CAPTure™ 15 Phosphorus

Product Overview

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The Compact Agricultural Phosphorus Treatment Structure, or CAPTure™, is a modular technology solution for removing soluble phosphorus from agricultural tile drainage and overland runoff before it discharges to local surface waters.

The CAPTure™ system was designed and created by Kieser & Associates, LLC (K&A) with financial support from the Great Lakes Protection Fund. The system is Patent Pending.

The problem with phosphorus

Phosphorus (P) is a critical nutrient for all forms of life. Agricultural production and managed urban landscapes often require additional phosphorus inputs in the form of fertilizers. While plants may use the majority of added fertilizer, some of it is inevitably lost to surface waters as rain carries both dissolved and particulate P in drainage or runoff. Phosphorus-laden drainage eventually reaches nearby streams and lakes via soil erosion, agricultural tile drains, or city stormwater system discharges.

While phosphorus is readily available to terrestrial plants, in aquatic systems it is often referred to as the "limiting nutrient." When agricultural and urban runoff enter aquatic systems, plant and algae growth has the potential to spiral to nuisance levels (Figure 1). If cyanobacteria are present as harmful algal blooms (HABs), these conditions can affect drinking water supplies and create hazardous exposures to humans, livestock, and pets.

Mitigating phosphorus losses from the landscape typically requires conservation practices and/or operational management in agriculture, and Best Management Practices in urban environments. Such practices can be efficient for capturing sediment-attached phosphorus (particulate P), however few of these address dissolved phosphorus…the most readily available form of P that causes water quality impairments.

Figure 1. A large algal bloom in Lake Erie as seen from space in 2011. (Source: https://www.usgs.gov/media/images/excess-nutrients-flowing-lake-erie-can-cause-serious-algal-blooms).

How CAPTure™ works

CAPTure™ was designed to fill this technology gap for treating soluble P. Developed with cost and ease of operation at the forefront, CAPTure™ boxes can treat large volumes of runoff over a period of hours to days when coupled with hydraulic controls such as drainage water management (DWM) structures.

The CAPTure™ systems offer:

1. *A small installation footprint*
2. *>40% dissolved P removal from tile flows & runoff*
3. *Ease of installation without heavy machinery*
4. *Easily replaceable media filters optimizing P capture while enhancing P recovery and reuse*
5. *Managed hydraulics to avoid tile and field flooding*

Phosphorus removal systems work by forcing phosphorus-laden runoff or drainage water into a structure containing phosphorus adsorbing filter media. Larger non-modular installations designed for less frequent replacement intervals result in higher installation costs, larger installation footprints, and challenging maintenance issues when media must be replaced. As these systems do not provide a direct benefit to farmers, adoption thus far has been limited. CAPTure™ aims to improve adoption by minimizing costs, streamlining installation (Figure 2), and engaging with third party funding sources.

Figure 2. First prototype tile drain CAPTure™ installation (left) and a modular installation of CAPTure™ boxes manufactured by AgriDrain™ (right).

CAPTure™ specifications

CAPTure™ box designs have evolved since their first prototype. The current iteration is manufactured by Agri Drain Corporation for K&A; specifications are listed in Table 1. Future iterations may differ slightly as system size and weight are optimized. Treatment assumptions of binding capacity and treatment volume before media replacement are given for an activated aluminum product. The CAPTure™ system can accommodate many different media types, which will affect treatment performance values. This "media neutral" approach ensures that the system can see improved performance as new filter media become available.

A single 4' x 5' CAPTure™ box can treat 20-25 acres of agricultural drainage

Table 1. Important CAPTure™ dimensions and treatment specifications. Items with * indicate assumptions using K&A's recommended activated aluminum filter media with a cumulative phosphorus removal target of 40-50% and an influent phosphorus concentration of 200 µg/L.

CAPTure™ Dimensions	Value
Box Length	60"
Box Width	48"
Box Height	32"
Box Weight (Empty)	450 lbs
Current Box Manufacturer	Agri Drain
Media Weight*	640 lbs
Treatment Area*	20-25 ac
Max Flow Rate*	100 GPM

CAPTure™ installation basics

CAPTure™ box installations require hydraulic controls to ensure an optimal 60-second contact time for efficient media capture of soluble P. CAPTure™ boxes can be installed on drain tile outlets with drainage water management (DWM) structures, as well as with detention basins (Figure 3). These structures/basins reduce sediment transmission into boxes while accommodating box treatment flows of up to 100 GPM. When drainage areas exceed 20-25 acres, multiple CAPTure™ boxes can be installed in parallel (Figure 4).

