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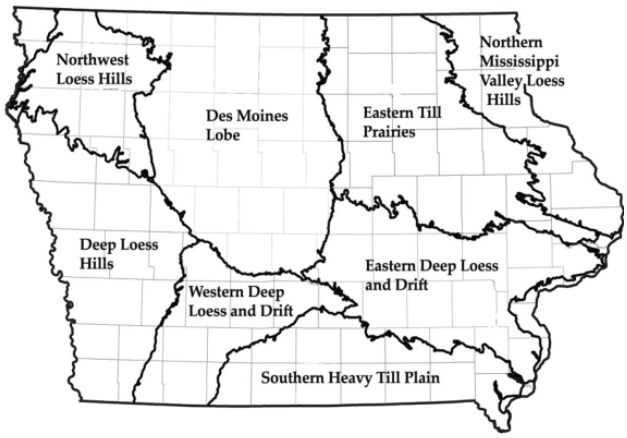
Understanding the Economics of Tile Drainage

There are more than six million acres of cropland in Iowa where wetness limits productivity. Slightly more than half of the 375 different soils series mapped in Iowa have problems with excess water. The drainage of farmland is obviously important for improving the productivity of Iowa agriculture. Based on the large number of acres susceptible to excessive wetness and the yield response from removing this wetness, farmers and landowners are becoming increasingly interested in drainage.

The two major methods of farmland drainage are surface drainage where standing water is removed using surface ditches and subsurface drainage where excess water is removed through a system of underground drainage tiles. This publication deals only with subsurface tile drainage.

Figure 1. Major soil association areas of Iowa.



The major soil association areas of Iowa are shown in Figure 1. Although artificial drainage can be utilized anywhere in the state, it is most prevalent in the "prairie-pothole" (Des Moines Lobe) region of the Clarion-Nicollet-Webster soil association of central and northern Iowa.

Designing a Subsurface Drainage System[1/]

The purpose of subsurface drainage is to lower the water table in the soil. The water table is the level at which the soil is entirely saturated with water. The excess water must be removed to a level below the ground surface where it will not interfere with plant root growth and development. Root growth requires air to be present in the soil. Both water and air need to be present in the spaces between the soil particles, often in equal proportions. If water fills all of these spaces (saturated), there is no room for air.

Tile drainage should be designed so the water table between tile lines can be lowered within 24 hours after a rain to a level that will not cause crop injury. Generally, most field crops are not injured if the water table is lowered to at least six inches below the ground surface in the first 24 hours after a rain. During the second day after a rain the water table should be lowered to approximately one foot and on the third day to 1.5 feet below the ground surface.

The soil types in an area to be drained greatly influence the type of system that will be installed and indicate if special problems should be anticipated.

Tile drains are placed at uniform depths where possible. The topography of the land influences the grades available, and it is often possible to orient the drains within the field to obtain a desirable grade. The grades should be sufficient to result in a non-silting velocity yet be flat enough that the maximum allowable velocity rate is not exceeded and the drain is not subjected to excessive pressure flow. Too much flow will cause erosion around the drain.

A subsurface drainage system will function only as well as the outlet for the drainage water. When planning a drainage system, it is essential that suitable outlets are available or there are opportunities to develop outlets. Outlets may be large underground

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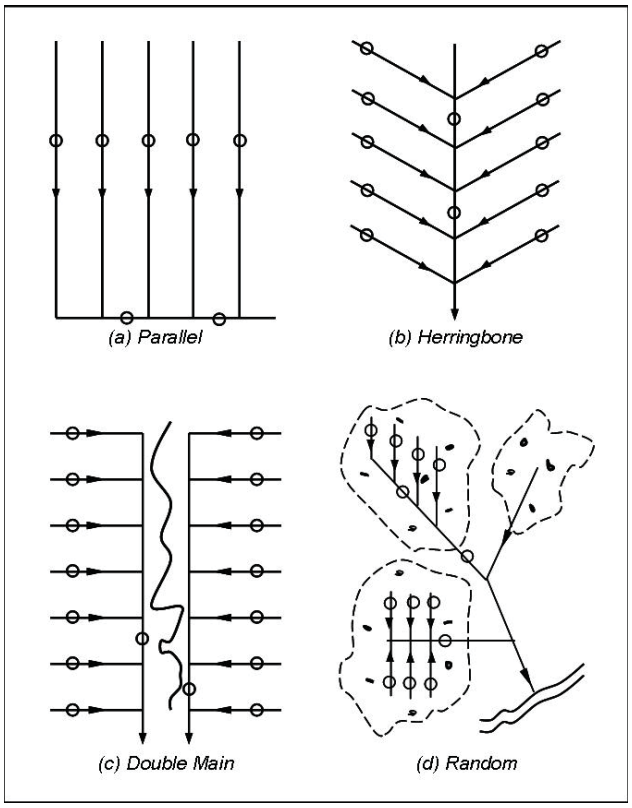
tile mains, open ditches or natural waterways. Outlets may be provided in watersheds where a drainage district has been created. However, many of these outlets may be old and overused. This is especially a problem in the prairie-pothole region of Iowa where there are a lot of small sloughs of standing water and very little slope or access to natural waterways.

