NONDEGRADATION REQUIREMENTS FOR SUBSURFACE WASTEWATER TREATMENT SYSTEMS REVIEWED PURSUANT TO TITLE 76-4, MCA

Montana Department of Environmental Quality

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APPENDICES

1. Introduction

The purpose of the nondegradation rules is to protect high quality state groundwaters and surface waters. Numerical nondegradation limits are defined using several methods and are described in the nondegradation rules [Administrative Rules of Montana (ARM) 17.30 sub-chapter 7]. An activity that may impact water quality must comply with the nondegradation requirements, ARM 17.30.706(1) (this applies whether the activity is or is not regulated by the Department). If the activity is permitted, approved, licensed or otherwise authorized by the Department, the Department must ensure compliance with the nondegradation requirements prior to issuing its permit, license or other authorizations (ARM 17.30.706(2)).

1.1. Applicability

The nondegradation rules (ARM 17.30 sub-chapter 7) apply to new or increased sources discharging to high-quality state waters, which include both groundwater and surface water. "New or increased source" is defined in ARM 17.30.702(17). "High-quality waters" is defined in 75-5-103(12), MCA and ARM 17.30.702(8). A high-quality water must also be a "state water", which is defined in 75-5-103(32), MCA. If a wastewater treatment system discharge is to a state water, but the state water is not a high-quality water, the nondegradation requirements are not applicable, but the discharge must still meet the state water quality standards (Department Circular DEQ-7) as required in the groundwater rules (ARM 17.30 sub-chapter 1) and surface water rules (ARM 17.30 sub-chapter 6).

The requirements in this circular only apply to wastewater treatment systems that are not required to obtain a Montana Groundwater Pollution Control System (MGWPCS) or Montana Pollutant Discharge Elimination System (MPDES) permit.

1.2. Application Materials

An application for nondegradation determination must be submitted to the Department for any proposed development that includes a new or increased source as defined in ARM 17.30.702(17). The application must include the following components:

- A cover letter or design report outlining:
    - the number and type of sources,
    - the location of the proposed development,
    - proposed source of water,
    - the number, location, reason, and size of any requested Source Specific Mixing Zones (SSMZ),
    - the number, location, reason, and size of any requested Source Specific Well Isolation Zones (SSWIZ),
    - the GWIC identification number of the well(s) supplying the background nitrate sample(s),
    - methods used to determine groundwater gradient and hydraulic conductivity,
    - any categorical exemptions (ARM 17.30.716) or deviations (ARM 17.36.601) requested, and

- contact information for the applicant or representative (mailing address, telephone number, e-mail).

- A scaled site location map (typically on a USGS topographic quadrangle map) showing the site location, nearest surface water, and nearby developments.
- A scaled vicinity map as described in ARM 17.36.103(d).
- A scaled lot layout map as described in ARM 17.36.104.
- Well logs for any wells used in determining groundwater parameters or other information, a map showing GWIC IDs and locations of all wells used, and copies of calculations performed.
- Soil descriptions for each test pit, including depths, soil textures, and any limiting layers (groundwater, bedrock, etc.) encountered.
- Nitrate sensitivity analyses for each source.
- Phosphorus breakthrough analyses for each source, including identity of surface water used in the analyses.
- Adjacent to surface water (trigger values) analyses for each source.
- Pathogen transport analyses for each source, if required.
- Citations (author, title, date) for any publications or maps referenced.
- Appropriate fees for requested services.

Any documents included in a current application under ARM 17.36.102 need not be duplicated in the application for nondegradation determination.

1.3. Deviations from Standards

The terms shall, must, may not, and require indicate mandatory items, and applicants must obtain approval from the department to deviate from these mandatory requirements. Other items, such as should, may, recommended, and preferred, indicate desirable procedures or methods. These non-mandatory items serve as guidelines for applicants and do not require approval for deviations. Deviations from the requirements of this circular may be granted pursuant to ARM 17.36.601. A request for a deviation must include adequate justification. “Engineering judgment” or “professional opinion” without supporting data is not adequate justification. The justification must address each of the items included in ARM 17.36.601. The Department will review the request and make a final determination on whether a deviation may be granted.

1.4. Determining High-Quality Water

Groundwater

All groundwater is considered state waters (75-5-103(32) MCA). High-quality groundwater is defined in 75-5-103(12), MCA by its rule classification. Groundwater classification is based on the natural specific conductance (SC) and listed in ARM 17.30.1006 (the natural condition of a state water is defined in MCA 75-5-306(2)). Groundwater is considered high-quality water unless the reviewing authority determines it is not high-quality water based on relevant information. To demonstrate groundwater is not high-quality, the natural SC of the groundwater impacted by the wastewater treatment system shall be determined using one of the following methods:

a. Recent (less than 1 year old from the date the results were submitted to the reviewing authority) groundwater samples collected from at least three separate wells/piezometers that are representative of the water quality in the proposed mixing zone, but not necessarily located within the proposed mixing zone;
b. Applicable information from a local, state or federal agency;
c. Applicable information from peer-reviewed literature; or
d. Other information as approved by the reviewing authority.

The minimum SC measured in representative samples will be used to determine the groundwater classification to be protective of state waters and the beneficial uses described in ARM 17.30.1006. In cases where groundwater is determined to be not high quality, the determination applies only to the specific project being considered, and is not a binding classification on the aquifer, past or future projects, or the area beyond the current project boundary.

Surface Water

State waters and high-quality waters are defined in 75-5-103 MCA. High-quality waters are also defined in ARM 17.30.702(8). Surface waters are considered high-quality state waters unless the reviewing authority determines it is not high-quality state water based on relevant information.

Examples of surface waters that are not considered state waters include but are not limited to:

a. Surface water in active mining pits (however, once the mining pit is inactive and no longer has an operating permit, the water body becomes a state water);
b. Sewage lagoons;
c. Ponds used exclusively for fire protection water reserves; and
d. Water in irrigation canals that do not return to state water.

High-quality surface waters include all state surface waters except the following pursuant to 75-5-103, MCA and ARM 17.30.702:

a. State waters that are not capable of supporting any one of the designated uses for their classification;
b. Class I surface waters are not high quality (Makarowski, 2020); and
c. State waters that have zero flow or surface expression for more than 270 days during most years.

1.5. Determining New or Increased Sources

For wastewater treatment systems that discharge to a high-quality state water, a nondegradation determination must be completed when the proposed discharge is a new or increased source. A “new or increased source” is defined in ARM 17.30.702(17). A source refers to the load of a parameter which is based on both the flow rate and parameter concentration. Sources that existed prior to April 29, 1993 (regardless of whether they followed the applicable regulations at the time of installation) are not new or increased sources.

Examples of “new” sources include but are not limited to:

a. A wastewater treatment system discharge that was approved on or after April 29, 1993, but lacks adequate documentation that it was reviewed by the appropriate authority for compliance with the nondegradation rules;
b. A wastewater treatment system that is expanded in size or moved to a location other than a previously approved area, and:
    i. the new wastewater treatment system is closer to any wells within 500 feet (200 feet for wastewater treatment systems serving individual or shared living units) of the new wastewater treatment system that may be impacted by the discharge; or
    ii. the new wastewater treatment system is closer to any high-quality state surface water within 1/2 mile (1/4 mile for wastewater treatment system serving individual or shared living units) of the new wastewater treatment system that may be impacted by the discharge.

Examples of "increased" sources include but are not limited to:

a. A wastewater treatment system discharge that has increased compared to what existed or was approved by the appropriate authority prior to April 29, 1993;
b. A wastewater treatment system discharge that has increased compared to what was approved by the appropriate authority on or after April 29, 1993; or
c. A wastewater treatment system serving an individual or shared living unit that was approved prior to April 29, 1993, where that approval does not include adequate information to determine the number of bedrooms that were approved. The source is increased only if the proposed number of bedrooms exceeds eight in any living unit.

