Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

FIELD MANUAL *on* BUFFER DESIGN *for* ATLANTIC CANADA

Canada

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The Agri-Environment Services Branch (AESB) of Agriculture and Agri-Food Canada (AAFC) is committed to an integrated approach to sustainable agriculture, which recognizes that environmentally responsible and competitive agriculture are part of an interconnected system.

Sustainable agricultural systems can only result from sound management of natural, economic and human resources.

Implementation of beneficial management practices for the preservation of soil, land and water resources and development of effective policy for promoting these practices contribute to the goal of an environmentally responsible and competitive agricultural sector in Canada.

ASSUMPTIONS

While spring snowmelt runoff can cause significant runoff events, in Atlantic Canada intense summer rain storms also cause major runoff events. Limited research has been conducted in Atlantic Canada with regards to vegetated buffer strips. As a result some inferences must be made from research done outside this region with varying climates and environmental conditions. This tool was adapted for use in Atlantic Canada agriculture from the Field Manual on Buffer Design for the Canadian Prairies recognizing that currently there is limited research and few practical decision support tools available.

The issues that we are trying to address include sediments in suspension (inorganic and organic residues) and associated nutrients, pesticides, and pathogens, soluble nutrients, and pesticides as aerosols drifting to the riparian area and/or stream.

Trapping of soluble nutrients is primarily achieved through infiltration. Permanent cover increases filtration in frozen soils.

Nutrients should be removed from the buffer through management (haying or appropriately timed grazing, coppicing of willows, selective logging) if regulations allow.

The tool is intended for use by agricultural practitioners with expertise in Beneficial Management Practices (BMPs) and farming, in particular cropping systems. The practitioner must use their judgement in applying the tool. The steps (or questions) in the tool require a yes or no answer when often the answer is somewhere in-between (it depends). Where recommendations do not seem appropriate for the situation, it is expected that the user of the tool will use their judgement in applying the recommendations.

GLOSSARY

Bank zone - the zone between the water's edge and the top of the bank, ideally in permanent vegetation, preferably native.

Buffer - a vegetated buffer between the top of the bank and the edge of the field.

Channel - conveys water intermittently or permanently and includes a stream or river, ditch, and water course.

Concentrated flow path - a poorly-defined channel that conveys water intermittently.

Intervention - a recommended action to be taken that is not an endpoint (outcome) in the Step Diagram.

No-disturbance zone - a 3m wide zone between the top of the bank and the edge of the field, comprising the minimum buffer recommended for safety reasons (to reduce the risk of bank failure from the weight of machinery). A no-machine setback may need to be wider than 3m for deeply-incised channels. The no-disturbance zone should be permanently vegetated with the same species as the bank zone, preferably native.

Outcome - a recommended action that is an endpoint in the Step Diagram.

Riparian area - the transitional area or zone between the aquatic environment (e.g. a stream or river) and the terrestrial upland, characterized by the interaction of stream processes (e.g. sediment deposition), soils that are often modified by abundant water, and lush, productive and diverse vegetation.

Sheet flow - overland flow or runoff making its way to the channel over a broad area along the channel, over relatively uniform land surfaces and slopes, with little evidence of concentrated flow paths or erosion channels.

Significant upland area - an upland area contributing runoff to the channel in an amount and frequency that needs to be buffered.

INTRODUCTION

Why use this tool?

To be effective, buffers should intercept overland flow and aid in filtering groundwater. The Buffer Design Tool was designed to assist agricultural professionals in designing and locating vegetated riparian buffers in Atlantic agricultural landscapes. The tool provides a guiding framework for implementing Beneficial Management Practices (BMPs) in specific agricultural landscapes to minimize the impacts of sediment, nutrient, pesticide, and pathogen losses, particularly nitrogen (N) and phosphorus (P), to fresh water. The tool was developed based on the assumption that no two landscapes are identical, and with the aim of maximizing environmental returns from vegetated buffers while minimizing loss of cropland in production.

What are the benefits of using the tool?

In an effort to protect watercourses, a number of jurisdictions in North America have promoted and, in some cases, regulated the creation of riparian buffers for cropland. Recurring questions have always been asked around the specifications for design of this BMP. How wide should the buffers be? What plant species should be used? And how should the buffers be managed? The answers to these questions have important consequences for both the environment and the agricultural producer.

Traditional buffer recommendations emphasize buffer width and vegetation and tend to assume simple landscapes with uniform slopes and watercourses with uniform morphologies. In practice, landscape and watercourse morphologies are complex. This tool is a method for assessing buffer needs on a site by site basis to identify where buffers should be placed and how buffers should be designed to intercept overland flow.

Well-managed buffer areas should have the vegetation periodically removed, harvested or thinned as a routine part of management in order to sustain or maintain the environmental functions of the buffer; however this is not always permitted within the relevant regulations. For this reason, productive farm land area in buffer is land and revenue lost to the farm operation. Where buffers remove more cropland than necessary to achieve the desired environmental outcome, the loss of that productive agricultural land affects the farmer. Conversely, where a buffer is under-designed, the intended environmental benefit is not achieved.

The underlying philosophy of the tool focuses on identifying the priority interventions that maximize environmental benefit, and not limiting environmental action to a single BMP. This means it assesses the need for a vegetated buffer in the context of looking at how alternative interventions may assist in achieving the environmental benefits. For example, in a landscape where soil erosion is on-going in an adjacent upland area, the tool tries to direct interventions toward controlling erosion rather than only concentrating on trapping sediment and nutrient transport by implementing a buffer.

Who should use the tool?

The primary user of the tool will be people who work with farmers assisting in the design of a vegetated buffer. Producers, land owners, land managers, community and watershed groups may also find the tool useful for understanding the complexities of vegetated buffers and interpreting cropping system landscapes and their risk for sediment, pesticide, pathogen and nutrient loss.

Where can I use this tool?

The tool is applicable to the cropping systems, soil conditions and climate of Atlantic Canada. The focus of the tool is on buffers for watercourses in agricultural landscapes.

How do I use the tool?

The tool incorporates a few methodologies to help guide decision-making:

i) A Logic Diagram for quick visual reference on the linkages and the decision-making logic framework

ii) Steps with detailed information on the factors involved in the decision-making process

iii) Case Studies to provide examples of some of the outcomes of the Tool.

To be effective, the tool should be used in conjunction with other reference resources such as soil maps, topographic maps and air photographs, and, it should be used in consultation together with the producer.

BACKGROUND

What is a Beneficial Management Practice?

A beneficial management practice or BMP is an on-farm management practice aimed at preventing or reducing non-point source (NPS) pollution to help minimize and mitigate impacts and risks to the environment.

What is a vegetated buffer strip?

A vegetated buffer strip is a natural or planted strip of vegetation consisting of grass, forage, shrubs or trees or a combination that is situated between agricultural land and a water body, but can also include vegetated strips planted on the contour within a field. The water bodies to be buffered are often watercourses, but include wetlands, rivers, lakes or anywhere water regularly passes through or pools; most often buffer strips are planted adjacent to these areas. The purpose of a vegetated buffer strip is to intercept NPS pollution in the form of nutrients, pesticides, pathogens and sediment in runoff water from the adjacent agricultural upland. Vegetated buffer strips can also serve other purposes such as intercepting spray drift and providing habitat corridors for wildlife. These strips of vegetation are used to buffer the water resource from adjacent upland land uses and filter out pollutants, particularly from runoff water, before it reaches the water body thus protecting soil, water, and air quality, and improving the biodiversity of the site.

Why are buffers important?

Buffers are important because they provide a physical barrier between the agricultural land and the water body. This physical separation prevents agricultural activities from taking place immediately adjacent to water. Deleterious substances can make their way from the adjacent upland into the water body attached to sediment or dissolved in runoff water or through spray drift. Buffers act to intercept those substances before they can reach the water body. There are a number of different mechanisms whereby contaminants can be removed by a vegetated buffer strip.

Removal of suspended sediments: **Vegetation in the buffer zone acts to decrease the velocity of runoff water flowing into the buffer thereby depositing sediments in the buffer.**

Removal of deleterious substances: **Nutrients, pesticides and pathogens can occur either bound to sediment particles or dissolved in the runoff water. Sediments that are deposited in the buffer prevent the attached substances from making their way into the water body. Vegetation in the buffer increases the infiltration rate of runoff water promoting the infiltration and utilization of dissolved nutrients by the plants inhabiting this zone. Microbial processes such as denitrification in water saturated soils and subsurface water may also be an important mechanism in the removal of nitrogen carried to the riparian area in runoff from upland sources. Pesticide residues and pathogens on the deposited sediments may be degraded microbiologically in the soil in the buffer.**

What are the basics of the Buffer Design Tool process?

The tool was created to assist technical staff and other agricultural practitioners in determining the critical areas on the landscape for a buffer. This tool was adapted for use in Atlantic Canada agriculture from the Field Manual on Buffer Design for the Canadian Prairies recognizing that currently there is limited research and few practical decision support tools available. The tool is a decision support tool which uses questions to assess the landscape and to determine if and where a vegetated buffer strip is needed. Buffer strips are not the entire solution to water quality concerns. Keep in mind that sometimes the tool will recommend BMPs other than vegetated buffer strips. Upland management and soil conservation systems are critical in terms of whole farm management, and in reducing runoff into vegetated riparian buffers. Vegetated buffer strips along watercourses are only part of the solution.

What are the limitations of the buffer tool?

While spring snowmelt runoff can cause significant runoff events, in Atlantic Canada intense summer rain storms also cause major runoff events. Limited research has been conducted in Atlantic Canada with regards to vegetated buffer strips. As a result some inferences must be made from research done outside this region with varying climates and environmental conditions.

The buffer tool uses Yes and No questions to evaluate the landscape. This is a simplified view and it is realized that across the landscape there is a gradient of change. It will therefore be up to the practitioner using this tool to make judgment calls based on their knowledge of the site and past experience.

HOW TO DO THE ASSESSMENT

Landowner Interview

Ask the landowner what objectives he has for the vegetated buffer. He may have more than one objective. For example, preventing nutrients and sediment from impacting water quality may be the primary objective. The landowner may also want to protect fish habitat or enhance biodiversity by protecting wildlife habitat adjacent to the stream.

The landowner's knowledge of local runoff patterns will help to inform the placement of the buffer. Arrange to schedule a field visit with the landowner. Does the area flood frequently? Is runoff from the field concentrated into one or more watercourse before it reaches the stream?

Ask the landowner if there are any concerns about the proposed buffer. There may be concerns about function (how it will work), loss of use for agricultural purposes and loss of income, or maintenance requirements.

Background Information Collection (office)
Maps and Air Photos

Maps are useful for locating the site and to form an impression of the setting. Useful maps include a land ownership map available through local municipalities, provincial government departments or websites, and topographic maps at several scales. A topographic map at a 1:50,000 scale can provide enough general topographic detail as to be a useful starting point in assessment. Soil maps may also be useful if available, although the scale may be too small to provide much detail. Many Atlantic soil maps are at 1:50,000 or smaller scales and consequently provide only limited soil detail at the farm field level. Soil maps at 1:20,000, 1:10,000 or larger scales would provide much more useful soil detail at the farm field level, but are not available for all areas. Maps help you assess the size of the watercourse, gain an understanding of the hydrology of the watershed, and assess the landscape and land use.

Air photos provide a birds-eye view of the site. Stereo pairs are particularly valuable for delineating sub-watersheds, identifying concentrated flow paths and detecting changes in topography that influence runoff. From air photos, you can assess the vegetation on and adjacent to the stream bank and may see indications of bank instability. You may also see upstream influences. Digital maps and air photos can be overlaid and used with Digital Elevation Models (DEMs) to assess surface drainage and land use. The DEM may have been obtained from stereo airphoto pair interpretation, detailed GPS survey or LIDAR. This sort of map information is also starting to become available from provincial government websites or web-based map servers.

