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Frequently Asked Questions About Subsurface (Tile) Drainage

Tom Scherer
NDSU Extension Agricultural Engineer

Gary Sands
University of Minnesota Extension Engineer

Hans Kandel
NDSU Extension Agronomist

Chris Hay
South Dakota State University Extension Engineer

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Installation of subsurface (tile) drainage systems in the upper Great Plains, especially the Red River of the North valley, has increased since the late 1990s. A wet climate cycle, along with increased crop prices and land values, are the major reasons this technology is being put to use. As a relatively new practice in this region, many questions are being asked about tile drainage.

This publication attempts to provide some answers.

1 Why are farmers installing tile (subsurface) drainage?

Tile drainage installation has accelerated in the Red River Valley drainage basin as well as other parts of North Dakota during the last 15 years. The recent interest in this practice is primarily due to seasonally high water tables. In springtime, many farmers have experienced difficulties in timely crop planting due to the wet conditions.

Soil salinity is also a problem in the Red River Valley and is related to water table behavior and soil moisture. Soil salinity in the Red River Valley alone encompasses more than 1.5 million acres and accounts for about $50 million to $90 million of lost annual revenue. Tile drainage is a management practice that offers the potential to control and reduce salinity in poorly drained soils.

2 Do my soils have too much clay to tile drain?

Tile drainage has been practiced successfully on a wide range of soil textures, from sandy to clayey. Coarser soils (silts and sands) can be drained with wider drain spacing, whereas finer soils (loams and clays) require narrower drain spacing. Soils with significant coarse silt or fine sand content may need a sock envelope around the pipe to prevent soil particles from entering the tile.

For a 4-foot drain depth and a drainage coefficient of 0.25 inch per day, a Fargo clay might require a drain spacing of around 40 feet, whereas the drain spacing for a Ulen fine sandy loam would be around 120 feet.

Soils in which shrinking/swelling clays or peat predominate, or soils that are sodic, may need special consideration with regard to tile drainage. Soils are classified sodic when the pH is in excess of 8.5 and the amount of sodium in the soil complex is much greater than the combined amount of calcium and magnesium.

3 Are my fields too flat to drain?

Level fields can be drained as long as minimum grades of 0.08 to 0.1 percent are maintained for tile laterals and mains. A tile at 0.1 percent grade has 1 foot of fall per 1,000 feet. On level ground, this means that the tile depth would vary by 1 foot over 1,000 feet. Many parts of the Red River Valley have a natural field slope of around 0.1 percent. A typical drainage system provides an outlet where tile can drain freely (by gravity) into a surface ditch.

4 How do I determine if a pump station is needed?

Where topography or depth of the outlet ditch does not allow for a gravity outlet, pumped outlets are used, provided a surface waterway exists to discharge the drainage water. A pumped outlet or “lift station” provides the lift required to get the drainage water from the elevation of the tile to the ground surface or higher and into the receiving waterway.

Typical electric-powered lift station

Pumped outlets increase the initial investment and operation/maintenance costs of the tile drainage system but may be economically feasible in many situations. A pumped outlet station includes a sump, pump, discharge pipe and usually an electric control panel. Important design features include the storage volume of the sump and capacity (flow rate) of the pump.

5 Am I experiencing negative effects from inadequate drainage on my farm, and how will tile drainage affect my overall farming operation?

Tile drainage will promote faster soil warmup and drying in the spring, and intermittent wet spots in fields will dry out more uniformly. A significant negative effect of inadequate drainage relates to the timeliness of spring and fall field operations.

Inadequate drainage can delay spring field operations from days to weeks and interrupt field traffic patterns due to nonuniform drying of the field.

Machinery traffic on soils that are too wet will cause increased soil compaction. Delays in planting mean a shorter growing season and fewer accumulated heat units for the crop.

Once the crop has been planted, inadequate drainage can cause stunted and shallow root growth, and sometimes complete crop failure due to excess-water stress (lack of oxygen in the root zone). Planting delay, soil compaction and excess-water stress combined can translate into significant negative crop yield impacts. The magnitude of the yield impact for a growing season depends on crop and variety, soils and the season's rainfall pattern.

