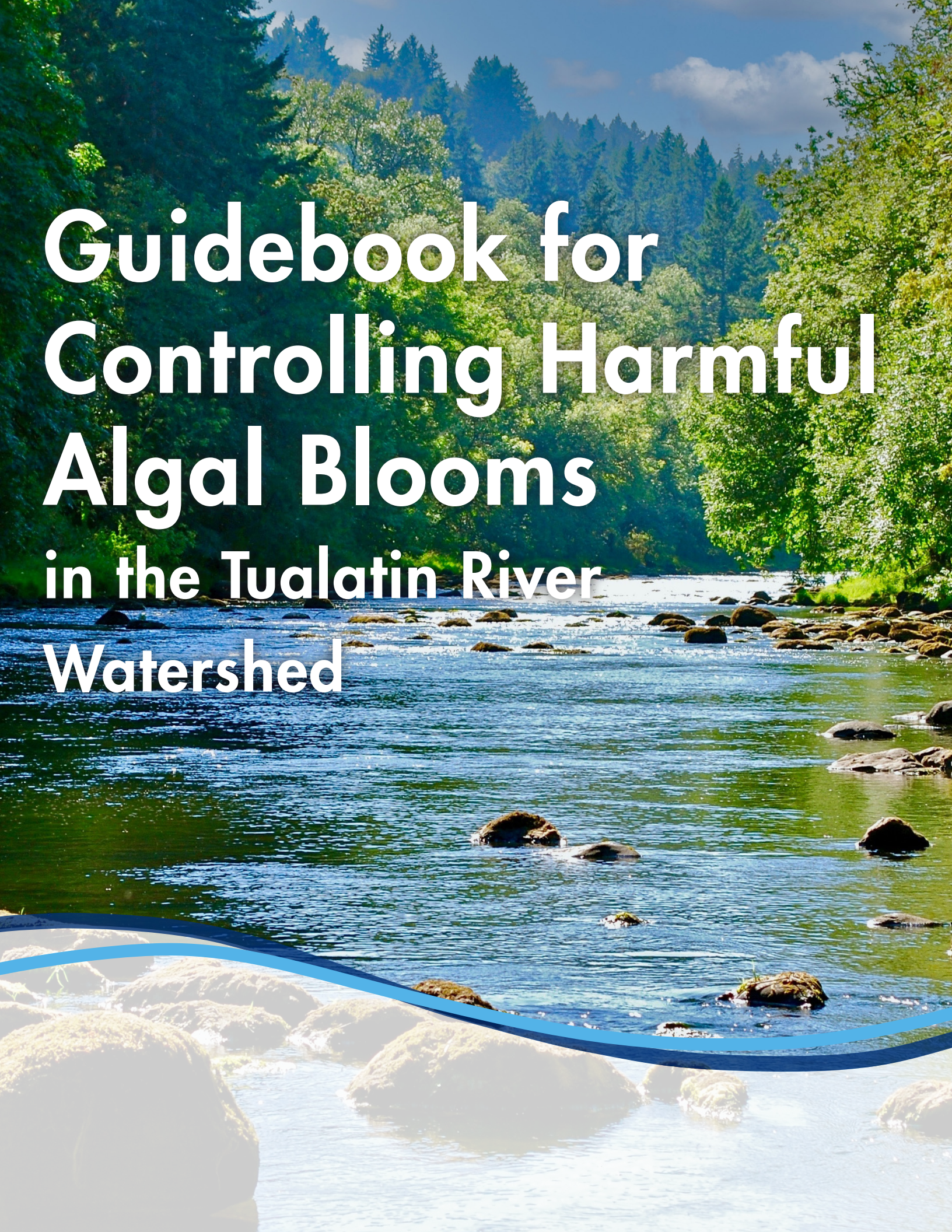

Guidebook for Controlling Harmful Algal Blooms

in the Tualatin River Watershed

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About this Report

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Background

The Joint Water Commission's (JWC) TREE Grant project, titled "Reducing Threats to Drinking Water from Surface Water Impoundments", addresses water quality concerns in the upper-Tualatin River watershed by identifying surface water impoundments in the JWC's drinking water source area (DWSA) (Figure 1) that have the potential to develop harmful algal blooms (HABs).

HABs can affect human health, aquatic ecosystems, the local economy, and surface water quality. Surface water quality in the upper-Tualatin River watershed is important to protect as it affects drinking water quality. Impaired surface water quality could lead to increased costs associated with surface water treatment and monitoring.

Additionally, if the cyanotoxin concentration in HABs are high enough it could lead to "Do Not Drink" advisories for at risk populations, such as children, the elderly, people who are pregnant, pets, and immunocompromised groups.

Cyanobacteria have been detected in streams in the DWSA several times over the last decade, and the JWC identified impounded surface water as a source for some of these HABs.

Through the TREE Grant project, the JWC is working with regional landowners to identify impoundments and provide informational resources in order to mitigate HABs. The goal of this partnership is to protect surface water quality, so we can continue providing high quality drinking water.

