

# **Report as of FY2007 for 2007SD106B: "Evaluation of Manure Application Risk on Frozen Soils"**

## **Publications**

Project 2007SD106B has resulted in no reported publications as of FY2007.

## **Report Follows**

# **Determining Soil Moisture and Temperature Condition Effects on Potential Run-Off for Cold Season Manure Application**

## **Principal Investigators:**

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## **Introduction**

This project is a continuation of a currently funded USGS 104b proposal to determine risk of application of manure on frozen soils and to develop risk assessment indexes for the period of frozen soil and probability of rainfall on frozen soils. The benefit of this research will be a fundamental understanding of the risk of late winter/early spring conditions which lead to excess runoff. These risk assessments based on historical soil temperature and rainfall data will be the outcome of the current 104b proposal. When completed data will be shared with producers and policy-makers in the state (through an advisory group already being established). Both ranchers and policy-makers (NRCS) are interested in the data to provide guidance about the risk of manure application to frozen soils in South Dakota. While we will not be able to be comprehensive and test all possible combinations of conditions (soils, slopes, rainfall rates, manure types, etc.), the testing of common management and climate conditions will provide established guidelines for potential run-off from manure-applied soils.

## **PROJECT INFORMATION**

### **Information transfer**

Presentations about the project and findings were given at the Beef Feeder Council meeting, East Dakota Water Development District Board, Board of Water and Natural Resources, and the Eastern SD Water Conference. Producer groups as well as other agencies were very interested in the results of this project. A project advisory group was established that includes livestock producer groups, SD Farm Bureau, staff from the SD DENR and the NRCS and SDSU staff involved in the project. Results of the project were distributed to the advisory group through regular meetings as they became available.

### **Problem and research objectives**

Currently NRCS guidelines for application of manure on frozen soils are being reviewed in South Dakota. Balancing the risk of application between producer needs and protection of water quality has been a major part of the discussion. Both producers and regulators have sought scientific data to support their cause. But lacking in the discussion has been specific data related to South Dakota based on South Dakota soils and climatic conditions. This project continues the process of evaluating those conditions to help deliver some assessment of risk of application based on soil temperature and soil moisture conditions as well as the risk of water quality impairment by run-off from frozen soils.

In addition, little work has focused on analyzing weather data to determine the risk of occurrence of conditions that are perceived as potentially detrimental to water quality from manure application on frozen ground. There are three winter conditions that are expected to yield runoff:

1. Frozen soil and snowmelt that cannot enter the soil;
2. Snowfall that insulates the soil from freezing but that is in excess to soil storage; and
3. Rainfall on snowpack or frozen soil.

These strategies are being chosen in discussion with a local advisory group to determine common manure management strategies.

The summarization of this data gathered from these combined experiments will begin to answer questions about the risk of manure application on frozen soils in South Dakota based on realistic in-field conditions and meet the following goals for the combined projects.

1. Complete an assessment of the risk of spreading manure on frozen soils,
2. Compare winter manure spreading practices in relation to location, timing and placement to determine which minimize impacts to water quality and develop BMPs,
3. Develop climatic risk factors using frequency of soil frost and rainfall events on the risk of manure application to assist livestock producers in timing manure applications during least risky time periods.

### **Methodology and Principal Findings and Significance for the project**

Year 1 of this project has produced a South Dakota soil temperature climatology. Winter rainfall climatology is under development. These two sets of data will be used to feed the next phase of the study, monitoring and gathering of run-off water for water quality testing with this study combined with potential parallel funding. Data gathered will be based around the testing the water gathered from run-off from the frozen soils. In-field rainfall simulations provided the various rainfall effects necessary to create the run-off from manure applied to frozen soils. Water quality data was gathered to measure the impact of manure applied to frozen soils on the run-off based on various management and soil temperature/moisture conditions. Summaries of these data will be used to create risk assessment products for manure application and help understand the potential impairments to water quality based on manure application.

The plot studies completed during March 2008 evaluated several treatments of winter manure applications followed by a simulated spring rainfall. Treatments included:

1. manure applied on frozen soil,
2. manure on frozen soil followed by snow,
3. manure applied to snow-covered soil receiving additional snow fall, and
4. a control (no manure on frozen soil).

Field conditions at the time of the rain simulation included both snow covered soil as well as bare soil as shown in Figure 1. Two plots were located in snow covered parts of the field at the time of manure application. Soil conditions were very different in the snow covered areas compared to the bare areas. Due to repeated freeze thaw cycles the soil under the snow covered areas was saturated and frozen solid (impermeable) at the time of the simulations. The bare areas were dryer and presented a more porous surface.

