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Nutrient reduction strategy: One farm, many practices

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Introduction

With the release of the Iowa Nutrient Reduction Strategy (2013) in early 2013 there has been increased interest in what practices can be utilized by farmers to reduce nutrient export to downstream water bodies. As highlighted by the ISU Extension and Outreach Special Publication 235 (2013) there are many in-field, land use, and edge-of-field practices that have potential to reduce nutrient export. However, to reach the nutrient load reduction goals of 45% on both nitrate-N and phosphorus will require a combination of practices. As a result, there is a need to examine individual fields or small watersheds considering the range of practices to assess how the practices can be combined to reach the desired outcomes. In this paper, we consider a case study watershed of about 1200 acres and examine individual and combinations of practices to reduce nitrate-N export from this area.

Existing conditions

The case study watershed is 1160 acres, has an average slope of 2.5%, and is almost all in row crop production (corn-soybean rotation) (Figure 1). From the Iowa Nutrient Reduction Strategy Science Assessment, the average nitrogen application for this Major Land Resource Area is 184 lb-N/acre for corn following soybeans. For the case study this application rate was used for assessing impacts of nitrogen management changes. To conduct a site-specific assessment for computing nitrate-N loads it would be important to collect on-site nutrient use information.

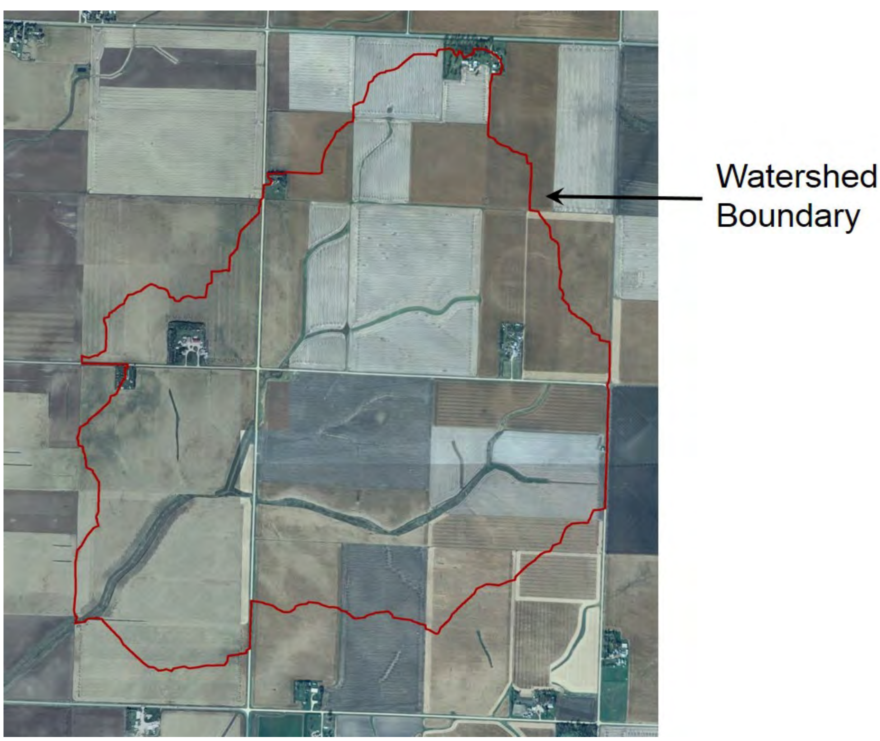

Figure 1. Watershed boundary

Nutrient reduction practices

While there are many nitrate-N reduction practices, four practices that would likely be well suited for this area are nitrogen management, cover crops, subsurface drainage bioreactors, and a wetland. Both nitrogen management and cover crops could be used over the entire area. Bioreactors would need to be positioned in an area to intercept field subsurface drainage. Potential siting locations for bioreactors are as shown in Figure 2. Siting for a wetland would be more challenging and many watersheds may not have a site well suited for wetland creation/restoration. However, there is a possibility that there is a potential wetland site as shown in Figure 3. Using these four practices as examples, the potential load reduction from implementation can be computed as standalone practices or when used in combination.

Nitrogen Management (Rate)

As noted above the estimated nitrogen application rate for this area is 184 lb-N/acre so if the application was reduced from this rate to the Maximum Return to Nitrogen for corn following soybeans using $5/bushel corn and $.50/lb nitrogen (134 lb-N/acre), it is estimated the nitrate-N concentration load might be reduced 29% from the baseline conditions based on the relationship from Lawlor et al. (2008) (Figure 4) (Table 1). The load reduction that could be made with reducing nitrogen application would be much less if the existing application rate is closer to the MRTN.

Cover Crops

Cover crops would be a practice that could work on the majority of the acres and would have both nitrate-N and phosphorus benefits. However, given that cover crops would fit best with a reduced-till or no-till system it might be difficult to get cover crops on all the acres. But if even 50% of the acres were planted to cover crops the estimated nitrate-N reduction would be 16% and over time there is likely to be soil quality benefits.

Subsurface drainage bioreactors

Subsurface drainage bioreactors are a practice where field drainage is routed through a bed or trench of woodchips and a portion of the nitrate-N in the drainage water is removed via denitrification. The acreage treated by each bioreactor might be in the range of 80-100 acres and the location would need to be sited where the drainage water can be intercepted and routed through the bioreactor. There are a few potential sites within this watershed that may work for installation of a bioreactor (Figure 2). Based on the summarized performance of the bioreactor it is estimated that if 25% of the area was treated with a bioreactor there might be slightly over a 6% reduction in nitrate-N load.

Wetlands

Wetlands sited to intercept subsurface drainage have been shown to be very effective for removing nitrate-N via the denitrification process. This concept has been used as part of the Iowa Conservation Reserve Enhancement Program (Iowa CREP - http://www.iowacrep.org/). These types of wetlands make take a few percent of the watershed area out of the production for the wetland and surrounding buffer. Reviewing the watershed area it appears there is the potential for a wetland just downstream from the watershed outlet (Figure 3). If positioned in this location it is estimated this wetland might reduce overall nitrate-N export by 52% when compared to the baseline condition. This wetland might also provide other watershed benefits including habitat, aesthetic value, and some flow attenuation. It should be noted that not all watersheds of this size would have a potential wetland site.

