Calculating Bacterial Load Reductions in South Carolina for GRTS Reporting

South Carolina Department of Health and Environmental Control
Bureau of Water
Division of Water Quality
Watersheds, Nonpoint Source, and Adopt-a-Stream Section

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Photo Credit: Frank S. Nemeth

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Introduction

This summary provides a demonstration of how bacterial load reductions are calculated for Section 319 implementation grant funded projects within South Carolina by the South Carolina Department of Health and Environmental Control (SCDHEC) for reporting to the Environmental Protection Agency (EPA) via the Grants Reporting and Tracking System (GRTS). The need for estimating these bacterial loads and load reductions arises from these features currently not being offered within the EPA Spreadsheet Tool for Estimating Pollutant Loads (STEPL) or Pollutant Load Estimation Tool (PLET) models. The values for loadings and load reductions in this summary are calculated for both fecal coliform (FC) and *E. coli* to accommodate historical findings and standards as well as the more recent emphasis of *E. coli* as the primary indicator for pathogens in the freshwaters of South Carolina. The inclusion of these calculations for *E. coli* are made to aid in furthering the understanding of the process, however, the actual conversion of FC values to *E. coli* values is facilitated through a South Carolina specific conversion factor that may not accurately translate to other states. While many potentially encountered best management practices (BMPs) and pollutant reduction efficiencies are provided, these listings are by no means exhaustive and additional ongoing investigative research continues to be required as new or different variations of BMPs are implemented by grantees during their respective projects. As available, pollutant reduction efficiencies are sought out to represent the best fit possible based upon the conditions found in the area where the BMP is installed. The provided pollutant removal efficiencies may not be equally applicable to conditions in all locations. In some cases, the shown pollutant reduction efficiencies are an average reflecting a range of values reported within a collection of researched publications. The included references are a baseline for providing a glimpse into the process for locating the included values within the tables and are not necessarily a full listing of all references utilized in the development of this process over time. Only those references that were able to be verified online at the time of composing this summary were listed to reduce confusion.

Example on How Bacterial Loadings and Load Reductions Are Calculated Based Upon Land Use

1) Calculating the Bacterial Load

BMP Type	BMP Location	Drainage Area (acres)	Land Use Type	Loading Rate (FC; per acre per year)	Total Load (FC; per year)	Total Load (*E. coli*; per year)
Riparian Buffer – Vegetative	North Bank of River	13	Forest	1.62E+09	2.11E+10	1.84E+10
Best fit based upon grantee provided information.	Grantee provided information.	Grantee provided information.	Grantee provided information.	From the Annual Bacterial Load by Land Use table on page 5.	This is the Drainage Area (acres) multiplied by the Loading Rate (FC; per acre per year).	This is the Total Load (FC; per year) multiplied by a SCDHEC conversion factor specific to SC for converting FC values to *E. coli* values (0.8725)[1].

2) Calculating the Bacterial Load Reduction

BMP Type	BMP Location	Total Load (FC; per year)	BMP Specific Pollutant Reduction Efficiency	Load Reduction (FC; per year)	Load Reduction (*E. coli*; per year)
Riparian Buffer – Vegetative	North Bank of River	2.11E+10	0.85	1.79E+10	1.56E+10
		From above.	From BMP Pollution Reduction Efficiencies table on pages 7 – 8.	This is the Total Load (FC; per year) multiplied by the BMP Specific Pollutant Reduction Efficiency.	This is the Load Reduction (FC; per year) multiplied by a SCDHEC conversion factor specific to SC for converting FC values to E. coli values (0.8725).

[1]Chestnut, D. and Rabon, B. Synopsis: Development and Adoption of the *Escherichia coli* Freshwater Water Quality Standard. South Carolina Department of Health and Environmental Control. Technical Report Number 015-2020.

