Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

FIELD MANUAL *on* BUFFER DESIGN *for the* CANADIAN PRAIRIES

Canada

Citation:

Stewart A., Reedyk S., Franz B., Fomradas K., Hilliard C. and S. Hall. 2010. Field Manual on Buffer Design for the Canadian Prairies. Agri-Environment Services Branch, Agriculture and Agrifood Canada.

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Catalogue No. A22-526/2011E
ISBN 978-1-100-17933-9
AAFC No. 11360E

Paru également en français sous le titre
Manuel de conception des bandes tampons dans les Prairies canadiennes.

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ASSUMPTIONS

The Buffer Design Tool is designed for use in the Canadian Prairies where the primary concern is high volumes of runoff from snowmelt. High summer rainfall events that generate significant runoff are less frequent.

The issues that we are trying to address include sediments in suspension (inorganic and organic residues) and associated nutrients, 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 must be removed from the buffer through management (haying or appropriately timed grazing).

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 inbetween (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 must intercept overland flow. The Buffer Design Tool was designed to assist agricultural professionals in locating and designing vegetated buffers in Prairie landscapes. The tool provides a guiding framework for implementing Best Management Practices (BMPs) in specific landscapes to minimize nutrient losses, specifically 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 streams, a number of jurisdictions in North America have promoted and, in some cases, regulated the creation of stream 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 streams with uniform morphologies. In practice, landscape and stream 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 shaped to intercept overland flow.

Although well-managed buffer areas should have the vegetation removed as a routine part of management, in almost all cases, plants harvested from the buffer will provide less economic return than a crop. For this reason, 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 cost is borne by 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 limit 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 goals. For example, in a landscape where erosion is on-going and severe in an upland area, the tool tries to direct interventions toward controlling erosion rather than only concentrating on blocking sediment and nutrient transport by implementing a buffer.

Who should use the tool?

The primary user of the tool will be agricultural professionals who have been approached by producers to assist with the design of a vegetated buffer strip. Producers, 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 nutrient loss.

Where can I use this tool?

The tool is applicable to cropping systems and the climate of the Canadian Prairies, where the spring melt represents the largest runoff event in most years. The focus of the tool is on lotic (flowing water) systems.

How do I use the tool?

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

i) A Step 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 topographic maps and air photographs, and, it should be applied together with the producer, in the field.

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. Water bodies can include streams, 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, (primarily N and P) and sediment in runoff water from the 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 upland landuses and filter out pollutants, particularly from runoff water, before it reaches the water body thus improving the quality of the soil, water, air and 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 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 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 nutrients: Nutrients can occur either bound to sediment particles or as dissolved nutrients in the runoff water. Sediments that are deposited in the buffer prevent the attached nutrients 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.

What are the basics of the Buffer Design Tool process?

The tool was created to assist technical staff in determining the critical area on the landscape for a buffer. This tool was designed specifically for Prairie Canada where currently there is little research and few practical decision support tools available. The tool is a decision support tool which uses Yes and No questions to assess the landscape to determine if and where a vegetated buffer strip is needed. Buffer strips are not the entire solution to water quality concerns. Keeping that in mind sometimes the tool will recommend other BMPs than vegetated buffer strips. Upland management is critical in terms of whole farm management and vegetated buffer strips along waterways are only part of the solution.

What are the limitations of the tool?

Little research has been conducted in Prairie Canada with regards to vegetated buffer strips. As a result inferences must be made from research done outside this region with varying climates and environmental conditions. In Prairie Canada it is thought that spring snowmelt runoff is the most critical runoff event. In many other areas of North America it is intense summer storms that cause the major runoff events. The differences in these processes have to be kept in mind.

The tool uses Yes and No questions to evaluate the landscape. This is a simplistic 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 experiences.

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 waterways before it reaches the stream?

Ask the landowner if there 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.

Maps and Air Photo Collection

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, and topographic maps at several scales. A topographic map at 1:250,000 scale helps place the site into the big picture, while a map at 1:50,000 scale provides more detail. Soil maps may also be useful if available, although the scale may be too small to provide much detail. Maps help you assess the size of the stream, 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 relief 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 drainage and land use.

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 this schematic.

A basic recommendation for all outcomes with well-defined channels is a permanently vegetated bank zone and an additional 3m no-disturbance zone.

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

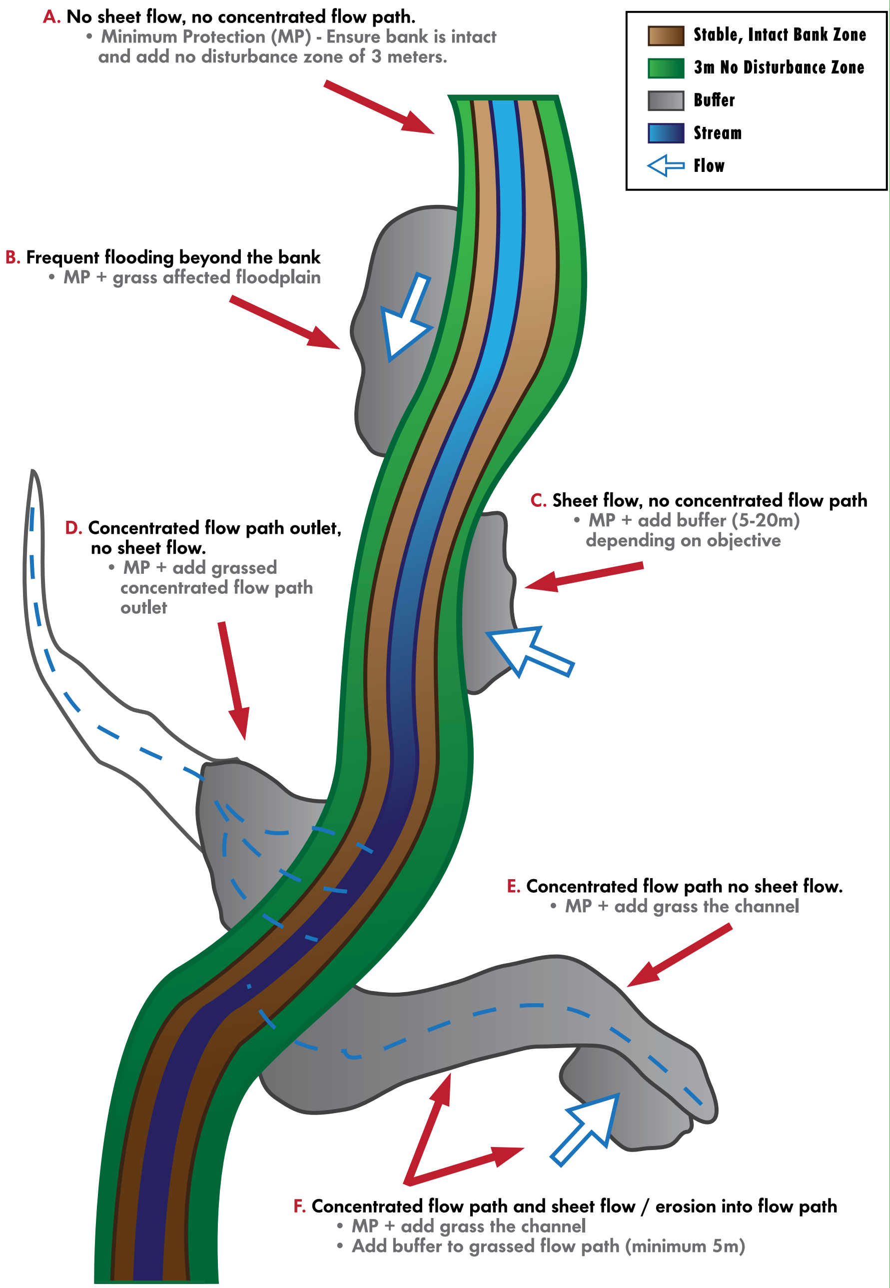
Where upstream watershed contributions are high enough to cause frequent flooding of the site, the recommendation is to seed the floodplain to permanent vegetation in addition to the basic protection of the bank and no-disturbance zone (**B**).

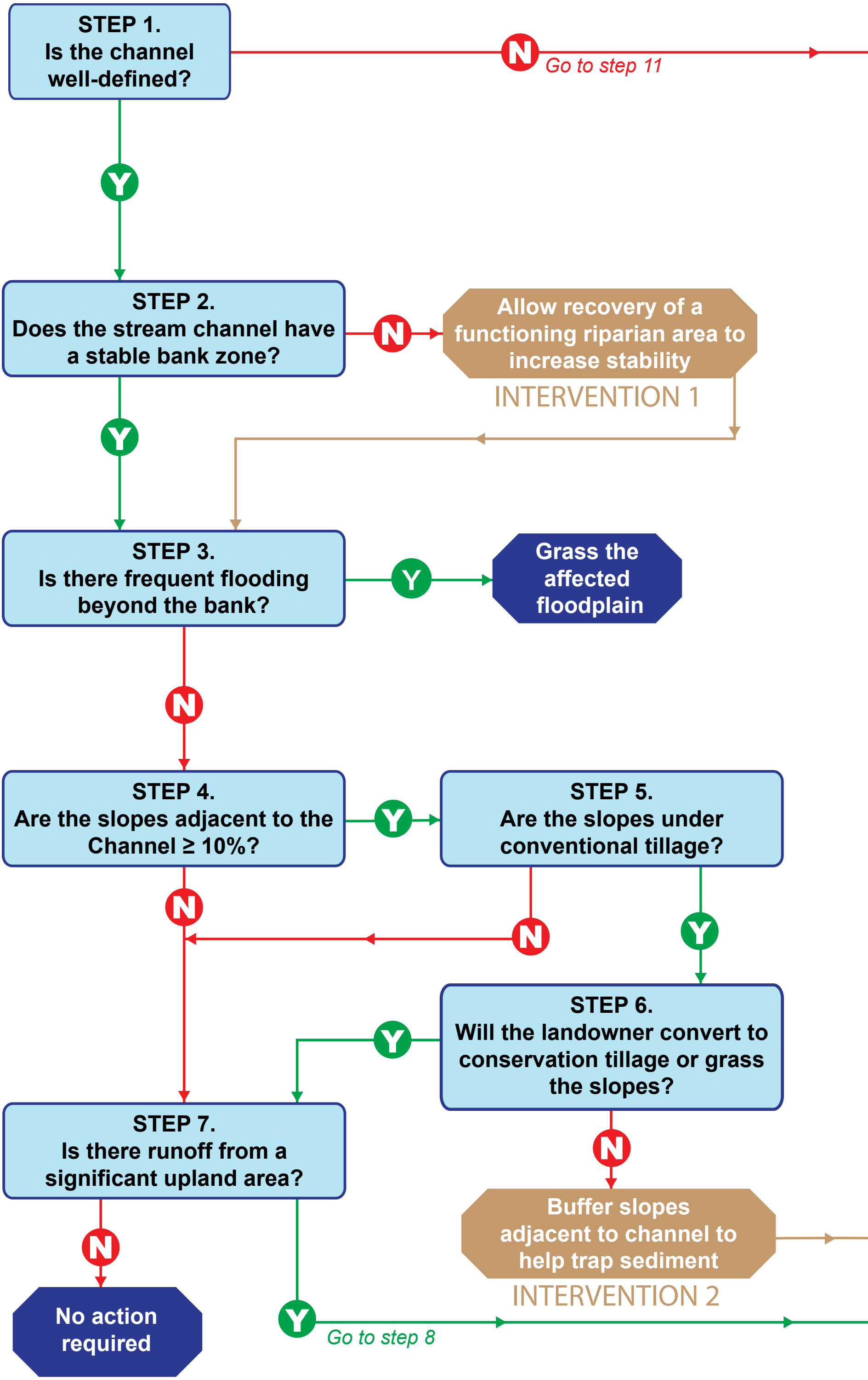
Where overland sheet flow enters the stream channel the length of stream affected by the sheet flow needs buffering (**C**). The dimensions of the buffer recommended will be determined by the purpose of the buffer, taking into consideration upland management practices that may affect the recommendation.

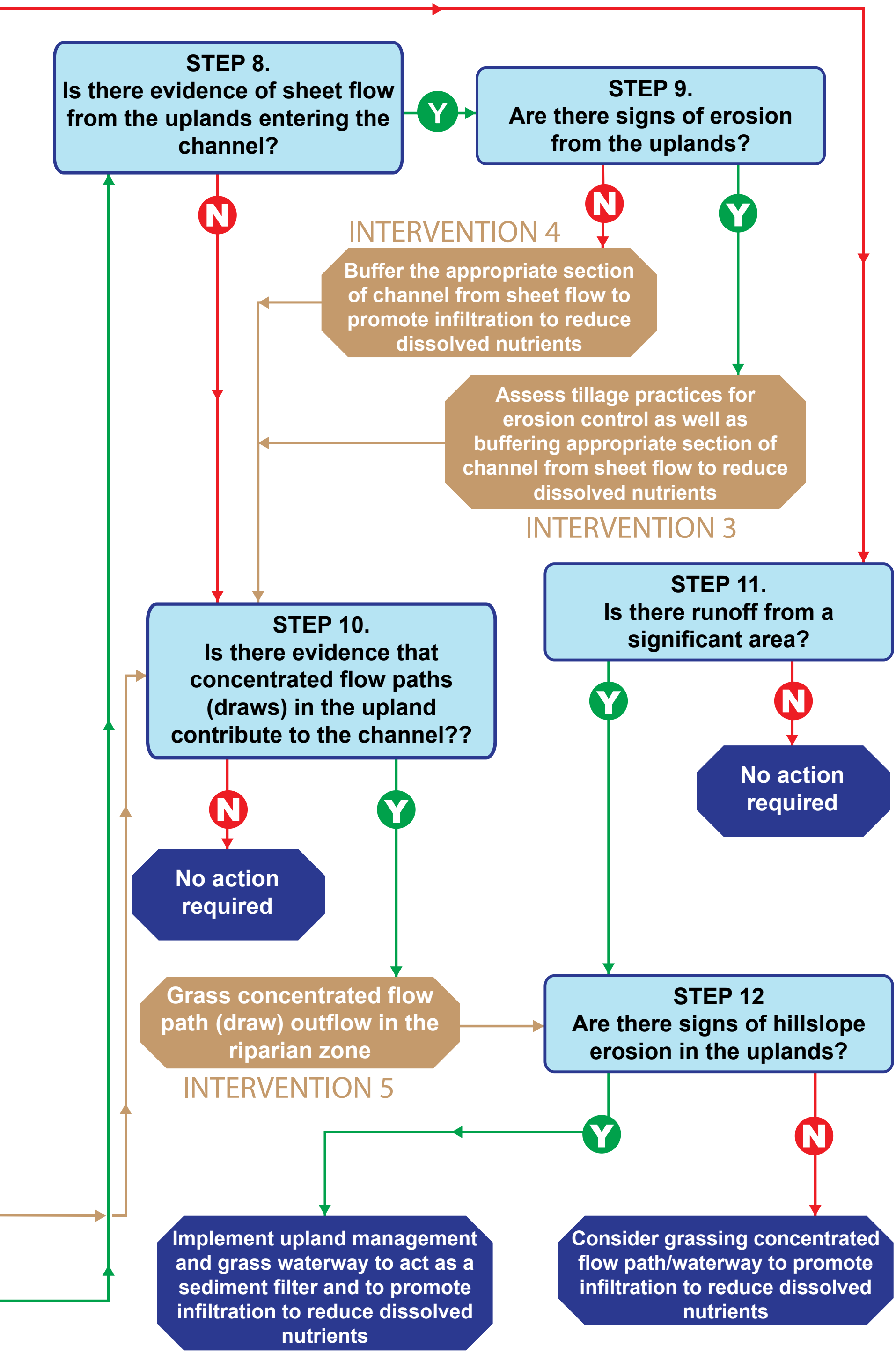
Concentrated flow entering the channel needs to have the buffer placed at the confluence, shaping the buffer to fit the concentrated flow path and sizing the buffer to exceed the normal lateral extent of the runoff (**D**).

Concentrated flow paths and channels that are not well defined are functionally the same. The basic recommendation to filter sediments and nutrients is to place the buffer in the flow path (poorly defined channel) in order to maximize sedimentation and infiltration (**E**).

If there is significant sheet flow and erosion from the upland the buffer may be extended beyond the flow path (poorly defined channel) in order to enhance sediment trapping (**F**).


A. No sheet flow, no concentrated flow path.
• Minimum Protection (MP) - Ensure bank is intact and add no disturbance zone of 3 meters.
Stable, Intact Bank Zone
3m No Disturbance Zone
Buffer
Stream
Flow
B. Frequent flooding beyond the bank
• MP + grass affected floodplain
C. Sheet flow, no concentrated flow path
• MP + add buffer (5-20m) depending on objective
D. Concentrated flow path outlet, no sheet flow.
• MP + add grassed concentrated flow path outlet
E. Concentrated flow path no sheet flow.
• MP + add grass the channel
F. Concentrated flow path and sheet flow / erosion into flow path
• MP + add grass the channel
• Add buffer to grassed flow path (minimum 5m)


STEP 1.
Is the channel well-defined?
N
Go to step 11
Y
STEP 2.
Does the stream channel have a stable bank zone?
N
Allow recovery of a functioning riparian area to increase stability
INTERVENTION 1
Y
STEP 3.
Is there frequent flooding beyond the bank?
Y
Grass the affected floodplain
N
STEP 4.
Are the slopes adjacent to the Channel ≥ 10%?
Y
STEP 5.
Are the slopes under conventional tillage?
N
N
Y
STEP 6.
Will the landowner convert to conservation tillage or grass the slopes?
Y
N
Buffer slopes adjacent to channel to help trap sediment
INTERVENTION 2
STEP 7.
Is there runoff from a significant upland area?
N
No action required
Y
Go to step 8


STEP 8.
Is there evidence of sheet flow from the uplands entering the channel?
Y
N
STEP 9.
Are there signs of erosion from the uplands?
N
Y
INTERVENTION 4
Buffer the appropriate section of channel from sheet flow to promote infiltration to reduce dissolved nutrients
Assess tillage practices for erosion control as well as buffering appropriate section of channel from sheet flow to reduce dissolved nutrients
INTERVENTION 3
STEP 11.
Is there runoff from a significant area?
Y
N
No action required
STEP 10.
Is there evidence that concentrated flow paths (draws) in the upland contribute to the channel??
N
Y
No action required
Grass concentrated flow path (draw) outflow in the riparian zone
INTERVENTION 5
STEP 12
Are there signs of hillslope erosion in the uplands?
Y
N
Implement upland management and grass waterway to act as a sediment filter and to promote infiltration to reduce dissolved nutrients
Consider grassing concentrated flow path/waterway to promote infiltration to reduce dissolved nutrients

STEP 1

Is the channel well-defined?

YES

A well-defined channel is one that is too deep and steep-sided for a tractor or similar field equipment to cross, will have a definite bank and will generally have bank vegetation that is not cultivated. All permanent streams are well-defined; some ephemeral stream channels may be well-defined.

GO TO STEP 2

STEP 1

Is the channel well-defined?

NO

Channels that are not well-defined may be quite obvious draws or seasonal runoff courses. These are channels that could be crossed with a tractor or similar field equipment.

GO TO STEP 11

STEP 2

Does the stream have a stable bank zone?

YES

The stream channel has a stable bank zone, typically made up of 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.

To be considered stable, the natural vegetation must extend 3m on to land level enough to be cultivated. This is the minimum protection zone required in all instances. There should be no pesticide application within this 3m and a wider buffer may be needed to control spray drift.

GO TO STEP 3

STEP 2

Does the stream have a stable bank zone?

NO

The stream channel does not have a stable bank zone, as indicated by bare soil, or slumping, failing or eroding banks, or periodic cultivation of the bank edge within 3m. Contributing factors to the instability should be identified and could include:

- invasion of non-native and weedy species
- stream-induced bank erosion indicated by undercutting
- springs forming points of weakness in the bank
- overland flow eroding the bank from top down

If overland flow is eroding the bank from above, this indicates a need for a buffer and should be recalled at Step 10 in the tool.

GO TO INTERVENTION 1

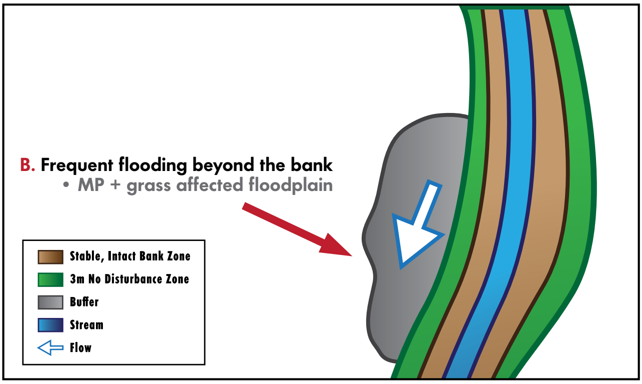
STEP 3

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), due to high upstream flows that are 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 due to wet conditions etc.

GRASS THE AFFECTED FLOODPLAIN.



STEP 3

Is there frequent flooding beyond the bank?

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. In spring there is seldom difficulty seeding because of flooding by the creek. Generally there are no crop losses or poor yields because of too much moisture.

GO TO STEP 4

STEP 4

Are the slopes adjacent to the stream channel ≥ 10%?

YES

The slopes adjacent to the stream channel are ≥ 10% or show signs of erosion. If cropped, steep slopes adjacent to streams elevate the risk of transport of sediment to a stream. The purpose of this step is to assess the potential for localized, near-stream erosion by runoff. If the slopes are steep or show signs of erosion then the conservation practices on the slope need to be assessed.

Note: *In some situations (e.g. heavy or saturated soils), 10% slope may be too great to avoid erosion under conventional tillage. The practitioner then needs to determine an appropriate site-specific slope class for Step 4.*

GO TO STEP 5

STEP 4

Are the slopes adjacent to the stream channel ≥ 10%?

NO

The slopes adjacent to the stream channel are < 10% and don't show signs of erosion.

GO TO STEP 7

STEP 5

Are the slopes adjacent to the stream under conventional tillage?

YES

The steep slopes near the stream channel are conventionally tilled. Conventional tillage is defined as tillage that leaves less than 30% crop residue on the soil surface. These slopes are at high risk for erosion.

GO TO STEP 6

STEP 5

Are the slopes adjacent to the stream under conventional tillage?

NO

The steep slopes near the stream channel are under conservation tillage or other suitable conservation management. Conservation tillage increases soil permeability and reduces soil erosion thereby limiting potential impacts of cropping on the stream.

GO TO STEP 7

STEP 6

Will the landowner switch to conservation tillage?

YES

The landowner will switch to conservation tillage.

GO TO STEP 7

STEP 6

Will the landowner switch to conservation tillage?

NO

The landowner will not switch to conservation tillage or adopt other conservation practices (e.g. contour cropping, terracing).

GO TO INTERVENTION 2

STEP 7

Is there potential for a significant amount of runoff?

YES

The stream channel has the potential to receive runoff from a significant upland area.

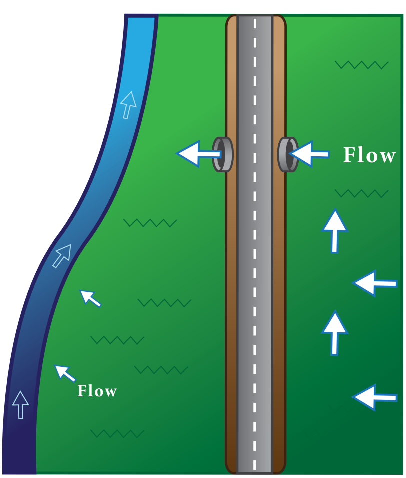
GO TO STEP 8

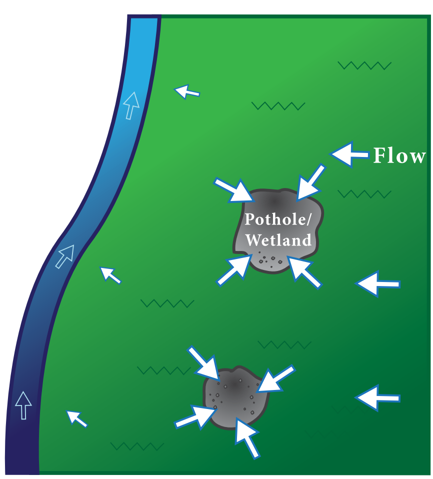
Note: *It is not always possible to observe or measure the runoff. Assessing the contributing area provides an alternative means to establish how much runoff might be expected.*

The upland contributing area may extend beyond the property and should be assessed in its entirety. Man-made structures (e.g. road ditches and culverts) need to be assessed to determine their effect on the potential runoff.

The size of the upland contributing area deemed to be significant is somewhat subjective. Evaluation of this area may be based on information from the landowner, delineating and evaluating the catchment on topographic maps or air photos, and considering normal snowmelt and rainfall runoff for the region. The size will vary in different ecoregions depending on precipitation and evapotranspiration balances.

The objective is to determine whether there is an amount and frequency of runoff that needs to be buffered.





STEP 7

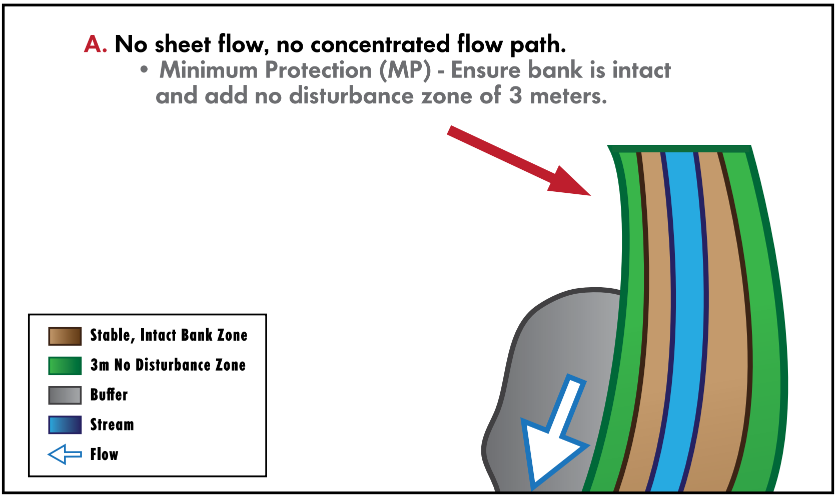
Is there potential for a significant amount of runoff?

NO

The stream channel does not have the potential to receive runoff from a significant upland area. Some reasons why little runoff might make it to the stream include:

- Water is diverted away through ditches
- Water is stored in wetlands
- Water infiltrates into the soil prior to reaching the stream
- The catchment area is very small

NO BUFFER REQUIRED BEYOND THE MINIMUM 3M NO-DISTURBANCE ZONE.



STEP 8

Is there evidence of sheet flow from the uplands entering the channel?

YES

There is evidence of sheet flow from the uplands along the stream channel.

GO TO STEP 9

STEP 8

Is there evidence of sheet flow from the uplands entering the channel?

NO

There is no evidence of sheet flow from the uplands along the stream channel.

GO TO STEP 10

Note: In nature, true sheet flow 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 stream channel over a broad area along the length of the channel, and in this context would be considered as sheet flow.

STEP 9

Are there signs of erosion from the uplands?

YES

The sheet flow also indicates signs of erosion from the uplands.

GO TO INTERVENTION 3.

Note: *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.*

STEP 9

Are there signs of erosion from the uplands?

NO

Although there is sheet flow, there are no signs of erosion from the uplands.

GO TO INTERVENTION 4.

Note: *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.*

STEP 10

Is there evidence that concentrated flow paths (draws) in the upland contribute to the stream channel?

YES

There is evidence that concentrated flow paths (draws) in the uplands contribute to the stream channel. Concentrated flow suggests that the contribution of runoff from the upland is occurring at specific locations along the channel. Generally this would be indicated by small draws that drain portions of the riparian area and/or the upland and release the water into the channel. Concentrated flow paths may have been identified earlier (Step 2) as overland flow eroding the bank and contributing to bank instability.

GO TO INTERVENTION 5.

STEP 10

Is there evidence that concentrated flow paths (draws) in the upland contribute to the stream channel?

NO

There is no evidence that concentrated flow paths (draws) in the uplands contribute to the stream channel.

NO FURTHER ACTION REQUIRED.

STEP 11

Is there potential for a significant amount of runoff?

YES

The stream channel has the potential to receive runoff from a significant upland area.

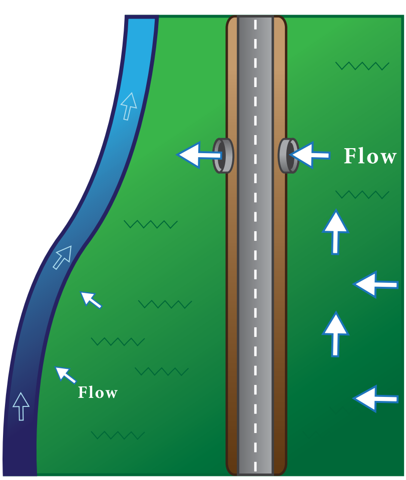
GO TO STEP 12

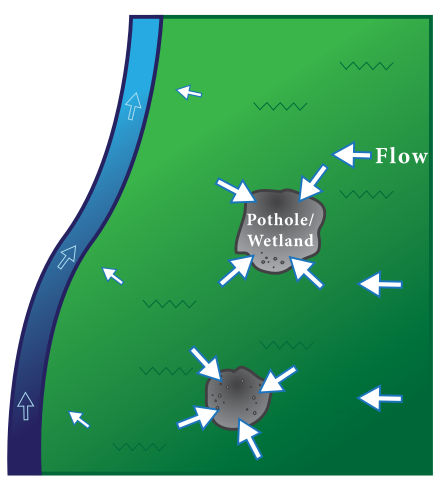
***Note:** It is not always possible to observe or measure the runoff. Assessing the contributing area provides an alternative means to establish how much runoff might be expected.*

The upland contributing area may extend beyond the property and should be assessed in its entirety. Man-made structures (e.g. road ditches and culverts) need to be assessed to determine their effect on the potential runoff.

The size of the upland contributing area deemed to be significant is somewhat subjective. Evaluation of this area may be based on information from the landowner, delineating and evaluating the catchment on topographic maps or air photos, and considering normal snowmelt and rainfall runoff for the region. The size will vary in different ecoregions depending on precipitation and evapotranspiration balances.

The objective is to determine whether there is an amount and frequency of runoff that needs to be buffered.





STEP 11

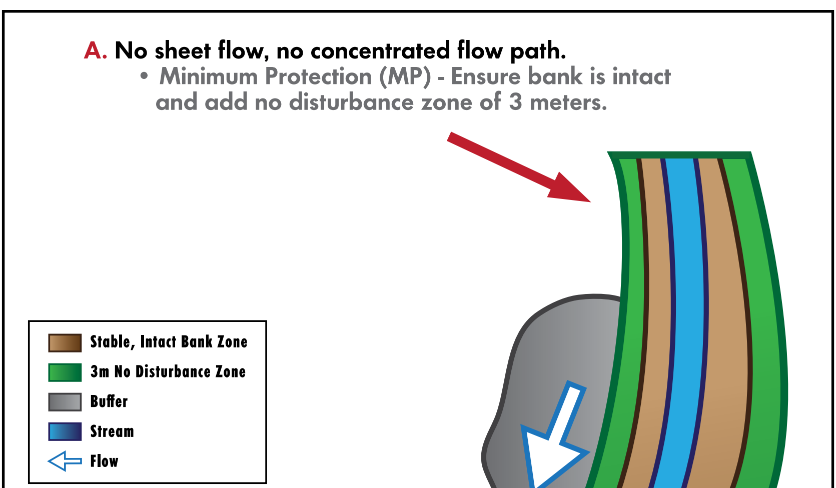
Is there potential for a significant amount of runoff?

NO

The stream channel does not have the potential to receive runoff from a significant upland area. Some reasons why little runoff might make it to the stream include:

- Water is diverted away through ditches
- Water is stored in wetlands
- Water infiltrates into the soil prior to reaching the stream
- The catchment area is very small

NO BUFFER REQUIRED BEYOND THE MINIMUM 3M NO-DISTURBANCE ZONE.



STEP 12

Are there signs of hillslope erosion in the uplands?

YES

There are signs of erosion on the upland slopes contributing runoff to the channel or in the channel itself. Signs of erosion include development of rills or gullying in the field or deposition at the edge of the field, rills in the channel, sheet erosion (shallow soil) in the upper reaches of the channel, or deposition (silting or markedly deeper soil) in the lower reaches of the channel.

Assess the upland tillage and conservation practices to see if changes can be made to reduce erosion.

If erosion is controlled: **GRASS WATERWAY TO PROMOTE NUTRIENT INFILTRATION. (OUTCOME E)**

If erosion is not controlled: **EXTEND BUFFER 5 M BEYOND THE FLOW PATH UP THE SLOPES IN ORDER TO INTERCEPT SEDIMENTS, AND GRASS WATERWAY TO PROMOTE NUTRIENT INFILTRATION. (OUTCOME F)**

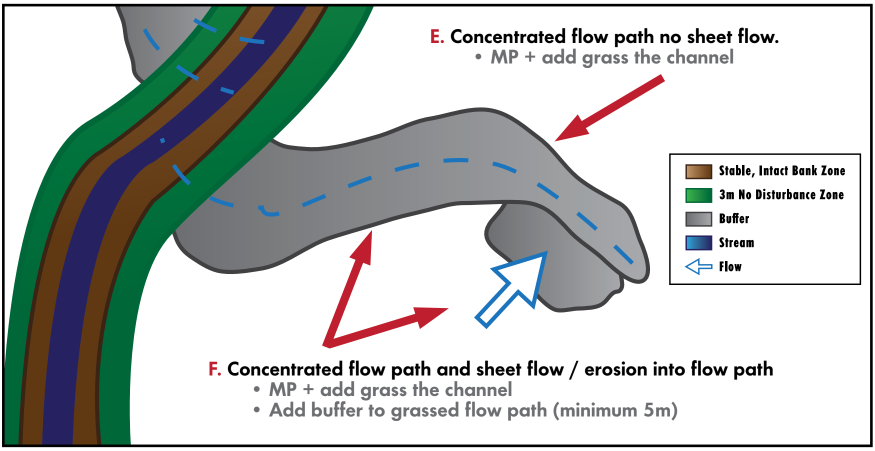
STEP 12

Are there signs of hillslope erosion in the uplands?

NO

There are no signs of erosion. Although there is little sediment transported in the runoff, the channel receives runoff from a significant upland area. It remains desirable to trap as many soluble nutrients as possible prior to that runoff reaching a downstream water body. Soluble nutrient trapping is best accomplished through infiltration, and infiltration is promoted in soils with permanent cover. Nutrient removal will occur through annual haying of the permanent cover crop.

GRASS WATERWAY TO PROMOTE NUTRIENT INFILTRATION.



INTERVENTION 1

Allow recovery of a functioning riparian area to increase stability. This recovery could be achieved naturally or with an engineered solution:

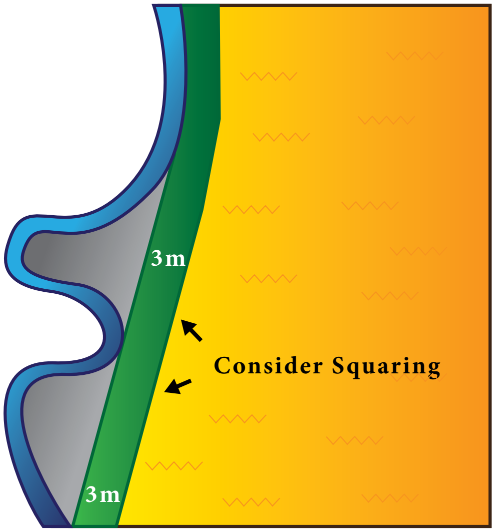
Natural Restoration

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 cropping line. Often there may be sufficient protective width on the inner curves of channels, 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 squaring off the field such that the minimum buffer width required is maintained at the outside bends of the channel.

INCREASE THE DISTANCE BETWEEN BANK EDGE AND CROPPING LINE TO A MINIMUM OF 3 M (STABILITY PROTECTION).

GO TO STEP 3.



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 and springs. 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).

RESTORE BANK THROUGH INTERVENTION (BANK RESTORATION) AND ENSURE MINIMUM BUFFER WIDTH OF 3 M EXISTS (STABILITY PROTECTION).

GO TO STEP 3.

Bioengineered wattle fence.

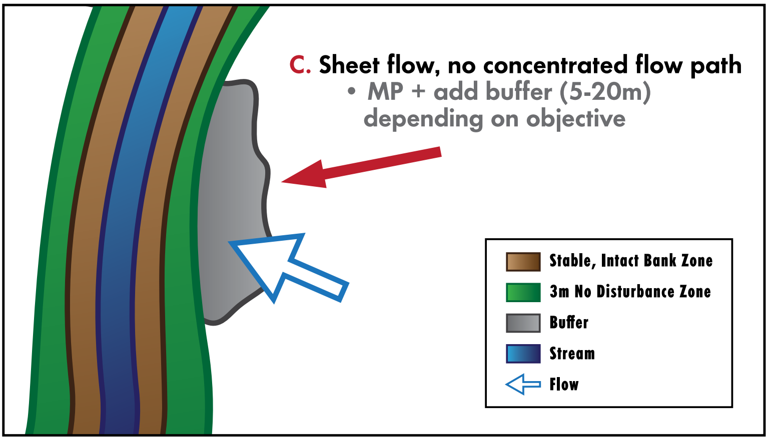
Biotechnical stone toe protection with brush layering.

INTERVENTION 2

Because of the high risk for erosion there is potential for sediment transport to the stream and a buffer along the entire stream channel is required. For effective sediment reduction, a minimum 5m buffer, made up of 2m plus the 3m bank protection zone is recommended.

BUFFER SLOPES ADJACENT TO STREAM CHANNEL.

GO TO STEP 10.



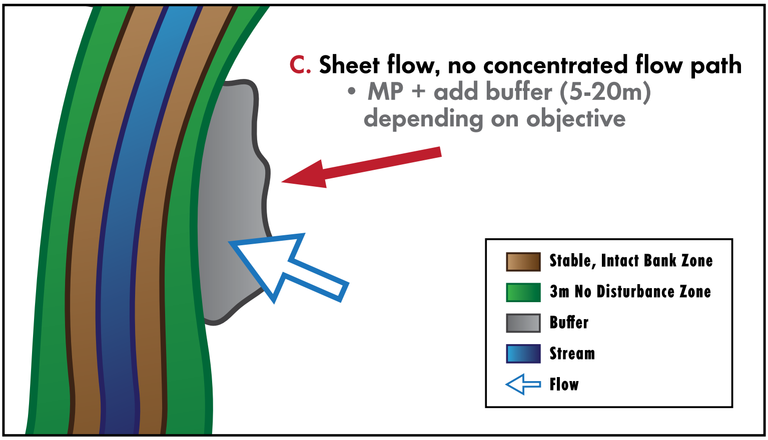
INTERVENTION 3

Assess the upland tillage and conservation practices to see if changes can be made to reduce erosion.

If erosion is reduced, a buffer along the section of channel receiving sheet flow is still recommended to reduce dissolved nutrients (through infiltration). The width is a function of the infiltration capacity since the pollutants of concern are soluble. See Suggested Minimum Widths for Buffers in the appendix on page 54.

BUFFER STREAM CHANNEL FROM SHEET FLOW.

GO TO STEP 10.

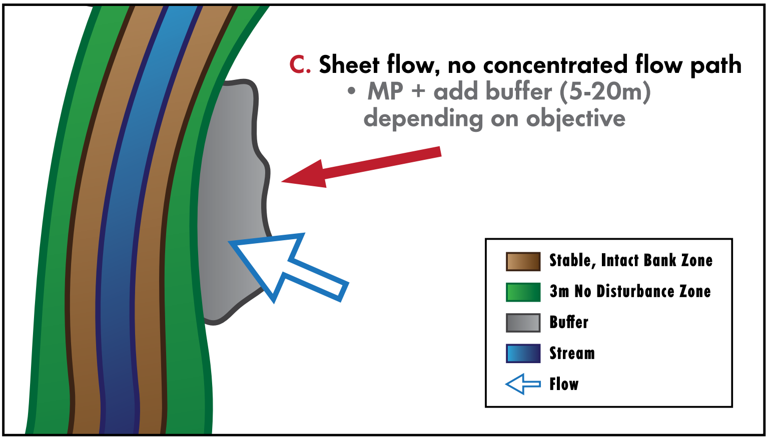


INTERVENTION 4

Because there is a significant amount of runoff, a buffer along the section of channel receiving sheet flow is recommended to reduce dissolved nutrients (through infiltration). The width is a function of the infiltration capacity since the pollutants of concern are soluble. See Suggested Minimum Widths for Buffers in the appendix on page 54.

BUFFER STREAM CHANNEL FROM SHEET FLOW.

GO TO STEP 10.

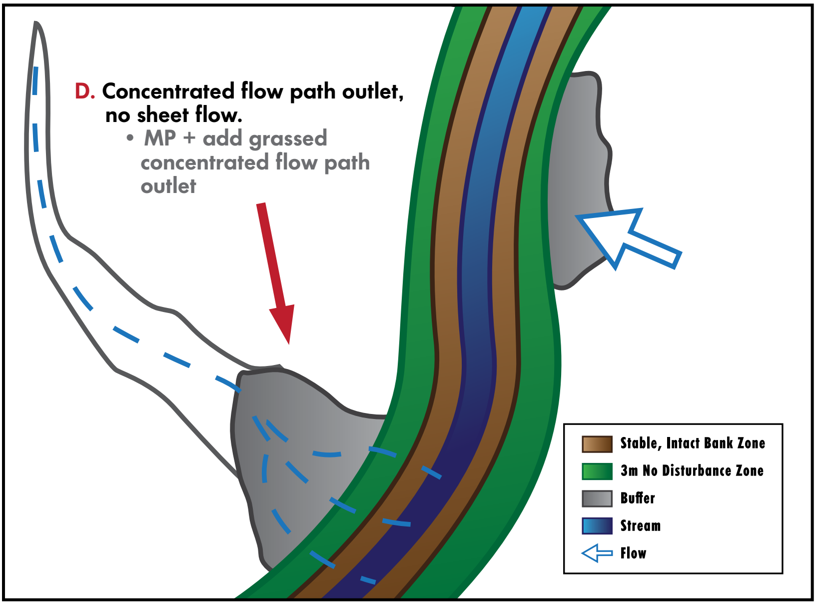


INTERVENTION 5

Concentrated flow entering the channel needs to have the buffer placed at the confluence, 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 stream be buffered up the channel at least as far as any signs of sediment deposition or erosion of the flow path, or a minimum of 15m.

GRASS CHANNEL OUTFLOW.

GO TO STEP 12.



6.1 Minimum Protection

Site: Pipestone Creek, Alberta

Pipestone Creek arises some 75 km west of the site (Figure 6.1.1). Over its course, the creek gradually cuts a deeper channel into the prairie, merging finally with the Gwynne Channel just upstream of the site. The Gwynne Channel is a broad flat-bottomed glacial meltwater channel cut about 200 feet into the surrounding prairie.

[Figure 6.1.1]

Pipestone Creek and Gwynne Channel are dammed just upstream of the site by a dam extending across the Gwynne Channel and forming Coal Lake (Figure 6.1.2). The dam effectively controls and regulates flow in the creek at the site. The site is the field below the dam on the east side of the creek.

[Figure 6.1.2]

STEP 1. The channel at the site is deeply incised. It may have been cleared of in-channel debris when the dam was constructed and the upper section of the channel modified to make the spillway. The channel is a major stream and is clearly well defined. (Figure 6.1.3).

STEP 2. The banks of the creek are steep. For the most part they are completely vegetated with grasses, forbs and shrubs, and are stable (Figure 6.1.3). However sections of the bank, mainly on outside bends are eroded or slumped (Figure 6.1.4). The slumping is consistent with in-stream erosion caused by high river flows, although it is possible the bank failures are a result of groundwater seepage weakening the bank. There is no evidence of overland flow entering the channel to cause the bank degradation.

[Figure 6.1.3]

6.1 Minimum Protection

The top of the banks are mostly in grass and shrub vegetation, an extension of the vegetation on the upper banks. In places however, particularly on outside bends, cultivation and cropping may be within a metre of the top of the bank and some bank degradation is occurring (Figure 6.1.5).

[Figure 6.1.4]

INTERVENTION 1. Consider stabilizing the Pipestone Creek channel bank to reduce bank erosion. Bioengineering techniques may be cost-effective. Establish a minimum 3 metre no-disturbance zone along the Creek above the bank. This will provide rooting to help strengthen the bank and stop machinery disturbance at the top of the bank.

STEP 3. Because of the flow controls at the dam just upstream from the site, there is seldom or never flooding beyond the bank and onto the floodplain.

[Figure 6.1.5]

STEP 4. The slopes adjacent to the bank and extending to the drainage divides are very gentle (Figure 6.1.6).

STEP 7. There is potential for runoff from the prairie level and from the valley wall to be a significant source of flow onto and across the site. However, at the prairie level (Figure 6.1.2) there are numerous sloughs which intercept much of the prairie runoff so that there is minimal drainage over the valley wall. The valley wall is a potential source of runoff to the site (Figure 6.1.2). A township road collects and redirects any runoff, and examination along the length

[Figure 6.1.6]

6.1 Minimum Protection

of the road found only a single small culvert. The size of the culvert and the absence of erosion or deposition at the outlet indicated that the valley wall contribution to runoff is minimal. The remaining potential source of runoff to the creek is the field. Al though there is an overall gentle slope toward the creek, much of the runoff is intercepted in low areas of the field (remnants of in-filled channels Figure 6.1.7). Thus at this site there is little runoff entering the stream across the cultivated field.

[Figure 6.1.7]

OUTCOME

Although there is no further need for buffering at this site, the stream channel is convoluted and from a practical management point of view the landowner might benefit if straight-line boundaries were established for the field (Figure 6.1.8). These boundaries would increase the average width of buffer, but the landowner would benefit in reduced operating costs in the short run and fewer bank problems and land losses in the long run.

[Figure 6.1.8]

6.2 Frequent Flooding

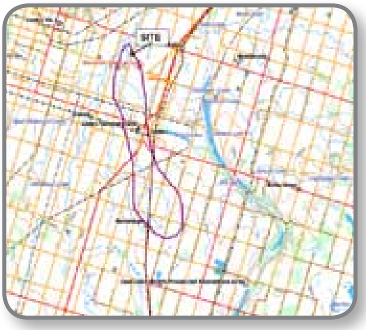
Site: Tributary of Whitemud Creek, Alberta

The site (Figure 6.2.1) is on the east side of a tributary to Whitemud Creek.

[Figure 6.2.1]

The tributary watershed above the creek is about 60 km^2. The watershed includes a portion of the Town of Leduc and a portion of the Edmonton International Airport property (Figure 6.2.2). Both developments augment peak flows, contributing drainage runoff to the creek through surface drains.

STEP 1. On the site, the creek is a well defined channel (Figure 6.2.3)



[Figure 6.2.2]

STEP 2. The banks are well vegetated and stable (Figure 6.2.4).

STEP 3. The creek has a clearly defined floodplain on the property (Figure 6.2.5) and the creek floods frequently (Figures 6.2.6, 7, and 8); the site flooding may in part be due to the enhanced creek flows caused by the drainages in Leduc and at the airport.

OUTCOME Because of the frequent flooding the recommendation is to convert the entire floodplain to buffer, to mitigate the effects of site flooding from upstream sources. Establishing a buffer in the floodplain will help protect the stream through enhanced sedimentation in the buffer area and reduce nutrient pick-up from the buffered area.

[Figure 6.2.3]

6.2 Frequent Flooding

[Figure 6.2.4]

[Figure 6.2.5]

[Figure 6.2.6]

[Figure 6.2.7]

[Figure 6.2.8]

6.3 Sheet Flow

Site: Unnamed ephemeral creek SE of Leduc, Alberta

The site (Figure 6.3.1) is a field in the SE corner of a section with an ephemeral creek that enters the site from the south and then turns eastward and leaves the section.

[Figure 6.3.1]

The creek has a relatively small watershed above the site, originating approximately 3 km south in rolling to gently hummocky terrain that has many draws converging to form the creek (Figure 6.3.2). The creek forms the west and north boundaries of the field study site (Figure 6.3.3).

[Figure 6.3.2]

STEP 1. The channel is well defined (Figure 6.3.4).

STEP 2. The banks are well vegetated and stable (Figure 6.3.4).

STEP 3. This unnamed creek is a first order stream and does not have a developed flood plain. Flooding beyond the bank is infrequent.

STEP 4. The slopes adjacent to the bank and extending to the east and south boundaries are gentle and quite uniform (Figures 6.3.4 and 5).

STEP 7. The roads on the east and south boundaries of the field divert runoff from adjacent properties (other than the main channel of the creek) so

[Figure 6.3.3]

6.3 Sheet Flow

that the interest is only the runoff from the field itself. The road ditches collect only a small fraction of the field runoff. The field is large enough to contribute significant amount of runoff.

[Figure 6.3.4]

STEP 8. Overland flow to the creek is sheet flow (Figure 6.3.6).

STEP 9. There were no signs of erosion from the uplands. The field is under conservation management with at most only a single fall cultivation if P fertilizer is deep banded; in spring when this assessment was carried out there had been no cultivation the previous year.

[Figure 6.3.5]

INTERVENTION 4. The recommendation at this site is to buffer the entire length of the creek from the sheet flow. The recommendation includes allowing a 3m no-disturbance zone adjacent to the bank. Since the field is in conservation tillage sediment in runoff is a minor concern. Thus, additional buffering is primarily to reduce soluble nutrient losses to the creek and buffer width would be selected with that objective in mind. A 10m buffer is recommended to remove 50% of the dissolved phosphorus. A 20m buffer is recommended to remove 80% of the dissolved phosphorus.

STEP 10. There is no evidence that overland flow is concentrated in any flow paths.

[Figure 6.3.6]

OUTCOME There are no additional actions required.

6.4 Concentrated Flow Path

Site: Melfort Creek near Resource, Saskatchewan

Melfort Creek arises from Eagle Lake some 10 km above the site and the watershed area of the creek above the site is greater than 100 km^2 (Figure 6.4.1). The site is a quarter-section on Melfort Creek near the former village of Resource. The creek runs through the northwest corner of the quarter-section (Figure 6.4.2).

[Figure 6.4.1]

STEP 1. The channel is a major stream and is clearly well defined.

STEP 2. A portion of the creek bank on the quarter is unstable (Figure 6.4.3). At this point the river is cutting into a small knoll. The bank degradation is due to bank erosion by the river. There is little or no overland runoff into the creek at the unstable bank because the knoll is small. Elsewhere the bank is stable and well-vegetated with grasses, shrubs and trees.

[Figure 6.4.2]

INTERVENTION 1. The unstable bank area is caused by river erosion of the bank. It is likely that the river will continue modifying the bank until a new equilibrium is achieved; however if there is concern then bank stabilization alternatives (such as biotechnology, gabions etc.) could be considered.

STEP 3. Flooding beyond the banks at the site is infrequent because Eagle Lake acts to store much of the melt water in the watershed.

[Figure 6.4.3]

STEP 4. The slopes adjacent to the bank and extending upland are very gentle (Figure 6.4.3).

STEP 7. There is a pronounced concentrated flow path that arises some 6km SE of the site and has a significant catchment area entering Melfort Creek through the quarter (Figure 6.4.2).

[Figure 6.4.4]

STEP 8. Along the channel in the quarter section of interest, there is only a small area of the quarter that could source runoff directly into the creek. This area is too insignificant to consider.

STEP 10. There is a pronounced concentrated flow path entering Melfort Creek through the quarter (Figure 6.4.2). The flow path outlet to Melfort creek is low-lying cropland and shows signs of sediment deposition (Figure 6.4.4).

[Figure 6.4.5]

INTERVENTION 5. The mouth of the flowpath entering Melfort Creek, encompassing the entire low lying area, should be seeded down as a buffer. The area is trapping some eroded sediment. The buffer will improve sediment trapping and increase opportunity for some of the run-off to infiltrate into the buffer rather than flow directly to the Creek.

STEP 12. Upstream, there is significant erosion of the flowpath (Figure 6.4.5) as well as reaches of deposition.

OUTCOME The site is under conservation tillage management. However, the overall catchment area for the concentrated flow path is under different ownerships and includes a variety of crop management systems. Efforts should be made with landowners higher in the concentrated flow path catchment area to grass the waterway and buffer the flowpath and/or to increase the area in conservation management.

6.5 Poorly Defined Channels

Site: Biggar, Saskatchewan

The site (Figure 6.5.1) is on a large draw in a strongly hummocky landscape.

[Figure 6.5.1]

STEP 1. The channel is poorly defined and is farmed (Figure 6.5.2).

STEP 11. The contributing area of the draw is about 3 km^2, and generates a significant amount of runoff.

