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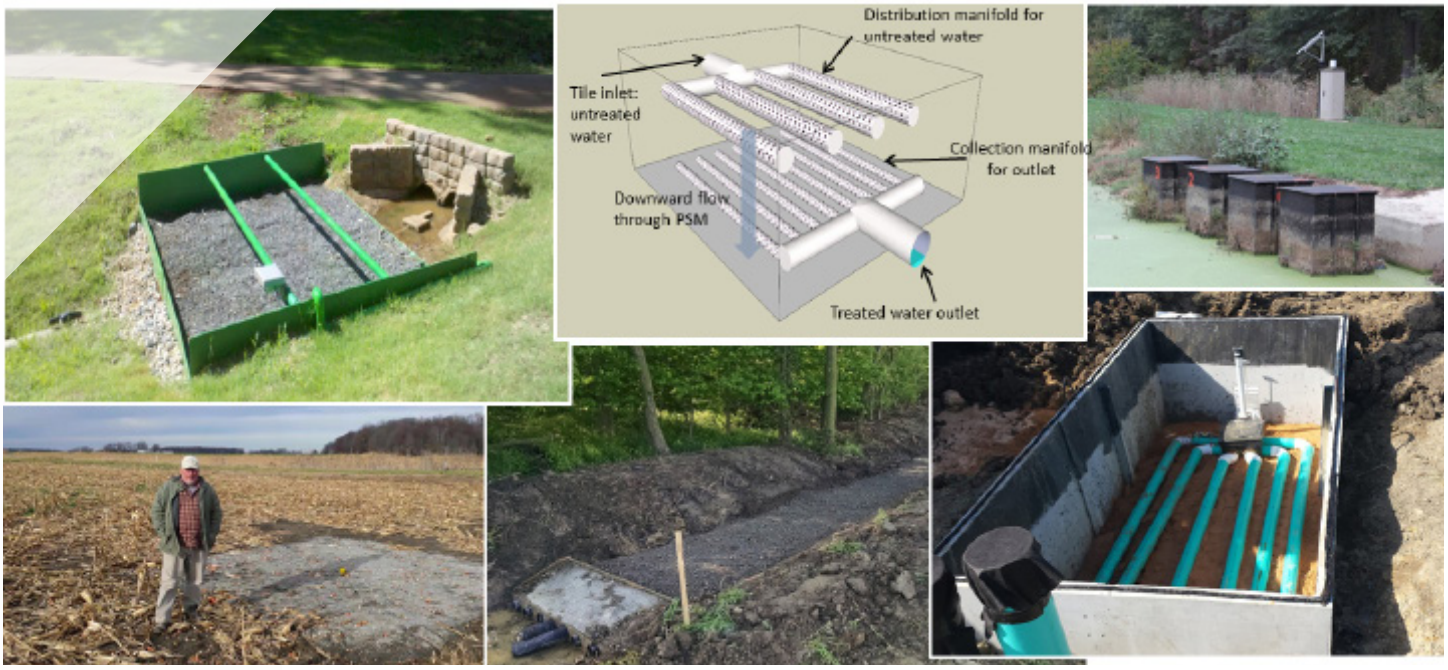

WATER QUALITY AND SUSTAINABLE AGRICULTURE

Phosphorus Removal Structures

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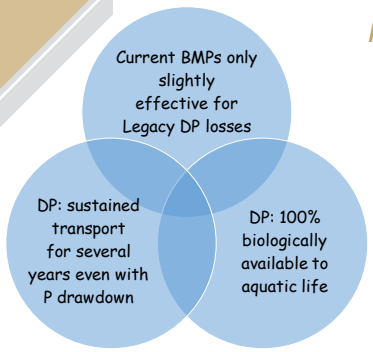
Phosphorus removal structures are a new best management practice for reducing surface water eutrophication by filtering dissolved phosphorus (DP) before it reaches a water body. This document briefly describes how, why, where, and when to use phosphorus removal structures.

What is eutrophication?

Eutrophication is the process by which a body of water becomes enriched in nutrients that stimulate the growth of aquatic plants resulting in the depletion of dissolved oxygen and poor ecosystem health

What causes eutrophication?

While eutrophication is a natural process, it is accelerated by increased inputs of phosphorus (P) and nitrogen (N) to surface waters. Of these nutrients, P tends to be the most damaging. The source of P to surface waters can be from point sources, such as wastewater treatment plants, and also from non-point sources such as urban and agricultural drainage. Non-point P sources can occur from soils that possess excessive P concentrations ("legacy P"), or soils recently amended with chemical fertilizer or animal manure.



