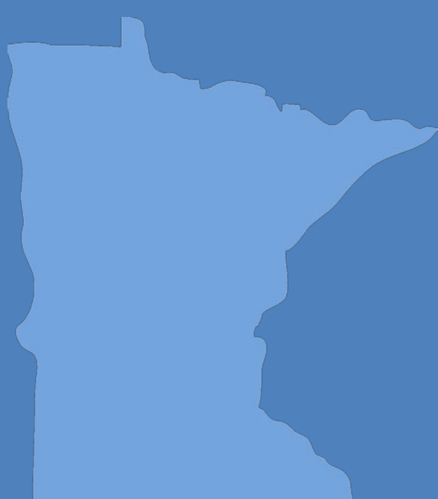
The Aquatic Biota Stressor and Best Management Practice Selection Guide



Minnesota Pollution Control Agency

July 2016

Authors

A. Bruce Paakh

Contributors/acknowledgements

The author thanks the following individuals for their important contributions to the development and review of this guidance tool and technical report review:

Land Use Type - Technical Teams

Agriculture - Chandra Carter (MPCA), Ed Clem (Becker County SWCD), Jenny Jasperson (MPCA), Chris Klucas (MPCA), Maggie Leach (MPCA), Peter Mead (Becker County SWCD), Mike Sharp (MPCA), Bill Thompson (MPCA), Dave Wall (MPCA)
Urban - Mike Findorff (MPCA), Mike Trojan (MPCA), Bruce Wilson (Respec)
Forestry - David Morley (USFS), Dr. Elon Sandy Verry (Ellen River Partners), Phil Votruba (MPCA)
Riverine - Dr. Luther Aadland (MDNR), David Friedl (MDNR), Dr. Elon Sandy Verry (Ellen River Partners)

Guide Tool Development

Joe Hadash (MPCA), Peter Mead (Becker County SWCD), Sue Norton (USEPA), Bill Thompson (MPCA), Bruce Wilson (Respec)

Editing and graphic design

PIO staff
Graphic design staff
Administrative Staff

The MPCA is reducing printing and mailing costs by using the Internet to distribute reports and information to wider audience. Visit our website for more information.

MPCA reports are printed on 100% post-consumer recycled content paper manufactured without chlorine or chlorine derivatives.

Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

This report is available in alternative formats upon request, and online at www.pca.state.mn.us.

Document number: wq-ws1-26

Contents

Introduction

The Aquatic Biota Stressor and Best Management Practice (BMP) Selection Guide (Guide) was developed to provide an easy-to-use reference table for linking the common stressors to aquatic biota with best management practices (BMPs) that can positively affect them. It was created for use by natural resource agencies, watershed project managers, local units of government, and landowners who are working to improve the biological health of aquatic systems.

The Guide was intended for use following the completion of the stressor identification process (USEPA, 2000) although it can be used without this level of rigorous assessment. It is designed to provide BMP selection that specifically targets the stressor(s) to aquatic biota of a stream system under study. The selection of BMPs for implementation on a specific parcel should take into consideration a host of site specific factors, work in conjunction with how the land is operated and will need to meet landowner approval. The comprehensive list of BMP alternatives for addressing stressors can expand the options from which to choose and allow the resource manager and landowner to select the best alternatives for a given situation. BMPs must be properly located, designed, implemented/constructed and maintained in order to be effective.

The Minnesota Pollution Control Agency (MPCA) began implementing the EPA aquatic biota stressor identification process (EPA, 2000) in 2007 in response to bio-monitoring studies that were finding impairments to aquatic life use in Minnesota (MN) streams. The work resulted in the development of stressor identification (SID) reports that document the science behind the determination of stressors on bio-impaired stream reaches. The SID reports are written for local resource managers so that they can prioritize protection and restoration work and apply for implementation grant funding.

Traditional TMDL projects/studies for chemical pollutants have developed their own set of practices and treatments that are used for bringing impaired waters into compliance with state water quality standards. An effort by the author to locate a guidance tool for targeting BMPs for the remediation of stressors acting on stream biology was unsuccessful. Follow-up discussion with Dr. Susan Norton, (EPA) revealed that although there had been discussion by some states regarding the development of such a chart, no one to the knowledge of EPA had developed a comprehensive tool for connecting the BMPs used to mitigate or treat aquatic biota stressors. Dr. Norton encouraged the author take on developing such a chart and thus began the start of the process to develop the Aquatic Biota Stressor and BMP Selection Guide.

The development of the Guide began with reviewing various BMP manuals and recording the information regarding practice effectiveness at addressing stressors. A table was created to record this information connecting the BMPs with the stressors they are known to impact. BMPs for the land use categories of agriculture, urban, forest and riverine were selected for inclusion in the chart as they generally include the most anthropogenicly altered land use categories that affect our stream resources.