Patterns of subsurface drainage systems
Select a drainage pattern that best fits the topography and the groundwater conditions. Some of the basic systems are shown in Figure 2.

Figure 2. Subsurface draining systems.



The herringbone system (b) consists of parallel tile laterals that enter the main at an angle, usually from both sides. This system is used for long, relatively narrow wet areas such as those next to flat drainageways. The parallel or gridiron system (a) is similar to the herringbone system except that the laterals enter the main from only one side. This system is used on flat, regularly shaped fields with uniform soil types. The double-main system (c) is a modification of the gridiron and herringbone systems. It is used where a depression, which is frequently a natural watercourse, divides the field. A random system (d) is used where the topography is undulating or rolling and contains isolated wet areas.

Investment Analysis

The major reason for installing subsurface drainage is to improve the productivity of the farmland. Higher yields translate into more returns. This is especially true in recent years due to higher grain prices. So the investment decision is based on whether the higher crop returns will justify the investment in subsurface drainage. A secondary benefit is that fields will dry out quicker, allowing planting and harvesting to be completed earlier in the spring and fall.It also provides a larger window of time for a farmer to plant and harvest the crop allowing it to be done in a more efficient manner in terms of time and money. This is especially advantageous for farmers who have large acreages to cover.

Specific advantages of tile drainage are:

1. More consistent yields
   - Allows for more efficient use of resources
   - Reduces financial risk
2. Earlier and more timely planting
3. Improved harvesting conditions
4. Less wear and tear on equipment
5. Less power required for field operations
6. Better plant stand
7. Less plant stress
8. Fewer plant diseases
9. Less soil compaction

Another major advantage of tile drainage is the increase in sale value of the land. If the land will be sold in the future, the advantages listed above will be capitalized into the value of the land.

Subsurface drainage is a long-term investment. The investment is made up-front but the benefits are spread over many future years. So the investment decision should be made with the time-lag in mind.

The most difficult part of computing a tile investment analysis is estimating the yield response from the improved drainage. The size of the expected yield improvement dramatically impacts the economic feasibility of installing tile drainage, as shown in the example below.

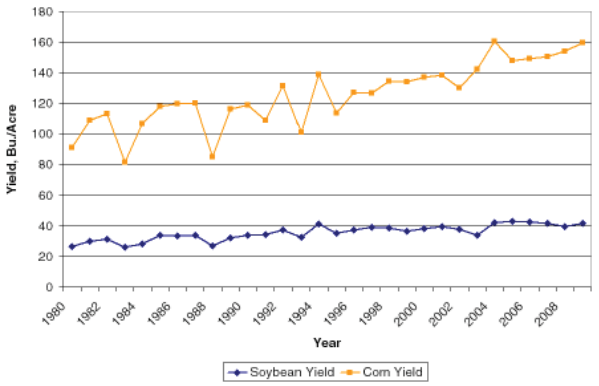
Example:
A 10 bushel per acre yield response from corn and a 4 bushel per acre yield response from soybeans will provide an average annual return of $35 for corn at a price of $3.50 price ($3.50 x 10 bu. = $35) and $36 for soybeans at a price of $9 ($9 x 4 bu. = $36). If the yield responses are 20 bushels for corn and 8 bushels for soybeans, the returns are double.

There are additional annual costs associated with these higher yield levels. For example, more fertilizer may be required to support these higher yields. Also, more hauling, drying and storage is required. In addition, there may be costs associated with the maintenance of the drainage system. So these additional costs need to be deducted from the returns listed above to compute a "net" return per year from installing drainage.

Estimating future returns

In the analysis above we assumed that the annual income stream will stay constant throughout the entire life of the tile. However, this may not be the case. Corn and soybean yields have increased over recent decades as shown in Figure 3. Corn yields have increased by 2.4 percent and soybean yields by 1.8 percent per year since 1980. Most experts expect this trend to continue, if not increase. The impact of trend yield increases over the life of the tile drainage can be substantial. The yield response to tile drainage can be estimated by comparing the area to be drained to portions of the field with similar soil types that are already adequately drained or don't need drainage.

Figure 3. Corn and Soybeans Yield Trends 1980-2009.



Investment analysis methods

Below are two ways of computing the economic returns from investing in subsurface drainage.

1) Payback Period – This is a relatively simple analysis. It is computed as the number of years required to repay the original investment in tile drainage.