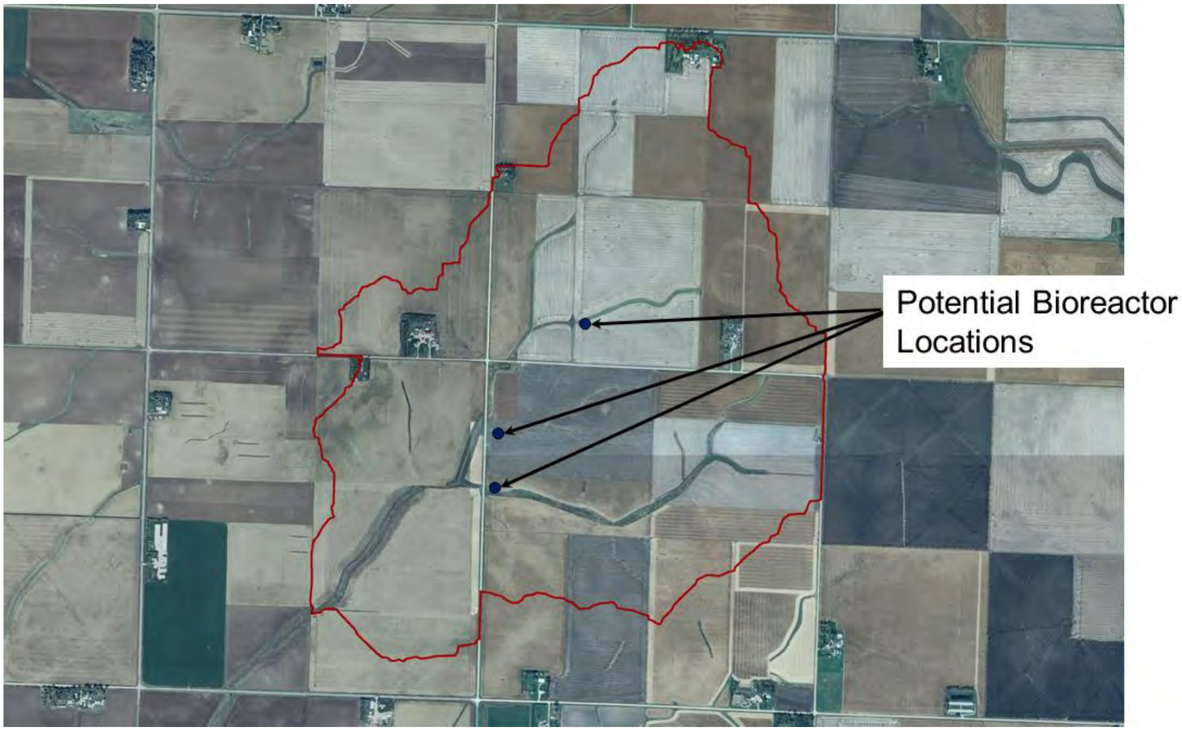

Figure 2. Potential locations for subsurface drainage bioreactors

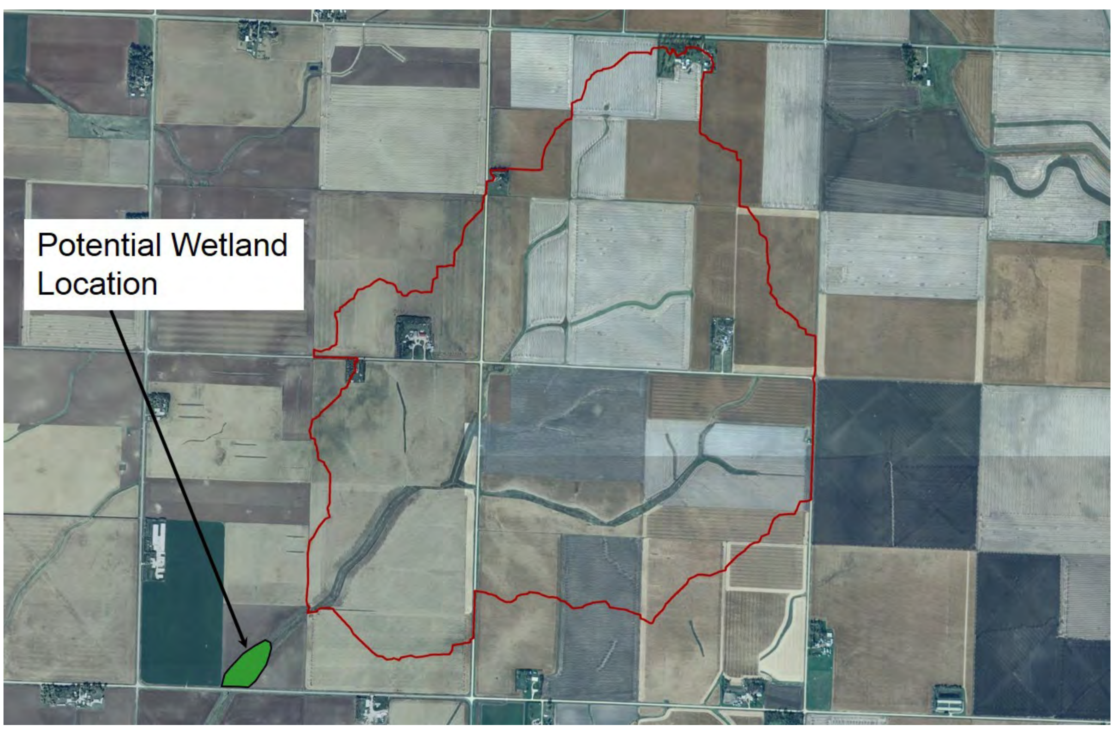

Figure 3. Potential location for a wetland

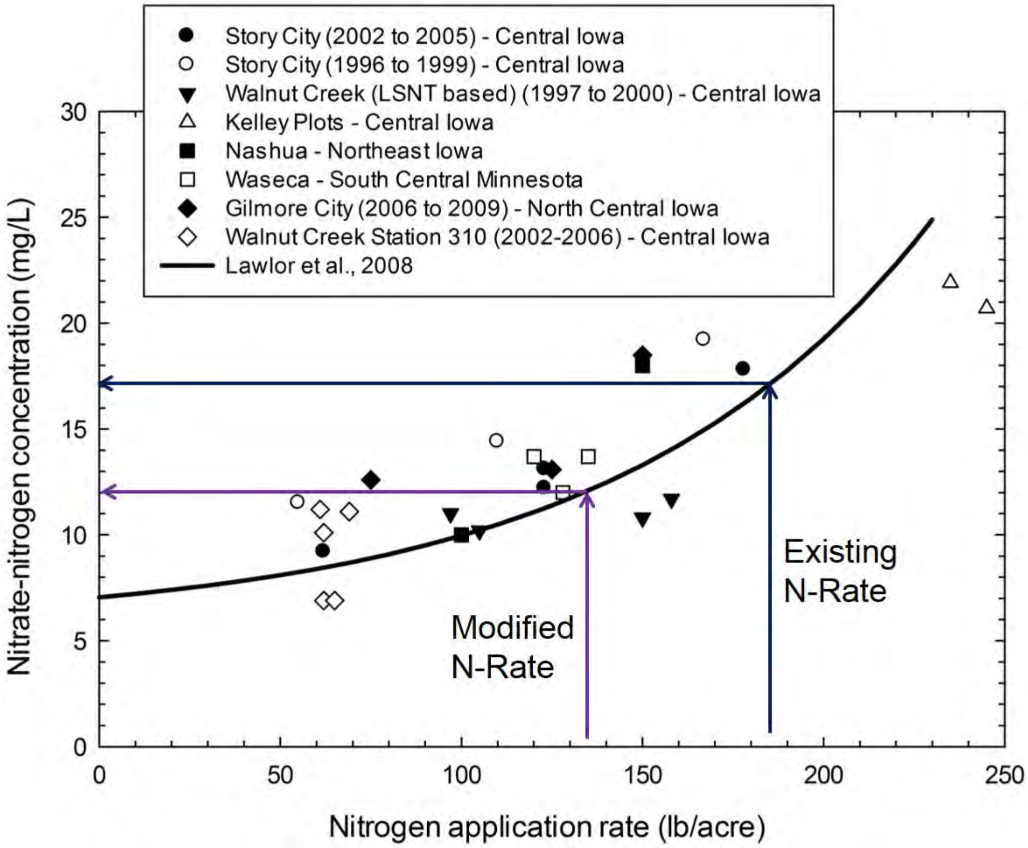

Figure 4. Overall nitrogen application rate effect on nitrate-N concentration in tile drainage

Table 1. Estimated nitrate-N concentration and load reduction from nitrate-N reduction practices

Condition – Practice	Nitrate-N Concentration (mg/L)	Nitrate-N Load (lb-N/acre)	% Reduction in Nitrate-N Load from the Baseline	Other Benefits
Existing	14.3	23.8		
Reduce N rate to MRTN (184 to 134 lb-N/acre)	10	16.8	29	
Cover Crops on 50% of Acres	12	20	16	Soil quality
Bioreactor for 25% acres	13	22.3	6.3	
Wetland to Treat 1160 Acres	6.8	11.4	52	Aesthetics, habitat, and flow

Combination of nutrient reduction practices

When reviewing the potential nitrate-N reduction benefits from the standalone practices it is obvious that other than the wetland no one practice would reach the 45% load reduction goals which would necessitate using a combination of practices. Using this approach there is potential to nearly achieve or in the case of utilization of a wetland exceed the goal. For the case where a wetland is used in combination with other practices to get greater than 45% reduction this could be desirable for an individual area especially if other locations are not able to meet the goal. In assessing various combinations the other