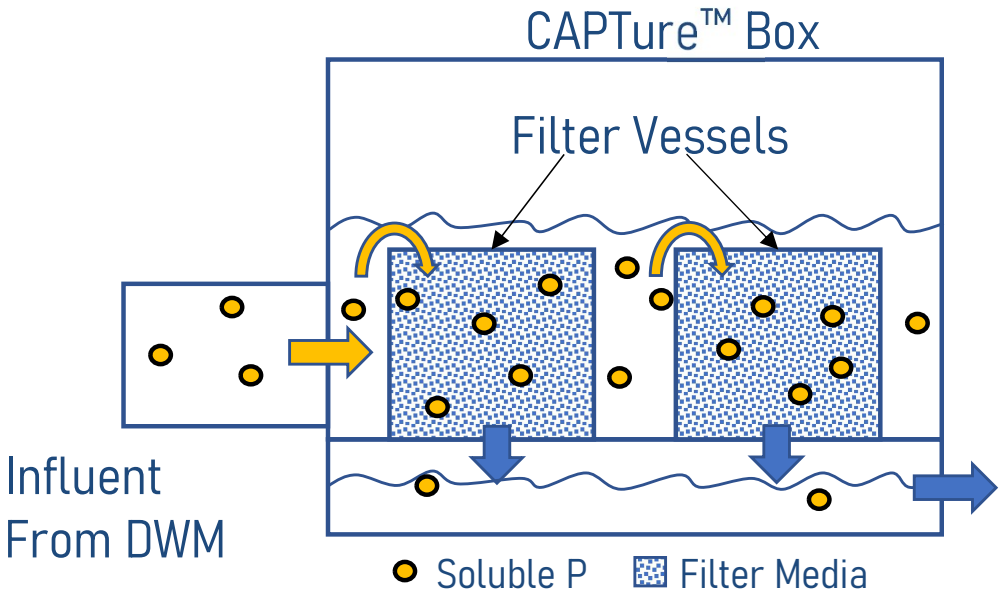

Figure 3. Illustration of phosphorus-laden water moving through a CAPTure™ box.

Figure 4. CAPTure™ installation with boxes in parallel for runoff and tile treatment of 100 acres. (See: https://youtu.be/POPVedDvZg8?si=EO4diP9Qpyie5a3e&t=127.)

CAPTure™ maintenance

CAPTure™ was designed from the ground up to be easy to install and maintain. A CAPTure™ installation requires filter media replacement once per year under "typical" conditions for:

- >40% phosphorus capture
- Soluble phosphorus loading rates of 10 pounds per year (or 0.5 $lb/ac{\cdot}yr^{-1}$) for the recommended drainage area (20-25 acres per CAPTure™ box).

Media replacement intervals will vary depending on site-specific treatment targets and loading rates.

No matter the replacement interval, swapping out CAPTure™ filter media is easy. Each CAPTure™ box contains a series of filter vessels (typically 12), inside of which is a filter media bag (Figure 5). To replace the filter media, the old bag is removed and replaced with a new one. Filter bags weigh less than 40 pounds each and can be easily moved by hand.

The ability to readily exchange filter media addresses one of the primary maintenance challenges with other phosphorus removal systems – replacement of sediment-clogged, spent media. By hydraulically managing CAPTure™ box influent and using replaceable filter media, the media is reserved for soluble P capture.

Figure 5. CAPTure™ box interior with filter vessels and filer media bags.

CAPTure™ vs. other conservation practices

CAPTure™ is an alternative to both traditional conservation practices and standard phosphorus removal systems. Traditional conservation practices include options such as cover crops, buffer strips, tillage management, and detention basins to control phosphorus losses in agricultural settings. These practices, however, are only effective for removing particulate phosphorus, of which up to one-third may ultimately become available for plant uptake in the aquatic environment (bioavailable).