6 Can the effects of salt buildup in soils be mitigated with tile drainage?

Soluble salts may accumulate in the root zone during a period of years with high water tables. Salinity can be measured by its ability to conduct electricity. One of the measurements is in millimhos/centimeter (mmho/cm). A soil sample is dried and equal parts of water and soil are mixed before measuring. With higher salt concentration, the conductivity readings will be higher. With levels of more than 1 mmho/cm, a yield reduction can be expected for most crops.

Studies have shown that leaching water through the profile and removing the salt via tile drainage will reduce the salt concentration in the root zone through time. Depending on seasonal rainfall or ability to irrigate, reducing the salt enough in high-concentration areas for optimum agricultural production may take a few years. This effect may occur more quickly in years with higher rainfall and may not occur at all in dry years. Reclaiming the land with a sequence of more tolerant crops such as barley is important before planting a salt-sensitive crop.

Will random or targeted tile drainage help control salt levels in saline seeps?

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Saline seeps may occur where soil water from high land slowly seeps laterally to lower areas and carries dissolved minerals (salts) with it. If the water comes near, or seeps out of the surface in the low area, it may evaporate and leave the salts behind.

Through time, salts can increase to an extent where the soil no longer can support crop growth. Tiling these low areas, along with the side slopes, will lower the water table and, depending on the amount of precipitation, eventually will leach the salts. A targeted drainage system of relatively few tile lines may be all that is needed to address a saline seep situation.

What are the economics of tile drainage for the crops that I produce?

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The economics of tile drainage systems depend on crop yield response, initial capital investment for the materials and installation of the system, and any annual operation and maintenance costs (such as electricity for pumped outlets).

Although crop yield response to drainage can be assessed directly, the impacts of inadequate drainage on soil quality (structure, microbial activity, etc.) are more difficult to measure and assign economic value. Many field crops show a positive response to drainage (on previously poorly drained soils), often with the best response from a combination of surface and tile drainage. The level of yield increase for a given year depends greatly on how poorly drained the soil was prior to drainage, and the timing of seasonal rainfall.

Research has shown that during many growing seasons, average yields may increase around 10 to 15 percent, depending on the aforementioned factors. Research on a clay loam soil has shown that wheat yield will be reduced by 42 percent and sugarbeet yield will be reduced by 29 percent of potential yield when the water table stays 15 to 20 inches below the surface for extended periods during the growing season.

In addition to yield increases associated with adequate drainage, operating expenses on the farm may be cut due to reduced cropping inputs, less fuel consumption, and timely field operations.

Several drainage pipe manufacturers have developed Web-based pages to evaluate tile drainage investment. A more detailed description of drainage economics can be found at this Iowa State University Extension website: *www.extension.iastate.edu/agdm/wholefarm/html/c2-90.html.*

Will drainage stress my crop in dry years?

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Tile drainage does not remove "plant available" water from the soil; it merely removes "gravitational" water that would drain naturally if unimpeded by confining layers in the soil. The greatest benefits of tile drainage typically are realized in wet years, but because drainage promotes deep root development, crops often will have better access to soil moisture in dry years. During extremely dry growing seasons, a tile-drained field certainly might have less available water at some point during the growing season than an undrained field.

Whether such an effect would offset the early season positive effects of drainage is unknown, and highly site- and year-specific. In general, where poorly drained soils exist, crop yields will be more uniform from year to year with tile drainage.

Drainage control structures (also known as controlled drainage or drainage water management) can be installed to provide the potential for limiting the release of drainage water into the ditch and conserve more soil water in the root zone. Similarly, the pump in a lift station can be turned off when drier growing conditions become a concern.

A lot of equipment is required to install tile drainage.

"Sock" on the tile.

Can I install a tile drainage system myself or have a neighbor do it to reduce costs?

Do-it-yourself (DIY) tiling is certainly an option that is being considered by many farmers/ landowners. With good equipment, good design and the necessary commitment of time and resources, DIY tiling may be a sound option and may save on installation costs. However, like any other field operation, an investment in specialized equipment and knowledge is required for DIY tiling.

Tiling typically requires at least a four-person crew, a tile plow, electronic controls (global positioning system and plow control), a backhoe, tile cart, and several large and medium-sized tractors.

Pipe depth and grade, pipe size and field layout are all extremely important in design and will determine the quality of performance of your system. Above all, making sure the tile system is designed and installed properly is important so it will perform well for many years.

When do I need to use a "sock" drain envelope or fine/narrow-slot tile?