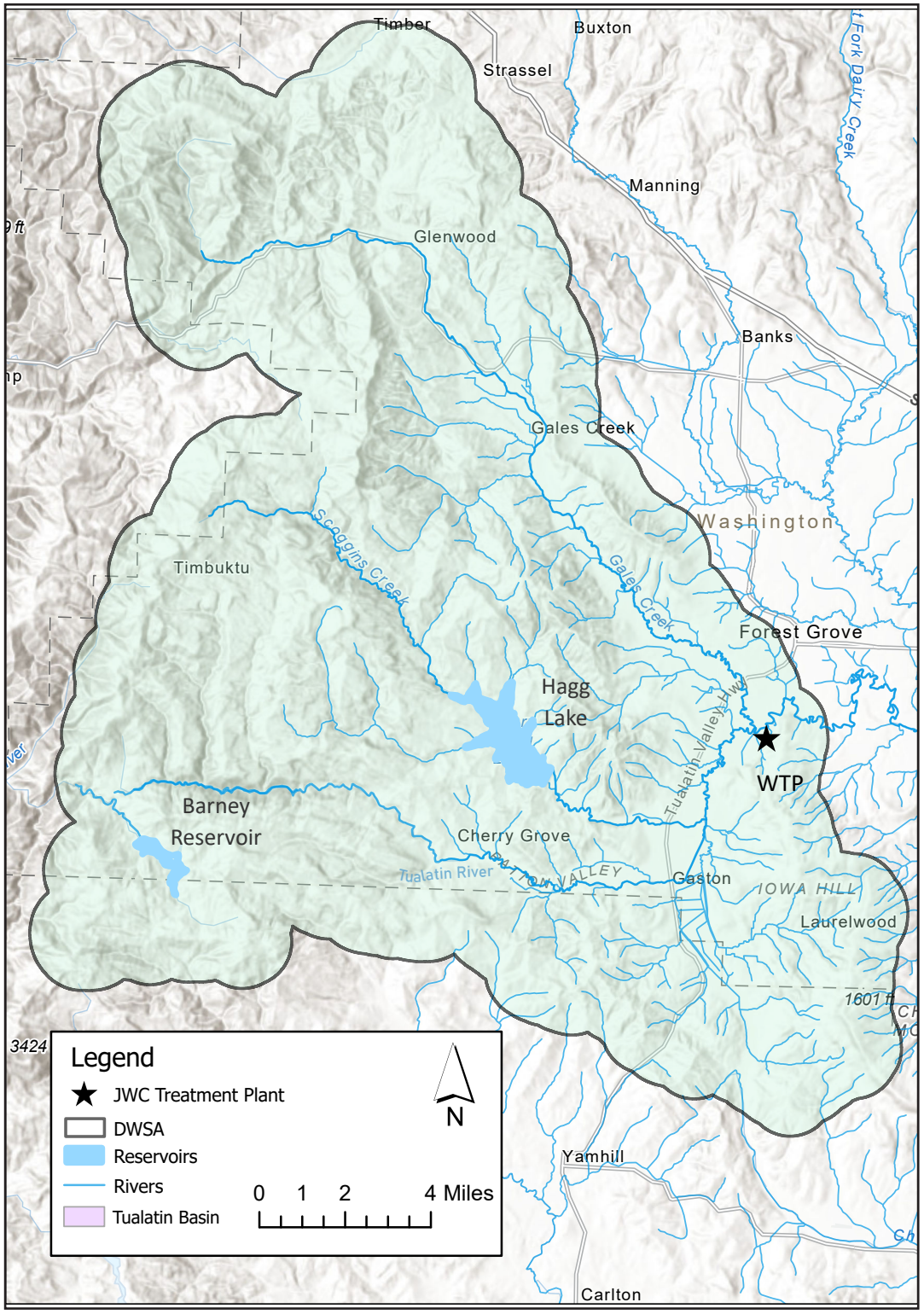


Figure 1

Harmful Algal Blooms

Algae occur naturally in the environment but can multiply out of control if excessive nutrients, like phosphorus (P) and nitrogen (N), are introduced to the system. The process of excessive nutrient load within a water body is known as Eutrophication. Algal blooms alone can be detrimental to aquatic habitats as a result of eutrophication, but they pose an even greater threat when the conditions are right for cyanobacteria to emerge and produce toxins.

Cyanobacteria and algae are often referred to in the same way when discussing HABs, but they differ from each other in that the former is prokaryotic whereas the latter is eukaryotic. Therefore, cyanobacteria evolved first and are much older phylogenetically. Whereas many algal species are key members of the aquatic food chain, cyanobacteria have physiological characteristics that make them a less desirable food source, leading to limited predation. Cyanobacteria also have unique qualities that allow them to outcompete algae to quickly become the dominant phytoplankton species.

Cyanobacteria

Cyanobacteria are Earth's oldest photosynthetic species, helping to create the oxygenated atmosphere billions of years ago. There are many species of cyanobacteria, some with the ability to fix atmospheric nitrogen, some that can adjust buoyancy, and some that produce cyanotoxins. These physiological adaptations allow cyanobacteria to outcompete algal species and become the dominant phytoplankton. Buoyancy regulation and toxin production are the two characteristics that most concern water managers. Buoyancy provides access to optimal growing conditions in the water, and toxins produced by some species target the liver or nervous systems. Surface accumulations of buoyant species can concentrate toxins, posing hazards for pets, wildlife, or recreational swimming.

Cyanobacteria benefit by having gas vesicles that allow them to adjust their position in the water column, whereas algae are slightly negatively buoyant and settle to the bottom. This allows cyanobacteria to shade the water column and suppress the growth of beneficial algal species. Buoyancy regulation is used to cycle cyanobacteria between nutrient rich areas near the pond bottom back to the photic zone near the surface. As a result of buoyancy, calm winds allow cyanobacteria to form surface films. Winds around 3 m/s promote blooms while higher speed winds (6 m/s) create a downward fluid field which causes cells to aggregate at the bottom (Gu et al. 2021). A surface film will move around a waterbody depending on wind direction and can be concentrated in different shoreline areas throughout the day, making management difficult.

As climate change creates conditions that warm surface waters it is expected that cyanobacteria will become even more dominant in the future. They can live in water warmer than other algal species can tolerate. However, while cyanobacteria exhibit several factors that allow them to proliferate, it is possible to create conditions that do not favor their growth. Most cyanobacteria species can fix nitrogen allowing them to thrive in conditions where the low nitrogen may limit algal productivity. The optimal Nitrogen:Phosphorus ratio for algal growth is 16:1, and lakes that have been enriched with phosphorus will have ratios lower than that.

Gu P, Zhang G, Luo X, et al (2021) Effects of different fluid fields on the formation of cyanobacterial blooms. Chemosphere 283:131219. https://doi.org/10.1016/j.chemosphere.2021.131219

Pond Algae

Algae and plant growth in ponds is a natural function of a healthy waterbody. Under ideal conditions the pond would have a mix of plants and algae, with neither being overwhelmingly dominant. Vegetation provides habitat for fish and stabilizes the sediment, while algae provide food for aquatic insects at the base of the food chain. When conditions in the watershed introduce excessive nutrients to the pond it can lead to excess algae growth that ultimately shades the water column and prevents plant growth. Under certain conditions the algal population will shift to cyanobacteria, which can lead to the problems discussed earlier.