In NB:
www.geonb.snb.ca/geonb/
www.snb.ca/gdam-igec/e/2900e_1.asp

In PEI:
www.gov.pe.ca/agriculture/index.php3?number=72488&lang=E

In NS:
www.gov.ns.ca/geonova/home/products/softpage/data_download.asp

In NL:
www.mapsnl.ca

Field Exercise - Applying the Tool

Now it's time to really assess the landscape first hand in the field. At this point you should take the background images and information you have and start down at the stream bank to begin the on-site component of the assessment. It's best if you do this together with the landowner, as they may have information relevant to some of the questions. The next section will guide you through the steps.

OUTCOMES

The possible outcomes from application of the buffer tool are illustrated by the following schematic.

A basic recommendation for all outcomes with well defined watercourses is a minimal buffer made up of a permanently vegetated bank zone and an additional no disturbance zone, the total width of which meets the respective provincial regulations for minimum buffer widths. Provincial regulations for minimum buffer widths vary from province to province with land-use and water-use. Summary tables of the regulations and regulated buffer widths, by province, are in the appendix (p. 74-83).

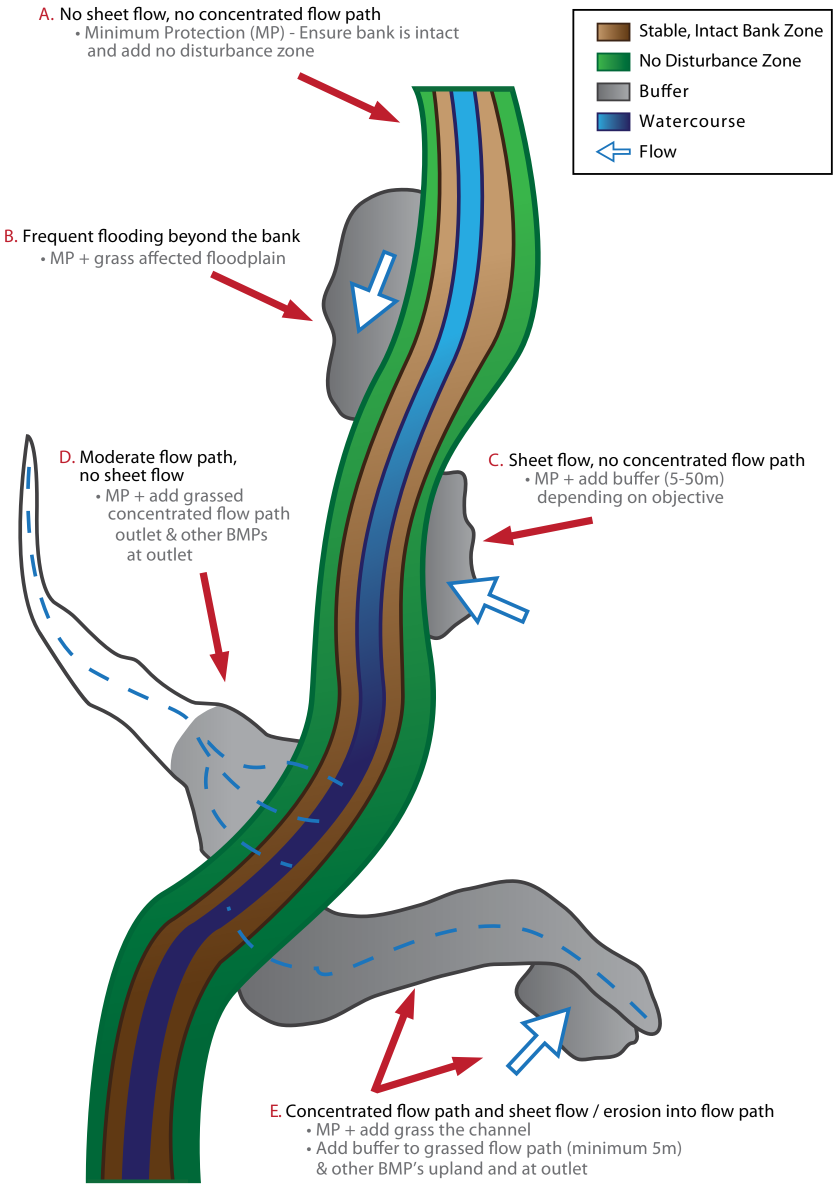
A. Where there is no frequent flooding and there is no significant overland runoff through the riparian zone into the watercourse, the basic recommendation is applied (A).

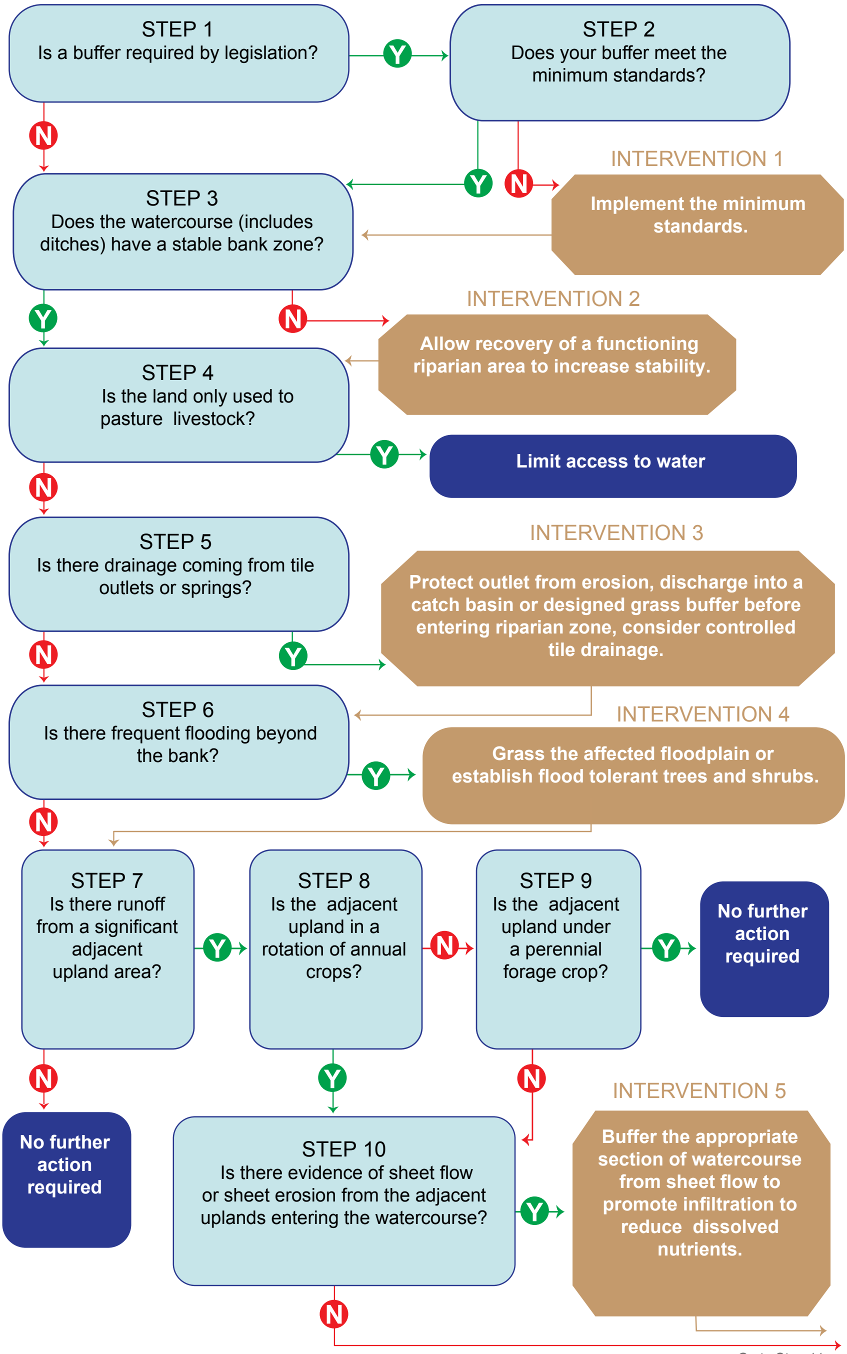
B. Where upstream watershed contributions and landscape characteristics to cause frequent flooding of the site the recommendation is to seed the floodplain to permanent vegetation in addition to the basic protection of the bank and no-disturbance zone (B).

C. Where runoff enters the watercourse the length of watercourse affected by the sheet flow needs buffering (C). The dimensions of the buffer recommended will be determined by the purpose of the buffer, taking into consideration adjacent upland management practices that may affect the recommendation.

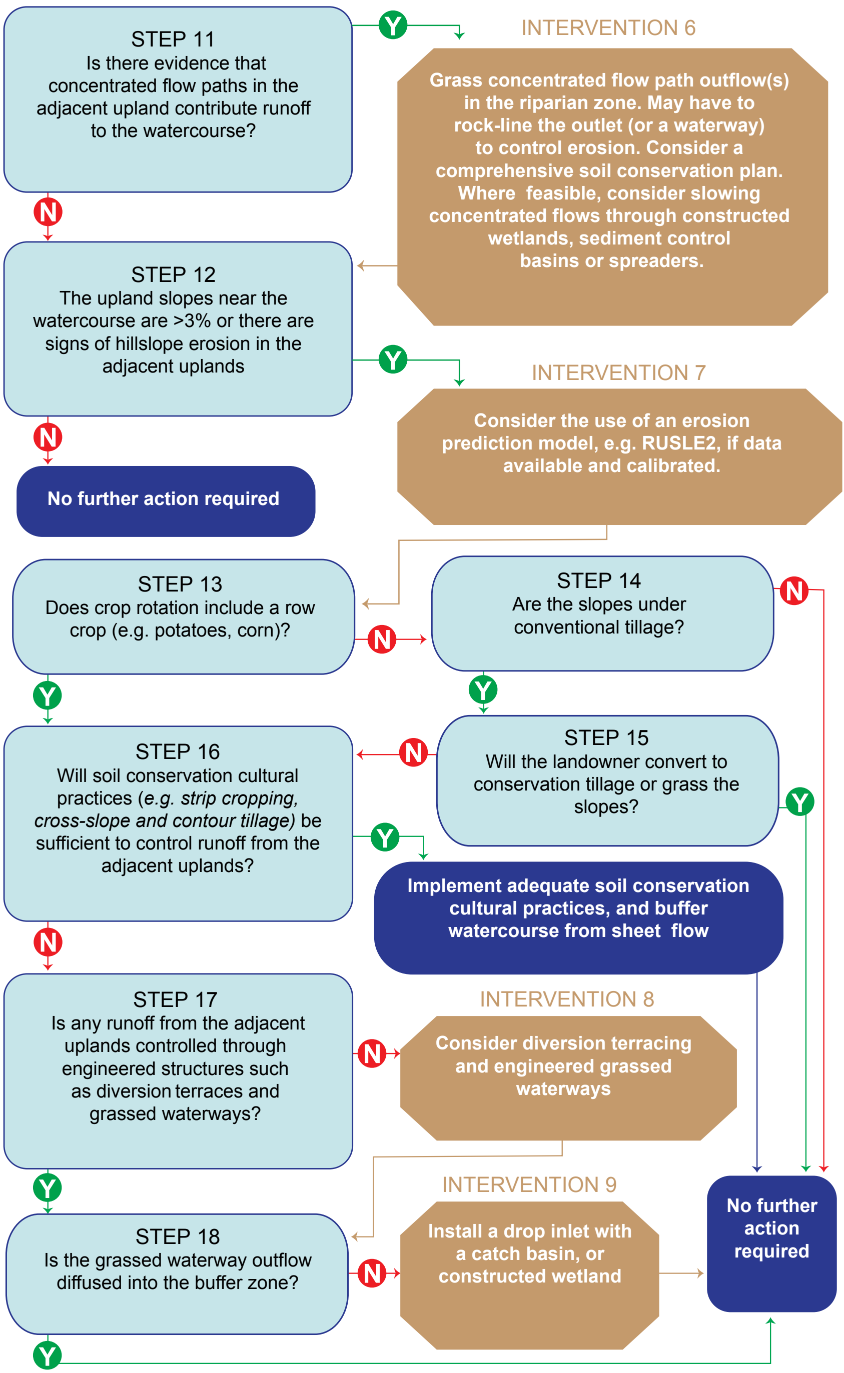
D. Concentrated flow entering the watercourse needs to have the buffer placed at the confluence of the flowpath, designing the buffer to fit the concentrated flow path and sizing the buffer to exceed the normal lateral extent of the runoff (D). The concentrated flow path channel could be grass or rock-lined to control erosion of the channel. It should also be appropriately re-shaped low, wide and parabolic to achieve more laminar flow, slower flow speeds and to reduce the risk of erosion or washout.

