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DATE: March 27th, 2025

SUBJECT: Hydroraking as a means of lake management

Executive Summary:

The objective of this summary is to outline the importance of lake management and to determine whether hydroraking is an appropriate plant-management tool for use in New Jersey lakes to control select invasive aquatic species plants, non-native plants, or native nuisance plants. This summary is supported by a review of scientific and technical literature, documentation prepared by other states, and consultation with multiple programs within the Department.

Hydroraking is an aquatic vegetation management technique that may be utilized either alone or in tandem with other techniques to restore and maintain healthy lake environments. Given the information presented below, hydroraking is a management technique that may be considered for targeted and select control of aquatic vegetation. However, hydroraking should be coupled with proper aquatic vegetation mapping and should be part of a larger management strategy. Hydroraking should not be used in place of dredging, in places where the aquatic vegetation is not suitable to be hydroraked, or in instances where non-targeted species are mixed in with the targeted vegetation. Hydroraking requires both a permit(s) and notice to the New Jersey Department of Environmental Protection (NJDEP) and is subject to restrictions of use and implementation.

Program Contribution:

Staff members from the following programs contributed to the content provided herein:

NJ DEP Chief of Staff

Division of Science and Research

Director's Office

Bureau of Risk Analysis

AC Area: Water Resource Management

Division of Water Monitoring Standards & Pesticides Control

Bureau of Freshwater and Biological Monitoring

Division of Water Supply and Geoscience

Bureau of Water Systems Engineering

AC Area: Watershed and Land Management

Division of Watershed Protection and Restoration

Division of Watershed Protection and Land Management

Bureau of Watershed Management

Bureau of Freshwater Wetlands and Highlands Permitting

AC Area: State Parks, Forests and Historic Sites

Assistant Commissioner's Office

Division of Parks and Forestry

Office of Natural Lands Management

AC Area: NJ Fish & Wildlife

Bureau of Freshwater Fisheries

Endangered and Nongame Species Program

Bureau of Marine Habitat and Shellfisheries

Office of Environmental Review

Preface:

This summary is aimed to give a general overview of the complex science of lake management with a specific focus on hydroraking, benefits and drawbacks associated with its implementation, and the permitting requirements necessary for approval.

Background – lake dynamics:

Limnology is the science of inland waters, including lakes, ponds, streams, and rivers. Limnology encompasses the broad study of the biological, chemical, and physical processes of these bodies of waters and how they overlap to create a functional habitat. Studying and understanding the science behind these processes and their relationships helps to better manage and protect these in inland waters.

Watershed contributions:

The watershed contributing to lakes in New Jersey may be quite large or may be very small in areas where the lake is remote or isolated at higher elevations. Water quality and chemistry varies greatly between the physiographic regions of the state (Procopio and Zampella, 2023), thus affecting the ecology of the lakes within them.

As water moves through these watersheds, nutrients and other contaminants entering the system move with the water. In a well-balanced and functioning lake ecosystem, nutrients naturally cycle in processes known as biogeochemical cycles. Broadly speaking, these cycles involve various biological and chemical processes in the lake and serve to regulate the level of various biologically important nutrients. When nutrient inputs become excessive, these cycles become unstable often resulting in the lake becoming enriched with nitrogen and phosphorous and leading to a disruption in the biogeochemical cycling with the lake (Wetzel, 2001).

Water quality:

Water quality and chemistry impact the function of the lake ecosystem (Marmen et al., 2020), and these metrics may be influenced by factors such as the underlying geology, the water source, and various anthropogenic influences in the watershed (Djodjic et al., 2021). A healthy lake is generally considered to be a lake with good water quality that can support a healthy ecosystem and diverse ecosystem.

Water quality parameters are often monitored or recorded to determine the health of a particular waterbody. These parameters may describe physical, chemical, or biological conditions; each providing a different insight into the ecological processes occurring within that body of water. Examples of physical parameters include temperature, turbidity, and general appearance (e.g., coloration). Chemical parameters may include dissolved oxygen, pH, and levels of various nutrients, mainly nitrogen and phosphorous but may include others. Biological parameters include fish diversity and population, plant diversity and population, zooplankton population and distribution, algae populations, and bacteriological assessments (USGS, 2018). Collectively, all three parameter types are influenced by watershed inputs and ultimately characterize the health and function of the lake. Watershed inputs, like nutrient and sediment loads, and resultant water quality characteristics are closely related to the land-use/land-cover composition of the watershed (Zampella et al., 2010; Vile and Henning, 2018; Procopio and Zampella, 2023).

Nutrient inputs/eutrophication:

The potential for biological productivity increases as a lake becomes more nutrient enriched. Lakes with high rates of nutrient inputs resulting in high biological productivity are classified as eutrophic. Eutrophication is a natural process part of the ontogeny, or evolution, of inland waters, which often culminates in sedimentation and filling in of a lake. Humans have accelerated this process in certain watersheds through the introduction of excessive nutrients and sediments to waterways and modifications of the watershed.

Nutrient availability:

Nutrient availability, and the presence of many other compounds and contaminants, may be introduced into the lake system either from external or internal sources. External sources include inputs from outside of the lake through watershed inputs. Internal sources constitute inputs from within the lake and often reflect release from sediments or other reserves that are distributed upon disturbance. In some situations, select nutrients may be conditionally supplied by multiple sources – meaning that nitrogen may be internally supplied but excess phosphorous may be primarily provided from external loadings. Under normal conditions, the aquatic food web is initially supported by a layer of photosynthetic primary-producing organisms, such as algae, diatoms, and cyanobacteria, which maintain activity year-round but increase in population in spring and summer months. This population serves as the nutrient source for larger organisms, such as zooplankton, and moving up the aquatic web to larger and more complex organisms such as fish. While primary producers serve as the base for the food web, some species provide additional important nutrients like biologically available nitrogen (organic nitrogen) or are part of complex nutrient cycling that occurs within a water body.

Mixing/Stratification:

The vertical mixing regime is an important function in lake dynamics. Monomictic lakes undergo a single mixing event (i.e., the lake mixes and stratifies once per year), whereas dimictic lakes undergo two complete mixing events per year – one in the fall and one in the spring. Some lakes in the state are also classified as polymictic because they frequently mix and have poor stratification. Once the lake has mixed, the water column begins to stratify based on the temperature gradient. Temperature stratification is ecologically important in lakes because it results in oxygen and nutrient gradients in the water column.

In the summer, after seasonal stratification has occurred, nutrients can be introduced into the top layer of the water column (the epilimnion) from either surface water runoff after rain events (i.e., external loading) or from the bottom layers (the hypolimnion) through mixing events driven by wind or any disruption of the stratified layers (i.e., internal loading). Total nutrient loading is the sum of external and internal load; with some bodies of water being supplied predominantly by internal load.

Aquatic zonation:

Physical zonation helps to define how plants are distributed throughout a lake system. The nearshore littoral zone can be distinguished separate from the open water areas. The littoral zone is often where the abundance of aquatic plants will be found. The open water area is vertically separated by the availability of sunlight and depth into the limnetic zone, the top of the water column where enough sunlight is available for plant growth, and the profundal zone which is deeper, and sunlight does not penetrate. The benthic zone describes the lake bottom and sediments.

Aquatic plants, while often found in the littoral zone, may span into the limnetic zone. The aquatic plants serve incredibly important functions in lakes, namely in the production of oxygen and providing shelter, spawning areas, and food sources for various aquatic organisms. Depending on the species, aquatic plants may also help stabilize sediment, reduce erosion, and increase water clarity and quality.

The composition of aquatic species varies by lake. Aquatic plants are classified as floating (surface), submersed (fully submerged), or emergent (both in and out of the water). Aquatic plant surveys are often conducted to determine the species, count, and geospatial area where these aquatic plants are found.

Plant reproduction:

Aquatic plants can spread through reproductive and non-reproductive means; using seeds dispersed through wind, water, and waterfowl to spread both to other areas of the waterbody or to other waterbodies. Some aquatic plants are capable of a reproductive process known as fragmentation, where segments of the plant biomass can regrow the entire plant.

Management of non-native, invasive, and native nuisance plant species:

Lake management strategies are often employed to control aquatic non-native, invasive, and native nuisance species. Non-native plant species introduced accidentally or purposefully and that cause, or are likely to cause, harm to economics, ecosystems, or human health are termed invasive. Invasive aquatic plants are problematic because they may outcompete native species and alter existing habitats, leading to a loss of other organisms in the lake. Native species may impede recreational access in lakes or extend over large reaches of the lake and account for an undesirable amount of vegetation cover. Removal of native species has been viewed as a way reduce nutrient content in lakes.

Management strategies can be selective or non-selective in their approach. Selective management strategies target only particular aquatic vegetation. Non-selective management strategies may remove all aquatic vegetation in an area. This is often accomplished by using aquatic herbicides and/or mechanical techniques to remove the plant mass. Hydroraking is an example of a non-selective mechanical management technique. Its use and limitations are described below.

Hydroraking and its use:

Hydroraking involves the use of a specialized rake that is attached to a floating barge via a hydraulic arm. This rake is designed to remove rooted vegetation, tree stumps and limbs, and other organic matter that accumulates at the sediment layer. Hydroraking is often employed for the removal of rooted plant masses in aquatic plant beds. Examples of commonly targeted plant species in New Jersey include spatterdock (*Nuphar luteum*) and white waterlily (*Nymphaea odorata*). Hydroraking can be used closer to shorelines and docks compared to other mechanical harvesting methods. Figure 1 shows an image of a hydroraking vessel.

Figure 1. A hydroraking vessel in the water. Material hydroraked is seen on the shoreline in the foreground. Image from Solitude Lake Management.

Hydroraking may be used to control select native, non-native, and invasive aquatic plant species. Hydroraking can be used to control native species which are experiencing overgrowth due to water quality impairments, including eutrophication. Aquatic plants that have emergent root or rhizome structures which exist in monoculture beds are among the best candidates for hydroraking.

Hydroraking has been employed successfully in areas of monocultured beds of aquatic vegetation; those areas which support only the target species. Because maneuvering the rake to avoid non-target aquatic plant species is problematic, aquatic beds which contain non-nuisance vegetation, or plants which spread by fragmentation, such as Eurasian Watermilfoil (*Myriophyllum spicatum*), Hydrilla (*Hydrilla verticillata*), Curly-leaf Pondweed (*Potamogeton crispus*), Water Hyacinth (*Eichhornia crassipes*), Coontail (*Ceratophyllum demersum*), and Water Chestnut (*Trapa natans*) are not advised to be hydroraked.

Hydroraking is not able to selectively target aquatic plant species. Hydroraking is considered a non-thorough or non-selective technique (Wagner, 2004), meaning that if a protected or desirable plant species is present in an area where hydroraking is to occur, hydroraking cannot selectively avoid that plant species. The hydrorake can also create extensive sediment disturbances during the process.

Hydroraking can be performed on unconsolidated bottom debris above the sediment layer (Desmarais, 2016). This function does not constitute dredging, as dredging targets both the unconsolidated bottom layer and the sediment layer for the purpose of nutrient control and removal (ITRC, 2021). There is overlap, as hydroraking may be considered a combination of mechanical weed harvesting and dredging (Olsen, 2013). Hydroraking is also used to combat lake issues that result from the accumulation of organic matter on top of the sediment, with the goal of nutrient reduction. Hydroraking does not address the causes of the excessive plant growth or the accumulation of organic matter.

Hydroraking is not meant to replace proper dredging. While increased depth results in the areas where hydroraking is performed, hydroraking should not be performed when dredging would be a more appropriate action. Dredging is often most appropriate when sediment accumulation is impacting navigation or when the lake system has been identified as impaired due primarily to internal loading of nutrients (NYSDEC, 2005).

Potential benefits of hydroraking:

As mentioned previously, hyrdoraking can be performed in close proximity to shorelines and other structures including docks. Hydroraking can be performed in water as shallow as one foot, and it can provide long lasting (1-3 years) targeted plant control (Desmarais, 2016). By nature of the hydroraking process, both the physical plant and associated root structures are normally removed in the hydroraked area.

Hydroraking can also be employed as a targeted management technique when there are concerns about herbicide application or proximity to potable water intake (NJWSA, 2018). It can be employed to control the overgrowth of native plant species as well. Hydroraking can be used in more targeted approaches to provide selective clearing in areas such as beaches and boating and fishing channels (Desmarais, 2016)

Combination of hydroraking with other control strategies such as herbicide application can provide lasting control of aquatic vegetation. With the removal of vegetation, internal nutrient loading may be reduced, potentially leading to long term ecological benefits. Any benefit identified here must be measured against the potential impacts.

Potential impacts from hydroraking:

Impacts to water quality:

Due to the mechanism of hydroraking, lake bottoms are disturbed creating water quality and clarity issues that may persist for some time. A temporary increase in turbidity and nutrients can be expected after hydroraking (Desmarais, 2016). Additional water quality features such as pH, DO, temperature, etc., may also be impacted depending on the sediment composition and water body characteristics. Long term studies on the impacts of hydroraking have shown that in some cases nutrients such as phosphorous can exceed measured levels prior to hydroraking, which may promote other nuisance species to proliferate (Panja et al., 2015). Additionally, removal of plants in shallow areas compromises the buffer zone between upland nutrient input and the pelagic zone, which can lead to increased nutrient loading in the water (NYSDEC, 2023).

Colonization of invasive species:

Hydroraking may marginally increase the risk of non-native or invasive aquatic plant vegetation proliferation if native plants are removed (NYSDEC, 2005). Native vegetation plays a role in stabilizing the ecosystem. When native plants are removed, aquatic invasive plants can compete for the resources left in the void from the native plant removal. By nature of nonselective control process of hydroraking, open spaces are left in the waterbody which provide colonization and recolonization opportunities for aquatic vegetation.

Unintentional increase of plant growth:

When hydroraking is performed on aquatic vegetative beds with multiple plant species, it is important to know how those species reproduce. Using hydroraking for plants that reproduce by fragmentation may exacerbate plant growth and be counterproductive.

Impacts to lake ecology:

The removal of aquatic plants may lead to a decrease in benthic invertebrates and other organisms that depend on these plants for food or habitat. During the process of hydroraking, benthic invertebrates may be removed or killed inadvertently (Wagner, 2004). Additionally, other aquatic species such as reptiles, amphibians, mussels, and other invertebrates may be negatively impacted either directly or indirectly. This may affect the overall function of the aquatic ecosystem.

Furthermore, the active removal of aquatic plants can have a significant impact on fish communities. Aquatic plants provide a safe environment for fish eggs to attach and develop. Without these plants, eggs may be exposed to predators and environmental stressors, reducing their chances of survival (Dibble, 2014). Aquatic plants contribute to oxygen production in the water through photosynthesis. Removing them can lead to lower oxygen levels, which can negatively affect the development of fish eggs and fry. Aquatic plants help filter and maintain water quality by absorbing nutrients and providing shelter for beneficial microorganisms. Without these plants, water quality may deteriorate, impacting the health of fish eggs and fry.

Additionally, aquatic plants offer physical protection from currents and other disturbances. Without this protection, eggs may be dislodged or damaged, leading to lower hatching rates (Dibble, 2014). Hydroraking may often be performed at a time when fish are spawning, juvenile in age, or otherwise vulnerable to environmental conditionals. Hydroraking can have a direct impact on spawning by destroying any eggs attached to plants or within nests; the mechanism of propulsion of the hydroraking vessel, the paddle wheels, and the action of the rake, create massive turbidity clouds of organic and inorganic fine sediments. These fine sediments can clog the pores in the eggs and the gills of adults, as well as newly hatched fry. Substantial turbidity has been demonstrated to impact fish (Rodrigues et al., 2023).

Potential impacts to the egg-laying and spawning behavior of certain North American fish and other aquatic species with specific requirements for vegetation are outlined below:

Minnows

Minnows play a crucial role in the aquatic ecosystem, serving as a food source for larger fish and contributing to the overall health of their habitats. Golden Shiners, for example, spawn in groups over algae or aquatic plants. The eggs stick to the vegetation once released and hatch in about four to seven days (Lazur and Chapman, 1996). Females can spawn multiple times in a season and lay up to 200,000 eggs. Common Shiners typically spawn in shallow waters with plenty of vegetation. The male prepares a nesting site by creating a depression in the substrate, often near submerged plants. The eggs are released and fertilized externally, sticking to vegetation for protection.

Pickerel

Chain Pickerel spawn in the spring in shallow, vegetated waters. The female lays her eggs and the male fertilizes them. The eggs hatch in about seven to ten days (Armbruster, 1959).

Largemouth & Smallmouth Bass:

Male Largemouth and Smallmouth Bass are known for their nest-building behavior (Suski and Philipp, 2004). They hollow out circular depressions in the substrate, often referred to as "nests," to protect the eggs once they are fertilized. The male guards the nest and the eggs until they hatch (Gerking, 1959).

Sunfish:

Many species within the sunfish family, including Bluegill and Pumpkinseed Sunfish, prepare and maintain “nests” in the lake bottom sediments. They will also guard the eggs and fry until they are independent (Cooke et al., 2008).

Endangered, Threatened, or Special Concern Species:

Several species recently listed as state Endangered, Threatened, or Special Concern (e.g., Bridle Shiner, Ironcolor Shiner, Blackbanded Sunfish, and Mud Sunfish) are highly dependent upon aquatic vegetation, therefore they must be considered prior to any hydroraking activity is permitted.

Native freshwater mussels that are on the NJ Endangered Species List may be vulnerable to negative effects of hydroraking if the process results in disturbance to sediments. Hydroraking is not to be used as a dredging technique, but the process of pulling up vegetation roots may disturb sediments where mussels are active. Therefore, for water bodies with rare mussel populations in the NJ Landscape Project mapping, hydroraking should avoid the mussel active season of April 1 through October 31, or the hydroraking should be aimed at cutting vegetation to minimize root and sediment disruption. For relief from that timing restriction, a habitat assessment of the proposed treatment area can be conducted to evaluate the likelihood of E&T mussel presence; if that likelihood is very low, the timing restriction could be lifted.

In general, water bodies where hydroraking is a necessary technique (for ecologically beneficial reasons) may not be water bodies that support other vertebrate species on the NJ Endangered Species List, specifically turtles. However, aquatic turtles over-winter in lake and pond sediments, and would be vulnerable to actions that disturb the sediments (such as pulling out vegetation roots). Disturbance to turtles that are in brumation (aka, hibernation) below the frost line in lakes would expose them to freezing conditions that could result in mortality. The sensitive period for brumating turtles – winter months – is opposite that of mussels and some fish, so an assessment of the habitat suitability for mussels, turtles, and fish is necessary to determine the relative risk to listed, rare, and important wildlife species. Which adds to the reason to carefully assess the scope and technique of hydroraking in all proposed situations, with respect to aquatic species in targeted locations.

Limitations and considerations for when to avoid hydroraking:

Since hydroraking is a non-selective removal mechanism, the approach should be avoided when Federal and/or State endangered plant species or other organisms (e.g., freshwater mussels) are present or State Plant Species of Concern (rare plant species) or other species of concern are present in the targeted area. It is advisable to avoid hydroraking areas where there is a presence of aquatic plants that reproduce through fragmentation or are too small to be picked up with the hydrorake.

Hydroraking should not be performed if the body of water has been recently treated with any nutrient inactivating compound during the same target season (e.g., alum, phoslock, etc.) because the hydrorake can compromise the inactivation activity of the compound and release the nutrients back into the water column (NJDEP, 2024).

Hydroraking should also be limited by fish breeding seasons. Warmwater species (such as bass and Bluegill) prefer warmer water temperatures for spawning (Wohlschlag, 1959). They generally spawn later in the spring or early summer when the water temperature reaches around 70-80°F (21-27°C) which generally occurs between April 1st and June 30th. Coolwater species (like perch and pickerel) often spawn in early spring when water temperatures are moderately cool, typically around 50-60°F (10-16°C) (Gillet and Dubois, 2007). Coolwater species will spawn as soon as the ice melts or breaks up which can happen as early as March 1st. Therefore, hydroraking should be avoided between April 1st of any given year through at least June 30th. If cooler water species are also present, this restricted period should begin on March 1st.

There also may be other timing restrictions based on the growing season or other biotic or abiotic conditions not specifically called out in this report. The applicator should justify in their application the timeframe for when hydroraking is going to occur.

Hydroraking in the marine environment:

Hydroraking, while effective in managing aquatic vegetation and sediment in freshwater bodies, can raise several habitat impact concerns if applied in the marine and coastal estuarine environment. First, any activity that would take or adversely impact the natural functioning of marine fish, including the reproductive, spawning and migratory patterns, species abundance or diversity of marine fish and shellfish and the habitats they depend on, is discouraged and heavily regulated. The New Jersey Marine Resources Administration, within the NJDEP, is charged with protecting, conserving, enhancing and managing New Jersey's marine resources and habitats. This authority is established through New Jersey Statutes Annotated (N.J.S.A) Title 23:2B and Title 50. The Coastal Zone Management Rules (CZM), N.J.A.C. 7:7, establish the rules of the NJDEP regarding the use and development of coastal resources and are used in reviewing coastal permit applications under the Coastal Area Facility Review Act, N.J.S.A. 13:19-1 et seq., the Wetlands Act of 1970, N.J.S.A. 13:9A-1 et seq., and the Waterfront Development Law, N.J.S.A. 12:5-3. The rules are also used in the review of water quality certificates subject to Section 401 of the Federal Clean Water Act, 33 U.S.C. § 1341, and Federal consistency determinations under Section 307 of the Federal Coastal Zone Management Act, 16 U.S.C. § 1456.

Potential concerns related to hydroraking in estuarine waters include general disruption of marine environments, especially seagrass beds, benthic shellfish beds and oyster reefs, which are critical habitats and an important home to a wide variety of species. The physical removal of certain species of vegetation (e.g., seagrasses) is prohibited by New Jersey's CZM rules. The physical process of hydroraking can suspend sediment from the seafloor, which can release trapped pollutants (such as heavy metals, nutrients, or toxins) into the water column. This can degrade water quality and lead to issues like algal blooms, localized oxygen depletion, or direct contamination of marine life and, in some cases, seafood products. Additionally, the sediment plumes created during hydroraking can smother habitats, potentially directly impacting them (e.g., smothering) and the species that rely on them for refuge, feeding, or breeding habitat. These activities could also disrupt sediment composition (impacting clams, worms, and other benthic invertebrates). Lastly, the machinery used for hydroraking can create noise pollution and physical disturbance to marine animals, particularly those migrating species that rely on undisturbed pathways to transit to critical breeding areas. Due to these potential concerns, hydroraking in marine and coastal environments should be approached cautiously, and any potential application carefully reviewed. Submerged Aquatic Vegetation (seagrasses), Shellfish habitat and Finfish Migratory Pathways are specifically managed under the Special Area Rules (at N.J.A.C. 7:7-9) within the CZM Rules.

Use of hydroraking for Harmful Algal Blooms:

Hydroraking should not be employed as the sole tool to combat a body of water experiencing frequent Harmful Algal Blooms (HABs). Since hydroraking does not reduce the nutrient load driving the algal activity and temporarily increases sediment in the water column, there is a chance that in systems with high levels of nutrients in the sediment, that hydroraking may elevate algal activity by temporarily increasing the nutrient levels in the water column. While removing plant biomass may reduce the internal nutrient load in the lake, harmful algal blooms may persist if external nutrient loads are not mediated (NJDEP, 2024).

Alternatives to hydroraking:

Alternatives to hydroraking include various physical, chemical, or biological controls. A review in Wagner (2004) outlines these options and is presented in the appendix of this report. Alternatives would be recommended based on the overall goal of the project, the water use (recreational vs. non-recreational | drinking water source), and which plant species are targeted.

Information needed prior to hydroraking:

Proper justification

Explicit justification for why hydroraking is necessary should be presented and clearly explained to the Department. In many cases, hydroraking may be better suited as a technique used in combination with other practices to address invasive or nuisance aquatic vegetation. Additionally, hydroraking should not be the sole management technique proposed given its range and scope of use.

Plant surveys

There may be situations where rare plant species may inadvertently be impacted by hydroraking. However, there may also be situations where hydroraking could reduce the population of an invasive species to encourage the growth of rare plant species populations. Therefore, an aquatic plant survey following the modified point intercept method (as outlined by Madsen, 1999), must be conducted in the area of interest before applying for a permit for hydroraking. This survey should be conducted between July- early October during the peak growing season to capture the distribution and abundance of the target species. An aquatic plant survey conducted and dated as outlined above must be provided in the area of interest before applying for a hydroraking permit. The importance of an accurate aquatic plant survey prior to hydroraking or other means of plant control is crucial as are follow up surveys to ensure revegetation of the impacted areas with native species.

Permit requirements:

Hydroraking requires a permit issued by NJDEP prior to any activity being performed (NJDEP, 2024). An aquatic plant survey of the proposed hydroraking area must be conducted and submitted with the permit application. This aquatic plant survey, as detailed above in the "plant survey" section, must also be conducted and must be included as part of the permitted process. As part of the permitting process, applicants and requesting entities should also provide a clear explanation of why hydroraking is necessary in each specific case, and why the proposed hydroraking activity would not constitute dredging activity, which requires separate permitting under N.J.A.C. 7:13 (Flood Hazard Area Control Act Rules). Some additional program specific guidance from the Division of Land Resource Protection follows.

Without a plant survey and sufficient explanation supporting the necessary use of hydroraking, the Department may request more information and pause its review of the activity until such information is provided by the applicant or requesting entity. NJ Fish & Wildlife must be consulted for all hyrdoraking requests during the permit review process and prior to commencement of any hydroraking activity to determine if, how, and when hydroraking shall be implemented. No outside entity or third party should apply for a DEP Permit to hydrorake DEP-owned or managed lakes.

Freshwater Wetlands Protection Act Rules (N.J.A.C 7:7A) and Flood Hazard Area Control Act Rules (N.J.A.C 7-13)

NJDEP Division of Land Resource Protection provides the following guidance regarding hydroraking and issuing permits. The activities listed below are not considered to be regulated activities and would **not** require a permit issued by the Division of Land Resource Protection. A permit may still be required by other programs within NJDEP depending on the body of water and scope of work.

- The removal of floating debris and vegetation that is not anchored into the lake bed sediments (e.g., leaf litter).
- The removal of obstructive or felled objects, or vegetation in boating channels.
- The removal of submerged aquatic vegetation, either by cutting the stems above the lake bed or by physical uprooting, so long as timing restrictions are adhered to as outlined in N.J.A.C. 7:13-11.5, Table 11.5; and that no endangered aquatic plant life, as listed by the U.S. Fish and Wildlife Service or the corresponding State service are disturbed.

The following conditions must also be met in order for a project to **not** constitute an activity that is considered to be a regulated activity by Land Resource Protection

- The project must be conducted entirely within open waters of the state and cannot result in any disturbances to freshwater wetlands, transition areas, and/or riparian zone vegetation.
- Any and all access points must be situated in a manner that does not result in any disturbances to freshwater wetlands, transition areas, and/or riparian zone vegetation.
- Any and all access points that are situated within a floodway or flood hazard area must be at grade and cannot involve the placement of any fill material.
- All materials removed from the lake must be deposited outside of any freshwater wetlands, transition areas, and/or riparian zones.

The following activities are regulated by the Division of Land Resource Protection and thus will trigger permit and permit review.

- The removal of submerged aquatic vegetation by excavation or scraping of the lake bed sediments, regardless of whether or not the sediments are consolidated
- Any dredging or disturbance of the lake bed sediments (aside from minor disturbances due to the removal of submerged aquatic vegetation that does not involve the excavation or scraping of the lake bed sediments)

Funding opportunities:

At the release of this report, there are no official Department funding opportunities specifically dedicated for hydroraking projects. However, funding may be available if hydroraking is included as a component of a water quality improvement project or a nutrient reduction/control project.

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Appendix

The following management options for the control of rooted aquatic plants are presented in Wagner (2004). Alternatives to hydroraking can be reviewed based on the overall goal of the project, the water use (recreational vs. non-recreational), and which plant species are targeted.

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
PHYSICAL CONTROLS			
1) Benthic barriers	♦ Mat of variable composition laid on bottom of target area, preventing growth ♦ Can cover area for as little as several months or permanently ♦ Maintenance improves results ♦ Usually applied around docks, in boating lanes, and in swimming areas	♦ Highly flexible control ♦ Reduces turbidity from soft bottom sediments ♦ Can cover undesirable substrate ♦ Can improve fish habitat by creating edge effects	♦ May cause anoxia at sediment-water interface ♦ May limit benthic invertebrates ♦ Non-selective interference with plants in target area ♦ May inhibit spawning/feeding by some fish species
1.a) Porous or loose-weave synthetic materials	♦ Laid on bottom and usually anchored by weights or stakes ♦ Removed and cleaned or flipped and repositioned at least once per year for maximum effect	♦ Allows some escape of gases which may be generated underneath ♦ Panels may be flipped in place or removed for relatively easy cleaning or repositioning	♦ Allows some plant growth through pores ♦ Gas may still build up underneath in some cases, lifting barrier from bottom
1.b) Non-porous or sheet synthetic materials	♦ Laid on bottom and anchored by many stakes, anchors or weights, or by layer of sand ♦ Not typically removed, but may be swept or "blown" clean periodically	♦ Prevents all plant growth until buried by sediment ♦ Minimizes interaction of sediment and water column	♦ Gas build up may cause barrier to float upwards ♦ Strong anchoring makes removal difficult and can hinder maintenance
1.c) Improving sediment composition	♦ Sediments may be added on top of existing sediments or plants. ♦ Use of sand or clay can limit plant growths and alter sediment-water interactions. ♦ Sediments can be applied from the surface or suction dredged from below muck layer (reverse layering technique)	♦ Plant biomass can be buried ♦ Seed banks can be buried deeper ♦ Sediment can be made less hospitable to plant growths ♦ Nutrient release from sediments may be reduced ♦ Surface sediment can be made more appealing to human users ♦ Reverse layering requires no addition or removal of sediment	♦ Lake depth may decline ♦ Sediments may sink into or mix with underlying muck ♦ Permitting for added sediment difficult ♦ Addition of sediment may cause initial turbidity increase ♦ New sediment may contain nutrients or other contaminants ♦ Generally too expensive for large scale application

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
2) Dredging	♦ Sediment is physically removed by wet or dry excavation, with deposition in a containment area for dewatering/disposal ♦ Dredging can be applied on a limited basis, but is most often a major restructuring of a severely impacted system ♦ Plants and seed beds are removed and re-growth can be limited by light and/or substrate limitation	♦ Plant removal with some flexibility ♦ Increases water depth ♦ Can reduce pollutant reserves ♦ Can reduce sediment oxygen demand ♦ Can improve spawning habitat for many fish species ♦ Allows complete renovation of aquatic ecosystem ♦ May allow for growth of desirable species.	♦ Temporarily removes benthic invertebrates ♦ May create turbidity ♦ May eliminate fish community (complete dry dredging only) ♦ Possible impacts from containment area discharge ♦ Possible impacts from dredged material disposal ♦ Interference with recreation or other uses during dredging ♦ Usually very expensive
2.a) "Dry" excavation	♦ Lake drained or lowered to maximum extent practical ♦ Target material dried to maximum extent possible ♦ Conventional excavation equipment used to remove sediments	♦ Tends to facilitate a very thorough effort ♦ May allow drying of sediments prior to removal ♦ Allows use of less specialized equipment	♦ Eliminates most aquatic biota unless a portion left undrained ♦ Eliminates lake use during dredging
2.b) "Wet" excavation	♦ Lake level may be lowered, but sediments not substantially dewatered ♦ Draglines, bucket dredges, or long-reach backhoes used to remove sediment	♦ Requires least preparation time or effort, tends to be least cost dredging approach ♦ May allow use of easily acquired equipment ♦ May preserve most aquatic biota	♦ Usually creates extreme turbidity ♦ Tends to result in sediment deposition in surrounding area ♦ Normally requires intermediate containment area to dry sediments prior to hauling ♦ May cause severe disruption of ecological function ♦ Impairs most lake uses during dredging

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
2.c) Hydraulic (or pneumatic) removal	♦ Lake level not reduced ♦ Suction or cutterhead dredges create slurry which is hydraulically pumped to containment area ♦ Slurry is dewatered; sediment retained, water discharged	♦ Creates minimal turbidity and limits impact on biota ♦ Can allow some lake uses during dredging ♦ Allows removal with limited access or shoreline disturbance	♦ Often leaves some sediment behind ♦ Cannot handle extremely coarse or debris-laden materials ♦ Requires advanced and more expensive containment area ♦ Requires overflow discharge from containment area
3) Dyes and surface covers	♦ Water-soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting plant growth ♦ Dyes remain in solution until washed out of system. ♦ Opaque sheet material applied to water surface	♦ Light limit on plant growth without high turbidity or great depth ♦ May achieve some control of algae as well ♦ May achieve some selectivity for species tolerant of low light	♦ May not control peripheral or shallow water rooted plants ♦ May cause thermal stratification in shallow ponds ♦ May facilitate anoxia at sediment interface with water ♦ Covers inhibit gas exchange with atmosphere and restrict recreation ♦ Cannot be used in water bodies with an active outlet
4) Mechanical removal ("harvesting")	♦ Plants reduced by mechanical means, possibly with disturbance of soils ♦ Collected plants may be placed on shore for composting or other disposal ♦ Wide range of techniques employed, from manual to highly mechanized ♦ Application once or twice per year usually needed	♦ Highly flexible control ♦ May remove other debris ♦ Can balance habitat and recreational needs	♦ Possible impacts on aquatic fauna ♦ Non-selective removal of plants in treated area ♦ Possible spread of undesirable species by fragmentation ♦ Possible generation of turbidity
4.a) Hand pulling	♦ Plants uprooted by hand ("weeding") and preferably removed	♦ Highly selective technique	♦ Labor intensive ♦ Difficult to perform in dense stands ♦ Can cause fragmentation

4.b) Cutting (without collection)	♦ Plants cut in place above roots without being harvested	♦ Generally efficient and less expensive than complete harvesting	♦ Leaves root systems and part of plant for possible re-growth ♦ Leaves cut vegetation to decay or to re-root ♦ Not selective within applied area
4.c) Harvesting (with collection)	♦ Plants cut at depth of 2-10 ft and collected for removal from lake	♦ Allows plant removal on greater scale	♦ Limited depth of operation ♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Limited selectivity within applied area ♦ More expensive than cutting
4.d) Rototilling	♦ Plants, root systems, and surrounding sediment disturbed with mechanical blades	♦ Can thoroughly disrupt entire plant	♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ Creates substantial turbidity ♦ More expensive than harvesting
4.e) Hydroraking	♦ Plants, root systems and surrounding sediment and debris disturbed with mechanical rake, part of material usually collected and removed from lake	♦ Can thoroughly disrupt entire plant ♦ Also allows removal of stumps or other obstructions	♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ Creates substantial turbidity ♦ More expensive than harvesting
5) Water level control	♦ Lowering or raising the water level to create an inhospitable environment for some or all aquatic plants ♦ Disrupts plant life cycle by dessication, freezing, or light limitation	♦ Requires only outlet control to affect large area ♦ Provides widespread control in increments of water depth ♦ Complements certain other techniques (dredging, flushing)	♦ Potential issues with water supply ♦ Potential issues with flooding ♦ Potential impacts to non-target flora and fauna

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
5.a) Drawdown	♦ Lowering of water over winter period allows desiccation, freezing, and physical disruption of plants, roots and seed beds ♦ Timing and duration of exposure and degree of dewatering are critical aspects ♦ Variable species tolerance to drawdown; emergent species and seed-bearers are less affected ♦ Most effective on annual to once/3 yr. basis	♦ Control with some flexibility ♦ Opportunity for shoreline clean-up/structure repair ♦ Flood control utility ♦ Impacts vegetative propagation species with limited impact to seed producing populations	♦ Possible impacts on contiguous emergent wetlands ♦ Possible effects on overwintering reptiles and amphibians ♦ Possible impairment of well production ♦ Reduction in potential water supply and fire fighting capacity ♦ Alteration of downstream flows ♦ Possible overwinter water level variation ♦ Possible shoreline erosion and slumping ♦ May result in greater nutrient availability for algae
5.b) Flooding	♦ Higher water level in the spring can inhibit seed germination and plant growth ♦ Higher flows which are normally associated with elevated water levels can flush seed and plant fragments from system	♦ Where water is available, this can be an inexpensive technique ♦ Plant growth need not be eliminated, merely retarded or delayed ♦ Timing of water level control can selectively favor certain desirable species	♦ Water for raising the level may not be available ♦ Potential peripheral flooding ♦ Possible downstream impacts ♦ Many species may not be affected, and some may be benefitted ♦ Algal nuisances may increase where nutrients are available
CHEMICAL CONTROLS			
6) Herbicides	♦ Liquid or pelletized herbicides applied to target area or to plants directly ♦ Contact or systemic poisons kill plants or limit growth ♦ Typically requires application every 1-5 yrs	♦ Wide range of control is possible ♦ May be able to selectively eliminate species ♦ May achieve some algae control as well ♦ May allow for more desirable plant growth	♦ Possible toxicity to non-target species ♦ Possible downstream impacts ♦ Restrictions of water use for varying time after treatment ♦ Increased oxygen demand from decaying vegetation ♦ Possible recycling of nutrients to allow

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
6.a) Forms of copper	♦ Contact herbicide ♦ Cellular toxicant, suspected membrane transport disruption ♦ Applied as wide variety of liquid or granular formulations, often in conjunction with polymers or other herbicides	♦ Moderately effective control of some submersed plant species ♦ More often an algal control agent	♦ Potentially toxic to aquatic fauna as a function of concentration, formulation, and ambient water chemistry ♦ Ineffective at colder temperatures ♦ Copper ion persistent; accumulates in sediments or moves downstream
6.b) Forms of endothall (7-oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid)	♦ Contact herbicide with limited translocation potential ♦ Membrane-active chemical which inhibits protein synthesis ♦ Causes structural deterioration ♦ Applied as liquid or granules	♦ Moderate control of some emersed plant species, moderately to highly effective control of floating and submersed species ♦ Limited toxicity to fish at typical MA dosages ♦ Rapid action	♦ Non-selective in treated area ♦ Potentially toxic to aquatic fauna (varying degrees by formulation) ♦ Time delays on use for water supply, agriculture and recreation
6.c) Forms of diquat (6,7-dihydropyrido [1,2-2',1'-c] pyrazinediium dibromide)	♦ Contact herbicide ♦ Absorbed by foliage but not roots ♦ Strong oxidant; disrupts most cellular functions ♦ Applied as a liquid, sometimes in conjunction with copper	♦ Moderate control of some emersed plant species, moderately to highly effective control of floating or submersed species ♦ Limited toxicity to fish at recommended dosages, low toxicity at typical MA doses ♦ Rapid action	♦ Non-selective in treated area ♦ Potentially toxic to zooplankton at high application rates ♦ Inactivated by suspended particles; ineffective in muddy waters
6.d) Forms of glyphosate (N-[phosphonomethyl glycine)	♦ Contact herbicide ♦ Absorbed through foliage, disrupts enzyme formation and function in uncertain manner ♦ Applied as liquid spray	♦ Moderately to highly effective control of emergent and floating plant species ♦ Can be used selectively, based on application to individual plants ♦ Rapid action ♦ Low toxicity to aquatic fauna at recommended dosages ♦ No time delays for use of treated water	♦ Non-selective in treated area ♦ Inactivation by suspended particles; ineffective in muddy waters ♦ Not for use within 0.5 miles of potable surface water intakes

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
6.e) Forms of 2,4-D (2,4-dichlorophenoxyl acetic acid)	♦ Systemic herbicide ♦ Readily absorbed and translocated throughout plant ♦ Inhibits cell division in new tissue, stimulates growth in older tissue, resulting in gradual cell disruption ♦ Applied as liquid or granules, frequently as part of more complex formulations, preferably during early growth phase of plants	♦ Moderately to highly effective control of a variety of emergent, floating and submersed plant species ♦ Can achieve some selectivity through application timing and concentration ♦ Fairly fast action	♦ Potential toxicity to aquatic fauna, depending upon formulation and ambient water chemistry ♦ Time delays for use of treated water for agriculture and recreation ♦ Not for use in potable water supplies
6.f) Forms of fluridone (1-methyl-3-phenyl-5-[-3-{trifluoromethyl} phenyl]-4[IH]-pyridinone)	♦ Systemic herbicide ♦ Inhibits carotenoid pigment synthesis and impacts photosynthesis ♦ Best applied as liquid or granules during early growth phase of plants	♦ Can be used selectively, based on concentration ♦ Gradual deterioration of affected plants limits impact on oxygen level (BOD) ♦ Effective against several difficult-to-control species ♦ Low toxicity to aquatic fauna	♦ Impacts on non-target plant species possible at higher doses ♦ Extremely soluble and mixable; difficult to perform partial lake treatments ♦ Requires extended contact time
6.g Forms of triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid)	♦ Systemic herbicide, registration pending in MA at this time ♦ Readily absorbed by foliage, translocated throughout plant ♦ Disrupts enzyme systems specific to plants ♦ Applied as liquid spray or subsurface injected liquid	♦ Effectively controls many floating and submersed plant species ♦ Can be used selectively, more effective against dicot plant species, including many nuisance species ