University of Wisconsin – Extension
DISCOVERY FARMS
University of Wisconsin – Madison

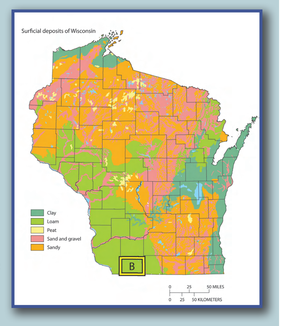
MANURE MANAGEMENT IMPACTS ON SURFACE-WATER RUNOFF QUALITY from a Wisconsin Agricultural Landscape

USGS science for a changing world

Dennis Frame [1], Fred Madison [1], Kevan Klingberg [1], Matt Komiskey [2], Todd Stuntebeck [2]
[1] UW-Discovery Farms – University of Wisconsin Extension, [2] U.S. Geological Survey, Middleton, WI

INTRODUCTION

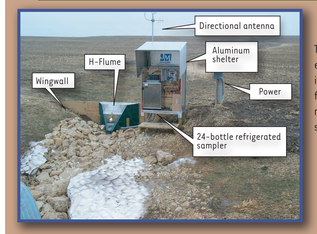
The University of Wisconsin Discovery Farms Program was created to determine the environmental impacts of the diverse farming systems that exist in Wisconsin. If negative impacts are identified, program staff works with the producer to see if the farming system can be modified to mitigate environmental impacts, while ensuring that the farming operation remains economically viable. Research information is also used to educate and improve communications among the agricultural community, consumers, researchers, and policy makers to better identify and implement effective environmental management practices that are based on real science and are compatible with profitable agriculture. The U.S. Geological Survey (USGS), in cooperation with UW-Discovery Farms, has installed 25 water-quality monitoring stations on seven farms in various physiographic and hydrologic settings in Wisconsin. The study design allows for water-quality comparisons to be made both within farm and between farms to help understand how each farming system affects water quality. Depending upon the hydrologic setting of the farm, monitoring stations can be located in grassed waterways, within streams, or in subsurface drain tiles. Sites are monitored for five to seven years, allowing for two to three years of background data, and three to four years of data collection after management changes are implemented.



Farm B

This poster focuses on data from Farm B in Lafayette County (outlined in yellow above). The farm is located in southwest Wisconsin and has managed a no-till / direct plant cropping system in a corn / soybean rotation for over 15 years. This farm also finishes beef steers and participated in a state-funded watershed project that helped pay for the implementation of barnyard runoff-control practices and field terraces. Farm B soils are classified as deep, well-drained silt loams, and are considered to be some of the most productive in the area. Livestock manure applications were a combination of surface-applied bedded pack beef manure, as well as liquid dairy manure from a neighboring farm. There are three surface-water-monitoring sites located within three separate grassed waterways, and the contributing basins range in size between 17 and 39.5 acres.

HOW ARE WATER-QUALITY DATA COLLECTED?

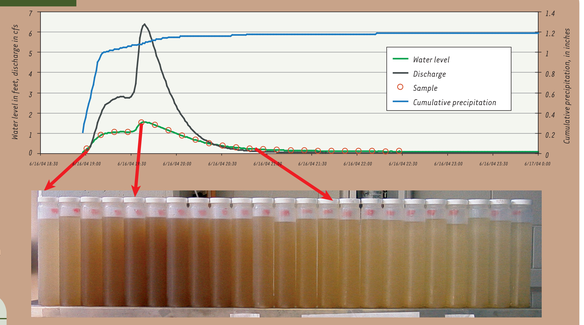


This is a typical equipment installation for surface-water monitoring stations.

All data are retrieved at least twice daily via communications devices. All data are stored in the USGS National Water Information System (NWIS) database.