Wastewater treatment system discharges that meet the following criteria are not required to have a groundwater mixing zone:

a. Were approved or existed prior to April 29, 1993;
b. Do not have an approved groundwater mixing zone; and
c. Are not considered a new or increased source according to the criteria in this subsection.

1.6. Determining Existing Sources from Historical Data

The criteria for new or increased sources are based on a potential change in existing water quality due to an activity after April 29, 1993 (per the definition in ARM 17.30.702(17)). In some situations, it may not be clear what type of activity (i.e. discharge) existed on April 29, 1993, particularly when the activity/discharge no longer exists. An example would be a house and septic system that existed and was used on April 29, 1993, but has since been abandoned or removed. In these situations, the following information will be acceptable to demonstrate an existing use:

a. Tax records showing a specific activity existed prior to April 29, 1993;
b. Aerial or land photographs taken near April 29, 1993 that show structures that would likely have been served by wastewater systems, outhouses, etc.; or
c. Corroborating affidavits from witnesses with knowledge of what existed on the property on April 29, 1993. Typically provided by the landowner, adjacent neighbors, and / or someone with personal knowledge of the site. The local government (county sanitarian or board of health) must agree with the evidence provided.

1.7. Data Requirements

Due to the wide variation in scale of nondegradation applications for subdivisions, the amount of hydrogeological, hydrologic, and water quality data required by the reviewing authority may vary between applications pursuant to ARM 17.30.706(2) and 17.30.505(1). Such information may include site-specific data and long-term monitoring to determine spatial and temporal changes in the site conditions.

2. Nitrate Sensitivity Analysis

2.1. Nitrogen Information

The mixing zone calculations are based on evidence that nitrogen in raw wastewater (ammonia, nitrite, nitrate, and organic nitrogen) is eventually transformed to nitrate (Morgan et. al., 2007).

The allowable nitrate concentration at the end of a groundwater mixing zone depends on the source of the nitrate, the type of SWTS proposed, and the background nitrate concentration (ARM 17.30.715(1)(d)). **Appendix G** provides a summary of those requirements.

2.2. Nitrate Dilution Model and Other Methods for Modeling Groundwater Mixing Zones

DEQ uses a nitrate dilution model based on the Bauman-Schafer model (Bauman and Schafer, 1984). Other models may be acceptable upon review and acceptance by the reviewing authority. Lengthy and/or complex reviews may require additional fees, on an hourly basis. The required calculations for nitrate dilution (nitrate sensitivity analysis) in a groundwater mixing zone (MZ) are provided in ARM 17.30.517(1)(d). **Appendix A** contains spreadsheets for calculating wastewater treatment system impacts for individual and cumulative wastewater treatment systems. **Appendix B** provides details and an example calculation.

As approved by the reviewing authority, other models or methods may be used for determining the nitrate concentration at the end of a groundwater mixing zone but the model must comply with the requirements in ARM 17.30.518 for groundwater source specific mixing zones (SSMZ). To provide a more efficient review process the Department encourages the use of models that are supported by the USEPA or USGS. Generally, these models will require less review time by the reviewing authority because the model validity has already been verified. There are models not supported by the USEPA or USGS that have adequate documentation and may also be valid to use. The reviewing authority should be consulted prior to use of these models to ensure they will be accepted. A list of information sources regarding computer models is provided in **Appendix C**.

Additional MZ and SSMZ details are provided in **Section 2.8**.

2.3. Determining Shallowest Groundwater

The nitrate sensitivity analysis shall be based on properties in the shallowest groundwater zone impacted by the wastewater treatment system effluent. In specific cases, existing wells, groundwater monitoring pipes, and pits may provide adequate data on the shallowest groundwater, if approved by the reviewing authority. If a test well must be installed to determine the location or hydraulic properties of the shallowest groundwater it shall meet all applicable well construction requirements in the Board of Water Well Contractors Rules (ARM 36.21 subchapters 6 and 8). The well should be drilled without drilling fluids if possible (drilling fluids may interfere with the ability to recognize water-bearing materials) and shall follow these procedures:

a. an engineer, geologist, hydrogeologist or other qualified individual (as approved by the reviewing authority) shall be on site to observe drilling and to collect and classify drill cuttings by a standardized method such as ASTM or USDA soil classification systems;
b. the well shall be drilled into the upper 15 feet (approximately) of the shallowest water-bearing unit (or less if the water-bearing unit is less than 15 feet thick), or down to a maximum depth as determined by the reviewing authority;
c. the well shall be completed with 15 to 25 feet (or other length as approved by the reviewing authority) of perforated casing, well screen, or open hole construction into the geologic material most likely to be water-bearing;
d. if groundwater is not immediately evident in the well, the well shall be covered to prevent surface water from entering the borehole and the presence of groundwater shall be re-checked at least 24 hours after the well construction was completed; and
e. if groundwater has entered the well after the 24-hour period, the nondegradation analysis will be based on the groundwater intercepted by the test well. If groundwater does not enter the well, the analysis will be based on hydrogeologic information from the first water-bearing unit below the geologic unit tested by the well.

2.4. Parameters for Nitrate Sensitivity Analysis

The nitrate sensitivity analysis requires estimated or measured site-specific parameters. The following subsections describe each of those parameters and the acceptable methods used to determine the parameter values.

2.4.1. Hydraulic Conductivity

The well(s) or information used for determining the hydraulic conductivity shall be representative of the water-bearing unit proposed for the groundwater mixing zone (see **Section 2.3**) as determined by the reviewing authority.

The methods acceptable to calculate hydraulic conductivity are described below. Assuming similar quality of data collection, the list is in the order of the most accurate to the least accurate method. Data collected using a method higher on the list are typically used over data collected via a lower method. However, on-site data are typically more applicable than off-site data. Therefore, as determined by the reviewing authority, on-site data using a less accurate method may in some cases be more applicable than data collected via a more accurate method from a more distant off-site source.

a. Long-term (typically at least 24 hours) on-site or near-site aquifer pumping test with observation wells;
b. Long-term (typically at least 24 hours) on-site or near-site aquifer pumping test without observation wells;

c. Published reports with estimated or extrapolated hydraulic conductivity values from distant aquifer tests;
d. Slug tests;
e. Drawdown Tests; and
f. Well log tests.

2.4.1.1. Aquifer Pumping Tests

Aquifer pumping tests (pumping tests) can be conducted on existing or new wells to calculate transmissivity. These tests can also be used for other purposes unrelated to nondegradation review such as water quantity and water dependability.

If a new well is constructed for the purpose of calculating transmissivity, the well shall be completed according to **Section 2.3**.

A pumping test to calculate transmissivity can be conducted with a single well or with one or more observation well(s). Observation wells must be completed in the same water-bearing unit as the pumping well. An observation well completed in the same water-bearing unit as the pumping well is required for estimating storativity.

The number of pumping tests required for a subdivision will depend on the size of the subdivision, the site-specific geology, the combined water usage, and the maximum well yield(s). Multiple well and test locations may be required when there is potential for highly variable groundwater conditions across the subdivision.