Annual Bacteria Load by Land Use[2]

Land Use Type		Fecal Coliform Loading Rate (CFU / acre – year)
Road	Minimum	2.87E+07
	Maximum	1.13E+08
	Median	7.27E+07
Commercial	Minimum	6.87E+08
	Maximum	3.84E+09
	Median	2.26E+09
Residential Low Density Single Family	Minimum	1.13E+09
	Maximum	6.46E+09
	Median	3.76E+09
Residential High Density Single Family	Minimum	1.82E+09
	Maximum	1.05E+10
	Median	6.06E+09
Residential Multi-family	Minimum	2.55E+09
	Maximum	1.45E+10
	Median	8.48E+09
Forest	Minimum	4.85E+08
	Maximum	2.75E+09
	Median	1.62E+09
Grass	Minimum	1.94E+09
	Maximum	1.09E+10
	Median	6.46E+09
Pasture	Minimum	1.94E+09
	Maximum	1.09E+10
	Median	6.46E+09
Cropland	No Manure	3.85E+10
	Poultry Litter Applied	2.63E+12
	Dairy Cow Litter Applied	7.09E+11

[2]Annual Bacteria Load by Land Use table values adapted from:

a) Mishra, A. et al., (2008). Bacterial Transport from Agricultural Lands Fertilized with Animal Manure. Water, Air, and Soil Pollution, 189:127-134.
b) Shaver, Ed et al., (2007). Fundamentals of Urban Runoff: Technical and Institutional Issues. 2nd Edition.

Example on How Bacterial Loadings and Load Reductions Are Calculated for Septic System Repairs / Replacements and Municipal Sewer System Tie-Ons[3]

BMP Type	Number Implemented	Loading Rate (FC; per household – year)	Total Load (FC; per year)	Total Load (*E. coli;* per year)
Onsite Wastewater Treatment System Projects	1	2.4176E+10	2.4176E+10	2.1094E+10
	Grantee provided information. A Number Implemented of one is equal to one septic system repair or replacement or one municipal sewer system tie-on.		This is the Number Implemented multiplied by the Loading Rate (FC; per household – year).	This is the Total Load (FC; per year) multiplied by a SCDHEC conversion factor specific to SC for converting FC values to *E. coli* values (0.8725).
The repair or replacement of a failing septic system and the tie-on to a municipal sewer system are both considered to be BMPs that remove all pollutants they may have been releasing into the local environment. As such, the load reduction for these specific BMPs is set equal to the total load calculated for them.				

[3]Bacterial loading rate per household – year derived from:

a) EPA STEPL Septic Worksheet
b) Horsley & Witten Inc. 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick and Freeport, Maine. Portland, ME: University of Southern Maine, Muskie School of Public Service, Casco Bay Estuary Partnership.

BMP Pollutant Reduction Efficiencies[4]

Agricultural BMPs

BMP Type	Fecal Coliform Reduction Efficiency	Comments
Alternative Water Source	0.30	Alternative water supply that includes fencing along the stream
Conservation Tillage	0.30	Any of various reduced tillage methods usually implemented on crop land
Controlled Stream Access for Livestock Watering	0.25	Stream bank fencing without alternative water supply; includes gated stream access and can include some streambank protection
Cover Crop	0.25	Vegetation is seasonal with no intended grazing, usually cropland
Critical Area Planting	0.50	Vegetation expected to be permanent; no intended grazing
Fence	0.30	For animal movement control only with no stream exclusion
Grass Buffer (15 ft wide)	0.75	
Grass Buffer (30 ft wide)	0.91	
Heavy Use Area Protection	1.00	Stabilizing areas where livestock congregate – water / feed troughs with gravel or concrete base
Heavy Use Area Protection – Sheltered	0.50	
Manure Transfer	1.00	Moving manure and associated pollutants completely out of the watershed
Pasture and Hay Land Planting	0.10	Vegetation is intended for grazing
Prescribed Grazing	0.25	Has cross fencing
Riparian Buffer – Vegetative	0.85	Can include trees and / or shrubs within plantings
Riparian Forest Buffer	0.90	Includes trees and shrubs plus a significant upland area
Runoff Management System	0.30	Controlling runoff from construction and / or a land use change
Sinkhole and Sinkhole Area Treatment	0.50	Buffering of sinkholes; may consist of grass filter strips
Streambank and Shoreline Protection	0.30	Involves fencing out stream bank without providing an additional watering source
Vegetated Sink Hole Buffer	0.50	Buffering and protection of area around a sinkhole; includes physical exclusion
Vegetative Buffer Strips	0.85	Grassed strips buffering waterways, ditches, and ponds
Waste Management System	0.85	Includes hard infrastructure (composters, sheds, etc.) as well as manure application practices
Wastewater Treatment Strip	0.50	Grassed strips to buffer waste accumulation areas – barns, stacking sheds, etc.
Water and Sediment Control Basin	0.70	Small excavated ponds or raised berms to retain and reduce erosional energy of stormwater
Watering Facility	0.20	Alternative water supply without fencing
Watershed Management Plan	0.85	

