

# Frequently Asked Questions about Subsurface (Tile) Drainage in the Red River Valley

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Installation of subsurface (tile) drainage systems in the Red River Valley of North Dakota and Minnesota has increased since the late 1990's due to a wet climate cycle, increased crop prices and increasing land values. As a fairly new practice in this region, many questions are being asked about tile drainage. This publication attempts to provide brief answers to some of the more commonly asked questions.



## 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 over the last 15 years. The recent interest in this practice in the region is due to a number of factors, including increased rainfall, seasonally high water tables, higher land values and higher crop prices. 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 over 1.5 million acres and accounts for about \$50 to \$90 million of lost 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 spacings, 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 inches per day, a Fargo clay might require a drain spacing of around 32 feet, whereas the drain spacing for a Ulen fine sandy loam would be around 120 feet. Soils where shrinking/swelling clays or peat predominate, or sodic soils, may need special consideration with regard to tile drainage. Soils are classified sodic when the pH is over 8.5 and the amount of sodium in the soil complex is much greater than the combined amount of calcium and magnesium.

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### **3. Are my fields too flat to drain?**

Level fields can be drained as long as minimum grades of 0.08% to 0.1% are maintained for tile laterals and mains. A tile at 0.1% grade has 1 foot of fall per thousand feet. On level ground, this means that the tile depth would vary by 1 foot over 1000 ft. Many parts of the Red River Valley have a natural field slope of around 0.1%. 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. 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?**

On poorly drained soils, tile drainage will promote faster soil warm-up 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 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 over a period of years with high water tables. Salinity can be measured by its ability to conduct electricity and may be expressed in units of mmhos/cm (milli-mhos). 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. Yield reductions can be expected for most crops with salinity levels above 1 mmho/cm. Studies have shown that leaching water through the profile and removing the salt via tile drainage may reduce the salt concentration in the root-zone over time. Depending on seasonal rainfall or ability to irrigate, it may take a few years before the salt in high concentration areas will be reduced enough for optimum agricultural production. This effect may occur more quickly in years with higher rainfall, and may not occur at all in dry years. It is important to reclaim the land with a sequence of more tolerant crops such as barley, before a salt sensitive crop is planted.

### **7. Will random or targeted tile drainage help control salt levels in saline seeps?**

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

### **8. What are the economics of tile drainage, for the crops that I produce?**

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 over many growing seasons, average yields may increase around 10 to 15 percent, depending on the aforementioned factors. Typical yield increases might be 10 to 30 bushels per acre for corn and 4 to 8 bushels per acre for soybeans. Research on a clay loam soil has shown that wheat yield will be reduced by 42 percent and sugarbeets 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, there may also be reductions in operating expenses on the farm due to reduced cropping inputs, less power consumption, and timely field operations. Several drainage pipe manufacturers have tools for evaluating the drainage investments. A more detailed description of drainage economics can be found at the following Iowa State Extension link:

[www.extension.iastate.edu/agdm/wholefarm/html/c2-90.html](http://www.extension.iastate.edu/agdm/wholefarm/html/c2-90.html).

### **9. Will drainage stress my crop in dry years?**

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 are typically realized in wet years, but because drainage promotes deep root development, crops will often have better access to soil moisture in dry years. During extremely dry growing seasons it is certainly possible that a tile-drained field might have less available water at some point during the growing season than a non-drained field. Whether or not 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 to conserve more soil water in the root-zone. Similarly, the pump in a lift station can be turned off when there is a concern about drier growing conditions.

#### 10. 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, 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 (GPS and plow control), a backhoe, tile cart and several large and medium sized tractors. Professional tiling contractors bring experience and familiarity with design procedures and standards of tile drainage systems. 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, it is important that the tile system be properly designed and installed, so it will perform well for many years.

#### 11. When do I need to use a “sock” drain envelope or fine/narrow-slot tile?

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 use of sock envelopes. In general, clay, silty clay, sandy clay, silty clay loam, and loams do not require envelopes due to their natural cohesiveness. The Natural Resource Conservation Service Web Soil Survey website, [websoilsurvey.nrcs.usda.gov](http://websoilsurvey.nrcs.usda.gov), can be used to determine the soil texture in the region of the tile depth. If there are 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 by 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. Sock may be needed if the medium to very coarse sand fraction (0.5 to 2.0 millimeter particle size) comprises more than 20 percent of the total.

#### 12. 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 when desired. 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, a potential is created to store water for drier periods during the growing season.

One or more “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.

It is important to consider the option of drainage water management in the initial design of the drainage system, 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. Fields that are nearly flat may only require one control structure (or the pumped outlet) to implement the practice, whereas fields with more grade may require several control structures.

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The benefit of drainage water management is that producers have one more tool to manage production risks. The drainage water management philosophy is to drain only that amount necessary to create adequate field conditions and retain water that may contribute to crop production. Under certain conditions, water retained with the control structures may offer the potential of increased 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 appropriately designed, water can be introduced into the water control structures (or the sump of the 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 will generally require closer drain spacing than a system designed only for conventional drainage.

**14. Are there water quality concerns associated with tile drainage?**

The water quality impacts of tile drainage can be both positive and negative. In general, when compared to surface drainage only, phosphorus and sediment losses via surface runoff may be reduced from tile-drained fields, while losses of nitrate-nitrogen and other dissolved constituents from the root-zone tend to be 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, due primarily, to the variability in annual precipitation.

A number of “conservation drainage” practices have been (and are being) developed to address water quality concerns. Some of these practices include: modified agronomic and crop production practices (fertilization timing/rate and crop selection); drainage water management or “controlled drainage (see Q #12); optimized drainage design; alternative surface inlets; woodchip bioreactors; saturated buffers; restored wetlands; and, two-stage drainage ditches. A regional Extension publication describing these practices in more detail will be available soon.

**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 over a century. The influence of tile drainage on streamflow involves complex processes that depend on many factors. Therefore, generalizations 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, there are some areas of general agreement from the research on tile drainage and streamflow. For the poorly drained, low permeability soils where tile drainage is typically used in the Upper Midwest, tile drainage will lower the water table, which increases

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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 over a longer time period than surface runoff, however, so baseflows (streamflows between storm or snowmelt events) tend to increase from tile drainage. Some computer modeling-based studies have suggested that the total water leaving the field (surface runoff plus tile and shallow groundwater flow) under a tile-drained scenario may increase on the order of 10%<sup>1</sup>. These studies have not been verified with field data. For large rain or snowmelt events or extended rain events on wet soils that exceed the infiltration ability of the soil—which are typically related to catastrophic flooding—streamflows are driven by surface runoff, and tile drainage has minimal impact on downstream flows and flooding.

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

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<sup>1</sup> 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.