North Saskatchewan Watershed Alliance

Riparian Health Assessment of Wabamun Lake

An Aerial Assessment Using an Unmanned Air Vehicle

May 2015

North Saskatchewan Watershed Alliance

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The North Saskatchewan Watershed Alliance (NSWA) is a non-profit society whose purpose is to protect and improve water quality and ecosystem functioning in the North Saskatchewan River watershed in Alberta. The organization is guided by a Board of Directors composed of member organizations from within the watershed. It is the designated Watershed Planning and Advisory Council (WPAC) for the North Saskatchewan River under the Government of Alberta's *Water for Life* Strategy.

This report was prepared by Mary Ellen Shain, M.Sc. of the North Saskatchewan Watershed Alliance.

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Sponsorship Acknowledgement

This project was initiated by the Wabamun Watershed Management Council (WWMC), a recognized Watershed Stewardship Group according to Alberta's *Water for Life* policy. The Council represents a cross-section of stakeholders in the watershed who are committed stewards of Wabamun Lake. The concept for the Council was originally proposed in 2004 by Dr. David Schindler in a report titled *Lake Wabamun: A Review of Scientific Studies and Environmental Impacts*. The Council was formed by Alberta Environment in the fall of 2006, and incorporated under the Alberta Societies Act in 2010.

The Wabamun Watershed Management Council is committed to developing a management plan that sustains the natural viability and health of Wabamun Lake and its watershed. This riparian assessment project will contribute greatly to the development of that plan.

The WWMC acknowledges the financial assistance of the Land Stewardship Centre for making this project possible. The Land Stewardship Centre contributed to the delivery of this project through the Watershed Stewardship Grant Program, funded by Alberta Environment and Sustainable Resource Development. The Land Stewardship Centre is committed to working with Watershed Stewardship Groups to increase public awareness of the importance of the grassroots initiatives that are having a positive impact on watersheds and communities across Alberta. Opinions expressed in this publication are those of the North Saskatchewan Watershed Alliance and not necessarily those of the Land Stewardship Centre.

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Images
Cover Page –Seba Beach at Wabamun Lake (photo produced by NSWA)
Figure 1 – Extracted from Teichreb and Walker (2008)
Figure 2 – Used with permission from Cows and Fish. www.cowsandfish.com
Figure 3 – Provided by Gruvpix Inc.
Figures 4-11 – North Saskatchewan Watershed Alliance
Appendix 1 – Provided by Walker Environmental Ltd., unpublished
Appendix 2 – Transport Canada (2015)
Appendix 3 – Extracted from Walker (2006)

Executive Summary

The North Saskatchewan Watershed Alliance (NSWA) was approached by the Wabamun Watershed Management Council in 2014 to assess the health of the Riparian Management Area of Wabamun Lake. The ensuing project was conducted using new aerial videography methods. These methods included video footage captured by a quad-copter unmanned air vehicle (UAV- commonly known as a drone), high-definition footage and ortho-rectified photographs on an ArcGIS platform. The use of this innovative approach was considered to be highly successful and cost- effective.

It is important to note that aerial riparian assessments provide coarse-scale results. It is appropriate to use coarse-scale assessments to generate information regarding broad trends in riparian health; this assessment is not intended to provide site-specific advice to landowners.

The results of this riparian health assessment indicate that approximately 57% of Wabamun Lake's Riparian Management Area is in healthy condition, 9% of the area considered moderately impaired and 34% of the area rated as highly impaired. Impairment implies that a Riparian Management Area is partly or fully incapable of performing valuable ecological functions.

The longest continuous stretch of impaired area is on the western shore adjacent to the Summer Village of Seba Beach. The longest continuous stretch of healthy area is on the eastern shore adjacent to the Paul Band First Nation territory. Residential development is the major cause of riparian disturbance on Wabamun Lake.

This assessment has been prepared as a general knowledge contribution to the Wabamun Watershed Management Council, and as background information to support the multi-jurisdictional planning process being led by Parkland County to develop the *Wabamun Lake Sub-watershed Land Use Plan*.

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Table of Contents

List of Figures

List of Tables

1.0 Introduction

The Riparian Management Area (RMA) of a lake is composed of the littoral zone, the riparian zone and the buffer zone (Walker 2008). The littoral zone is the region of shallow inshore water which supports the growth of emergent and submergent vegetation. In this study, only the emergent vegetation could be considered because of the inability to assess submergent vegetation from the air. The riparian zone is defined as the "transitional area between upland and aquatic ecosystems. Riparian zones have variable width and extent above and below ground, and perform various functions. These lands are influenced by, and exert an influence on, associated water bodies including alluvial aquifers and floodplains. Riparian lands usually have soil, biological and other physical characteristics that reflect the influence of water and hydrological processes" (Alberta Water Council 2013). The buffer area is the upland region immediately adjacent to the riparian zone (Figure 1 and Figure 2).

RMAs perform a myriad of ecosystem functions: improving water quality by processing sediment and nutrients; slowing storm flows; improving resilience against drought; stabilizing the bank and shoreline; providing habitat to terrestrial and aquatic life; and maintaining overall biodiversity (AESRD 2012).

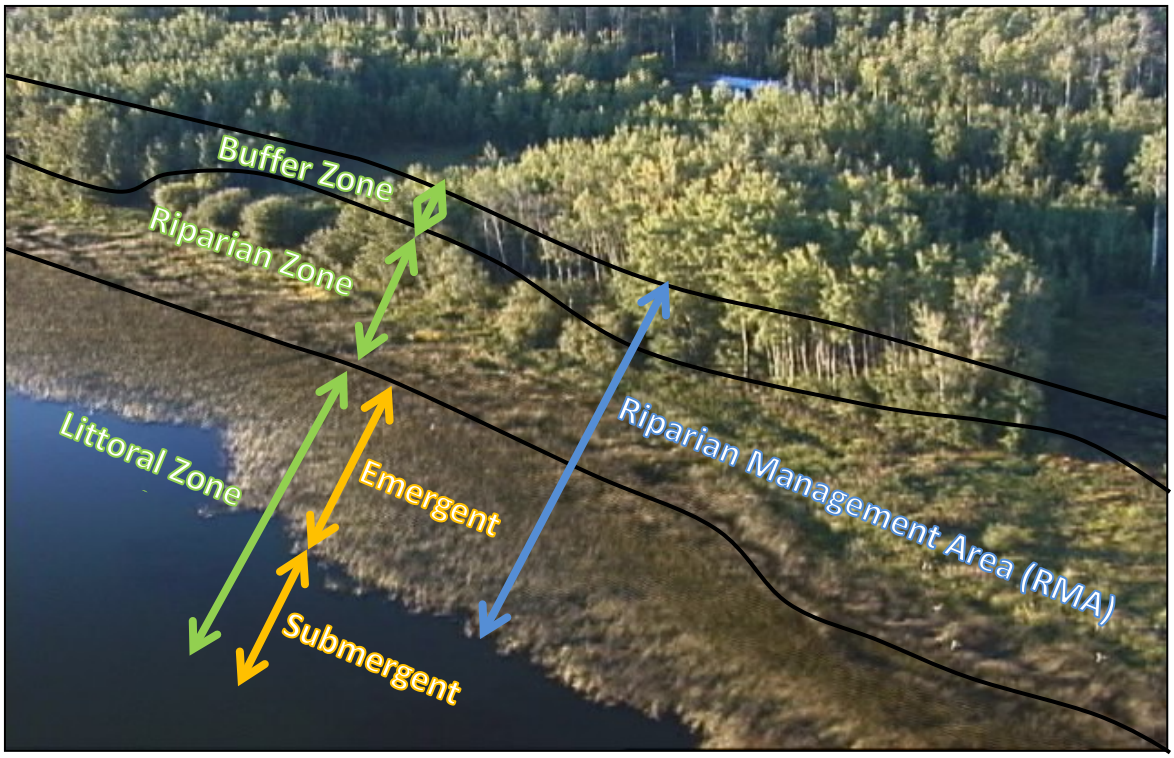

Figure 1 Diagram of a Riparian Management Area (RMA) and its components: the emergent vegetation zone, the riparian zone, and the buffer zone. Source: Teichreb and Walker (2008).

A riparian health assessment is a method to estimate the ability of the RMA to perform a number of these key ecological functions by estimating the amount of human-caused change to the area.

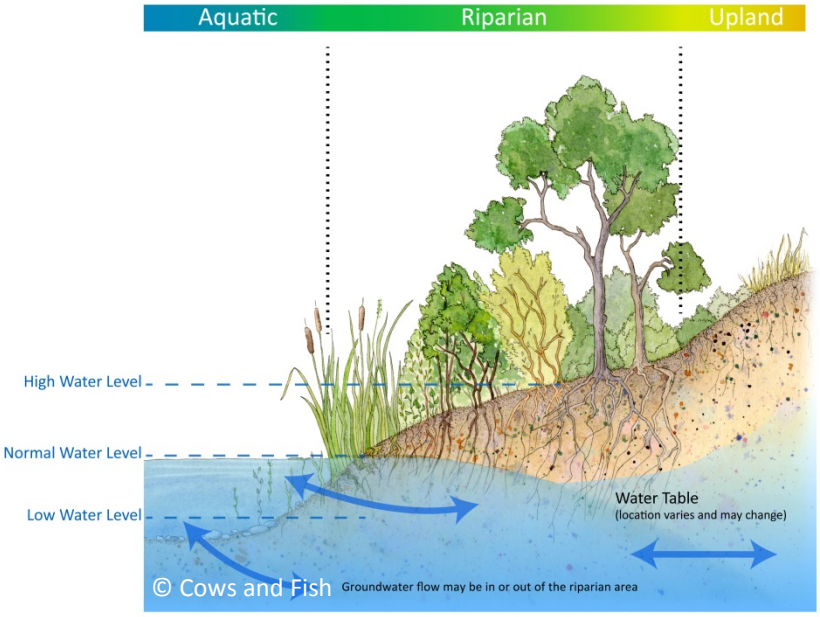

Figure 2 Diagram of a riparian zone. Used with permission from Cows and Fish.