BMP Pollutant Reduction Efficiencies[4]

Urban and Household BMPs

BMP Type	Fecal Coliform Reduction Efficiency	Comments
Alternative Septic System	1.00	A non-standard system, such as a mound system
Coastal Wetland Vegetation Establishment	0.85	Establishment of vegetative buffers and / or infiltration / interception for reduced freshwater inputs
Infiltration Ditches	0.60	
Onsite Wastewater Treatment System Projects	1.00	Repairs, conventional replacements, and tie-on to a municipal sewer system
Rain Garden / Bioretention Basin	0.62	

[4]BMP Pollutant Reduction Factors table values pulled and / or adapted from:

a) Byers, H.L. et al., 2005. Phosphorus, Sediment, and E. coli Loads in Unfenced Streams of the Georgia Piedmont, USA. Proceedings of the 2005 Georgia Water Resources Conference, held April 25 – 26, 2005 at the University of Georgia, Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.
b) Center for Watershed Protection. National Pollutant Removal Database V. 3 September 2007.
c) Desbonnet et al. 1995. Development of Coastal Vegetated Buffer Programs Coastal Management. Volume 23.
d) Horner, et al. 1994. Fundamentals of Urban Runoff Management: Technical and Institutional Issues. Terrene.
e) Karthikeyan, R. 2012. Fate and Transport of E. coli in Rural Texas Landscapes and Streams. Texas Water Resources Institute.
f) Mednick, A.C. 2011. Development of a Tool for Predicting and Reducing Bacterial Contamination at Great Lakes Beaches. Bureau of Science Services, Wisconsin Department of Natural Resources.
g) Mishra, A. et al. 2008. Bacterial Transport from Agricultural Lands Fertilized with Animal Manure. Water, Air, and Soil Pollution, 189.
h) Patni, N.K. et al. 1985. Bacterial Quality of Runoff from Manured and Non-Manured Cropland. Transactions of the ASAE. 28(6): 1871-1877.
i) Pitt, R. 2011. The National Stormwater Quality Database (NSQD) Summary for EPA and Cadmus.
j) Redmon, L. et al. 2012. Lone Star Healthy Streams Beef Cattle Manual. Texas Water Resources Institute.
k) Sullivan, T.J. et al. 2007. Efficacy of Vegetated Buffers in Preventing Transport of Fecal Coliform Bacteria from Pasturelands. Environmental Management 40:958-965.
l) Texas Commission on Environmental Quality. 2007. Seventeen Total Maximum Daily Loads for Bacteria, Dissolved Oxygen, and pH in Adams Bayou, Cow Bayou, and Their Tributaries.
m) University of Georgia. 2006. Protecting Riparian Buffers in Coastal Georgia: Management Options. UGA River Basin Center, School of Law, and Land Use Clinic.
n) Wagner, K. et al. 2008. Environmental Management of Grazing Lands Final Report. Publications from USDA-ARS / UNL Faculty. 508.
o) Yagow, G. 2001. Fecal coliform TMDL: Mountain Run Watershed, Culpeper County, Virginia. Virginia Tech, Department of Biological Systems Engineering.