Additional snow fell just prior to the commencement of rain simulation. This presented the opportunity to include a treatment of fresh snow over a recent manure application as shown in Figure 3. The control plots and manure on frozen soil plots were protected by tarps to prevent snow accumulation.



Figure 1. Undergraduate student Josh Warne spreads manure on a plot prior to rain simulation.



Figure 2. Bare Frozen Soil



Figure 3. Manure Covered by 3" of Snow



Figure 4. Snow-Manure-Snow

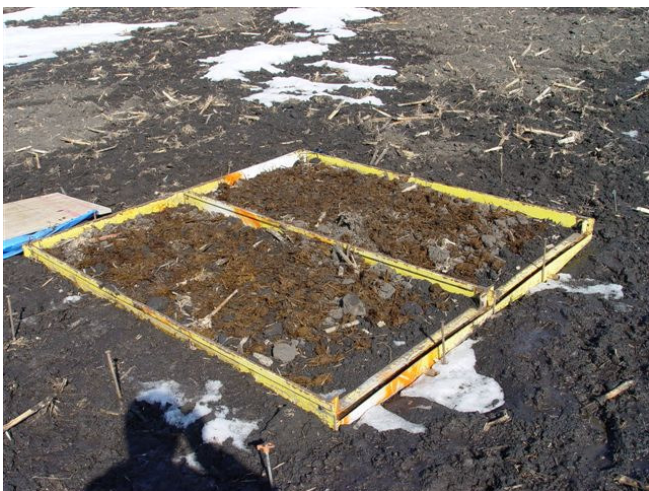


Figure 5. Manure on Frozen Soil



Figure 6. Rain rate was measured at the beginning of each simulation.

Results of rain simulations are presented in Figures 7-10. Concentrations of both total dissolved P and total P were highest for the snow-manure snow treatment. Total dissolved P concentrations were also elevated on the other manured treatments (Figure 7). Ammonia nitrogen concentrations and TKN were higher than the control for all manured treatments (Figures 8 and 9). Fecal coliform bacteria numbers were highest for the snow manure snow treatment (Figure 11). Suspended solids concentrating in runoff from the control plots was higher than the three manured treatments (Figure 10). This finding is consistent with other studies that reported a mulching effect of manure that reduced soil erosion. (Young, 1974; Young and Mutchler, 1976; Hensler et al., 1970, Meals et.al., 1991).

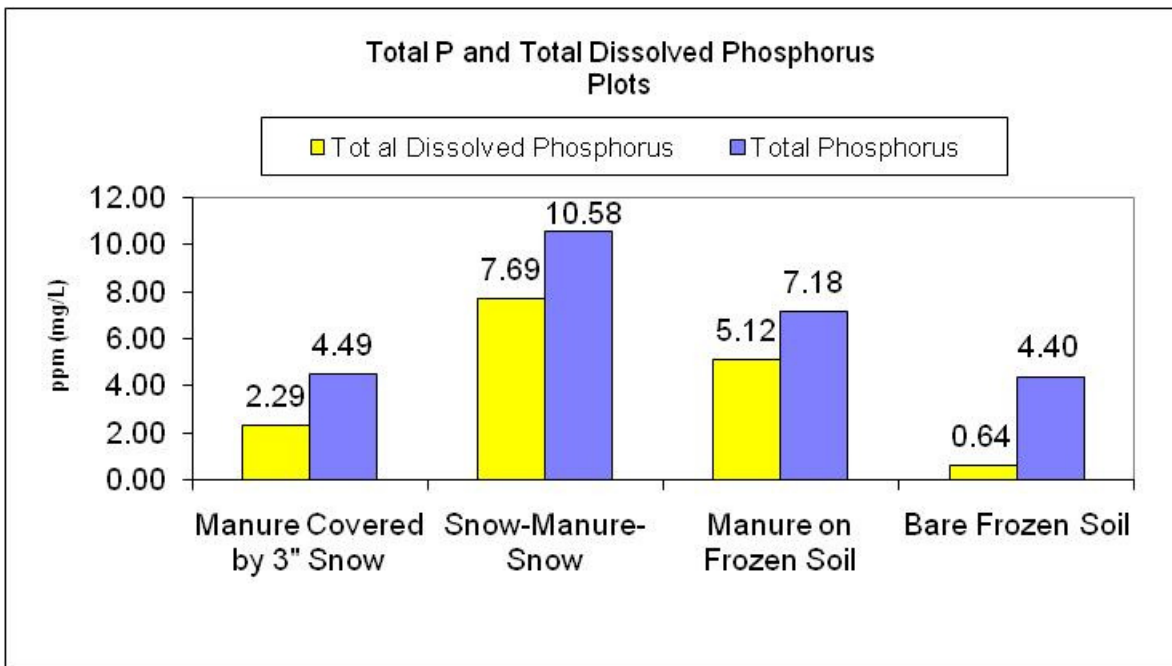


Figure 7. Total P and Total dissolved P in plot runoff.