A riparian health assessment is a useful tool in the larger scope of lake, river and wetland management. The results can illustrate when the integrity of resources (e.g. aquatic and terrestrial biota) are compromised and an ecosystem is constrained from providing services that would benefit the entire community. In the case of a lake, an unhealthy RMA could be a reflection of several factors: historic and/or current development policy deficiencies; lack of enforcement of existing bylaws and policies; and a lack of ecological knowledge on the part of lakeside property owners.

There are different methods that can be used to perform a riparian health assessment, providing fine-scale to coarse-scale results. The use of aerial video footage is considered coarse-scale. The advantages of using this method to evaluate the health and integrity of RMAs include the following: a large region can be assessed continuously without the need for permission from landowners, which can be time-consuming; a permanent record can be captured in a single study and processed anytime; and the process is cost-effective. Disadvantages of aerial assessments include the lack of detail on specific sites, and the lack of detail on species composition and biodiversity. It is appropriate to use coarse-scale assessments to generate information regarding broad trends in RMA health; it is not appropriate to use coarse-scale assessments to provide site-specific advice to landowners (AWC 2013).

Aerial videography methods have been utilized and reviewed by several authoritative agents in Alberta, including Alberta Environment and Sustainable Resources Development, Walker Environmental Ltd. and the Alberta Conservation Association. The Alberta Conservation Association compared the aerial method to the traditional ground-based method on the Battle River and found that the resulting RMA health scores were similar (Mills and Scrimgeour 2004; Teichreb and Walker 2008). In another study, Alberta Environment staff compared the two methods and concluded that the aerial method is practical and cost-effective as a rapid assessment tool “even though it cannot match the accuracy of ground-based methods” (Alberta Environment 2010).

Walker Environmental Ltd. report that aerial video footage has been captured for approximately 25 lakes in Alberta, but assessments have only been conducted for 17 lakes (Walker, unpublished data). See Appendix 1 for a summary of results from these other studies. Previous video footage was collected for Wabamun Lake in 2002 via helicopter; unfortunately, these survey images have not yet been evaluated.

The most popular approach to capturing aerial video footage to date has been by helicopter and the use of the *Redhen* GPS tracker. The limitations of this approach are high expense, difficulties in scheduling qualified pilots and the restrictiveness of the minimum flight altitude. For this project, an alternate method was chosen: an unmanned air vehicle (UAV) carrying a *GoPro Hero* camera in conjunction with a *Flytrex Core* GPS data-logger. This method was experimental but proved to be quite successful. The resulting video footage was of high quality with stable imagery in high definition.

The scoring method used in this study was identical to the version used by Walker Environmental Ltd. The Walker version has been used extensively to assess other lakes in Alberta. Training on the use of these methods was generously provided by Walker Environmental Ltd. to the North Saskatchewan Watershed Alliance. This version is based on standard methods developed by Mills and Wicklum (1996) that were subsequently modified to extend the RMA to include a portion of the buffer zone. This is a useful modification due to the fact that in some areas on lakes the riparian zone is naturally narrow, thus shifting emphasis to the buffer zone to perform the RMA ecosystem functions (Teichreb and Walker 2008).

Lake shorelines in Alberta consist of both public and private lands. One modern 'best management practice' is to establish Reserve Lands (RL) between new developments and water bodies for the purpose of maintaining the natural condition of a shoreline. Reserve Lands are municipally owned spaces. Establishment of a Reserve Land is prescribed, though not required, under Alberta's *Municipal Government Act*. When a municipality chooses to establish a Reserve Land, the *Municipal Government Act* prescribes that the municipality designate the Reserve Land using specific categories: environmental reserve, municipal reserve, school reserve, or road and utility reserve, etc. These categories are intended to establish a long-term purpose for each Reserve Land site.

Figure 3 Example of Reserve Lands on Wabamun Lake. Reserve Lands are shown in red. All other lands in this image are held privately.

Most of the Reserve Lands adjacent to Wabamun Lake have not been specifically designated using a provincial category. Instead, the purposes and management of the Reserve Lands are outlined in the bylaws of each municipality. For the municipalities on Wabamun Lake, Reserve Lands are often referred to as "Park" (Parkland County 2002); certain activities are restricted to protect these spaces, although the purposes of each Reserve Land are not often defined in the bylaws. The Summer Villages of Seba Beach, Lakeview and Betula Beach also have Reserve Lands that exist between private development and the lakeshore. These areas are also sometimes referred to as "Park" (Betula Beach 2014). In almost every bylaw, removal of vegetation is prohibited in Reserve Lands, unless permission is granted by the municipality.

Another legal 'best management practice' is to establish Environmental Reserve Easements on land titles, for the purpose of protecting and enhancing the environment. However, the health of easements on Wabamun Lake cannot be reported upon because the records were inaccessible at the time of this study.

2.0 Methods

2.1 Videography

Video footage of Wabamun Lake was captured over three days in early August 2014. The unmanned air vehicle (UAV) (Figure 3) was launched from a boat that was provided by members of the Wabamun Watershed Management Council. A pontoon boat was used at first, but proved to be too slow to keep up with the UAV, so a speed boat was used instead. As the UAV captured data from the air, the 3-person crew followed below in the boat. The crew was made up of the boat pilot, the UAV pilot, and project manager who provided feedback on video footage while in the field. The UAV was navigated using a 5.8 GHz radio remote control, with the assistance of live footage that was broadcasted via Bluetooth from the UAV to a *SmallHD AC7* field monitor. Flight time was limited by the battery charge life (approximately 10-15 minutes); it was essential to have several batteries available to be recharged in the field.

Figure 4 Photograph of the unmanned air vehicle (UAV), camera, and controller.

For safety, the drone was not flown over private property, but rather over the lake with the camera angled 30-45 degrees towards the shoreline. The angle provided a depth perspective that proved to be valuable for the assessment.

Video footage was taken from a height of approximately 30-40 meters above lake level (ensuring that the entire RMA was visible) using a *DJI Phantom* Quadcopter UAV that housed a stabilized *GoPro Hero3* camera (weighing approximately 1.2 kg). The drone was flown at an approximate speed of 10 kilometers per hour. Footage was taken in full HD resolution (1920 x 1080 pixels) at 30 frames per second. Geo-spatial data were recorded using a *Flytrex Core 2.0* GPS data logger which was mounted to the drone.

Transport Canada recently released new safety regulations for operating UAVs for the purpose of work and research. Under these new regulations this project met the criteria for a Permission Exemption, because the UAV weighed less than 2 kg and the other exemption requirements were met. See Appendix 2 for more details on Transport Canada`s Exemption Requirements.

2.2 Video Processing

In the post-production processing step, *DashWare* software was used to synchronize the spatial data—including altitude, speed and GPS coordinates—with the video footage. A permanent video record now exists with the spatial data overlaid onto the video footage, making it possible to perform various assessments (Figure 4).

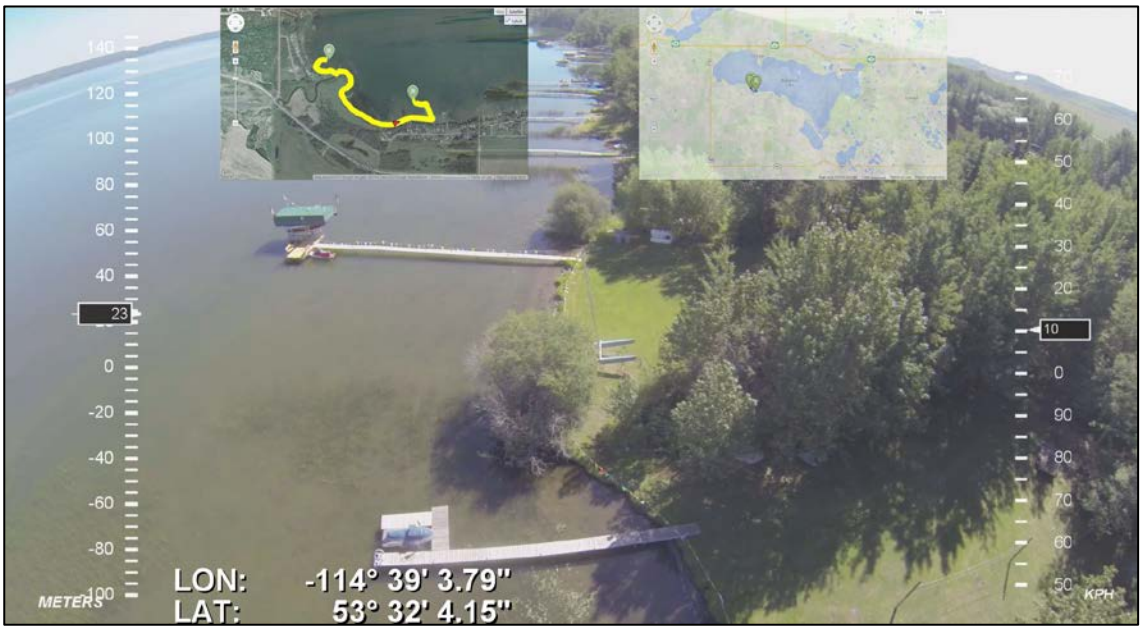

Figure 5 Screen shot of post-processed video footage. The footage now includes spatial data overlaid. The bar-scale on the left is measured in meters above the launch height. The bar-scale on the right is speed measured in kilometers per hour.