The need for an envelope (sock), or narrower slots, on the drainage pipe depends on the soil texture in the region of the tile depth in the field. Generally, poorly graded fine sands and coarse silts require the use of sock envelopes.

In general, clay, silty clay, sandy clay, silty clay loam, silts and loams do not require envelopes due to their natural cohesiveness. The Natural Resources Conservation Services (NRCS) Web Soil Survey website *(http://websoilsurvey.nrcs.usda.gov/)* can be used to determine the soil texture in the region of the tile depth.

If you have doubts or questions, then a soil sieve or particle size analysis should be done. This is a relatively easy mechanical procedure that can be performed by a commercial soil-testing lab or the soil-testing lab at NDSU. The analysis will determine the sand, silt and clay fractions of the soil, and the range of soil particle sizes.

No sock is needed if the clay fraction is greater than 30 percent. A sock may be needed if the medium to very coarse sand fraction (0.5 to 2 millimeter particle size) accounts for more than 20 percent of the total.

What is "controlled" drainage or "drainage water management"?

Controlled, or managed, drainage systems incorporate structures that allow the producer/manager to raise the outlet elevation at strategic locations in the drainage system to control the release of drainage water and potentially maintain a shallower water table.

Controlled drainage systems offer the potential to conserve soil water in the root zone and reduce drainage flows and the loss of dissolved nutrients (nitrogen and phosphorus) from the field. If the timing of rainfall is favorable, controlled drainage creates the potential to store water for drier periods during the growing season.

One or more special control structures, or the pumped outlet itself, may be used to control the drainage system. Control structures utilize stop-logs or baffles to set the desired water table elevation at the location of the structure; a pumped outlet may be turned off to create the same effect.

Considering the option of drainage water management in the initial design of the drainage system is important so that the layout of the system accommodates the goal of drainage management to the fullest extent and maximizes the effectiveness of the practice.

Typically, fields with average field grade from 0 to 0.5 percent are best suited for the practice, but other factors such as field slope uniformity and access to control structure locations are important, too. A field that is nearly flat may require only one control structure (or a pumped outlet) to implement the practice, whereas a field with more grade may require several control structures.

The benefit of drainage water management is that producers have one more tool to manage production risks. Under certain conditions, water retained with the control structures may increase crop yield.

13 Can I irrigate through the tile drainage system, or "subirrigate"?

"Subirrigation" is the practice of providing water to the root zone through a drainage water management system. If a source of irrigation water is available and the drainage system is designed appropriately, water can be introduced into control structures, special inlets or the sump of a pumped outlet to raise the water table and make water available to the crop.

To make this practice work, a sufficient source of water is needed to supply the water needs of the crop, usually during July and August. As with drainage water management, for this practice to be effective, the subirrigation system must be designed before installation of the tile. A system designed for subirrigation generally will require closer drain spacing than a system designed only for conventional drainage.

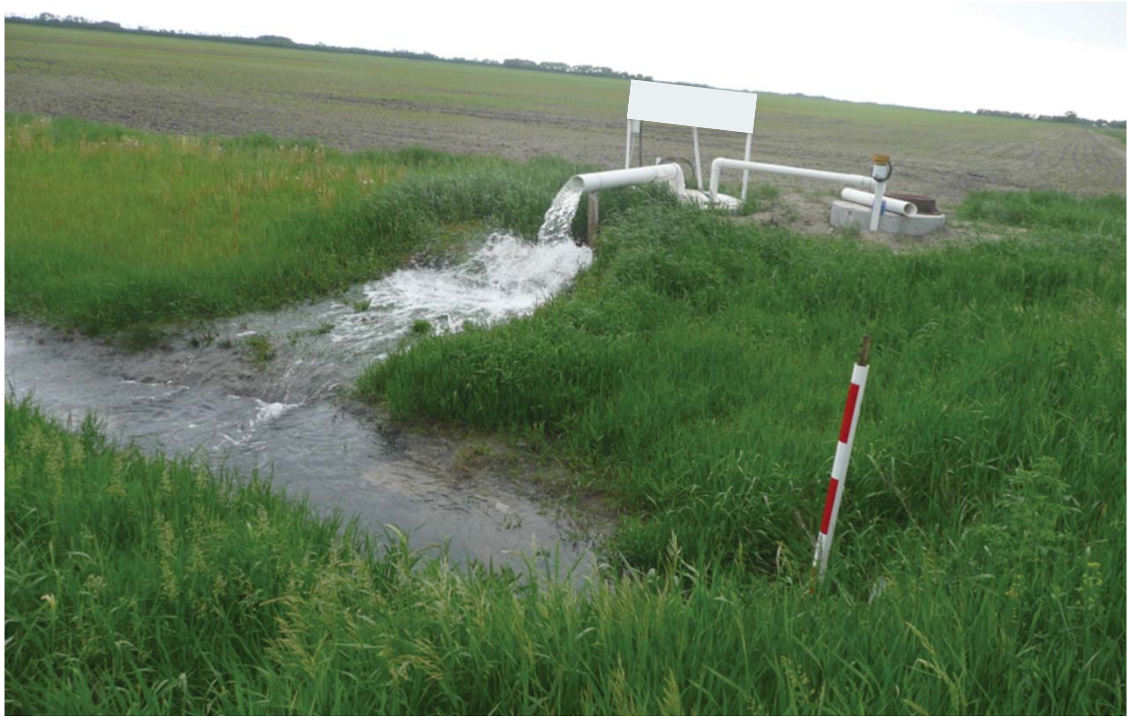
14 Are any water quality issues associated with tile drainage?

