HB 1437 Introduction / Support Cindy Schreiber-Beck, District 25 Representative

SECTION 1 clarifies what is eligible for cost share from the ND Water Commission. Because of conflicting definitions in century code, the amendment was necessary. The amendment states that snagging and clearing and deepening or widening of existing drains are eligible for reimbursement.

Sections 2 and 3 are the result of a collaborative effort between county water resource personnel, an attorney for county water resource districts and industry representatives. The main goal was to improve the application and the permitting process for subsurface water management systems. The improvements provide efficiencies for the applicant and the water board while meeting the necessary requirements.

SECTION 2 addresses the permitting requirements for installing a subsurface water management system of 80 acres of land or more and provides a penalty of an infraction if the section is violated.

- An application form is developed by the state engineer (hopefully with input from water resource personnel) requiring similar information that was previously required.
- The limitation of the drainage coefficient and the specific requirements of surface intakes were removed.
- A natural watercourse is defined.
- Instead of the applicant obtaining the deeds, (along with the names and addresses of all owners listed on the deed), as evidence of ownership of the project land and the land downstream up to a mile from the discharge, the bill requires evidence of ownership according to the tax rolls -- a simpler process that eliminates the review of the deeds by legal counsel
- The charge to the applicant is **up to** $500; previously the charge was $150 which seldom covered the costs the county water resource district incurred for a legal counsel to review the deeds.
- Unless the district notifies the applicant that the application is incomplete and provides a list of the information required within three business days of the receipt of the application, the application is deemed complete.
- The project design may not be disclosed.
- The district may attach conditions to an approved permit if the conditions address specific issues.
- The district has 30 days from the date of the completed application to approve the application; if not approved within the time limit, the permit is deemed approved.
- Once the permit is approved, landowners, up to 1 mile downstream, are notified via first-class mail.
- Approval of a project does not prohibit a downstream party unreasonably damaged by the discharge from seeking damages in a civil action.

SECTION 3 addresses the requirements for the installation of a subsurface water management system that is less than 80 acres and provides a penalty of an infraction if the section is violated.

- No permit is required but the following information must be provided:
  - System's maximum discharge, the discharge location and direction of flow
- The design and installation requirements include:
  - The pump and control structures at pump outlets are installed properly (P. 8, lines 26-30)
  - Control structures are installed and capable of being closed or turned off during critical flood periods.
- If the discharge enters an assessment drain that applicant is not paying into, the water resource district may include the property into the assessment district.

SECTION 4 is the emergency clause.

I request your favorable consideration of this proposed legislation. Thank you for your attention.

AE1690 (Revised)

Frequently Asked Questions About Subsurface (Tile) Drainage

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Driven to Discover

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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.

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.

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.

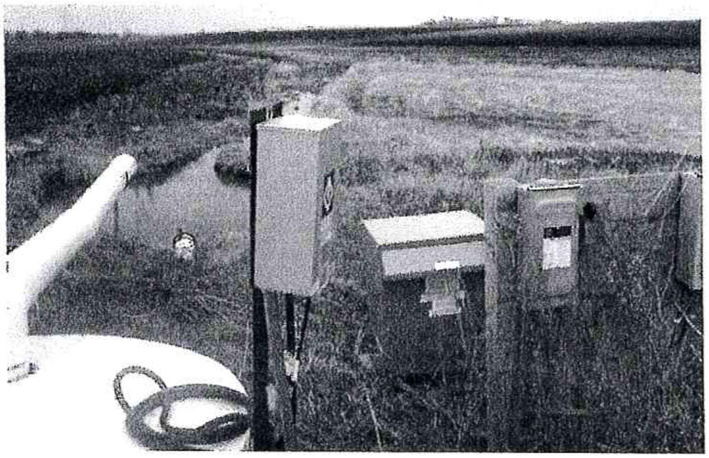
Soils in which shrinking/swelling clays or peat predominate, or soils that are sodic, may need special consideration with regard to tile drainage. Soils are classified sodic when the pH is in excess of 8.5 and the amount of sodium in the soil complex is much greater than the combined amount of calcium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

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.

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.

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.

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?

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?