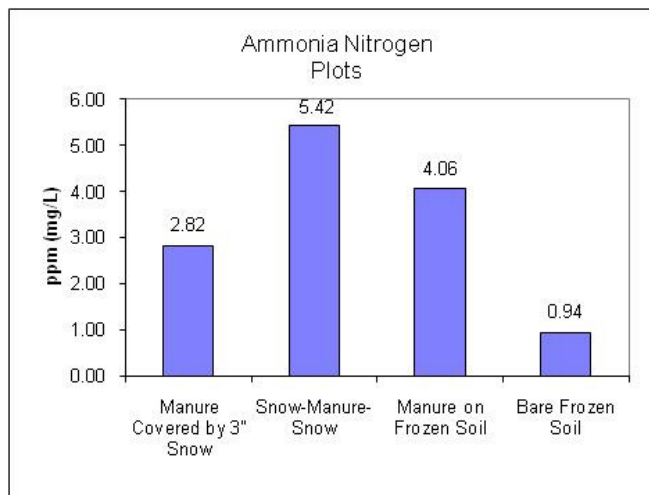


Figure 8. Ammonia nitrogen in plot runoff.

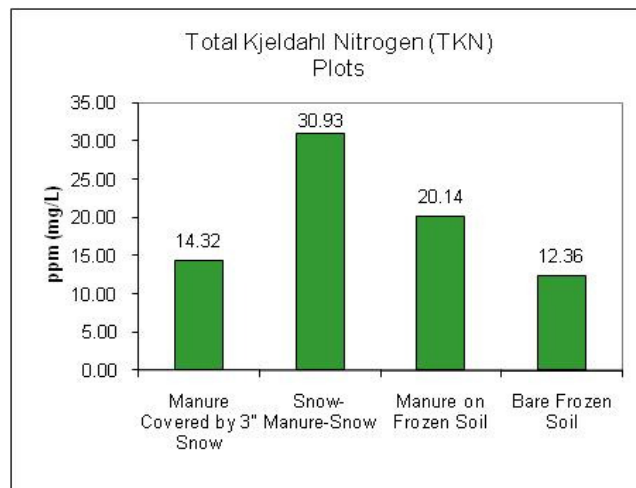


Figure 9. Total Kjeldahl in plot runoff.

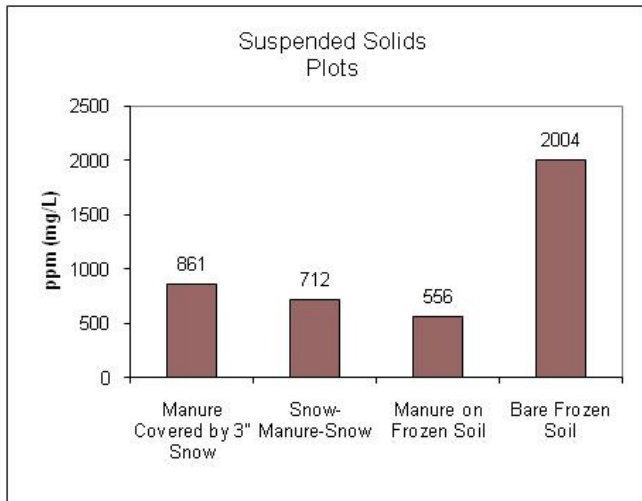


Figure 10. Suspended solids in plot runoff.

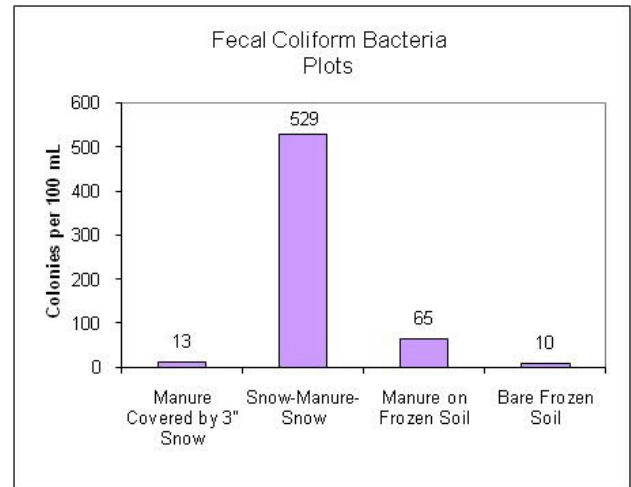


Figure 11. Fecal coliform bacteria in plot runoff.