There are many papers and guidance documents that discuss the subject of using BMPs for addressing various environmental concerns. Although a literature search was conducted, it was not exhaustive, and focused simply on gathering the necessary information, from credible sources, to build a useful relationship guide that link stressors with BMPs.

The literature used in the development of this guide is generally based on work done in Minnesota and the Midwest. Although the BMP stressor relationships indicated in the table should be applicable nationwide, there may be manuals specific to states or regions of the country that may better serve a project in that specific region. In addition, there may be stressors and BMPs unique to a specific area that are not listed within this Guide or BMPs that have been developed for specific soils or climate that differ from the Midwest. As previously indicated, the literature used to complete this chart was deemed sufficient for the purpose of showing the stressor / BMP linkages although a comprehensive literature search was not undertaken.

Most of the literature sources used in this guide ranked the ability of the BMPs for how well they acted upon a stressor. In almost all cases, that ranking was carried through to the table without edit. There were some situations, during the compilation of this information that required best professional judgment in determining the strength of a BMP in addressing a particular stressor. This occurred, in part, due to differences in the ranking systems used in the various papers referenced, and the need to adjust a rank in order to normalize the ranking when two different sources were cited for a single point in the chart that had different ranks. There were also a couple of instances where the ranking appeared to be suspect or biased, when best professional judgement was used to adjust the BMP rank.

These few minor edits are not considered an issue because they will have little to no effect on the practical use of this chart. Variability in locations throughout the United States in terms of hydrology, soils, watershed characteristics, biotic response to stressors and landuse intensity will all play into the usefulness of specific BMPs regardless of the rankings presented within this chart. Put another way, the rankings are presented as a guide, and those utilizing this tool will have much more to do with choosing the correct BMPs for a specific application then whether they are ranked high or moderate in their ability to effect change in a stressor on the biota. The purpose of this tool is to present the information in an organized fashion and then get out of the way of the local implementer who can use his/her experience and knowledge to create the most effective treatments, in the right locations for effecting the greatest benefit for a given implementation budget.

Using the Guide

The BMPs listed within this Guide are first organized by land use type (i.e., Agricultural, Riverine, Urban and Forestry), and then by treatment group (e.g., source controls, filtration, settling, nutrient removal, etc.). Each BMP is listed (alphabetically) under the treatment group heading that best characterizes the BMP. The names of the BMPs used in the guide are the names that are used in the United States Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS) Field Office Technical Guide. The NRCS Practice Code numbers, for those BMPs that are found in the Field Office Technical Guide, follow the BMP name in the Guide.

Use of the chart involves picking a stressor from the top of the table and scrolling down the column into the land use type(s) (in the far left column) that apply to the stream reach under study. To find the BMPs within a landuse group that can affect a stressor, one should look for a colored dot in the stressor column and then locate the BMP in the row under column C. Cells within the table are color coded to indicate the relationship that has been identified between the BMP (in the row) and the stressor (in the column). Cells that are marked with a blue or yellow dot indicate that there is documentation in the literature that the BMP can have a positive effect on the stressor. A green dot indicates that there is a strong likelihood that the BMP will have a positive effect on the stressor. A red dot in a cell indicates that the BMP could aggravate the stressor. The colored dots specifically indicate the following:

(l) Well documented in literature. High confidence that proper implementation of BMP will ameliorate the stressor. The stressor is a primary target of the BMP.
(l) Some study in literature. Moderate confidence that proper implementation of BMP will ameliorate the stressor. The stressor is a secondary or ancillary target of the BMP.
(l) Not identified in literature that was reviewed, however it is reasonable to assume that the BMP will have a positive effect on the stressor. The BMP theoretically has the potential for reducing the stressor.
(l) BMP has potential to aggravate the stressor.

The numbers behind the blue and yellow dots in the Guide are literature reference numbers. Refer to the Literature Cited section to reference the literature used to support the information in the table. The Literature Cited, Credits sheet also contains the names of individuals on the Technical Teams who helped to develop and review the content within specific land use categories.

Improved BMP effectiveness

Limited budgets and long lists of impaired waters that require protection and restoration is the reality that resource managers face in Minnesota and likely elsewhere. The need to demonstrate project effectiveness to both funding sources and local stakeholders has increased along with the competition for funding. As resource professionals we have a responsibility to get the greatest environmental benefit for the public dollars we are entrusted with and this tool can play a part in making that happen.

