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Ref: pages 155-157; and Table 17 on page 212: The following comments relate to the potential options and applications for the practice of **Drainage Water Management (Controlled-Drainage)** to reduce nitrate loss from agricultural cropland carried in subsurface drainage outflow. Nitrate loss from agricultural cropland that is drained, particularly in the Midwestern States, is a concern because it enters drainage channels and streams leading to the Mississippi River System and thus flows to the Northern Gulf of Mexico and contributes to Hypoxia.

In general I am pleased with the extent of the EPA SAB Hypoxia Advisory Panel's discussion in their report on the potential application of the on-farm practice of drainage water management (controlled-drainage) as one option for reducing nitrate loss from drained cropland. The importance of applying this on-farm management system on most of the drained cropland throughout the Midwest that is most suitable and easy to install, that is on land with surface slopes less the 0.5%, for both for new and retrofitting existing drainage systems, should be emphasized more in my opinion than the current wording in the report. The report correctly states that new and innovative technological developments are forthcoming that will make applying the practice to cropland with slopes greater than 0.5%, and certainly up to 1.0% and in some cases perhaps up to 2.0%. Drainage Water Management is perhaps one of the most effective and economically feasible on-farm management practices that can be applied without major changes to the landscape, and it has been approved by NRCS in some Midwestern States for cost-sharing to farmers who implement the practice. The discussion in the report is correct in that the principal process involved in reducing nitrate loss in subsurface drainage discharge is the reduction of discharge volume by control structures installed at the drain outlets that retard outflow during selected periods of each cropping season or each year. The research that has been reported at several locations indicate that the reduction in nitrate discharged with the subsurface drainage outflow is almost directly proportional to the reduction in drainage discharge volume due to the outlet control structures. For some research studies reported from North Carolina (Skaggs), Ohio (Fausey), and Louisiana (Grigg and Fouss), reductions in outflow, and correspondingly the reduction in nitrate loss, have been from 40 to 50% when compared to uncontrolled subsurface drainage.

Only limited research has been conducted on the level of denitrification that occurs in the soil profile when the water table depth is held above the subsurface drainpipes (i.e., shallower than the drainpipes) for extended periods of time, for example in the Fall following crop harvest. Further experiments are needed to quantify the denitrification that occurs in the soil profile when the water table exists above the drainpipe depth for extended periods. Such experiments are especially needed in regions of the Midwest and Southern States where extreme cold air temperatures and freezing soils do not occur. With a better understanding of the denitrification that occurs in the soil profile where controlled-drainage systems are implemented, management and timing of adjustments for water table depth set points could perhaps be optimized to take a much better advantage of the denitrification factor, and thus further reduce the nitrate concentrations in the soil profile during certain periods of each season. However, one needs to keep in mind that the denitrification will not be large a factor in reducing total nitrate discharge from the subsurface drains as controlling the drainage outflow volume during the season, but in some cases the denitrification may be significant enough that the operation of the controlled-drainage system should insure that denitrification is enhanced as much as possible.

There is considerable discussion in the SAB's report concerning surface runoff when the water table depth is "held" shallow by controlled-drainage; actually controlled drainage does not "hold" the water table at any set depth, but merely permits drainage to occur in the soil profile only down to the outlet control set depth – any water table movement deeper than the controller set depth occurs due to evapotranspiration or lateral seepage from the soil profile. Thus, the controlled-drainage systems are unlike "water table control systems" for which both controlled-drainage and subirrigation modes of operation are implemented; the subirrigation mode permits putting water back through the drainpipes and into the soil profile to raise or "hold" a water table that is receding due to evapotranspiration and/or lateral seepage. It is proposed by some advocates of drainage water management systems (myself included) that the controlled-drainage set depth at the drain outlet control structure should be deep enough to allow some infiltration of rainfall, thus minimizing excessive surface runoff for typical storm events; for example, setting the controlled-drainage structure for a 30-in. depth in the profile would be a better operational mode that if the control structure were set at a 12- or 18-in. depth. For the typical subsurface drainpipes that are installed at the 36- to 48-in. depth, the 30-in. level for the controlled-drainage setting would allow soil profile voids for infiltration, thus reducing the potential for excessive runoff for some typical storms, and also the 30-in. depth is deep enough to avoid crop root damage for most crops by excessive soil-water conditions for extended periods of time.

The SAB report also discusses various options for reducing fertilizer inputs to reduce the potential for loss of nitrate applied in excess of the crop needs. If appropriate changes are made in fertility application and timing practices, and considering the revised fertility practices integrated or combined with controlled-drainage where the timing of water management operations is integrated or coordinated with fertility applications – keeping in mind short-term weather forecasts – then even greater reductions in the potential for loosing nitrates in subsurface drainage discharge could be realized. This will require a higher level of decision making for the combined or integrated management of water and fertilizers, with timing decisions based on short-term weather forecasts, but this type of management will very likely be a requirement to meet the goals that have been set forth for meeting reductions in nitrate loss from drained cropland and the eventual shrinking of the hypoxic zone in the Northern Gulf of Mexico. As to whether this can be a voluntary management program, or will require some new regulation, is still a serious matter for discussion. Some of the suggestions made in other public comments about the power of the press and opinions of the public on such matters can play a major role is getting new and innovative management practices adopted and used without the need for new regulations – I hope that this latter scenario is the case that proves to work for fixing the problems resulting from the excessive loss of nitrate from drained cropland in the Midwest. It should be the initial approach, led by the Cooperative Extension Service and NRCS, before new regulations are considered.

The SAB report presents a good discussion on the use of bio-filters or bio-reactors in combination with controlled-drainage systems. I do not see the bio-filters as a stand-along management practice to remove nitrate from subsurface drainage discharge. I will only make two additional points here: (1) I consider the use of bio-filters, or –reactors as a complimentary practice that should be applied beyond the controlled-drainage outlet structure to further reduce nitrate in the drainage discharge that is not removed by the controlled-drainage implementation. I have seen reports (e.g., from Illinois and Iowa) where the additional reduction in nitrate in the bio-filter is 50%. Thus, this would provide a total reduction of nitrate in the order of 75% when controlled-drainage and a downslope bio-filter is installed prior to allowing the drainage discharge to enter an open drainage channel or canal, etc. Point (2): It is recognized that for high flow events the peak flows need to by-pass the bio-filter; in such cases, routing the overflow into wetland resource areas to remove the excess nitrate should be considered where ever possible or feasible.

Another point for my discussion here concerns the timing for implementing the different controlled-drainage modes during a cropping season or on an annual basis. The SAB report discusses the concern of allowing the water table to drain to deeper deeps in the Spring, prior to preparing the cropland for planting and during the actual time it is planted, because of the potential nitrate release that coincides with the time of year when nitrate flow into the Gulf has the biggest impact on that year's hypoxic zone size (area). The amount of nitrate that would be lost from the cropland by this Spring time change in the drainage control depends on the denitrification that took place over the winter months when the water table was held shallower, and secondly on the timing for application of the fertilizer for the current season's crop. It must be emphasized that it is essential that the soil profile for most of the Midwestern cropland be drained deeper in the Spring to allow for seedbed preparation and planting (that was one of the major reasons for the farmer installing the drainage in the first place – perhaps many years ago), but likewise it can be pointed out that drainage of the cropland during the actual growing season is typically not as important due to changes in rainfall patterns in many Midwestern areas and increasing ET demands by the growing crop. In fact for some of the Midwestern soils in some cases it may not be necessary or even desirable to implement the controlled-drainage mode during the active crop growing season, however, it is my recommendation that the drain outlet should still be maintained at a level (depth) somewhat less than the drainpipe depth to prevent nearly direct discharge following rainfall events of infiltrated rain that can carry readily available nitrate in the soil profile; research during drought seasons has shown periodic discharges from uncontrolled drainage systems during occasional rainfall events to be excessively high in nitrate content (Agricultural Research magazine, Vol. 50, No. 10, p. 4-8, 2002). It seems to me that it may become necessary in some soils to apply time-release fertilizer to control the potential for loss in drainage discharge. This will require additional research to properly integrate the time-release fertilizer application practice with drainage water management, however, such research should also address another important issue and that is just much fertilizer needs to be applied to optimize crop yield and farmer profits. I realize that currently time-release fertilizer is more costly, but considering less could be applied and thus potentially substantially less loss in drainage discharge, the economic impact to the farmer's profit may be minimal or even an increase in profit. Research is needed on this important point.

The last point I will make in these comments is that for most cases to manage subsurface drainage discharge from cropland such that nitrate loss is minimized will require a suite of practices – not just one practice will do it. Even when controlled-drainage is most effective, it has been found to reduce nitrate loss by only 50% - significant yes, and important because it is an on-farm practice and not one implemented downstream. But, the job is still not done. Thus other practices will need to be combined or integrated with drainage management or other primary practices to provide a comprehensive management system. One discussed in the SAB report that is very effective in many cases is diversion of drainage channel or small stream flow through wetland resource areas to remove excess nitrate and sediment before the drainage water is allowed to return to the main stream or river for "flow to the Gulf." In almost all cases the wetland diversion approach is an off-site and down-stream management system, and many times not in control of the farmer. Thus, other organizations or groups need to be instrumental in the implementation and management of such diversion systems. I consider the wetland diversion option as a "polishing treatment" for the drainage discharge water to further improve its quality. It should not be the only approach implemented however, as noted; a Suite of Practices will be required to do the job.