2.3 Health Assessment Scorecard

The scoring methodology used in this study was described by Teichreb and Walker (2008). It is a modified version of the scorecard that was first developed by Scrimgeour and Wicklum (1996) of the Alberta Conservation Association. In this modification, the authors extended the segment width to include a portion of the upland buffer zone, renaming the area of interest the 'riparian management area' (RMA). To make the results more relevant to policy makers in this area, the segment width was extended to 30 meters from the water's edge.

In the modification developed by Teichreb and Walker (2008) no attempt was made to assess the segment length by land ownership parcels; rather, the beginning and end of each segment is determined by homogeneity (sameness) of that segment. In other words, when there was a significant change in the condition of the RMA, a new segment would begin. The length of segments in this analysis can range from several meters to several kilometers, potentially spanning many ownership parcels and political boundaries (Figure 5).

Figure 6 Diagram illustrating Riparian Management Area segments by length and width.

The scorecard poses seven questions that reflect important ecological services that are provided by a healthy RMA. See Appendix 3 for the original riparian health assessment scorecard. For each segment, the trained technician observed the video and provided an answer to each question using an Excel spreadsheet that was pre-designed for this purpose. In the spreadsheet, the scores were recorded for each question, the total score was tallied (the maximum being 11 points), and then each segment was assigned a rating. The ratings were *Healthy* (8.5 points or more, corresponding to >78% of maximum possible points), *Moderately Impaired* (between 6-8 points, corresponding to 51% - 77%) or *Highly Impaired* (5.5 points or less, corresponding to <50%) (Teichreb and Walker, 2008).

For this project, additional data were collected for each segment including the quantification of bare ground, beaches, docks and boats where they were evident in the RMA. The geo-spatial coordinates for the beginning and end of each segment were recorded in the spreadsheet as well.

2.4 Mapping Using Ortho-Rectified Photographs

An ortho-rectified photo is an aerial photograph that has been geographically corrected in a digital format such that the scale is uniform, making it useful for Geographical Information System (GIS) analyses. The availability of high definition ortho-rectified photographs was helpful for this project. They were made available by Parkland County (see item 1 in Section 2.5). First, they were relied upon for obtaining more precise coordinate positions of the segments (because the coordinates gathered *in situ* represent the UAV location rather than the shoreline location). Second, the bird's-eye view provided an alternative to the angled video footage, correcting for the potential distortion of distant features. Third, the ArcGIS tools could be used to easily measure the length and area of important features (for example, the percentage of area that a building occupies in a segment). Finally, the ortho-rectified photographs were used for areas where no video footage could be captured.

Once the health assessment was complete, the data were imported into ArcGIS as a "point feature". The point feature was used to split an existing "line feature" (see item 2 in in Section 2.5), which represents the shoreline of Wabamun Lake as individual segments. Each segment in this new line was then provided with a unique segment code that allowed it to be joined with a table containing the health rating. It was then exported as a new "line feature", called *Wabamun_HealthAssessment*, containing the segment location data, segment length (meters) and health score. The attribute table for this feature was exported into Excel to update the original spreadsheet so to include the length of each segment. The creation of a GIS "shapefile" has made it simple to share the data and to perform subsequent analyses.

To determine the health rating within each jurisdiction, boundary layers (see items 4-7 in in Section 2.5) were overlaid on the *Wabamun_HealthAssessment*, and the inclusive segments were exported as new shapefiles for each jurisdiction. Segments that exceeded the outer limits of the boundary layer were edited to fit the jurisdictional boundaries. New segment lengths were then calculated.

2.5 GIS Data Layer References

1. Parkland County. *Parkland_25CM_BLOC1-5.sid*. Alberta. Scale 1:350,000. 2013.
2. Alberta Environment & Alberta Geological Survey. *waba_bdy_py_tm.* Alberta. Scale 1:80,000.
    - Modification: Polygon was converted into a line feature. It was then amended to remove wetlands that were mistakenly identified as islands. Goosequill Bay was added to the shoreline. The mining outlets were removed from the feature.
3. North Saskatchewan Watershed Alliance. *Wabamun_ HealthAssessment*. Alberta. 2015.
    - Wabamun_HealthAssessment was created in GCS_North_American_1983_CSRS, coordinate system and using the NAD_1983_CSRS_10TM_AEP_Forest map projection. This is a standard projection used by Alberta Environment and Sustainable Resource Development.
4. Parkland County. *Parkland_Parcels_May2014.* Stony Plain, AB. 2014
5. Alberta Environment and Sustainable Resource Development. *BF_Summer_Village_Polygon.* Edmonton, AB*.* 2011.
6. Alberta Environment and Sustainable Resource Development. *BF_Indian_RES_Polygon*. Edmonton, AB. 2014.
7. Alberta Environment and Sustainable Resource Development. BF_Village_Polygon. Edmonton, AB. 2014.

3.0 Results

To estimate an average health rating for Wabamun Lake, the sum of the weighted scores was calculated using segment length as the priority factor. The results of this study show that Wabamun Lake has a score of 7 out of 11 possible points, meaning that the Riparian Management Area (RMA) is moderately impaired in its capacity to perform riparian functions. This rating can be further broken down: 57% of the RMA is rated as healthy; 9% of the RMA is rated as moderately impaired; and 34% of the RMA is rated as highly impaired (Figure 6).

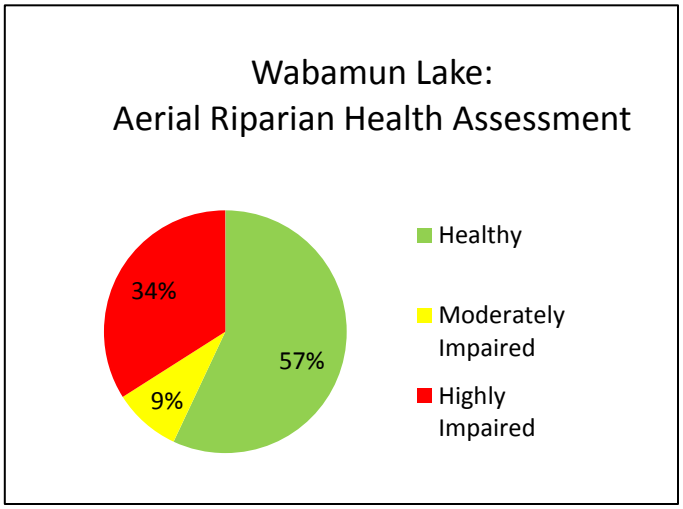

Figure 7 Results of the Wabamun Riparian Health Assessment.

Other details were gathered in this study (Table 1) including the length of beaches, length of hard armouring and area of bare ground. There are numerous unnatural beaches[1] on Wabamun Lake, amounting to approximately 4.6 linear kilometers. It was observed that there was a high degree of erosion in areas where trees were removed from the RMA; some residents have taken action to reduce erosion by armouring the shoreline with rip-rap such as large boulders, cinder blocks or concrete pads. The total length of shoreline with hard armour amounted to 5.9 linear kilometers. Bare ground[2] was also measured. The amount of bare ground in the RMA of Wabamun Lake amounted to 25.9 square kilometers. These three features are not mutually exclusive, and often exist in the same regions.

The outcome of each question in the scorecard can indicate the manner in which riparian functions have been compromised (Table 2). Generally speaking, the highly impacted RMAs of Wabamun Lake are in residential developments, which have expansive lawns with species compositions that appear to be dominated by turf grass. Turf grass, in comparison to native grass, is not functional in terms of erosion control or runoff filtration due to its shallow root system (Fitch and Ambrose 2013). In residential areas, trees have often been removed between buildings and the shoreline, and emergent vegetation is usually

[1] Unnatural beaches are defined as shoreline where any man-made alternations have occurred. This could include introduction of artificial sand or removal of vegetation from a naturally sandy shoreline.
[2] Bare ground is coarsely defined as areas of exposed soil resulting from vegetation removal. These areas include unpaved dirt parking lots and extensive unnatural beaches (greater than 4 meters in width)

absent in the littoral zone. The difference between the results of question 5 & 6 of the scorecard likely indicates that 9% of the RMA of Wabamun Lake contains permanent structures, such as a house or other large building, within 30 meters of the shoreline.

Table 1 Summary of results for the 2014 Wabamun Lake riparian health assessment.

Item	Result
Total shoreline length	67.4 km
Total number of segments	355
Total weighted sum of scores	7/11 (Moderately Impaired)
1. Rating: Healthy	Length= 38.4 km; Percent= 57%
2. Rating: Moderately impaired	Length= 6.0 km; Percent= 9%
3. Rating: Highly impaired	Length= 22.9 km; Percent= 34%
Total length of unnatural beach	4.6 km
Area of bare ground	25.9 km^2
Length of hard armoured shoreline	5.9 km

Table 2 Weighted average outcomes, of all segments, for each question asked in the scorecard. Outcomes are calculated by dividing the total points obtained by possible points available for each question. Higher outcomes equate to healthier riparian ecosystems. Based on Scrimgeour and Wicklum (1996); updated by Teichreb and Walker (2008).