The following procedures should be followed when planning and conducting a pumping test.

a. The reviewing authority shall be consulted prior to conducting an aquifer pumping test to ensure the test details (e.g., well location, well construction, pumping rate, discharge location, etc.) are acceptable;
b. The well must have a completed well log (per ARM 36.21.639) with lithologic descriptions;
c. Groundwater levels shall be monitored at a minimum frequency of 15 minutes (to nearest 0.01 ft) for at least 48 hours prior to beginning the aquifer pumping test to evaluate groundwater level trends. The test results may be corrected for any groundwater level trends;
d. For calculating transmissivity, the test shall be conducted at a pumping rate that will sufficiently stress the aquifer, but not draw the well dry. Pumping water levels should not drop below the top of the well perforations. The test shall be designed to create an adequate drawdown curve that can be analyzed via the Cooper-Jacob straight-line method, the Theis curve-matching method, or other appropriate methods based on the hydrogeologic conditions.
e. For calculating transmissivity, the pumping rate should be maintained at a constant rate. If the pumping rate is varied, the timing and pumping rate of those changes must be documented, otherwise the test may be invalid.
f. The pumping rate shall be measured immediately after turning the pump on, at least every 30 minutes during the first 3 hours of pumping, and at least every hour thereafter if discharge fluctuates by more than 5%; otherwise, measurements every 4 hours are acceptable;

g. The drawdown portion of the test shall be at least 24 hours long;
h. Recovery data shall be collected for at least as long as the drawdown period, or until 95% of measured drawdown has recovered, whichever is longer;
i. The water level during both the drawdown and recovery phases shall be measured according to the frequency schedule in Aquifer Test Form No. 633 (available on the Montana Department of Natural Resources and Conservation (DNRC) website) to the nearest 0.01 ft;
j. Electronic pressure transducer/data logger instrumentation, electric well probes, pressure gauges on turbine pumped wells, or graduated steel tapes are acceptable methods of measuring groundwater levels;
k. Discharged water shall be conveyed a sufficient distance from the production and observation wells to prevent recharging the aquifer during the test (including the recovery period). Adequate water conveyance devices include pipe, hose, lined ditch, or an existing irrigation system. However, if the water is discharged into a state surface water directly or through a conveyance device, a nondegradation analysis may need to be conducted [ARM 17.30.706(1) and 75-5-317(2)(f), MCA], and a discharge permit may be required from the Department pursuant to 75-5-401(1), MCA; and
l. Aquifer pumping test results shall be submitted electronically to the reviewing authority on Aquifer Test Data Form No. 633.

2.4.1.2. Published Data

Published data may be acceptable for estimating aquifer parameters representative of the proposed mixing zone(s) if it provides adequate information on the test procedures and data reduction. Computer simulations adequately calibrated to measured data may also be used to determine hydrogeologic parameters. Sources of published data are usually from a government agency such as USEPA, USGS, or MBMG. Data from non-government agencies (educational institutions, for example) may also be acceptable. The MBMG Groundwater Information Center (GWIC) database includes pumping test results for many wells.

2.4.1.3. Slug Tests

Slug tests can be conducted on existing or new wells to calculate transmissivity. Each well used for a slug test must have a completed well log (per ARM 36.21.639) with lithologic descriptions to be acceptable. If a new well is constructed for the purpose of calculating transmissivity, the well shall be completed according to **Section 2.3**.

Wells used for a slug test should have at least a one-foot screened, perforated, or open-hole interval to provide acceptable test results. Wells completed as open bottom (solid casing extends from the top to the bottom of the borehole) are unlikely to be acceptable for slug testing.

The number of slug tests required for a subdivision will depend on the size of the subdivision and the site-specific geology. Multiple test locations may be needed to calculate a representative transmissivity because slug tests only measure a small volume of the water-bearing materials immediately adjacent to the well screen. Multiple test locations may also be needed when there is potential for variable aquifer properties across the subdivision. The reviewing authority may recommend several tests per location to determine a more representative average value.

Butler (2019) provides a good reference for conducting slug tests.

The following procedures should be followed when conducting a slug test:

a. The reviewing authority shall be consulted prior to conducting a slug test to ensure the test details (e.g., well locations, well construction, etc.) are acceptable;
b. The well must have a completed well log (per ARM 36.21.639) with lithologic descriptions;
c. The test shall be conducted to create an adequate drawdown that can be analyzed via the Bouwer-Rice method (Bouwer and Rice, 1976; Bouwer, 1989), the Hvorslev method (Hvorslev, 1951) or other appropriate methods based on the hydrogeologic conditions;
d. The initial water level change required to conduct an adequate slug test depends on the water-bearing zones' hydraulic conductivity (larger water level change is needed for water-bearing zones with larger hydraulic conductivity). The change shall be large enough to allow time for recording a sufficient number of data points to create an adequate graphical slope before water levels equilibrate to static conditions;
e. Water level data shall be measured to the nearest 0.01 ft. The adequate sampling interval is dependent on the rate of water level recovery, the interval should be more frequent if water level recovery is rapid.
f. Electronic pressure transducers/data logger instrumentation, electric well probes, or graduated steel tapes may be used to measure water levels. Data loggers are often necessary to collect an adequate number of data points;
g. Static water levels shall be measured prior to the test.
h. A rising head (slug out) or falling head (slug in) test may be conducted on wells where the static water level is above the screened, perforated, or open-hole section of the well. A falling head test shall not be conducted when the static water level is below the top of the screened, perforated, or open-hole interval (a falling head test in those conditions tests the geologic media above the water table which may not be applicable to the properties below the water table).

2.4.1.4. Well Log Tests

The methods and formulas to calculate transmissivity from a well log test are described in **Section 2.4.2**. The well must have a completed well log (per ARM 36.21.639) with lithologic descriptions. Approximate locations of most wells are available from the MBMG GWIC database (in some cases those estimated locations may not be accurate enough, in those situations more accurate locations may be required by the reviewing authority).

Due to the higher degree of error in well log tests as compared to other methods described previously, the average of at least three applicable well log tests shall be used to estimate transmissivity, unless fewer are approved by the reviewing authority. The reviewing authority may also require more than three well logs based on site-specific conditions.

Well log tests are typically conducted via one of three methods: pump, bailer or air. Data from pumped wells often provides more representative transmissivity values. When an adequate number of applicable tests using pumps are available, they may be used preferentially over air and bailer tests to calculate transmissivity.

If a well log indicates there was zero drawdown during the test, the test likely did not adequately stress the aquifer, and is probably unsuitable for calculation of specific capacity. A well log showing only one or two feet of drawdown should not be used if others are available.

2.4.1.4.1. Drawdown Tests

As approved by the reviewing authority, a 4-hour long drawdown test may be conducted to provide more accurate specific capacity values than a typical well log test. The methods and formulas to calculate transmissivity from a drawdown test are described in **Section 2.4.2**. For a well located on-site or near site, a drawdown test on a single well may be adequate to estimate the transmissivity as determined by the reviewing authority, otherwise multiple wells shall be required as described in **Section 2.4.1.6**.

The following procedures should be used when a drawdown test is conducted for calculating specific capacity:

a. The reviewing authority shall be consulted prior to conducting drawdown tests to ensure the test details (e.g., well location, well construction, pumping rate, discharge location, number of tests, etc.) are acceptable;
b. The well must have a completed well log (per ARM 36.21.639) with lithologic descriptions;
c. A pump shall be used to withdraw water from the well;
d. The well should be pumped at a constant pumping rate with less than 10% variation during the test. If more than 10% variation occurs the lowest measured flow rate shall be used for the calculations, otherwise the average rate shall be used;
e. The pumping rate (gallons per minute) shall be measured at the start of the test and at least every hour thereafter. Pumping rate can be measured using an in-line flow meter, weir, graduated bucket and watch method, or other method as approved by the reviewing authority. The water level in the well shall be at static conditions at the start of the test. For purposes of this test procedure, static conditions are defined as:
    - For measurements to the nearest 0.1 ft, water levels measured at least 20 minutes apart have less than a 0.1 ft variation; or
    - For measurements to the nearest 0.01 ft, water levels measured at least 2 minutes apart have less than 0.02 ft of variation; for depths greater than 300 ft the variation should be less than 0.1 ft;
f. The water level shall be measured (to the nearest 0.1 or 0.01 ft) immediately before the pump is turned on and at least every 15 minutes during the test;
g. The well shall be pumped for at least 4 hours;
h. Electronic pressure transducer/data logger instrumentation, electric well probes, pressure gauges on turbine pumped wells, or graduated steel tapes are acceptable methods of measuring groundwater levels if they are accurate to at least 0.1 ft; and
i. Discharged water shall be conveyed at least 50 ft from the pumped well to prevent recharging the aquifer during the test (the reviewing authority may require a further distance based on site-specific conditions). Adequate water conveyance devices include pipe, hose, lined ditch, or an existing irrigation system. However, if the water is discharged into a state surface water directly or through a conveyance device, a nondegradation analysis may need to be conducted [ARM 17.30.706(1) and 75-5-

317(2) (f), MCA], and a discharge permit may be required from the Department pursuant to 75-5-401(1), MCA.