The following figures show the trend over time of soil temperature freeze-out and freeze-in dates for the Cottonwood Research Farm. The trend toward warmer winters is showing here where the soil is thawing slightly earlier in the spring and slightly later in the fall. This is a large impact on the frozen soil period and the period of time when manure spreading activity could occur.

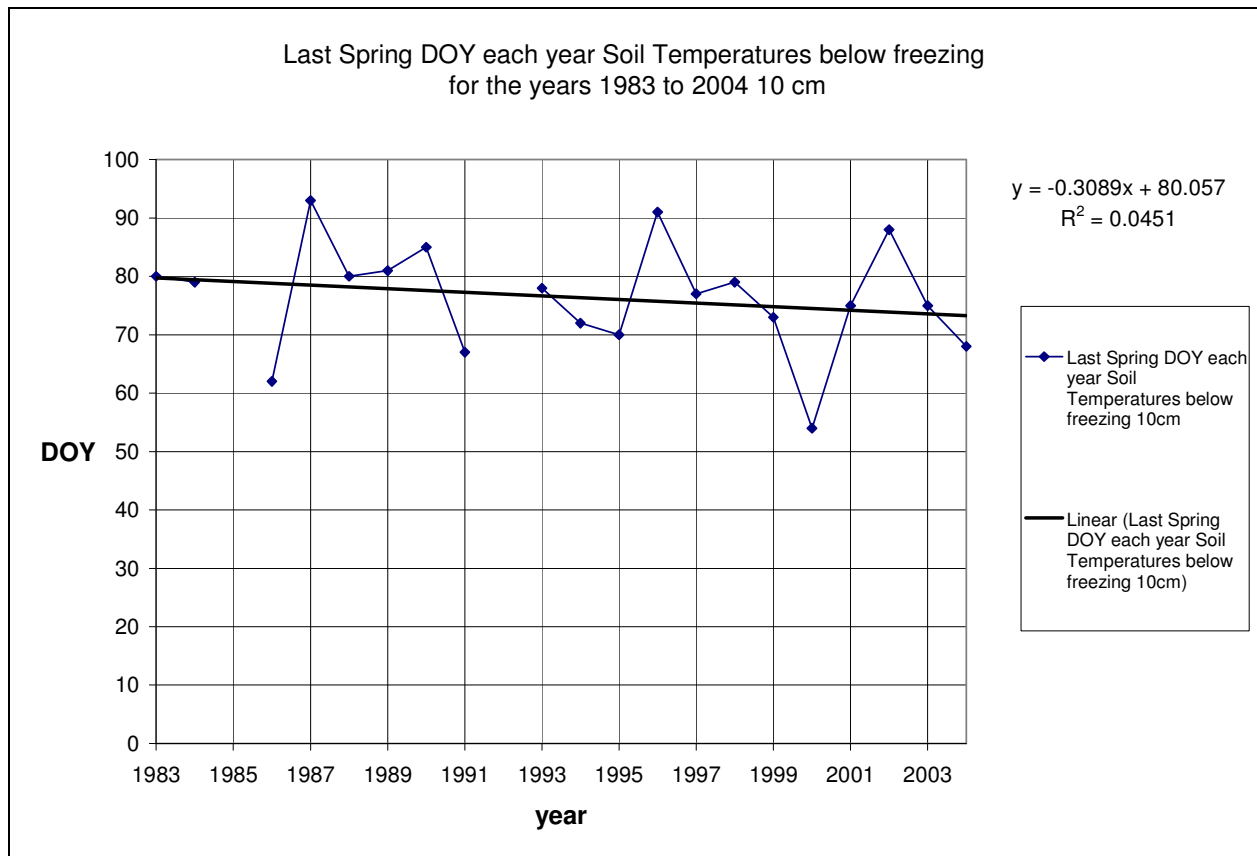


Figure 12: Last day of year where 10 cm soil temperature was below freezing.

