History of the UMD WREC Cover Crop Program

The initial phase of the cover crop studies began in 1984 with studies of water and nutrient transport processes in Maryland Coastal Plain cropland. Two adjacent field watersheds were fully instrumented to measure the movement of water and nutrients through surface and groundwater flow paths throughout the entire year. The fields were planted continuously with corn since it is the predominant crop in the region and the major crop that requires the highest nitrogen application rates. Since winter cover crops were not typically planted in Maryland during the 1980's, the fields were left fallow from corn harvest until spring planting the next year from 1984 through 1987. During this period, it was determined that more than 80% of the nitrogen lost from the fields was leached from the root zone (~the top 2 feet of the soil profile) as nitrate-nitrogen, primarily during late fall and winter when most groundwater recharge occurs. Even when applying nitrogen fertilizers at the recommended rate and using optimum timing to maximize uptake efficiency, annual nitrogen leaching losses were found to average 20-30 pounds/acre, and resulted in groundwater nitrate-nitrogen concentrations under the fields in excess of 10 ppm, the drinking water standard. Stream sampling in the mid-Eastern Shore agriculturally dominated watersheds corroborated the WREC research watershed findings as stream base flow nitrate concentrations were found to be 10 to 100 times higher than those from forested watersheds, and stream base flow nitrate was the dominant component of annual nitrogen loads delivered to Chesapeake Bay from Eastern Shore watersheds.

Extensive soil sampling in some plot studies conducted in 1987-88 was used to determine that the amount of nitrate in the root zone at the beginning of the winter leaching/groundwater recharge period was the primary determinant of annual nitrate leaching losses and total field nitrogen losses. Some of these losses are the result of how much nitrogen fertilizer was applied, but a major component also was the result of nitrate released in the soil late in the growing season after corn nitrogen use had stopped as the corn completed its life cycle. A second finding of these studies was that rye planted after corn harvest could take up a major fraction of soil nitrate before the onset of the groundwater recharge season, thereby greatly reducing the potential for nitrate leaching.

To test the effectiveness of cover crops at the field watershed scale, following the 1988 corn harvest rye cover crops were planted in the two study watersheds. For the next 8 years, corn was planted every year in the two watersheds using no-till methods in one and conventional tillage in the other, and each year following grain harvest rye cover crops were planted as soon as possible. Nitrogen application rates to the corn crops remained constant throughout the period at approximately 140 pounds/acre. Groundwater nitrate concentrations (Figure 1) were measured several times each year in a total of 16 wells in the two watersheds. Since there is a significant quantity of water stored in the soil profile between the root zone and the water table, the effect of cover crops on groundwater nitrate concentrations took about 8 years to be fully reflected in the groundwater samples. The upward spike in groundwater nitrate concentrations in the first two years after cover crops were first planted is the result of high nitrate losses stored in the soil profile as a result of summer droughts in 1986 and 1987 that reduced corn nitrogen uptake and resulted in unusually high nitrate leaching losses. The drop in nitrate concentrations in the no-till watershed was more rapid primarily because on average the water table is closer to the soil surface, resulting in less water storage between the root zone and surface of shallow groundwater.

As a follow-up to the field watershed studies described above, a second study was conducted to track the movement of nitrate in groundwater under cropland to its discharge point into surface water, and also to determine the time required for changes in nitrate leaching to be reflected in discharging groundwater nitrogen loads delivered to surface waters. Much of the cropland on the Eastern Shore, and all of that located at UMD WREC is located directly adjacent to tidal waters, and groundwater discharges through the intertidal zone rather than into a stream that flows to tidal waters. But whether in an inland setting where groundwater is discharged into a stream, or in fields next to tidal waters, the basic process of groundwater recharge and discharge is the same with shallow groundwater moving laterally to discharge points into a surface water body at a lower point in the landscape. A cross-section of the field where this study was conducted and the groundwater monitoring system is shown in Figure 2 with the discharge zone being the intertidal zone of the Wye River. In addition to the groundwater sampling wells, extensive soil sampling was conducted to the depth of the water table to track nitrate movement from the root zone to the water table. Throughout this study the field was planted in a corn-soybean rotation as it had been for many years before monitoring began with nitrogen applied to the corn at a rate of 180 pounds/acre. Winter cover crops had not been used in this field in recent history. Following the 1993 growing season, a rye winter cover crop was planted after harvest and every year thereafter.

