with an additional 38% classified as High Intactness, for a combined total of 60% (Table 10). This objective could include specifying an individual target for the desired amount of Moderate and High Intactness habitat separately, (e.g., ≥25% Moderate and ≥50% High), or as a combined target (e.g., ≥75% Moderate + High). In addition, or as an alternative, overall targets for this objective can be set for each HUC 8 subwatershed and/or for each municipality.

Table 10. Proportion of riparian areas that have been classified in each of the riparian intactness categories, summarised by various spatial extents (HUC 6 watershed, HUC 8 subwatershed, Municipality).

Spatial Extent	**Proportion (%) of Shoreline within Intactness Category**					
	Very Low	**Low**	**Moderate**	**High**	**Very Low + Low**	**Moderate + High**
Medicine-Blindman Rivers Watershed	33	8	22	38	41	60
Blindman River Subwatershed	37	6	17	41	43	58
Medicine River Subwatershed	29	9	24	39	38	63
Red Deer & Sylvan Lake Subwatershed	43	6	22	29	49	51
Clearwater County	20	4	12	64	24	76
County of Wetaskiwin	0	1	0	99	1	99
Lacombe County	33	15	36	16	48	52
Ponoka County	38	5	13	44	43	57
Red Deer County	38	10	33	19	48	52
City of Red Deer	12	7	44	37	19	81
Penhold	100	0	0	0	100	0
Innisfail	35	3	18	44	38	62

Once watershed or municipal targets have been set, finer scale spatial targets can be set for individual lakes or creeks. For example, riparian habitat along creeks in the headwaters of the Medicine and/or each HUC 8 subwatershed could be prioritized for conservation, or as an alternative, riparian areas along creeks with important ecological values, such as threatened or sensitive fisheries, could be prioritized for conservation.

Alternatively, a target such as having ≥75% of each waterbody's shoreline classified as Moderate or High Intactness could be applied to throughout the watershed (Environment Canada 2014). If such a target were to be adopted for the Medicine-Blindman Rivers watershed, data from this study suggests that 10% of the waterbodies assessed in the Blindman River subwatershed, 38% of the waterbodies in the Medicine River subwatershed, and 0% of the waterbodies in the Red Deer River & Sylvan Lake subwatershed meet or exceed this target (Table 11). If this target was reduced to 50% then the number of waterbodies that meet this target increases to 50% in the Blindman subwatershed, 81% in the Medicine River subwatershed, and 50% in the Red Deer & Sylvan Lake subwatershed (Table 11).

<u>Actions:</u>

There are a number of actions that could be taken to achieve conservation targets specified under this objective, including (but not limited to):

- Incentivize voluntary conservation of riparian habitat on private land through payment for ecosystem services, changes to tax regimes, or other BMP programs.

- Develop education and outreach programs to encourage stewardship and conservation of riparian habitats on private land.
- Secure high conservation priority riparian habitats through purchase or through other land securement mechanisms available to conservation groups, land trusts, or municipalities.
- Develop provincial and/or municipal development setback and riparian land management policies.
- Create a municipal habitat conservation and restoration fund to allow for the securement of high priority riparian conservation areas.

Table 11. Proportion of shoreline length that has been classified in each of the riparian intactness categories, summarised by individual waterbodies within each of the HUC 8 subwatersheds.

HUC 8 Subwatershed	Waterbody	Proportion (%) of Shoreline within Intactness Category					
		Very Low	Low	Moderate	High	Very Low + Low	Moderate + High
Blindman River	Anderson Creek	43	11	25	21	54	46
	Blindman River	71	2	7	20	73	27
	Boyd Creek	44	7	28	20	51	48
	Lloyd Creek	11	2	5	82	13	87
	Rainy Creek	34	5	23	38	39	61
	Unnamed Creek 01	3	41	38	17	44	55
	Unnamed Creek 02	32	18	40	11	50	51
	Unnamed Creek 03	38	19	24	18	67	32
	Unnamed Creek 04	27	3	36	34	30	70
	Unnamed Creek 05	68	7	22	4	75	26
Medicine River	Block Creek	39	9	16	37	48	53
	Blueberry Creek	10	7	30	52	17	82
	Dickson Creek	28	10	50	12	38	62
	East Lobstick Creek	10	9	11	70	19	81
	Gilpatrick Creek	25	16	44	15	41	59
	Horseguard Creek	24	10	21	46	34	67
	Lasthill Creek	19	2	10	69	21	79
	Lobstick Creek	20	4	10	66	24	76
	Medicine Creek	31	14	36	20	45	56
	Nuorison Creek	32	37	19	12	69	31
	Open Creek	21	1	9	69	22	78
	Open Creek Reservoir	3	12	0	85	15	85
	Tindastoll Creek	51	9	29	11	60	40
	Welch Creek	25	3	7	64	28	71
	West Lobstick Creek	27	7	21	45	34	66
	Wilson Creek	32	1	6	61	33	67
	Unnamed Creek 06	48	12	27	13	60	40
Red Deer & Sylvan Lake	Piper Creek	41	7	30	21	48	51
	Sylvan Creek	25	2	29	43	27	72
	Waskasoo Creek	51	8	17	24	59	41
	Unnamed Creek 07	91	6	3	0	97	3
	Unnamed Creek 08	98	0	2	0	98	2
	Unnamed Creek 09	59	3	38	0	62	38
	Unnamed Creek 10	28	3	41	28	31	69
	Unnamed Creek 11	24	6	17	53	30	70

Objective 2:

- Reduce flood risk by restoring riparian habitats that have been impacted or impaired.

Measure:

- Proportion (%) of shoreline assessed as Very Low and/or Low Intactness.