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.*

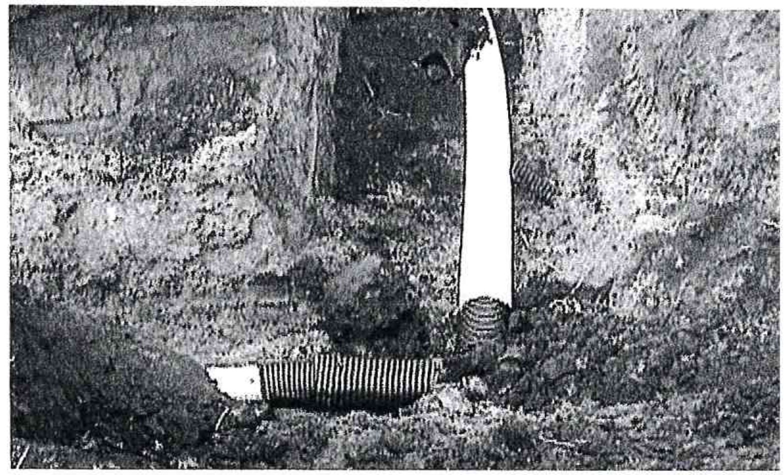
Will drainage stress my crop in dry years?

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.

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.

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.

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

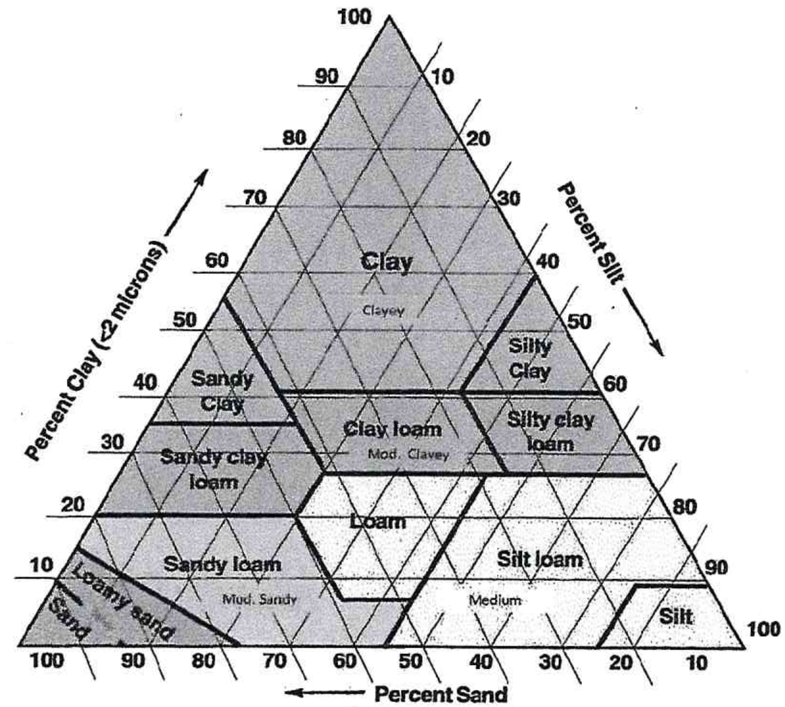
600-10-13; 500-1-14; 1M-3-15

Soil

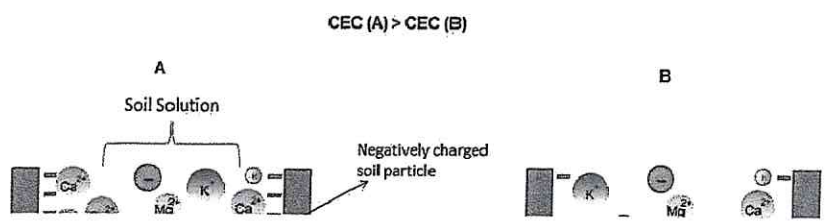
Soil Characteristics

Soil texture is characterized by the percentage of clay, silt, and sand present in a soil sample.

Clay and **organic matter** both carry a net negative charge which attracts nutrients with a positive charge. This is what gives soil its nutrient holding capacity and is described as **CEC (Cation Exchange Capacity)**. Nutrients that carry a negative charge will be repelled by soil particles and are thus, mobile in the soil.