2.4.1.4.2. MBMG Well Inventory Data

The MBMG GWIC database includes additional information to calculate transmissivity from specific capacity for some wells that have been sampled or inventoried by the MBMG. The information is available through a link on the electronic version of the well log titled “view field visits for this site”. When available for a well, the information may include static water level, pumping water level, and pumping rate. The remainder of the information needed to calculate transmissivity should be available in the well log.

The methods and formulas to calculate transmissivity from an inventoried well are described in **Section 2.4.2**. For a well located on-site or near site, inventory data from a single well may be adequate to estimate the hydraulic conductivity as determined by the reviewing authority, otherwise multiple wells shall be required as described in **Section 2.4.1.6**.

2.4.2. Estimating Hydraulic Conductivity from Specific Capacity

The specific capacity of a water bearing unit is calculated using the pumping rate and the maximum drawdown measured using one of the methods described in **Sections 2.4.1.4, 2.4.1.5 and 2.4.1.6**. Specific capacity can be related to transmissivity by one of two equations, the modified Cooper-Jacob Equation (Driscoll, 1986) or the Razack and Huntley equation (Fetter, 1994) (see **Appendix D**). The Razack and Huntley equation is based on data only from unconsolidated materials in Morocco (Fetter, 1994). Therefore, the Razack and Huntley equation cannot be used in consolidated material such as solid rock or fractured rock. The Cooper-Jacob equation can be used in both unconsolidated and consolidated water bearing units. In wells where both methods are applicable the applicant can choose which method to use. These two equations are only applicable to short-duration well log yield tests or drawdown tests (4 hours or less); long-term aquifer pumping tests with adequate data (see **Section 2.4.1.1**) should be analyzed by an appropriate method such as the Cooper-Jacob straight-line method or the Theis curve-matching method.

2.4.3. Hydraulic Gradient and Groundwater Flow Direction

Wells used for determining the hydraulic gradient shall be completed in or representative of the water-bearing unit proposed for the groundwater mixing zone (see **Section 2.2**) as determined by the reviewing authority. Well completion includes well screen, perforations, open hole or open casing in the applicable water-bearing unit.

The slope and direction of the groundwater hydraulic gradient can vary seasonally and in response to anthropogenic effects, such as pumping from wells. In most cases, the variations are minimal and do not need to be accounted for. However, in some cases the variation may be significant and may require seasonal monitoring to determine the fluctuations. When seasonal variations in direction are significant and can allow the effluent to migrate in different directions in the groundwater, the reviewing authority may require a SSMZ that is wider than a standard MZ to ensure the mixing zone includes the state water that may be impacted by the effluent.

The methods acceptable to calculate hydraulic gradient are described below. Assuming similar quality of data collection, the list is in the order of the most accurate to the least accurate method. Data collected using a method higher on the list will usually be used over data collected via a lower method. On-site data are typically more applicable than off-site data. Therefore, as determined by the reviewing authority, on-site data using a less accurate method may in some cases be more applicable than data collected via a more accurate method from a distant off-site source.

a. Triangulation of static water elevations measured in on-site/near-site wells;
b. Published potentiometric maps of the shallowest aquifer; and
c. One-third of regional topographic slope.

2.4.3.1. Triangulating Static Water Elevations

A worksheet for calculating hydraulic gradient from three wells is included in **Appendix E**. The following procedures shall be followed when measuring site-specific hydraulic gradient.

a. Three or more wells that define a plane (i.e., are not oriented in a straight line in map view) shall be used;
b. Each well shall be completed in the same water-bearing unit as the proposed mixing zone;
c. Each well should be located on-site unless acceptable off-site wells are available;
d. Each well must have a completed well log (per ARM 36.21.639) with lithologic descriptions;
e. The elevation of the measuring point of each well shall be surveyed to the nearest 0.01 ft. Well elevations can be measured against a single arbitrary reference point (elevations do not need to be relative to mean sea level);
f. Static water levels shall be measured to the nearest 0.01 ft. Static water level is defined as water levels measured at least 2 minutes apart shall have less than 0.02 ft of variation; for static water level depths greater than 300 ft the variation shall be less than 0.1 ft. Static water levels from well logs do not meet the accuracy, static, or time requirements in this section and therefore are not acceptable. All water levels shall be measured on the same date unless separate dates are approved by the reviewing authority; and
g. The wells shall be located on a USGS topographic map or other suitable and scaled site map. The well locations shall be surveyed unless they can be accurately located via other methods. The location information on well logs is typically not adequate to accurately locate wells for this purpose. Well logs in the MBMG GWIC database may include a link titled “view field visits for this site”. If the data in that link includes a latitude/longitude listed along with a survey-grade gps method and datum, the location may be accurate.

2.4.3.2. Published Data

Published data are acceptable for determining hydraulic gradient if it provides adequate information on how the hydraulic gradient/potentiometric map was determined, and the resolution is sufficient to determine hydraulic gradient at the wastewater treatment system. Extrapolation/extension of potentiometric contours shall not be used to determine hydraulic gradient.

Calibrated computer simulations may also be used to determine hydraulic gradient. Sources of published data are usually from a government agency such as USEPA, USGS, or MBMG. Data from non-government agencies (educational institutions, for example) may also be acceptable.

2.4.3.3. Regional Topography

Hydraulic gradient is often similar to a subdued expression of the regional topographic slope (Haitjema and Mitchell-Bruker, 2005). Therefore, the groundwater gradient can be conservatively estimated as one-third of the regional topographic slope in many cases. Regional topography is the general topographic slope across a regional area where the site is located, not a local slope such as immediately across the absorption system location (see example in **Appendix F**). Hills, lakes, and abrupt changes in slope may invalidate this method.

Using this method, the minimum hydraulic gradient shall be 0.001 feet/foot (ft/ft) and the maximum hydraulic gradient is 0.05 ft/ft (hydraulic gradients are not typically larger than that value).

If one-third the regional topographic slope is not reasonable due to site-specific conditions (e.g., water level would rise above the land surface at the estimated hydraulic gradient without any evidence of springs), a larger gradient that is reasonable may be used as approved by the reviewing authority.

2.4.4. Background Nitrate Concentration

The measured background nitrate concentration is used to determine the existing groundwater quality in the nitrate sensitivity analysis. The well(s) or springs sampled for the background nitrate concentration shall be in or representative of the water in the proposed mixing zone (see **Section 2.2**) as determined by the reviewing authority. If possible, the sampled well should be one of the wells used in determining aquifer characteristics (**Section 2.4**). Wells must have a completed well log (per ARM 36.21.639) with lithologic descriptions.

The water sample should be less than 1 year old from the date the results were submitted to the reviewing authority. Older samples may be accepted if the samples are representative of current conditions and approved by the reviewing authority.

One nitrate sample is often sufficient to characterize the background concentration. However, due to site-specific conditions, the reviewing authority may require groundwater samples from multiple wells and/or samples collected on multiple dates to determine spatial or seasonal fluctuations When multiple samples are required, the average or median of the results may be used unless the concentrations between wells or dates vary significantly and the average or median would not be protective of state water; in such cases the low or high measured concentration or other statistical value that is protective of state waters and beneficial uses (ARM 17.30.1006) shall be used. In areas of elevated nitrate concentrations, the reviewing authority may require analysis of other constituents in the groundwater (e.g., chloride, nitrogen/oxygen isotopes, etc.) to determine the origin of the nitrate.

Acceptable groundwater nitrate sample data may be available via the MBMG GWIC database or the USGS water quality portal.

2.4.4.1. Groundwater Sampling Procedures

Groundwater samples shall be representative of the water-bearing unit that the well or spring is completed in. The following procedures shall, at a minimum, be followed when collecting a groundwater sample.

a. Samples shall be collected prior to any water treatment or filtration system;
b. Wells should be purged of at least three well volumes if they are not used on a daily basis;
c. Samples shall be collected, preserved, and delivered according to procedures and time frames required by the laboratory;
d. Sample results shall be reported as nitrate+nitrite (as N), nitrate (as N) is also acceptable;
e. The laboratory detection limit shall be 0.1 mg/L or less; and
f. The well location shall be marked on a USGS topographic map or similar map, or the lot layout, and identified by GWIC number, if available.