To successfully reduce algae dominance, it is necessary to reduce nutrients, particularly phosphorus, that feed their growth. The first step is to determine if phosphorus is coming from within the pond or from the watershed. A deep layer of organic material at the bottom of the pond is often the cause of internal phosphorus loading. This material may have accumulated from leaves or other organic material falling into the pond from adjacent vegetation, biomass from years of aquatic plant growth, or from soils naturally high in phosphorus. Microbial activity that breaks down the organic material consumes oxygen, which can lead to a release of phosphorus into the water column.

Phosphorus can also come from outside the pond in the form of high nutrient runoff from the watershed. Activities in the watershed can generate phosphorus and nitrogen effluent that can end up in ponds and streams. Anthropogenic activities within the watershed have been shown to be the best predictor of cyanobacteria dominance (Doubek et al. 2015).

Therefore, methods to reduce algae populations in lakes and ponds fall into the two broad categories of preventing a bloom or controlling a bloom once it occurs. Preventing a bloom is a proactive approach that attempts to find and reduce nutrients that feed a bloom. Once the pond is actively growing cyanobacteria it requires management steps to either kill the cyanobacteria or remove nutrients that feed its growth.

Ponds can be the ideal environment for cyanobacteria blooms due to the adaptions mentioned earlier. Ponds are small enough to avoid significant wind mixing, shallow enough that cyanobacteria have access to the entire water column, and can still thermally stratify, leading to high internal phosphorus loading. Agriculture ponds are particularly high-risk because they are accessible by cattle and can have very high phosphorus concentrations, as are ponds that receive runoff from fertilized fields.

Doubek JP, Carey CC, Cardinale BJ (2015) Anthropogenic land use is associated with N-fixing cyanobacterial dominance in lakes across the continental United States. Aquat Sci 77:681–694. **https://doi.org/10.1007/s00027-015-0411-x**

Climate Change

As the planet warms due to increased CO_2 in the atmosphere, the resulting weather conditions will make ponds more likely to grow cyanobacteria. It will be important for property owners to maintain pond health by mitigating the effects of climate change. This can be accomplished by implementing practices that counter the effects of a warming environment.

Anticipated changes to the pond environment are:

- Shorter, more intense rain events will increase erosion and transport sediment and nutrients to the pond.
- Warming conditions will result in a longer growing season with hotter summers
- Summers in Oregon will have less influence from marine layer low clouds and more hours of sunlight
- More sunlight and warmer water favors cyanobacteria
- Warmer water means ponds are stratified longer, leading to increased internal nutrient loading

Work with your local watershed council or Soil and Water Conservation District to find out how you can prepare for these conditions.

Assessing Pond Condition

The first step in managing cyanobacteria growth is finding out where nutrients are coming from, either from internal cycling or from watershed inputs. Once this is known it becomes easier to apply specific management practices — physical, chemical, or biological — to reduce nutrients.

The best way to determine nutrient sources is to measure the concentration in the water. If a pond has no obvious inputs during summer but the phosphorus concentration continues to increase, then internal nutrient loading is happening.

If a stream carries nutrients and sediment into the pond during winter or summer, then external loading is occurring. Most ponds have a combination of internal and external loading and testing will help identify the sources.

In this region, the growing season for algae coincides with summers that see little rainfall. This means an isolated pond with no connection to perennial streams may not receive any runoff for most of the summer but could see algae or cyanobacterial growth from nutrients that accumulated during the winter. This is why Best Management Practices (BMPs) are important all year round!

Identifying Causes of Poor Water Quality

Looking out at your pond, you may see something floating on the surface instead of open water. Identifying what is on the water is the first step to figuring out how to remedy the situation. The following section has common examples of surface material that impedes water quality.

Use images on the following pages to identify the condition in your pond and reference the description for control options.

Cyanobacteria

If you see bright green films or surface mats there is a possibility that the pond is experiencing a cyanobacteria bloom. Cyanobacteria have an adaption that allows them to adjust their buoyancy, and under certain conditions will rise and create a distinctive surface layer.

If you see this, please keep pets and people away from the water and refer to the Oregon Health Authority document found at **HealthOregon.org/HAB** for more information.

If you are not sure if it is a cyanobacteria bloom, follow OHA guidance: "When in Doubt. Stay Out!"

These blooms can be cleared with algaecide, but it may release toxins in the water and does not keep a subsequent bloom from forming. **The best way to prevent cyanobacteria is to reduce nutrients.**

Summary:

- Prefers warm water with high phosphorus
- The best way to control cyanobacteria is to reduce nutrients in the pond
- During an active bloom an algaecide can be used, but this will not prevent the bloom from recurring since nutrients are still available
- Aeration may be an option for reducing nutrients and disrupting the buoyancy advantage

Filamentous Algae

Filamentous algae grow in long, stringy mats on the pond bottom and on plant stems, drawing nutrients directly from the water. While the mats can rise to the surface and cause odors as they decay, they are not harmful on their own, but can accumulate toxins if cyanobacteria are mixed in.

Algae abundance is a sign of excess nutrients in the water, so steps should be taken to reduce nutrient inputs. Removing algae with a rake or net is the best way to control nuisance mats without harming other pond life. Removing the mats will also remove nutrients from the pond.

Summary:

- Grows on the pond bottom using nutrients directly from surrounding water
- Can surface and form unsightly mats
- Rake or skim to remove surface mats
- Reduce nutrient in the pond (refer to nutrient control flyer)
- Can use pond dye to limit light penetration and slow growth (refer to habitat alteration flyer)
- Algaecides will kill filamentous algae, but will kill beneficial algae and could harm aquatic invertebrates

Floating Plants

Sometimes a pond will look green from a distance, but it may not be from algae. The green coloration may come from tiny floating plants, commonly called duckweed.