A soil triangle is used to describe soil textures. Courtesy of https://ag.purdue.edu/agry/agryclub/PublishingImages/Textural%20Triangle%20Final.jpg



Soils with different CECs will bind the positively charged cations on to negatively charged soil particles. Negatively charged anions of sulfur (SO_4^{2-}), nitrogen (NO^{3-}), and phosphorus (HPO_4^{2-}) will not bind to the negatively charged

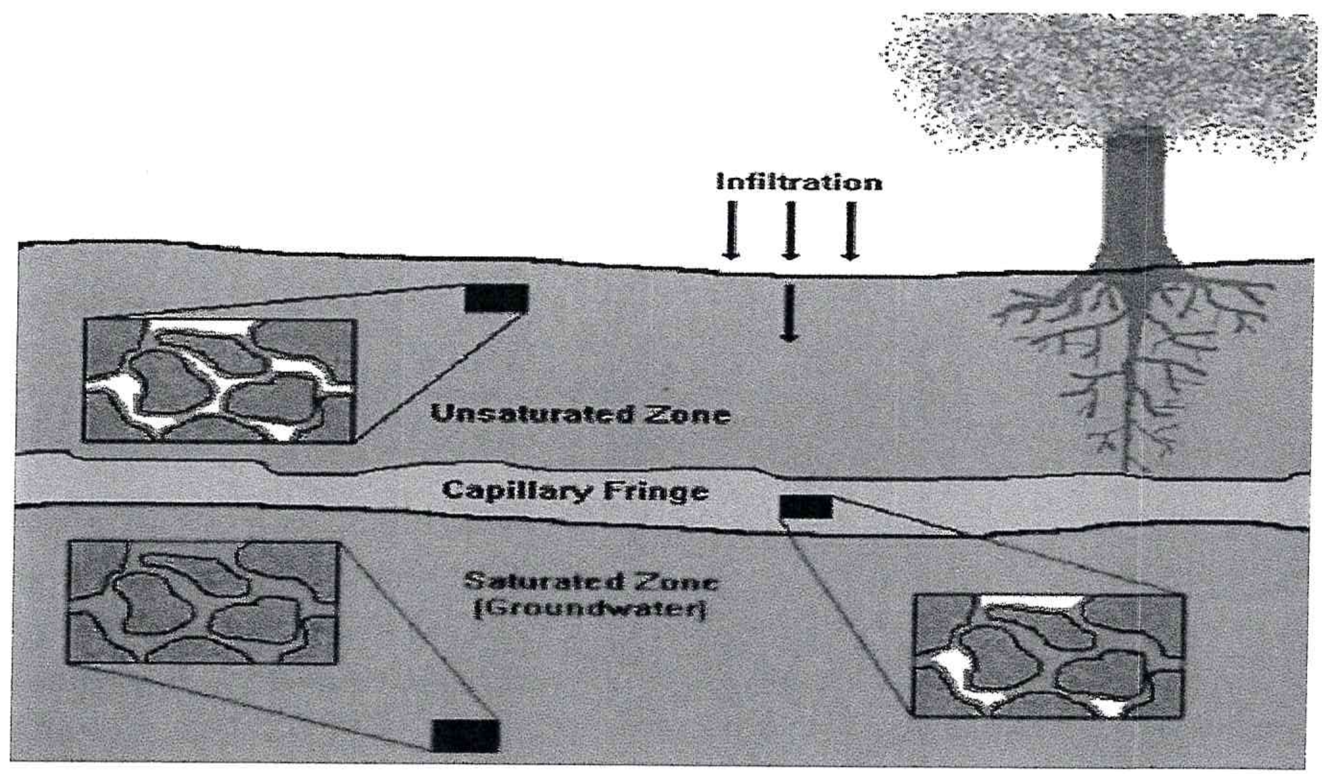
Soil

Soil & Water Profile

The picture shows the typical profile of water in soil. The **capillary fringe** is the point where **diffusion** causes water movement from the **saturated zone** (high water concentration) to the **unsaturated zone** (low water concentration).

Tile acts much the same way as water moves towards the dry zone around the tile. Restrictive layers, such as bedrock, a plow pan or a clay hard pan, can stop water movement in the soil profile.

Soil particle size influences water holding capacity and movement. Small particles, such as clay, have more surface area, therefore they hold more water.