Similar to Objective 1, this measure can include multiple and nested spatial extents, and can also include finer scale spatial targeting of particular regions or high-priority waterbodies.

Targets:

Riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby protecting surrounding lands from flooding (Orewole et al. 2015; Olokeogun et al. 2020). Thus, limiting the amount and extent of riparian habitat that has been severely impacted and restoring these areas should be an important goal for riparian habitat management in the watershed, particularly in areas that are prone to flooding. At present, 33% of the Medicine-Blindman Rivers watershed has been classified as Very Low Intactness, while an additional 8% has been classified as Low Intactness, for a combined total of 41% (Table 10). A target for this objective could include specifying a desire to reduce to zero the length of shoreline that has been classified as Very Low Intactness at the watershed, sub-watershed, and/or municipal scale. Alternatively, individual (e.g., ≤5% Very Low and ≤20% Low) or combined targets (e.g., ≤25% Very Low + Low Intactness) for the proportion of Very Low and Low Intactness could be specified at a range of landscape scales. As with Objective 1, finer scale targets can also be set for individual lakes or streams under this objective.

Actions:

There are a number of actions that could be taken to achieve the targets specified under Objective 2, including (but not limited to):

- Incentivize riparian habitat restoration on private land through payment for ecosystem services, changes to tax regimes, or other BMP programs.
- Develop education and outreach programs to encourage private land restoration, particularly for landowners located upstream of flood prone areas .
- Partner with conservation organizations to promote and encourage restoration on private lands.
- Create a municipal habitat conservation and restoration fund to pay for riparian habitat restoration on public lands.

Objective 3:

- Manage external pressures on riparian system function.

Measure:

- Pressure score of local catchments adjacent to streams.

As part of this study, local catchment areas throughout the watershed have been delineated, and pressure scores have been calculated, which broadly characterize the existing condition of each catchment as it relates to the type of land cover and the intensity of land use that is present. These catchments and their associated scores offer measures for generally assessing and tracking land use and land cover changes through time.

Targets:

- No net increase in the pressure score of local catchments adjacent to streams.
- Net increase in the cover of natural vegetation (e.g., forest) and/or wetlands within High Pressure catchments adjacent to streams.

Generally, the focus of this objective should be on minimizing the impacts of large scale and cumulative land cover or land use change on riparian areas and associated stream habitats. While it is unlikely that there will be reversals to existing land use or land cover to create an improvement to pressure scores, a realistic goal for this objective would be to identify high priority local catchments where the target for management is a no net increase in the current local catchment pressure score.

An additional target for this objective could include a net increase in the cover of natural vegetation (e.g., forest, shrubs, grassland), and/or wetlands. An increase in the amount of permeable surfaces and low intensity land uses in areas adjacent to riparian habitats will have a net positive effect on riparian and stream function and condition.

Actions:

The following is a list of actions that could be undertaken to achieve the targets specified under Objective 3:

- Incentivize voluntary conservation of wetland habitat and natural vegetative cover on private land through payment for ecosystem services, changes to tax regimes, or other BMP programs.
- Develop education and outreach programs to encourage stewardship and conservation of wetlands and other natural vegetation on private land.
- Secure wetland and other natural habitats in high priority catchments through purchase or through other land securement mechanisms available to conservation groups, land trusts, or municipalities.
- Create municipal land use bylaws that restrict land clearing or high intensity land use activities in local catchments designated as high priority for conservation.

7.0 Existing Tools for Riparian Habitat Management

Riparian land management in Alberta falls under the jurisdiction of the federal, provincial, and municipal governments. While Alberta does not have legislation or policy that explicitly manages riparian lands, there are a number of laws, regulations, standards, policies, and voluntary programs that can be used to direct the management of riparian lands, or land that directly adjoins riparian lands. The following sections highlights the key legislation, policies, and programs that are currently in place for riparian land management in the province of Alberta. Note that this is not intended to be an exhaustive list; rather, it is intended to highlight legislation, policy, and programs that are considered to be the most relevant and commonly employed to achieve riparian land conservation in the province.

7.1. Guidelines, Policies, and Legislation

Federal jurisdiction over riparian areas in Alberta is somewhat limited in scope. Exceptions to this include the authority to manage natural habitats and associated wildlife on federal land (e.g., First Nation Reserves, National Parks), as well as the authority to regulate migratory birds, fish and fish habitat, navigable waters, and species at risk. A summary of relevant federal laws and regulations that may apply to riparian management in the watershed are listed in Table 12.

At the provincial level, there a number of statutory laws, regulations, and standards that directly or indirectly relate to the management of riparian habitat on both private and public land. The responsibility for managing riparian land falls to a number of provincial ministries and departments, and the mechanisms through which riparian lands are managed varies with respect to whether these habitats are located on private land (White Zone) or public land (Green Zone). In addition, the nature of the disposition and the activities associated with the land use(s) (e.g., forestry, oil and gas, agriculture, or urban development) influences how riparian lands are managed on both private and public land.

In instances of overlapping land use or activities (e.g., forest harvest operating together with oil and gas exploration), the manner in which riparian lands are managed is directed by the laws, regulations, and standards that are specific to that particular land use or activity. In these situations, coordination between the various government ministries responsible for enacting those laws, regulations, or standards is an important aspect of successful riparian management outcomes. Regardless of where the riparian land is located, or what the land use and associated activities may be, the provincial government has jurisdiction over the management of all water in the province under the *Water Act*, as well as all lands that are defined as “public” (regulated under the *Public Lands Act*), which includes the bed and shore of all permanent waterbodies, regardless of whether these waterbodies are located on private land.