Example:
If the cost of installing tile drainage is $500 per acre and the expected annual net cash return in crop returns from tile drainage is $100 per acre, the payback period is 5 years ($500 / $100 = 5 years).

The payback period does not take into account the "time value of money" from the time the tile is purchased until the returns are received (interest on the money). If money is borrowed to install the tile, the debt payment (interest and principle) is subtracted from the annual cash return and only the equity portion of the investment is used to compute the payback period.

2) Internal Rate of Return (IRR) – The IRR is based on future cash flows rather than future profits (ROI).

Example:
The $100 additional cash return over the lifetime of the tile is compared to the $500 tile investment and results in an IRR of 20 percent.

If money is borrowed to install the tile, the debt payment (interest and principle) is subtracted from the annual cash return and only the equity portion of the investment is used in the computation. The IRR takes into account the time period between the time of the investment and the future years in which the annual returns are received. The IRR is based on the concept of "time value of money" which states that money received now is of more value than money received at some point in the future.

Income tax implications
The methods outlined above do not take income taxes into account, so it is a "before tax" analysis. However, income taxes have a significant impact on the returns that can be expected from an investment in tile drainage. Combining your marginal tax rates for federal and state income taxes, along with self-employment tax (when appropriate), provides an estimate of the how much of your returns will be paid to the government.

In general, the additional revenue (e.g. grain sales from additional production) generated from tile drainage is taxable income and the added costs (added fertilizer, tile maintenance, etc.) are tax deductible. So the added "net" return is taxable income. In addition, the annual depreciation of the tile investment is tax deductible. The government allows land owners to depreciate tile over a period of 16 years on a fixed schedule. In situations where the investor is activity involved in the farming operation (e.g. farmers owner/operator), much of the investment may be deducted in the year of installation through an IRS provision called Section 179. After taxes have been taken into account in determining annual net returns, the resulting returns are considered to be "after tax."

Typical Tile Investment Strategies

A variety of investment strategies have emerged for the installation of tile drainage. Some of these are based on installations over a period of time. Others are investment arrangements between tenants and landlords on rented land.

Investment timing strategies

1) Install subsurface drainage on the entire field
With this strategy, the decision is made to install drainage tile on the entire field or farm. Bids and designs are obtained from various tilers, and the decision is made to move forward with tiling the entire field or farm.

2) Design the entire drainage system but install over a period of years – This is similar to the strategy above in that the drainage system for the entire field or farm is designed up-front. However, the actual investment and installation of tile drainage is spread over a period of years, often as income becomes available.

3) Invest a fixed amount of money in drainage
With this strategy, the investment decision is based on spending a fixed amount of money on drainage. The system is then designed to get the most drainage benefit from the limited amount of money. Although this may optimize the benefit from the investment, it often leads to a "patchwork" system as subsequent investments are made over a period of years and does not provide for the best overall drainage system.

Landlord/tenant strategies

1) Landlord Investment Strategy – The traditional landlord/tenant investment strategy is for the landlord to make the tiling investment and charge the tenant a higher cash rental rate. The higher cash rental rate is due to higher yields achieved from the drainage and provides the landlord with a return on his/her tiling investment.

• The additional cash rent can be computed from the estimated increase in net return from tile installation. For example, if the cash rental rate is currently based on the typical rate in the local community, the new rate will be the typical rate plus the additional net return from the estimated increase in net returns from drainage.

• The additional cash rent can be computed based on a fixed rate of return from the tile investment. For example, if the tiling investment is $500 per acre and a rate of return of 8 percent is desired, the additional cash rent is $40 per acre ($500 x 8% = $40). If the cash rental rate is currently based on the typical rate in the local community, the new rate will reflect this typical rate plus $40.

2) Tenant Investment Strategy – The tenant makes the tile investment on the landlord's farm. Because the landlord makes none of the investment, the cash rental rate does not increase due to the increase in productivity. The additional net returns go to the tenant as compensation for the tiling investment.

A major concern for the tenant is whether he/she will have access to the land for a long enough period of time to justify the capital investment. One approach is to enter into a long-term lease between the two parties. However, individuals often do not want to lock themselves into a lease for this length of time. In Iowa, farm leases of five or more years in length must be recorded and multiple-year leases may not exceed 20 years.

Another option is to continue with one year leases but execute an ancillary contract dealing specifically with the tiling. Under this contract the tenant receives a pro-rata buyout of the tiling investment from the landowner if he/she ceases to rent the farm during the lifetime of the tile.

For example, assume the tiling investment is $400 per acre and the life of the investment is 20 years. If the tenant ceases to rent the land after five years, he/she receives a payment of $300 per acre. Leaving after 15 years results in a payment of $100 per acre and after 20 years there is no payment.