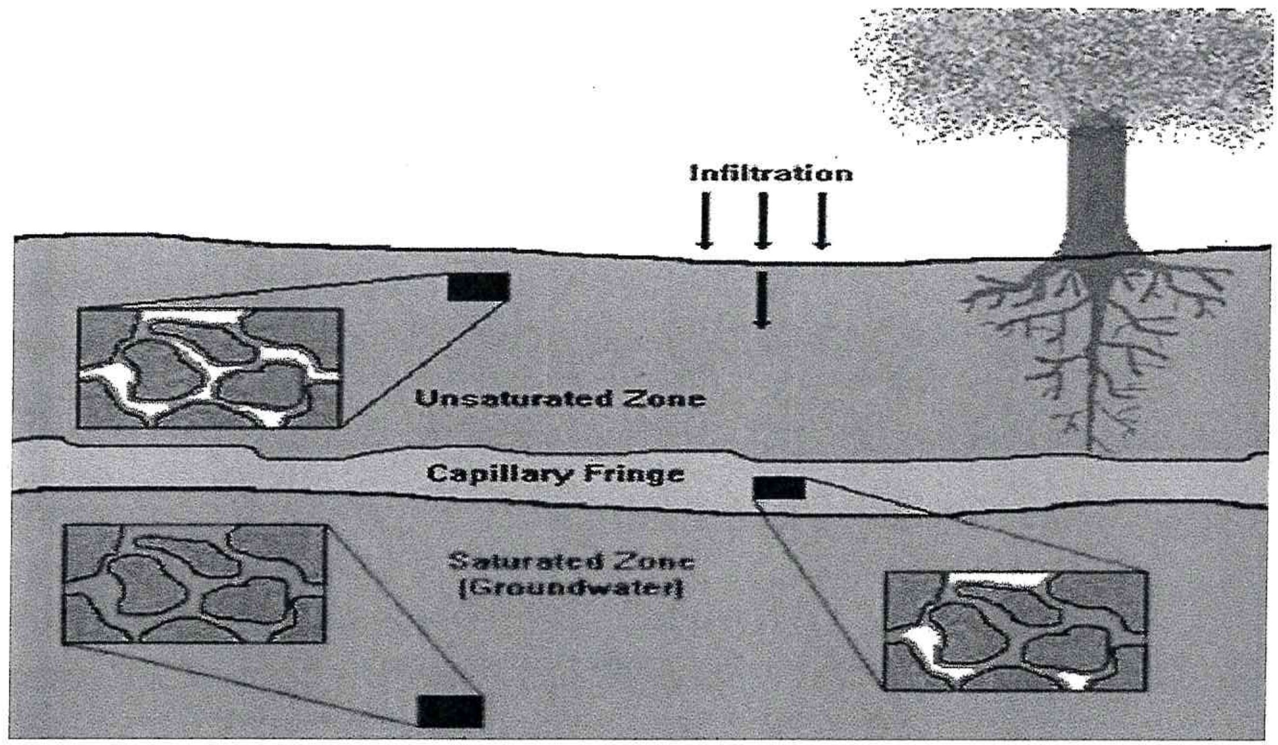
Soil

Soil & Water Profile

Water from precipitation enters the soil through **infiltration** via the macro-pores in the soil. The **unsaturated zone** exists when the macro-pores between soil particles are not completely filled with water. Below the unsaturated zone is the **saturated zone** - the area where all soil macro-pores are filled with water. This is where the **water table** is located.

Between the two zones lies the **capillary zone** - the area where water moves via diffusion from the area of high water concentration (saturated zone) towards the surface into the unsaturated zone.

This concentration gradient is why water moves against gravity into the unsaturated zone.