In addition to provincial laws and regulations, the Government of Alberta has a wide range of policies, standards, or guidelines that provide direction for the management of natural areas, wildlife, and wildlife habitat. The majority of these policies are voluntary and require the application of best management practices to achieve the desired management goals. One exception to this is the provincial wetland policy. Wetlands are regulated as waterbodies under the *Water Act*, and as such, an approval is required to undertake any works that may impact a wetland. Thus, the principles and goals of the wetland policy and the associated wetland compensation guide are enforced through the *Water Act* application process.

A list and description of provincial laws, regulations, and policies that may apply to the management of riparian areas in the watershed is provided in Table 13.

Table 12. List and description of Federal laws and regulations that may apply to the management of riparian areas in the Medicine-Blindman Rivers watershed.

Federal Law or Regulation	**Application to the Management of Riparian Areas**
Migratory Bird Convention Act	This legislation is based on international treaty signed by Canada and the United States of America that aims to protect migratory birds from indiscriminate harvesting and destruction on all lands within Canada. Under this Act, efforts should be made to provide for and protect habitat necessary for the conservation of migratory birds, and to conserve habitats that are essential to migratory bird populations, such as nesting, wintering grounds, and migratory corridors.
Fisheries Act	Includes provisions for the protection of fish and fish habitat, and requires an authorization for activities that cause serious harm to fish.
Species At Risk Act	The Federal government has jurisdiction over all SARA-listed species on federally owned lands, including national parks, Department of National Defence lands, and First Nations Reserve lands. Management of SARA-listed species on provincial crown land, or on lands held by private citizens of Alberta, falls under the jurisdiction of the provincial government. In these cases, the provincial government is obligated to protect listed species to the same standards set forth by the Federal government. In cases where provincial governments do not meet these standards, the Federal Minister may issue an order in council to protect federally listed species that occur on provincial or private lands

Table 13. List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Medicine-Blindman Rivers watershed.

Legislation, Regulation, or Policies	Application to the Management of Riparian Areas
Agricultural Operation Practices Act	Regulates and enforces confined livestock feeding operations planning for siting, manure handling/storage, and environment standards.
Alberta Land Stewardship Act	Creates authority of regional plans and enables the development of conservation and stewardship tools that can be used to acquire and manage natural areas. These tools include conservation easements, conservation directives, conservation offsets, and transfer of development credits.
Alberta Wetland Policy & Wetland Mitigation Directive	Pursuant to the *Water Act*, the provincial wetland policy prohibits the unauthorized drainage or disturbance of wetlands. The stated goal of the policy is to “conserve, restore, protect, and manage Alberta’s wetlands to sustain the benefits they provide to the environment, society, and economy”. If wetland loss or impacts are authorized by the province under the *Water Act*, the permittee is responsible for the replacement of lost wetland habitat at the ratio stipulated by the province. While this policy does not explicitly manage riparian land, there is opportunity within the stated goals and intent of this policy to extend the policy to include riparian lands.
Environmental Protection and Enhancement Act (EPEA)	This legislation aims to protect air, land and water by regulating the process for environmental assessments, approvals, and registrations. In particular, stormwater drainage that is directed to any surface waterbody requires an EPEA approval. Further, the Environmental Code of Practice for Pesticides provides a standard for operating practices that restrict the deposition of pesticides into or onto any open waterbody.
Municipal Government Act (MGA)	Updated in June 2018, the modernized MGA provides municipalities with the authority to adopt statutory plans and bylaws that direct land use and development at subdivision. The MGA also grants limited rights to designate reserves at subdivision that can be used to conserve natural areas, and gives municipalities authority to regulate water on municipal lands, manage private land to control non-point source pollution, and adopt land use practices that are compatible with the protection of the aquatic environment, including development setbacks on waterbodies
Municipal Land Use Policies	Pursuant to Section 622 of the MGA, these Policies were established by Municipal Affairs to supplement planning provisions in the MGA and the Subdivision and Development Regulation, and to create a conformity of standard with respect to planning in Alberta. Section 5 of the Land Use Policies encourages municipalities to identify significant waterbodies and watercourses in their jurisdiction, and to minimize habitat loss and other negative impacts of development through appropriate land use planning and practices. In addition, Section 6 encourages municipalities to incorporate measures into planning and land use practice that minimizes negative impacts on water resources, including surface and groundwater quality & quantity, water flow, soil erosion, sensitive fisheries habitat, and other aquatic resources.

Continued …

Table 13 *continued …* List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Medicine-Blindman Rivers watershed.

Legislation, Regulation, or Policies	Application to the Management of Natural Areas
Public Lands Act	Regulates and enforces activities that affect the Crown-owned bed and shore of waterbodies, as well as Crown-owned riparian and upland habitats (e.g., forest and grazing leases).
Stepping Back from the Water: A Beneficial Management Practices Guide for New Developments Near Waterbodies	This document provides discretionary guidance to local authorities to assist with “decision making and watershed management relative to structural development near waterbodies”, and includes recommendations for development setbacks (buffers) on waterbodies to protect aquatic and riparian habitats.
Soil Conservation Act & Regulations	Regulates activities that may cause erosion and sedimentation of a waterbody.
Surveys Act	Definitions for the “legal bank” of a waterbody, upon which the Crown-owned “bed and shore” is defined. The legal boundary between the bed and shore and the adjacent lands is the naturally occurring high water mark, and may not extend to include the full extent of riparian lands adjacent to a waterbody.
Water Act	The stated purpose of this Act is to support and promote water conservation and management. Under the Act, any activity that causes or has the potential to cause an effect on the aquatic environment requires an approval. Regulations and Codes of Practice under this Act apply to water and water use management, the aquatic environment, fish habitat protection practices, in-stream construction practices, and storm water management.
Weed Control Act	Noxious and prohibited noxious weeds listed under Schedule 1 must be controlled (noxious weed) or destroyed (prohibited noxious weed) by the owner of the land on which the listed weed occurs.
Wildlife Act & Species at Risk Program	Regulates and enforces protection of wildlife species and their habitats, which may include riparian dependent species

While the provincial government holds the authority to regulate water and public land throughout the province, municipalities are given the authority to manage lands within their jurisdiction under the *Municipal Government Act* (MGA), which was modernized and revised in July 2018. Under Part 1, Section 3, the Act outlines the following purposes of a municipality:

1) To provide good governance and foster the well-being of the environment;
2) To provide services that are in the opinion of council to be necessary or desirable;
3) To develop and maintain safe and viable communities; and
4) To work collaboratively with neighbouring municipalities to plan, deliver, and fund intermunicipal services.

A primary power given to municipalities is land use planning and development, which allows municipalities to set the conditions under which lands are subdivided and developed. Further, each municipality must develop statutory planning documents that provide a framework and vision for development and land use within their jurisdictions. Statutory planning documents that are required include:

- Municipal Development Plans
- Intermunicipal Development Plans
- Area Structure Plans
- Area Redevelopment Plans

Within these planning documents, municipalities can provide specific direction for development requirements that may influence the conservation of riparian habitat. In addition to statutory planning documents, municipalities can influence the management of riparian areas by enacting Land Use Bylaws that set forth requirements for development setbacks on environmentally sensitive lands. For example, municipalities can provide specific direction for development requirements in or near riparian habitat, or set forth minimum development setback widths on Environmental Reserve (ER), environmentally sensitive land, or waterbodies and watercourses.

The MGA also gives municipalities the power to enact land use bylaws, as well as the authority to designate land as Environmental Reserve at the time of subdivision. Environmental Reserves are defined in Section 664 as waterbodies or watercourses, lands that are unstable or subject to flooding, and lands "not less than 6 metres in width abutting the bed and shore" of a waterbody or watercourse. While the Act allows municipalities to take a 6 metre (or more) setback on Environmental Reserve lands, the conditions under which this taking is permitted is limited to cases where the setback is required to prevent pollution or provide public access to the bed and shore of the waterbody or watercourse. In addition to the limited opportunities that are available for conserving riparian land as Environmental Reserve, Section 640(4)(l) of the Act allows municipalities to establish development setbacks on lands subject to flooding, low lying or marshy areas, or within a specified distance to the bed and shore of any waterbody.

7.2. Acquisition of Riparian Lands

It is important to note that while there is a wide range of different federal, provincial, and municipal laws and policies that regulate activities within or near riparian areas, these regulations by themselves to do not necessarily result in the conservation of riparian habitat. In many cases, existing laws regulate *activities* that may impact riparian habitats (e.g., the provincial *Water Act*), but do not regulate the habitats themselves. As a result, many of the existing laws result in approvals that allow for the removal or alteration of riparian areas under certain conditions outlined within the approval. In some cases, these regulations require compensation or replacement of impacted habitats (e.g., the Provincial wetland policy and the federal *Fisheries Act*), but typically, existing laws and policies do not prevent land development, and there is very little provision for riparian habitat conservation in existing laws and policies, particularly as it relates to federal and provincial regulation.

At the municipal level, most municipalities have environmental and land use legislation, policies, and guidelines that provide direction for how to target riparian habitats and other natural areas for conservation, as well as guidance for how to integrate these habitats into a neighbourhood post-development. However, there are only a small number of tools or mechanisms available that enable the *acquisition* of lands by the municipality (or a third party) for the purpose of conservation. In some cases, these tools are only available to municipalities at particular times during the development process (e.g., at subdivision). In other instances, there may be restrictions on the amount of land that municipalities can set aside for conservation, as natural area conservation must be considered alongside other land use demands, such as school and park sites. In many cases, municipalities may have undertaken an ecological inventory to identify high priority areas for conservation, and have the appropriate legislation or policies in place to manage these areas, but may lack the appropriate tools (or associated resources) to acquire high priority conservation areas.

One of the most effective conservation mechanisms for aquatic habitats within municipalities is the *Public Lands Act*. Pursuant to this legislation, the Province of Alberta owns the bed and shore of all permanent and naturally occurring waterbodies, including lakes, rivers, streams, and wetlands. Under this Act, all permanent and naturally occurring waterbodies are Crown land, and development must avoid these features. If development can not be avoided, the Crown determines whether temporary construction or permanent occupation will be authorized, and in many cases, authorized activities that result in the loss of Crown land is subject to compensation. In the case of riparian habitats along streams and rivers and permanent wetlands, the determination of whether riparian areas are considered to be part of the Crown claimed waterbody is contingent on the existence of a legal survey, and the location of the water boundary that is determined by the surveyor, as per the Surveyors Act. In this regard there are known inconsistencies with respect to how surveyors determine the location of the water boundary, and this may or may not include riparian habitat.

The second provincial legislation that enables municipalities to develop and implement land conservation and stewardship tools is the *Alberta Land Stewardship Act* (ALSA). Under ALSA, the following tools may be utilized to conserve riparian areas in municipalities:

Conservation Easement:

A conservation easement is a voluntary contractual agreement between a private landowner and a qualified organization, such as a municipality, Land Trust organization, or conservation group. There are only three allowable purposes for a conservation easement under the *Alberta Land Stewardship Act*, and these include the protection, conservation and enhancement of 1) the environment, 2) natural scenic or aesthetic values, or 3) agricultural land or land for agricultural purposes. Under a conservation easement, the landowner retains title to the land, but certain land use rights are extinguished in the interest of conserving and protecting the land. The land use restrictions that apply to the property are negotiated and agreed to at the outset (for example, a restriction on subdivision), and the conservation easement (and the land use restrictions) are registered on title and are transferred to a new land owner if the land is sold. Conservation easements can be negotiated by a private land owner at any time, but the easement must be held by a qualified organization.

