Grand River Water Management Plan
TECHNICAL BRIEF

Report No.:	WMPSC-2013-01-03	**Date:**	January 16, 2013
To:	Water Management Plan Project Team		
From:	Anne Loeffler, member, Water Quality Working Group		
Subject:	A Review of Best Management Practices to address Agricultural Sources and Pathways of Nitrogen, Phosphorus and sediment		

RECOMMENDATION

For information only

REPORT:

Introduction

The following objectives were identified in the Terms of Reference for the Water Quality Working group:

- to identify the Best Management Practices (BMPs) most effective to deal with the key mechanism/processes involved in the transport of nutrients in the watershed; and
- to compare this list of BMPs with the BMPs currently implemented by the Rural Water Quality Program (RWQP) and identify information and knowledge gaps.

There is consensus among the water quality working group members that nonpoint/diffuse sources of nutrients from lands that have a surplus of nitrogen/phosphorus from the over-application of manure and/or fertilizers are a major source of nutrients and sediment to the river system. While nutrient inputs from large point sources are an important issue, this brief deals with addressing the agricultural and rural sources.

The GRCA currently delivers the Rural Water Quality Program on farms throughout the watershed. The RWQP started in the Region of Waterloo in 1998 and has slowly expanded to include the entire watershed. Through this program, staff deliver technical and financial assistance to farmers who wish to address potential water quality impairment issues on their farms. Participation in the program is voluntary. The program is funded mostly by the upper tier municipalities. Local steering committees prioritize BMP applications and decide appropriate funding levels to direct the available funding. Through the RWQP program structure, the GRCA is also able to direct some provincial, federal and corporate funding sources to those areas where no municipal funding is available. The list of eligible BMPs is shown in Table 1.

Federal and provincial cost share programs such as the Canada-Ontario Farm Stewardship Program (COFSP) also offer cost share incentives for a number of BMPs. Province-wide programs such as COFSP

are currently available on a first come, first served basis and do not directly prioritize water quality issues.

BMP identification and characterization

Several North American literature reviews have been conducted recently to assess the effectiveness of agricultural BMPs (see References section). This research must be carefully evaluated within the context of local geomorphic and hydrologic conditions. BMP effectiveness has been shown to be extremely site-specific and may vary considerably between sites from the watershed level down to the individual field level. Specific site conditions must always be considered before making decisions regarding which BMPs to implement. It is important to have a wide suite of practices to choose from to address a specific issue. It is also important to recognise that the implementation of a suite of BMPs may be necessary for maximum benefit since multiple transport pathways for multiple forms and types of nutrients are often in operation on agricultural lands during any given season. As a result, a multi-barrier approach, rather than reliance on a single or a few BMPs, is recommended.

To qualify as a Best Management Practice, a practice must be a proven, practical and affordable approach to conserving soil, water, and other natural resources. New technologies and practices are being developed (or likely will be) to address nutrient issues, however they are not considered BMPs until proven. BMPs promoted in Ontario and which could influence nutrient management are listed and described in Appendix 1.

The ACT (**A**void, **C**ontrol, and **T**rap) approach (NRCS, 2012) characterizes BMPs to fit into a multi-barrier approach to address different sources and pathways of nutrients from agricultural sources as follows:

- Does the BMP **avoid** the creation of the problem?
- Does it **control** its movement of the potential contaminant from the source?
- Does it **trap** (or treat) the potential contaminant before it enters a watercourse?

Table 1 aligns BMPs by the potential contaminants (e.g. phosphorus, nitrogen, sediment) and predominant pathways for their movement. While greatest priority should probably be given to BMPs that avoid the creation of a problem, BMPs that control and trap nutrients must also be part of the toolkit.

Experts at the OMAFRA workshop on the Assessment of Agricultural Best Management Practices (April 2012) agreed that there is no one single BMP that will solve the problem everywhere. Many BMPs may also have undesirable side effects, such as increased release of greenhouse gases. Some potential negative side effects of specific BMPs are of particular interest:

- Conservation tillage, which is practiced to decrease particulate phosphorus and sediment losses, may result in increased dissolved phosphorus levels in surface runoff if fertilizer is left on the surface rather than being banded below the surface.

- Techniques to enhance water infiltration, and reduce transport of dissolved phosphorus across the soil surface, may lead to increased leaching of nitrate.