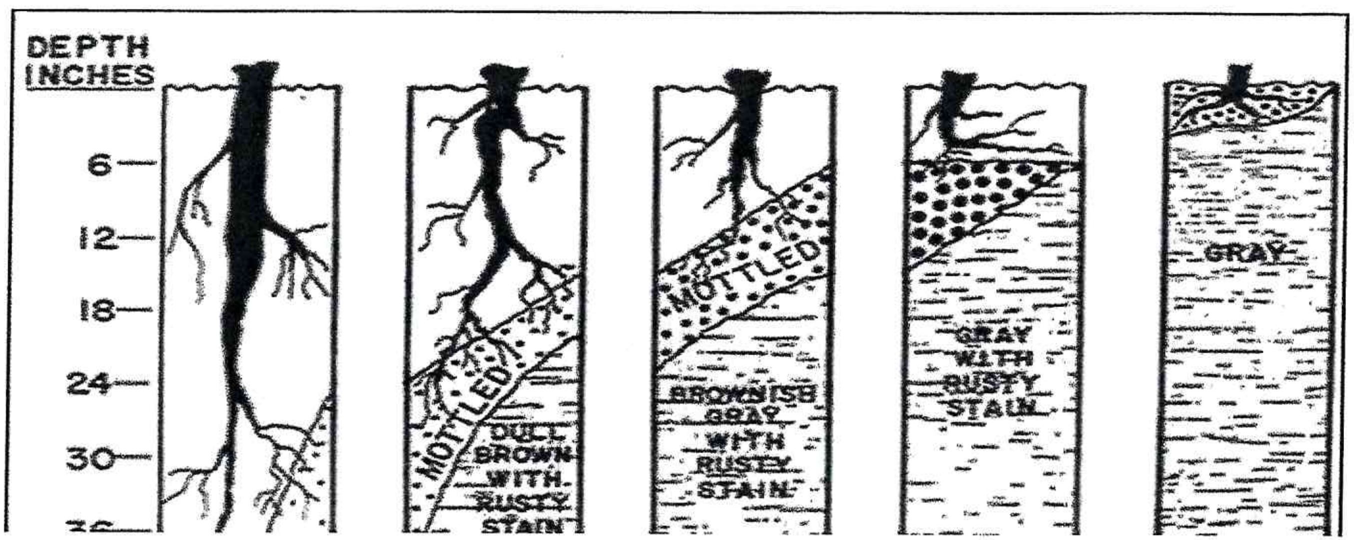
Soil

Soil Drainage Classes

The **depth of the root zone** is clearly influenced by the depth of the water table in the soil profile. Roots will not grow past the water table due to a lack of oxygen in the soil profile. The lack of oxygen forms a **hypoxic zone** (lacks oxygen) and causes chemical reactions with the soil, as noted by the change in color.

This is the result of chemical reactions in the soil in which certain elements, such as iron (rusty stain) and clays tend to form horizons in the soil.

The clay becomes grayed and exhibits a dark brown to



Soil Nutrients

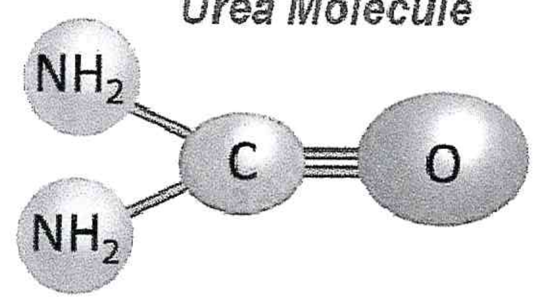
Nitrogen

Nutrients such as **nitrogen** can change form through chemical and biological processes. By understanding the type of charge each form of nitrogen fertilizer carries, one can choose the appropriate form to reduce the likelihood of **leaching**, **denitrification** or **volatilization**.

It is important to understand the charge on nitrogen molecules, as this dictates the pathway towards plant uptake or losses into the environment.

Positively charged molecules, such as ammonia (NH^{4+}), can bind with negatively charged soil particles which reduces losses. Negatively charged molecules (nitrate – NO^{3-}) can be lost into the environment as gases (nitrogen gas - N_2) or via soil water.

Urea Molecule



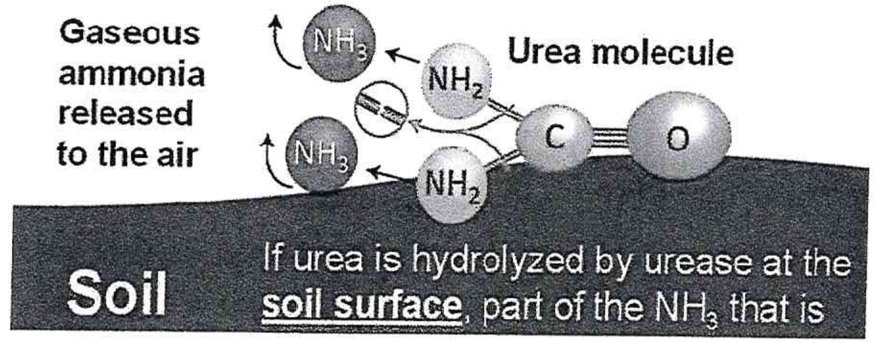
Urea molecule containing two nitrogen atoms. Dupont Pioneer. 2016

Soil Nutrients

Nitrogen

Mobile nutrients in the soil are water soluble and will have a tendency to leach as water moves through the soil profile. Nitrate (NO^{3-}) losses from leaching into tile drainage can amount to 10-40 lbs/A/yr in humid, high rainfall environments (>25 inches/yr.) which stresses the need to apply the correct form of nitrogen fertilizer at the right time in order to minimize losses (The Fertilizer Institute, 2013).