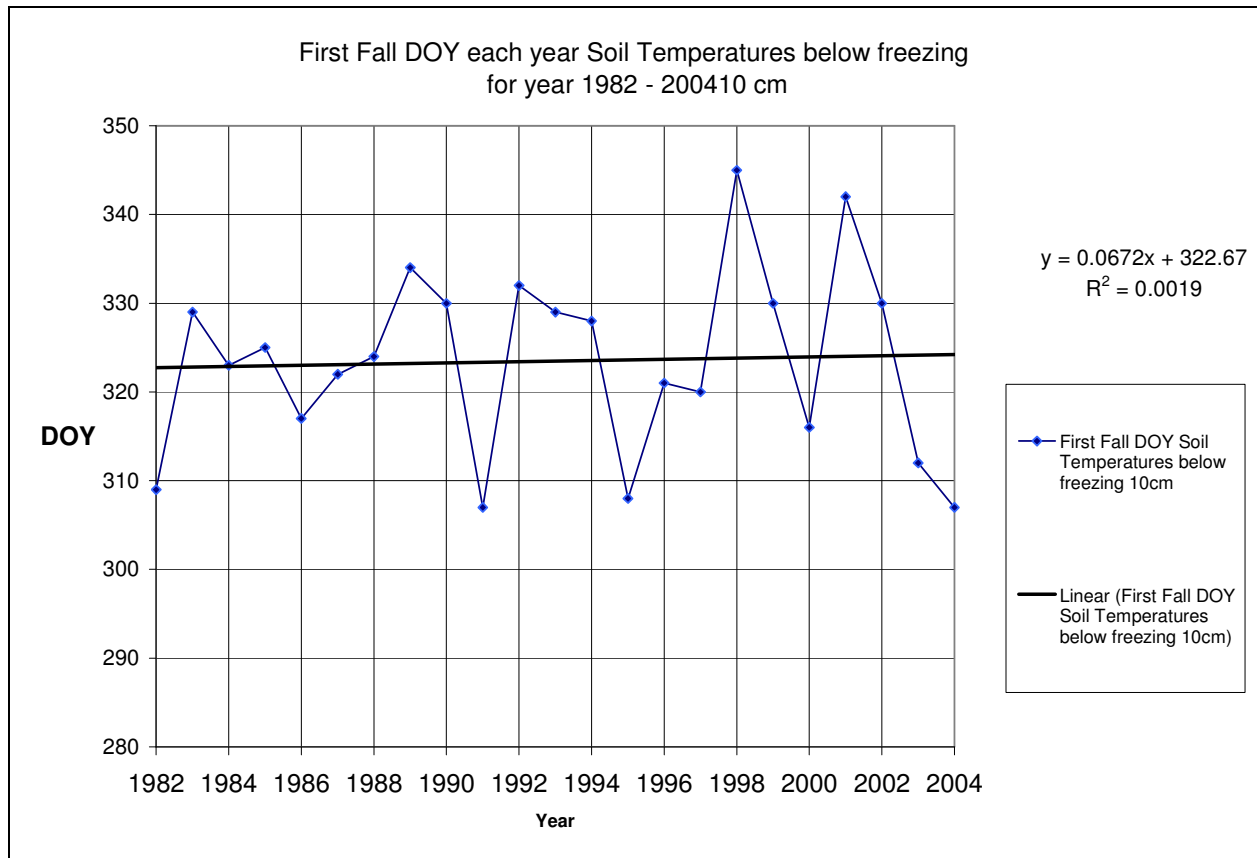


Figure 13: First day of year in fall when soil was frozen.

### Student Support

- **Matt Hubers**, graduate student in Animal and Range Sciences
  - Rain simulations
- **Joanne Anderson**, graduate student in Geospatial Sciences
  - Soil temperature climatology
  - Winter rain climatology
- **Josh Warne**, undergraduate student in Geographic Information Systems
  - Soil sampling
  - Set up plots
  - Rain simulations
  - Plot tear-down
  - Temperature and soil moisture sensor installation
- **Dan Ostrem**, undergraduate student in Agricultural and Biosystems Engineering
  - Temperature and soil moisture sensor installation
  - Data downloading
- **Amber Moberg**, undergraduate student in Nursing
  - Rain simulations
  - Plot take-down
  - Sample filtrations
  - Data downloading
- **Shaina Sabel**, undergraduate in Agricultural and Biosystems Engineering
  - Plot set-up

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- Plot take-down
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### **Notable Awards and Achievements**

It is expected that these results will impact the way winter manure applications are managed in South Dakota. Findings will be made available to the SD DENR as they review the Current CAFO permit during 2009.

### **References**

Hensler, R.F., R.J. Olsen, S.A. Witzel, O.J. Attoe, W.H. Paulson, and R.F. Johannes. 1970. Effect of method of manure handling on crop yields, nutrient recovery and runoff losses. Transactions of the ASAE 13:726-731.

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