2.4.5. Other Parameters in Nitrate Sensitivity Analysis

2.4.5.1. Nitrate Concentration in Wastewater Treatment System Effluent

The default value for effluent total nitrogen concentration from a conventional wastewater treatment system is 50 mg/L for typical residential strength wastewater, which is based on average raw wastewater strength of 60 mg/L and a 10 mg/L reduction to account for treatment in the wastewater treatment system. The effluent value of 50 mg/L is consistent with published values (USEPA, 2002; McCray et. al., 2005; Lowe et. al., 2007; Toor, Lusk and Obreza, 2011; Geza, Lowe and McCray, 2013)

The nitrogen content of wastewater from commercial sources may vary depending on the commercial use, however the default concentration is the same as residential wastewater (50 mg/L). For non-residential effluent the reviewing authority may alter this concentration based on the proposed use and known concentrations for similar uses or request additional information to determine an appropriate nitrogen concentration for the specific use proposed. When future uses may change, the reviewing authority may account for that in determining the appropriate effluent concentration.

The concentration of nitrogen in the effluent can be decreased by using nitrogen reducing treatment systems (level 2 systems). A list of the nitrogen reducing treatment systems approved by the Department and the corresponding nitrate effluent concentrations is located on the Department’s subdivision webpage.

Discharges utilizing a level 2 wastewater treatment system with an influent total nitrogen concentration that is above typical residential strength wastewater must submit data from existing systems with similar influent strength to determine an appropriate total nitrogen effluent concentration. The data submitted shall be equivalent to the data required for nutrient reducing systems in ARM 17.30.718.

Discharges containing sewage (as defined in 75-5-103(29), MCA) are subject to the ground water mixing zone limits for sewage (ARM 17.30.715(1)(d)(ii) through (iv)). Discharges that contain any industrial waste require a discharge permit pursuant to ARM 17.30 sub-chapter 10.

2.4.5.2. Nitrogen Natural Attenuation Rate

Estimating the rate of natural nitrogen attenuation to determine the reduction in nitrogen loading used in the groundwater mixing zone calculations and the surface water impacts analysis may be conducted pursuant to ARM 17.30.517(1)(d)(vi). Application of the nitrogen attenuation method by the MEANSS model (Regensburger, 2024) is described in **Appendix H**.

If a different method than discussed in **Appendix H** is used to estimate the natural nitrogen attenuation rate in the vadose and/or saturated zone, the reviewing authority will review and determine if the method and results are acceptable. A project plan describing details of the proposed study/method must be approved by the reviewing authority prior to implementation. The reviewing authority will determine the adequacy and applicability of the study/method results. Depending upon the complexity of the review, fees for review time may be assessed

2.4.5.3. Effluent Volume

The estimated average effluent volume for an individual living unit is 200 gallons per day (gpd) of wastewater; this is consistent with published values (USEPA, 2002 and Lowe et al., 2007). In comparison, the maximum day design flow for a 3-bedroom individual living unit wastewater treatment system is 300 gpd (see Department Circular DEQ-4). The nitrate sensitivity analysis and phosphorus breakthrough analysis use estimated average wastewater flows instead of maximum day design flows for residential systems to provide a more accurate representation of impacts to state waters as listed below.

1 bedroom	150 gpd
2 -5 bedrooms	200 gpd
Each additional bedroom	add 50 gpd

Wastewater flows for nonresidential uses (including recreational vehicles) shall be based on the design flow requirements in Department Circular DEQ-4 Chapter 3.

Wastewater systems that have widely fluctuating seasonal or daily effluent rates such as tourist-based businesses (e.g., campgrounds, ski areas, etc.) require additional analysis to determine the appropriate flow rate. For the nitrate analysis, the flows during the seasonal high use shall be used unless the reviewing authority approves a lower flow rate. If lower flow rates than the seasonal high rates are used (for example, the annual average) are proposed adequate hydrogeological information shall be submitted to demonstrate that the site-specific conditions in the unsaturated and groundwater zones will create consistent year-round concentrations at the end of the groundwater mixing zone that do not vary in response to variable seasonal loading.

2.5. Groundwater Mixing Zones

Mixing zones are defined in 75-5-103(20), MCA and ARM 17.30.502(6). Mixing zones allow for complete mixing of the effluent with the receiving water, so that at the end of the mixing zone the contaminant concentration is evenly distributed across the mixing zone. Wastewater treatment system discharges are given MZ lengths pursuant to ARM 17.30.517. SSMZ are also available (ARM 17.30.518).

Hydrogeologic and chemical parameters used in the MZ or SSMZ determinations shall be representative of those parameters that exist in the proposed mixing zone.

Mixing zones are required for both primary and replacement absorption systems. Acceptable methods for representing mixing zones on lot layouts are shown in **Appendix I**. Specific requirements for MZ and SSMZ are provided in the following sub-sections.

2.5.1. Standard Mixing Zone Thickness

The MZ thickness is 15 feet (ARM 17.30.517(1)(d)(iii)(A)). However, when the shallow groundwater zone is less than 15 feet thick (e.g., a gravel aquifer that is underlain by low permeability unit at less than 15 feet below the water table) the mixing zone thickness shall be based on the saturated groundwater thickness above the lower permeability unit.

2.5.2. Standard Mixing Zone Width

The MZ width is determined by the total width of the absorption system (primary and replacement absorption systems are calculated separately) as measured perpendicular to the groundwater flow direction. The width increases downgradient from the absorption system due to natural dispersion at a 5-degree angle per ARM 17.30.517(1)(d)(iii)(B). The 5-degree widening is included in the nitrate sensitivity analysis spreadsheets (**Appendices A and B**).

For elevated sand mounds (ESM), the dimensions of the discharge area shall be based on the basal area of the sand mound for laterals that are raised no more than 2 feet above the natural ground surface and a mound slope of no less than 3:1. The calculations to determine dimensions shall assume that the natural ground surface has no slope.

2.5.3. Standard Mixing Zone Length

Standard groundwater mixing zone lengths are listed in ARM 17.30.517(1)(d)(ix).

2.5.4. Groundwater Source Specific Mixing Zones (SSMZ)

When a groundwater SSMZ is requested the necessary information pursuant to ARM 17.30.518 shall be submitted. The reviewing authority will determine if the SSMZ can be approved.

Information submitted for a groundwater SSMZ application shall meet the following requirements:

a. The proposed wastewater treatment system shall be pressure dosed (see Department Circular DEQ-4);
b. Hydraulic conductivity shall be determined from an aquifer pumping test conducted in accordance with **Section 2.4.1.1**;
c. Hydraulic gradient shall be determined from measured groundwater elevations in accordance with **Section 2.5.1.1**, or from published data in accordance with Section **2.5.1.2**;

d. For SSMZ less than 100 feet long, the mixing zone thickness shall be proportionally reduced to account for the shorter mixing zone length. For example, a SSMZ length of 25 feet requires an equal 75% reduction of the mixing zone thickness from 15 feet to 3.75 feet. The minimum length for a SSMZ is 10 feet;
e. The effluent quality shall be residential strength; and
f. For SSMZs that are shorter or narrower than the MZ, 4-log pathogen inactivation (99.99% inactivation) shall be demonstrated at the end of the SSMZ (see **Appendix J**). As approved by the reviewing authority, other methods to demonstrate 4-log pathogen inactivation may be submitted.

If the request for SSMZ includes a longer, deeper or wider mixing zone than a MZ, the applicant shall demonstrate (as reviewed and approved by the reviewing authority) that complete mixing does not occur at the end of the standard mixing zone, and the additional length, depth or thickness is needed to achieve complete mixing at the end of the mixing zone. Complete mixing is a less than 10% variation in concentration across (vertically and horizontally) the end of the mixing zone.