Two important factors play into BMP effectiveness that should be considered when designing implementation projects. The primary purpose of the Aquatic Biota Stressor and BMP Selection Guide is to specifically select BMPs that will most effectively mitigate stressors on the biology. Those stressors can be identified through both a general assessment of the watershed with assumed stressors or they can be identified through the more rigorous and formal SID process (EPA 2000). Figure 1 provides a conceptual table where these two methods are compared against using traditional BMPs (BMPs most commonly used by local Implementers) vs. using this guide to select BMPs specific to the stressors acting on the biology of the stream system under study. Realistic expectations are presented that show that the dollars invested in understanding the stressors play an important role in overall project success measured in environmental results (i.e. if you don't understand the problem it's difficult to resolve it). In addition, choosing BMPs that will specifically address the stressors identified will have a greater impact on those stressors verses choosing the standard suite of water quality BMPs commonly used in the area of project.

Rigor /Detail in BMP Selection - Precision of Goal	Simple SID Assessment or Assumptions	Detailed SID Study	BMP Effectiveness at Addressing Aquatic Biota Stressors
General BMP Practice Selection	Poor	Poor to Fair	Poor to Fair
Stressor Targeted BMP Practice Selection	Fair to Good	Good to Excellent	Fair to Excellent
Cost of SID Study	Low to Moderate	Moderate to High	-------

Figure 1. Realistic expectations of biological stressor reductions (environmental results) from watershed project design decisions.

When considering the cost to complete a detailed SID study one should take into consideration that the upfront expense for this work likely has long-term benefits to the project and stream system under study. Effectively protecting and restoring water resources is often an iterative process that is often measured in decades not years. Land use impacts to our waters typically occurred over an extended period of time and addressing those impacts and restoring health to our aquatic resources often requires a well-targeted effort and persistence over time. Conducting a SID study to accurately identify the stressors on the biology can be considered a pre-requisite to implementation if the goal is to accurately focus on the cause of the biological impairments and restore biological integrity. Selecting BMPs that specifically target those stressors will fine tune the implementation strategy so that funds go toward treating the stressors having the greatest impact on the biology.

Figure 2 presents the concept that it is through the proper targeting of BMP location in combination with targeted BMP practice selection that will help to assure the highest net environmental gain for the dollar spent. This chart uses the same "Rigor in BMP Selection" column used in Figure 1 but adds the "BMP Location Selection" variable. The broadcast or shot gunned BMP approach (a.k.a. random acts of conservation) is compared to targeted BMP location. The targeted BMP location approach involves both selecting specific streams that are priority for protection or restoration and then focusing on the proper minor sub watersheds for BMP implementation. The cost effectiveness of the options are presented to give the reader perspective and help make the point that it is through specific targeting that our projects will effect change.

Rigor in BMP Selection	Broadcast or Random BMP Location	Targeted BMP Location Selection	Net Environmental Gain / $ Spent
General BMP Practice Selection	Poor	Fair to Good	Low to Moderate
Targeted BMP Practice Selection	Poor to Fair	Good to Excellent	Moderate to High
BMP Effectiveness	Poor to Fair	Fair to Excellent	-------

Figure 2. Impact of BMP targeting (both practice and location) on stressor reduction or environmental effectiveness.

A final word regarding the use of BMPs and setting realistic expectations; environmental scientists and watershed managers face some serious challenges in protecting and restoring water resources. There are several relatively new threats to water quality that must be considered when setting realistic expectations for project success. Climate change and the resulting increase in large storm events (> 3" downpours) and increased storm intensity are sending higher pollutant loads into our lakes and streams. This along with tile drainage has increased stream flashiness with higher peak flows and an increased rate of stream channel erosion. The improved drainage efficiency in our urban and agricultural watersheds has resulted in prolonged low flow and no-flow conditions in some of our watersheds that has lead to dissolved oxygen issues and substantial habitat loss. The loss of sensitive set-a-side acres (notably CRP land) serves another blow to our surface water resources. As we face these challenges in our watersheds we must bring the best science to the table if we expect to hold ground - let alone make measureable improvement to our stream biology and chemistry.

BMPs can be implemented as stand-alone practices or in series in what is termed "treatment trains." A treatment train approach utilizes a sequence of BMPs that treat pollutants often starting with pollution prevention, then source controls followed by treatments such as filters, settling, and infiltration. Utilizing this approach can result in higher rates of pollutant reduction and a more sustainable, lower maintenance set of BMPs. This guide is organized so that the pollution prevention/source control BMPs are listed at the top and the more advanced or follow-up BMPs in the treatment train approach follow in each of the land use categories.