The results shown in Figure 3 show the progressive decline in nitrate concentrations in different parts of the flow system after winter cover crops started being used. The intermediate vadose zone (IVZ) is the part of the soil profile between the crop rooting zone and the water table. It can be seen in Figure 2 that the thickness of this zone decreases moving from higher areas of the field towards the Wye River. As would be expected, nitrate concentrations decreased the soonest in the shallowest part of the system, the upper layer of the IVZ, with the deeper groundwater samples being the last to respond. Since this field was located directly adjacent to the discharge zone, discharge zone nitrate concentrations started to respond almost immediately since leachate near the field edge had a very short travel distance to the water table and discharge zone. In addition to concentration monitoring, the rate of groundwater discharge also was monitored at this site (Figure 4), making it possible to determine the actual change in the nitrogen loading to the Wye River at this site due to the use of cover crops. Since cover crops do not change discharge volume, changes in nitrate concentration will eventually result in similar changes in nitrogen loads. High discharge volumes from 1996-1998 kept discharge loads elevated somewhat relative to the change in concentration but when discharge volume was near average in 1999 the full impact of cover crops on nitrate loads was apparent with a more than 60 percent reduction compared to typical flow years before cover crop use began. Like the results shown in Figure 1, many years of continuous cover crop use were required before groundwater and discharge water fully reflected the impact of the use of cover crops. It also should be noted that nitrogen discharge from this site, since it is located so close to the discharge zone, would be expected to have a more rapid response to cover crops compared to more inland settings were average groundwater travel times from the root zone to the discharge zone are longer.

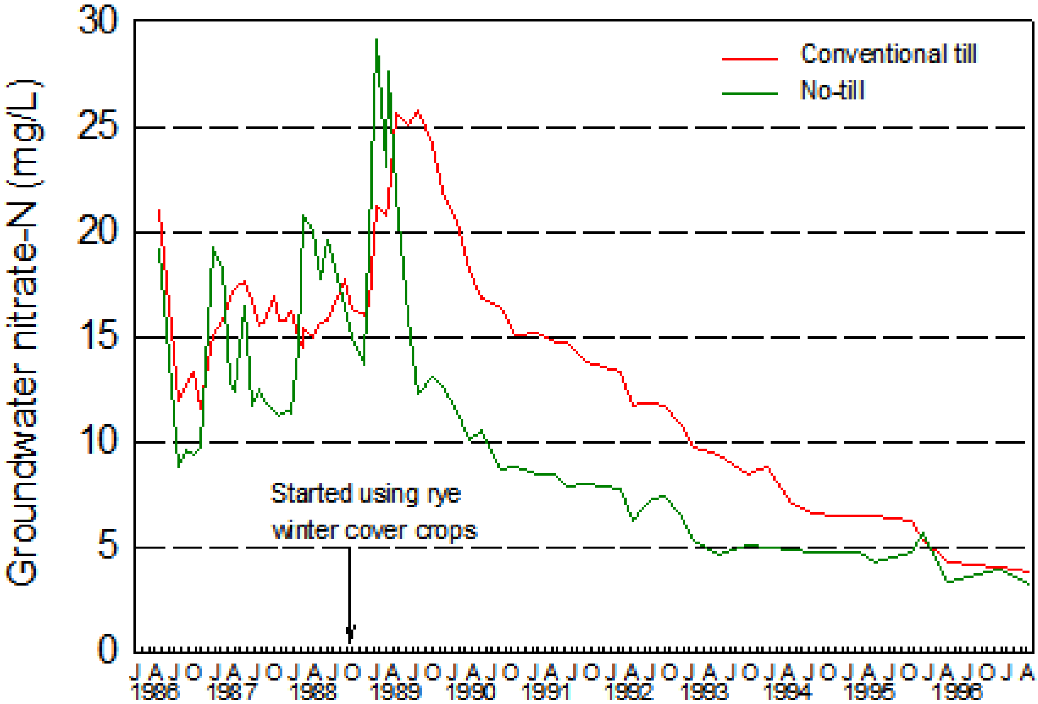

Figure 1. Average groundwater nitrate concentrations under fields planted continuously with corn with the use of cover crops initiated following the 1988 growing season.

