DENITRIFYING BIOREACTOR

(No.)
Code 605

DEFINITION
A structure that uses a carbon source to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow via enhanced denitrification.

PURPOSE
This practice is applied to achieve the following purpose:

- Improve water quality by reducing the nitrate nitrogen content of subsurface agricultural drainage flow.

CONDITIONS WHERE PRACTICE APPLIES
This practice applies to sites where there is a need to reduce nitrate nitrogen concentration in subsurface drainage flow.
This practice does not apply to underground outlets from practices, such as terraces, where the drainage source is primarily from surface inlets.

**CRITERIA**

**General Criteria Applicable to All Purposes**
Evaluate and avoid or minimize impact to cultural resources, wetlands and Federal and state protected species to the extent practicable during planning, design and implementation of this conservation practice in accordance with established National and Florida policy, General Manual (GM) Title 420-Part 401; Title 450-Part 401, Title 190-Parts 410.22 and 410.26, National Planning Procedures Handbook (NPPH) Florida Supplements to Parts 600.1 and 600.6, National Cultural Resources Procedures Handbook (NCRPH), National Food Security Act Manual (NFSAM), and the National Environmental Compliance Handbook (NECH).

Compliance with all applicable Federal, State and local regulations and ordinances is required.

If wetlands are present then complete an appropriate wetland determination per established procedures.

**Performance and Capacity.** Design the capacity of the bioreactor based on one of the following:

- Treat peak flow from a 10-year, 24-hour drain flow event.
- Treat at least 15 percent of the peak flow from the drainage system.
- Treat at least 60 percent of the long-term average annual flow from the drainage system using locally proven criteria (e.g., drainage coefficient).

Disregard flow from surface inlets when calculating design subsurface drain flow for capacity purposes.

Avoid surface intakes in the system to minimize size of the denitrifying bioreactor and trash and other contaminants the entering system.

Design the bioreactor hydraulic retention time for a minimum of 3 hours at the peak flow capacity. Account for the porosity of the media and use the average depth of flow through the media. The effective volume of the reactor is calculated as:

\[ V = L \times W \times \frac{(d_{in} + d_{out})}{2} \times P \]

Where:

- \( V \) = effective volume of media (ft\(^3\))
- \( L \) and \( W \) are the length and width of media chamber (ft)
- \( d_{in} \) and \( d_{out} \) are the depth of the inlet water and outlet water (ft)
- \( P \) is the porosity of the material (decimal percentage)

Design the bioreactor to achieve at least a 30-percent annual reduction in the nitrate nitrogen load of the water flowing through the bioreactor.

If reducing conditions may result in the production of methyl mercury, make additional provisions to ensure that stagnant conditions do not develop in the media chamber.

A hydrogen sulfide smell at the outlet indicates that all nitrates have been reduced and the potential for methyl mercury exists. If the hydrogen sulfide smell is noted, all flashboards in the outlet structure will be removed from outlet structure until the bioreactor is completely drained.

**Location.** Do not locate denitrifying bioreactors in bottom depressional areas where stagnant water can reside. For the same reasons, bioreactors should not be used simultaneously with controlled drainage (water table management) if restricting the drainage results in keeping the bioreactors flooded for long periods of time.
Media Chamber. Use a medium for the carbon source that is reasonably free from dirt, fines, and other contaminants. Distribute the media within the bioreactor to achieve a uniform flow path.

Use geotextile or plastic lining for the bottom, sides, and top of the bioreactor as needed to prevent migration of soil particles into the bioreactor and minimize bypass of treatment flow by leaching from the media chamber.

Design the bioreactor media for an expected life of at least 10 years. To create a longer lifespan, provide provisions for periodic renewal of the media.

Design the media chamber to prevent development of preferential flow pattern. For a media chamber with a length to width ratio of 4:1 or greater, use a perforated distribution pipe at the chamber inlet and a perforated collection pipe at the chamber outlet. For wider chambers, design a multiple-header distribution system so that the width served by each header is no greater than 25 percent of the chamber length.

Specify the carbon media that goes in the chamber. If wood chips are the media, specifically note that no high tannin content wood such as oak, cedar or redwood are to be used. Do not use any wood that has been treated for ground contact (pressure treated).

Wood chips ranging in size from ¼ - inch to 1 – inch will be used, if wood chips are the media for the bioreactor.

Water Control Structures. Design the bioreactor inlet and outlet water control structures to provide the required capacity and hydraulic retention time. Use the criteria in Florida NRCS conservation practice standard (CPS) Structure for Water Control, Code 587 for the design.

Select or design water control structures that control the upstream water elevation and provide safe bypass of flows in excess of the design capacity.

Select a design water surface elevation at the upstream water control structure that will prevent upslope crop damage from an elevated water table.

Provide a low elevation orifice or opening of some type on the bottom of the set of flashboards in outlet structure to assure the media chamber drains in a maximum of 48 hours during periods of no-drain flow.