Conservation Directive:

A conservation directive allows the Alberta Government to identify private lands within a regional plan for the purpose of protection, conservation, or enhancement of environmental, natural scenic, or aesthetic values. Ownership of the lands is retained by the land owner, and the directive describes the precise nature and intended purpose for the protection, conservation, or enhancement of the lands. A conservation directive must be initiated by the provincial government, and to date, this tool remains largely untested (Environmental Law Centre 2015).

Conservation Offset:

A conservation offset is a tool that allows industry to offset the adverse environmental effects of their activities and development by supporting conservation activities and/or efforts on other lands. In order for conservation offsets to be effective, there must first be guidelines and rules for where offsets can be applied, and provisions for accountability, including monitoring and compliance. While conservation offsets are available as a tool for the conservation of natural areas in the Medicine-Blindman Rivers watershed, work would first have to be done to create a proper framework to create eligibility rules, pricing and bidding rules for selling and buying offsets, and rules for combining buyers and sellers.

Transfer of Development Credits (TDCs):

Transfer of development credits is a tool that creates and incentive to redirect development away from specific landscapes in order to conserve areas for agricultural or environmental purposes. This tool allows land development and conservation to occur at the same time, while also allowing owners of the developed and undeveloped lands to share in the financial benefits of the development activity. A TDC program can be used to designate lands as a conservation area for one or more of the following purposes:

- The protection, conservation and enhancement of the environment;
- The protection, conservation and enhancement of natural scenic or aesthetic values;
- The protection, conservation and enhancement of agricultural land or land for agricultural purposes;
- Providing for all or any of the following uses of the land that are consistent with the following purposes: recreational use, open space use, environmental education use, or use for research and scientific studies of natural ecosystems; and
- Designation as a Provincial Historic Resource or a Municipal Historic Resource under the *Historical Resources Act*.

Before TDCs can be used by municipalities as a conservation tool, they must be established through a regional plan, or they must be approved by the Provincial Government.

Outside of the conservation tools that have been created through the *Alberta Land Stewardship Act*, there are other mechanisms through which municipalities may acquire lands for conservation, most of which rely on voluntary conservation action taken by private land owners. These tools may be utilized at any time during the municipal planning and development process, and include:

Land Purchase:

Municipalities can purchase land from a private land owner at any time for the purpose of conservation. For example, the City of Edmonton established a Natural Areas Reserve Fund in 1999, with the purpose of using these funds to purchase and protect natural areas. While land purchase for conservation is an option that is available, many municipalities do not have the financial resources available to purchase lands within their municipal boundaries, as the market value for these lands can be very high.

Land Swap:

In some cases, a land developer may be willing to “swap” or exchange natural areas for other developable lands that are owned by the municipality. In this case, the municipality and the developer would enter into an agreement to exchange the lands, such that the natural areas can be conserved.

Land Donation:

Land donation involves the transfer of ownership from a private land owner to the municipality, or to a conservation organization or land trust, who would hold the land for conservation in perpetuity. Lands that are donated to a conservation organization or land trust are eligible for the federal government’s Ecological Gifts program which provides donors with significant tax benefits.

The final set of conservation tools are directly available to municipalities, and are the most common and frequently used tools for acquiring riparian areas as part of land development and planning. However, these tools are enabled through the *Municipal Government Act*, which only gives municipalities the authority to use these tools at the time of subdivision. Thus, municipalities can only utilize these tools through formal land development and planning processes.

Environmental Reserve (ER):

Environmental Reserves are defined in the Act as waterbodies, watercourses, lands that are unstable or subject to flooding, and lands “not less than 6 metres in width abutting the bed and shore” of a waterbody or watercourse. While the Act allows municipalities to take a *minimum* of a 6 metre setback on Environmental Reserve lands (with no stated maximum), the conditions under which this taking is permitted is limited to cases where the setback is required to prevent pollution or provide public access to the bed and shore of the waterbody or watercourse. In addition, Section 640(4)(l) of the Act allows municipalities to establish development setbacks on lands subject to flooding, low lying or marshy areas, or within a specified distance to the bed and shore of any waterbody.

Environmental Reserve Easement:

In instances where the municipality and the landowner agree, Environmental Reserve lands may be designated as an Environmental Reserve Easement. An ER Easement serves the same purpose as ER, but differs in that the title of the reserve lands remains with the land owner; however, ER easements are registered on title by caveat in favour of the municipality.

Conservation Reserve:

Under Section 664.2(1), municipalities may designate an area as a Conservation Reserve if the area contains significant environmental features that are not required to be provided as Environmental Reserve. Under the Act, the purpose of taking the Conservation Reserve is to protect and conserve the significant environmental features in a manner that is consistent with other statutory planning documents. In designating a Conservation Reserve, the municipality must compensate the landowner in an amount that is equal to the market value at the time of the subdivision approval application.