Nitrogen can be lost to the environment through several processes depending on the type nitrogen molecule. Anhydrous ammonia is a commonly used nitrogen source due to its low cost and high nitrogen content. In order to minimize the escape of gaseous NH_3 into the air, this fertilizer is typically injected into the soil at a depth of 6-8 inches where it quickly reacts with soil water to form ammonium (NH_4^+) ions.



The positively charged molecule (NH_4^+) can then bind with negatively charged clay or organic matter particles where it is stored in a plant available form and is not susceptible to leaching. Conversely, urea reacts to form **gaseous ammonia** or NH_3^- which is either taken up by plants or lost into the

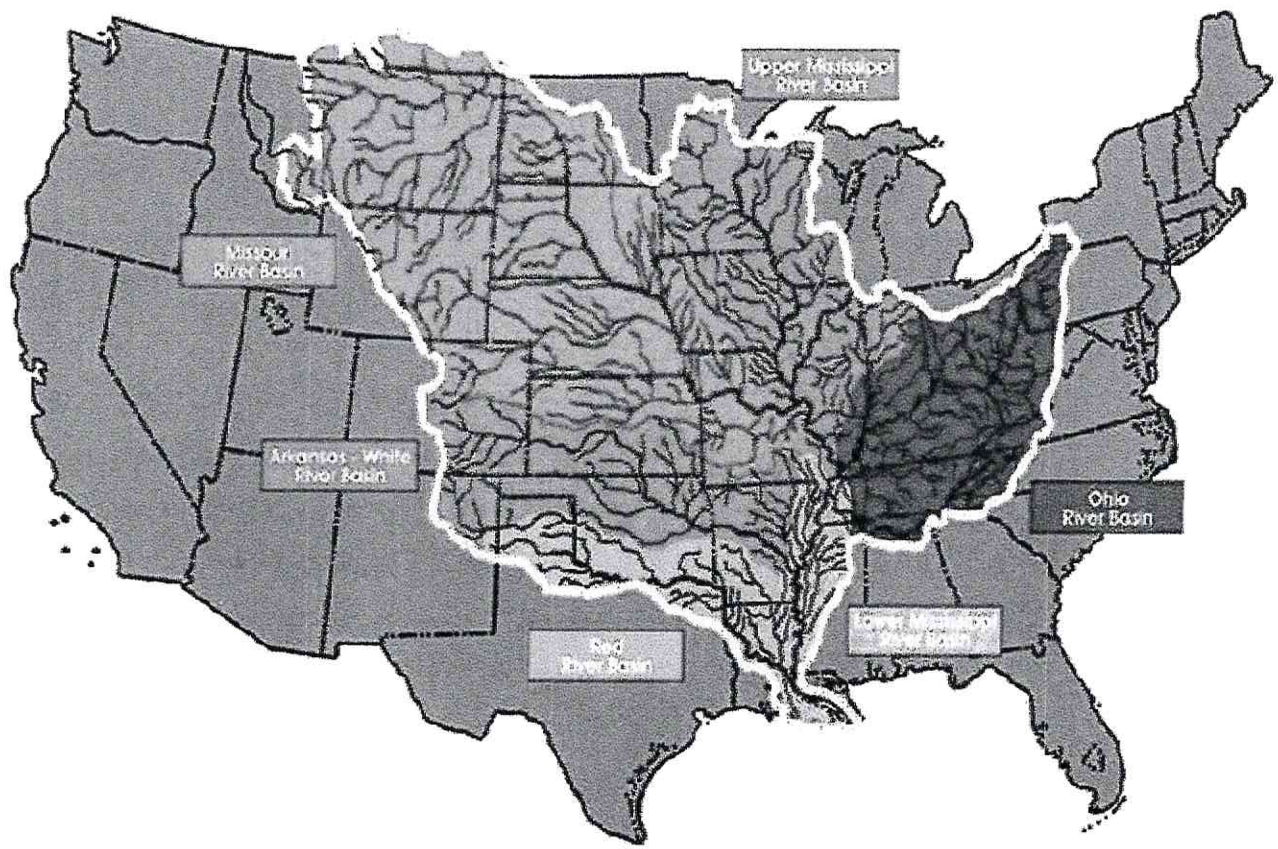
Soil Nutrients

Phosphorus

It is important to understand the primary pathway of **phosphorus** loss is **soil particles**.