E. For a concentrated flow path with sheet flow and erosion into the flow path, the basic recommendation to filter sediments, nutrients, pesticides and pathogens is to place a buffer in the flow path (poorly defined flow channel) in order to maximize sedimentation and infiltration. If there is significant runoff and erosion from the adjacent upland, the buffer may be extended beyond the flow path (or poorly defined flow channel) in order to enhance sediment trapping (E).


A. No sheet flow, no concentrated flow path
• Minimum Protection (MP) - Ensure bank is intact and add no disturbance zone
Stable, Intact Bank Zone
No Disturbance Zone
Buffer
Watercourse
Flow
B. Frequent flooding beyond the bank
• MP + grass affected floodplain
D. Moderate flow path, no sheet flow
• MP + add grassed concentrated flow path outlet & other BMPs at outlet
C. Sheet flow, no concentrated flow path
• MP + add buffer (5-50m) depending on objective
E. Concentrated flow path and sheet flow / erosion into flow path
• MP + add grass the channel
• Add buffer to grassed flow path (minimum 5m) & other BMP's upland and at outlet


STEP 1
Is a buffer required by legislation?
STEP 2
Does your buffer meet the minimum standards?
INTERVENTION 1
Implement the minimum standards.
STEP 3
Does the watercourse (includes ditches) have a stable bank zone?
INTERVENTION 2
Allow recovery of a functioning riparian area to increase stability.
STEP 4
Is the land only used to pasture livestock?
Limit access to water
STEP 5
Is there drainage coming from tile outlets or springs?
INTERVENTION 3
Protect outlet from erosion, discharge into a catch basin or designed grass buffer before entering riparian zone, consider controlled tile drainage.
STEP 6
Is there frequent flooding beyond the bank?
INTERVENTION 4
Grass the affected floodplain or establish flood tolerant trees and shrubs.
STEP 7
Is there runoff from a significant adjacent upland area?
STEP 8
Is the adjacent upland in a rotation of annual crops?
STEP 9
Is the adjacent upland under a perennial forage crop?
No further action required
No further action required
STEP 10
Is there evidence of sheet flow or sheet erosion from the adjacent uplands entering the watercourse?
INTERVENTION 5
Buffer the appropriate section of watercourse from sheet flow to promote infiltration to reduce dissolved nutrients.
Y
N

Go to Step 11...


STEP 11
Is there evidence that concentrated flow paths in the adjacent upland contribute runoff to the watercourse?
Y
N
INTERVENTION 6
Grass concentrated flow path outflow(s) in the riparian zone. May have to rock-line the outlet (or a waterway) to control erosion. Consider a comprehensive soil conservation plan. Where feasible, consider slowing concentrated flows through constructed wetlands, sediment control basins or spreaders.
STEP 12
The upland slopes near the watercourse are >3% or there are signs of hillslope erosion in the adjacent uplands
Y
N
INTERVENTION 7
Consider the use of an erosion prediction model, e.g. RUSLE2, if data available and calibrated.
No further action required
STEP 13
Does crop rotation include a row crop (e.g. potatoes, corn)?
N
Y
STEP 14
Are the slopes under conventional tillage?
N
Y
STEP 16
Will soil conservation cultural practices (e.g. strip cropping, cross-slope and contour tillage) be sufficient to control runoff from the adjacent uplands?
N
Y
STEP 15
Will the landowner convert to conservation tillage or grass the slopes?
N
Y
Implement adequate soil conservation cultural practices, and buffer watercourse from sheet flow
N
STEP 17
Is any runoff from the adjacent uplands controlled through engineered structures such as diversion terraces and grassed waterways?
N
Y
INTERVENTION 8
Consider diversion terracing and engineered grassed waterways
INTERVENTION 9
Install a drop inlet with a catch basin, or constructed wetland
No further action required
STEP 18
Is the grassed waterway outflow diffused into the buffer zone?
N
Y

STEP 1

Is a buffer required by legislation?

YES

A buffer is required by legislation.

GO TO STEP 2

Riparian buffers. *(nb: relevant legislation varies from province to province, and varies with land use and water use)*

NO

A buffer is not required by legislation.

GO TO STEP 3

STEP 2

Does your buffer meet the minimum standards?

YES

There is an existing buffer that meets the minimum standards required by legislation.

GO TO STEP 3

NO

GO TO INTERVENTION 1

These buffers may not meet minimum buffer width regulations or guidelines.
(photo right side from: Service New Brunswick)

(nb: regulated and/or guideline minimum buffer widths vary from province to province, and vary with land use and water use)

INTERVENTION 1

Follow legislated requirements to set aside a buffer and implement minimum standards.

The minimum requirements for buffers vary from province to province.

Minimum legislated requirements for buffers are summarized in the Appendix (p. 74-83).

GO TO STEP 3.

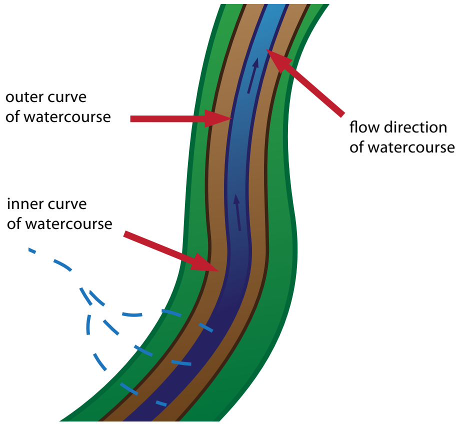
STEP 3

Does the watercourse (includes ditches) have a stable bank zone?

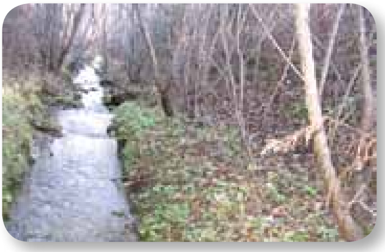
YES

The watercourse has a stable bank zone, typically made up of a succession of vegetation communities from emergents (e.g. sedges) at the water's edge through willows and alders to grasses and forbs and possibly upland shrubs and trees; however, the vegetation may vary with region and bank morphology. The bank vegetation is considered to extend on to land level enough to be cultivated. This bank vegetation is identified as a key factor in ensuring bank stability. There should be no pesticide application within this bank area and a wider buffer may be needed to control spray drift. Often there may be sufficient protective width on the inner curves of watercourses, but less on the outer curves of the bank where cultivation cuts too close to the bank.

GO TO STEP 4



STEP 3



Stable Bank Zones

NO

The watercourse does not have a stable bank. The contributing factors should be identified and could include periodic cultivation of the bank edge, livestock access, invasion of poorly rooted plant species, stream-induced bank erosion, springs or other features that may cause instability. Further investigation of possible contributing factors is beyond the scope of this tool.

GO TO INTERVENTION 2

Unstable Bank Zones

INTERVENTION 2

Allow the recovery of a functioning riparian area to increase bank stability. This recovery could be achieved **naturally** or with a **designed solution**:

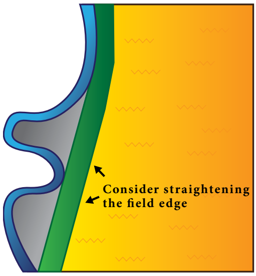
Natural Restoration

A stable bank zone usually includes a succession of vegetation communities from emergents (e.g. sedges) at the waters edge though willows to grasses and forbs and possibly upland shrubs; however the vegetation may vary with region and bank morphology. Bank restoration could occur naturally if given sufficient rest from pressure by increasing the distance between the bank edge and the field edge. Often there may be sufficient protective width on the inner curves of watercourses, but less on the outer curves of the bank where cultivation cuts too close to the bank.

This option requires that a community of natural vegetation exists in order to repopulate the affected areas, and that the structural damage to the bank is not severe. Consideration can be given to straightening the field edge such that the minimum buffer width required is maintained at the outside bends of the watercourse.

Increase the distance between the bank edge and the field (for streambank stability protection) and restrict livestock access.

Increase The Distance Between Bank Edge And Field For Streambank Stability Protection



INTERVENTION 2

Engineered Restoration

Some bank restoration may require engineering or a special solution. Options could include bioengineering, stabilization, or special buffers for unique features such as seeps, springs or severely eroded streambanks. These solutions are beyond the scope of this tool and require consultation with regulatory agencies (e.g. Provincial Ministries of Environment, Fisheries and Oceans Canada).

Increase the distance between the bank edge and the field (for stability protection) and restrict livestock access.

GO TO STEP 4

Engineered Streambank Restoration or Reinforcement and Bio-Engineered Streambank Restoration

STEP 4

Is the land only used to pasture livestock?

YES

The land next to the watercourse is used to pasture livestock. Livestock can trample riparian vegetation, compact and erode the soil by hoof action (pugging or poaching), and contaminate water with their waste adding nutrients, bacteria, and other pathogens.

Limit access to water by fencing cattle away from the bank *(fencing requirements vary from province to province)*; use hardened cattle crossings where permitted *(bridges or culvert crossings recommended)*; harden in-stream cattle watering sites where watering sites are permitted *(alternate watering sources recommended).* Where fencing is not required, encourage livestock to stay away from water by providing alternate sources of water off-site and placing salt and mineral blocks away from the water. Restrict access of cattle grazing in the riparian zone *(if permitted)* to short periods of time when soils are not wet and growth is established (e.g. late summer or fall). Contact a watershed group or agricultural practitioners in your area for a Riparian Health Assessment using the Cows and Fish or other riparian zone assessment tools.

LIMIT ACCESS TO WATER

Fencing along the riparian zone to prevent cattle from entering the watercourse or riparian zone

STEP 4

NO

The land is not only used to pasture livestock. The land is used to grow a crop.

Hay and rows crops growing upslope of a riparian zone

GO TO STEP 5

STEP 5

Is there drainage coming from tile outlets or springs?

YES

Drainage is coming from outlet tile or springs.

- Protect the outlet from erosion.
- Where required or feasible, discharge drainage into a catch basin, constructed wetland, or designed grass buffer before the water enters the riparian zone.
- In some cases, where the soil is deep enough and field gradients allow, it may be feasible to consider controlled tile drainage to keep nutrients in the soil.

GO TO INTERVENTION 3

Streambank not protected from erosion by tile drainage water outflow.

NO

Drainage is <u>not</u> coming from outlet tile or springs.