Scorecard Question	Wabamun Lake: Average outcome
1. More than 85% of the RMA is covered with vegetation of any kind	80%
2. Cattails and bulrushes are visibly growing in the adjacent littoral zone	57%
3. More than 15% of the RMA contains woody plants (eg. willow, birch, poplar)	70%
4. Within the woody area (identified in question 3), the abundance of trees are dense	59%
5. In less than 35% of the RMA, there are signs of human activity (e.g. cutting or mowing of vegetation)	59%
6. In less than 35% of the RMA, there are signs of human caused alteration to the soil (e.g. cultivation of soil, addition of concrete, patios, buildings)	68%
7. The segment appears impacted (see Appendix 3 for details)	51%

A map was created to illustrate the distribution of the health rating scores around Wabamun Lake (Figure 7). Approximately 53% of the RMA of Wabamun Lake is managed by Parkland County, 20% by Paul First Nation, 13% by summer villages, 9% by the Province of Alberta and 5% by the Village of Wabamun. A summary was created to compare the health scores of each jurisdiction (Figure 8). Summaries were also created to compare the health scores between each summer village (Figure 9) and between each subdivision and hamlet on Wabamun Lake (Figure 10). See Appendix 4 for a detailed summary of the riparian health assessment data.

The region with the longest continuous stretch of healthy RMA is adjacent to the Paul Band First Nation territory, on the eastern shore. Due to extenuating circumstances, there was no video footage captured for a large portion of the eastern shore. However, it was still possible to perform a health assessment for this region using a combination of ortho-rectified photographs and field observations. This area has undergone a recent fire, evident by the lack of trees in a mature age class. Despite this, the forest is regenerating and currently has a dense stand of saplings. In addition, the littoral zone adjacent to this area is dense with bulrushes and cattails that appear to provide important habitat for the lake's Western Grebe population, clearly observed in the field during the videography phase. There is no residential development in this region, although there is a golf course adjacent to the lake in the northwest corner of the territory.

The longest continuous stretch of highly impaired RMA is adjacent to the Summer Village of Seba Beach, on the western shore. In this region, the impacts of residential development are the most severe and reflect historical practices which would not meet modern 'best management practices' for lakeside living. Many large buildings are well within 30 meters of the shoreline, occupying between 40-60% of the Riparian Management Area. The riparian zone has been replaced by numerous unnatural beaches, including one that is almost a kilometer long and lacking vegetation of any type. Furthermore, the adjacent littoral zone is devoid of emergent vegetation. The integrity of the RMA in this region is highly impaired, meaning that it is unlikely to be performing any significant riparian functions.

Approximately 52% of the RMA within Parkland County's subdivisions and hamlets is contained within Reserve Lands (Figure 11). This assessment of this RMA indicates that 31% is healthy, 23% is moderately impaired and 46% is highly impaired. It was evident that adjacent landowners were often using these Reserve Lands as a continuation of their own private properties. Despite this, RMAs contained within Reserve Lands have markedly better scores compared to RMAs contained within private properties, wherein only 9% are healthy, 12% are moderately impaired and 79% are highly impaired.

Of the total RMA managed by all summer villages on Wabamun Lake, approximately 34% is contained within Reserve Lands. The proportion of RMA within Reserve Lands varies by summer village. For example, the RMA managed by Betula Beach is entirely within Reserve Land, while at Seba Beach, approximately 46% is contained within Reserve Land. The Summer Villages of Kepasiwin and Point Allison have no RMA land within Reserve Land. A summary was created to compare the health ratings of land contained within Reserve Land vs. outside of Reserve Land (Figure 12). In the case of Seba Beach

and Lakeview, the condition of RMA within Reserve Land was more impaired than land managed outside of Reserve Land.

There is room to improve RMA condition in all jurisdictions. Protection or restoration actions vary in difficulty depending on the severity of the impairment and legal authority of land managers to take action. For example, land managers may have legal authority to restore Reserve Lands, to enforce policies and bylaws on recently impaired lands and to create new policies to prevent further impairment. They may not have the legal authority to enforce policies or bylaws on impaired lands that predate the policies and bylaws; in that case, restoration actions would be voluntary.

A table was created to summarize the relative difficulties of various actions, and their potential, cumulative, beneficial effects on the lake (Table 3). “Difficulty” is measured as an estimate of restoration costs and legal costs due to ownership where 0 = low and 1 = high. Reserve Lands refer to publicly owned land, either by a municipality or by the Crown. Non-Reserve Lands refer to land owned privately. The cumulative effect represents all jurisdictions working together to achieve each successive action.

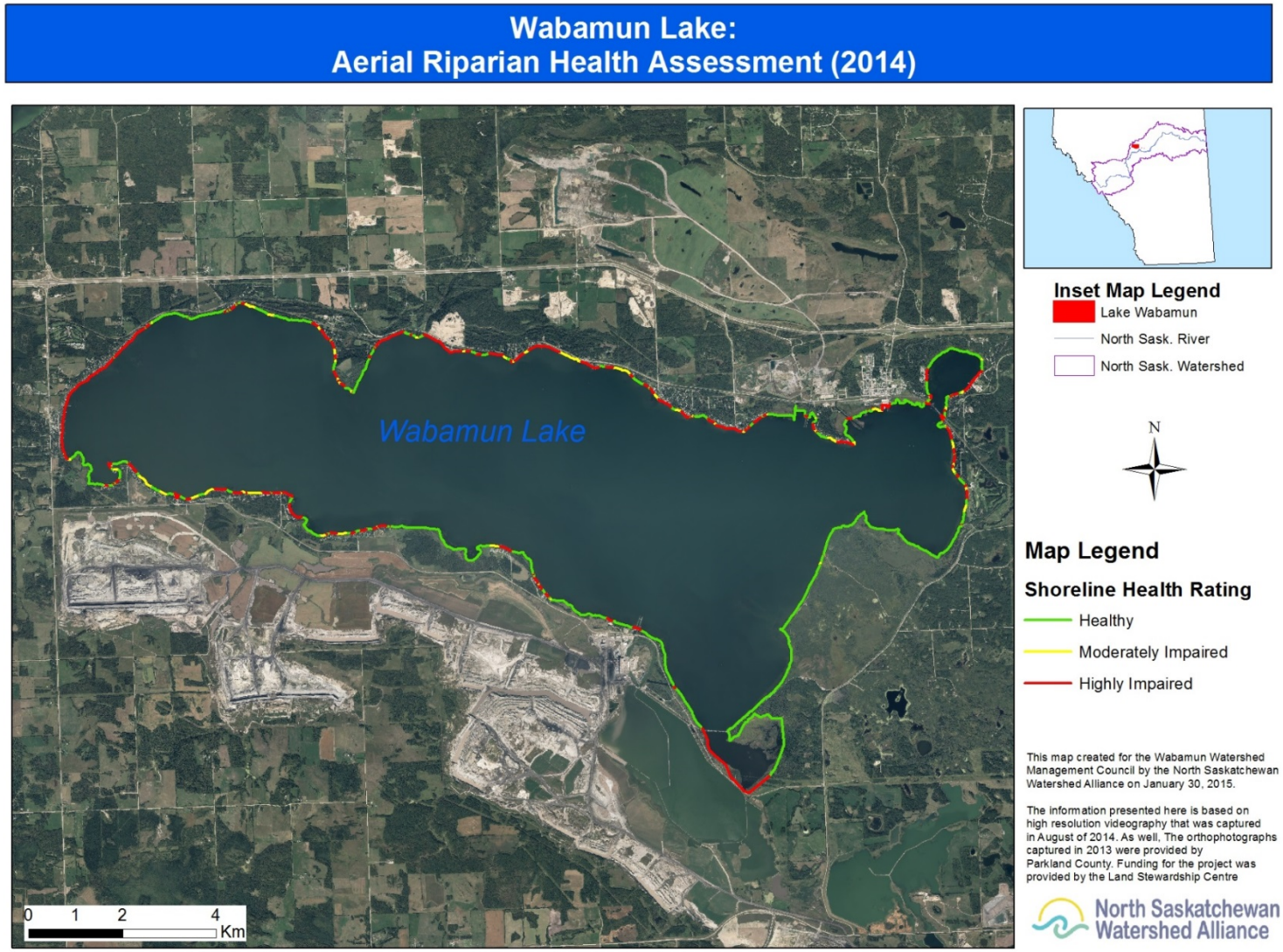

Figure 8 Map showing results of the Wabamun Lake Riparian Health Assessment. Green= Healthy; yellow= Moderately Impaired; red=Highly Impaired.

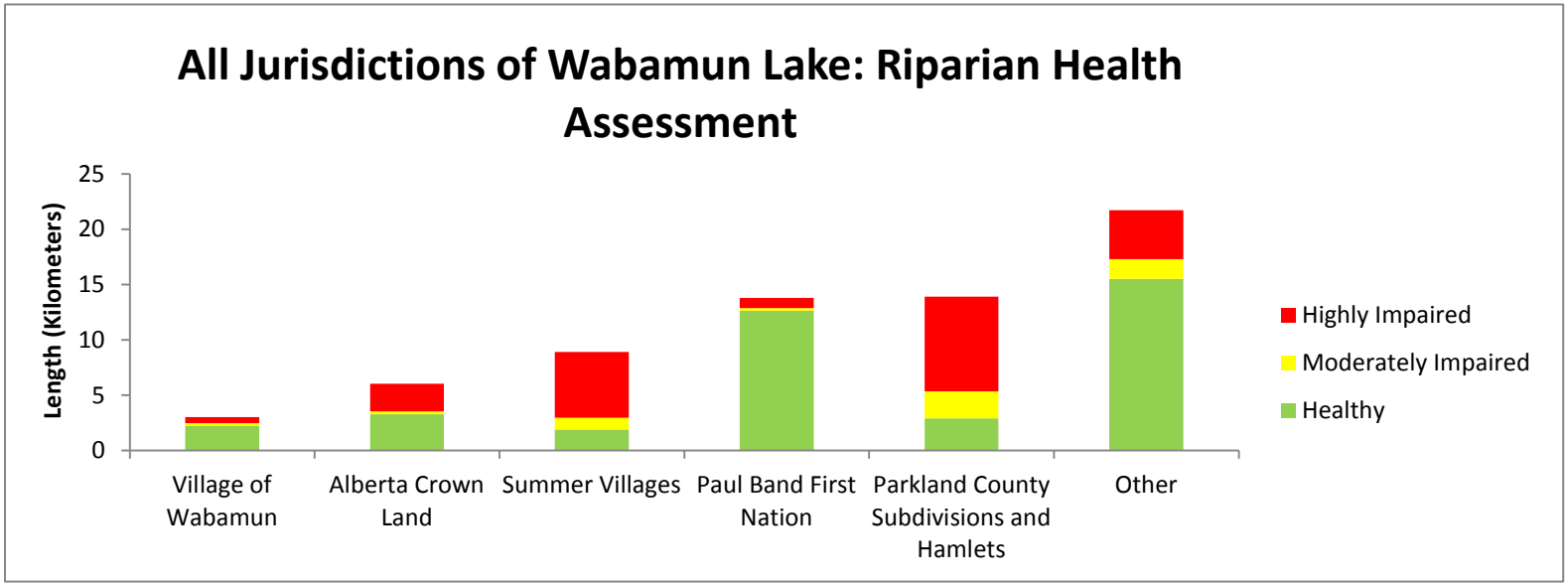

Figure 9 Summary of results comparing all jurisdictions on Wabamun Lake. The region described as "other" is land that is controlled by Parkland County but not included in subdivisions or hamlets.