Phosphorus is fixed to soil particles and it is the loss of soil particles due to erosion that transports sediments, and thus phosphorus, to waterways.

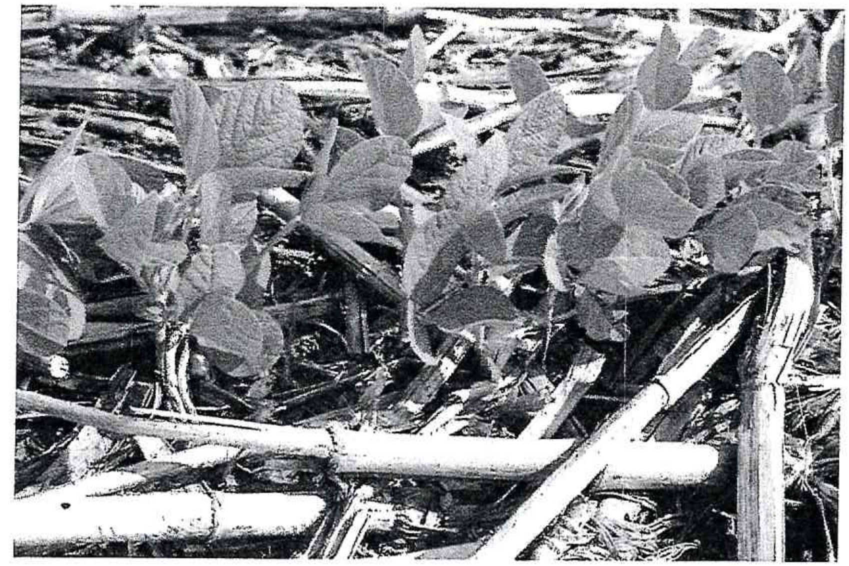
A common misconception with phosphorus is the pathway it takes. Phosphorus is bound to soil and considered immobile. This means it is not suspended



The above picture shows the Missouri River, Arkansas-White River, Red River,

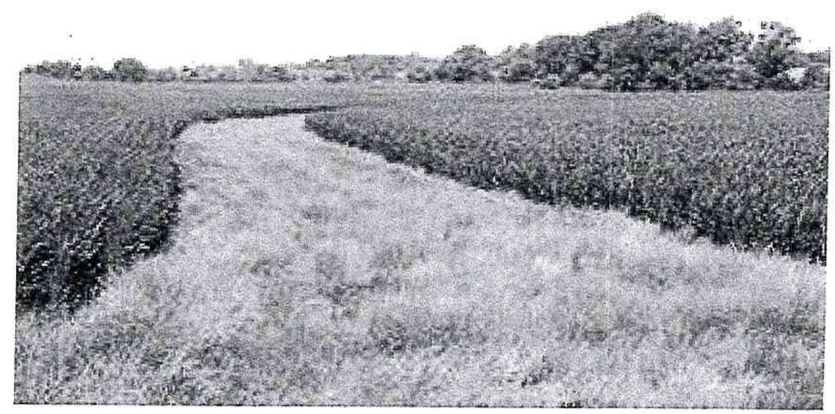
Soil Nutrients
Phosphorus

Since the primary loss of phosphorus is due to soil loss, erosion control is the best defense against phosphorus losses. This can be accomplished through practices, such as no-till, minimum tillage, high residue practices, vegetative filter strips, grass waterways or sediment ponds. This prevents the soil particles from reaching surface waters.



No-till soybean in corn residue where a significant amount of crop residue remains on the soil surface, protecting the soil from water erosion and improving soil tilth.