Constituent List

- Suspended sediment
- Total dissolved solids
- Total phosphorus
- Dissolved reactive phosphorus
- Nitrate plus nitrite nitrogen
- Ammonium nitrogen
- Total Kjeldahl nitrogen
- Chloride

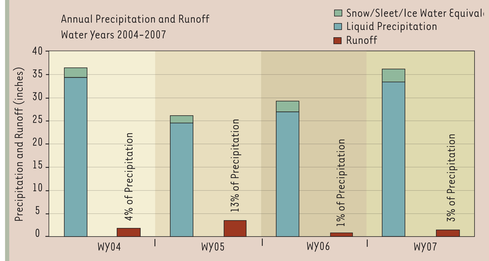


This is a hydrograph for a typical runoff event. Bottles shown are the actual samples collected during this runoff event.

An event loss or yield (pounds / acre) is calculated by multiplying the constituent concentration by the event volume and dividing by the basin area.

AGRICULTURAL RUNOFF DATA

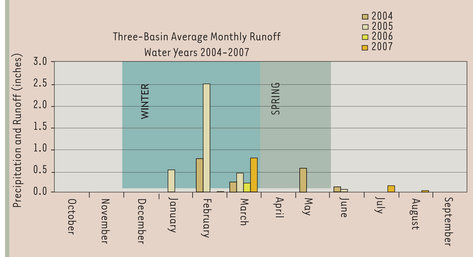
How much surface-water runoff was produced by these farm fields?



Precipitation Highlights:

- Above or below average precipitation in any year was not necessarily related to runoff amount.
- Approximately 5 percent of measured precipitation contributed to surface-water runoff.

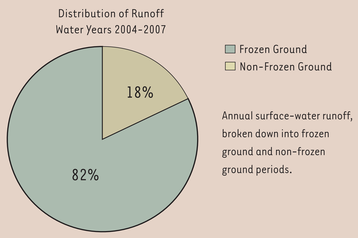
When did the surface-water runoff occur?



- Most surface-water runoff occurred either when the ground was frozen, or when soils were wet and vegetative cover was minimal.

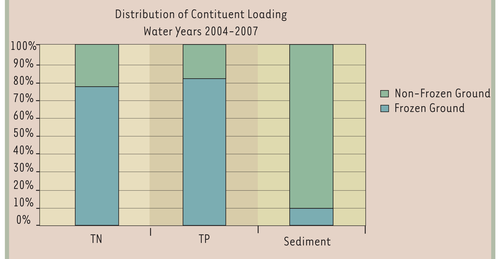
More than 75 percent of all nutrient losses occurred when the ground was frozen.

What does the frozen ground period contribute to the annual surface-water runoff?



Annual surface-water runoff, broken down into frozen ground and non-frozen ground periods.

- More than 80 percent of surface-water runoff occurred when the ground was frozen.



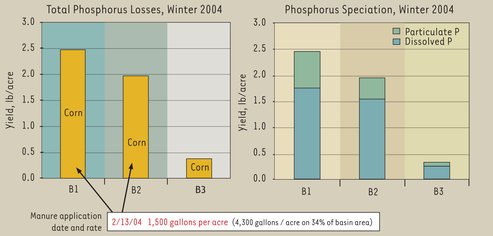
- More than 75 percent of total nitrogen and more than 80 percent of total phosphorus were lost to surface-water runoff when the ground was frozen.
- Less than 10 percent of the annual suspended sediment runoff occurred when the ground was frozen.

These observations indicate that a majority of the nutrient losses were not associated with sediment loss. Why?
Manure management was an important factor.

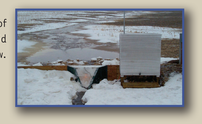
MANURE MANAGEMENT IMPACTS

In Wisconsin, livestock manure is applied in many different ways and at different times of the year depending on the producer's management style. Manure is applied by surface spreading, as well as by injection and incorporation into the soil. Some producers apply manure every day. Others, who have storage, wait until crops are gone and the soil is firm enough to drive equipment on. In Wisconsin, these conditions typically occur in early spring or late in the fall and into the winter. Unfortunately, the time periods that Wisconsin producers typically spread manure often coincide with seasonal periods when the potential for surface-water runoff is high. This creates a potential risk to water resources.