7.3. Public Engagement

Public engagement is a critical component to the successful conservation and management of riparian areas. Without the support of the public, successful implementation of restoration and management programs are not possible. Further, many of the acquisition tools outlined above rely on voluntary participation by the public (e.g., land donations and conservation easement). Thus, ensuring that the public are aware of the various voluntary programs that exist for riparian habitat conservation, as well as formulating active partnerships that can capitalize on the public’s willingness to participate in such programs, is critical to the conservation and restoration of riparian habitats. Public engagement can take several forms, including the following:

Education, Extension and Outreach:

Increasing public awareness and appreciation for natural areas is a critical component to effective conservation and management. Thus, creating educational opportunities and programs, as well as supporting local conservation and stewardship groups is critical to achieving desired riparian conservation and restoration objectives in the Medicine-Blindman Rivers watershed.

Partnerships:

Given the limited number of tools available to municipalities for the acquisition of riparian areas on private lands, engaging in strategic partnerships to promote voluntary land conservation and management activities is essential. Central to this is developing partnerships with land trusts and conservation organizations, developing strong inter-municipal policies, and partnerships with the provincial government to promote and enhance collaboration and improve conservation outcomes

All of the tools outlined in this section are currently available to stakeholders in the Medicine-Blindman Rivers watershed for the purpose of conserving and managing riparian habitats; however, in order to focus management action in the watershed, it is essential that the RDRWA and its partners first define objectives and targets for the conservation, restoration, and management of riparian habitats. Once these objectives and targets have been outlined, specific action and the relevant tools associated with those actions can be identified. In some cases, there may be existing tools in place to achieve the desired management outcomes. In other cases, there may be gaps in the available tools, and new policies, partnerships, or programs may need to be developed in order to achieve the desired management objectives.

8.0 Conclusion

The overall goal of this project was to quantify and characterize the intactness of riparian management areas in the Medicine-Blindman Rivers watershed, and to further assess pressure on riparian system function by evaluating land use and land cover within local catchments immediately adjacent to the waterbodies included in this study. The results of this work provide the Red Deer River Watershed Alliance and its stakeholders with an overview of the status of riparian areas, and further provides a foundation of scientific evidence upon which to build a systematic and adaptive framework for riparian habitat management throughout the watershed.

In total, approximately 1,782 km of shoreline was assessed in the Medicine-Blindman Rivers watershed as part of this study. Notably, an additional 460 km of shoreline within the watershed has been previously assessed along the Blindman River (Fiera Biological 2018d), as well as along the shorelines of Gull and Sylvan Lakes and their tributaries (Fiera Biological 2018e), for a combined total of 2,242 km of shoreline within the watershed evaluated using the GIS approach. Results from this study indicate that 60% of the shoreline assessed is either High (38%) or Moderate (22%) Intactness, with the remaining 41% classified as Very Low (33%) or Low (8%) Intactness. Within the Medicine-Blindman Rivers watershed, the greatest length of shoreline classified as Very Low or Low Intactness was located within the Red Deer & Sylvan Lake subwatershed, and primarily within the jurisdiction of Lacombe County.

The next step in the advancement of meaningful riparian management and conservation in the Medicine-Blindman Rivers watershed will be to formalize a framework for action that includes defining achievable management outcomes and measurable targets, which can then be used to inform relevant collective action by key stakeholders. These actions can then be monitored on a regular basis to provide an evaluation of outcomes that feed into an adaptive and reflexive approach to riparian management through time. Importantly, this study contributes to a larger riparian assessment initiative across central Alberta that has included a number of other Watershed Planning and Advisory Councils (North Saskatchewan Watershed Alliance, Battle River Watershed Alliance, Athabasca Watershed Alliance), as well as the Government of Alberta. To date, this initiative has assessed over 6,000 km of shoreline, with another 20,000 km currently in process and expected to be completed in 2021. This on-going work is focused on lakes, streams, and creeks located outside the Medicine-Blindman Rivers watershed, but overlap with a number of the municipalities from this study, including Clearwater, Ponoka, Wetaskiwin, and Lacombe Counties. Combined, these riparian assessments will significantly advance watershed planning and stewardship activities within the Red Deer River watershed, and elsewhere in Alberta.

8.1. Closure

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Appendix A: Intactness & Prioritization Summary Table

Table 14. Length (km) and proportion (%) of shoreline classified into each Intactness category, summarized by municipality and waterbody.

Waterbody Name	Intactness								TOTAL	
	Very Low		Low		Moderate		High			
	km*	%	km*	%	km*	%	km*	%	km*	%
Anderson Creek										
Ponoka County	25.6	43	6.4	11	15.2	25	12.9	21	60.1	100
Blindman River										
Ponoka County	42.6	71	1.0	2	4.3	7	12.3	20	60.2	100
Block Creek										
Clearwater County	12.3	39	2.7	9	5.0	16	11.5	37	31.5	100
Blueberry Creek										
Clearwater County	3.2	10	2.2	7	9.3	30	16.1	52	30.8	100
Boyd Creek										
Ponoka County	19.8	44	3.2	7	12.4	28	9.1	20	44.5	100
Dickson Creek										
Red Deer County	11.4	28	3.9	10	20.3	50	4.8	12	40.4	100
East Lobstick Creek										
Clearwater County	2.4	10	2.3	9	2.7	11	17.3	70	24.7	100
Gilpatrick Creek										
Lacombe County	1.4	19	0.7	10	1.8	25	0.9	12	4.8	66
Red Deer County	0.1	1	0.4	5	2.0	27	0	0	2.5	34
Horseguard Creek										
Clearwater County	29.6	20	6.9	5	22.9	15	63.6	43	123.0	82
Lacombe County	6.5	4	7.8	5	8.1	5	3.8	3	26.2	18
Lasthill Creek										
Clearwater County	7.7	19	0.9	2	4.3	10	28.3	69	41.2	100
Lloyd Creek										
County of Wetaskiwin	0.0	0	0.2	0	0.0	0	22.0	19	22.2	19
Ponoka County	12.5	11	1.6	1	5.5	5	74.4	64	94.0	81
Lobstick Creek										
Clearwater County	15.4	20	3.0	4	7.4	10	51.2	66	77.0	100
Medicine Creek										
Clearwater County	15.8	4	0.0	0	5.0	1	35.8	9	56.6	13
Lacombe County	41.0	10	20.8	5	56.5	13	11.3	3	129.6	31
Ponoka County	45.3	11	4.5	1	6.9	2	32.4	8	89.1	21
Red Deer County	25.2	6	25.9	6	77.7	19	15.6	4	144.4	34
Nuorison Creek										
Lacombe County	1.7	28	1.8	30	1.0	17	0.7	12	5.2	87
Red Deer County	0.3	5	0.4	7	0.1	2	0	0	0.8	13
Open Creek										
Clearwater County	0.3	0	0.1	0	0	0	21.8	35	22.2	35
Ponoka County	9.9	16	0.5	1	4.2	7	26.2	42	40.8	65
Open Creek Reservoir										
Clearwater County	0.1	3	0.4	12	0.0	0	2.8	85	3.3	100
Piper Creek										
Red Deer	0.5	1	0.8	1	13.1	21	11.3	18	25.7	41
Red Deer County	21.3	34	3.4	5	9.1	14	3.3	5	37.1	59
Rainy Creek										
Lacombe County	16.1	34	2.6	5	10.8	23	18.2	38	47.7	100