Another possibility is Azolla, or water fern, which is a larger floating plant that starts out green but turns a reddish brown when it is dying. Both plants are native and provide food for waterfowl. However, they can completely cover a pond and lead to low oxygen and phosphorus release from the sediment.

Summary:

- Can completely cover a pond, preventing light from penetrating into the water
- Best way to remove is by skimming off the surface, but it will be an ongoing process
- Reducing nutrients in the pond will limit floating plant growth
- Aeration may sustain oxygen levels and reduce a bloom.

Opaque Water

A pond may not be green, but it may not be clear either. A brown tinted pond could be a result of sedimentation deposits into the pond, decaying plant matter, diatoms, or a growth of green or brown algae.

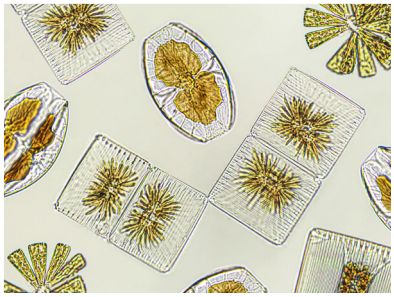
If the pond is brown after a rain event it is likely due to sedimentation deposition, and it will clear in a few days.

If the water is brown during the summer months, it is most likely from diatoms and algae.

If there is an abundance of algae causing a brown pond, it is best to leave it be since these beneficial algal species are using nutrients that may feed a cyanobacteria bloom.

Summary:

- Diatoms and other algae species play an important role at the base of the aquatic food chain
- Opaque water from an algae bloom slows the growth of aquatic plants or cyanobacteria
- Reducing nutrients in the pond will reduce algae growth
- Treating with algaecide may shift the population to cyanobacteria or aquatic plants



Physical Controls

AERATION

Example System

Mill Pond covers one acre and is 10 feet deep. Historically the pond was used to store logs before milling, but the site is now a park heavily used during summer. The pond is kept full by groundwater with no surface inputs. Every summer the pond has cyanobacteria blooms that cause park management to post signage restricting recreational activities.

A study determined the sediment was releasing phosphorus during summer stratification, so an aeration system was proposed. An electrical source in a nearby system was proposed. An electrical source in a nearby public bathroom was used to power the compressor, which was housed in a small vault near the edge of the pond. A three inch underground sleeve connected the vault to the pond and air lines were routed through the sleeve to the water. While it took some time to install electricity and the vault, the in-water work and compressor connections were accomplished within a day.

Issue: During the summer, a pond can thermally diverge. This results in warmer water on the surface and colder water near the pond bottom. However, the two layers do not mix. This leads to oxygen depletion at the bottom of the pond, and the potential for phosphorus to be released from the sediment. Mixing the water from top to bottom will move oxygenated surface water to the pond bottom, reducing nutrients and improving habitat for aquatic life.

Solution: An aeration system circulates water and keeps it from separating into cold and warm layers. Water circulation can be achieved by mechanical or pneumatic pumps, with the goal of mixing the entire water column.

Cost: $$ – $$$

The least expensive and most common way to circulate a pond is to use diffused aeration. The only mechanical part is a small air compressor on shore connected to air diffusers in the pond via weighted hoses.

The size and depth of the pond will determine final cost, as larger waterbodies require more diffusers and larger compressors.

Advantages

- For small ponds the compressors are quiet and have low energy consumption
- Unlike pumps, there are no mechanical parts inside the pond that would need serviced.
- Circulating water can disrupt cyanobacteria growth and promote beneficial algae
- Improves habitat for amphibians, invertebrates, and fish

Disadvantages

- Initial installation of weighted hoses and diffusers can be time consuming
- There needs to be an electrical source near the pond
- Will not work if the majority of phosphorus coming into the pond is from external sources

DREDGING

Example Project

Ranch Acres used to be a large dairy operation but now the property has been converted to viticulture, with the goal of establishing a winery and tasting room. A legacy from the dairy operation is a holding pond historically used for manure processing. The goal is to use this pond as a central feature of the winery since it is adjacent the future tasting room.

The pond was not entirely cleaned out after shuttering the dairy so the bottom has a layer of high nutrient sludge. This led to high phosphorus conditions due to anoxic sediment release.

Aeration, dredging, and sediment treatment were considered for reducing phosphorus, but since the sludge layer is several feet thick and a deeper pond was one of the goals, dredging was the preferred option.

The property owner checked with regulatory officials and it was determined this would fall into the agricultural maintenance category and would not require permits. The pond was pumped out and sediment removed with a long reach excavator. The dredged material was stockpiled in an upland location to dry and in the future be used as fertilizer for the vineyard.

Issue: Nutrients are retained in pond sediment as they accumulate on the bottom through settling and plant decomposition.

Dredging is often used to make a pond deeper. The process will also remove high-nutrient sediment, which can be beneficial in preventing future mobilization of nutrients. However, dredging will reduce nutrient store and negatively impact the pond ecosystem.

Solution: A pond can be dredged using two basic methods depending on if it can be drained. When the pond still has water, it can be wet dredged by pumping or excavating material. Sediment will have to be dried before hauling unless the material will be used onsite. Dry dredging requires the pond to be drained and conventional excavation equipment can then be used to remove material. It may still be necessary to dry the sediment before disposal depending on whether the site can take wet material.

Permitting may be required before dredging, and it can take time for large or complex dredge projects. The sediment must be tested to determine where spoils can be dumped. It may be necessary to take steps to minimize impacts downstream or outside immediate dredge areas.

Cost: $$ – $$$$

Dredging can be expensive for larger ponds that require wet dredging, but for smaller waterbodies that can be drained, conventional excavation equipment can be used to lower costs.

Permitting costs may be substantial so make sure to contact the regulatory agencies before work starts to determine what steps will be necessary.