Both CAPTure™ and standard phosphorus removal systems target soluble phosphorus, nearly 100% of which is bioavailable. As standard phosphorus removal systems are large, difficult (expensive) to install and maintain, and susceptible to early failure, CAPTure™ eliminates these issues with its replaceable filter design. CAPTure™ therefore compares favorably with these other options on a per-pound basis of bioavailable phosphorus removal utilizing currently available activated aluminum filter media (Figure 6). Other filter media in development have the potential to improve cost-effectiveness over the activated aluminum now in use with CAPTure™.

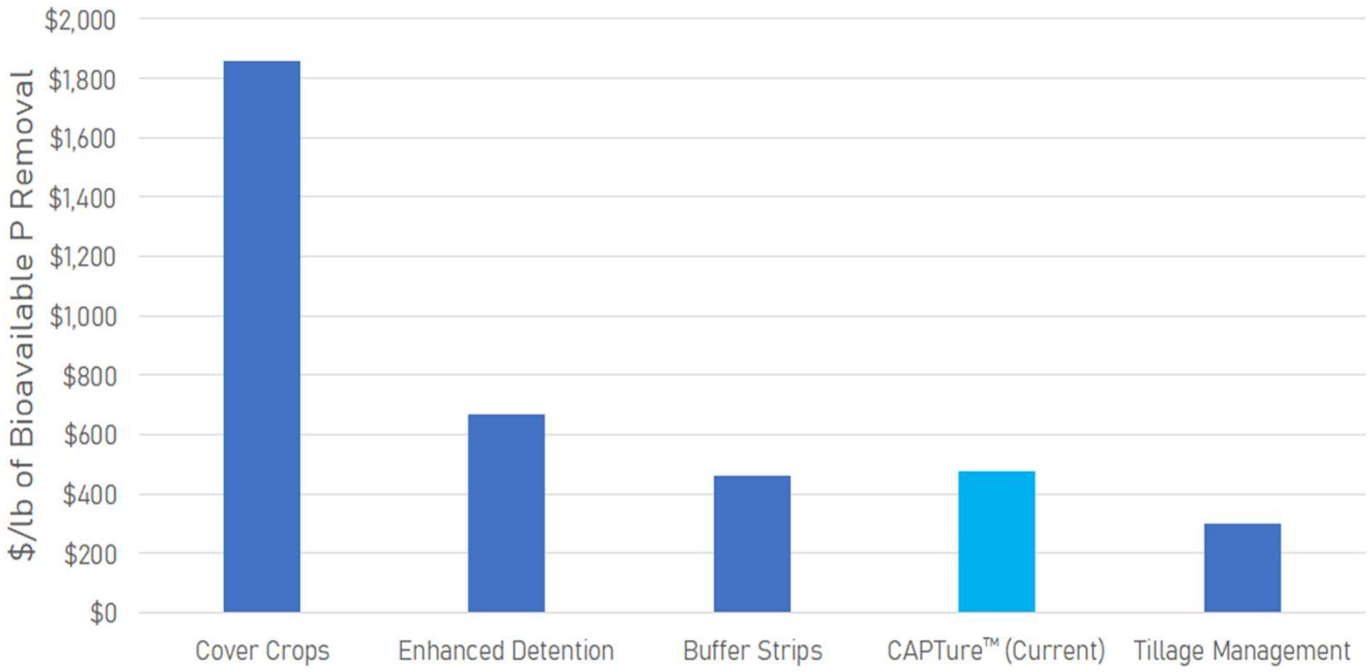

Figure 6. Cost-effectiveness of bioavailable P removal for different phosphorus-targeting practices.

CAPTure™ testing & field study results

CAPTure™ has been tested both in the field and in laboratory settings. Laboratory testing has focused on bench-scale media sorption capacity, while field testing has focused on at-scale, proof-of-concept. The CAPTure™ system is media neutral, but criteria for optimal media selection is short-contact time, high absorption capacity, availability and cost. Activated aluminum products have emerged as the most cost-effective, long-lasting media of choice at this time. While further media options are in the works, Figure 7 illustrates CAPTure™ performance with currently available activated aluminum products.