The use of treatment train method of building BMPs into the landscape is encouraged due to the benefits this approach provides. The concept involves using a set of practices in combination to treat the stressor. An example of using this approach would be a situation where sediment is the stressor and it is determined that it is coming from upland agricultural sources. The sediment is filling in (embedding) coarse gravel substrate and causing poor diversity and IBI scores in the fish community. A treatment train approach could involve an increase in the use of conservation tillage (no till or reduced tillage) in the sub watershed. In addition, cover crops (conservation cover) could be used where possible on fields that are most susceptible to erosion. These BMPs are both found under the Pollution Prevention - Source Controls treatment group under the Agricultural Land Use and are used to reduce the loss of soil/sediment at the source. Grassed waterways (found under the Filtration treatment group) would be a tactic to capture the sediment that makes it way to the field edge. Sediment basins (found under the Settling treatment group) could be used to reduce the sediment levels that make it into the ditch systems serving the fields.

It is the combination of methods in different treatment groups that increase the level of pollutant reduction and protection of the resource. Any one of the practices used would be helpful but by combining several methods the pollutant reduction is increased and the longevity of the practices (especially the downstream grassed waterways and sediment basins) is improved and the required maintenance of these practices reduced as less sediment reach these practices with adequate source controls.

Summary

The Aquatic Biota Stressor and BMP Selection Guide fills a void that existed in having an easy to use reference table for selecting BMPs for reducing the impact of stressors affecting aquatic biota. The Guide can assist those working on watershed projects with an initial assessment of protection and restoration options that are available, and their relative effectiveness for improving the health of biologically impaired systems. The most environmentally effective watershed implementation projects will target both practice selection and practice location at specific stressors. Once a suite of options are selected to address a stressor, there are many manuals available that present detailed information regarding BMP design, siting, proper installation and maintenance.

Literature Cited

U.S. Environmental Protection Agency. 2000. Stressor Identification Guidance Document. EPA 822-B-00-025. U.S. Gov. Print Office, Washington, DC. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/stressorid.pdf

Reference Number and Literature Cited in the Guide.

1. Miller, T.P., J.R. Peterson, C.F. Lenhart, and Y. Nomura. 2012. The Agricultural BMP Handbook for Minnesota. Minnesota Department of Agriculture. [Online]. Available at http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf
2. Minnesota Pollution Control Agency. 2011. Pollution Prevention and the MS4 Program: A Guide on Utilizing Pollution Prevention to Meet MS4 General Permit Requirements [Online]. Available at http://www.pca.state.mn.us/index.php/view-document.html?gid=11849
3. Minnesota Department of Natural Resources, Division of Forestry. 1995. Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota. Schroeder Communications, Delano, MN.
4. Minnesota Department of Natural Resources, Division of Forestry. 1990. Water Quality in Forest Management: Best Management Practices in Minnesota.
5. Aadland, L. P. 2010. Reconnecting Rivers: Natural Channel Design in Dam Removals and Fish Passage. Available at http://files.dnr.state.mn.us/eco/streamhab/reconnecting_rivers_intro.pdf
6. Minnesota Stormwater Steering Committee. 2005. The Minnesota Stormwater Manual. MPCA. Available at ftp://ftp.odot.state.or.us/techserv/Geo-Environmental/Stormwater%20Team/Reference_Documents/Manuals/MN_Stormwater_Manual1.pdf
7. EPA Water Archives. Linking Restoration Practices to Water Quality Parameters. Table 3-1. Relative Effect of Selected Stream Restoration Practices. http://water.epa.gov/type/watersheds/archives/chap3.cfm
8. Minnesota Forest Resources Council. 2013. Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers. Minnesota Forest Resources Council, St. Paul, Minnesota.
9. Kolka, R.K., S. D. Sebestyen, E.S. Verry and K. N. Brooks. 2011. Peatland Biogeochemistry and Watershed Hydrology at the Marcell Experimental Forest. Chpt. 13. Hydrological Responses to Changes in Forest Cover on Uplands and Peatland. Pgs. 420-422. CRC Press. Boca Raton, FL.
10. Kolka, R.K., S. D. Sebestyen, E.S. Verry and K. N. Brooks. 2011. Peatland Biogeochemistry and Watershed Hydrology at the Marcell Experimental Forest. Chpt. 12. Forest Management Practices and Silviculture. Pgs. 380-382. CRC Press. Boca Raton, FL.
11. Dr. Luther Aadland. MDNR. July 7, 2014. Personal Communication.
12. Kjaersgaard, J., C. Hay and T. Trooien. 2015. Saturated buffers to remove nitrate from tile drain water. SDSU. Online at: http://www.sdstate.edu/abe/wri/research-projects/saturated-buffers.cfm
13. USDA - Natural Resources Conservation Service. Field Office Technical Guide. Online at: http://efotg.sc.egov.usda.gov/treemenuFS.aspx and Conservation Practice Physical Effects (CPPE) Matrix online at: http://efotg.sc.egov.usda.gov/references/public/MN/cppematrix2.pdf