Advantages

- Will make the pond deeper
- Will remove plant material and seed bank, potentially reducing aquatic plant growth
- Will remove high nutrient soil and reduce the amount of nutrients released in the water column
- Allows the pond to be "reset" by establishing beneficial native plants

Disadvantages

- Can be expensive due to testing and permitting requirements, especially if the pond is created by impounding a perennial stream
- Fish and other aquatic life may not survive wet dredging, and certainly will not survive dry dredging
- The shoreline will be impacted and will need restoration if an excavator is used
- Nutrient rich runoff from the sediment pile must be kept from flowing back into the pond or adjacent streams

Contacts for Dredging Information within the Upper - Tualatin River Watershed

Oregon DSL:
Michael DeBlasi
Michael.Deblasi@DSL.Oregon.gov
503-986-5226

Oregon DEQ:
Haley Teach
Haley.Teach@DEQ.Oregon.gov
503-702-9753

ACOE:
Trey Fraley
Robert.H.Fraley@USACE.Army.mil

LAND USE

Managing runoff to ponds is important because the relatively small volume of water they hold means any input can have a pronounced effect on the nutrient concentration. Land use has a heavy influence on many of the pathways by which nutrients enter a pond. Sources include manure runoff, fertilizer runoff, leaves and grass clippings, and waterfowl waste. There are management practices available to reduce the concentration of nutrients introduced to waterways. **Efforts should be focused on manure management, proper fertilizer use, erosion prevention, and livestock exclusion.**Identifying the precise source of nutrients in diverse land use environments can be difficult, therefore multiple treatments may be required to address the situation. Taking some of the following steps can keep the watershed healthy and reduce the impact of runoff. There is also a vast array of information to help farmers steward their land — information is listed in the Resources section at the end of this brochure.

Lawn Care

Issue: Ponds are often a highlight of the landscape and many feature lawns to the water's edge. This becomes a problem for pond health when fertilizer, weed, and pest control products run off the lawn into the water.

The soil in this region is naturally high in phosphorus, so phosphorus-free varieties should be used.

Solution: The best way to ensure you are using the proper amount of fertilizer on lawns and crops it to test the soil and follow recommendations provided.

In general, it is best to limit the use of lawn fertilizer and chemicals within 30 feet of a pond. Ideally, ponds would include a 30-foot-wide perimeter of native riparian vegetation. This buffer strip can filter lawn chemicals and fertilizers before they reach the water.

Additionally, leaves and lawn clippings can contribute significantly to phosphorus concentrations in a pond. Once they settle to the bottom, they consume oxygen as they break down, which can degrade habitat and further increase phosphorus. **Raking leaves and lawn clippings away from the edge will prevent them from blowing in.**

Animal waste management

Issue: Animal waste can be a significant source of nutrient runoff to a waterway.

Solution: Manure management is crucial for keeping these nutrients and bacteria from the waterway.

For example, a 1,000-pound horse will produce 35 to 50 pounds of manure per day; approximately nine tons per year not including the bedding. Nutrients in horse manure will vary depending on the feed used, but in general contains 11 lbs. nitrogen and 2 lbs. phosphorus.

Range and Pasture Management

Issue: Maintaining a mud-free pasture keeps animals healthy and reduces sediment and nutrient transport to streams. Western Oregon weather can make it difficult to manage pastureland. Summer weather is too dry to maintain a healthy pasture, while pasturing during winter rain leads to muddy fields.

Solution: The best solution is to have a paddock with all-weather footing that drains well during winter. Some pasture lands may have swales or ditches that carry water during the rainy season. These may also stay green longer into the summer and be attractive grazing areas. Access to these low spots should be limited so they do not get trampled from overuse and end up with a large volume of manure.

This is particularly important since these waterways will become active during the rainy season, leading to manure and sediment washing downstream. This is also the case for perennial creeks and ponds that carry water year around.

Restricting animals from shoreline areas will keep manure out of the waterway and will maintain a healthy riparian area.

Conservation Farming

Issue: Traditional farming practices tend to be a major source of waterway pollution in the United States. The main purpose of conservation farming is to reduce soil and nutrient transport from agriculture land to adjacent waterways. This does not have to be exclusive to tilled cropland and is appropriate for hay fields and pasture.

Solution: Conservation farming includes several practices from crop rotation, conservation cover, contour buffer strips, fertilizer management, and many others. If you are interested in finding out how conservation farming can be applied to your operation, contact the Oregon State University (OSU) Extension Service or the Tualatin Soil and Water Conservation District for assistance.

OSU Extension Service has several free publications to guide small farm owners in managing their farms. Refer to the Resources page for more information about range and pasture management.

Information provided in the Resources section is targeted towards equine and small animal facilities, not confined cattle feeding operations, which are regulated at the state level and require a permit for operations.

Biological Controls

Case Study

A pond at Taylor Farm had been used for catfish rearing. A result of their feeding activity was very few aquatic plants and phosphorous released into the water from sediment disturbance. Summer cyanobacteria growth took advantage of high nutrients.

It was recommended the catfish be removed to reduce suspended sediment and promote aquatic plants. The pond was lowered to concentrate the fish for collection. While the pond was down the sediment was evaluated for organic material and nutrient content. Organic material was limited because plants were not allowed to grow and nutrients were not exceedingly high because fish were regularly removed from the pond.

Water lilies were planted in shallow areas to provide shade and Wapato were planted along shoreline areas to promote habitat restoration to return the pond to a natural state.

It took a couple years for the plants to become established, but the result is a pond with robust native emergent plants and some submersed plants in deeper water. In later years a floating wetland was anchored in the deeper part of the pond to provide shade and keep the water column cool.

Issue: A lack of aquatic plants leads to no competition for nutrients, leading to a proliferation of algae and cyanobacteria. Bottom feeding fish also disturb the sediment, which releases nutrients into the water column. Biological methods that remove bottom feeding fish and establish aquatic plants can be a good way of providing a more balanced and healthy aquatic ecosystem that is less favorable to cyanobacteria growth.

Floating Plants

Solution: Several companies market floating wetlands to reduce nutrients in a pond. They serve the dual function of providing shade and extracting nutrients from the water column.