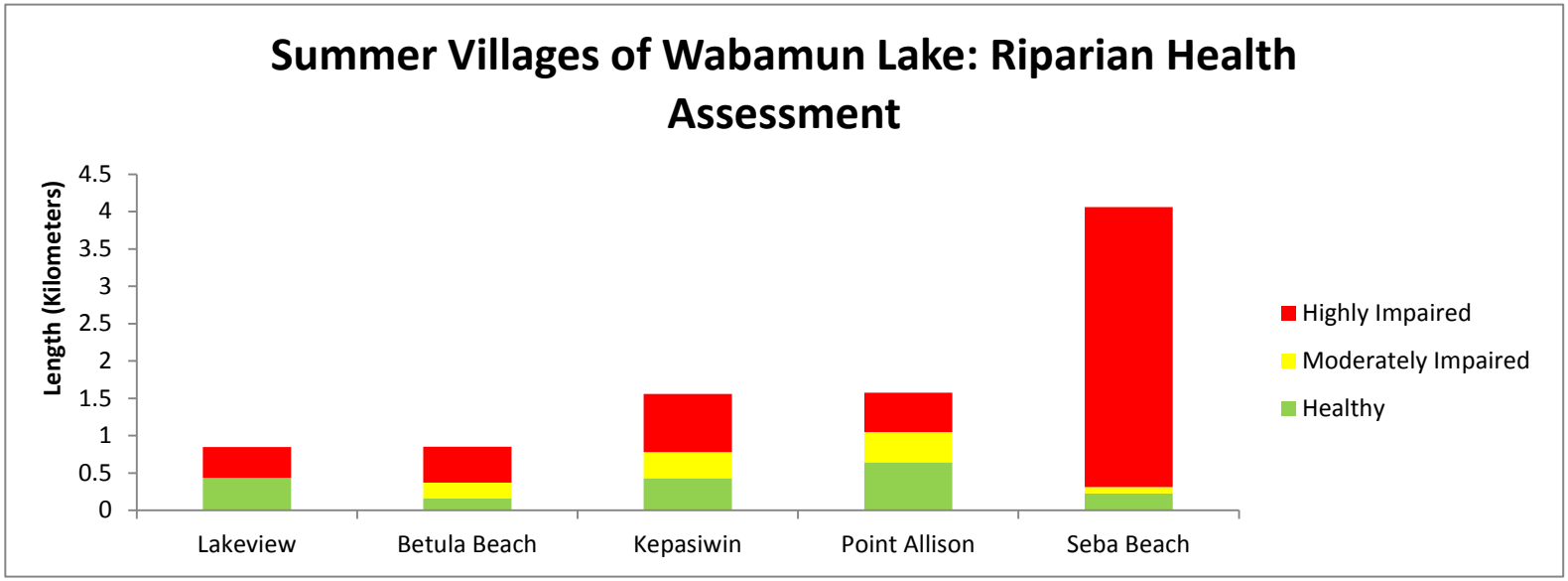

Figure 10 Summary of results comparing Summer Villages on Wabamun Lake.

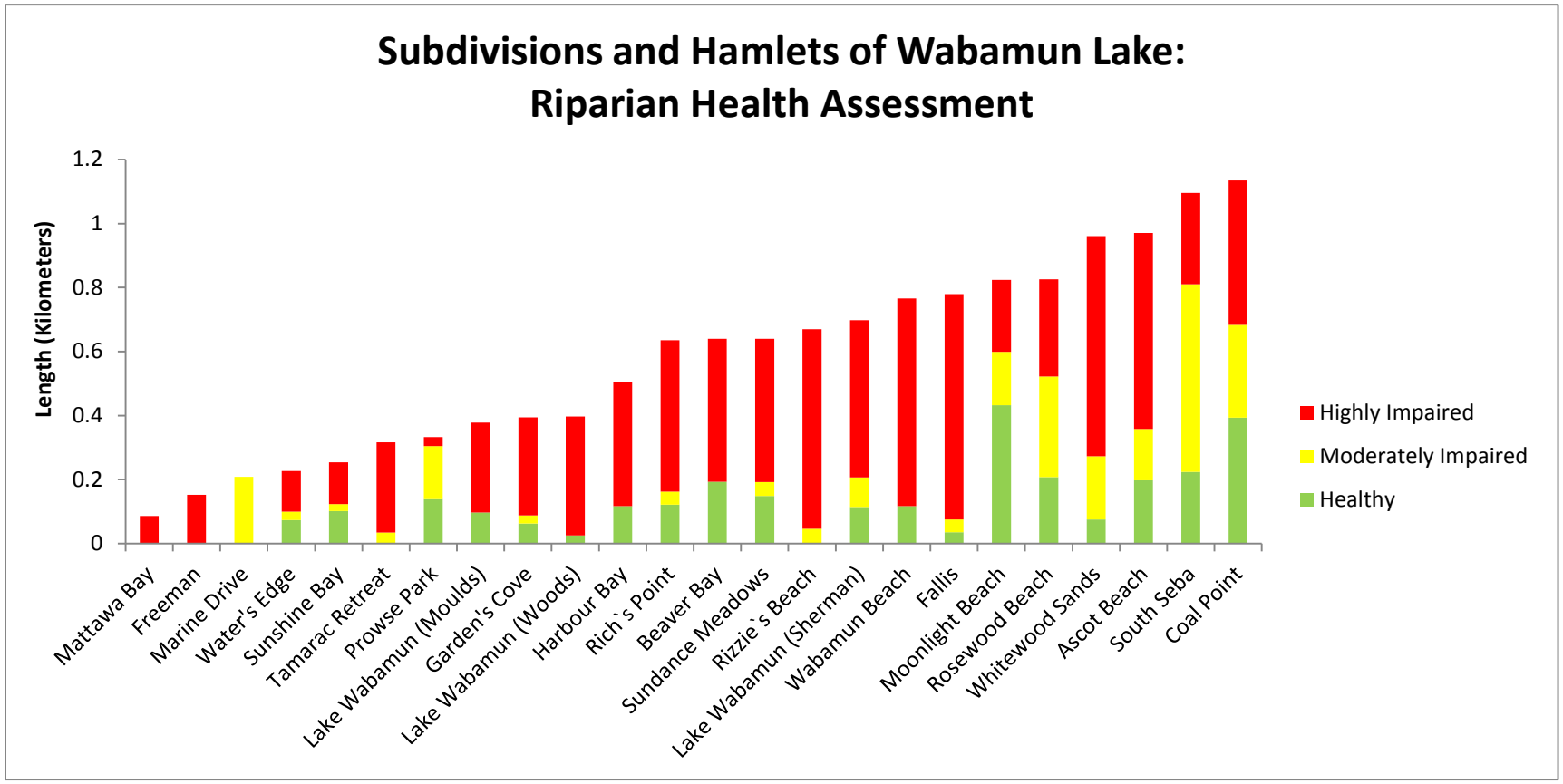

Figure 11 Summary of results comparing subdivisions and hamlets on Wabamun Lake.