Land Use Type	Treatment Group	BMP's	STRESSORS TO AQUATIC BIOTA														
			Physical					Chemical							Toxic		
								Nutrients									
			Flow Alteration *	Habitat	Sediment	Connec-tivity	Thermal Loading	Total P	Soluble P	Nitrate N	Ammonia N	Chloride	Salts	D. O.	Pesti-cides	Metals	Oil & Grease
Agricultural	Education, Training & Regulation	Ag Drainage System Design Training	🟢		🟢	🟢	🟢	🟢	🟢	🟢	🟢			🟢			
		Controlled Tile Ordinance	🟢														
		Ditch Set-back Ordinance, MN 103E.021			🟢			🟢						🟢			
		Individual Sewage Treatment System Regs & Training						🟢	🟢	🟢	🟢	🟢		🟢		🟢	🟢
		MN Shoreland Ordinance – 50' Shoreland Setback			🟢			🟢	🟢	🟢	🟢			🟢	🟢		
		Restricted Use Pesticide Training (MN)													🟢		
		Wetland Conservation Act, 401 Certification	🟢		🟢			🟢									
	Pollution Prevention - Source Controls	Biochar Soil Amendment	🟢		🟢		🟢	🟢	🟢	🟢	🟢				🟢		
		Conservation Cover (327)	🟡[13]	🟡[1]	🟡[1, 13]			🟡[1, 13]	🟡[13]	🔵[1, 13]				🟡[13]	🟡[13]		
		Conservation Crop Rotation (328)			🟡[13]				🟡[13]	🔵[1, 13]					🟡[13]		
		Conservation Tillage – No Till (329), Reduced Till (345)			🔵[1, 13]			🔵[1, 13]	🔵[1, 13]	🔵[1, 13]					🔵[13]		
		Contour Farming (330)			🟡[1, 13]			🟡[1, 13]	🟡[13]	🟡[13]					🟡[13]		
		Cover Crop (340)			🔵[1, 13]			🟡[1, 13]	🟡[13]	🔵[1, 13]					🟡[13]		
		Grade Stabilization Structure (410)	🟡[1]		🟡[1, 13]												
		Grade Stabilization @ Side Inlets (410)			🟡[1]			🟡[1]									
		Nutrient Management (590)			🔵[1]			🔵[1, 13]	🔵[1, 13]	🔵[1, 13]	🔵[1, 13]			🟡[1]			
		Integrated Pest Management (595)													🔵[1, 13]		
		Terrace (600)			🔵[1, 13]			🟡[13]	🟡[13]	🟡[13]					🟡[1, 13]		
	Filtration	Contour Buffer Strips (332)			🔵[1, 13]			🟡[13]	🟡[13]	🟡[13]					🔵[1, 13]	🟡[13]	🟡[13]
		Field Border (386)		🟢	🔵[1, 13]		🟢	🔵[1, 13]	🔵[1, 13]	🔵[1, 13]	🔵[1, 13]				🔵[1, 13]		
		Filter Strip (393)		🟢	🔵[1, 13]		🟢	🔵[1, 13]	🔵[1, 13]	🔵[1, 13]	🔵[1, 13]				🔵[1, 13]	🔵[13]	🔵[13]
		Grassed Waterway (412)	🟡[1, 13]		🔵[1, 13]	🟡[13]		🟡[13]	🟡[13]	🟡[13]	🟢				🟡[1, 13]		
		Vegetative Barrier (601)			🟡[13]			🟡[13]	🟡[13]	🟡[13]					🟡[13]		
	Infiltration	Alternative Tile Intakes	🟡[1]		🟡[1]			🟡[1]	🟡[1]				🟢				
		Structure for Water Control – Controlled Drainage (587)	🟡[1, 13]			🟢	🟡[13]	🟡[1]	🟡[1]	🟡[1]			🟢				
		Drainage Water Management (554)						🟡[13]	🟡[13]	🔴[13]					🟡[13]		
		Irrigation Water Management (449)			🟡[1]			🟡[1, 13]	🟡[13]	🟡[1, 13]					🟡[1, 13]	🟡[13]	🟡[13]
		Tile System Design	🟡[1]							🟡[1]			🟢				
	Settling	Alternative Side Inlet	🟡[13]		🟢			🟢		🟢	🟢				🟢		
		Culvert Downsizing/Road Retention	🟡[1]		🟡[1]			🟢									
		Sediment Basin (350)	🟡[13]		🔵[1, 13]			🔵[1, 13]	🟡[13]	🟡[1, 13]	🟡[1, 13]				🟡[13]		
		Water & Sediment Control Basin (638)	🟡[1, 13]		🔵[1, 13]			🟡[1]	🟡[1]								
	Nutrient Removal	Saturated Buffers – Vegetated Subsurface Drain (739)	🟡[12, 13]					🟡[12]	🟡[12]	🟡[12, 13]							
		Two Stage Ditch Design	🟡[1]	🟡[1]	🟡[1]		🟢	🟢		🟡[1]				🟢			
		Wetland Creation (658) – Constructed Treatment	🟡[13]	🟡[1]	🟡[1, 13]			🟡[1, 13]	🟡[13]	🟡[1, 13]	🔵[7]			🟡[1]	🟡[13]	🔵[7]	🟡[13]
		Wetland Enhancement (659)			🟡[13]			🟡[13]	🟡[13]	🟡[13]					🟡[13]		🟡[13]
		Wetland Restoration (657)	🟡[1]	🟡[1]	🟡[1, 13]			🟡[1, 13]	🟡[13]	🟡[1, 13]	🔵[7]				🟡[1, 13]	🔵[7]	🟡[13]
		Woodchip Bioreactor (Denitrification Beds)						🟡[1]	🟡[1]	🟡[1]					🟡[1]		
	Livestock Management	Constructed Wetland (656)						🔵[13]	🔵[13]	🔵[13]	🔵[13]						
		Feedlot Clean Water Diversion			🟡[1, 13]			🟡[1]	🟡[1]	🟡[1]	🟢		🟢				
		Fence (382) – Livestock Exclusion		🟡[1]	🟡[1]		🟡[1]	🟢	🟢	🟢	🟢			🟢			
		Prescribed Grazing (528) – Rotational			🟡[1, 13]		🟡[1, 13]	🟡[1, 13]	🟡[13]	🟡[1, 13]	🟡[13]				🟡[13]		
		Stream Crossing (578)			🟡[13]			🔴[13]	🔴[13]	🔴[13]	🔴[13]						
		Vegetated Treatment Area (635) – Feedlot Wastewater	🟡[13]		🔵[1, 13]			🔵[1, 13]	🔵[1, 13]	🔵[1, 13]	🔵[13]		🟢				
		Waste Storage Facility (313) – Manure						🔵[1, 13]	🔵[13]	🔵[1, 13]	🔵[13]						