Gap identification

- For the current Grand River Rural Water Quality Program (RWQP), watershed municipalities supply the funding to assist farmers with implementing BMPs. The level of funding assistance available to farmers across the watershed varies widely by upper tier municipality. Local steering committees prioritize BMP applications and decide appropriate funding levels to direct the available funding
- Due to the lack of resources, no financial assistance can be offered at present to address agricultural nutrient issues in some areas that have been identified as priority areas, including the headwaters of the Nith River. In addition, funding assistance is extremely limited at present in the municipalities of Perth, Halton, and Hamilton.
- The funding of manure storages, one of the most expensive BMPs, is currently restricted to Waterloo, Wellington and Brant Counties. Livestock operations in other counties in the watershed therefore currently have no assistance available to them through the RWQP.
- Annual incentive payments to keep fragile agricultural land out of production are limited to Waterloo Region and Wellington County. For example, planting trees and native cover on fragile lands such as steep slopes helps to reduce erosion and limit the mobilization of sediment and phosphorus into streams.
- While nutrient management planning services are currently funded in most parts of the watershed, consideration should be given to effective means of promoting all aspects of nutrient management, include the 4-R Nutrient Stewardship program which includes the **R**ight rate, **R**ight time, **R**ight source, and **R**ight placement of all nutrients (www.ipni.net/4R).
- Current programming provides incentives primarily for capital projects. There is a need to develop tools and mechanisms to provide incentives for practices such as cover cropping, crop rotation, and strip cropping. Many of the nutrient stewardship BMPs fall into the category of practices rather than being capital projects or structures that can be incented in a traditional cost share program. These capital projects are often in the “trap” category, recovering nutrients as they leave the field, but they are either less effective than avoiding or controlling the nutrient losses in the field, or they need to work in concert with in-field practices to be most effective.
- Some issues are best addressed at a broader level than at the farm scale. For example, thought could be given to rural stormwater planning at a subwatershed scale. The RWQP currently does not have a mechanism for providing funding for collaborating multiple landowners at the community or subwatershed level.
- Generally, funds are available for farmers only. With the exception of tree planting projects and well projects in some municipalities, rural non-farm property owners are not eligible for support through existing programs.
- Federal and provincial cost share programs play an important role in supporting BMP adoption locally. The number of BMPs implemented through the RWQP is related to the availability of

funding from other programs such as the Canada-Ontario Farm Stewardship Plan. When financial support available through other cost share programs is fully allocated, implementation through the RWQP becomes limited and farmers hold off on implementing projects to await a new influx of funds.

- Currently there is no funding for monitoring implementation and individual or collective performance of BMPs.

Key recommendations for moving forward

- There is a need to develop a watershed-wide Rural Water Quality Program that provides technical and funding assistance to priority farms in all municipalities in the watershed.
- Enhanced assistance may be appropriate in priority areas or subwatersheds
- Currently municipal tax structures provide a disincentive for naturalization projects on agricultural land. A modified system that provides property tax breaks to people who conduct naturalization or tree planting projects should be investigated.
- A wide range of BMPs is needed in the toolkit rather than focussing on a limited number of practices.
- There is a need to recognize that rural non-farm property owners control a significant proportion of the rural landscape, and programs need to be adapted and available to them as well as the farming sector.
- Adapt the RWQP program as innovative technologies become proven as Best Management Practices. A mechanism should be developed to review and incorporate new BMP's into the RWQP toolkit.
- Demonstration projects should be considered for incorporation into the current RWQP funding structure.
- Flexibility in incentive programming structure is important. One option to be considered is the bundling of incentives or practices i.e. making regular soil testing mandatory to receive performance incentive payments for establishing cover crops.
- Monitoring programs should be in place to measure the effectiveness of the implementation of BMPs at the subwatershed scale. Also, the implementation of BMPs on all farms (not just those farms participating in the RWQP) should be tracked to help understand the relationship between BMP implementation and water quality.
- As in the past, the collective knowledge of technical experts at Agriculture and Agri-Food Canada as well as the Ontario Ministry of Agriculture, Food and Rural Affairs should continue to inform the selection of BMPs in the RWQP.