[Figure 6.5.2]

STEP 12. Fall cultivation has buried much of the crop residue leaving the field vulnerable to erosion (Figures 6.5.3 and 4). Both deposition and erosion take place in the channel.

[Figure 6.5.3]

OUTCOME A sequence of recommendations that may be adopted over time include:

1. Reduce the amount of tillage in the cropping system to maintain residue for protection against soil erosion.

2. Grass the channel to promote infiltration and trap sediments in the down channel flow.

3. If erosion is still an issue, buffer the channel from the overland flows on either side of the channel to trap sediment before it enters the channel. The recommended size of the buffer is the 3m no-disturbance zone plus 2m added width for sediment trapping, for a total width of 5m.

[Figure 6.5.4]

6.6 Combination

Site: Swift Current Creek, Saskatchewan

The site is located in the valley of Swift Current Creek near the Town of Swift Current (Figure 6.6.1). The site is a pronounced meander in Swift Current Creek (Figure 6.6.2).

[Figure 6.6.1]

The north side of the creek forms a distinctive 'peninsula' managed as a single uniform field (A) with a drainage divide running through it. The west and south edges of the site are bounded by roads. The west side (B) of the site is managed separately from the east side (D), the two sides being separated by an area of very steep land and banks between the creek and the south boundary of the site (C). There is a grassed waterway through the field on the east side and the east boundary of the site is approximately a drainage divide (see Figure 6.6.3).

[Figure 6.6.2]

STEP 1. The channel is a major river and is clearly well defined.

STEP 2. The banks are stable and generally well-vegetated except that cropland is cultivated to the very top of the bank and there may be spray damage to the upper bank vegetation (Figures 6.6.4 and 5).

[Figure 6.6.3]

INTERVENTION 1. For reaches A,B and D the recommendation is to establish the 3m no-disturbance areas along the top of the bank to stop cultivation damage to the top of the bank and to buffer spraying. Initially a seeded forage would be appropriate; ideally over time the bank and no-disturbance zones would be colonized by native species.

6.6 Combination

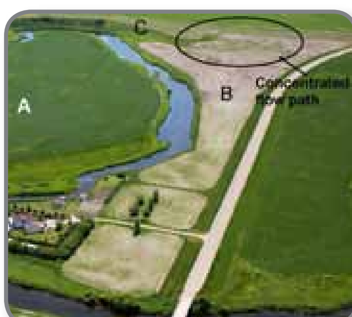
STEP 3. The creek headwaters are in the Cypress Hills. The Duncairn Dam on Swift Current Creek is about 20 km upstream of the site as the crow flies and a greater distance in river-distance. The dam regulates flow to some degree; however there are many tributaries between the dam and the site and so, in addition to regulated fluctuations in the creek, the site is also affected by river responses to weather events. The creek is also controlled by a weir in the town of Swift Current downstream which, at times of high river flow, may back the river up to above the site. Never-the-less the creek seldom or never floods beyond its bank at the site.

[Figure 6.6.4]

STEP 4. The slopes adjacent to the bank and extending to the drainage divides are very gentle (Figures 6.6.4 and 5).

[Figure 6.6.5]

STEP 7. The catchment areas for reaches A, B and D are small and there is not a significant runoff. For A, the runoff divide runs through the middle of the 'peninsula' effectively giving two small runoff slopes. For B, some of the runoff is to the roadside ditch and only a small area contributes directly to the creek over the field. For D much of the catchment area is in forage cover and contributes little runoff except in the area where a grassed waterway (buffered channel) is already in place. The catchment area for reach C is small as the south boundary road diverts landscape runoff. However, some of the diverted runoff crosses the site between B and C in a concentrated flow path and is joined by another concentrated flow path from the ditch on the west side of the property. For section C we conclude that there may be significant runoff.



[Figure 6.6.6]

6.6 Combination

STEP 8. There is no evidence of sheet flow in reach C.

STEP 10. There is a concentrated flow path that is joined by another concentrated flow path from the ditch (Figure 6.6.6).

INTERVENTION 5. The concentrated flow path outlet in the riparian area is already in grass.

STEP 12. There are minor signs of hillslope erosion.

OUTCOME Although the landowner has not identified a concern with runoff through the concentrated flow path, we recommend buffering the path back to the junction of the two pathways by shifting the field boundary north.

Suggested Minimum Widths for Buffers

Buffering Sheet Flow

Buffers put in place to treat sheet flow need to extend along the creek for the whole extent of sheet flow into the creek.

Based on a literature review of existing research, the following minimum widths are recommended for sediment and dissolved phosphorus:

- 5m for sediment trapping and minimum for spray drift interception (2m + the 3m minimum protection zone)
- 10m for 50% reduction in dissolved phosphorus and minimum for in-stream habitat protection (7m + the 3m minimum protection zone)
- 20m for 80% reduction in dissolved phosphorus (17 m + the 3m minimum protection zone).

These recommendations are based on the available science as reported in the literature and are subject to change as new research is published.

Buffering Concentrated Flow Outlets

Buffers in concentrated flow paths are similar to grassed waterways for water erosion control. There are few sources for guidelines regarding sizing buffers for concentrated flows paths and channels that are not well defined. Establishing sizing guidelines is also complicated by upland management practices which can be important in establishing runoff volumes, sediment loading and nutrient transport.

In the absence of more detailed work, the following approach is recommended for buffering concentrated flow path outlets:

- Examine the flow path along its full length for erosion and deposition
- At a minimum buffer up the channel at least as far as any signs of sediment deposition or erosion of the flow path, or at least 15m.
- Consider altering production practices in order to reduce flows
- Extend the buffer beyond the signs of erosion or deposition if the landscape is prone to erosion or high runoff.

Setbacks for Pesticide Spray Drift

Setbacks for pesticide spray drift are mandated by the Pest Management Regulatory Agency of Health Canada (PMRA). Follow the directions on the label on the pesticide container. Also comply with your Provincial requirements (e.g. Alberta Environment's Code of Practice for Pesticides).

Selected Publications/Resources for Riparian Vegetation Species Selection

Ducks Unlimited Canada – Native Plant Solutions

Penner C.G. and Wark D.B. Critical Areas Revegetation. Native Plant Solutions.

Wark D.B. , Gabruch L.K., Penner C., Hamilton R.J. and Koblum T.G. Revegetating with Native Grasses in the Northern Great Plains. Native Plant Solutions.

Plant Attribute Fact Sheets – available online from Ducks Unlimited Canada. Go to www.ducks.ca and search for the above documents.

Alberta Agriculture and Rural Development

Alberta Agriculture Food and Rural Development. 2002. Buffer Zones for a Healthy Watershed. Fact Sheet # IB001-2002.

Alberta Agriculture Food and Rural Development. 2009. Alberta Forage Manual, 2nd Edition. Agdex 120/20-1. Available for purchase.

Go to www.agric.gov.ab.ca and search for the above documents.

Saskatchewan Forage Council

Saskatchewan Forage Council – Online Forage Species Selection Tool/ Dryland Forage Species Adaptation Program - go to www.saskforage.ca and search for the Online Forage Species Selection Tool.

Manitoba Forage Council

Manitoba Forage & Grassland Reference Manual.

Go to www.mbforagecouncil.mb.ca and search for the document.

Agriculture and Agri-Food Canada - AESB Agroforestry Development Centre

Trees and Shrubs for Agroforestry on the Prairies - adapted species available through the Prairie Shelterbelt Program.

Go to www.agr.gc.ca and search for Agroforestry Development Centre or the above document.

Cows and Fish - Alberta Riparian Habitat Management Society

Go to www.cowsandfish.org.

Overlap in sinuous riparian areas

Prairie Agricultural Machinery Institute

Determining Options to Lower Mechanical Overlap in Sinuous Riparian Areas. Go to www.pami.ca and search for fact sheets on field overlap.

Notes