Land Use Type	Treatment Group	BMP's	STRESSORS TO AQUATIC BIOTA														
			Physical					Chemical							Toxic		
								Nutrients									
			Flow Alteration *	Habitat	Sediment	Connectivity	Thermal Loading	Total P	Soluble P	Nitrate N	Ammonia N	Chloride	Salts	D. O.	Pesticides	Metals	Oil & Greas
Riverine	Vegetative Cover	Streambank and Shoreline Protection (580)	●[1]	●[1, 13]	●[1, 13]		●[13]	●[13]	●[13]	●[13]							
		Streambank Stabilization with Vegetation	●[7]	●[7]	●[6,7]		●[7]	●[6]	●[6]	●[6]	●[7]			●[7]			
		Re-establish Riparian Trees & Brush	●[7]	●[7]	●[7]		●[7]				●[7]			●[7]		●[7]	
		Riparian Forest Buffer (391)			●[13]		●[13]	●[13]	●[13]	●[13]					●[13]		
		Riparian Herbaceous Cover (390)		●[1, 13]	●[1, 13]		●[1, 13]	●[1, 13]	●[13]	●[1, 13]					●[13]		
	In-Stream Restoration	Alter Dam Operation to Mimic Natural Conditions	●[7]	●[7]													
		Dam Removal	●[5]	●[5]	●[7]	●[5]	●							●[5]			
		Grade Control / Drop Structures	●[7]	●[7]	●[7]						●[7]			●[7]			
		Nature-Like Fish Passage		●[11]	●[11]	●[11]											
		Proper Culvert Sizing or Replace with Bridge	●	●	●	●											
		Reset Culverts @ Proper Elevation		●		●[1]											
		Restore Natural Stream Meander and Complexity	●[7]			●[11] **								●[7]			
		Restore Riffle Substrate		●[7]	●[7]						●[7]			●[7]			
		Retrofit Dams with Multilevel Intakes					●[7]										
		Stream Habitat Improvement and Management (395)		●[13]	●[13]	●[13]	●[13]										
		Terraces				●[11] **											
		Two Stage Ditch	●	●	●[1]	●[11] **	●	●	●	●[1]							