benefits provided by the practices may want to be considered. For example, while the scenario with utilization of the MRTN and bioreactors may achieve a 34% reduction, these two practices provide few other benefits whereas the scenarios that include wetlands and/or cover crops may provide other benefits.

Table 2. Estimated nitrate-N concentration and load reduction from combinations of nitrate-N reduction practices

Condition – Practice	Nitrate-N Concentration (mg/L)	Nitrate-N Load (lb-N/acre)	% Reduction in Nitrate-N Load from the Baseline	Other Benefits
Existing	14.3	23.8		
Reduce N rate to MRTN	10	16.8	29	
Cover Crops on 50% of Acres with MRTN	8.6	14.3	40	Soil quality
Bioreactor for 25% acres with MRTN	9.4	15.8	34	
Wetland to Treat 1160 Acres with MRTN and Cover Crops on 50% of Acres	4.1	6.8	71	Aesthetics, habitat, flow, and soil quality

Conclusions

Reducing nutrient movement to downstream water bodies is likely to become increasingly critical in the years ahead. The Iowa Nutrient Reduction Strategy Non-Point Source Science Assessment identified many practices that could be used to reduce nutrient loading. For an individual farmer there may be many practices that could be implemented and in many cases combinations of practices may be needed to achieve the goals. In addition, when considering practices it may be important to evaluate what other benefits might be provided by the practice.

References

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