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Riparian Setback Matrix Model

Riparian Setback Recommendations for Leduc County's Pigeon Lake and Wizard Lake Area Structure Plans

Prepared for:

Leduc County
Suite 101, 1101 5th Street
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May 2010

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May 25, 2010

Mr. Sylvain Losier
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Suite 101, 1101 5th Street
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Dear Mr. Losier,

RE: Leduc County Riparian Setback Matrix Model Draft Setback Recommendations

Thank you for the opportunity to prepare the Riparian Setback Matrix Model for use as a planning tool in the County of Leduc. This model was created to assist planners with the task of taking Environmental Reserve on behalf of the municipality at the time of subdivision. Taking adequate Environmental Reserve around Environmental Sensitive Areas (including waterbodies) is critical in maintaining healthy aquatic ecosystems. This model was developed over a three year period for Lac La Biche County, before becoming established as policy. It has been established as policy at several municipalities since then. The version presented here has been modified and customized for use in Leduc County, and gives Environmental Reserve setbacks from 6 to 30 meters. This is a significant improvement over the current practice of establishing a 6 m setback regardless of what might be dictated by site conditions.

If you have any questions or concerns, please feel free to contact me at (780) 757-5530 or via email at jay.white@aquality.ca.

Yours truly,
AQUALITY ENVIRONMENTAL CONSULTING LTD.

Per:____

Jay S. White, M. Sc., P. Biol.
Principal

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2 Introduction

2.1 Purpose

Facing increasing development pressures around lake resources, the need to protect and restore the riparian areas within Leduc County has become increasingly apparent. The Riparian Setback Matrix Model is a management tool that was developed in 2007 by Aquality for Lac La Biche County (formerly Lakeland County) to assist planners with the taking of Environmental Reserves or establishing Development Setbacks, and has been incorporated in their municipal bylaws. Aquality has modified the model to meet the development needs and conservation objectives of Leduc County. The Riparian Setback Matrix Model creates unique, defensible Environmental Reserve setbacks based on slope, height of bank, groundwater table level, and vegetation/ground cover. The Environmental Reserve or Development Setbacks will help to protect riparian lands and maintain the ecological goods and services that healthy and functional riparian areas provide for future generations' benefit.

The purpose of this document is to help municipalities and developers determine the appropriate area of an Environmental Reserve (ER) to maintain healthy and functional riparian areas free from pollution, while providing public access that will not impede natural functions. In addition, the Riparian Setback Matrix Model can be used to determine appropriate development setbacks and land uses for all private lands located adjacent to environmentally sensitive and or significant lands within a municipality.

2.2 Environmental Reserves

During subdivision of a parcel of land, under conditions prescribed in the *Municipal Government Act* (MGA), a municipality may acquire "reserve lands". Reserve lands include "environmental reserves" which are essentially "undevelopable" lands that must be left in their natural state or used as a public park, and "municipal reserves", "school reserves", or "municipal and school reserves", which are dedications of up to 10% of the remaining "developable" lands in the parcel after the removal of environmental reserves and any lands required for roads and public utility lots. If insufficient land is available, the developer may provide a monetary payment equivalent to the market value of up to 10% of the developable lands (cash in lieu). Dedicated reserves become property of the municipality in which they are located. A municipality is not required to compensate the landowner for any lands taken as "reserve" during the subdivision process.

As stated in the MGA, a municipal council may require the dedication of ER if the lands proposed for subdivision consist of: a) a swamp, gully, ravine, coulee or natural drainage course, b) land that is subject to flooding, or land that is unstable, or c) a strip of land, not less than six metres in width, abutting the bed and shore of any lake, river, stream or other body of water (Figure 1). If the lands adjacent to the minimum required 6 meter strip are also subject to subsidence, flooding, contain swamps and natural drainage courses, the required dedication of ER may result in a much wider strip than 6 meters. The strips of land abutting a lake are taken for two purposes: to prevent pollution, or to provide public access to and beside the bed and shore (Stewart, 2006).

ER is dedicated to protect provincially owned beds and shores and water resources from "pollution". Therefore, the definition of "pollution" that a municipality adopts in its Land Use Bylaw must specify what constitutes a pollutant within their community. For prairie lakes already high in nutrients such as phosphorus and nitrogen, added nutrients further impair water quality and cause noxious algal blooms, taste and odour problems, anoxic conditions and even fish kills. Phosphorus has been identified in several studies as causing water quality problems across the Province (Hamilton 1985, Mitchell 1998, Mitchell 2000, Mitchell 2001, Schindler *et al*. 2004, White and Prather, 2004). Nutrients, especially phosphorus, can be defined by Leduc County as pollutants and steps need to be taken to protect aquatic systems from additional nutrients making their way into watercourses via point and non-point source discharges. One of the most effective ways to protect aquatic ecosystems and prevent pollution is to ensure that riparian areas are intact, healthy and functional.