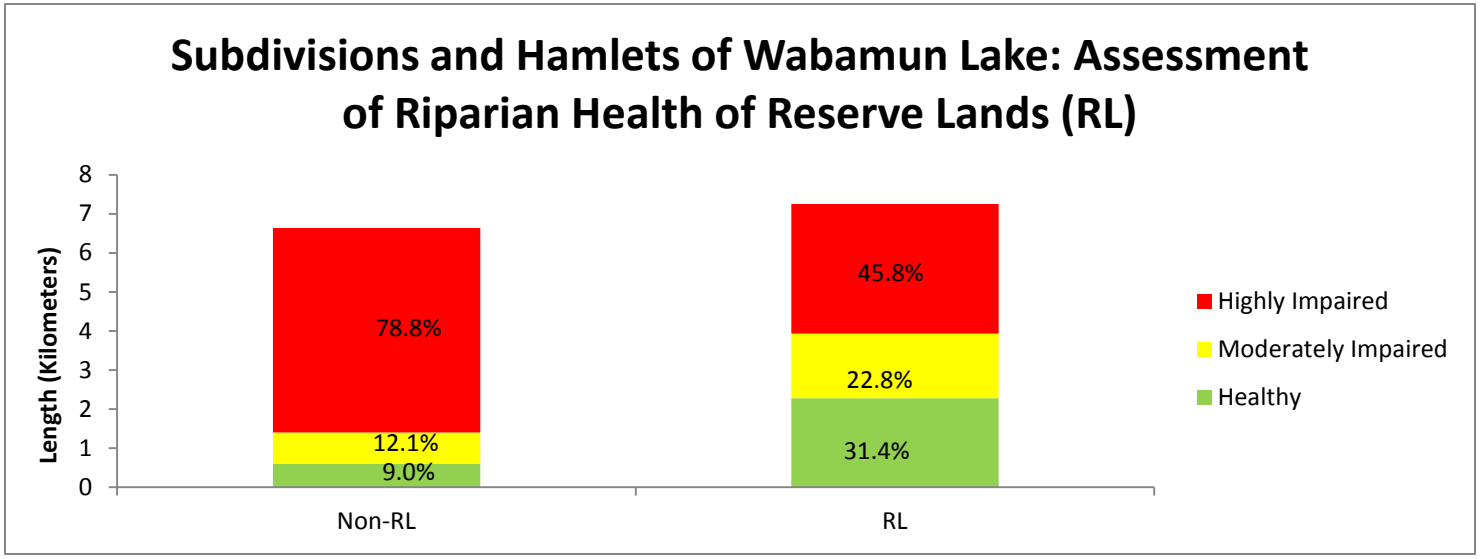

Figure 12 Summary of results comparing the health of Riparian Management Areas contained within Reserve Lands (RL) of subdivisions and hamlets. Results are compared to non-Reserve Lands (non-RL) of subdivisions and hamlets. Reserve Lands refer to land located adjacent to Wabamun Lake that is owned by the municipality.

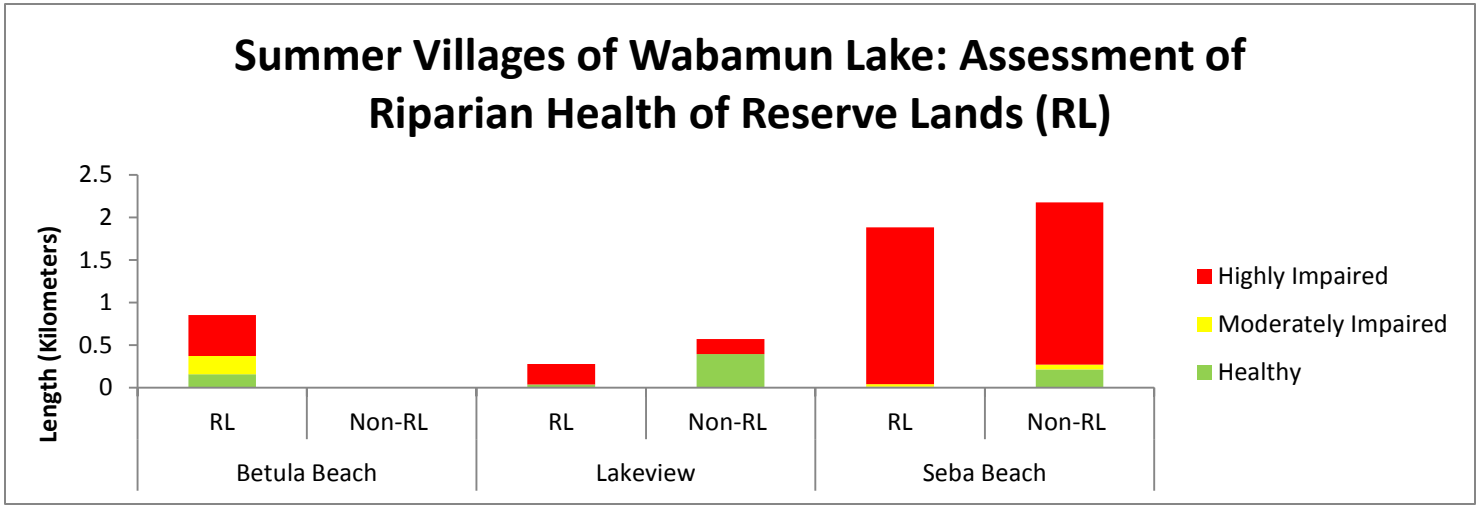

Figure 13 Summary of results comparing the health of Riparian Management Areas contained within Reserve Lands (RL) of Summer Villages. Results are compared to non-Reserve Land (non-RL). Reserve Lands refer to lands located adjacent to Wabamun Lake that are owned by a municipality.

Table 3 Potential cumulative benefit of restoration actions by all jurisdictions combined. "Difficulty" is measured as an estimate of restoration costs (R) and legal costs due to ownership (L) where 0 = low and 1 = high. Reserve Lands refer to publicly owned land, either by a municipality or by the Crown. Non-Reserve Lands refer to land owned privately.

Relative Difficulty	Potential restoration action in Riparian Management Area (RMA)	% RMA managed by all Jurisdictions	Cumulative Benefit
Low (R=0, L=0)	Preserve existing, healthy RMA (both Reserve Lands and non-Reserve Lands)	57%	**57%**
Medium (R=1, L=0)	Restore moderately impacted and highly impacted RMA (Reserve Land including Municipal and Crown owned lands)	15%	**72%**
Medium (R=0, L=1)	Restore moderately impacted RMA (non-Reserve Lands)	6%	**78%**
High (R=1, L=1)	Restore highly impacted RMA (non-Reserve Land)	22%	**100%**

4.0 Discussion

Aerial videography can be a useful tool for performing "coarse-filter" riparian health assessments for large areas such as Wabamun Lake. Cost and time efficiencies are enhanced through the use of an unmanned air vehicle (UAV) to collect video footage. This equipment is simple to employ and does not require a special piloting license. Compared to video footage collected *via* helicopter, the UAV method produces superior quality data because of the low altitudes and slower speeds during flight, and the gyroscopic image stabilizer which eliminates vibrations. Additionally, the use of a UAV allows the possibility of recording field observations, as well as the possibility of interacting with lake users, both excellent advantages that are not possible when gathering footage *via* helicopter.

In terms of equipment cost savings, the UAV method is very economic; the cost of buying a UAV and camera package outright (~$1350) is approximately half the hourly cost of renting a helicopter (~$3500/hr)[3]. Furthermore, a purchased UAV may be reused for future projects. However, in terms of time spent collecting footage in the field, this method is less efficient than *via* helicopter; a helicopter traveling at an optimal speed can be 4.3-5.5 times faster than a UAV[4]. Overall, for this project, the cost of using a UAV was approximately half the expected cost of using a helicopter.

Future projects will have unique cost estimates depending on factors such as proximity of the water body to a helicopter launch pad (i.e. the "dead haul" time), access and cost of renting a speed boat to support a UAV, and time spent transferring equipment from lake to lake in large-scope projects.

Although aerial riparian health assessments have been conducted on 17 other lakes in Alberta, the human factors impacting those lakes vary greatly; direct lake to lake comparisons of riparian health may, therefore, not be appropriate. Wabamun Lake is a large recreational lake in close proximity to a major urban population; the extent and history of human activity on its shoreline is significantly different from lakes in more rural areas.

Riparian health assessments are one of many tools that can be used to determine ecosystem health. However, riparian areas should not be relied upon exclusively for protecting lake health; action must

[3] Mills and Scrimgeour (2004) calculated an hourly rental cost for the helicopter used in their study as $2,925. Using the Bank of Canada Inflation Calculator, the estimated hourly rental rate for 2015 would be $3,519.63. The current (March 2014) price of a *Phantom Quadcopter* UAV, listed on *Amazon.ca*, is $806.18; the price of a GoPro camera, listed on *gopro.com,* is $499.99; and the current price of a *Flytex Core* GPS unit, listed on flytrex.com, is 49.99. The total cost of purchase for the UAV package used in this study is estimated at $1,356.16

[4] Mills and Scrimgeour (2004) identified that the ideal helicopter speed, considering the balance between safety and image quality, is 55-65 kilometers per hour. The researchers in this Wabamun Lake study found that the ideal speed to operate the UAV, to balance battery life and image quality, is 10- 15 kilometers per hour. Using these estimates, a helicopter is 4.3 - 5.5 times faster than a UAV.

also be taken upland areas of the watershed. If development pressures are not properly managed in the upland regions, even a healthy riparian area may not fully protect a lake from impact.

The watershed of Wabamun Lake has numerous development pressures affecting it. These include: residential development; agricultural development; mining development (in approximately 25% of the watershed); linear development (a railway line with a history of a major oil spill at Wabamun Lake, oil pipeline crossings, roads, highways and power transmission lines); and recreational development (including golf courses and RV lots). Further evaluation should be taken to understand the interaction between the RMA and the remaining watershed of Wabamun Lake, and to support land use planning initiatives that manage risk to the lake.

Riparian health assessments are also useful tools for identifying problematic social tendencies, and several were identified at Wabamun Lake. For example, many residents on Wabamun Lake have developed or maintain private beaches. Any development on the bed and shore of a lake—including unnatural beach development, and maintenance or hard armouring—require specific approval under the *Water Act* and, in some circumstances, the *Fisheries Act*. The general purpose of these regulations is to prevent harm to the aquatic environment, which may occur through the introduction of deleterious substances or permanent alteration of fish habitat.

Another concerning tendency is encroachment into publically-owned Reserve Lands by residents that own adjacent properties. In many areas the Reserve Lands are rated as being highly impaired, sometimes contravening their purpose as an environmental barrier between a subdivision development and the water body. Likewise, encroachment has occurred onto Crown Land. Any activities that may injuriously affect watershed capacity are prohibited on Crown Land, unless a permit has been approved under the *Public Lands Act*.