GO TO STEP 6

INTERVENTION 3

Water flowing from tile drainage outlets can cause soil erosion or streambank erosion. The area around tile drainage outlets should be adequately protected from erosion through the use of an appropriate combination of rock riprap and vegetation, depending on the flow volume and the steepness of the slope. Several outlet designs are possible, using straight or inclined outlets, with or without drop inlets. Engineering and design specifications for protecting tile drain outlets from erosion are available in several publications. For example,

www.omafra.gov.on.ca/english/engineer/facts/90-233.htm

Where required or feasible, discharge tile drainage into a catch basin, constructed wetland, or designed grass buffer before the drainage enters the riparian zone. This will allow sediments to settle out, nutrients to infiltrate or be absorbed by vegetation and will reduce erosion. Design specifications for catch basins, constructed wetlands and grassed buffers are discussed in several publications. For example,

catch basins:

www.gnb.ca/0173/30/0173300013-e.asp

constructed wetlands:

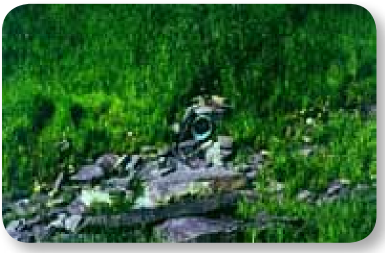
www.gov.ns.ca/agri/rs/envman/appendix_d.pdf

www.gov.pe.ca/photos/original/eef_wildlife_p1.pdf

In some cases, where the soil is deep enough and field gradients allow, it may be feasible to consider controlled tile drainage to keep nutrients in the soil. The volume of drainage coming from outlet tiles can be periodically reduced through the use of a controlled drainage system. Such systems only allow drainage flow from the tile outlet when the water table in the soil above the drainage collection tiles reaches a certain set maximum acceptable height above the tiles. The retention of the water in the soil for longer periods aids in retaining nutrients in the soil and allows for greater nutrient uptake by plants. Consequently, smaller quantities of nutrients will be lost with tile drainage water thereby reducing the amount of nutrients that may eventually enter watercourses or other water bodies. The engineering and design requirements for a controlled drainage system are quite variable and very site-specific. If you consider this option, you should have an engineer prepare an appropriate plan. For example,

www.agf.gov.bc.ca/resmgmt/publist/500Series/564000-1.pdf

GO TO STEP 6



Streambank protected from erosion by tile drainage water outflow.

STEP 6

Is there frequent flooding beyond the bank?

YES

There is frequent flooding of the riparian zone beyond the bank (i.e. there is an active floodplain) that is unlikely to be controllable on-site. There is potential for erosion and for release of pollutants (nutrients and/or pesticides) if the zone is cultivated. Converting the zone to permanent cover will minimize the impact of flooding on site and provide conditions that will slow flows and promote sediment deposition. Frequent flooding may be defined by a time-frame (once every 2-3 years) or by asking questions about frequency of crop losses, delays in seeding or harvesting due to wet conditions etc.

GO TO INTERVENTION 4

STEP 6

Flooding of riparian zone beyond the streambank

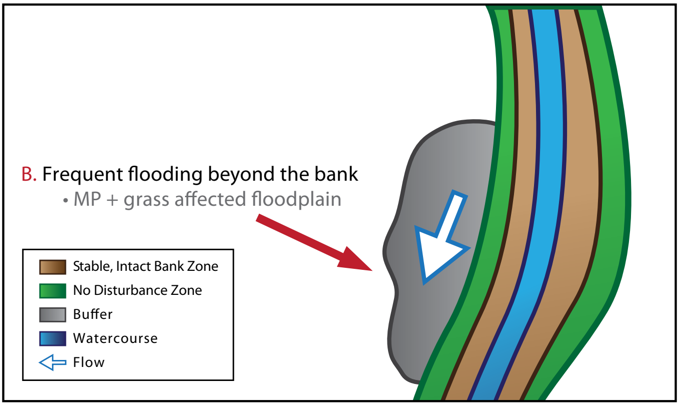
NO

The zone beyond the bank rarely floods. Infrequent flooding of the zone suggests that it is not an active or well-defined floodplain and that the groundwater table is not very shallow. Generally crops would grow well.

GO TO STEP 7

INTERVENTION 4

Grass the Affected Floodplain or establish flood tolerant trees and shrubs.



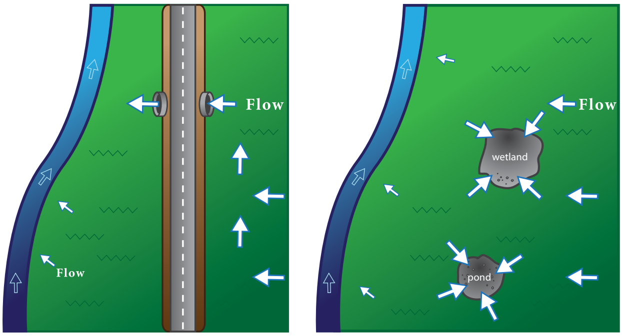
GO TO STEP 7

STEP 7

Is there runoff from a significant adjacent upland area?

YES

The watercourse has the potential to receive runoff from a significant adjacent upland area. Evaluation of the adjacent upland contributing area may be based on information from landowner, delineating and evaluating the catchment area of the runoff and considering normal snowmelt and rainfall runoff for the region.
The size of the catchment deemed to be significant is somewhat subjective; the size will vary in different ecoregions depending on management practices and on the precipitation and evapotranspiration balances. The adjacent upland contributing area should also be assessed in terms of the management practices and structures used in the fields (e.g. road ditches, culverts, diversion terraces and grassed waterways) to determine their effect on the potential runoff. The objective is to determine whether there is an amount and frequency of runoff that needs to be buffered.



GO TO STEP 8

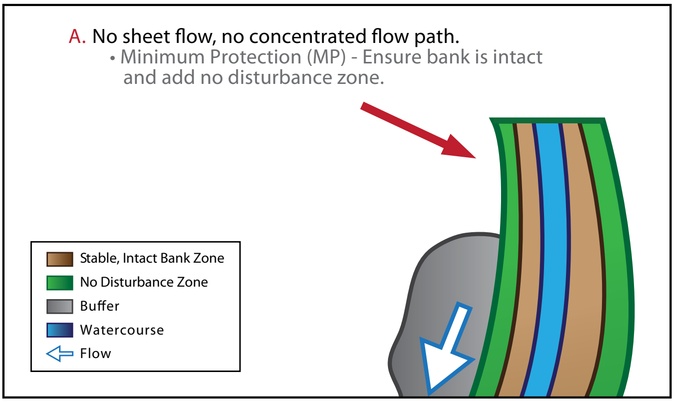
STEP 7

NO

The watercourse does not receive significant volumes of runoff.

NO FURTHER ACTION REQUIRED

RESPECT REGULATED MINIMUM BUFFER WIDTHS



STEP 8

Is the adjacent upland in a rotation of annual crops?

YES

The adjacent upland is in a rotation of annual crops.

GO TO STEP 10

Annual crops in rotation

NO

The adjacent upland is NOT in a rotation of annual crops.

GO TO STEP 9

STEP 9

Is the adjacent upland under a perennial forage crop?

YES

The land is under a perennial forage crop (hay or pasture). Maintain a minimum buffer from top of bank to maintain integrity of the bank. Follow provincial setbacks for manure application and also for fencing (where required).

NO FURTHER ACTION REQUIRED

RESPECT REGULATED MINIMUM BUFFER WIDTHS

Land under a perennial forage crop and hay

NO

The land is NOT under a perennial forage crop (hay or pasture).

GO TO STEP 10

STEP 10

Is there evidence of sheet flow or sheet erosion from the adjacent uplands entering the watercourse?

YES

There is evidence of sheet flow or sheet erosion (inter-rill erosion) from the adjacent uplands along the watercourse. Buffer the appropriate section of the watercourse from sheet flow to promote infiltration to reduce dissolved nutrients and pesticides and to trap sediment-bound pollutants in runoff.

GO TO INTERVENTION 5

Evidence of sheet flow or sheet erosion in the adjacent uplands

Note: In nature, true sheet flow (or sheet erosion) probably does not exist. Water tends to come together to create rivulets, but if the land surface is relatively uniform and the slope is relatively uniform, and there is little evidence of larger concentrated flow paths, or erosion channels, then it is likely that runoff is making its way to the watercourse over a broad area along the length of the watercourse, and in this context would be considered as sheet flow.

STEP 10

NO

There is no evidence of sheet flow from the adjacent uplands along the watercourse.

GO TO STEP 11

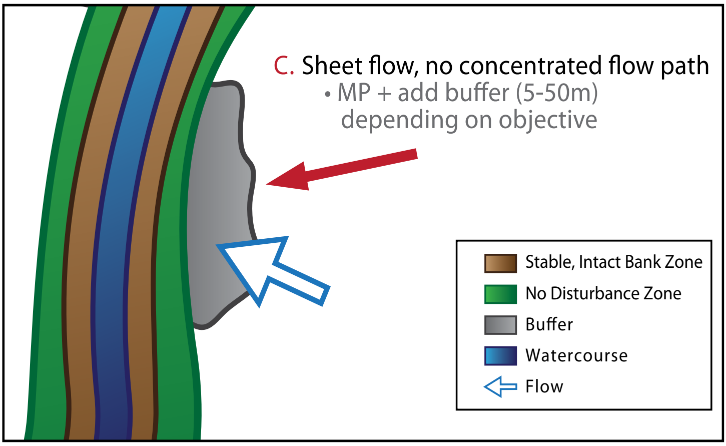
INTERVENTION 5

Because there is a significant amount of runoff, a buffer along the section of watercourse receiving sheet flow is recommended to promote infiltration to reduce dissolved nutrients, pesticides and pathogens and to trap sediment-bound pollutants in runoff.

For trapping sediments, sediment-bound nutrients, sediment-bound pesticides or pathogens 5 to 30 meters or wider widths may be required, depending upon the field slope, slope length, crops and provincial legislation.

For dissolved nutrients, the width may be mostly a function of the soil's infiltration capacity since the pollutants of concern are soluble. For soluble nutrient-reduction, a range of 15 to 50 meters of buffer is recommended depending upon the soil's infiltration capacity and the adjacent field slope.

BUFFER WATERCOURSE FROM SHEET FLOW



GO TO STEP 11

STEP 11

Is there evidence that concentrated flow paths in the adjacent upland contribute runoff to the watercourse?

YES

There is evidence that concentrated flow paths in the adjacent uplands contribute runoff to the watercourse. Concentrated flow suggests that the contribution of runoff from the adjacent upland is occurring at specific locations along the watercourse. Generally this would be indicated by small depressions or rills that drain portions of the riparian area and/or the adjacent upland and release the water into the watercourse.

Evidence of concentrated flow from adjacent uplands

Grass the concentrated flow path outflow(s) to act as a sediment, pesticide and pathogen filter and to promote infiltration to reduce dissolved nutrients and pesticides. Consider a comprehensive soil conservation plan. Where feasible, consider slowing concentrated flows through constructed wetlands or sediment control basins, or by spreading out the flow laterally. May have to rock the outlet (i.e. construct a rock chute spillway), construct a drop structure, or rock-line a grassed waterway to control erosion.

GO TO INTERVENTION 6

NO

There is no evidence that concentrated flow paths in the adjacent uplands contribute runoff to the watercourse.

GO TO STEP 12

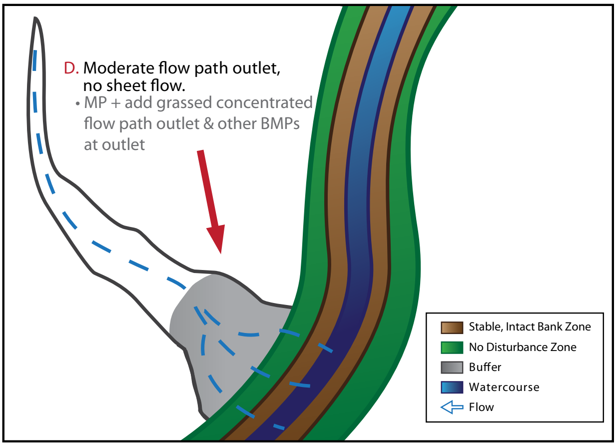
INTERVENTION 6

Grass the concentrated flow path outflow(s) in the riparian zone to act as a sediment filter and to promote infiltration to reduce dissolved nutrients and pesticides. Consider a comprehensive soil conservation plan. Where feasible, consider slowing concentrated flows through constructed wetlands or sediment control basins, or by spreading out the flow laterally. May have to rock-line the outlet (i.e. construct a rock chute spillway), construct a drop structure, or rock-line the waterway to control erosion. For low sloped land (< 3%), land-leveling may be an option to convert concentrated flows into sheet flows.

