# Appendix B – Method for Estimating Attenuation of Nutrients from Septic Systems Model Results (MEANSS) for the Madison TMDL Planning Area

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This appendix contains the results of the Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS) model for the Madison TMDL Planning Area, and is intended to aid readers in understanding how this information was used for nutrient loading in Section 5.0, Nutrient TMDL Components, in the main body of the TMDL document.

# B1.0 MEANSS MODEL DESCRIPTION

The following is a brief description of the MEANSS model and how the model is used to estimate nutrient loadings to surface water from septic systems. The location of each septic system in the six sub-watersheds shown in the tables was estimated by plotting points at the center of each structure classified as "dwelling," "mobile home," or "farm/ranch" in the Montana Structures Framework (http://geoinfo.msl.mt.gov/Home/msdi/structures_and_-addresses). Other structures such as commercial establishments, government buildings, hospitals, schools, etc. are not included in the analysis because effluent from the population covered under the dwellings, mobile homes, and farm/ranch categories likely accounts for wastewater usage from those public facilities. Also, many of the public facilities in the six sub-watersheds are located in Ennis, which has a public wastewater system that is accounted for separately from the septic system loading in the TMDL document. The structure location database is used as an estimate of the drainfield location because there is no electronic database of drainfield locations.

Once the septic locations were determined, a spreadsheet approach, Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS), was used for estimating the reduction of nitrogen and phosphorus between disposal at the drainfield and subsequent discharge to surface water. The parameters used to estimate nitrogen and phosphorus reduction are described below.

MEANSS is only designed for use on a larger basin-wide scale that effectively allows averaging of the wide variation of processes that occur in the subsurface between wastewater discharge in the vadose zone and subsequent migration into the surface water.

# B2.0 NITROGEN

MEANSS uses a matrix and is based on the three primary factors impacting the amount of nitrogen attenuation via denitrification: soil type beneath the drainfield, soil type in the riparian area, and distance to surface water (**Table B-1**). Soil type is based the Natural Resources and Conservation Service (NRCS) hydrologic soil group (HSG) classification system (**Table B-1**). In the matrix, each drainfield is assigned a percent denitrification factor for each of the three criteria. The percentages assigned for each column are then added to provide the total percent nitrogen removal for that septic system. The nitrogen loading rate (for example, 30.5 lbs/year for a conventional septic system) to the surface water is then reduced accordingly. Any system with a percent reduction of 100% or more is assumed to contribute no nitrogen to the surface water. This method assumes steady-state conditions exist in that it does not account for the time needed for the nitrogen load to migrate towards the receiving surface water. That lag time is dependent on the distance to the receiving water and the travel rate through both the vadose and saturated zones. MEANSS also does not account for in-stream nutrient cycling.

**Table B-1. MEANSS Septic System Nitrogen Loading Matrix**

| Percent Nitrogen Load Reduction[1] | Soil Type @ Drainfield[1] | Soil Type within 100' of surface water[2] | Distance to surface water (ft) |
|---|---|---|---|
| 0 | A | A | ≤ 100 |
| 10 | B | | > 100 - 500 |
| 20 | C | B | > 500 - 5000 |
| 30 | D | C | > 5000 - 20,000 |
| 50 | | D | > 20,000 |

[1] The total nitrogen reduction is the sum of the individual reductions for each column of the table. For example, the nitrogen load reduction associated with a drainfield in a type C soil that drains to a surface water with type B soil, and is 200 feet from the nearest surface water would be 50 percent (e.g., 20% + 20% + 10% = 50%, or 30.5 lbs/year * 0.5 = 15.25 lbs/year).

[2] Soil drainage class:

A = excessively drained or somewhat excessively drained

B = well drained or moderately well drained

C = somewhat poorly drained

D = poorly drained or very poorly drained

Defining the hydrologic soil group (HSG) at the drainfield, the HSG within 100 feet of surface water, and the distance to surface water in the matrix are completed using GIS analysis of the NRCS database called the Soil Survey Geographic Database (SSURGO) and the National Hydrography Dataset (NHD). SSURGO is used to determine the hydrologic soil group. The NHD is used to determine locations of perennial streams for the distance factor.

The HSG for each drainfield was based on the GIS intersection of the Montana Structures data and the SSURGO map for the dominant HSG at each drainfield. To determine the HSG adjacent to surface water for each septic system, the HSG at the closest perennial stream was determined by map analysis of each drainfield. Where no data was available at a drainfield site or river site in SSURGO, the HSG from the nearest classified soil was used. Distance to surface water was based on buffers created in GIS at the 100, 500, 5,000 and 20,000-foot distances.