Finally, the most notable observation is the loss of land to the eroding shoreline in areas where woody material has been removed from the riparian zone. This activity pattern has led to the subsequent implementation of bank armouring as an intervention tool to prevent further soil loss.

This riparian health assessment has been prepared as a general knowledge contribution to the Wabamun Watershed Management Council, and as background information to support the multi-jurisdictional planning process being led by Parkland County to develop the *Wabamun Lake Sub-watershed Land Use Plan*.

The following organizations offer excellent guidance and assistance on riparian restoration to any party, including individual landowners.

- Agroforestry and Woodlot Extension Society (AWES): *Riparian Restoration Program*
- Alternative Land Use Systems (ALUS): *Green Acreages Program*
- Alberta Riparian Habitat Management Society (Cows and Fish)
- Nature Alberta: *Living by Water Project*
- Land Stewardship Centre (LSC): *Green Acreages Guide and Workbook*
- Wabamun Watershed Management Council (WWMC): *Lakefront Naturalization Guide*

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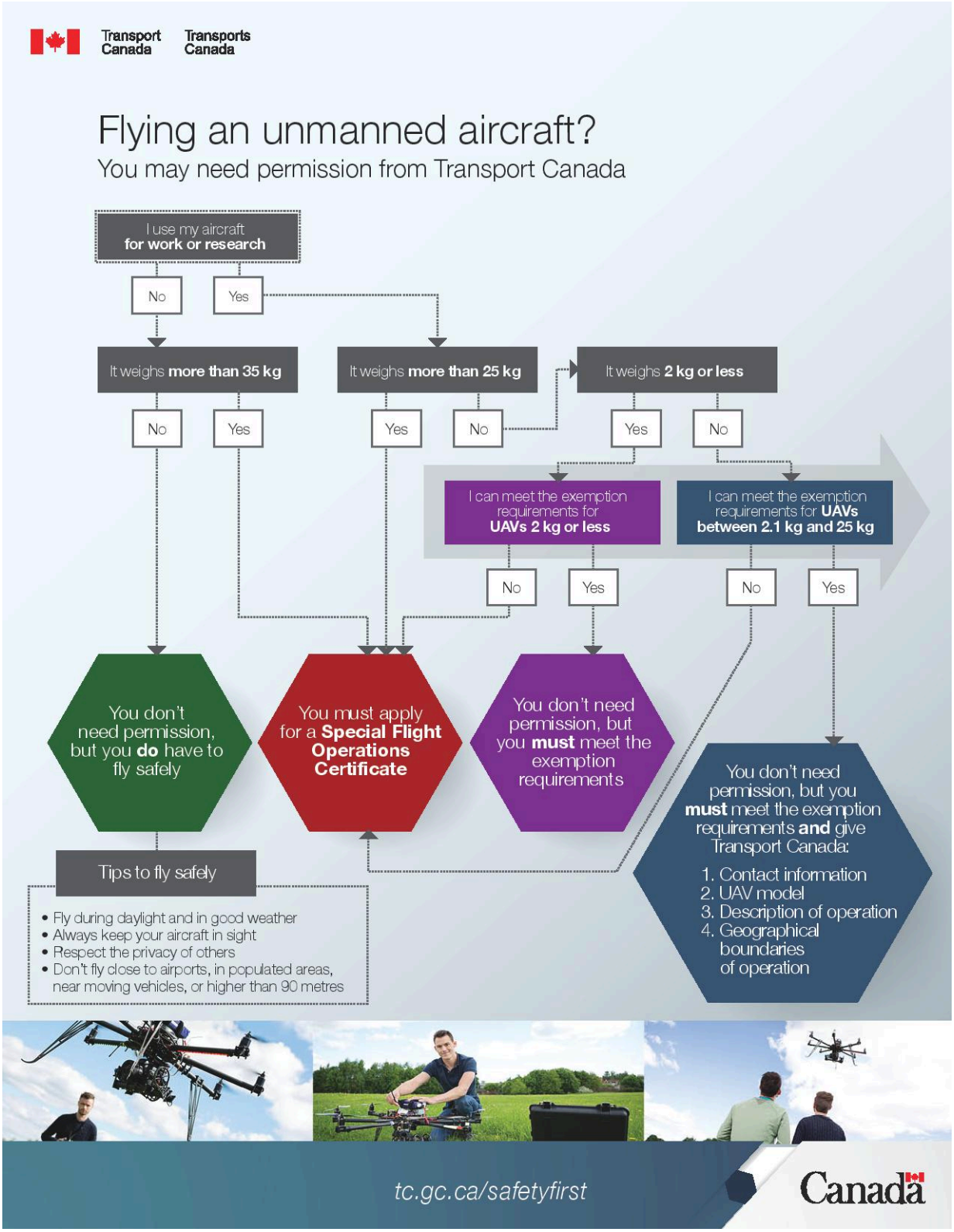
Appendix 1-Summary of Results from Aerial Health Assessments of Lakes in Alberta (Walker, Unpublished)

Riparian Aerial Videography of Lakes in Alberta									
Area of Alberta	Year	Lake	Distance (km)	Shoreline Health and Integrity Assessment in %			Filming and Data Preparation By	Video Format	Proponent and Data Holder
				Healthy	Moderately Impaired	Highly Impaired			
Northeast	2001	Vincent	13		?		ACA / ASRD	VHS/DVD	ACA / ASRD
Northeast	2002	Bonny	14		video only		ACA / ASRD	VHS/DVD	ACA / ASRD
NorthcCentral	2002	Buck	32		video only		ACA / ASRD	VHS/DVD	ACA / ASRD
Northeast	2002	Fork	25		video only		ACA / ASRD	VHS/DVD	ACA / ASRD
Central	2002	Gull	50		?		ACA / ASRD	VHS/DVD	ACA / ASRD
North Central	2002	Isle	37		video only		ACA / ASRD	VHS/DVD	ACA / ASRD
North Central	2002	Lac Ste Anne	53		video only		ACA / ASRD	VHS/DVD	ACA / Alberta Environment (AENV)
North Central	2002	Wabamun	58		video only		ACA / ASRD	VHS/DVD	ACA / ASRD
Northeast	2002	Muriel	44	0%	76%	24%	ACA and Walker Env. Ltd.	VHS/DVD	ACA / ASRD
Central	2002	Pigeon	46	29%	6%	65%	ACA / ASRD	VHS/DVD	ACA / ASRD
Northeast	2004	Moose	56	61%	13%	26%	ACA / ASRD	VHS/DVD	Moose Lake Watershed Society / ACA
Northeast	2005	Lac La Biche	129	70%	20%	10%	ACA / ASRD	VHS	County of Lac La Biche / ACA
Northeast	2006	Crane	12	79%	70%	14%	Walker Environmental	DVD	Lakeland Industry and Community Association (LICA) / ACA
Northeast	2006	Ethel	10	80%	11%	9%	Walker Environmental	DVD	LICA / ACA
Northeast	2006	Hilda	12	78%	13%	9%	Walker Environmental	DVD	LICA / ACA
Northeast	2006	Marie	29	82%	9%	9%	Walker Environmental	DVD	LICA / ACA
Northeast	2006	Tucker	16	99%	0.5%	0.5%	Walker Environmental	DVD	LICA / ACA
North	2006	Lesser Slave	254	57%	22%	11%	Walker Environmental	DVD	ACA
Central	2006	Buffalo	111	34%	29%	37%	Walker Environmental	DVD	ASRD
Central	2007	Gull	50	36%	35%	29%	Walker Environmental	DVD	ACA / ASRD / DFO
Central	2007	Sylvan	37	51%	7%	42%	Walker Environmental	DVD	ACA / ASRD / DFO
Central	2008	Battle	17	82%	12%	6%	Walker Environmental	DVD	Battle River Watershed Alliance / AENV
Central	2008	Pigeon	46	30%	5%	65%	Walker Environmental	DVD	ACA / ASRD / DFO
North	2009	Baptiste	25	59%	11%	30%	Walker Environmental	DVD	Baptiste, Island and Skeleton Lakes Watershed Councils
North	2009	Island	23	69%	12%	19%	Walker Environmental	DVD	Baptiste, Island and Skeleton Lakes Watershed Councils
	2014	Wabamun	67.37	57%	9%	34%	NSWA	MP4	Wabamun Watershed Management Council

No. of Lakes Filmed	26
No. Lakes Assessed	17
Total Km Filmed	1199
Total Km Assessed	917

Appendix 2 -Transport Canada UAV Exemption Requirements



Appendix 2 -Transport Canada UAV Exemption Requirements

Exemption requirements for operating UAVs without permission

THIS INFOGRAPHIC IS FOR EASE OF REFERENCE ONLY. YOU MUST CONSULT THE OFFICIAL EXEMPTIONS.