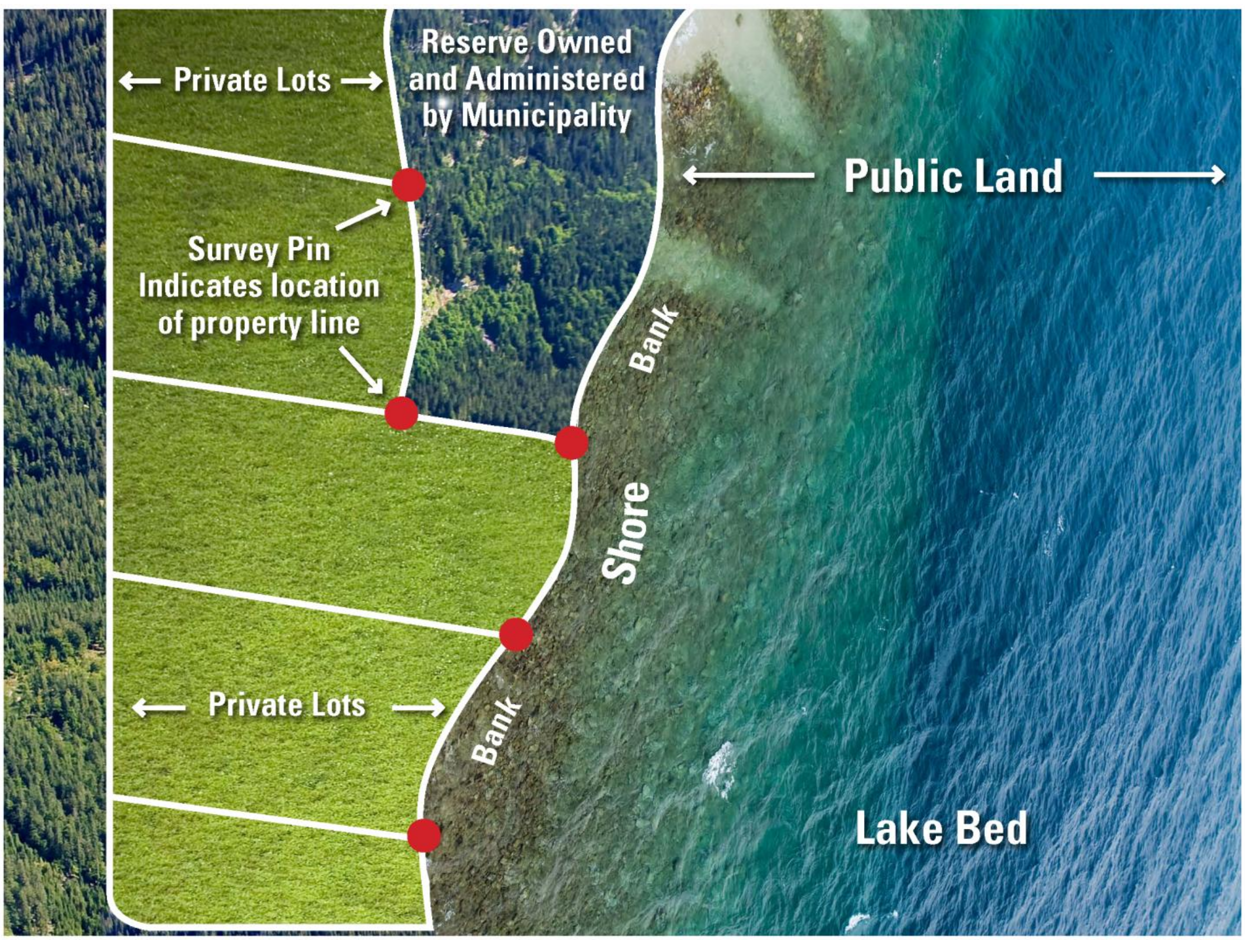

Figure 1. Illustration of lake bed, shore and bank which is owned by the Province and the Environmental Reserve land that is taken during the subdivision process and owned by the Municipality.

Sometimes, residents think that their property rights allow them to use adjacent ER parcels for exclusive or private purposes. They landscape, cut down trees, mow vegetation along streams, and plant gardens outside their lot lines with invasive species of flowers, shrub and trees. ER shore lands are often fenced or barricaded or restricted against the natural flow of people and floodwaters even when ER strips lie between their property and the bed and shore of a river or lake. Environmental Reserves are sometimes littered with lawn clippings, leaves, tree branches stumps and other debris, while ravines and river valleys are littered with garbage wastes that are non-biodegradable and do not readily decompose in the natural environment.

People compete with wildlife for ER adjacent to rivers and lakes which act as wildlife corridors or migratory bird habitat, and provide shade, shelter, food and water for flora and fauna. Some citizens consider ER private playgrounds to walk dogs, cycle, and ride all-terrain vehicles. These activities create ad-hoc pathway systems, adversely affecting the natural ground cover and vegetation, pollution, erosion of escarpments and ravines, and sedimentation of adjacent watercourses and bodies of water. When conflicts arise among ER users with different values, complaints are made directly to the municipality about erosion, fencing, litter, illegal dumping, off-leash dogs and pet wastes. As the owner of ER, a municipality has the responsibility to control access and use to ensure that these sensitive landscapes are sustained for current and future generations. This can be done through a Reserve Bylaw or other policy sanctioned by the municipality.

ER can also be required to provide public access to the beds and shores and the water, creating an inherent conflict between users who value ER for equally important, but competing functions. Riparian development setbacks should have as few channels and walking paths as possible. Channels and walking paths will increase the amount of surface runoff that reaches surface waters and decrease the effectiveness of the setback. Surface runoff from adjacent lands, depending on the land use, may contain sediment, nutrients, pesticides, bacteria, parasites, toxic chemicals and other pollutants. Functional and intact riparian areas remove these pollutants and prevent them from entering a waterbody, but paths (channels) through these areas decrease their effectiveness. The role of ER and riparian land protection is particularly important around waterbodies that serve as the drinking water source for communities.

Community access points to provincial beds and shores can minimize cumulative detrimental effects. Communal beach, dock and swimming areas are recommended as alternatives to allowing multiple points of access. Communal access in areas with the least environmental sensitivity, with the lowest quality riparian or wildlife habitat (e.g. non-fish spawning habitat) or land that is already disturbed will help protect intact, sensitive and healthy habitat. Developers and regulators should work together to identify areas that are more suited for public access such as boat launch or dock that will minimize habitat loss or environmental damage.

2.3 Environmental Reserve Easements and Conservation Easements

It is important to recognize that since 1994 when the current MGA was enacted, a municipality may enter into an agreement with an owner of a parcel of land that is subject to a proposed subdivision to create an "environmental reserve easement" for the lands that would otherwise be dedicated as ER for "protection and enhancement of the environment". An ER easement is registered under the *Land Titles Act* and is a covenant on the land ensuring that lands are left in their natural state, and the easement is enforced by the municipality.

Under the *Environmental Protection and Enhancement Act*, landowners can voluntarily enter into a legal agreement called a conservation easement to preserve habitat while retaining title to the property. The landowner relinquishes certain ownership rights in order to protect the landscape’s natural character. Qualified easement holders include land trusts, municipalities or conservation groups such as Ducks Unlimited Canada or the Nature Conservancy of Canada.

2.4 Development Setbacks for Buildings

A municipality is responsible for the planning and development of private lands within its geographical boundaries. Through provisions in the *Land Use Bylaw* (LUB), a municipal council can control the development of "buildings" on land that is subject to flooding or subsidence, or that is low lying, marshy or unstable; or, land that is adjacent to or within a specific distance of the bed and shore of any lake, river, stream or other body of water ("environmentally significant lands"). What constitutes a “building” is defined in the MGA to include all structures except highways and bridges. Controlling development of buildings within prescribed development setback areas can be done through policy statements and *Land Use Bylaw* provisions. The opportunity to create appropriate development setbacks and land uses in riparian areas is underutilized by municipal governments. The Riparian Setback Matrix Model presented here will assist Leduc County to create a defensible “natural environmental reserve” land use designation with associated permitted and discretionary land uses. The natural riparian function of each landscape that a municipality wishes to preserve will determine the extent of the development setback required. The Riparian Setback Matrix Model will direct municipalities to adopt appropriate development setback policies and enact appropriate Land Use Bylaw provisions that are inclusive of Area Structure Plans or Watershed Management Plans to ensure integration of policies and directives.

2.5 Riparian Areas

Vegetation in riparian areas is different from that of uplands. Riparian areas stay green longer and produce more biomass than uplands, partly due to soil types but mostly due to an elevated water table. The types and abundance of vegetation can help to identify riparian areas. The vegetation is different and tends to attract livestock, wildlife and humans. Riparian areas are highly productive and can be reliable producers of forage, shelter, fish, wildlife and water. These areas are especially useful when drought or flooding occurs by attenuating flood waters and reducing erosion (Alberta Riparian Habitat Management Society, 2006).

Riparian zones act as buffers that function to protect water quality. Contaminants are absorbed onto sediments, taken up by vegetation and transformed by soil microbes into less harmful forms (Klapproth and Johnson 2000). They have long been proven effective in reducing nutrients, sediments and other anthropogenic pollutants that enter surface waters via overland and subsurface flow (Klapproth and Johnson 2000; Lee and Smyth 2003; Mayer *et al* 2006).

In addition to protecting surface waters, riparian areas are valuable wildlife and plant habitat. They provide nesting sites for several bird species, habitat for reptiles and amphibians and safe corridors for several species of mammals such as deer and moose (Wenger 1999). Although riparian areas make up only a small fraction of our landscape, they are disproportionately important to fish and wildlife, recreation, agriculture, and society in general. As much as 80% of Alberta's wildlife relies in whole or in part on riparian areas to survive (Alberta Riparian Management Society, 2006). The health and functioning of riparian areas can be influenced by human activities including road construction, resource extraction, agriculture, urban or rural development, and recreation. Unfortunately, most riparian lands are privately owned and therefore difficult to protect unless a municipality enacts development setbacks in riparian lands from a body of water such as a river or lake.