# B3.0 PHOSPHORUS

DEQ's method for estimating phosphorus loading to surface waters from septic systems uses a matrix similar to nitrogen (**Table B-2**). The matrix combines three factors that have been shown to impact the amount of phosphorus attenuation: soil type beneath the drainfield, calcium carbonate percent in the soil beneath the drainfield, and distance to surface water. In the matrix (**Table B-2**), each drainfield is assigned a percent phosphorus reduction for only one of the first three columns (the soil and calcium carbonate type), and then an additional percent phosphorus reduction for the fourth column (distance to surface water). The percentages assigned for each column are then added to provide the total percent phosphorus removal for that septic system. The phosphorus loading rate (6.44 lbs/year for a conventional or level 2 system) to the surface water is then reduced accordingly. Any system with a percent reduction of 100% or more is assumed to contribute no phosphorus to the surface water. This method assumes steady-state conditions exist in that it does not account for the time needed for the phosphorus load to migrate towards the receiving surface water. That lag time is dependent on the distance to the receiving water and the travel rate through both the vadose and saturated zones.

**Table B-2. MEANSS Septic System Phosphorus Loading Matrix**

| Percent Phosphorus Load Reduction[1] | Soil Type @ Drainfield[2] ($CaCO_3$ ≤ 1%) | Soil Type @ Drainfield[2] ($CaCO_3$ > 1% and < 15%) | Soil Type @ Drainfield[2] ($CaCO_3$ ≥ 15%) | Distance to surface water (ft) |
|---|---|---|---|---|
| 10 | A | A | A | ≤ 100 |
| 20 | | | B | |
| 40 | | B | C | |
| 50 | | | | > 100 - 500 |
| 60 | B | C | D | |
| 80 | C | D | | > 500 - 5,000 |
| 100 | D | | | > 5,000 |

[1] The total phosphorus reduction is the sum of the two reductions for soil type/$CaCO_3$ and distance. For example, the phosphorus load reduction associated with a drainfield that is in a type C soil with greater than 15 percent $CaCO_3$ (40 percent) and is 300 feet from the surface water (50 percent) would be 90 percent (40% + 50% = 90%, or 6.44 lbs/year * 0.9 = 5.8 lbs/year removed prior to discharge to surface water).

[2] Soil drainage class:
A = excessively drained or somewhat excessively drained
B = well drained or moderately well drained
C = somewhat poorly drained
D = poorly drained or very poorly drained

In the phosphorus analysis, the HSG at the drainfield and the distance to surface water are the same as used in the nitrogen analysis. The $CaCO_3$ for each drainfield was based on the GIS intersection of the Montana Structures data and the SSURGO $CaCO_3$ percent value. Soils between 24 inches to 60 inches below ground surface were used to determine the dominant $CaCO_3$; most drainfields are buried 24 inches deep, therefore the analysis did not use the upper 24 inches of soil. Where no data was available at a drainfield site in SSURGO, the $CaCO_3$ from the nearest dominant classified soil was used, or if there was no clear dominant type, then the $CaCO_3$ was estimated as the middle of the three categories used in MEANSS (1 to 15 percent).

# B4.0 Potential Uncertainty Associated with MEANSS

MEANSS is designed to be a simple method to provide an estimate of nutrient loadings from septic systems. As such, it has several simplifications of actual processes that control nutrient attenuation that can create uncertainty in the final results. These simplifications, and other potential sources of uncertainty, include:

- MEANSS is a steady-state method, which does not account for seasonal variation of wastewater discharge that could be caused by high groundwater recharge rates during spring runoff and other times of heavy recharge. The seasonality of discharge rates is likely more pronounced for septic systems located closer to surface waters as compared to those located further away with a longer travel time to the surface water.
- Since the model is steady-state, there is an implicit assumption that nutrient breakthrough is occurring regardless of age or date of the septic installation.
- The effluent loading values used in MEANSS are based on average values (i.e., per capital flow and concentration), and does not account for septic systems that may have higher levels of