A rock-lined outlet and a drop inlet structure in two different concentrated flow paths on farm fields.

Concentrated flow entering the watercourse needs to have the buffer placed at the confluence of the runoff, shaping the buffer to fit the concentrated flow path and sizing the buffer to exceed the normal lateral extent of the runoff. In the absence of more detailed work we recommend that concentrated flow outlets to the main watercourse be buffered up the flow path channel at least as far as any signs of sediment deposition or erosion of the flow path, or a minimum of 15 m.

GRASS CONCENTRATED FLOW PATH



GO TO STEP 12.

STEP 12

Are the upland field slopes near the watercourse > 3% or are there signs of erosion in the adjacent uplands?

YES

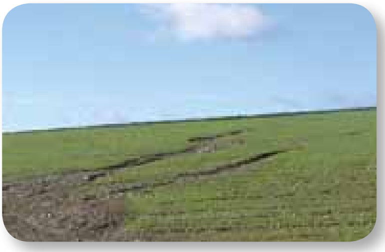
The adjacent upland field slopes near the watercourse are > 3 % or there are signs of erosion from the adjacent uplands.

Moderate to steep upland field slopes adjacent to watercourses elevate the risk of transport of sediment to a watercourse. The purpose of this step is to assess the potential for soil erosion by runoff. If the slopes are steep or show signs of erosion then the conservation practices on the slope need to be assessed.

Evidence of erosion may include such things as rills parallel to the slope, reorientation of crop residues parallel to the slope, and accumulation of sediments uniformly across the bottom of the slope. Sheet (inter-rill) and rill erosion may also be evident indicating signs of erosion from the adjacent uplands.

Assess the tillage, cropping and conservation practices in the adjacent fields to see if changes can be made to reduce erosion.

GO TO INTERVENTION 7



Adjacent upland field slopes > 3 % near a watercourse with signs of erosion

STEP 12

NO

The upland slopes near the watercourse are less than or equal to 3% and there are no signs of erosion from adjacent uplands.

NO FURTHER ACTION REQUIRED
RESPECT REGULATED MINIMUM BUFFER WIDTHS

INTERVENTION 7

Consider the use of an erosion prediction model, e.g. Revised Universal Soil Loss Equation 2 (RUSLE2).

(Caution - the data necessary may not be available or calibrated in some regions).

The Revised Universal Soil loss equation provides a fairly simple means of estimating soil loss from farm fields under varying crop management and tillage practices. It has been widely used for this purpose and will provide some insight into the management required on the adjacent upslope farm fields. Assess the tillage and conservation practices in the adjacent fields using RUSLE2 to see if changes can be made to reduce erosion.

The RUSLE2 software program and supporting documentation may be obtained from the following US website:

http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm

GO TO STEP 13.

STEP 13

Does the crop rotation include a row crop (e.g. potatoes, corn)?

YES

The crop rotation includes a row crop (e.g. potatoes, corn).

GO TO STEP 16

Crop rotations including a row crop. Row crops may lack adequate vegetative cover for the soil early in the season and post harvest, and may provide inter-row runoff flowpaths.

NO

The crop rotation does not include a row crop (eg: potatoes, corn).

GO TO STEP 14

STEP 14

Are the slopes adjacent to the watercourse under conventional tillage?

YES

The upland slopes near the watercourse are conventionally tilled (i.e. there is less than 30% residue left on the surface). Conventionally tilled high sloped lands are at high risk for erosion especially if cultivated up and down the slope. Assess the tillage practices in the adjacent upland fields to see if changes can be made to reduce erosion. Even with tillage practice changes, because there is potential for significant runoff, a buffer along the section of watercourse receiving sheet flow could be effective to reduce dissolved nutrients (through infiltration). An effective width will be a function of whether the tillage practice changes are made. If erosion is reduced in the adjacent upland fields, then an effective buffer width would be mostly a function of the infiltration capacity where the pollutants of concern are soluble. If erosion potential is not reduced, the width must also consider trapping potential for sediments and the nutrients, pathogens and pesticides attached to those sediments.

GO TO STEP 15

Fields with conventional tillage

STEP 14

NO

The upland slopes near the watercourse are not conventionally tilled (i.e. there is 30% or more residue left on the surface).

NO FURTHER ACTION REQUIRED

RESPECT REGULATED MINIMUM BUFFER WIDTHS

STEP 15

Will the landowner convert to conservation tillage or grass the slopes?

YES

The landowner will convert to conservation tillage or grass the slopes.

NO FURTHER ACTION REQUIRED

RESPECT REGULATED MINIMUM BUFFER WIDTHS

No-till grain planting into crop residues and no-till pasture remediation

NO

The landowner will not convert to conservation tillage or grass the slopes.

GO TO STEP 16

STEP 16

Will soil conservation cultural practices (eg: strip cropping, cross-slope and contour cropping) be sufficient to control runoff from the adjacent uplands?

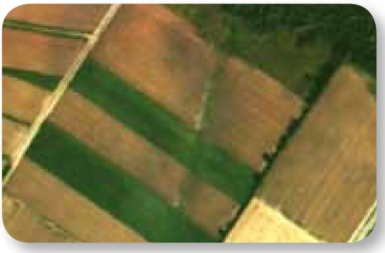
YES

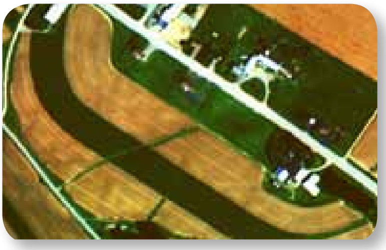
Implement adequate soil conservation cultural practices, and buffer watercourse from sheet flow runoff.

NO FURTHER ACTION REQUIRED

RESPECT REGULATED MINIMUM BUFFER WIDTHS

nb: Cross-slope and contour cropping are often more effective in combination with diversion terraces or berms (see step 17).





A field with cross-slope strip cropping; and a field with strip cropping on the contour (photos from: Service New Brunswick)

STEP 16

NO

Other soil conservation practices are not followed (e.g. strip cropping, cross-slope and contour cropping). Because of the high risk for erosion and runoff there is potential for sediment transport, soluble nutrient transport, and runoff containing pesticides and pathogens being transported to the stream. A buffer along the entire watercourse could be effective. The width should be great enough to effectively trap sediment, pathogens or pesticides and to allow for infiltration of soluble nutrients.

GO TO STEP 17

STEP 17

Is the runoff from the adjacent uplands controlled through engineered structures such as diversion terraces and grassed waterways?

YES

The adjacent uplands are diversion terraced and the concentrated flow from the diversion terraces flows through engineered grassed waterways. Diversion terracing breaks up slope lengths, reduces soil erosion, and increases on-field water infiltration, reducing runoff towards the buffer.

GO TO STEP 18

Fields with diversion terraces, with terrace outflow through engineered grassed waterways

STEP 17

NO

The adjacent uplands are not diversion terraced. Consider diversion terracing systems to break up slope lengths and reduce soil erosion. Engineered grassed waterways will be required to handle the concentrated flow from the diversion terraces.

GO TO INTERVENTION 8

Row crop fields without diversion terraces, cropped up-and-down slope.

INTERVENTION 8

Consider diversion terracing systems and engineered grassed waterways

Row crop fields, such as potatoes for example, can have considerable runoff particularly when the field slopes are steep and long. In this situation, runoff water may cause soil erosion and may carry sediments, nutrients, pesticides or pathogens into the watercourse. To reduce runoff and erosion it is recommended that the uplands fields adjacent to the watercourse be diversion terraced on the contour and that the water outflow from those diversion terraces be routed through engineered grassed waterways.

Design criteria for such diversion terrace systems and grassed waterways are available from several sources, such as:

diversion terraces:

http://www.gnb.ca/0173/30/0173300012-e.asp

grassed waterways:

http://www.gnb.ca/0173/30/0173300006-e.asp

GO TO STEP 18


Fields with diversion terraces and engineered grassed waterways

STEP 18

Is the grassed waterway outflow diffused into the buffer zone?

YES

The grassed waterway outflow is diffused into the buffer zone.

NO FURTHER ACTION REQUIRED
RESPECT REGULATED MINIMUM BUFFER WIDTHS

Grassed waterway outflows diffused to vegetated buffer zones
photos from: Service New Brunswick

NO

The grassed waterway outflow is not diffused into the buffer zone. Install a drop inlet with a catch basin, or constructed wetland.

GO TO INTERVENTION 9

INTERVENTION 9

Install a drop inlet with a catch basin, a sediment control basin, or a constructed wetland to diffuse grassed waterway outflow into the buffer zone

Water flowing from grassed waterway outlets can cause soil erosion or streambank erosion.

Where required or feasible, diffuse water flowing from grassed waterway outlets into a drop inlet with a catch basin, a sediment control basin, a constructed wetland, or designed grass buffer before the outflow enters the riparian zone. This will reduce erosion and allow sediments to settle out, nutrients to infiltrate or be absorbed by vegetation. Design details for catch basins, constructed wetlands and grassed buffers are discussed in several publications. For example,

catch basins:

http://www.gnb.ca/0173/30/0173300013-e.asp

constructed wetlands:

http://www.gov.ns.ca/agri/rs/envman/appendix_d.pdf

http://www.gov.pe.ca/photos/original/eef_wildlife_p1.pdf

Drop inlet at end of grassed waterway, and a grassed waterway with outlet protection

10.1 Minimum Protection

Site: Coverdale, New Brunswick

This site west of Moncton is adjacent to Turtle Creek, a tributary to the Petitcodiac River. The Petitcodiac is a tidal river, and the tidal influence is evident at this site. The site is near sea level (Figure 10.1.1).

[Figure 10.1.1]

The field in question is adjacent to the east side of the creek and is dyked land. It is bordered by a high bank that separates the dyked land from the uplands (Figures 10.1.2, 3, and 4).

[Figure 10.1.2]
(courtesy of Service New Brunswick)

STEP 1. A buffer is required by legislation. A 5m buffer for watercourses is required for existing farms. A farm ditch requires a 2m buffer.

STEP 2. The buffer adjacent to the creek may not meet the minimum standard of 5m in all locations (Figure 10.1.5).

INTERVENTION 1. Ensure the buffer meets the minimum standards.

[Figure 10.1.3]
(courtesy of Service New Brunswick)

10.1 Minimum Protection

STEP 3. The watercourse appears to have a stable bank zone.

[Figure 10.1.4]

STEP 4. The land is not used to pasture livestock. Forage is grown.

STEP 5. No drainage from tile outlets or springs was observed. However, this field was observed from the road only.

STEP 6. The dyked land is protected from flooding by the dyke. There does not appear to be potential for frequent flooding above the low bank adjacent to the creek (the dyke).

[Figure 10.1.5]

STEP 7. There does not appear to be runoff from a significant adjacent upland area. The dyked land immediately adjacent to the creek is flat. There is a wooded bank that separates the dyked land from uplands beyond the wooded bank. Contours on the topographical map are not closely spaced together, indicating relatively gentle slopes. In this vicinity, the wooded slope would buffer runoff from the uplands above.

OUTCOME Minimum protection is required for the field in this location. Ensure a minimum 5m buffer adjacent to the creek.

10.2 Frequent Flooding

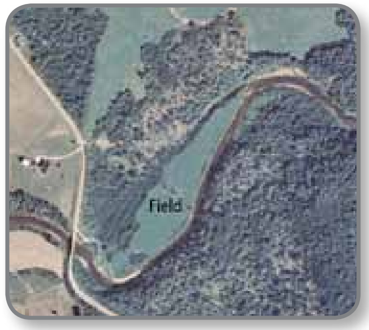
Site: Colpitts Settlement, NB

This site southwest of Moncton is adjacent to the Little River, a tributary to the Petitcodiac River. The Petitcodiac is a tidal river, but there is no evidence of tidal influence at this site on the Little River. The site is about 40m above sea level (Figure 10.2.1). The topography of the area is hilly with the Little River incised in the main valley. A number of brooks draining side valleys are indicative of an area of abundant precipitation.