Defining a riparian area (riparian buffer strip) that is far enough from a receiving water body to effectively protect the water and the aquatic ecosystem has been the subject of much debate. A “one size fits all” approach has traditionally been used by provincial regulators and is still being used today. However, it is becoming increasingly apparent that water bodies require a unique set of guidelines to define appropriate riparian buffer widths and development setbacks. It is essential that municipalities establish appropriate land uses adjacent to bodies of water, including wetlands, to avoid or minimize development impacts of our valuable water resources, as provided in the provincial Land Use Policies. The importance of establishing and protecting a properly-sized buffer strip is extremely important for source water protection.

2.6 Environmental Legislation

The MGA and *Environmental Protection and Enhancement Act* are not the only pieces of legislation that protect environmental reserves and riparian buffers. There are at least twelve municipal, Provincial and Federal bylaws and acts that serve to protect these sensitive areas (Table 1), some with very broad powers of application (Figure 2). Several Provincial policies and strategies are also in place to protect the aquatic environment including the *Strategy for the Protection of the Aquatic Environment*, *Water for Life* Strategy and others that are consistent with Alberta’s Commitment to Sustainable Resource and Environmental Management and Strategy for the Protection of the Aquatic Environment. The new *Framework for Watershed Management* Planning should provide municipalities with a suite of mechanisms to work with partner stakeholders, landowners and other jurisdictions to ensure that water resources are protected for future generations. Our common challenge will be to understand and implement these various pieces of legislation for the benefit of environmental protection within long term development integration.

Table 1. Legislation and policy involving riparian land management.

Legislation/policy	Description
Fisheries Act - Fisheries and Oceans Canada	Regulates and enforces on harmful alteration, disruption and destruction of fish habitat in Section 35.
Water Act – Alberta Environment (AENV)	Governs the diversion, allocation and use of water. Regulates and enforces actions that affect water and water use management, the aquatic environment, fish habitat protection practices, in-stream construction practices, storm water management.
Environmental Protection and Enhancement Act (EPEA) – AENV	Management of contaminated sites, storage tanks, landfill management practices, hazardous waste management practices and enforcement.
Alberta Land Stewardship Act (Land Use Framework) – Alberta Sustainable Resource Development (ASRD)	This legislation supports implementation of the Land-use Framework. It creates the seven land-use regions, establishes the Land-use Secretariat and gives authority for regional plans, creation of Regional Advisory Councils and addresses the cumulative effects of human and other activity.
Agricultural Operations Practices Act (AOPA) – Natural Resources Conservation Board (NRCB)	Regulates and enforces on confined feedlot operation and environment standards for livestock operations.
Historical Resources Act – Culture and Community Spirit	Concerns any work of humans that is primarily of value for its prehistoric, historic, cultural or scientific significance, and is or was buried or partially buried in land or submerged beneath the surface of any watercourse or permanent body of water.
Municipal Government Act (MGA) – Municipal Affairs	Provides municipalities with authorities to regulate water on municipal lands, management of private land to control non-point sources, and authority to ensure that land use practices are compatible with the protection of aquatic environment.
Provincial *Public Lands Act* - ASRD	Regulates and enforces on activities that affect Crown-owned beds and shores of water bodies and some Crown-owned uplands that may affect nearby water bodies.
Provincial *Safety Codes Act*- Municipal Affairs	Regulates and enforces septic system management practices, including installation of septic field and other subsurface disposal systems.
Regional Health Authorities Act – Alberta Health	RHA have the mandate to promote and protect the health of the population in the region and may respond to concerns that may adversely affect surface and groundwater.
Wildlife Act – ASRD	Regulates and enforces on protection of wetland-dependent and wetland-associated wildlife, and endangered species (including plants).
Parks Act & *Wilderness Areas, Ecological Reserve and Natural Areas Act* – ASRD and Community Development	Both Acts can be used to minimize the harmful effects of land use activities on water quality and aquatic resources in and adjacent to parks and other protected areas.

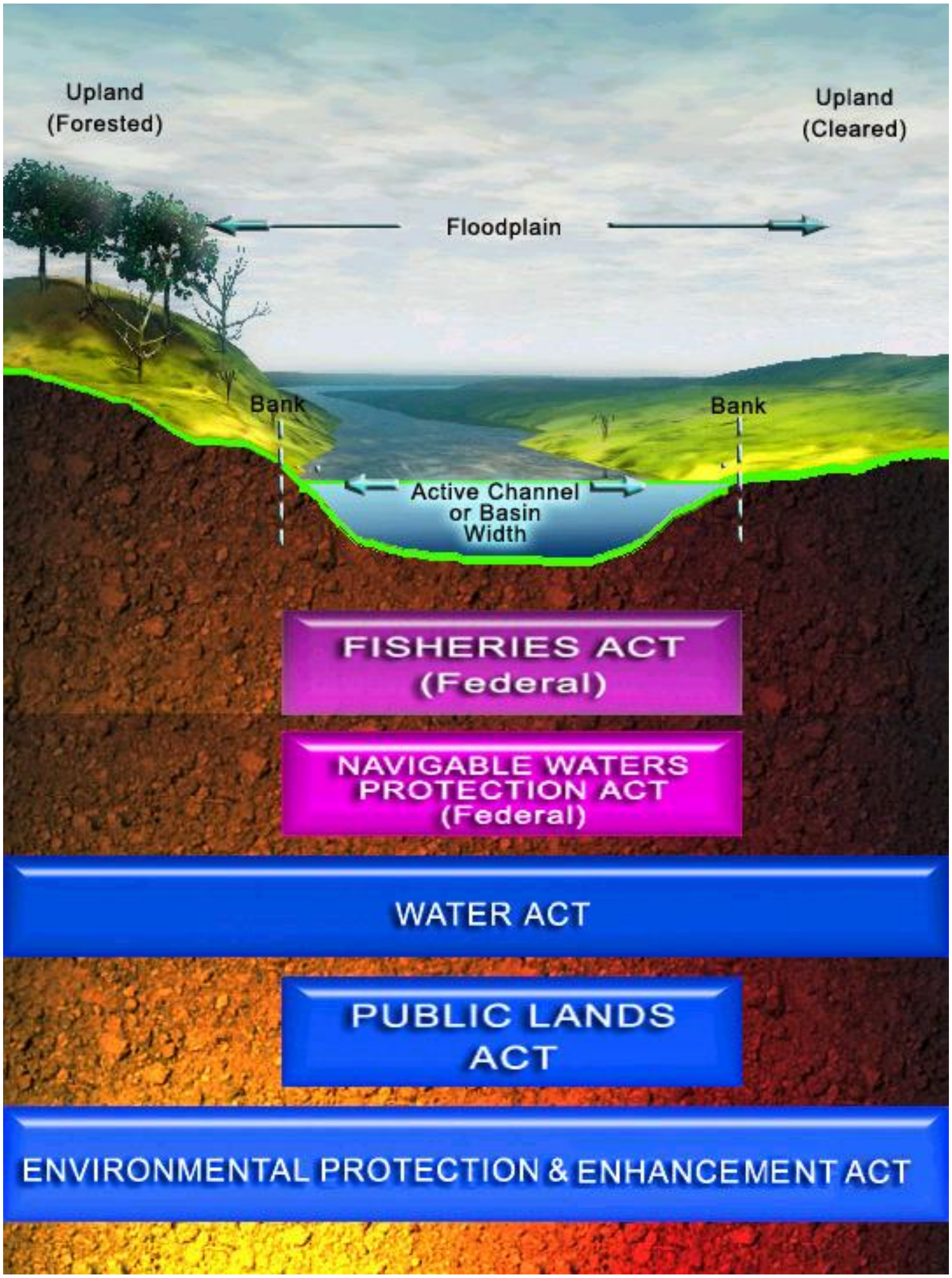

Figure 2. Federal and Provincial legislation that can be used to protect riparian habitats.