Continued …

Table 14 *continued*. Length (km) and proportion (%) of shoreline classified into each Intactness category, summarized by waterbody and municipality.

Waterbody Name	Intactness								TOTAL	
	Very Low		Low		Moderate		High			
	km*	%	km*	%	km*	%	km*	%	km*	%
Sylvan Creek										
Red Deer County	7.9	25	0.7	2	9.1	29	13.3	43	31.0	100
Tindastoll Creek										
Red Deer County	31.0	51	5.6	9	17.3	29	6.5	11	60.4	100
Innisfail	5.2	4	0.1	0	0.7	1	3.1	2	9.1	7
Penhold	23.3	17	0.1	0	0	0	0	0	23.4	17
Red Deer	4.8	4	2.3	2	6.4	5	4.9	4	18.4	14
Red Deer County	49.5	37	5.8	4	11.1	8	16.9	13	83.3	62
Welch Creek										
Clearwater County	16.6	16	1.9	2	5.8	6	53.5	51	77.8	74
Ponoka County	4.8	5	1.6	2	0.3	0	20.6	20	27.3	26
West Lobstick Creek										
Clearwater County	4.7	27	1.3	7	3.6	21	7.9	45	17.5	100
Wilson Creek										
Clearwater County	0.1	0	0.1	0	1.0	1	33.8	34	35.0	35
Ponoka County	26.5	27	0.6	1	4.0	4	32.7	33	63.8	65
Unnamed Creek 01										
Ponoka County	0.1	3	1.2	41	1.1	38	0.5	17	2.9	100
Unnamed Creek 02										
Ponoka County	3.6	32	2.0	18	4.6	40	1.2	11	11.4	100
Unnamed Creek 03										
Ponoka County	3.0	38	1.5	19	1.9	24	1.4	18	7.8	100
Unnamed Creek 04										
Ponoka County	3.1	27	0.4	3	4.1	36	3.9	34	11.5	100
Unnamed Creek 05										
Lacombe County	7.7	68	0.8	7	2.5	22	0.4	4	11.4	100
Unnamed Creek 06										
Red Deer County	20.9	48	5.2	12	11.9	27	5.8	13	43.8	100
Unnamed Creek 07										
Red Deer County	12.3	91	0.8	6	0.4	3	0.0	0	13.5	100
Unnamed Creek 08										
Red Deer County	5.8	98	0.0	0	0.1	2	0.0	0	5.9	100
Unnamed Creek 09										
Red Deer County	4.6	59	0.2	3	3.0	38	0.0	0	7.8	100
Unnamed Creek 10										
Red Deer County	4.4	28	0.4	3	6.4	41	4.4	28	15.6	100
Unnamed Creek 11										
Innisfail	2.9	4	0.5	1	3.5	5	7.1	10	14.0	20
Red Deer County	12.9	19	3.5	5	7.8	11	30.3	44	54.5	80

*NOTE: All municipal data summaries were generated by using a spatial intersect rule in ArcGIS. Summarizing the data in this way assigns the entire length of an RMA that intersects a municipal boundary to a given municipality, even if the RMA extends beyond the municipal boundaries. Consequently, the sum of the shoreline length assessed for each intactness and prioritization category is greater than the values summarized by individual waterbody, HUC 8 and HUC 6.

Table 15. Length (km) and proportion (%) of shoreline classified into each prioritization category, summarized by municipality and waterbody.