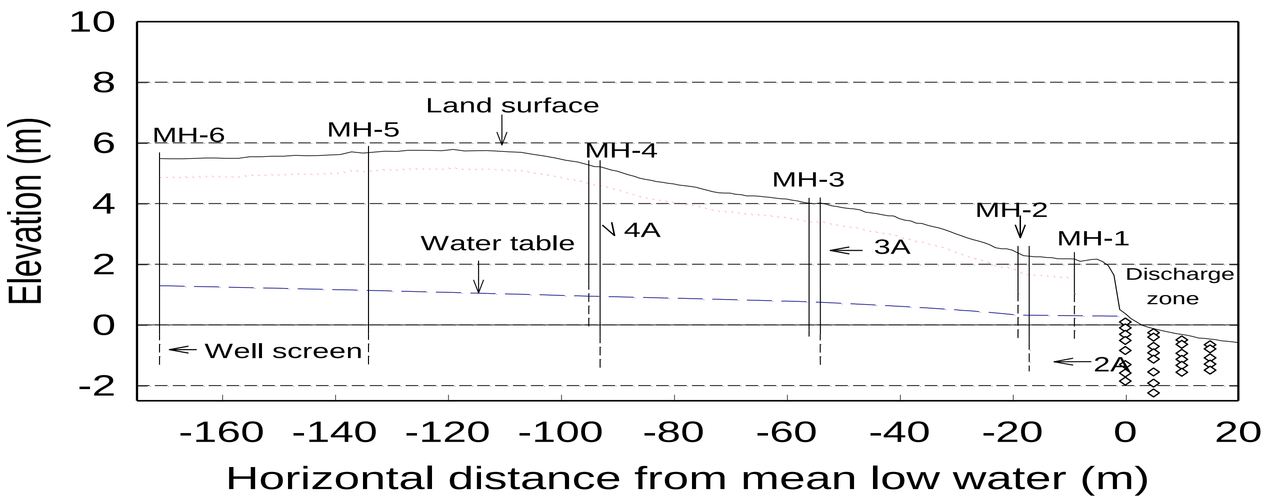

Figure 2. Cross-section of the study area and the monitoring system used to track the effects of cover crop use on nitrate-nitrogen delivered to the Wye River.