3 Development of the Riparian Setback Matrix Model

Internet and library searches were undertaken to survey the scientific and grey literature for sources of riparian information. With a focus on peer-reviewed primary literature, we reviewed riparian development setback documents looking for recommendations on slope, soils, vegetation, bank height, and groundwater influence. Additionally, the properties of riparian zones and different vegetation types were reviewed in relation to nutrient and other pollutant attenuation.

Based on the review of the literature and other documents, a matrix was designed to include slope, soils, bank height, groundwater influence, and vegetation type. For each category, setback distances were recommended for different properties of each category.

Previous versions of the model include soil characteristics as a component contributing to the calculation of setbacks. However, for the Pigeon Lake and Wizard Lake Area Structure Plans where the model is proposed to be applied, soils are fairly homogenous (Alberta Soil Information Centre, 2001; Leduc County, 2010) and are unlikely to contribute to differences in setbacks between sites. For this reason, they have been dropped from the model setback calculations. If Leduc County were to apply the RSMM for broad use across the Municipality, soils should be re-evaluated and considered for use.

Leduc County Council has agreed to a maximum setback of 30 meters for the taking of Environmental Reserve. Therefore, the model upper bounds are 30 meters, while the lower bound is 6 m as stipulated under the *Municipal Government Act.*

4 The Riparian Setback Matrix Model

4.1 Riparian Setback Matrix Model - Setback Determinations

The Riparian Setback Matrix Model (RSMM) is meant for all types of waterbodies within the Pigeon and Wizard Lake Area Structure Plans. Parameters or measurements requiring special surveys or other technical considerations are highlighted in red. Steep slopes, which may require a special survey by a qualified geotechnical professional, are highlighted in red.

Table 2. Riparian Setback Matrix Model for Leduc County

Waterbody Name: Waterbody Location:

Waterbody Type (circle one): Lake/Pond River/Stream Wetland

STEP 1	Slope Category (%)	Slope (%)	Distance Adjustment
	0 - 4.9	______	6 m
	5 - 14.9	______	6 m + 2.4 m per % of slope over 5%
	≥ 15	______	Requires a geotechnical survey†
	SLOPE SETBACK	______	(RANGE: 6m to 30m)

STEP 2	Height of Bank	Bank Height (m)	Distance Adjustment
	< 3 m	______	6 m
	3 to 15 m	______	2x height of bank
	≥ 15 m	______	30 m
	BANK HEIGHT SETBACK	______	(RANGE: 6m to 30m)

STEP 3	Groundwater Influence	Select one:	Distance Adjustment
	Distance to water table	______	
	0 - 9.9 m	______	30 m
	10 - 19.9 m	______	15 m
	≥ 20 m	______	6 m
	GROUNDWATER SETBACK	______	(RANGE: 6m to 30m)

STEP 4	Vegetative Cover Type	% Cover	Distance Adjustment (m / % cover type)
	Forested	______	0.06
	Shrub	______	0.12
	Grass and Herbaceous Plants	______	0.20
	Bare Ground	______	0.30
	VEGETATION SETBACK	______	(RANGE: 6m to 30m)

STEP 5	Overall Setback Calculation		
	Determine maximum setback from Steps 1-4 above	______	
	TOTAL CALCULATED SETBACK*:		

* - The minimum and maximum setbacks based on the calculations outlined above are 6 m and 30 m, respectively.

† - Sites with slopes of >15% require a geotechnical survey in all circumstances, to be carried out by a qualified professional (see *Professional Requirements for Site Assessments*).

4.2 How to use the Riparian Setback Matrix Model

As discussed in sections 2.2 - 2.4 of this document, the Riparian Setback Matrix Model may be used by a municipality, under the authority of the *Municipal Government Act*, to establish Environmental Reserves, Environmental Reserve Easements, Conservation Easements, and development setbacks for buildings (all of which are included hereafter as "riparian setback"). The amount of riparian setback to be taken will be determined by using the Riparian Setback Matrix Model. Riparian setback distances will be determined at several sites along the water's edge, and as such the area determined as riparian setback will vary throughout the site; some areas will require greater setbacks and others will require much less. The riparian setback will vary throughout the parcel of land depending on slope of the land, height of any banks present, groundwater influence, soil type and vegetative cover.

The amount of property bordering the water's edge will also affect how riparian setbacks are determined. To start using the Riparian Setback Matrix, setback points will need to be established. The number of points used to determine riparian setbacks will vary based on the area to be developed.

1. **Establish the number and location of setback points required.**
   - 1.1. Whereas the location of the point will be:
   - 1.2. At the point where vegetation (living or dead) characteristic of an aquatic environment end changes to that of upland vegetation. This vegetation includes but is not limited to; Sedges, Bulrushes, Cattails and Willows.
   - 1.3. If no vegetation exists, the setback point will be determined from the current edge of water.
   - 1.4. Whereas the length of land bordering the water body, stream or wetland is:
     - 1.4.1. **Greater than 200 meters** – The outside setback point will be no more than 100 meters from the property line along the water body, stream or wetland. The subsequent setback points will be equally spaced no more than 200 meters apart.
     - 1.4.2. **200 meters to 50 meters** – Two (2) setback points will be required equal distance apart and equal distance from each property line.
     - 1.4.3. **Less than 50 meters** – One (1) setback point will be required at the discretion of Leduc County. Please contact Leduc County administration to determine the location of this setback point.
2. **Slope of the land** must be determined by a legal land surveyor at each of the setback points. From each setback point, determine the slope of the land perpendicular to the water body, stream or wetland. The setback distance for slope is calculated as follows:
   - 2.1. If the slope is **<5%**, the setback distance requirement is 6 m.
   - 2.2. If the slope is **5-14.9%**, the setback distance will be 6 m + 2.4 m for every 1 % increase in slope after the minimum.
   - 2.3. If the slope is **≥15 %**, then a geological survey is required. The total setback required for this site will be determined by a registered professional. The determined setback must take into

account the slope, height of bank, groundwater influence, soil type and vegetative cover. Setback requirements will be subject to the approval of the subdivision authority.

2.4. Record slope, under measured slope in Step 1 and enter the calculated distance adjustment in the TOTAL Box in Step 1.

2.5. If the determined setback is greater than or equal to 30 m, skip to step 6; otherwise, continue to step 3.

3. **Height of Bank** must be determined by a legal land surveyor at each of the setback points. From each setback point, determine the height of bank perpendicular to the water body, stream or wetland. NOTE: Height of bank will be determined at the same time as slope by the surveyor.
    3.1. Put a check mark next to the appropriate bank height in Step 2.
    3.2. Identify and enter the required distance adjustment in the TOTAL Box in Step 2.
    3.3. If the determined setback is greater than or equal to 30 m, skip to step 6; otherwise, continue to step 4.
4. Determine the **depth to the water table** for the site. This information can be obtained from a geotechnical report, or from local well data by a qualified hydrogeologist.
    4.1. Put a check mark next to the appropriate groundwater depth in Step 3.
    4.2. Identify and enter the required distance adjustment in the TOTAL Box in Step 3.
    4.3. If the determined setback is greater than or equal to 30 m, skip to step 6; otherwise, continue to step 5.
5. Determine the **vegetation cover** of each type for the site.
    5.1. From each setback point, determine the vegetation type perpendicular to the water body, stream or wetland, by creating a 1 m x 10 m plot.
    5.2. Determine the percent of the plot that is grass, shrub, forested, and bare ground.
    5.3. Multiply the percentage of each vegetation cover class by the respective distance adjustment for each type.
    5.4. Put the required adjusted distance beside each respective vegetation cover.
    5.5. Add up the setback requirements from all vegetation cover types to obtain the total vegetation cover setback.
    5.6. Continue to step 6.
6. **Determine the baseline setback** based on slope, bank height, groundwater depth, and vegetation cover.
    6.1. If any of the setbacks calculated from steps 2 – 5 are equal to 30 m, the baseline setback for that point is 30 m.
    6.2. Otherwise, the baseline setback is the maximum of the setbacks determined in steps 2 – 5.
7. **To establish riparian setbacks**, determine setback distances from each setback point. Connect setback points. Setback to the property line will be done perpendicularly from the nearest determined setback point. (See diagram on Page 9 for clarification).

See the attached examples and sample worksheets for more information.

4.3 Slope and Bank Height

Slope and bank height are important factors in determining an appropriate riparian setback width. Steeper slops are more susceptible to erosion and can increase the velocity of overland flow (runoff) and reduce buffer contact time (Wenger 1999; Li *et al* 2006). Dillaha *et al* (1988, 1989) found that as buffer slope increased from 11 % to 16%, sediment removal efficiency declined by 7-38%. Li *et al* (2006) also found that as slope gradient increases, that loss of nutrients also increases. Fox and Brown (1999) found that flow velocities increased with increased slope, with the rate of increase following an approximately linear relationship over the range of slopes considered by this model. The Connecticut Association of Wetland Scientists (2004) suggested a minimum buffer width of 25 feet with a width increase of 3 feet (~1m) for every degree of slope. Others have suggested that there be minimum buffer of 30 m with an increase of 0.61 m for every 1 % increase in slope (Wenger 1999; Sasson 2003). The City of Calgary (2006) recommends that the development setback distance should increase by 1.5 m for every 1% increase in slope after 5%. Based on these and other documents, the minimum setback for slope was established at 6 m, with a linear increase in the setback distance of 2.4 m for every degree in slope over 5%.

Bank height was addressed in the Draft Watershed Management Plan for the Nose Creek Watershed (Palliser, 2005). It was suggested that where there is ≥15% slope, an additional setback from the top of the bank should be added to the riparian development setback. This would provide a stable slope allowance (Palliser, 2005). These recommendations were adopted into our matrix model by requiring that there be a geotechnical survey conducted when the slope is ≥15 %. The slope and height of bank should be determined by a legal land surveyor in order for the model to be legally defensible.

4.4 Groundwater Influence

Groundwater and subsurface flows can also contribute nutrients and pollutants to surface waters (Figure 4), and groundwater itself can become compromised when polluted runoff infiltrates through the soil. For the protection of the surface and groundwater, it is recommended that shallower water tables have larger development setback distances. Devito *et al* (2000) found that lakes located in regional recharge or local discharge areas received proportionally greater phosphorus inputs from surface and near-surface flows, and were therefore more susceptible to watershed disturbances. It was also found that in deeper water tables with primarily subsurface flows, phosphorus is more readily absorbed to the soil and taken up by plant roots. However, in shallower water tables where soil is often waterlogged, overland flow is more common and there was little phosphorus removal (Devito *et al*, 2000). There is very little reference in the literature to groundwater influence when determining effective riparian setback distances. Therefore, this category of the model was developed with the knowledge that deeper groundwater has generally had a longer residence time in the soils (Li *et al*, 2006) and allows for more water to absorb to soil particles (Devito *et al*, 2000). Water that has longer contact with soil has more time for physical, chemical and biological breakdown of pollutants. Shallower water tables are more likely influenced by the immediate surroundings and the water will have had a shorter residence time; additionally, it is more likely to discharge into the surface waters of concern.

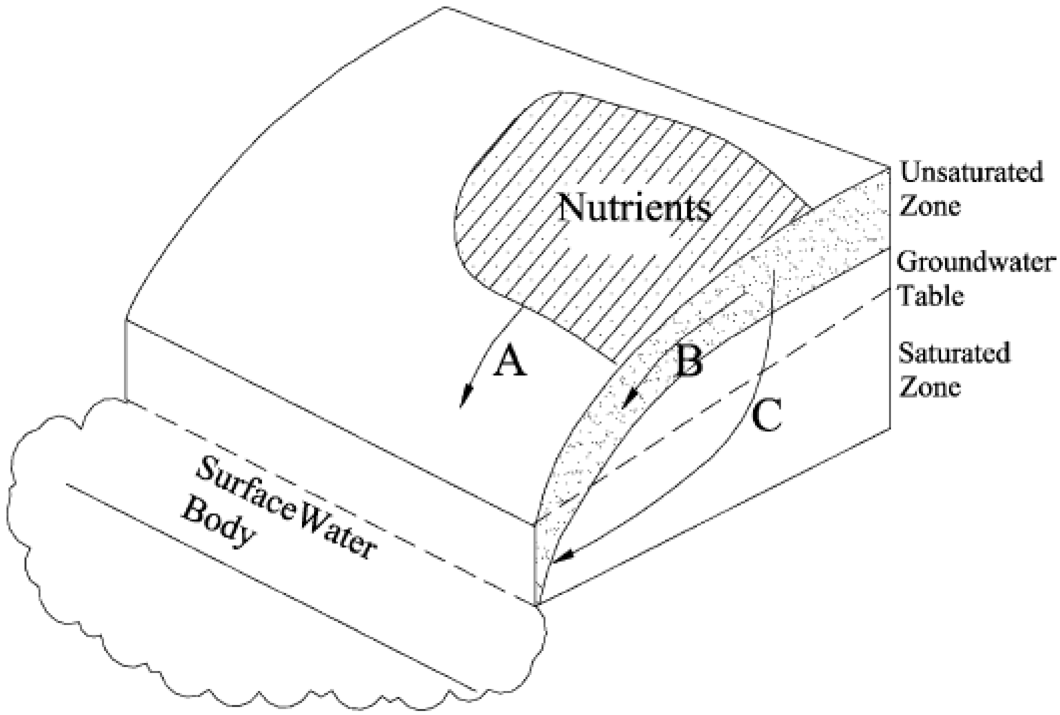

Figure 3. Potential pathways for nutrient and pollutant input from sloping lands to surface water: (A) surface runoff, (B) subsurface flow, and (C) groundwater (Taken from Li *et al* 2006).