Floating wetlands consist of a raft with soil added to support wetland plants. The rafts can be various sizes depending on the application. In addition to blocking sun from feeding algae and rooted plants, they pull some nutrients from the water. Additionally, native plants on the island provide habitat for wildlife and pollinators.

Nutrients are removed both by plants via roots that hang into the water, and by biofilms attached to roots and other underwater structures. Providing the island structure is only half the process, the nutrients captured by the plants must be removed. This can be accomplished by cutting and removing aerial vegetation and by stocking and removing perch to eat biofilm from the underwater structure.

Floating wetlands can provide several benefits to pond owners, but the coverage needed to remove adequate phosphorus may be substantial. Talk to a professional about the expected benefits in your particular pond.

Floating wetlands alone cannot eliminate cyanobacteria blooms, but if used in conjunction with other BMP's they can help improve pond water quality.

Visit **www.IISD.org/projects/floating-treatment-wetlands** or scan this QR code to learn more:

Aquatic Plants

Solution: Depending on how the pond is used, fostering a robust aquatic plant population may be a good way to reduce algae growth. **Aquatic plants shade the water column, take up nutrients, and provide habitat for a variety of aquatic life.** While they will not completely eliminate algae, they can suppress growth of some species. A pond dominated by aquatic plants may not work if the pond is used for recreational fishing or swimming but could still be appropriate if the pond is used for irrigation or wildlife enhancement.

Floating plants like native water lily *(Nuphar lutea)* are a good way of providing shade in shallow sections of a pond. These native plants spread out and cover large portions of a pond and their broad leaves shade the water column to help keep it cool and block light.

Barley Straw

Solution: Barley straw has shown to produce degradation byproducts that control cyanobacteria. It does not kill algae but inhibits its growth so it is best to utilize it before algae gets too dense. The straw is loosely bagged and placed on the surface before the algae growing season and removed in the fall to prevent organic material from settling on the pond bottom. Implementation requires two to three bales per surface acre as a general rule.

Eliminate Bottom Feeding Fish

Solution: The best way to control algae is to reduce the amount of phosphorus in the water. Bottom feeding fish like catfish, carp, or Koi (members of the carp family) till the soil to get at any edible plant matter, insects, eggs, or larvae that are available. The process exposes deeper layers of sediment to overlying water, encouraging phosphorus release. **Eliminating these fish species will reduce sediment disturbance.**

Cost: $ – $$$

Adding dye or promoting water lilies is an inexpensive way to limit light. Shade cloth is more expensive and requires maintenance. Floating wetlands have high upfront costs, with maintenance variables depending on aesthetic or water quality needs.

Advantages

- Biological methods can be low cost and rely on natural processes to control algae
- No algaecides are used with biological methods so aquatic insects and amphibians are not affected
- Can disrupt cyanobacteria growth and promote beneficial algae
- Improves habitat for amphibians, invertebrates, and fish

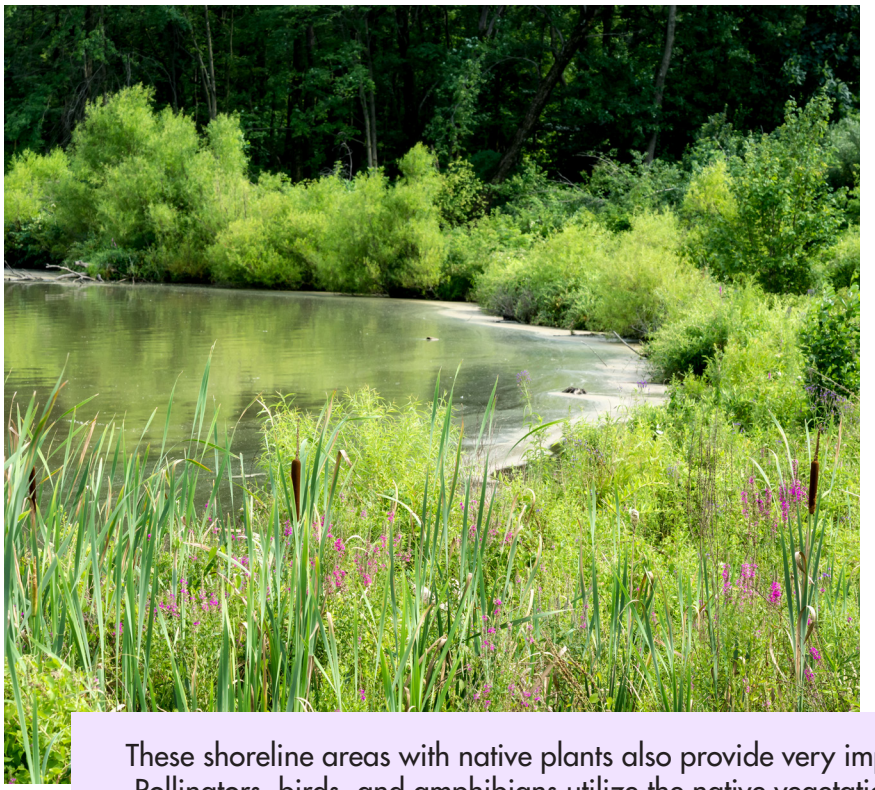
Disadvantages

- If too much shade is provided it could limit beneficial algae and lead to oxygen depletion
- Floating wetlands should be harvested occasionally so nutrients in the plant biomass are not returned to the pond
- Floating leaved plants and wetlands restrict recreational uses of the pond
- Biomass from dead aquatic plants should be removed at the end of the season to reduce nutrient cycling

Forebay or Wetland

Solution: A successful method of reducing pond inputs is to build a forebay or establish wetland plants in a shallow section of the pond at the input source.

These features will capture the material before it enters the pond and filter nutrients. The goal is to have an area large enough to adequately slow water and filter sediment, while also being small enough that it is easy to clean and



Shoreline Buffer

Solution: Natural shorelines around ponds and streams offer several benefits. They provide wildlife habitat, stabilize the banks, and filter runoff before it reaches the pond.