If a groundwater mixing zone intersects and extends beyond a hydrologically connected state surface water, the groundwater mixing zone ends at the edge of the ordinary high-water mark of the surface water. Pursuant to ARM 17.30.506(2)(h) the requirements for setting mixing zones that apply to direct discharges to surface water will also apply to the discharge. A nondegradation analysis may need to be conducted [ARM 17.30.706(1) and 75-5-317(2) (f), MCA], and a discharge permit may be required from the Department pursuant to 75-5-401(1), MCA.

2.6. Wells and Groundwater Mixing Zones

The required setbacks between groundwater mixing zones and wells are defined in ARM 17.36.323, ARM 17.30.506(2)(b), and ARM 17.30.508(2). As determined by the reviewing authority, these setbacks may not apply to properly constructed wells in confined aquifers because the well may be hydraulically separate from the mixing zone that is located in the shallow groundwater above the confining unit.

2.7. Applicability of Mixing Zones

The reviewing authority may not be able to approve a mixing zone due to site-specific conditions per ARM 17.30.506(2)(g).

2.8. Cumulative Effects

Cumulative groundwater effects between two or more wastewater treatment systems in the same subdivision or common development (including multiple phases of a development) must be accounted for (ARM 17.30.506(2)(f)) unless all the wastewater treatment systems in a common development are approved pursuant to ARM 17.30.716.

Cumulative effects between proposed wastewater treatment systems and previously approved or existing upgradient and downgradient wastewater treatment systems in unrelated developments must also be accounted for. However, for upgradient wastewater treatment systems only, if the background groundwater nitrate sample(s) adequately account for groundwater impacts, the upgradient development is already accounted for in the cumulative effects analysis. The reviewing authority will determine which wastewater treatment systems in unrelated developments must be included in the cumulative effects assessment.

All nearby existing or approved upgradient or downgradient wastewater treatment systems (including any lots approved pursuant to ARM 17.30.716) that meet the criteria above for inclusion in cumulative effects analysis with a proposed development shall be included in the cumulative effects analysis. See **Appendix A** for spreadsheets for individual and cumulative nitrate sensitivity calculations. Additional explanation of the cumulative analysis criteria and example calculations are provided in **Appendix B**.

2.8.1. Groundwater Cumulative Effects Criteria for Nitrogen

The criteria for assessing whether the groundwater cumulative effects analysis exceeds the nondegradation criteria or the water quality standard for both on-site and off-site lots are listed in Table 1.

2.8.2. Cumulative Effects for Increased Sources

If an existing or approved wastewater treatment system discharge submits an application to increase the source (see **Section 1.3**), the nondegradation review shall be conducted on the entire proposed flow, not just the increased amount. This is necessary to account for the cumulative effects of the existing source and the proposed increased source. The cumulative analysis is only conducted to determine if the increased portion of the source meets the nondegradation requirements. The existing source is not being reviewed for approval, but only included for determining cumulative effects.

2.9. Confined Groundwater

If the shallowest groundwater is confined, the nitrate cannot affect that groundwater, and the nitrate impact to groundwater is nonsignificant. However, the horizontal migration of the wastewater must still be evaluated with respect to potential nitrate and phosphorus impacts to surface waters (see **Section 6**) or adjacent unconfined groundwater that might be impacted. When the shallowest groundwater is confined, the effluent is assumed to migrate in the direction of topographic slope from the discharge point unless other credible information supports a different direction as approved by the reviewing authority.

If the effluent will not impact groundwater due to confined conditions, a mixing zone will not be granted for the wastewater treatment system.

Information adequate to demonstrate the shallowest groundwater is confined includes but is not limited to the following methods (See **Appendix K**). Where necessary, more than one line of evidence demonstrating confined conditions may be required by the reviewing authority.

a. Evidence of laterally continuous geologic material that is impervious based on published reports and/or adequate information from multiple well logs;
b. Appropriate storativity value (typically between 0.001 and 0.00001) determined from aquifer pumping test with observation well(s) and lithology consistent with a confining layer; or
c. Other information as determined acceptable by the reviewing authority.

Information that is generally not acceptable to demonstrate confined conditions includes but is not limited to:

a. Water level fluctuations in a water-bearing unit that correspond to barometric fluctuations (Hubbell, et. al., 2004; Hare and Morse, 1997); and
b. Static water levels in a well that rise above the first water-bearing unit noted on the well log (see Appendix K for additional details).

3. Phosphorus Breakthrough Analysis

The phosphorus breakthrough (PBT) criteria require soil adsorption capacity of 50 years (Appendix L) prior to discharge to high-quality state surface water (ARM 17.30.715(1)).

If a state surface water is not hydrologically connected to groundwater it does not need to be assessed for impacts from a wastewater treatment system. The assessment of hydrologic connection shall include the entire length of surface water where wastewater treatment system effluent may enter the surface water. Determining hydrologic connection is described in **Section 6**.

PBT shall be conducted on both the primary and replacement absorption systems.

3.1. Width of Effluent Plume

The dispersion angle of 5° used in the nitrate sensitivity analysis (**Section 2.8.1.2**) shall be used in the calculation of phosphorus breakthrough. The dispersion angle is included in the phosphorus breakthrough calculation sheet (**Appendix L**).

3.2. Distance to Surface Water

Distance to the high-quality surface water shall be based on the distance between the downgradient edge of the absorption system and the ordinary high-water mark of the receiving surface water.

The distance to surface water is based on the requirements in ARM 17.30.715(4).

3.3. Distance Between Absorption Systems for Cumulative Effects Analysis

For cumulative effects the distance between two wastewater treatment systems shall be measured from the downgradient edge of the upgradient wastewater treatment system to the upgradient edge of the downgradient wastewater treatment system (see **Appendix M**).

3.4. Depth to Limiting Layer

The amount of soil directly beneath the wastewater treatment system that is available for absorption of phosphorus is dependent upon the depth to a limiting layer. A limiting layer can be seasonal groundwater, an impervious layer such as clay, or bedrock which prevents the wastewater from further vertical movement or has no absorption capacity for phosphorus.

The information used to demonstrate depth to a limiting layer is listed below.

a. Depth to limiting layer from the on-site test pit;

b. Depth to limiting layer estimated as the bottom of the test pit if no limiting layer is encountered;
c. Shallowest depth to water based on groundwater monitoring in a test pit observation point during the high-water period using the requirements in Appendix C of Department Circular DEQ-4;
d. Shallowest depth to water in a near-site or on-site water well, that is completed in the shallowest groundwater, using the same frequency and timing requirements for test pit observation points in Appendix C of Department Circular DEQ-4; or
e. Other information as determined acceptable by the reviewing authority.

The imported sand that is beneath the laterals in a sand mound system (up to a maximum depth of 2 feet) should be used in determining the soil thickness available for adsorption above the limiting layer.

3.5. Mixing Depth

The phosphorus mixing depth in groundwater shall be 0.5 foot for coarse-textured soils or 1.0 foot for fine-textured soils. Fine-textured soils are defined for this purpose as medium sand, sandy loam or finer according to soil texture descriptions in Department Circular DEQ-4 Chapter 2. Soil types should be determined by test pits; however, the reviewing authority may require a sieve analysis and/or hydrometer test to determine soil classification. The soil texture used to define the mixing depth shall be the soil type immediately above the limiting layer, or where the limiting layer is assumed to be (e.g., the bottom of a test pit with no limiting layer).

The mixing depth for an evapotranspiration absorption (ETA) system shall be 1.0 foot based on the fine-grained nature of the natural material below ETA beds.

3.6. Absorption System Length as Measured Perpendicular to Groundwater Flow

The length of the absorption system measured perpendicular to groundwater flow shall be used to determine the width of the soil available to adsorb phosphorus from the absorption system to the surface water. If the absorption system laterals have unequal length or offset laterals, the reviewing authority may reduce the length to account for uneven distribution of wastewater across the length.