The water quality impacts of tile drainage are positive and negative. In general, when compared with surface drainage only, phosphorus and sediment losses via surface runoff are lower from tile-drained fields, while losses of nitrate-nitrogen and other dissolved constituents in the root zone are greater. The extent of the increase or decrease of these constituents also depends on farm management practices, and the magnitudes of the losses are highly variable from year to year.

15 What is the relationship between tile drainage and downstream flow and flooding?

Tile drainage impacts on downstream flow and flooding have been the subject of much debate for more than a century. The influence of tile drainage on stream flow involves complex processes that depend on many factors. Therefore, generalizations

Drainage pump station discharge mixes with surface runoff.



such as tile drainage "causes" flooding or tile drainage "prevents" flooding oversimplify the issue.

Some of the important factors that will determine the impact of tile drainage on downstream flow and flooding include soil types, rainfall (or snowmelt) amount and intensity, point of interest (near the field outlet or over a larger watershed), time frame of interest, existing soil moisture conditions, and the extent of surface drainage (including surface intakes) and channel improvements.

Despite this complexity, the research on tile drainage and stream flow contain some areas of general agreement. For the poorly drained, low-permeability soils where tile drainage typically is used in the upper Midwest, tile drainage will lower the water table, which increases soil water storage capacity and infiltration. This reduces the amount of surface runoff and the peak flows coming from the field.

For small or moderate rain or snowmelt events, this may help reduce downstream peak flows that are often a concern for flooding. Discharge from tile drainage occurs during a longer time period than surface runoff, however, base flows (stream flows between storm or snowmelt events) tend to increase from tile drainage.

For large rain or snowmelt events or extended rain events on wet soils that exceed the infiltration ability of the soil – which typically are related to catastrophic flooding-stream flows are driven by surface runoff, and tile drainage has minimal impact on downstream flows and flooding.

Because of the many factors and complexity involved, computer models are used to help understand how drainage impacts hydrology. Studies based on computer modeling suggest that the water yield (surface runoff plus tile and shallow groundwater flow) with tile drainage will be similar to the water yield without drainage.

Some studies have shown some increase (on the order of 10 percent[1]) in overall water yield from tile drainage, while others have shown no change or even a decrease. These studies, however, have not been verified with field data.

Moving beyond the field scale to larger watershed scales, the complexity increases greatly with more variation in all of the factors contributing to stream flow, and thus, isolating the impacts of tile drainage at these scales becomes much more difficult. Therefore, the influence of tile drainage on stream flow and flooding at these larger scales is not yet well-understood.

[1] Hydrologic and Water Quality Impacts of Agricultural Drainage. 1994. Skaggs, R.W., M.A. Brevé and J.W. Gilliam. Critical Reviews in Environmental Science and Technology 24(1) 1-32.

The golden rule of drainage water management is to drain only that amount necessary to create adequate field conditions and retain water that may contribute to crop production.

NDSU tile drainage research plots.
Note the water level control boxes.

Photos by Tom Scherer, Hans Kandel and Xinhua Jia

For more information on this and other topics, see www.ag.ndsu.edu

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