[Figure 10.2.1]

The field in question is adjacent to the west side of the river. The field is in the floodplain and is bordered by a wooded slope that separates the floodplain from the uplands (Figures 10.2.2 and 3).

STEP 1. A buffer is required by legislation. A 5m buffer for watercourses is required for existing farms. A farm ditch requires a 2m buffer.



[Figure 10.2.2]
(courtesy of Service New Brunswick)

STEP 2. The buffer adjacent to the creek may not meet the minimum standard of 5m in all locations (Figure 10.2.4). The buffer adjacent to the ditch may not meet the minimum standard of 2m in all locations (Figure 10.2.5).

INTERVENTION 1. Ensure the buffer meets the minimum standards.

STEP 3. The watercourse appears to have a stable bank zone. However, in some locations the bank has been cleared right to the edge. Shrubs and trees are being planted in the riparian area to provide resistance to erosion. The bank may have been reshaped to increase bank stability and reduce the risk of flooding. This can increase erosion of the opposite bank if the river is evented from accessing the floodplain.

[Figure 10.2.3]

10.2 Frequent Flooding

STEP 4. The land is not used to pasture livestock. Forage is grown.

STEP 5. No drainage from tile outlets or springs was observed.

STEP 6. This field is in the floodplain. However, evidence of flooding was not observed during the site visit in early May, 2009. The landowner may advise if this field frequently floods.

[Figure 10.2.4]

INTERVENTION 4. The general recommendation is to grass the floodplain or establish flood tolerant trees and shrubs. On this site, the floodplain is grassed. This will minimize the impact of flooding on site and provide conditions that will slow flows and promote sediment deposition.

[Figure 10.2.5]

STEP 7. Investigate whether there is runoff from a significant adjacent upland area. The field is not large and would not be considered a significant adjacent upland area. The field is narrow and follows the contour along the river. There is a significant upland area above the field but the slope is wooded and this would buffer runoff from the slope and above.

OUTCOME No further action required, other than ensuring a minimum 5m buffer from the river. Although farm ditches require only a minimum 2m buffer, on this site a ditch was observed with a direct connection to the river (Figure 5). A 2m buffer adjacent to the ditch would not provide adequate protection for the river if this field were in some other crop (not in hay). A minimum 5m buffer would then be recommended for a ditch also. Keeping this field in permanent cover would minimize cropping impacts to the river and is recommended.

10.3 Sheet Flow

Site: Wilmot Valley, PEI

This site west of Charlottetown is adjacent to the Wilmot River. The Wilmot River is a tidal river. The site is near sea level (Figure 10.3.1). The site is also under study in Agriculture and Agri-Food Canada's research on "Using Willow Riparian Buffer Strips for Biomass Production and Riparian Protection".

The field in question is adjacent to the east bank of the Wilmot River (Figures 10.3.2 and 3).

[Figure 10.3.1]

STEP 1. A buffer is required by legislation. A 15m buffer for almost all watercourses is required. In the case of a tidal watercourse, the boundary of the watercourse is the top of the bank, or the high water mark where there is no discernable bank.

STEP 2. The buffer meets the minimum standard of 15m (Figure 10.3.4).

[Figure 10.3.2]
(courtesy of the Government of Prince Edward Island)

STEP 3. The watercourse appears to have a stable bank zone.

STEP 4. The land is not used to pasture livestock. Crops are grown.

STEP 5. No drainage from tile outlets or springs was observed.

STEP 6. There is no evidence of frequent flooding. There is a low bank in this reach of the river, but the buffer is above the high water mark (Figure 10.3.5).

[Figure 10.3.3]

10.3 Sheet Flow

STEP 7. There is runoff from a significant adjacent upland area.

STEP 8. The adjacent upland is in a rotation of annual crops.

STEP 10. There is evidence of sheet flow and sheet erosion from the adjacent uplands entering the buffer, but not the watercourse (Figure 10.3.6). In the absence of a buffer, sediment might reach the watercourse. A buffer promotes infiltration to reduce dissolved nutrients, as well as trapping sediments.

STEP 11. There is no evidence of concentrated flow paths in the adjacent upland contributing runoff to the buffer (or the watercourse).

STEP 12. The field slope above the watercourse is >3%, but the slope lessens near the watercourse to <3% (Figure 10.3.7). No signs of hillslope erosion in the adjacent uplands were observed.

OUTCOME A slope of <3% adjacent to the watercourse and no signs of hillslope erosion leads to an outcome of no further action required. However, the average slope of the length of the field is >3% and the farmer may have concerns about hillslope erosion. The following intervention would be recommended:

INTERVENTION 7. Consider the use of an erosion prediction model, e.g. RUSLE2, if data is available and calibrated. Continue on to Step 13.

[Figure 10.3.4]

[Figure 10.3.5]

[Figure 10.3.6]

10.3 Sheet Flow

STEP 13. The crop rotation may include a row crop (e.g. potatoes).

STEP 16. If a row crop were grown, soil conservation cultural practices (e.g. strip cropping, cross-slope and contour tillage) should likely be sufficient to control runoff from the adjacent uplands.

OUTCOME Implement adequate soil conservation cultural practices, if a row crop is grown. An additional recommendation is to grow a cover crop after harvest of a row crop, to keep soil and nutrients on the field. The buffer combination of grass and shrubs should work well on this site, for retaining sediment and the uptake of nutrients (Figure 10.3.8).

[Figure 10.3.7]

[Figure 10.3.8]

10.4 Concentrated Flow Path

Site: Meadowbank, PEI

This site west of Charlottetown is adjacent to the West River, at the confluence with the Clyde River. The West River is a tidal river, and an estuary at this site. The site is near sea level (Figure 10.4.1). The site is also under study in Agriculture and Agri-Food Canada's research on "Using Willow Riparian Buffer Strips for Biomass Production and Riparian Protection".

The field in question is adjacent to the north side of the West River (Figures 10.4.2 and 3).

[Figure 10.4.1]

STEP 1. A buffer is required by legislation. A 15m buffer for almost all watercourses is required. In the case of a tidal watercourse, the boundary of the watercourse is the top of the bank, or the high water mark where there is no discernable bank.

STEP 2. The buffer meets the minimum standard of 15m (Figure 10.4.4).

STEP 3. The watercourse appears to have a stable bank zone.

STEP 4. The land is not used to pasture livestock. Crops are grown.

STEP 5. No drainage from tile outlets was observed. There is some evidence of springs nearby between the buffer and the estuary.

STEP 6. There is no evidence of frequent flooding. There is a low bank in this reach of the river, but the buffer is above the high water mark (Figure 10.4.5).

[Figure 10.4.2]
(courtesy of the Government of Prince Edward Island)

[Figure 10.4.3]

10.4 Concentrated Flow Path

STEP 7. There is runoff from a significant adjacent upland area.

STEP 8. The adjacent upland is in a rotation of annual crops. This field was subsequently observed in soybeans, with the adjacent field in potatoes.

STEP 10. There is no evidence of sheet flow entering the watercourse, but there is evidence of sediment entering the buffer. A buffer promotes infiltration to reduce dissolved nutrients, as well as trapping sediments.

[Figure 10.4.4]

STEP 11. There is evidence of concentrated flow paths in the adjacent upland contributing runoff to the buffer (Figure 10.4.6). Concentrated flow paths outlet to vegetated areas. In the absence of a buffer, the concentrated flow paths would contribute runoff directly to the watercourse. The buffer is grassed and planted to shrubs (mostly willow). The buffer, in particular the shrubs, slows concentrated flows allowing sediment to settle out (Figure 10.4.7).

[Figure 10.4.5]

INTERVENTION 6. Consider a comprehensive soil conservation plan.

STEP 12. The upland slopes near the watercourse are >3% and there are signs of hillslope erosion in the adjacent uplands.

INTERVENTION 7. Consider the use of an erosion prediction model, e.g. RUSLE2, if data is available and calibrated.

[Figure 10.4.6]

10.4 Concentrated Flow Path

STEP 13. Crop rotation could include a row crop, as potatoes are grown in the adjacent field.

STEP 16. The evidence of heavy sedimentation in the willow riparian buffer is evidence that additional soil conservation practices are required on this field.

Cultural practices (strip cropping and cross-slope or contour tillage) should be implemented when seeding a crop. However, this field is vulnerable to uncontrolled runoff and soil erosion. Cultural methods alone are unlikely to be sufficient to control runoff from the adjacent uplands.

STEP 17. Runoff from the adjacent uplands is not controlled through engineered structures such as diversion terraces and grassed waterways.

INTERVENTION 8. Consider diversion terracing and engineered grassed waterways.

STEP 18. If an engineered grassed waterway is constructed, ensure the outflow is diffused into the buffer zone. If not, a drop inlet with a catch basin, or a constructed wetland should be installed.

OUTCOME The buffer meets the minimum standard and the combination of grass and shrubs will retain sediment and take up nutrients (Figure 10.4.8). However, the buffer may be overwhelmed by uncontrolled runoff and sediments from the adjacent uplands. Additional soil conservation practices (cultural and engineered) are recommended.

[Figure 10.4.7]

[Figure 10.4.8]

10.5 Combination

Site: Moncton, New Brunswick

This area north of Moncton is characterized by hills and parallel ridges trending to the north-east (Figure 10.5.1). This is the headwaters area for a number of rivers that flow in different directions, indicating a landscape with much relief and abundant precipitation. The soils observed in the field are shallow and close to bedrock. Runoff to the rivers will be quick.

[Figure 10.5.1]

House and yard site are located at the top of a ridge, with the field to the north sloping steeply down through a series of benches to a stream. The stream flows to the north-east through a wetland area, which is the stream's floodplain. The field is bordered by a road on the west side and a ditch on the east side (Figures 10.5.2 and 4), as well as by the road at the top of the ridge on the south side. The road at the top of the ridge may contribute some run-off to the east ditch, but runoff from the field is generated onsite (in effect a mini-watershed). Contributing drainage area of the field and yard site are about 5.3 hectares.

[Figure 10.5.2]
(courtesy of Service New Brunswick)

There is a drainage ditch (Figure 10.5.3) that drains mostly to the east ditch. A small part (the west end of the drainage ditch) drains to the road ditch bordering the field on the west side. The drainage ditch intercepts all overland runoff from above. There is drain tile above and parallel to the drainage ditch with an outlet to the east ditch. Another drain tile below and perpendicular to the drainage ditch has an outlet to the wetland area. The wetland area along the stream (the floodplain) widens where it is joined by the outlet of the east ditch.

[Figure 10.5.3]
(courtesy of Service New Brunswick)

10.5 Combination

STEP 1. A buffer is required by legislation. A 5m buffer for watercourses is required for existing farms (Figure 10.5.5). A farm ditch requires a 2m buffer.

STEP 2. The buffers generally meet the minimum standards. The wetland area that the stream flows through is well-vegetated and buffers the stream (Figure 10.5.6).

STEP 3. The stream has a stable bank zone. There has been some down-cutting in the east ditch.

STEP 4. The land is not used to pasture livestock.

STEP 5. There is drainage coming from tile outlets. The outlets do not appear subject to erosion.

STEP 6. There likely is frequent flooding of the floodplain (the wetland). This area is already well-vegetated.

STEP 7. There is runoff from a significant adjacent upland area. The area is not large, but slopes are relatively steep and there is significant precipitation. Contributing area below the drainage ditch that could provide sheet flow directly to the stream is about 2 hectares. Without the cut-off drainage ditch, the adjacent upland area would be even more significant. Runoff would be increased because of a larger contributing area; hillslope erosion would be greater because of a longer slope length.

[Figure 10.5.4]
View south to the field (beyond the stream crossing at the dip in the road).