The ideal buffer strip is at least 30 feet in width and contains a variety of native grass and shrub species that provide wildlife habitat in addition to structure.

The pond perimeter should have emergent aquatic vegetation that stabilizes near-shore soil and reduces erosion from wave action while providing habitat for turtles, frogs, juvenile fish, mussels, and insects.

These shoreline areas with native plants also provide very important wildlife habitat. Pollinators, birds, and amphibians utilize the native vegetation for food and shelter with access to water when they need it. A healthy pollinator population helps adjacent agricultural land by providing a valuable service to nut and berry orchards.

Goose Management

Issue: Canada and cackling geese are native to the region, and they historically migrate south for the winter. However, increased temperatures as a result of climate change leave geese less likely to migrate. Goose waste can be a significant source of phosphorus to a pond.

Solution: An effective way to discourage geese is to make it harder for them to move between the pond and lawn. Taller shoreline vegetation can provide a visual break between a lawn and the water. This discourages geese from grazing on lawns because they cannot easily reach the safety of water when they feel threatened. The tall vegetation also provides a hiding place for predators, and geese do not like to forage where they do not have a clear escape route to safety.

Several other methods of goose management are available, including lasers, noise generators, flags or streamers, predator effigies, chase dogs, egg addling, and exclusion devices. Information on these methods and other wildlife control practices can be found at the Internet Center for Wildlife Management , ODFW, OSU Extension, or USFWS. Contacts for these agencies are listed within the "Resources" section.

Up to 48% of the phosphorus and nitrogen contained in the feces becomes available within one day when deposited directly to the water, and geese have been shown to defecate up to 92 times per day (Dessborn et al., 2016).

Cost: $$ – $$$

Most of these practices are very inexpensive once established but could be quite costly to initiate. Creating a forebay, wetland, or shoreline buffer may require removing invasive plants, taking land out of production, and moving soil to create conditions where the BMP can be successfully implemented. However, limiting fertilizer use, directing leaves and clippings away from the water, and controlling geese can be relatively inexpensive.

To learn more about construction and wildlife resources to aid in pond development, visit these resources:

The Oregon DEQ Construction Stormwater BMP Manual

https://www.oregon.gov/deq/wq/Documents/wqpBMPManual.pdf

EPA Stormwater BMP's

https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater

Internet Center for Wildlife Management

https://icwdm.org

Citation: Dessborn, Lisa & Hessel, Rebecca & Elmberg, Johan. (2016). Geese as vectors of nitrogen and phosphorus to freshwater systems. Inland Waters. 6. 111-122. 10.5268/IW-6.1.897.

Chemical Controls

Phosphorus Inactivation

Aluminum sulfate has been used for over 200 years to control phosphorus, both in lakes and at water treatment plants. Alum comes in both liquid and powdered form, with liquid being most used. There are two methods of using alum depending on the phosphorus source. If internal loading is the source, via phosphorus released from the sediment, then alum can be used to cap the sediment with aluminum and bind phosphorus before it enters the overlaying water. If phosphorus comes from the groundwater or external sources liquid alum can be continuously injected into the water to provide persistent control.

During any alum application it is best to have a buffer, such as lime, available in case the pond pH becomes too low and pH needs to be restored to neutral.

Lanthanum products have been formulated in both powdered or liquid forms and are used similar to alum. It is not as important to monitor pH conditions during a lanthanum treatment because the product is closer to neutral when it is applied.

Issue: During the summer, ponds have a higher probability at becoming anoxic due to increased nutrients and warmer temperatures. This could lead to stratification and could potentially lead to cyanobacteria blooms. The goal of phosphorus inactivation is to remove phosphorus from the water column and bind it in the sediment. This makes it unavailable to feed algae.

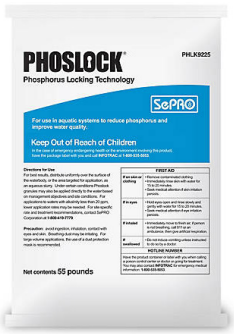
NOTE:

Permits may be required for an alum or Phoslock application. Contact the Oregon Department of Environmental Quality for guidance.

If a phosphorus inactivation treatment is something you are considering, please contact a professional lake manager for planning and any permitting that may be necessary.

Solution: Phosphorus inactivation works by adding metals to the water to bind with phosphorus throughout the water column and the sediment layer. There are two options for phosporus inactivation:

1. Aluminum sulfate (alum) is the most common since it binds to phosphorus over a wide range of pH and oxygen conditions. Alum is widely used to remove phosphorus from water. **Aluminum binds with phosphorus and settles to the pond bottom, preventing the nutrient from feeding growth.** Alum can be used in two ways, either applied to the surface as a one-time treatment, or continuously injected to provide ongoing phosphorus control. Alum forms aggregates of aluminum hydroxide, which rapidly grow into visible floc, and settles into the pond bottom over time.



2. Phoslock is an alternative to aluminum — a bentonite clay product specially formulated to include the rare earth element **lanthanum** that is very efficient at binding phosphorus. It works similarly to alum but does not reduce the pH during a heavy application. Phoslock has been used on lakes since the early 2000's. It is quite a bit more expensive than alum, but certain pond conditions may favor its use.

Conditions specific to the pond will determine which product to use to effectively reduce cyanobacteria populations.

Cost: $$–$$$

Cost will depend on how the pond is treated. Both aluminum sulfate and Phoslock can be expensive depending on how much is used, but the unit price comes down when more is purchased. For a small pond an application would not take specialized equipment since the liquid product can be sprayed directly on the water. A larger pond would require a boat capable of handling the weight of product and application equipment.