Table 1. Using the ACT (Avoid, Control, Trap) approach to characterize agricultural BMPs on private land
Black = currently part of the RWQP BMP toolkit in most municipalities- Red = currently NOT part of the RWQP toolkit
Purple = funding limited to Wellington County RWQP

Source	Sediment	Particulate Phosphorus	Soluble Reactive Phosphorus	Nitrogen
Pathway	**Erosion**	**Erosion**	**Runoff**	**Infiltration**
Avoid	• Livestock fencing • Buffer strips • Streambank stabilization structures • Machinery crossings • Windbreaks • Fragile land retirement • **Cover crops** • Crop rotation • Setbacks	• Nutrient management planning • Phosphorus rate • Phosphorus source • Phosphorus placement • Phosphorus timing • Livestock fencing • Buffer strips • Streambank stabilization structures • Machinery crossings • Windbreaks • Fragile land retirement • **Cover crops** • Crop rotation • Feed regimes to reduce nutrients in manure • Setbacks	• Nutrient management planning • Phosphorus rate • Phosphorus source • Phosphorus placement • Phosphorus timing • Livestock fencing • Clean water diversion • Manure storage • Milkhouse or other wastewater treatment or storage • Decommission unused manure storage • Fragile land retirement • Crop rotation • Feed regimes to reduce nutrients in manure • Setbacks	• Nutrient management planning • Nitrogen rate • Nitrogen source • Nitrogen placement • Nitrogen timing • Livestock fencing • Manure storage • Clean water diversion • Decommission unused manure storage • Dead stock composting facilities • Fragile land retirement • **Cover crops** • Crop rotation • Irrigation management • Feed regimes to reduce nutrients in manure
Control	• Soil conservation planning • Water and sediment control basins • Grassed waterways • Drop structures • Terraces • Livestock fencing • Tile outlet stabilization • **Cover crops** • Strip cropping • Residue management	• Soil conservation planning • Water and sediment control basins • Grassed waterways • Drop structures • Terraces • Tile outlet stabilization • Strip cropping • Livestock fencing • **Cover crops** • Residue management	• Manure storage • Milkhouse waste treatment • Soil conservation planning • Fertilizer storage and handling facilities • Grassed waterways • terraces • **Cover crops** • **Tile drain control structures** • Strip cropping	• Manure storage • Fertilizer storage and handling facilities • **Cover crops** • **Tile drain control structures**
• Table 1 (continued)				

Source	**Sediment**	**Particulate Phosphorus**	**Soluble Reactive Phosphorus**	**Nitrate Nitrogen**
Pathway	**Erosion**	**Erosion**	**Runoff**	**Infiltration**
Trap	• Buffer strips • **Wetland creation** • Rural stormwater planning	• Buffer strips • **Wetland creation** • Tile water treatment • Rural stormwater planning	• Buffer strips • **Wetland creation** • Tile water treatment	• Buffer strips • **Wetland creation** • Tile water treatment • Tile drain control structures

Appendix 1: Definitions and short descriptions of BMPs listed in Table 1

Source: For the purposes of Table 1, the source of nutrients or sediment is the consideration of both land cover/use and land management practices. For instance, a source category as defined for the water management plan would include a nonpoint (or diffuse) source that may include animal manure applied onto agricultural lands. See Table A1 below for an illustration of a variety of nutrient and sediment source categories identified for the watershed.

Pathway: Predominant mechanism by which contaminants move towards water resources. For example, erosion, runoff, infiltration/discharge of groundwater.

ACT Approach: The ACT approach focuses on the function/mechanism by which a management practice mitigates the occurrence, form or movement of a potential contaminant, in this case sediment or various nutrient forms.

Avoid: Reduce the amount of potential contaminant at source by reducing its use/occurrence in the field in the first place

Control: Alter the amount or movement of the potential contaminant in field by transforming the contaminant or partitioning to different pathways or altering (slowing) the pathway

Trap/Treat: Removal of the potential contaminant from pathway, typically at edge of field. May include removal by transformation (e.g. denitrification) or trapping and removing. This should be a permanent solution e.g. P trapped in vegetation that is removed is not available to dissolve when plant material freezes, and so does not move with snowmelt**Buffer strip** – a strip of permanent vegetation, usually a mix of trees, shrubs and grasses at least 3 meters wide along the side of a watercourse. It provides habitat and protection for water quality from erosion, excess nutrient runoff, and contaminants.

Clean water diversion– Eavestrough, berms, and/or roofs to divert clean rain water and surface water from livestock yards and manure storages, thereby decreasing the volume of contaminated runoff. Can also be diversions around structures such as greenhouses, farmsteads, or parking lots.

Cover crop – A crop grown in rotation with regular crops for ground cover rather than for harvest. These crops (e.g. red clover or oil seed radish) can absorb leftover nutrients from the soil, and may release them to the next crop. They may help reduce leaching of nutrients into ground water.

Crop rotation – Using a different crop in the same field for each new planting. Crop rotation improves crop yields, and makes it easier to control insects and weeds. If legumes are included in the rotation, nitrogen will be carried over to the next crop.

Dead stock composting– A process of managed decomposition of deadstock achieved by mixing deadstock with substrate at the proper ratio. Micro-organisms, in the presence of oxygen, break down the organic matter to produce a stable, dark, soil-like material that has very little odour. Composting can be done in a bin system, windrows, inside a container (in-vessel) or a building.

Decommissioning unused manure storage – unused manure storages may accumulate rain water and eventually overrun or leak residual nutrients into ground and surface water.

Drop structure – a structure to control erosion in an area of concentrated flow by directing water from a higher level to a lower level. May include rock chute spillways or drop pipe inlets.

Nutrient rate – BMPs for selecting the appropriate rate of fertilizer, manure or other sources of nutrients to avoid losses of unused nutrients. Includes assessing nutrient supply from all sources and assessing plant demand. Includes soil testing for existing nutrient levels. May include variable rate application to address spatial variability within fields.

Nutrient source – BMPs for selecting the appropriate nutrient source and form to ensure a balanced supply of nutrients that suit the soil properties. May include commercial fertilizers, livestock manures, bio-solids, and credits from previous crops. May include controlled nutrient release products such as slow nitrogen release products.

Nutrient placement – BMPs for appropriate nutrient application may include banding, injection, incorporation, and side dressing. Need to recognize crop rooting patterns and manage spatial variability within fields.

Nutrient timing – BMPs for applying nutrient sources at appropriate times to minimize nutrient losses to the environment. Involves assessing the dynamics of crop uptake and soil supply, and determining timing when risk of loss is least.

Fertilizer storage and handling facilities – facilities to allow for the safe handling and loading of fertilizers into application equipment.

Fragile land retirement – removing fragile agricultural land subject to severe wind and water erosion from agricultural production and establishing trees or other permanent vegetation. Examples may include steep slopes and other erosion-prone lands, floodplains, and poorly drained lands.

Grassed waterway – a broad, shallow, permanently vegetated channel designed to safely convey concentrated runoff from farm fields to a stable outlet.

Livestock fencing – fencing erected to restrict livestock access from watercourses to protect streambanks and eliminate manure inputs. Livestock fencing projects often require the installation of livestock stream crossings and alternate water sources.

Machinery crossing – structure built to allow machinery to safely cross a watercourse without causing damage to the stream bed or bank.

Manure storage – concrete or steel structures, tanks or buildings to contain livestock manure and manure runoff.

Nutrient management planning – creating plans that evaluate appropriate nutrient application rates and other regulatory standards of application. Nutrient management plans should incorporate or consider all of the 4Rs (right rate, right source, right time, and right place) of nutrient stewardship.

Residue management (conservation tillage) – tillage methods and planting systems that keep soil covered with crop or crop residue after harvest, over winter, before planting and after planting to reduce the risk of erosion and the delivery of sediment and nutrients to watercourses. Conservation tillage leaves 30% or more of the soil surface covered with crop residue after planting.

Rural stormwater planning – developing a plan to contain and/or treat surface runoff from a subwatershed. The intent is to deal with rural stormwater at a broader scale than the farm scale.

Setback (or separation distance) – distance maintained between application (of nutrient, pesticide) and water resource of concern

Soil conservation planning – developing a plan to evaluate the potential of various BMPs to reduce soil erosion. Should be done by qualified consultants.

Streambank stabilization – may include bioengineering techniques, ditchbank seeding, spillway drop structures, and culvert or tile outlet protection.

Strip cropping –systems of crop strips across a slope to control soil erosion. Usually consist of alternate strips of forage crops and cereal/row crops, between 23 to 46 m in width.

Terraces – earthen berms that intercept runoff and divert it into a subsurface drainage system, reducing erosivity and volume of overland flow

Tile outlet control structures – structures that control subsurface drainage volume and nutrient losses through tiles.