[Figure 10.5.5]

[Figure 10.5.6]

10.5 Combination

STEP 8. The adjacent upland is in a rotation of annual crops. Part of the field has been in strawberries, and also in a cover crop.

[Figure 10.5.7]

STEP 10. There is no evidence of sheet flow to the stream under the current cover crop. However, if cultivation were to take place below the drainage ditch, it is anticipated there could be sheet flow to the wetland. During spring snowmelt and summer rainstorm events, the wetland might be flooded. In this scenario, a buffer adjacent to the wetland would be recommended to promote infiltration of dissolved nutrients.

[Figure 10.5.8]

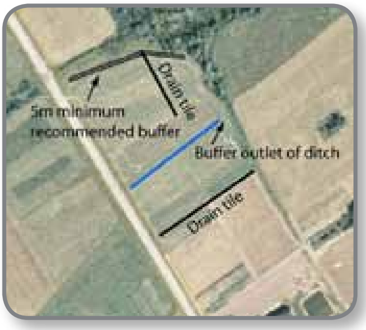
INTERVENTION 5. A minimum 5m buffer adjacent to the wetland is recommended. The area adjacent to the wetland is planted to high-bush cranberries. This crop in the buffer area provides an economic return to the farmer (Figure 10.5.7). The farmer may be willing to create a wider buffer if it generates an economic return. The buffer should be maintained even if land management changes. The buffer in combination with the wetland/vegetated floodplain is intended to capture dissolved nutrients from sheet flow.

[Figure 10.5.9]

STEP 11. The drainage ditch and the east ditch could be considered concentrated flow paths contributing runoff to the watercourse. There has been some sediment deposition at the junction of the drainage ditch and the east ditch. This area might benefit from the planting of cattails to take up nutrients and dissipate energy. The bottom of the east ditch (where it joins the stream) is well vegetated.

10.5 Combination

STEP 12. The upland slopes near the watercourse are >3%, and there are signs of hillslope erosion above the drainage ditch (Figure 10.5.8). The average slope is about 7.5% with a total slope length of 400m from the top of the road to the stream. The slope is interrupted approximately 2/3 of the way down by the drainage ditch. Effective slope length between the drainage ditch and the stream is approximately 150m.



[Figure 10.5.10]
(courtesy of Service New Brunswick)

INTERVENTION 7. Consider the use of an erosion prediction model, e.g. RUSLE2, if data available and calibrated. In this case, the combination of a cut-off drainage ditch, tile drains, and existing buffer adjacent to the well-vegetated floodplain appear to work well together to manage erosion.

STEP 13. The crop rotation includes a row crop of strawberries below the drainage ditch (Figure 9).

STEP 16. Soil conservation cultural practices (e.g. strip cropping, cross-slope and contour tillage) should be sufficient to control runoff from the adjacent uplands. Maintain adequate soil conservation practices, and buffer watercourse from sheet flow.

OUTCOME Recommend maintaining a buffer adjacent to the wetland for the possibility of sheet flow. Consider planting cattails to take up nutrients at the outlet of the drainage ditch (where it joins the east ditch).

Runoff on this field is interrupted by cross-slope rows of shrubs and trees that shorten slope length. These will take up nutrients and water and reduce impacts down-slope. The combination of runoff control by rows of shrubs and trees and the drainage ditch, tile drainage, and soil conservation practices (strip cropping and cross-slope planting) work well on this field.

10.6 Combination

Site: Salisbury, New Brunswick

This area southwest of Moncton along the Petitcodiac River is near sea level. The Petitcodiac River is a tidal river, but the area is far enough upstream that response to incoming and outgoing tides is muted. The area is gently sloped for the most part with some relatively steep slopes separating the adjacent uplands from the river. The natural vegetation is trees with a mixture of deciduous and coniferous species. A number of brooks draining side valleys are indicative of an area of abundant precipitation (Figure 10.6.).

[Figure 10.6.1]

The field is bounded by the river on the east side, roads to the west and north, and a small brook on the north-west side. The field is separated in two by a swale allowing access to farm machinery. The swale also intercepts runoff from above and redirects it to the road ditch. A ditch borders the field on the south side. We will look at the lower part of the field between the swale and the ditch adjacent to the river (Figures 10.6.2 and 3). Only a small part of the lower field is sloped towards the brook and generates little runoff.

[Figure 10.6.2]
(courtesy of Service New Brunswick)

STEP 1. A buffer is required by legislation. A 5m buffer for watercourses is required for existing farms. A farm ditch requires a 2m buffer (Figures 10.6.4 and 5).

STEP 2. The buffers meet minimum standards and are well vegetated (Figures 10.6.4 and 5).

[Figure 10.6.3]
(courtesy of Service New Brunswick)

10.6 Combination

STEP 3. The watercourse and ditch have a stable bank zone (Figure 10.6.6).

STEP 4. The land is not used to pasture livestock.

STEP 5. There is drainage coming from a tile outlet. The outlet is protected from erosion and discharges to a vegetated area before entering the riparian zone (Figure 10.6.5).

STEP 6. There does not appear to be frequent flooding beyond the bank.

STEP 7. The field is gently sloped with some relatively steep slopes down to the river, in an area with abundant precipitation. The farmer advises he sees little runoff from the field as the corn rows are planted cross-slope. The swale cuts off runoff from above and shortens slope length. If one decides there is not runoff from a significant adjacent upland area, there is no further action required. In this case, the legislated buffers would suffice. Let's assume there is runoff from a significant upland area and see what the tool would recommend.

STEP 8. The field is used to grow annual crops (corn).

STEP 10. There is no evidence of sheet flow entering the watercourse, but there likely would be if insufficient residue were left on the soil surface (Figure 10.6.7).

[Figure 10.6.4]
Field is beyond the ditch.

[Figure 10.6.5]
Orange post marks the outlet of drain tile.

[Figure 10.6.6]
Outlet of ditch to river.

10.6 Combination

INTERVENTION 5. A buffer of 5m to 30m may be necessary to trap sediments and sediment-bound pollutants. A buffer of 15m to 50m may be necessary to capture dissolved nutrients. However, the natural buffer along the river is well vegetated and likely adequate in combination with the grassed laneway between the crop and the edge of the natural buffer (Figures 10.6.8 and 9).

[Figure 10.6.7]

STEP 11. There is evidence that concentrated flow paths contribute runoff to the watercourse. The outlet from the field runs through the grassed laneway and natural buffer (Figure 10.6.10).

STEP 12. The slope in the field is <3% and there are no signs of hillslope erosion. There is no further action is required.

[Figure 10.6.8]
Laneway

OUTCOME There appears to be runoff from a significant upland area because of abundant precipitation. Buffers beyond the minimum required would be recommended. The existing laneway in combination with the natural buffer should be adequate, however. The swale does cut off runoff from above and shortens slope length. The farmer plants corn on the cross-slope which is a soil conservation cultural practice. It is also important to retain residue on this field to minimize overland flow and runoff. Concentrated flow paths outlet to vegetated areas. Tile outlets are protected from erosion and discharge to vegetated areas. The combination of the swale cutting off runoff from above, tile drainage, cultural practices of planting on the cross-slope and leaving

[Figure 10.6.9]
Natural buffer

10.6 Combination

crop residue, and the grassed laneway in combination with the natural buffer adjacent to the river work well on this field.

[Figure 10.6.10]

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Recommended Plant Species for Riparian Buffers in Atlantic Canada

Detailed species recommendations can be found in:

"Beneficial Management Practices for Riparian Zones in Atlantic Canada".
SEE: pages 23 to 31
available at: *http://www.islandnaturetrust.ca/*

'Technical Guide for Agroforestry Systems" *A manual for Atlantic Canada*.
available at: *http://www.ccse-swcc.nb.ca*

"Farmstead Shelterbelts. Planning, planting and maintenance"
available at: *http://www.wbvecan.ca/*

APPENDICES

Provincial riparian buffer legislation and guidelines in Atlantic Canada with an influence on the design of riparian buffers for agricultural fields[1]

	minimum riparian buffer width (legislated)	riparian buffer width measured starting from	wider riparian buffer / setbacks required for drinking water source protection[2]	wider riparian buffer / setbacks required for forestry or woodlot operations[2]
NS	*	*	yes	yes
NB	5 m *5m for existing farms (new farms cannot clear to 5 m)*	bank of the watercourse or wetland	yes *only in watersheds under the Watershed Protected Area Designation Order*	yes
PEI	15 m	edge of sediment bed or usually edge of water *(for non-tidal streams); top of bank or high water mark (tidal)*	no	no
NL	15 m	high water mark	yes	yes

watercourse alteration permits or permission required to work in the regulated part of the riparian zone[2]	**fencing to exclude cattle from watercourses required? [2]**	**cattle fords allowed? [2]**	**selective harvesting allowed within riparian buffer zone? [2]**
yes	no	yes	yes
yes *(for work within 30 m of the watercourse)*	recommended & required in designated watersheds	culverts & bridges are the preferred option	yes
yes *(for work within 15 m of the watercourse)*	recommended & required for intensive livestock operations	no	limited *(prune trees) cut & harvest forage*
yes	no	*	no

[1] Riparian zones on agricultural land must also respect *all* relevant federal government statutes.
[2] A Watercourse Alteration Permit (NB, PEI, NS) or permission (NL) is required to do any work within the regulated part of the riparian buffer zone. See summary of provincial regulations in the appendix for details province-by-province.
* Requirements may be case-by-case, and/or site-specific at the provincial level.

Legislation, regulations, and guidelines are subject to change. These summary tables are a non-official interpretation. Always confer with the appropriate Provincial and Federal authorities before making any changes within or adjacent to a riparian area.

Riparian buffer requirements in New Brunswick[1,2]
A watercourse and wetland alteration permit is required[1] before working within 30 meters of a watercourse or wetland. Some of these activities include, but are not limited to:
• tree or vegetation removal
• disturbing ground; except by grazing animals, but including tilling, ploughing, harrowing, seeding, harvesting of vegetables, flowers, grains and ornamental shrubs, and any other agricultural activity prescribed by regulation that occurs more than 5 m from the bank of the watercourse
• operating heavy machinery
• construction of bridges, installation of culverts or fording sites
• any change made to existing structures in a watercourse
• operation of machinery on the bed of the watercourse other than at a recognized fording place
• any deposit or removal of sand, gravel, rock, topsoil or other material into or from a watercourse
• installation of water intake structures
Tree & brush removal:
• enough vegetation must be maintained along the banks of a watercourse to provide shade and bank stability
• material is not allowed to be removed from or deposited within the watercourse
• trees may not be felled into or across a watercourse
• where alders occur along a watercourse no cutting is permitted
• erodible soil must not be exposed when harvesting within 30 meters of a watercourse
• no debris from tree harvest is allowed to enter a watercourse
• no sediment or bare ground should be exposed within 30 meters of a watercourse

Selective harvesting:
• only 30% of merchantable trees may be removed from the 30 meter buffer zone
• tree harvest must be evenly distributed within the buffer zone
• harvesting is only allowed in the same area once in 10 years
• harvesting within 15 meters of the watercourse edge must be done manually without the use of heavy equipment
Watershed Protected Area Designation Order ***(a.k.a. watercourse setback designation order, Clean Water Act)***
• was created to protect surface water in watersheds used as sources of municipal public drinking water supplies.
• a 75 meter setback was established on streams, lakes, ponds or wetlands from which water is drawn, including the tributaries supplying these water bodies.
• agriculture, forestry and other land-use activities are controlled within this 75 meter setback to prevent point (discharge pipes) and non-point source surface water runoff.
• Types of activities allowed within the 75 meter setback can be found outlined in the *Guide to New Brunswick's Watershed Protected Area Designation Order*.