Land Use Type	Treatment Group	BMP's	STRESSORS TO AQUATIC BIOTA														
			Physical					Chemical							Toxic		
								Nutrients									
			Flow Alteration *	Habitat	Sediment	Connectivity	Thermal Loading	Total P	Soluble P	Nitrate N	Ammonia N	Chloride	Salts	D.O.	Pesticides	Metals	Oil & Grease
Urban	Education, Training & Regulation	Erosion & Sediment Control Training		green	blue 2			orange 2	orange 2	orange 2	orange 2			blue 2			
		Establishing a Buffer Ordinance	blue 2	green	blue 2		blue 2	orange 2	orange 2	orange 2	orange 2						
		Establishing an Infiltration Standard(s)	blue 2		blue 2		blue 2	orange 2	orange 2	orange 2	orange 2						
		Illicit-Discharge Identification & Risk Reduction						orange 2	orange 2	orange 2	orange 2			blue 2			blue 2
		Pet Waste Ordinance						orange 2	orange 2	orange 2	orange 2			blue 2			
		Storm Drain Stenciling						orange 2	orange 2	orange 2	orange 2			blue 2		blue 2	blue 2
	Pollution Prevention - Source Controls	Park & Open Space Fert/Chem Appl. Programs						orange 2	orange 2	orange 2	orange 2			blue 2	green		
		Composting Programs			orange 6			orange 6	orange 6	orange 6	orange 6			green			
		Fertilizer Management						green	green	green	green						
		Hazardous Material Storage & Handling													green	blue 2	blue 2
		Open Space Design	blue 2	green	blue 2		blue 2	orange 2	orange 2	orange 2	orange 2						
		Reducing Impervious Surfaces	blue 2		blue 2		blue 2	orange 2	orange 2	orange 2	orange 2	blue 2				blue 2	blue 2
		Residential Waste Collection & Clean-up Programs		green				orange 2	orange 2	orange 2	orange 2			blue 2		blue 2	
		Septic System Maintenance Programs			blue 2			orange 2	orange 2	orange 2	orange 2			blue 2			
		Street & Parking Lot Sweeping			blue 2			orange 2	orange 2	orange 2	orange 2			blue 2			
		Urban Forestry	blue 2		green		blue 2	orange 2	orange 2	orange 2	orange 2					blue 2	
		Vehicle Washing			orange 6			orange 2	orange 2	orange 2	orange 2			blue 2		blue 2	blue 2
		Volume Control Using Compost /Soil Amendments	blue 2		blue 2			orange 2	orange 2	orange 2	orange 2						
		Winter Road Materials Management			blue 2			orange 2	orange 2	orange 2	orange 2	blue 2	blue 2			blue 2	
	Infiltration	Green Roofs	blue 2		blue 6		blue 2	blue 6	blue 6	blue 6	blue 6					blue 6	
		Improved Turf			blue 6			orange 6	orange 6	orange 6	orange 6						
		Infiltration Basin/Trench	blue 2		blue 2		blue 2	blue 2 6	blue 2 6	orange 2	orange 2					blue 2	
		Pervious Pavements	blue 2		blue 2		blue 2	orange 2	orange 2	orange 2	orange 2	blue 2				blue 6	blue 6
		Vegetated Swales	green		blue 6			blue 6	blue 6	blue 6	blue 6					blue 6	blue 6
	Filtration	Bioretention						blue 6	blue 6	blue 6	blue 6			green		blue 6	blue 6
		Dry Swales	blue 2		blue 2		blue 2	blue 6	blue 6	blue 6	blue 6					blue 6	blue 6
		Filter Strips/Buffers	blue 2		blue 2		blue 2	orange 2	orange 2	orange 2	orange 2						
		Permeable Pavement with Underdrains	green		green			green									
		Sand Filters						blue 6									
		Tree Trenches/Boxes	green				green	green	green	green	green						green
		Wet Swales	blue 6		blue 6			blue 6	blue 6	blue 6	blue 6					blue 6	blue 6
	Reuse	Rainwater Harvest/Reuse & Rain Barrel Programs	blue 2		blue 2			blue 6	blue 6	blue 6	blue 6	blue 6			blue 6	blue 2	blue 6
		Underground Storage Systems	green														
	Settling	Constructed Wetland	green		blue 6			blue 6	blue 6	blue 6	blue 6,7					blue 6	blue 6
		Hydrodynamic Separators			green												green
		Stormwater Ponds	green		green		red 6	blue 6	blue 6	green	green					blue 6	blue 6
	Chemical Treatment	Iron & Aluminum Enhanced BMPs			blue 6			blue 6	blue 6	blue 6	blue 6					blue 6	