Provide an outlet that will completely drain the media chamber to facilitate bioreactor management and maintenance.

Protection. Protect the bioreactor from intermittent surface storm flows that could result in flushing out of the established biofilm.

Construct the ground surface above the bioreactor to shed water and to allow for settlement. Dispose of excess soil excavated during the installation of the bioreactor by blending with the adjacent landscape in accordance with Florida NRCS CPS Spoil Spreading, Code 572 or hauling off-site.

To prevent compaction of the bioreactor media, identify the bioreactor location with appropriate signage or fence the site to avoid equipment travel over the bioreactor. If there will be equipment traffic for mowing or other purposes, provide adequate cover to prevent damage to the bioreactor.

During release of tile drainage water from the water control structures, flow velocity in the tile lines must not exceed the maximum velocity prescribed by Florida NRCS CPS Subsurface Drain, Code 606.

Protect all disturbed non-crop construction areas by seeding or mulching within 7 days of construction. See Florida NRCS CPS Critical Area Planting, Code 342 for criteria on seed selection, seedbed preparation, fertilizing, and seeding. For installation of the denitrifying bioreactor in an existing filter strip.
or other conservation practice, revegetate disturbed areas according to the seeding requirements of the conservation practice disturbed by construction.

**CONSIDERATIONS**

Other practices and management systems can achieve a reduction of nitrate nitrogen levels separately or in conjunction with the denitrifying bioreactor. Examples include Florida CPS Nutrient Management, Code 590; Cover Crop, Code 340; and Drainage Water Management, Code 554.

If tailwater conditions will create stagnant conditions within the denitrifying bioreactor do not use this practice.

Determining the normal nitrate levels expected in the tile discharge water prior to design work will aid in establishing design parameters.

Add inoculants to improve the function of the bioreactor.

Mix inert materials such as gravel with the required amount of reactive carbon source to provide the required bioreactor volume, porosity, and flow rate.

Situating the bioreactor on a low bench will minimize interference with the drainage needs of the area served during the growing season.

Exclude surface water from the bioreactor as much as possible by selecting a location away from areas that will pond surface water during storm events.

When designing the bioreactor using methods based on a percentage of the peak flow from the drainage system, target 15 to 20 percent of peak flow for best performance.

Be aware of the effects on downstream flows or aquifers that would affect other water uses or users. For example, the initial flow from the bioreactor at start up may contain undesired contaminants.

If site topography is such that planned elevated water table upstream of the bioreactor might negatively affect crop performance, manage water levels at the upstream end of the bioreactor according to criteria in Florida NRCS CPS Drainage Water Management, Code 554.

Maintain the design water elevations throughout the year if an elevated water table upstream of the bioreactor will not negatively affect crops.

**PLANS AND SPECIFICATIONS**

Prepare plans and specifications for constructing the denitrifying bioreactor shall be in keeping with this standard and describing the requirements for constructing the practice to achieve its intended purpose.

The owner or operator is responsible for securing all required permits or approvals and for performing in accordance with such laws and regulations. The landowner and/or contractor is responsible for contacting utility locators to locate all buried utilities in the project area.

Plans and specification must include, but not limited to—

- Location and plan view of the layout of the denitrifying bioreactor and associated components
- Typical cross section(s) of the bioreactor
- Profile(s) of the bioreactor including inlet(s) and outlet(s)
- Details of required structures for water level control, such as material, size, and elevations
- Material specifications for the bioreactor media
OPERATION AND MAINTENANCE

Provide a site-specific operation and maintenance (O&M) plan to the landowner or operator before the practice is installed and review the O&M plan with them.

Include guidance in the O&M plan for the routine maintenance and operational needs of the denitrifying bioreactor. Specified actions should include normal repetitive activities in the application and use of the practice, along with repair and upkeep of the practice.

The plan must be site specific and include, but not be limited to, a description of the following:

- Planned water level management and timing.
- Inspection and maintenance requirements of the bioreactor and contributing drainage system, especially upstream surface inlets.
- Requirements for monitoring the status of the bioreactor media and replacement/replenishment of media as needed.
- Monitoring and reporting criteria that demonstrate system performance.
- Monitoring to ensure conditions are not favorable for the production of methyl mercury.
- Monitoring information to improve the design and management of this practice as needed.

REFERENCES

Florida NRCS Conservation Practice Standards:
  Cover Crop, Code 340
  Critical Area Planting, Code 342
  Drainage Water Management, Code 554
  Nutrient Management, Code 590
  Spoil Spreading, Code 572
  Structure for Water Control, Code 587
  Subsurface Drain, Code 606
General Manual
  Title 420-Part 401
  Title 450-Part 401
  Title 190-Parts 410.22 and 410.26
National Cultural Resources Handbook
National Environmental Compliance Handbook
National Food Security Act Manual
National Planning Procedures Handbook
Florida Supplements to Parts 600.1 and 600.6