4.5 Vegetation Type

Vegetation slows the velocity of overland water flow and allows increased infiltration and sediment deposition (Connecticut Association of Wetland Scientists 2004). Once in the soil, chemical, biological and physical processes remove pollutants through filtering and absorption (Connecticut Association of Wetland Scientists 2004). Plants and microflora also remove nutrients and pollutants through absorption (Connecticut Association of Wetland Scientists 2004). In an extensive review of the literature, Mayer *et al* (2005) found that grassed buffers were the least effective at removing nitrogen from surface and subsurface flows, whereas forested buffers were the most effective (Figure 3). Wenger (1999) reported that both grass and forested buffers were effective for sediment and nutrient removal, but that shrub or forested buffers were more effective for bank stabilization and decreasing erosion. Gilliam (1997) reported that forested buffers were more effective than grass for sediment and nutrient removal, and that a combination of grass and forest was the most effective buffer. The presence of emergent vegetation enhanced the effectiveness of the riparian setback. Based on these and other documents, we designed the matrix so that grass buffers would have the largest distance adjustment.

The matrix was designed with vegetation of different types having additive effects. The aim of the model is to remove a specified percentage of pollutants from runoff. Since each vegetation cover type is capable of removing pollutants at a different rate, the use of an additive model with different weights for each vegetation class will ensure the removal of a consistent percentage of pollutants regardless of cover type at a given location.

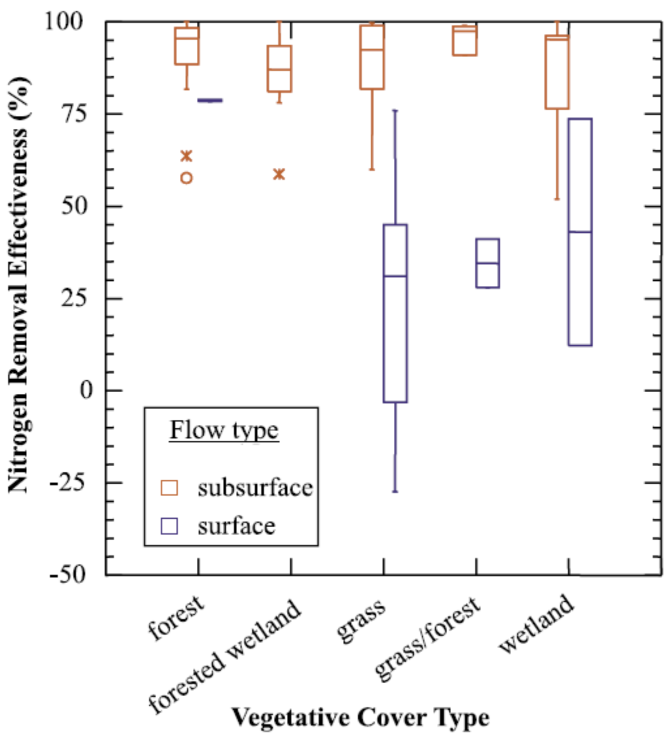

Figure 4. Nitrogen removal effectiveness in riparian buffers by buffer vegetation type and water flow path.

The center vertical line of the box and whisker plot marks the median of the sample. The length of each box shows the range within which the central 50% of the values fall. Note: we do not use wetland or forested wetland cover type in our model. Taken from Mayer *et al* (2005).

5 Professional Requirement for Site Assessments

Although every effort has been made to make the Riparian Setback Matrix Model accessible to as wide an audience as possible, the determination of setbacks should not be undertaken without enlisting the assistance of a professional(s) with qualifications appropriate for the conditions and complexity of the site (Table 3).

Table 3. Professional requirements for site assessments

Condition	Professional Requirements for setback determination
Low slope, obvious transition from aquatic to upland vegetation, groundwater table known from nearby wells	
Complex vegetation communities with no obvious transition from aquatic to upland vegetation	Qualified Aquatic Environmental Specialist (QAES) or Qualified Wetland Aquatic Environment Specialist (QWAES)
Moderate slopes (5-15%)	Legal land surveyor
Steep slopes (>15%)	Geotechnical professional (Geological Engineer, hydrogeologist)
Extensive river meander* or presence of floodplain	QAES/QWAES + Geotechnical professional
Unknown water table depth	Hydrogeologist

* - The turns in a river associated with meander result in large, potentially overlapping riparian setback areas. Meander often indicates bank instability, channels that vary in position from year to year, and generally results in a larger area than would otherwise be expected being incorporated into riparian areas. The model as currently formulated is not designed to handle this case, and requires a geotechnical assessment of bank/channel stability, and a QAES/QWAES assessment to determine the long-term/historical high water marks and extent of riparian vegetation.

6 Summary and Conclusions

Riparian setbacks are useful in reducing the amount of pollutants that reach surface waters. However, they are not perfect, and in storms and floods their effectiveness will be reduced. Therefore, every step possible should be taken to reduce pollutants at their source, and sources should be restricted from floodplains whenever possible, regardless of development setback distance (Wenger 1999). Certain land uses, such as storage of toxic chemicals should never occur adjacent to ER lands or within riparian development setbacks. The cumulative effects of urbanization adjacent to bodies of water and in riparian areas requires careful monitoring and adaption to ensure seemingly innocuous development activities are not polluting our waters. Determining appropriate land uses in environmentally sensitive lands is an important policy consideration for Municipalities that want to ensure long term community and environmental sustainability.

This Riparian Setback Matrix Model was designed using information and recommendations from several pieces of literature and other academic and government documents. There is continuous research on this subject, and new recommendations are continuously being made so future revisions may be required. There are several other categories that may additionally be considered, especially with soils. These include vegetation density and percent cover and for soils, soil type and texture, organic content, pH, and conductivity. However, we feel that this model will be an effective method for determining an effective riparian development setback. As the RSMM is used and more information comes available, adjustments can be made to suit different requirements and needs, depending upon municipal suitability and environmental integrity.

6.1 Remote Sensing and the RSMM

The determination of riparian setbacks as formulated in the above model is based on on-the-ground surveys of potential development or subdivision sites. As such, determining setbacks for large numbers of parcels or over large areas may require a large temporal and financial commitment. However, if sufficiently high resolution remote sensing or other spatial data are available, it may be possible to extend the RSMM to a GIS platform where setbacks could be determined as a desktop exercise, possibly in a semi-automated fashion. However, the resolution for the required GIS data would need to be very high. Unless GIS data were already available or required for other purposes, this approach would be cost prohibitive. At minimum, the required data would include digital elevation models with 1-2 m lateral and 0.5 m or less vertical resolution for slope and bank determination, 1:5,000 or 1:10,000 aerial photos for vegetation cover determination, and 1:20,0000 scale soil texture and groundwater depth maps. The cost associated with purchasing or producing such data are currently high, so unless they are already available or required for other purposes, it would likely not be fiscally worthwhile to obtain them.

6.2 Other Considerations

The riparian development setback should have as few disturbances such as channels and walking paths as possible. Channels, compaction and walking paths will increase the amount of runoff that reaches surface waters and decrease the effectiveness of the setback. Community pathway systems should be developed using permeable construction materials with naturescaping around the edges. Community access points to provincial beds and shores, communal beach development and communal docks are recommended to minimize cumulative detrimental effects instead of allowing many access points or private beach development on reserve lands.

We believe that the Riparian Setback Matrix Model will be of great value to the County of Leduc and other municipalities across Alberta that are serious about protecting their Environmental Reserve lands and sensitive riparian lands. The model is scientifically-based, legally defensible and will allow municipalities to take adequate Environmental Reserve to prevent the most common forms of pollution in Alberta, instead of guessing, using an arbitrary setback or simply requesting the 6 m minimum.

Identifying and protecting riparian areas supports two of the main goals of Alberta's *Water For Life* strategy of ensuring safe, secure drinking water supplies and healthy aquatic ecosystems. Municipalities that adopt this approach will benefit from source water protection within their jurisdiction and will ultimately save thousands of dollars on long term water treatment costs.