Year	Tile Value	Year	Tile Value
0	$400	11	$180
1	$380	12	$160
2	$360	13	$140
3	$340	14	$120
4	$320	15	$100
5	$300	16	$80
6	$280	17	$60
7	$260	18	$40
8	$240	19	$20
9	$220	20	$0
10	$200		

The length of the buyout period is negotiable between tenant and landlord. The buyout payment can be made by the landlord. An alternative is for the new tenant to make the buyout payment to the tenant that is leaving and take over the remaining life of the contract.

3) Shared Investment Strategy – The landlord and tenant share the tiling investment and use a crop-share lease. The investment is shared in the same proportion as the crop is shared in the leasing arrangement (e.g. 50/50). With this arrangement, each party receives the additional net returns in the same proportion as the investment. An arrangement is made where the tenant will receive a prorated buyout if he/she leaves the farm before the useful life of the tile is expended. An alternative is for the landlord to make the investment and modify the crop share lease provisions to reflect the change in contribution.

Getting Started

If the tiling will be performed by an outside contractor, get bids from a variety of tile contractors. Have them prepare the tile layout for your farm and then provide a bid for doing the job. You need to compare both the bid and the layout when choosing among contractors.

Prepare a plan

The person doing the drainage design should prepare a plan and construction notes for the contractor.

The plan should be corrected for any modifications during construction. The plans should include a map showing the locations, sizes and grades of all lines and appurtenances. Contractors with GPS equipment can provide detailed tile maps. Profiles or construction notes of all mains and sub-mains should be included. One or more copies of the final plan and notes, along with construction modifications, should be given to the landowner. The owner should keep two copies. File one copy with your legal papers of the land and keep a working copy with your farm records. If plans, notes and maps are lost or misplaced, it will cause considerable confusion and difficulty in the future when the drainage system needs to be repaired or rebuilt.

Contact USDA

You need to get approval from the United State Department of Agriculture (USDA) for any farmland that will be installed with tile drainage. Start the process by contacting your county Farm Service Agency (FSA) office and provide them with a description of the exact acreage on which you are planning to install tile drainage. This information will be provided to the Natural Resource Conservation Service (NRCS) to make a determination if any "wetlands" are included in the drainage area. Land areas considered to be "wetlands" by USDA cannot be tile drained. After its investigation, NRCS will provide you with a Certified Wetland Determination.

Tile Drainage Inspection and Maintenance[1/]

You should inspect your tile drainage system regularly and conduct maintenance when required. Prompt repair of any drain failure will keep the system in working order and prevent permanent damage to the entire system.

1) Inspection – Subsurface drainage systems do not require extensive maintenance, but the maintenance that is required is extremely important. If subsurface drains are working, water will stand in the field for only a short time after a heavy rain. If water stands for a few days, the drain may be partly or completely blocked.

2) Cleaning outlet ditches – Many subsurface drainage systems fail because outlet ditches are blocked. If the outlet ditch is filled with sediment, a survey should be conducted to determine the extent of the cleanout work.

3) Cleaning surface inlets – Poorly constructed surface inlets are subject to severe damage and require frequent repair. Inlet covers often become sealed with trash and should be checked frequently. Clean the covers after a heavy rain and replace them carefully.

4) Repair blowouts – Holes that have developed over subsurface drains should be repaired at once. Otherwise, large amounts of soil may wash into the line and block the entire system.

5) Remove sediment – Sediment traps can be used for subsurface drains laid in fine sand or silty soils. If cleaned regularly, traps keep soil from filling the lines.

6) Protect drain outlets – Gullies commonly form at unprotected outlets of subsurface drains. Gullies may damage the field, silt up the drainage ditch and reduce the flow of water from the subsurface drain.

7) Control rodents – A flap gate or fixed pin guard can be used to prevent rodents and other small animals from entering and blocking outlets.

8) Control tree roots – Trees such as willow, elm, soft maple, cottonwood and other water-loving trees within approximately 100 feet of the drain should be removed. A clearance of 50 feet should be maintained from other species of trees.

9) Ochre accumulations in the drain – Ochre, which is an iron oxide, may block the drain when iron in solution moves from the soil to the drain and accumulates.

[1/] Iowa Drainage Guide, Iowa State University Extension, Special Report 13, revised June 2008.

Additional information available on the drainage of Iowa farmland

Iowa Drainage Guide (a $25 purchase) includes 1) Iowa drainage laws, 2) drainage guidelines for Iowa soils, 3) subsurface drainage, 4) surface drainage, 5) open channels, 6) pump drainage. *www.extension.iastate.edu/store/ItemDetail.aspx?ProductID=6064&SeriesCode=&CategoryID=&Keyword=SR%2013*

Iowa Drainage Law Manual *www.ctre.iastate.edu/pubs/drainage_law/index.htm*

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