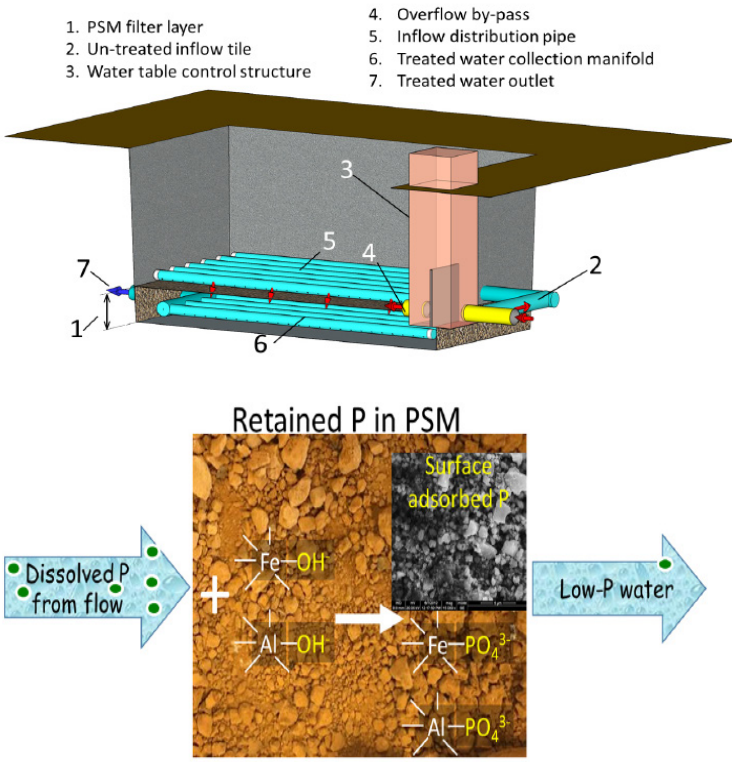
Poor water quality

Phosphorus is transported to surface waters as both dissolved (DP) and "particulate" P (PP). Particulate P is P that is adsorbed onto transported sediments, while DP is already "free" in solution. Conventional BMPs are only able to limit PP transport, not DP. Unlike PP, DP is immediately 100 percent biologically available to aquatic life and its transport is sustained for many years from soils with excessive P concentrations. For these reasons, the P removal structure was developed to trap DP in runoff. The recent re-eutrophication of Lake Erie (pictured above) is attributed to dissolved P.

The phosphorus removal structure

A P removal structure is a large, landscape scale filter for DP, intended to intercept and trap P from "hot spots" before reaching a surface water body. The P removal structure has four basic principles:

1. Contains solid media with high affinity for P, commonly known as a "P sorption material", or PSM.
2. PSM is contained and placed in a hydrologically active area with high DP concentrations.
3. High DP water is able to flow through the contained PSM at a sufficient rate.
4. The PSM is able to be removed and replaced after it is no longer effective.

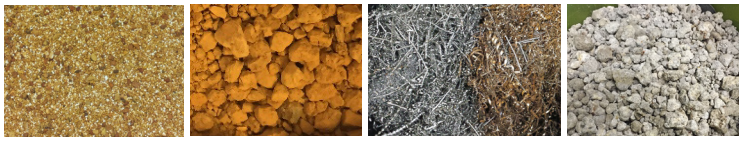


Example of a P removal structure and components, specifically a subsurface tile drain P filter using iron and alumunimum metal hydroxides.

Phosphorus Sorption Materials (PSMs)

Some PSMs are manufactured while others are by-products. Most PSMs produced as by-products from industry must first be screened for trace metals before use in a P removal structure. Regular steel slag should only be used for treating surface water, not subsurface drainage, since bicarbonate contained in tile drainage willl cause slag to clog.

P sorption materials are generally rich in aluminum, iron, or soluble calcium. Several are shown below.

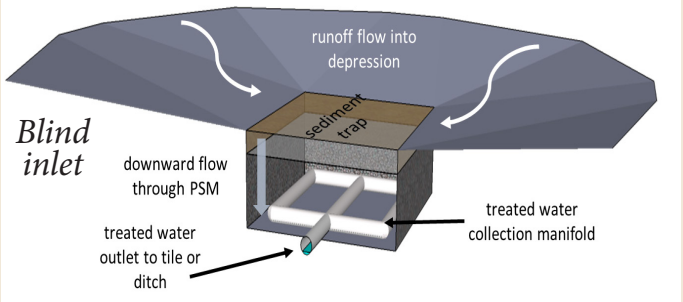


Manufactured PSM "Actiguard" | *Mine drainage residuals* | *Steel metal shavings* | *Steel slag*

Types of P removal structures

P removal structures can be built in many different formats. They can be located on the surface, subsurface, in ditches, tile drains, drainage swales, drop inlets, blind/surface inlets, etc. Any unit that possesses the four basic components is essentially a P removal structure. Several examples of P removal structures are shown below:

Ditch P removal structure



Choosing a suitable location

In order to qualify as a potential site for construction of a P removal structure, a site must possess:

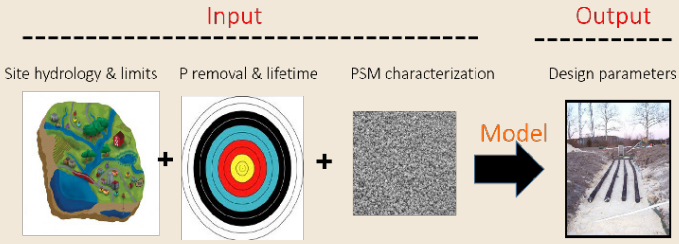
1. Flow convergence to a point where water can be directed into a structure, or the ability to manipulate the landscape
2. At least 0.2 ppm dissolved P (DP) in water, or source soil with at least 200 lb/acre Mehlich-3 P.
3. Hydraulic head required to "push" water through structure: function of elevation change or drainage ditch depth
4. Sufficient space to accommodate PSM

Keep in mind that the P removal structure is ideally targeted to capture DP from legacy P soils, not recently applied manure and fertilizer in which less expensive 4R principles can be utilized.

Designing a P removal structure

P-TRAP
PHOSPHORUS TRANSPORT REDUCTION APP

Several inputs and target goals are required for designing a site specific structure. The freely available P-Trap software (P transport reduction app), can be used to quickly design a structure with any available PSM. The software and other information is found at: https://www.ars.usda.gov/nserl/ptrap



Structures are constructed based on a desired P removal goal and lifetime in accordance with site conditions (flow rate and DP concentration). For example, a 10yr-40% goal means that the structure is designed for removing 40% of all the DP that flows into a structure over 10 years. For details on P removal structures and how to gather inputs, see Penn, C.J., and J.M. Bowen. 2017. Design and construction of P removal structures for improving water quality. Springer Publishing.

Contact your local NRCS conservation district about Standard # 782 if you are interested in having a structure constructed.

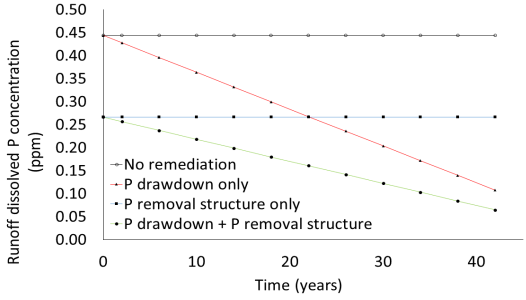
Example P removal structures

The blind inlet shown above was constructed with about 15 tons of steel slag which removed over 45% of the 3-yr DP load, plus >70% of glyphosate and dicamba. Note that blind inlets constructed with the traditional imestone material will not remove DP due to low calcium solubility.

The subsurface tile drain filter above was designed to remove 40% of the 10-yr DP load, using only 2.5 tons of an iron-coated activated alumina material, a manufactured PSM. This material will be regenenerated in-place after 10 years, through a P-stripping technique developed by USDA.

Cost and justification

The only other conservation practice that can truly remove soil P is drawdown via plant uptake and harvest. Although necessary, it requires many years to reduce DP concentrations. During that long draw-down period, P removal structures can trap P in drainage water (see figure below). Cost varies from $3 to $20K, depending on the size of the field, DP loading, site conditions, choice of PSM, and P removal goals. P-TRAP is useful for estimating size and therefore cost. To date, the most cost effective PSM in most situations is metal shavings mixed with gravel.



For updates and further information, see House of Phos @ ChadPenn12 on Twitter and https://youtu.be/LUfZo9zBk6I