Waterbody Name	Priority								TOTAL	
	High Restoration		Moderate Restoration		Moderate Conservation		High Conservation			
	km*	%	km*	%	km*	%	km*	%	km*	%
Anderson Creek										
Ponoka County	25.2	42	6.8	11	14.9	25	13.2	22	60.1	100
Blindman River										
Ponoka County	42.0	70	1.6	3	10.2	17	6.3	10	60.1	100
Block Creek										
Clearwater County	13.2	42	1.8	6	8.4	27	8.1	26	31.5	100
Blueberry Creek										
Clearwater County	5.4	18	0.0	0	25.4	82	0.0	0	30.8	100
Boyd Creek										
Ponoka County	21.6	48	1.5	3	14.2	32	7.3	16	44.6	100
Dickson Creek										
Red Deer County	9.4	23	5.9	15	20.1	50	5.1	13	40.5	100
East Lobstick Creek										
Clearwater County	4.2	17	0.6	2	11.0	44	9.0	36	24.8	100
Gilpatrick Creek										
Lacombe County	1.4	19	0.7	10	1.8	25	0.9	12	4.8	66
Red Deer County	0.1	1	0.4	5	2.0	27			2.5	34
Horseguard Creek										
Clearwater County	27.4	18	9.1	6	38.3	26	48.1	32	122.9	82
Lacombe County	7.2	5	7.1	5	11.0	7	1.0	1	26.3	18
Lasthill Creek										
Clearwater County	7.0	17	1.6	4	11.2	27	21.4	52	41.2	100
Lloyd Creek										
County of Wetaskiwin	0.0	0	0.2	0	0.0	0	22.0	20	22.2	20
Ponoka County	12.4	11	1.7	2	19.3	17	57.0	51	90.4	80
Lobstick Creek										
Clearwater County	15.4	20	3.0	4	7.4	10	51.2	66	77.0	100
Medicine Creek										
Clearwater County	15.7	4	0.1	0	5.0	1	35.8	9	56.6	13
Lacombe County	39.9	10	21.9	5	53.7	13	14.1	3	129.6	31
Ponoka County	28.0	7	21.8	5	6.2	1	33.1	8	89.1	21
Red Deer County	12.6	3	38.5	9	44.7	11	48.7	12	144.5	34
Nuorison Creek										
Lacombe County	1.7	28	1.8	30	1.0	17	0.7	12	5.2	87
Red Deer County	0.3	5	0.4	7	0.1	2			0.8	13
Open Creek										
Clearwater County	0.2	0	0.2	0	0	0	18.8	31	19.2	32
Ponoka County	0.0	0	10.4	17	0.0	0	30.4	51	40.8	68
Open Creek Reservoir										
Clearwater County	0.1	3	0.4	12	0.0	0	2.8	85	3.3	100
Piper Creek										
Red Deer	1.3	2	0.0	0	23.3	38	0.0	0	24.6	40
Red Deer County	24.7	40	0.0	0	12.4	20	0.0	0	37.1	60
Rainy Creek										
Lacombe County	17.8	37	0.9	2	19.3	40	9.7	20	47.7	100

Continued …

Table 15 *continued*. Length (km) and proportion (%) of shoreline classified into each prioritization category, summarized by waterbody and municipality.

Waterbody Name	Priority									
	High Restoration		Moderate Restoration		Moderate Conservation		High Conservation		TOTAL	
	km*	%	km*	%	km*	%	km*	%	km*	%
Sylvan Creek										
Red Deer County	7.6	25	0.9	3	1.7	6	20.7	67	30.9	100
Tindastoll Creek										
Red Deer County	31.0	51	5.6	9	17.3	29	6.5	11	60.4	100
Waskasoo Creek										
Innisfail	5.3	4	0.0	0	3.7	3	0.0	0	9.0	7
Penhold	12.7	10	5.1	4	0	0	0	0	17.8	14
Red Deer	7.1	6	0.0	0	11.3	9	0.0	0	18.4	15
Red Deer County	47.0	37	5.5	4	27.8	22	0.2	0	80.5	64
Welch Creek										
Clearwater County	10.8	11	7.7	8	5.6	6	49.6	49	73.7	73
Ponoka County	2.8	3	3.5	3	0.3	0	20.6	20	27.2	27
West Lobstick Creek										
Clearwater County	2.0	11	4.0	23	2.1	12	9.4	54	17.5	100
Wilson Creek										
Clearwater County	0.0	0	0.1	0	0.0	0	34.7	35	34.8	35
Ponoka County	17.2	17	9.8	10	1.4	1	35.3	36	63.7	65
Unnamed Creek 01										
Ponoka County	0.1	3	1.2	41	1.1	38	0.5	17	2.9	100
Unnamed Creek 02										
Ponoka County	3.5	31	2.1	18	4.6	40	1.2	11	11.4	100
Unnamed Creek 03										
Ponoka County	4.4	57	0.0	0	3.3	43	0.0	0	7.7	100
Unnamed Creek 04										
Ponoka County	3.6	31	0.0	0	8.0	69	0.0	0	11.6	100
Unnamed Creek 05										
Lacombe County	8.4	73	0.2	2	2.9	25	0.0	0	11.5	100
Unnamed Creek 06										
Red Deer County	20.6	47	5.5	13	11.8	27	5.9	13	43.8	100
Unnamed Creek 07										
Red Deer County	12.3	91	0.8	6	0.4	3	0.0	0	13.5	100
Unnamed Creek 08										
Red Deer County	5.8	98	0.0	0	0.1	2	0.0	0	5.9	100
Unnamed Creek 09										
Red Deer County	4.6	59	0.2	3	3.0	38	0.0	0	7.8	100
Unnamed Creek 10										
Red Deer County	1.5	10	3.3	21	5.9	38	4.9	31	15.6	100
Unnamed Creek 11										
Innisfail	3.3	5	0.1	0	5.3	8	5.3	8	14.0	20
Red Deer County	13.7	20	2.8	4	25.5	37	12.6	18	54.6	80

*NOTE: All municipal data summaries were generated by using a spatial intersect rule in ArcGIS. Summarizing the data in this way assigns the entire length of an RMA that intersects a municipal boundary to a given municipality, even if the RMA extends beyond the municipal boundaries. Consequently, the sum of the shoreline length assessed for each intactness and prioritization category is greater than the values summarized by individual waterbody, HUC 8 and HUC 6.

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