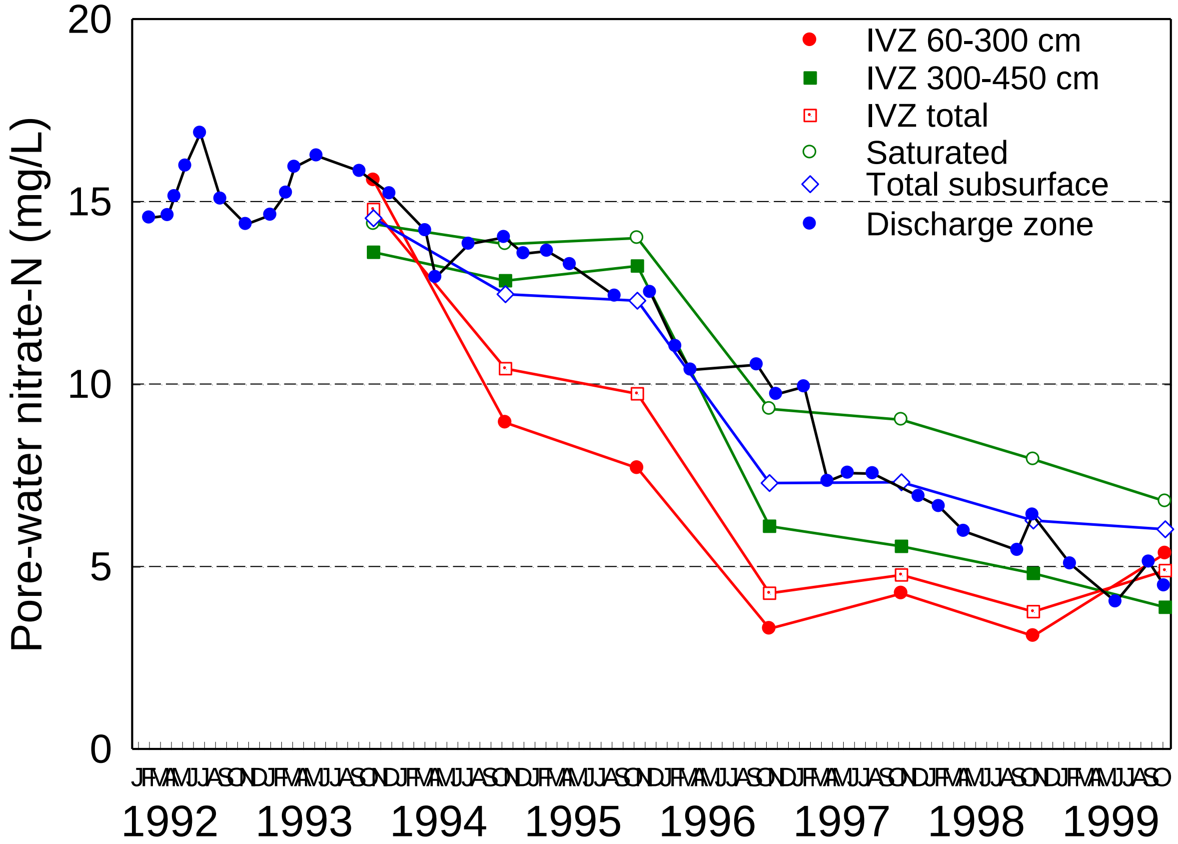

Figure 3. Nitrate-nitrogen concentrations in various components of the groundwater flow system under a crop field adjacent to Wye River where the use of rye winter cover crops was initiated in a corn-soybean rotation following the 1993 growing season. Intermediate vadoze zone (IVZ) is the area of the soil profile between the root zone and the water table (the red and blue lines in Figure 2).

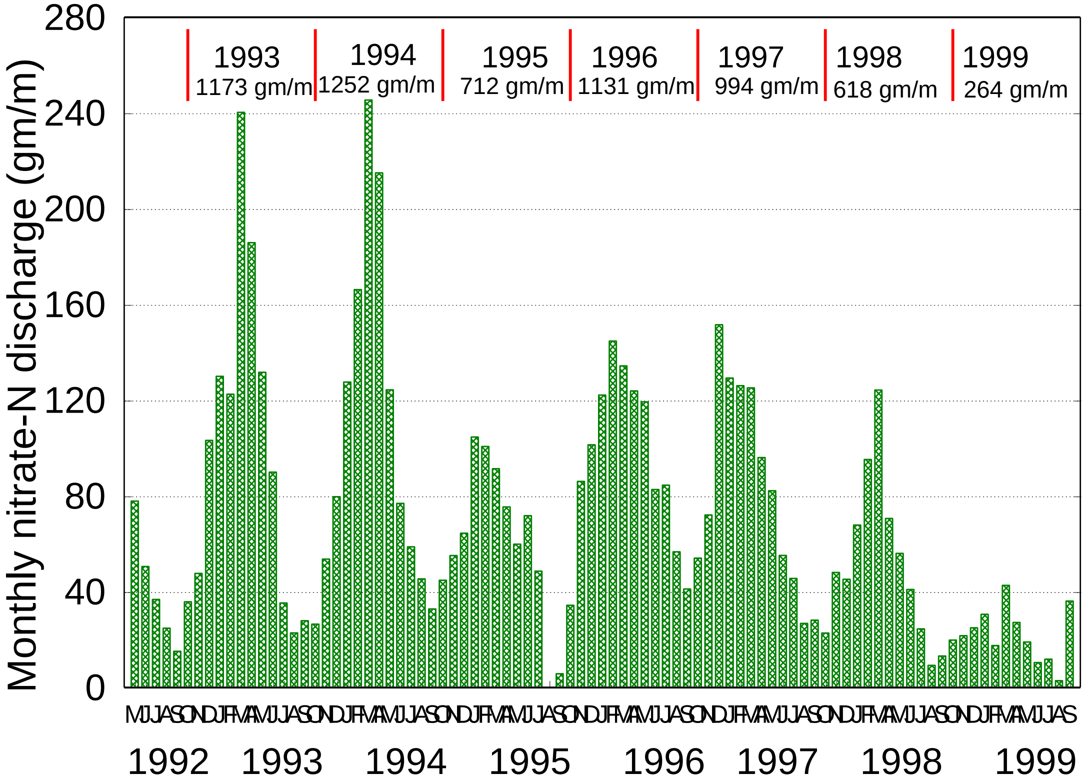

Figure 4. Monthly and annual nitrate-nitrogen discharge into the Wye River per unit width (1 meter) of shoreline from a crop field planted in a corn-soybean rotation with rye cover crop use initiated in the fall of 1993.

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