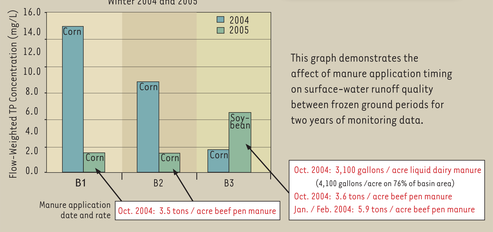
What is the affect of manure application timing to phosphorus losses?



- Liquid dairy manure was surface applied on Feb.13, 2004 in basins B1 and B2.
- Management (other than manure application) in the basins was similar, highlighted by the same crop type in all three basins.
- The magnitude of total phosphorus losses in surface-water runoff during periods of frozen ground was greater in B1 and B2 than at B3. This is likely due to the manure application on Feb. 13, 2004.
- The ground on Feb. 13, 2004 was frozen and snow covered. Runoff began on Feb. 18, 2004.
- Most of the total phosphorus lost during periods of frozen ground was in the dissolved form.



Basin B1 at the start of snowmelt, showing liquid manure on top of snow.



This graph demonstrates the affect of manure application timing on surface-water runoff quality between frozen ground periods for two years of monitoring data.

- Sites B1 and B2 showed a decrease in total phosphorus concentrations between frozen-ground periods for 2004 and 2005, while B3 showed an increase.
  - The decrease at B1 and B2 is likely due to not applying manure in Feb. 2005.
  - The increase at B3 is likely due to the Jan. and Feb. manure applications in 2005.
  - Most of the winter 2005 runoff occurred between Feb. 3-14.
- The manure applied in basin B3, Jan. – Feb. 2005, was beef pen manure, indicating that both liquid and solid manure consistencies can impact agricultural surface-water runoff quality when applied immediately prior to snow melt.
- Despite relatively low manure application rates, increased levels of phosphorus were measured when applications were immediately preceding runoff events.

Beef pack manure being applied.

SUMMARY OF FINDINGS

Over the four years of this study:

- Approximately 80 percent of surface-water runoff occurred when the ground was frozen.
- Surface-water runoff occurred primarily in the late winter (February and March) and again in spring, when vegetative cover was minimal and soils were wet (April – June).
- The periods in which producers typically spread manure to fields in Wisconsin often coincide with the periods in which surface-water runoff is most likely, creating a potential risk to water resources.
- A small percentage of the annual suspended sediment losses occurred when the ground was frozen.
- Over 75 percent of annual nitrogen losses occurred when the ground was frozen.
- Over 80 percent of annual phosphorus losses occurred when the ground was frozen.
- Nutrients lost to surface-water runoff in the frozen ground period were mostly in the dissolved form.
- Nutrient losses were not necessarily associated with sediment losses.
- Most of these nutrient losses were likely due to manure application on frozen, snow covered ground, shortly before snowmelt.
- Both liquid (dairy) and solid (beef) manure applications resulted in nutrient losses to surface-water runoff.

Liquid manure on snow.

- Timing is critical to avoid detrimental impact to water quality when spreading winter manure.
- Livestock manure applied immediately prior to runoff events has a high risk of increasing nitrogen and phosphorus concentrations in surface-water runoff.
- Understanding the relationships between water quality and the timing, rates, and methods of manure application – particularly in the winter – is a big step toward understanding the impact of Wisconsin agriculture on the environment.

Other contributors to the University of Wisconsin - Discovery Farms Program include:

Natural Resources Conservation Service
Wisconsin Department of Natural Resources
Wisconsin Milk Marketing Board
Professional Dairy Producers of Wisconsin
Wisconsin Dairy Business Association
Wisconsin Pork Producers Association
Wisconsin Farm Bureau

UW-Discovery Farms Program
P.O. Box 429
Pigeon Falls, WI 54760
www.uwdiscoveryfarms.org

USGS Wisconsin Water Science Center
8505 Research Way
Middleton, WI 53562
wi.water.usgs.gov