3.7. Absorption System Area – Length and Width

The land area covered by the absorption system shall be used to determine the area of soil directly beneath the bottom of the absorption system that is available to adsorb phosphorus.

For purposes of calculating the absorption system area, the maximum allowed distance between absorption system laterals is 10 feet. For example, if 2 laterals are spaced on 14-foot centers, only 10 feet of that separation can be used in calculating the amount of soil available for phosphorus absorption beneath the absorption system.

An additional 2 feet can be added to each of the outside laterals to account for horizontal dispersion of the effluent for calculating the absorption system width. For example, if the absorption system consists of 3 laterals on 7-foot centers, the width in the calculations is equal to: 2’ + 7' + 7' + 2' = 18 feet.

For elevated sand mounds (ESM), the dimensions of the discharge area shall be based on the basal area of the sand mound for laterals that are raised no more than 2 feet above the natural ground surface and a mound slope of no less than 3:1. The dimension calculations shall assume that the natural ground surface has no slope.

3.8. Phosphorus Concentration and Effluent Volume

3.8.1. Concentration

The default value for effluent phosphorus concentration from a wastewater treatment system is 10.6 mg/L for typical residential strength wastewater, which is within the range of values reported by the USEPA (2002), Lombardo (2006) and Lowe et. al. (2007). This concentration accounts for current low levels of phosphorus in household detergents, it is used as a default average value for residential and non-residential effluent. For non-residential effluent the reviewing authority may alter this concentration based on the proposed use and known concentrations for similar uses or request additional information to determine an appropriate phosphorus concentration for the specific use proposed. When future uses may change, the reviewing authority may account for that in determining the appropriate effluent concentration.

3.8.2. Volume and Load

The quantity of effluent is based on the same requirements for nitrogen (see **Section 2.7.1.3.**).

The PBT spreadsheet (**Appendix L**) calculates the applicable load based on user inputs of concentration and volume.

Wastewater systems that have widely fluctuating seasonal or daily effluent rates such as tourist-based businesses (e.g., campgrounds, ski areas, etc.) can use the average annual flow to determine the yearly phosphorus load for use in the phosphorus breakthrough spreadsheet. The phosphorus calculation uses total load and total available soil for adsorption and thus is not dependent on seasonal load fluctuations.

3.9. Soil Phosphorus Adsorption Capacity

The default value for the soil's ability to adsorb phosphorus is 200 ppm in **Appendix L**. Site-specific soil adsorption values from laboratory analysis may be submitted to provide a site-specific value. Soil samples collected for laboratory analysis shall be representative of the entire soil profile. The location and number of samples to determine a site-specific phosphorus adsorption value shall be determined by the reviewing authority and are site-specific depending on the local variability of soils, the type and size of treatment system, and other site conditions.

Soil sample analyses must account for the coarse fraction of the sample (typically gravel and larger particles) that is removed prior to the laboratory analysis. For example, if 25% of the soil sample is gravel and is removed prior to laboratory analysis, the laboratory adsorption value should be correspondingly decreased by 25% for the final adsorption value. The laboratory soil adsorption value (in ppm) shall be the adsorption value that corresponds to a solute phosphorus concentration of 10.6 mg/L.

3.10. Soil Weight

The default value for soil weight is 100 pounds/cubic foot (lbs/ft^3). A site-specific value may be used, the same criteria for the number and location of samples described for soil adsorption (Section 3.8) apply. The samples must be collected via a method that provides an undisturbed sample to preserve the density of the sample for laboratory analysis.

3.11. Cumulative Effects

Cumulative groundwater effects between two or more wastewater treatment systems in the same subdivision or common development (including multiple phases of a development) must be accounted for (ARM 17.30.506(2)(f)) unless all the wastewater treatment systems in a common development are approved pursuant to ARM 17.30.716.

Cumulative effects between proposed wastewater treatment systems and previously approved or existing upgradient and downgradient wastewater treatment systems in unrelated developments must also be accounted for. The reviewing authority will determine which wastewater treatment systems in unrelated developments must be included in the cumulative effects assessment.

All nearby existing or approved upgradient or downgradient wastewater treatment systems (including any lots approved pursuant to ARM 17.30.716) that meet the criteria above for inclusion in cumulative effects analysis with a proposed development shall be included in the cumulative effects analysis. See **Appendix L** for individual and cumulative PBT spreadsheet calculations. Additional explanation of the cumulative analysis criteria and example calculations are provided in **Appendix M**.

Only the worst case(s) cumulative scenario must be submitted to demonstrate compliance with the nondegradation criteria.

3.11.1. Cumulative Effects for Increased Sources

See **Section 2.11.2** for conducting cumulative effects of increased sources.

4. Waste Segregation Systems and Gray Water

Requirements for gray water systems are in ARM 17.36.919 and in Department Circular DEQ-4 chapters 6 and 8. Disposal of gray water through a wastewater treatment system must comply with all the requirements in this circular. The nitrogen and phosphorus loading rates from a gray water wastewater treatment system shall be based on the tables in **Appendix N**.

Except as described in **Section 4.1**, disposal of gray water through an irrigation system that meets the requirements in the above referenced rule and circular will be reviewed as a wastewater treatment system in this circular.

4.1. Gray Water Irrigation Systems for Public Sewage Systems

Irrigation of gray water systems from public sewage systems is not a new or increased source of nitrogen or phosphorus if the irrigation is conducted at agronomic uptake rates in accordance with requirements in Department Circular DEQ-2.

5. Nonsignificant Categories

This section provides details for the nonsignificant categories in ARM 17.30.716. A wastewater treatment system that meets the criteria in ARM 17.30.716 does not require further analyses for impacts to groundwater or surface water. No deviations from the requirements in this section will be accepted.

However, for cumulative effects analyses the following requirements apply:

a. Cumulative effects analysis in groundwater and surface water are not required if all the lots in a common development or phases of subdivision are nonsignificant pursuant to ARM 17.30.716;
b. Cumulative effects analysis in groundwater are required for all lots if one or more of the lots in a common development or phases of subdivision do not meet the nonsignificance criteria in ARM 17.30.716;
c. Cumulative effects analysis in surface water are required for all lots that are required to assess surface water impacts pursuant to ARM 17.30.715(4) if one or more of the lots in a common development or phases of subdivision do not meet the nonsignificance criteria in 17.30.716; and
d. Whenever the cumulative effects analysis in b) or c) demonstrate the proposed activity is significant, that significance determination only applies to the lots that do not meet the nonsignificance criteria in ARM 17.30.716; the lots that meet the nonsignificance criteria in ARM 17.30.716 remain nonsignificant.

5.1. ARM 17.30.716(3) – General Criteria

See **Section 3.2** for measuring distance to state surface waters.

Residential strength wastewater is defined in department circular DEQ-4.

5.2. ARM 17.30.716(4)(b)

The number of subdivision lots that were created during each fiscal year will be determined by the department on an annual basis. The fiscal year runs from July 1 to June 30. Contact the department or use the department's subdivision web site for an updated list of counties that meet this requirement.

City and town populations should be determined using the current Montana Department of Commerce list of populations in Montana at: https://ceic.mt.gov/People-and-Housing/Population.

5.3. ARM 17.30.716(4)(c) – Table 1

See **Section 2.6.1** for details on background groundwater nitrate concentrations.

Pressure distribution must meet the requirements in department circular DEQ-4.

The depth to limiting layer shall be determined from all the applicable and required on-site soil profiles. (test pits may need to be excavated deeper than required in department circular DEQ-4 to meet this requirement). Groundwater monitoring points will also be used to meet this requirement only if groundwater monitoring is necessary to meet requirements in department circular DEQ-4. Limiting layer is defined in department circular DEQ-4.

The depth to bedrock and groundwater should be determined using a minimum of three on-site or nearby well logs that indicate there are no bedrock units or water-bearing materials shallower than 50 feet, or by other adequate information such as published reports. The reviewing authority may require additional local well logs, geologic reports, or other information to verify the depth to bedrock and groundwater. The depth to groundwater in ARM 17.30.716(4)(c)(ix) does not use the same criteria for depth to limiting layer as ARM 17.30.716(4)(c)(viii) and does not need to be based on a seasonal high measurement.