7 References

7.1 Riparian Setback Matrix Model References by Category

Parameter	References
Vegetative Cover Type	Mayer *et al*, 2005
	Conneticut Association of Wetland Scientists, 2004
	Chargin River Watershed Partners Inc., 2001
	Wenger, 1999
	Gilliam *et al* 1997
	Klapproth, 2000
Slope	Conneticut Association of Wetland Scientists, 2004
	Calgary City Council, 2006
	City of North Royalton, 2005
	Fox and Brown, 1999
	Sasson, 2003
	Wenger, 1999
Height of Bank	Palliser Environmental Services Ltd., 2005
Groundwater Influence	Li *et al*, 2006
	Devito *et al*, 2000

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8 Appendix A – Vegetation Definitions

Grass & Herbaceous Plants: Any grass or non-woody vegetation (including grasses, forbs, rushes, sedges).

Shrub: Shrubs will be defined as woody plants differing from a tree by its low stature (>2m) and by generally producing several basal shoots instead of a single trunk. Tree seedlings (saplings) <2m will also be considered as shrubs.

Forested: A tree or group of trees with an average height of at least 2 m and an associated understory.

Bare Ground: An area where the soil is exposed, either naturally or through human or livestock influences. There may be sporadically occurring plants present.

Aquatic Vegetation: Plants that grow in water or in saturated soils (i.e. bulrushes, sedges, cattails, rushes, willows).

Upland Vegetation: Plants that grow away from the water in drier soils (i.e. aspen, birch, white spruce and pine trees; shrubs such as rose, mountain ash, juniper and Saskatoon; grasses such as fescue, common grass, wild rye and wheat grass).

9 Appendix B – Sample RSMM Worksheets and Example Calculations

9.1 Example Setback Calculations

A parcel of land is situated with 75m of shoreline along a lake.

9.1.1 CALCULATING SLOPE SETBACKS

The measured slope at both survey sites on the parcel of land is 9%. This slope falls in the category that does not require a check with Leduc County administration. The setback distance will be 6 m + 9.6 m for the additional 4% slope over 5% (6 m + (4 × 2.4 m) = 15.6 m).

9.1.2 CALCULATING BANK HEIGHT SETBACKS

The measured bank height at both survey sites on the parcel of land is 2 m. The setback distance calculated for bank height will be 6 m (all sites with bank heights less than 3 m are assigned a setback of 10 m).

9.1.3 CALCULATING GROUNDWATER DEPTH SETBACKS

Based on a hydrogeological study of the area, reviewed by a qualified hydrogeologist, the depth of the water table for the parcel of land is determined to be approximately 15 m. This places the depth in the 10-19.9 m depth category, and the resulting setback is 15 m.

9.1.4 CALCULATING VEGETATION SETBACKS

Plot 1 is covered by 20% grass & herbaceous vegetation, 30% shrubs, 40% forested, and 10% bare ground.

a.Forested (40% × 0.06) = 2.4 m

b.Shrub (30% × 0.12) = 3.6 m

c.Grass & herbaceous (20% × 0.20) = 4.0 m

d.Bare ground (10% × 0.30) = 3.0 m

TOTAL Vegetation Setback = (2.4 m + 3.6 m + 4.0 m + 3.0 m) = 13.0 meters.

Plot 2 is covered by 20% forested, 0% shrub, 50% grass & herbaceous vegetation, 30% bare ground, and 0% impermeable surfaces.

a.Forested (20% × 0.06)= 1.2 m

b.Shrub (0% × 0.12) = 0.0 m

c.Grass & herbaceous (50% × 0.20) = 10.0 m

d.Bare ground (30% × 0.30) = 9.0 m

TOTAL Vegetation Setback = (1.2 m + 0.0 m + 10.0 m + 9.0 m) = 21.2 meters.

See the attached Riparian Setback Matrix Model sample worksheets and the schematic diagrams of two setback point below for more clarification.

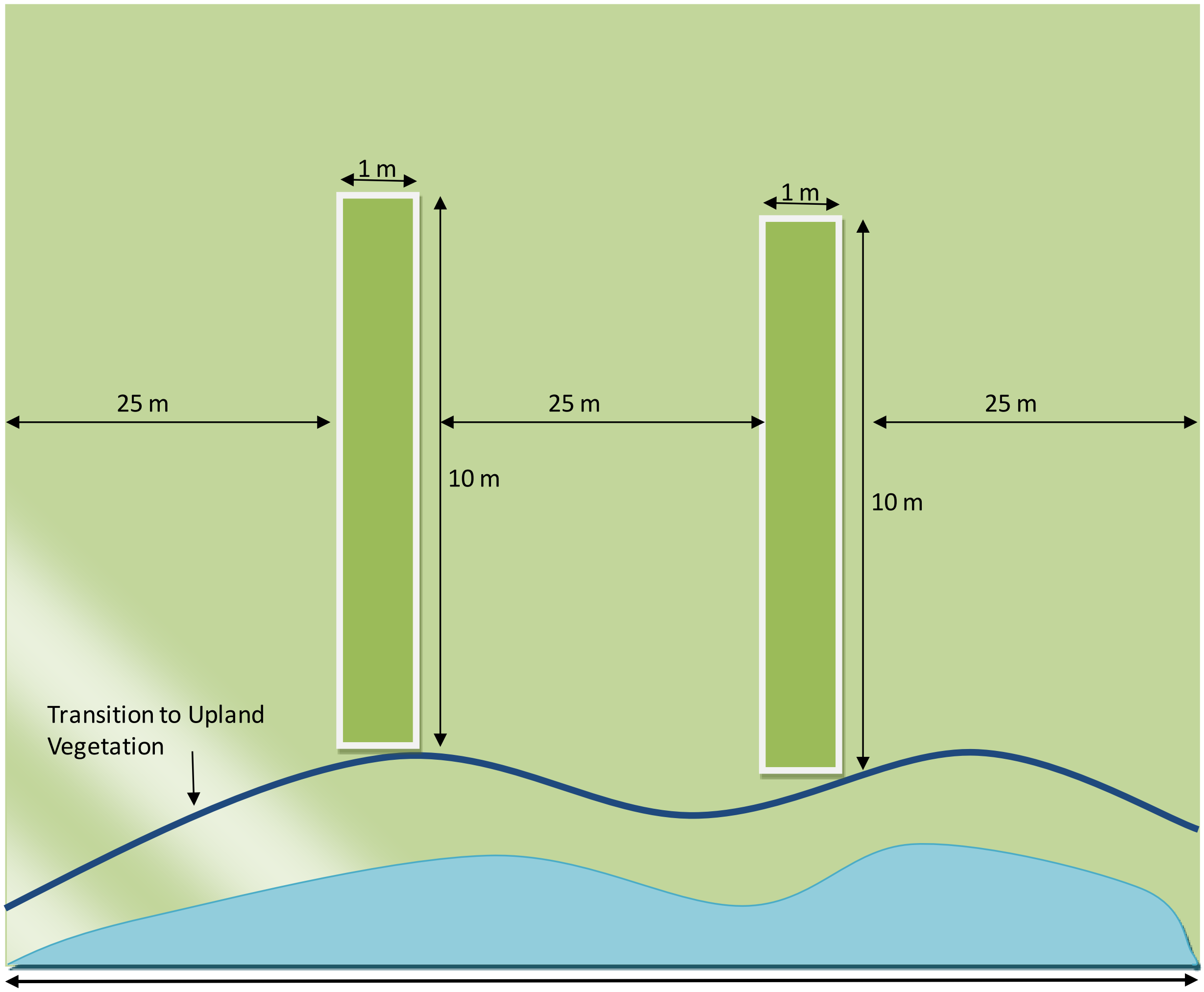

Figure 5. Laying out setback determination sites and vegetation sampling plots for a parcel of land 75 m long.