UAVs 2 kg or less

- Be safe, well trained and know the rules of the sky
- Be 18 years old, or at least 16 years old to conduct research under academic supervision
- Have at least $100,000 liability insurance
- Be alert—not tired or under the influence of alcohol or drugs
- Inspect your UAV and site before flight to ensure they are safe
- Get permission before you go onto private property
- Inform Air Traffic Services if your UAV enters controlled airspace
- Give right-of-way to manned aircraft
- Fly during daylight and in good weather
- Keep your aircraft in direct line of sight and always be able to see it with your own eyes
- Verify that radio frequencies/transmissions won't affect control of your UAV
- Have an emergency plan ahead of time
- Carry a copy of your UAV exemption, proof of liability insurance, contact information, and aircraft system limitations
- Follow the manufacturer's operating and emergency procedures, including those if the remote control loses contact with the aircraft
- Respect laws from all levels of government
- Operate only one UAV at a time, with a single remote control
- Immediately stop all operations if you can no longer meet the exemption requirements or if the safety of a person, property or other aircraft is at risk
- Stay at least 30 metres away from people, animals, buildings, structures, and vehicles not involved in the operation

UAVs between 2.1 kg and 25 kg

- Be safe, well trained and know the rules of the sky
- Be 18 years old
- Have at least $100,000 liability insurance
- Be alert—not tired or under the influence of alcohol or drugs
- Inspect your UAV and site before flight to ensure they are safe
- Get permission before you go onto private property
- Carry a copy of your UAV exemption, proof of liability insurance, contact information, and UAV system limitations
- Respect laws from all levels of government
- Keep your UAV in direct line of sight and always be able to see it with your own eyes
- Operate only one UAV at a time, with a single remote control
- Give right-of-way to manned aircraft
- Fly during daylight and in good weather (no clouds, snow or icy conditions)
- Create and follow procedures for landing and recovering your UAV and for contacting emergency responders and air traffic control.
- Have an emergency plan ahead of time
- Follow the manufacturer's operating and emergency procedures, including those if the remote control loses contact with the aircraft
- Verify that radio frequencies/transmission and eletronic devices won't affect control of your UAV
- Assess the risk of losing connection with the UAV and decide when to use the flight termination setting
- Have a fire extinguisher on site
- Inform Air Traffic Services if your UAV enters controlled airspace
- Follow the manufacturer's maintenance/assembly instructions
- Ensure the UAV does not have an emergency locator transmitter
- Report accidents to Transport Canada and stop operations until you have addressed the risks
- Immediately stop all operations if you can no longer respect the exemption requirements or if the safety of a person, property or other aircraft is at risk
- Stay at least 150 metres away from people, animals, buildings, structures, and vehicles not involved in the operation

DO NOT:

- Fly closer than 9 km from forest fires, airports, heliports, aerodromes, or built-up areas
- Fly over military bases, prisons or in controlled or restricted airspace
- Fly over crowds or higher than 90 metres
- Participate in special aviation events, air shows or system demonstrations
- Carry dangerous goods or lasers

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Appendix 3- Lentic Riparian Health Assessment Scorecard (Walker, 2006)

Aerial Videography – Riparian Management Area Health and Integrity Assessment Scorecard for Lakes July 2006

This scorecard follows the general health and integrity approach described in Scrimgeour and Wicklum (1996) and Mills and Scrimgeour (2004). The scorecard, applied to low altitude (< 70 metres) aerial videography, delivers a rapid, **"coarse filter"** assessment of riparian management area *health and ecological function* on individual polygons that can be summarized to describe the health and integrity of the entire lake. This information can be used to direct conservation and management activities at those human actions negatively impacting the health or integrity in the riparian management area.

Assessment Questions and Scoring.

1. 85% or more of the polygon area is covered with vegetation of any kind? (Polygon area does not include area covered by water. "Natural" applies to shorelines that would support < 85% vegetation – including natural sandy or rock/cobble shorelines.)

Yes____ (2 points), **Natural**_____ (1point), **No**_____ (0 points)

2. Cattails and bulrushes are visibly growing in the littoral zone adjacent to the polygon area? (Identifying immature bulrush and cattail stands may be difficult. On some lakes these species do not grow because of site and/or climate conditions. It is important you know this prior to deciding if their absence is natural or human caused.)

Dense to Medium ____ (1 point), **Medium to Sparse** ____ (0.5 points), **None** ____ (0 points)

3. Woody plants like willow, birch or poplar cover 15% or more of the polygon area? (In some cases riparian areas do not have the potential for woody plants because of soil chemistry and other factors, i.e., saline and drainage. In some cases woody plants do not meet this threshold because of site and successional reasons. "Natural" applies to those naturally sandy or rock/cobble shorelines that inhibit woody growth.)

Yes____ (1 point) **Natural**_____ (0.5 point) **No**_____ (0 points)

4. Within the 15% woody zone, what is the abundance of woody plants? (If the answer to Question 3 is no, this question receives 0 points)

Dense to Medium ____(1 point) or **Sparse to Medium** ____ (0.5 points)

5. 35% or more of the polygon shows visual signs of human caused removal or alteration of vegetation? (e.g., includes conversion of native vegetation to lawn grass, mowing, grazing, cutting of woody vegetation, etc.).

Yes____ (0 points) **No**_____ (2 points)

6. 35% or more of the polygon shows visual signs of human caused physical alteration? (e.g., addition or removal of sand or rock, harrowing beaches, retaining walls, boat houses, decks, patios, walking or ATV trails, cattle activity, etc.)
Yes____ (0 points) **No**_____ (3 points)

7. What picture does most of the polygon look like?
Picture A? ___ (1 point) **Combination of A and B?**__(0.5 points) **Picture B?**___ (0 points)

Total possible points = 11 .
Actual points (sum from questions above) = _____.

Summary of Question Scores

If the score is **more than 8** it is likely the Riparian Management Area is **healthy**.

If the score is **6.0 to 8.0** it is likely the Riparian Management Area is **moderately impaired**.

If the score is **less than 6** it is likely the Riparian Management Area is **highly impaired**.

Courtesy Alberta Conservation Association
Updated July 2006 by Walker Environmental from the ACA's 2003 scorecard.

Appendix 4 Wabamun Lake Riparian Health Assessment (2014) Data Summary

Table 4. Data summary for all jurisdictions on Wabamun Lake. Data are presented as length (meters) and percentages.

	Length of Riparian Management Area					
Name	**Healthy**		**Moderately Impaired**		**Highly Impaired**	
Village of Wabamun	2235	74%	236	8%	534	18%
Alberta Crown Land	3258	54%	255	4%	2499	42%
Summer Villages	1894	21%	1051	12%	5952	67%
Paul Band First Nation	12638	92%	219	2%	930	7%
Parkland County: subdivisions & hamlets	2879	21%	2458	18%	8555	62%
Parkland County: other land	15496	71%	1781	8%	4430	20%
Total Length	**38400**		**6000**		**22900**	
Percentage of Total Length	**57%**		**9%**		**34%**	

Table 5. Data summary for summer villages on Wabamun Lake. Data are presented as length (meters) and percentages.

	Length of Riparian Management Area					
Name	**Healthy**		**Moderately Impaired**		**Highly Impaired**	
Lakeview	434	51%	0	0%	414	49%
Betula Beach	158	19%	213	25%	482	57%
Kepasiwin	431	28%	347	22%	781	50%
Point Allison	645	41%	404	26%	528	33%
Seba Beach	226	6%	87	2%	3747	92%
Total Length	**1894**		**1051**		**5952**	
Percentage of Total Length	**21%**		**12%**		**67%**	

Table 6. Data summary for subdivisions and hamlets on Wabamun Lake. Data are presented as length (meters) and percentages.

	Length of Riparian Management Area					
Name	**Healthy**		**Moderately Impaired**		**Highly Impaired**	
Mattawa Bay	0	0%	0	0%	86	100%
Freeman	0	0%	0	0%	152	100%
Marine Drive	0	0%	209	100%	0	0%
Water's Edge	74	33%	26	11%	127	56%
Sunshine Bay	102	40%	21	8%	131	52%
Tamarac Retreat	0	0%	35	11%	281	89%
Prowse Park	139	42%	166	50%	28	8%
Lake Wabamun (Moulds)	97	26%	0	0%	281	74%
Garden's Cove	63	16%	25	6%	306	78%
Lake Wabamun (Woods)	26	7%	0	0%	371	93%
Harbour Bay	117	23%	0	0%	388	77%
Rich`s Point	122	19%	40	6%	473	74%
Beaver Bay	193	30%	0	0%	447	70%
Sundance Meadows	149	23%	43	7%	448	70%
Rizzie`s Beach	0	0%	46	7%	624	93%
Lake Wabamun (Sherman)	114	16%	93	13%	491	70%
Wabamun Beach	117	15%	0	0%	649	85%
Fallis	36	5%	39	5%	704	90%
Moonlight Beach	432	52%	167	20%	225	27%
Rosewood Beach	208	25%	314	38%	304	37%
Whitewood Sands	75	8%	198	21%	688	72%
Ascot Beach	198	20%	160	16%	613	63%
South Seba	224	20%	586	53%	286	26%
Coal Point	393	35%	290	26%	452	40%
Total Length	**2879**		**2458**		**8555**	
Percentage of Total Length	**21%**		**18%**		**62%**	

Table 7. Data summary for Reserve Lands (RL) in subdivisions and hamlets on Wabamun Lake. Data are presented as length (meters) and percentages.

		Length of Riparian Management Area					
Name	**Land Type**	**Healthy**		**Moderately Impaired**		**Highly Impaired**	
All subdivisions and hamlets	Non-RL Land	600	9%	805	12%	5236	79%
All subdivisions and hamlets	RL Land	2279	31%	1653	23%	3319	46%
Total Length		**2879**		**2458**		**8555**	
Percentage of Total Length		**21%**		**18%**		**62%**	

Table 8. Data Summary for Reserve Lands (RL) in summer villages on Wabamun Lake. Data are presented as length (meters) and percentages.

		Length of Riparian Management Area					
Name	**Land Type**	**Healthy**		**Moderately Impaired**		**Highly Impaired**	
Betula Beach	RL Land	158	19%	213	25%	482	57%
Betula Beach	Non-RL Land	0		0		0	
Lakeview	RL Land	39	14%	0	0%	239	86%
Lakeview	Non-RL land	395	69%	0	0%	175	31%
Seba Beach	RL Land	12	1%	29	2%	1842	98%
Seba Beach	Non-RL Land	214	10%	58	3%	1905	88%
Total Length		**818**		**300**		**4643**	
Percentage of Total Length		**14%**		**5%**		**81%**	