* **Notes:**

[1] **A number of agricultural activities do not require a** *watercourse and wetland alteration permit* as long as standards are agreed upon and approved by the New Brunswick Department of Agriculture including:

- the installation of drainage tile for agricultural land
- Construction of an agricultural drainage ditch as long as there is no danger of pollution as a result of construction and operation of the ditch and as long as the ditch does not break the watercourse bank

[2] New Brunswick's **Topsoil Preservation Act** requires a permit for the removal of topsoil from a site or a parcel of land. For more detailed information, contact the New Brunswick Department of Environment.

Legislation, regulations, and guidelines are subject to change. These summary tables are a non-official interpretation. Always confer with the appropriate Provincial and Federal authorities before making any changes within or adjacent to a riparian area.

APPENDICES

Riparian buffer requirements in Newfoundland and Labrador[1, 2]
• there is a crown land reserve of 15 meters along all water represented on a 1:50,000 NTS topographic map
• a buffer zone is measured from the high water mark and is required to be forested
• there is a 15 meter buffer zone requirement on all watercourses larger than 1 meter wide not represented on a 1:50,000 NTS topographic map
• when the slope of the land exceeds 30% the width of the buffer zone is required to be 15 meters plus 1.5 times the slope (%)
• depending on the land use or practices (including pesticide use, pesticide storage, or maintenance buildings) occurring adjacent to the watercourse the buffer zone width requirement could be as wide as 400 meters
Selective harvesting:
• harvesting of trees, shrubs, and plants is not permitted within forested riparian zones in Newfoundland and Labrador. Crown land issued to farmers will often have these reserves along streams and rivers surveyed out of the lease.

* **Notes:**

[1] In protected public water supply areas, buffer zone widths are:

Water Body	Width of Buffer Zones
Intake pond or lake	• a minimum of 150 metres
River intake	• a minimum of 150 metres for a distance of one km upstream and 100 m downstream
Main river chanel	• minimum of 75 metres
Major tributaries, lakes, or ponds	• a minimum of 50 metres
Other water bodies	• a minimum of 30 metres

(ref: policy WR 95-01, 1995, rev 1999)

[2] **Approval to alter a body of water** must be requested in writing from the Department of Environment.

Legislation, regulations, and guidelines are subject to change. These summary tables are a non-official interpretation. Always confer with the appropriate Provincial and Federal authorities before making any changes within or adjacent to a riparian area.

Riparian buffer requirements in Nova Scotia[1,2]
Wildlife Habitat and Watercourse Protection Regulations
In Nova Scotia the Wildlife Habitat and Watercourses Protection Regulations apply to those people carrying out forestry operations in a forest, on forest land or on any woodland in Nova Scotia. These regulations include:
Special Management Zones (SMZ):
• 20 meter SMZ (buffer strips) on watercourses, equal to or greater than 50 cm in width, situated on or adjacent to forest land on which a forestry operation is carried out (includes all lakes and ponds, saltwater bodies, marshes with permanent water openings, and streams/rivers equal to or greater than 50 cm in width) •when land slope exceeds 20% within 20 meters of a watercourse boundary, for every 2% increase beyond 20% 1 meter must be added to the SMZ width and may increase to a maximum of 60 meters in width
• machinery for forestry operations is not permitted within 7 meters of the watercourse • no forestry operator may reduce the basal area of living trees to less than 20 meters2/hectare • no forestry operator may create an opening in the dominant tree canopy larger than 15 meters at its greatest dimension • on watercourses less than 50 cm, or on adjacent to forest land on which forestry operation is carried out, machinery is not permitted within 5 meters of the watercourse
• on all watercourses a forestry operator shall insure that understory vegetation and non-commercial trees within 20 meters of the edge of any watercourse are retained to the fullest extent possible
• on all watercourses no forestry operator shall conduct any activity within 20 meters of the edge of any watercourse that would result in sediment being deposited in the watercourse
Legacy Trees and Habitat Structure: In Nova Scotia, on any harvest site greater than 3 hectares of forest land, forest clumps of at least 10 living, or partially living, trees must be left standing for each hectare of forest land cut.
• the trees left standing shall be in the same proportion by species as the forest stand being harvested
• the trees left standing shall be as large or larger than, in height and diameter, the average height and average diameter, measured at the height of 1.3 meters from the ground, of the trees within the forest stand being harvested • each forest clump must contain at least 30 trees • for each 8 hectare area of forest land cut, there shall be at least one forest clump

• where there is more than one clump, clumps should be no more than 200 meters apart and at least 20 meters but no more than 200 meters from the edge of the forest stand being cut
• where there is one clump it should be at least 20 meters but no more than 200 meters from the edge of the forest stand being cut
• no harvesting is permitted within any forest clump
• a forestry operator shall ensure that levels of snags and coarse woody debris on all harvest sites are similar to natural patterns to the fullest extent possible.

* **Notes:**

[1] **Any alteration to a surface watercourse** is designated as an activity under the provincial Environment Act, Activities Designation Regulations. This requires a permit from the Nova Scotia Department of Environment.

[2] Setbacks restrictions (buffers) may also apply within *Designated Protected Water Areas* that are sources of water supply for a public water works. Consult the *"Recommended Agricultural Practices within Municipal Drinking Water Supply Areas in Nova Scotia"*.

Legislation, regulations, and guidelines are subject to change. These summary tables are a non-official interpretation. Always confer with the appropriate Provincial and Federal authorities before making any changes within or adjacent to a riparian area.

Riparian buffer requirements in Prince Edward Island[1]
Provincial legislation in Prince Edward Island requires buffer zones 15 meters wide on all watercourses and wetlands in PEI.
On PEI a watercourse means an area which has a sediment bed and may or may not contain water, includes the full length and width of the sediment bed, bank and shore of any stream, spring, creek, brook, river, lake, pond, bay, estuary or coastal body, any water therein, and any part thereof, up to and including the watercourse boundary. A watercourse boundary means (i) in a non-tidal watercourse, the edge of the sediment bed, and (ii) in a tidal watercourse, the top of the bank of the watercourse, and where there is no discernable bank, means the high water mark of the watercourse. The buffer zones are not required on watercourses that are solely landlocked ponds, or on wetland areas that are solely landlocked ponds, seasonally flooded flats or wooded swamps, bogs or meadows.
Any alteration of a watercourse or a wetland within 15 meters of the watercourse or wetland boundary requires Watercourse or Wetland Activity permit.
Crop Production:
You **may not** grow agricultural crops or use pesticides in a buffer zone except those next to wetlands that are completely shrub swamps, bogs, wooded swamps, seasonally flooded flats, meadows or landlocked ponds. You may also plant and cut the grass in a buffer zone. Agricultural equipment may turn in a buffer zone.
Grassed Headlands:
If you grow row crops such as potatoes, all rows that end within 200 metres of a watercourse or wetland must end a) in at least 10 metres of grass that was established before the year the row crop is grown, **or** b) at the edge of the buffer zone. This rule does not apply to growing corn. A grass headland is not needed where there is an approved management plan for the property.
Intensive livestock operations:
If you have an intensive livestock operation, you may not: • allow any livestock waste to enter any watercourse or wetland • build or expand any intensive livestock operation within 90 metres of any watercourse or wetland without authorization.

Trees, shrubs and vegetation:
You may not disturb, remove, alter, disrupt or destroy vegetation in any manner, including but not limited to the cutting of live trees or live shrubs. The cutting of live trees in a wooded swamp is exempt.
You **may** prune trees and shrubs in buffer zones and you may plant grass, trees and shrubs as long as you only use hand tools.

* **Notes:**

[1] **Any alteration to a watercourse** or wetland requires a Watercourse or Wetland Activity permit.

Legislation, regulations, and guidelines are subject to change. These summary tables are a non-official interpretation. Always confer with the appropriate Provincial and Federal authorities before making any changes within or adjacent to a riparian area.

Suggested buffer widths for various buffer functions

	OMAFRA[1]	Hawes & Smith[2]	Dosskey[3]	Wenger[4]	USDA-NRCS[5]	NZ[6]
Buffer function						
bank stability	> 5 m	30-98 ft	20 ft	49-98 ft		
sediment removal	10-30 m	> 200 ft	25 ft	82-328 ft	15-180 ft	5-27 m
soil-bound nutrients	10-30 m				15-180 ft	5-27 m
soluble nutrients	15-50 m	16-164 ft	50-90 ft	50-100 ft		10-30 m
pathogen removal	> 30 ft	> 30 ft				
pesticide removal		49-328 ft		> 49 ft		
aquatic habitat	15-30 m	33-164 ft	35-50 ft			10-20 m
terrestrial habitat	10-300 m	> 300 ft	40-70 ft	220-574 ft	10-20 m	10-20 m

[1] Table 4, p. 18, In Agriculture and Agri-Food Canada. *Beneficial Management Practices for Riparian Zones in Atlantic Canada,* as adapted from Ontario Ministry of Agriculture and Food, Best Management Practices,: Buffer Strips

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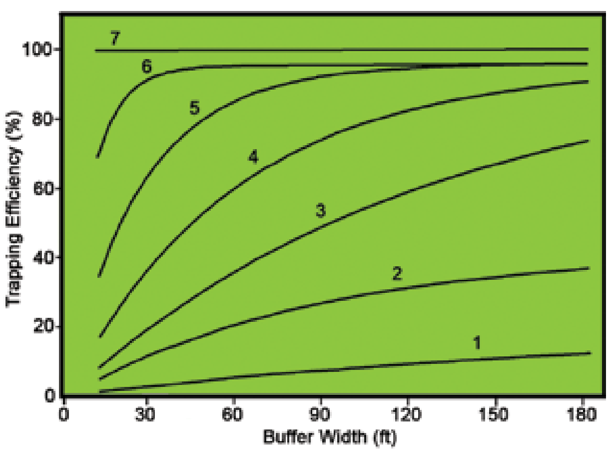
APPENDICES

Selecting buffer widths

The efficiency of a vegetated buffer at trapping contaminants increases with increasing buffer width.

The general relation between buffer width and trapping efficiency is demonstrated in this figure below from Bentrup (2008), based upon the work of Mike Dosskey from the USDA NRCS NAC. Lines 1 to 7 represent the trapping efficiency for contaminants transported either in solution or attached to suspended sediments for differing soil types. If you wish to use this figure for buffer design purposes, please consult the complete description of how to use and interpret this figure which can be found in the document:

> Bentrup, G. 2008. **Conservation buffers: design guidelines for buffers, corridors and greenways.** Gen. Tech. Rep. SRS-109. Asheville, NC. Department of Agriculture, Forest Service, Southern Research Station. 110 p. *A collaborative partnership of USDA, Forest Service - NRCS - National AgroForestry Centre.*
>
> available online at: *www.bufferguidelines.net*
> *(accessed Aug. 12, 2010)*



Field Notes

Step/Question	Decision	Notes
1. Is a buffer required by legislation?		
2. Does your buffer meet minimum standards?		
3. Does the watercourse (includes ditches) have a stable bank zone?		
4. Is the land only used to pasture livestock?		
5. Is there drainage coming from tile outlets or springs?		
6. Is there frequent flooding beyond the bank?		
7. Is there runoff from a significant adjacent upland area?		
8. Is the adjacent upland in a rotation of annual crops?		
9. Is the adjacent upland under a perennial forage crop?		
10. Is there evidence of sheet flow or sheet erosion from the adjacent uplands entering the watercourse?		
11. Is there evidence that concentrated flow paths in the adjacent upland contribute runoff to the watercourse?		

Step/Question	Decision	Notes
12. The upland slopes near the watercourse are >3% or there are signs of hillslope erosion in the adjacent uplands.		
13. Does crop rotation include a row crop (e.g. potatoes, corn)?		
14. Are the slopes under conventional tillage?		
15. Will the landowner convert to conservation tillage or grass the slopes?		
16. Will soil conservation cultural practices (e.g. strip cropping, cross-slope and contour tillage) be sufficient to control runoff from the adjacent uplands?		
17. Is any runoff from the adjacent uplands controlled through engineered structures such as diversion terraces and grassed waterways?		
18. Is the grassed waterway outflow diffused into the buffer zone?		

Notes