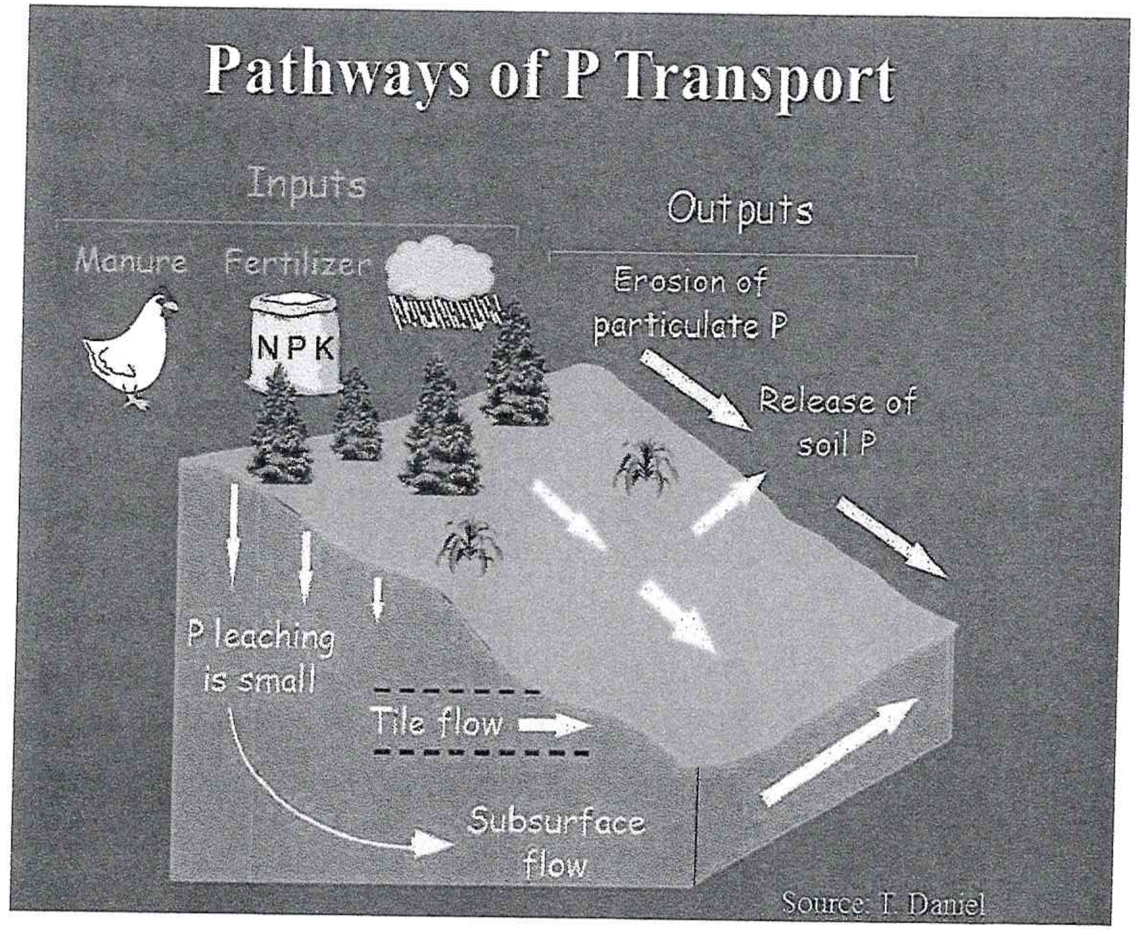
Practices that reduce soil loss due to erosion will have the biggest impact on reducing phosphorus losses. Practices that reduce soil disturbance and the likelihood of erosion should be implemented as **Best Management Practices (BMP).** Tillage destroys soil structure because it breaks up soil aggregates which stabilize the soil structure and hold nutrients. Good soil aggregation leads to



The largest and most common loss of phosphorus (P) is particulate loss from soil erosion. The phosphorus is attached to soil particles and is plant unavailable.

Dissolved P is plant available due to its suspension in soil water. Leaching of dissolved P is much more difficult to target due to the difficulty of measuring the levels of dissolved P in soil, as well as effective ways to remove it from soil water, especially in tile discharge water.

Phosphorus sorption beds are a new technology targeted at solving this problem.



The above picture from Ohio State University shows the pathways of phosphorus transport from fields such as soil particulate erosion and leaching of soluble Phosphorus into groundwater. Soluble P is plant available, particulate P is not. http://www.slideshare.net/LPELC/removing-phosphorus-from-drainage-water-the-phosphorus-removal-structure

Summary

Nutrient losses from agricultural fields continues to be an ever increasingly scrutinized aspect of modern agriculture, specifically concerning water quality.

By using Denitrifying Bioreactors and Phosphorus Sorption Beds, farmers can significantly reduce the impact of nutrient losses in tile drainage water.

Nutrients are mobile in water (solution); therefore, losses to leaching can be significantly reduced by lowering the water table through the use of tile drainage.

Furthermore, water control gates in the tile line

The above picture shows the collection of water samples at tile outlets which will be sent to the lab for analysis. Courtesy of Iowa State University.