treatment (e.g., level 2 septic systems) or for systems with higher or lower usage due to occupancy rates.
- Failed septic systems are not accounted for in MEANSS because subsurface failures of drainfields typically do not effect nutrient treatment, while failures that allow untreated nutrients to enter surface water via overland flow typically are repaired quickly and do not have a significant effect on long-term nutrient loading of surface waters.
- Once the reductions for distance and soil type are accounted for, the entire remaining nutrient load is assumed to enter the surface water. This assumes that all septic loads in shallow groundwater are in connection with, and enter surface water. However, in many cases only a portion of the shallow groundwater will actually enter surface water. Some of the groundwater may flow underneath and by-pass the stream or it may parallel the surface water but remain as groundwater beneath the surface water. This conceptual discrepancy would tend to over-predict the amount of nutrients entering the surface water, and would be more likely to introduce error as the distance between the septic system and surface water increases.
- The soil information used from SSURGO is not designed to be used on field-level scale as is being done in MEANSS. The accuracy of the soil information could affect the accuracy of MEANSS.
- Although MEANSS has been validated against other models and against measured field data, the reduction percentages used for distances and soil types are only estimates. The uncertainty ranges associated with those percentages have not been determined.

As more site-specific information regarding septic systems becomes available, or as more accurate models are developed for calculation septic loadings, the results of MEANSS can be updated or replaced to improve the TMDL source assessment.

# B5.0 MEANSS Model Results for the Madison TMDL Planning Area

**Tables B-3** and **B-4** on the next page contains the MEANSS Model results used for specific waterbodies in the Madison TMDL Planning Area to assess potential nitrogen and phosphorus loading from septic systems.

**Table B-3. Madison TMDL Planning Area MEANSS Nitrogen Analysis**

| **Sub-Basin Name** | **Number of Septic Systems** | **% Nitrogen removed due to drainfield soil** | **% Nitrogen removed due to soil type at river** | **% Nitrogen removed due to distance** | **Total Percent Nitrogen Removed Prior to Stream Discharge** | **Total Nitrogen Load from Septic Systems (lbs/day)[1]** | **Total Nitrogen Load Entering Streams (lbs/day)** |
|---|---|---|---|---|---|---|---|
| O'Dell Spring Creek (HUC 10) | 178 | 8.88 | 14.83 | 14.16 | 37.87 | 14.87 | **9.24** |
| Elk Creek (HUC 12) | 17 | 15.29 | 29.41 | 21.18 | 65.88 | 1.42 | **0.48** |
| Hot Springs Creek (HUC 10) | 51 | 8.04 | 19.61 | 16.27 | 43.92 | 4.26 | **2.39** |
| Moore Creek (HUC 12) | 192 | 6.46 | 25.05 | 19.17 | 50.68 | 16.04 | **7.91** |
| South Meadow Creek (HUC 12) | 74 | 6.35 | 20.00 | 16.35 | 42.70 | 6.18 | **3.54** |
| Blaine Spring Creek (partial HUC 12) | 131 | 11.30 | 18.02 | 18.17 | 47.48 | 10.95 | **5.75** |
| **Average** | | **8.46** | **18.96** | **17.08** | **44.49** | | |
| **Sum** | **643** | | | | | **53.73** | **29.32** |

[1] Nitrogen loading from each septic system is estimated as 30.5 lbs/yr

**Table B-4. Madison TMDL Planning Area MEANSS Phosphorus Analysis**

| **HUC-6 Sub-basin** | **Number of Septic Systems** | **% Phosphorus removed due to soil type** | **% Phosphorus removed due to distance** | **Total Percent Phosphorus Removed Prior to Stream Discharge** | **Total Phosphorus Load from Septic Systems (lbs/day)[1]** | **Total Phosphorus Load Entering Streams (lbs/day)** |
|---|---|---|---|---|---|---|
| O'Dell Spring Creek (HUC 10) | 178 | 30.28 | 61.69 | 87.47 | 3.14 | **0.39** |
| Elk Creek (HUC 12) | 17 | 40.59 | 78.82 | 96.47 | 0.30 | **0.01** |
| Hot Springs Creek (HUC 10) | 51 | 22.55 | 67.06 | 85.49 | 0.90 | **0.13** |
| Moore Creek (HUC 12) | 192 | 18.85 | 76.82 | 93.70 | 3.39 | **0.21** |
| South Meadow Creek (HUC 12) | 74 | 35.27 | 68.78 | 91.76 | 1.31 | **0.11** |
| Blaine Spring Creek (partial HUC 12) | 131 | 25.73 | 73.59 | 92.44 | 2.31 | **0.17** |
| **Average** | | **26.67** | **70.33** | **91.12** | | |
| **Sum** | **643** | | | | **11.34** | **1.03** |

[1] Phosphorus loading from each septic system is estimated as 6.44 lbs/yr