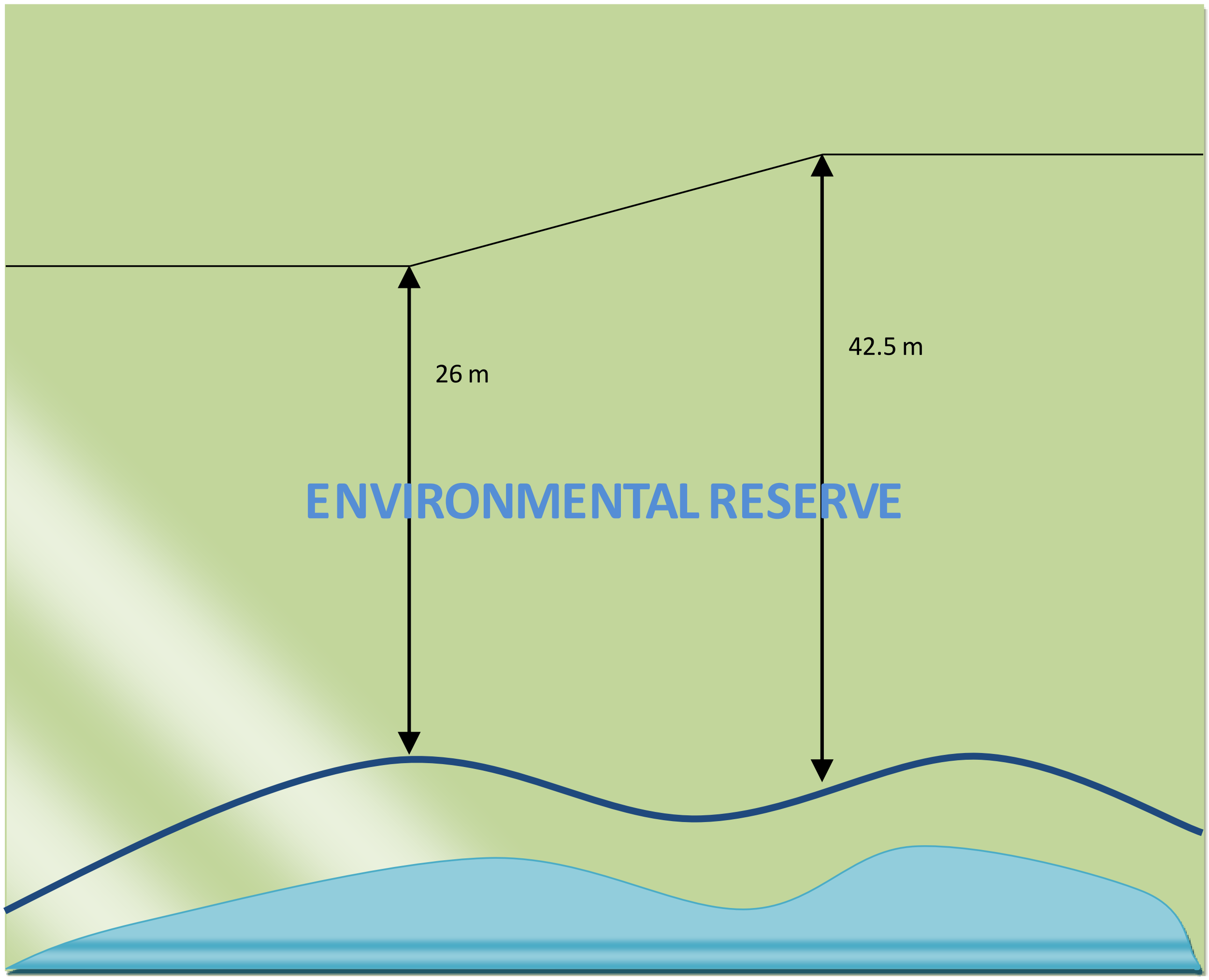

Figure 6. Establishment of Environmental Reserve Boundaries based on the setbacks calculated

9.2 SAMPLE RSMM WORKSHEETS FOR EXAMPLE SITE

Waterbody Name: Waterbody Location:

Waterbody Type (circle one): Lake/Pond River/Stream Wetland

STEP 1	Slope Category (%)	Slope (%)	Distance Adjustment
	0 - 4.9		6 m
	5 - 14.9	9	6 m + 2.4 m per % of slope over 5%
	≥ 15		Requires a geotechnical survey†
	SLOPE SETBACK	15.6 m	(RANGE: 6m to 30m)

STEP 2	Height of Bank	Bank Height (m)	Distance Adjustment
	< 3 m	2	6 m
	3 to 15 m		2x height of bank
	≥ 15 m		30 m
	BANK HEIGHT SETBACK	6 m	(RANGE: 6m to 30m)

STEP 3	Groundwater Influence	Select one:	Distance Adjustment
	Distance to water table		
	0 - 9.9 m		30 m
	10 - 19.9 m	15	15 m
	≥ 20 m		6 m
	GROUNDWATER SETBACK	15 m	(RANGE: 6m to 30m)

STEP 4	Vegetative Cover Type	% Cover	Distance Adjustment (m / % cover type)
	Forested	40	0.06
	Shrub	30	0.12
	Grass and Herbaceous Plants	20	0.20
	Bare Ground	10	0.30
	VEGETATION SETBACK	13.0 m	(RANGE: 6m to 30m)

STEP 5	Overall Setback Calculation		
	Determine maximum setback from Steps 1-4 above	15.6 m	
	TOTAL CALCULATED SETBACK*:		

Waterbody Name: Waterbody Location:

Waterbody Type (circle one): Lake/Pond River/Stream Wetland

STEP 1	Slope Category (%)	Slope (%)	Distance Adjustment
	0 - 4.9		6 m
	5 - 14.9	9	6 m + 2.4 m per % of slope over 5%
	≥ 15		Requires a geotechnical survey†
	SLOPE SETBACK	15.6 m	(RANGE: 6m to 30m)

STEP 2	Height of Bank	Bank Height (m)	Distance Adjustment
	< 3 m	2	6 m
	3 to 15 m		2x height of bank
	≥ 15 m		30 m
	BANK HEIGHT SETBACK	6 m	(RANGE: 6m to 30m)

STEP 3	Groundwater Influence	Select one:	Distance Adjustment
	Distance to water table		
	0 - 9.9 m		30 m
	10 - 19.9 m	15	15 m
	≥ 20 m		6 m
	GROUNDWATER SETBACK	15 m	(RANGE: 6m to 30m)

STEP 4	Vegetative Cover Type	% Cover	Distance Adjustment (m / % cover type)
	Forested	20	0.06
	Shrub	0	0.12
	Grass and Herbaceous Plants	50	0.20
	Bare Ground	30	0.30
	VEGETATION SETBACK	21.2 m	(RANGE: 6m to 30m)

STEP 5	Overall Setback Calculation		
	Determine maximum setback from Steps 1-4 above		
	TOTAL CALCULATED SETBACK*:	21.2 m	