Advantages

- Can quickly remove phosphorus from the water column
- A surface application will clarify pond water
- Can reduce the amount of phosphorus that comes from the sediment
- Continuous alum injection can be used to reduce phosphorus when external loads are most prevalent
- Lanthanum products have minimal impact on pH

Disadvantages

- Flocculation products may form at the surface and take several days to settle
- Alum applications require monitoring to ensure pH does not get below 6
- Depending on the method used, phosphorus could still be released under anoxic or high pH conditions
- These applications may have lower effectiveness if there is a large external phosphorus source

Algaecides

Algaecide Concerns

Algaecides should be the last option for cyanobacteria control. While they will reduce the population of cyanobacteria and algae, they do nothing to change the conditions that allowed cyanobacteria to thrive initially. As a result, algaecide treatments will have to be repeated throughout the growing season as long as conditions are favorable for their growth.

If the pond has a high population of toxin producing cyanobacteria, an algaecide treatment can release toxins from the cells into the surrounding water. The pond should be tested for algal toxins regularly if it is used for recreation, irrigation, or accessible by pets or wildlife.

Before using an algaecide product it is best to contact a water quality specialist to discuss options for algae or cyanobacteria control.

A permit is required for algaecide application.
Contact the Oregon Department of Environmental Quality to start process:

Oregon.gov/DEQ/WQ/WQPermits/Pages/Pesticide.aspx

Issue: In cases where cyanobacteria need to be immediately controlled there are products available that will quickly kill algae cells.

Solution: Algaecides are liquid or pelletized products that disrupt photosynthesis, nutrient metabolism, or other cellular functions cyanobacteria and algae need to grow. While it rapidly reduces the cyanobacteria population, it is indiscriminate and will kill beneficial algae as well. **Some algaecides are toxic to aquatic insects and certain algae have become resistant to specific algaecides.**

Another option is to use a peroxide-based product to immediately control algae. Peroxide is an oxidizer that will break down the cell walls of algae and cyanobacteria but is much safer for fish and aquatic insects. Like with any algaecides, cyanobacteria will continue to grow, and applications will have to be repeated unless nutrients in the pond are reduced.

Cost: $ – $$$

Cost of algaecides depends on the product used and how often the applications must be repeated. The permitting process to allow algaecide use may be expensive.

Advantages

- Rapid removal of algae and cyanobacteria from the water column
- Some forms of algaecide are less toxic to non-target species

Disadvantages

- Treatments will have to be repeated unless conditions are made less favorable for cyanobacteria growth
- Cyanobacteria toxins can be released into the water after a treatment
- Can be toxic to non-target species
- Some algae have become resistant to certain treatments

Resources

Sustainable Agriculture Research and Education

Western.Sare.org/Sare-in-your-State/Oregon

SARE is a program by the U.S. Department of Agriculture's National Institute for Food and Agriculture that provides competitive grants and educational materials. Our programs are conducted cooperatively by farmers, ranchers, researchers, and ag professionals to advance farm and ranch systems that are profitable, environmentally sound, and good for communities.

Horses for Clean Water

HorsesForCleanWater.com

Horses for Clean Water is a program developed by horse owners for horse owners. Our mission is to help other horse owners manage their land in the best way possible for horse health and the environment.

National Grazing Lands Coalition

GrazingLands.org

The National Grazing Lands Coalition (NatGLC) is dedicated to providing voluntarily ecologically and economically sound management of all grazing lands for their adaptive uses and multiple benefits to the environment and society through science-based technical assistance, research and education.

National Resources Conservation Service

NRCS.USDA.gov/wps/portal/nrcs/site/or/home

Since 1935, the Natural Resources Conservation Service (originally called the Soil Conservation Service) has provided leadership in a partnership effort to help America's private land owners and managers conserve their soil, water, and other natural resources.

Tree for All

JoinTreeTorAll.org

One of America's largest and most successful landscape conservation programs, Tree for All takes a community-based, systems approach to building watershed resiliency. Since 2005, Tree for All partners have restored more than 140 river and tributary miles in Oregon's Tualatin River Watershed.

OSU Extension Service

Extension.OregonState.Edu/Washington

Extension Service provides information and expertise across communities to inspire youth and adults to be lifelong learners, encourage a culture of healthy people and environments, and to collaborate with community partners & agencies to address real-world problems in Washington County.

Tualatin River Watershed Council

TRWC.org

The Tualatin River Watershed Council proactively fosters better community stewardship and understanding of the Tualatin River Watershed resources, works to address issues and ensures resilient and sustainable watershed health, functions, and uses.

Tualatin Soil and Water Conservation District

TualatinSWCD.org

They use practical and innovative methods to keep waterways, soils, habitats, forests, farms—and our community — healthy.

Tualatin Riverkeepers

TualatinRiverKeepers.org

Tualatin Riverkeepers is a community-based organization that protects and restores the Tualatin River watershed. They build watershed stewardship through engagement, advocacy, restoration, access, and education.

NRCS Field Office Technical Guide for Oregon

EFOTG.SC.Egov.USDA.gov/#/state/OR/documents/section=1&folder=12358

Technical guides are the primary scientific references for NRCS. They contain technical information about the conservation of soil, water, air, and related plant and animal resources.

Rutgers University Equine Science Center

ESC.Rutgers.edu

The Rutgers Equine Science Center is dedicated to better horse care through research and education to advance the well-being and performance of horses and the equine industry.

USDA National Agruculture Laboratory

Nal.USDA.gov/Legacy/WAIC/Manure-Management

The National Agricultural Library (NAL) facilitates the creation of agricultural knowledge through the acquisition, curation, and dissemination of the information needed to solve agricultural challenges today and in the future.

Extension Horses

Horses.Extension.org

Extension Horses, Inc. is a group of professionals from different Land Grant Universities around the country that collaborate to bring the public research-based information for educational use. We are a group of horse lovers just like you! Our group is dedicated to bringing you resources to help you make more informed decisions about your horse.

OSU Extension Service Mud and Manure Management

Extension.OregonState.Edu/Collection/Mud-Manure-Management-Resources-Small-Farms

Publications and documents demonstrating the art of Mud and Manure Management for the pastures and forage crop. These contain useful information that are important when managing and producing livestock on pasture.

Joint Water Commission

Guidebook for Controlling Harmful Algal Blooms in the Tualatin River Watershed

2023