Land Use Type	Treatment Group	BMP's	STRESSORS TO AQUATIC BIOTA														
			Physical					Chemical							Toxic		
								Nutrients									
			Flow Alteration *	Habitat	Sediment	Connectivity	Thermal Loading	Total P	Soluble P	Nitrate N	Ammonia N	Chloride	Salts	D. O.	Pesticides	Metals	Oil & Grease
Forestry	Pollution Prevention - Source Controls	Avoidance of Logging Residue into Waterbodies		Yellow [3,4]	Yellow [3,4]		Green	Green	Green					Green			
		Careful Pesticide Selection													Yellow [3,4]		
		Erosion Control (water bars, silt fence, etc.)			Green			Green	Green								
		Integrated Pest Management													Yellow [3,4]		
		Minimization of Soil Disturbance			Yellow [3,4]			Green	Green								
		Precautions During Pesticide Use Cycle													Yellow [3,4]		
		Properly Clearing Debris in Rights-of-Way			Yellow [3,4]	Yellow [3,4]											
		Proper Use of Mechanical Site Prep Techniques			Yellow [3,4]												
		Soil Protection/Seeding			Yellow [3,4]			Green	Green								
		Site Reconnaissance/Protect Sensitive Areas	Yellow [3,4]	Yellow [3,4]	Yellow [3,4]	Yellow [3,4]	Yellow [3,4]	Yellow [3,4]	Yellow [3,4]	Yellow [3,4]	Yellow [3,4]			Yellow [3,4]	Yellow [3,4]		
		Water Diversion Structures	Yellow [3,4]		Yellow [3,4]								Green				
		Wetland Protection	Green	Yellow [3]		Yellow [3]											
	Infrastructure Management	Appropriate Wetland Road Construction	Yellow [3]	Green	Yellow [3,4]			Green	Green								
		Appropriate Winter Road Construction			Yellow [3,4]			Green									
		Closure of Inactive Roads & Post-Harvest	Yellow [3,4]	Green	Yellow [3,4]			Green									
		Forest Road Cross-Drainage			Yellow [3,4]			Green									
		Location & Sizing of Landings			Yellow [3,4]			Green	Green								Green
		Maintaining Active Forest Roads			Yellow [3,4]	Yellow [3,4]		Green									
		Proper Alignment of Forest Roads	Green		Yellow [3,4]	Green		Green									
		Proper Water Crossings	Yellow [3,4]		Yellow [3,4]	Yellow [3,4]		Green									
		Road Construction, Excavation, & Surfacing			Yellow [3,4]			Green	Green								
	Vegetative Cover / Structure	Improving Tree Longevity & Diversity of Composition		Blue [8]		Blue [8]											
		Minimization of Young Forest/Open Area Cover	Blue [9]	Blue [9]	Blue [9]												
		Prescribed Burning		Yellow [3,4,8]	Yellow [3,4,8]	Blue [8]											
		Riparian Management Zone Widths		Blue [8]	Blue [8]	Blue [8]	Blue [8]	Blue [8]	Blue [8]	Blue [8]	Blue [8]			Blue [8]			
		Shade Strips Adjacent to Lakes, Streams & Wetlands		Yellow [3,8]			Yellow [3,8]							Green	Blue [8]		Blue [8]
	Infiltration	Proper Timing of Harvest (minimize compaction) or of Vegetative Treatments	Blue [8,10]	Blue [8,10]	Blue [8,10]			Blue [8,10]	Blue [8,10]	Blue [8,10]	Blue [8,10]						
	Filtration	Filter Strips Adjacent to Lakes, Streams & Wetlands		Yellow [3,4,8]	Yellow [3,4,8]			Yellow [3,4,8]	Yellow [3,4,8]	Yellow [3,4,8]	Yellow [3,4,8]				Yellow [3,4,8]		

Key: A dot in a cell (with the exception of red) indicates the BMP should have a positive affect on the stressor.	
Blue	Well Documented. Stressor is primary target of BMP.
Yellow	Some Study. Stressor is secondary target of BMP.
Green	Reasonable to assume stressor affected by BMP.
Red	BMP has potential to aggravate the stressor.
1,2,3…	Literature Cited Supporting the BMP-Stressor Relationship

Notes:

A. * BMPs for Flow Alteration may be included for their impact to reduce the effects of either low and/or high flow.
B. ** Indicates that this BMP addresses lateral connectivity (access to floodplain) rather than longitudinal connect
C. The numbers in parenthesis behind some of the BMPs are the NRCS Conservation Practice (CP) numbers.
D. Habitat for the purposes of this guide refers to the physical, structural attributes of stream habitat.
E. Salts or Ionic Strength is typically measured by conductivity, salinity or total dissolved solids.
F. September, 2015 version.