Tile outlet stabilization – the use of erosion resistant material, such as rock riprap on top of a filter cloth, to protect the stream or ditchbank area from erosion where water exits a tile drain.

Tile water treatment – bioreactors, detention ponds or treatment ponds that treat tile water at the end of the tile.

Wastewater treatment or storage – the proper treatment or containment of washwater from milk pipelines, milking parlours, and other components of dairy production facilities, as well as on-farm processing, greenhouse, bunker silo, solid manure pile wastewater or runoff containment, treatment and/or reuse.

Water and sediment control basins – an earthen berm that intercepts and ponds runoff, then releases it slowly into a subsurface drainpipe in less than 24 hours.

Wetland creation – creation of wetlands to hold back and slowly release surface runoff from farm fields.

Windbreaks - rows of trees planted on field borders to reduce wind speeds, protect crops and reduce the risk of soil erosion by wind.

Table A1. Watershed source categories of nutrients and sediment and the key transport mechanism associated with moving nutrients / sediment from land to surface water.

Nutrient & Sediment Source Category			Issue	Key transport mechanisms
I	II	III		
Non Point Sources	Forested, wetland areas	Stormwater	Sediment, Phosphorus	Runoff
	Rural (Non Agriculture)	Stormwater	Sediment, Phosphorus	Runoff
	Agriculture	Manure	Phosphorus, Nitrogen	Runoff, infiltration
		Inorganic fertilizer	Phosphorus, Nitrogen	
		Non Agricultural Source Materials (NASM)	Phosphorus, Nitrogen	
		Soil Erosion	Sediment	Runoff
	Urban	Stormwater	Sediment, Phosphorus	Runoff
	In-River	Sediment	Sediment, Phosphorus	In-river flows; bank scouring; weirs/dams; internal cycling of nutrients
	Large Water Mgmt Reservoirs	Sediment	Phosphorus	Internal cycling of nutrients
	Septic Systems	Effluent	Nitrogen	Infiltration
Point Source	Wastewater Treatment Plants	Effluent	Phosphorus Nitrogen	Direct discharge
	Agriculture Washwaters		Phosphorus Nitrogen	Direct discharge

Appendix 2: Recent literature reviews and suggested reading

- Boston, Trevor, Barry Evans, and Conrad Stang. 2010. **Review of Agri-Environmental BMP effectiveness. Identifying performance expectations for applications in the Lake Simcoe watershed.** Prepared for the Ontario Ministry of Agriculture, Food and Rural Affairs by Greenland International Consulting Ltd.
- Cumrine, John P. 2011. **A working document for the development of a BMP toolbox for reducing dissolved phosphorus runoff from cropland to Lake Erie**. Heidelberg University, National Center for Water Quality Research.

- Hart, Murray R., Bert F. Quin, and M Long Nguyen. 2004. **Phosphorus runoff from agricultural land and direct fertilizer effects: a review.** Journal of Environmental Quality, Vol. 33: 1954-1972.

Other suggested reading

- University of Minnesota Extension. 2008. **BMPs for Nitrogen on coarse textured soils.**
- Osmond, Deanna, Don Meals, Dana Hoag, Mazdak Arabi, Al Luloff, Greg Jenings, Mark McFarland, Jean Spooner, Andrew Sharpley, and Dan Line. 2012**. Improving conservation practices programming to protect water quality in agricultural watersheds: Lessons learned from the National Institute of Food and Agriculture – Conservation Effects Assessment Project**. Journal of Soil and Water Conservation 67(5): 122A-127A. www.swcs.org
- Schnepf and Cox (editors), 2006. Environmental Benefits of Conservation on Cropland: The Status of Our Knowledge. Soil and Water Conservation Society, Ankeny, Iowa. 326 pp.
- WESA. 2012. Hydrogeological Assessment Wilmot Centre Well Field. Executive Summary Report. Project No. W-B8791-08. Prepared for the Regional Municipality of Waterloo.

References

- Ontario Environmental Farm Plan
  www.ontariosoilcrop.org/en/programs/canada_ontario_environmental_farm_plan_efp.htm
- Best Management Practices series
  www.omafra.gov.on.ca/english/environment/bmp/series.htm
- 4R Plant Nutrition: A Manual for Improving the Management of Plant Nutrition
  www.ipni.net

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