6. Adjacent to Surface Waters

Impacts of wastewater treatment systems on state surface waters shall be assessed in accordance with ARM 17.36.124, ARM 17.30 sub-chapters 5, 6 and 7, and Department Circular DEQ-7.

Specific non-significance criteria for surface water impacts are provided in ARM 17.30.715(1)(g). The spreadsheet for calculating trigger values is provided in **Appendix O**. For nutrients (nitrogen and phosphorus) the analysis is based on the seasonal 14-day 5-year (seasonal 14Q5) low flow statistic. The 14Q5 period includes the months of July, August, September, and October.

6.1. Nitrogen

The criteria for assessing nitrogen impacts from wastewater treatment systems to state surface waters are dependent on both the distance from the wastewater treatment system to the surface water and the site soil conditions pursuant to ARM 17.30.715(4).

6.1.1. Effluent Loading

Default Estimate

Nitrogen effluent volume used in calculations must be based on **Section 2.7.1.3**. Without any site-specific data the default estimate is that 100 percent of the effluent volume discharged from the wastewater treatment system will reach the surface water.

The default effluent nitrogen concentration must be based on the concentration and natural nitrogen attenuation rate described in **Sections 2.7.1.1** and **2.7.1.2**, respectively.

Site-Specific Calculations

Site-specific calculations may be used to determine the nitrogen load impacting the surface water instead of the default values described above pursuant to ARM 17.30.715(4)(d)(ii), however, both the site-specific volume and concentration must be determined. The analysis will evaluate the amount of site-specific groundwater dilution of the wastewater effluent and the volume of that diluted wastewater effluent that reaches the impacted surface water. The information necessary to determine those values can vary greatly from site to site; the minimum information necessary will likely include but not necessarily limited to some or all of the following elements:

- Ground water potentiometric maps using multiple monitoring wells (and possibly multiple dates) completed in the shallow water-bearing unit contributing to the surface water during the seasonal 14Q5 period;
- Surface water piezometers to determine the interaction between groundwater and surface water;
- Groundwater-surface water tracer tests to estimate the percent contribution of the effluent from the proposed site to the impacted surface water;
- One or more long-term pumping tests from well(s) completed in the shallow water-bearing unit to determine the applicable spatial variability of hydraulic conductivity and storativity between the proposed site and impacted surface water;
- Soil porosity, including spatial variability, within the shallow water-bearing unit; and
- Groundwater flow model calibrated to site-specific data used in conjunction with particle-tracking or contaminant transport model.

A project plan describing details of the proposed study must be approved by the reviewing authority prior to implementation. The reviewing authority will determine the adequacy and applicability of the study results.

6.2. Phosphorus

If the phosphorus 50-year breakthrough criterion is satisfied (ARM 17.30.715(1)(e)), additional analysis of phosphorus impacts to the surface water is not required. If the proposed discharge(s) does not meet the 50-year phosphorus breakthrough limit, the wastewater treatment system must also be evaluated for phosphorus impacts to state surface water using the criteria in ARM 17.30.715(1)(g) and 17.30.715(4).

6.2.1. Effluent Loading

Phosphorus effluent volume used in calculations must be based on **Section 2.7.1.3**. The default estimate is that 100 percent of the effluent volume discharged from the wastewater treatment system will reach the surface water. Information to support a lower effluent volume reaching the surface water may be submitted for review by the reviewing authority.

Phosphorus effluent concentration must be based on **Section 3.7.1**.

6.3. Hydrologic Connection

For determining impacts to high-quality state waters pursuant to ARM 17.30.715(1)(g) if the state surface water is not hydrologically connected to groundwater it does not need to be assessed for impacts from wastewater treatment system sources. The hydrologic connection assessment shall include the entire length of surface water where wastewater treatment system effluent may enter the surface water at the ordinary high-water mark. The area where effluent may enter surface water is defined by extension of the groundwater mixing zone to the surface water including the 5-degree expansion (ARM 17.30.517(1)(d)).

A work plan to assess hydrologic connection shall be submitted to the reviewing authority for review and approval prior to conducting an assessment. The most common method to demonstrate the lack of a hydrologic connection is to demonstrate the static water elevations in the groundwater adjacent to the surface water are lower than the surface water elevation as measured in the direction of groundwater flow or estimated groundwater flow; see **Appendix P** for additional details. Hydrologic connection must be based on the time period used for trigger value analysis, the seasonal 14Q5, which includes July, August, September and October.

Man-made water bodies constructed and lined with an impermeable liner are not in hydrologic connection to groundwater if the liner meets the watertight liner requirements for evapotranspiration (ETA) systems in Department Circular DEQ-4, chapter 6.

6.4. Confined Groundwater

The requirements to assess impacts to state waters pursuant to ARM 17.30.715(1)(g) applies to sites where the shallowest ground water is confined. The topographic slope (or the slope of the top of the confining layer if it is known) from the wastewater treatment system location to the surface water should be used to determine the distance to surface water.

6.5. Cumulative Effects for Common Developments and Wastewater Treatment Systems Approved under ARM 17.30.716

The surface water impact determinations (including trigger value analyses) are applicable to each common development but are not intended to apply to cumulative effects of multiple unrelated activities, such as multiple unrelated subdivisions. Multiple phases of a single development are considered a common development. The wastewater treatment system included in cumulative surface water impact calculations shall include all proposed, existing and approved wastewater treatment systems in the common development that meet the requirements for assessing impacts to surface water as described in ARM 17.30.715(Sources approved or existing before April 29, 1993), may not be subject to the nondegradation requirements pursuant to the definition of "new or increased source" in ARM 17.30.702(17).

6.6. Determining Surface Water Dilution

6.6.1. Streams and Rivers

The available dilution for streams and rivers in **Appendix O** is the seasonal 14Q5 flow statistic for the impacted section of the stream. Seasonal 14Q5 values at many United States Geological Survey (USGS) gauge locations across the state are available (USGS, 2004). For ungauged sites seasonal 14Q5 values can be calculated via the USGS Streamstats program (USGS, 2016). The Streamstats program description is located at: https://www.usgs.gov/streamstats. The Streamstats application is located at: https://streamstats.usgs.gov/ss/ . Streamstats will not provide results for streams in certain portions of the state where the governing equations are not valid. In those circumstances, a similar but simpler method described in **Appendix Q** shall be used. When Streamstats does provide the applicable 14Q5 value, the method in **Appendix Q** is less accurate and shall not be used.

The DNRC also records streamflow rates on rivers and irrigation ditches across the state, that information is available at: https://gis.dnrc.mt.gov/apps/stage/ .

Braided rivers consist of two or more naturally diverging and converging channels that are part of the same waterbody. Different channels in a naturally braided stream have relatively similar biological, hydrological and physical characteristics. A channel that is a part of the waterbody must have continuous water flow from the point it diverges to the point it converges back to the waterbody at the river discharge rate consistent with the ordinary high-water mark. All channels, as defined here, share the same 14Q5 with the main waterbody. Artificial channels or diversions are not considered braided channels of a waterbody.

6.6.2. Lakes, Ponds, and Wetlands

The seasonal 14Q5 dilution volume for lakes, ponds, and wetlands (lakes) can be calculated using the same methods as for streams when the lake is connected via an inlet or outlet to a stream system. Alternatively, flow can be determined by groundwater flow into or out of a lake, or a combination of the 2 methods. Estimating groundwater flow rate into or out of a lake using Darcy's Law is described in **Appendix R**.

Some lakes (often referred to as pothole or kettle lakes) are an expression of the groundwater table and have no discernable surface water inflow or outflow. Unless these potholes have had their uses specifically downgraded in the surface water rules (ARM 17.30 sub-chapter 6) they are subject to the same definitions of "state waters" and "high-quality state waters" as other surface waters, and therefore must meet the same requirements as other lakes.

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