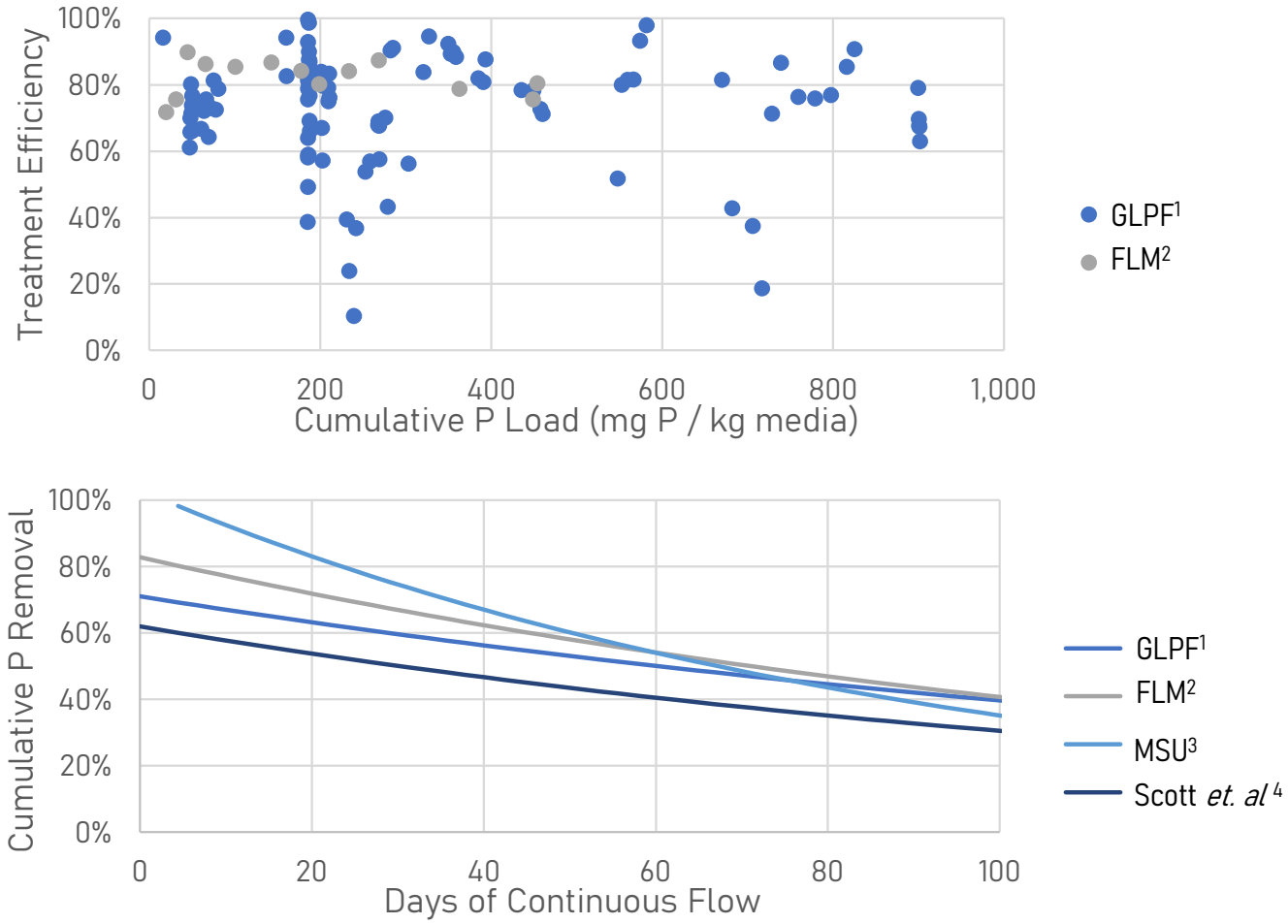

Figure 7. Field testing results (top) and extrapolated performance life (bottom). "Days of Continuous Flow" assumes a single CAPTure™ box receiving 45 GPM constant flow containing 200 µg/L of soluble phosphorus.

1. GLPF field test. https://glpf.org/funded-projects/advancing-systematic-and-fundamental-changes-in-agricultural-water-resources-management/
2. FLM field test: https://fundforlakemichigan.org/project/enhanced-treatment-techniques-for-removal-of-phosphorus/
3. MSU lab filter media sorption capacity testing. See note 1 for project link.
4. SPC Scott, I., J. Penn, C., & Huang, C. H. (2020). Development of a regeneration technique for aluminum-rich and iron-rich phosphorus sorption materials. *Water*, 12(6), 1784.

For CAPTure™ product & application information, contact K&A

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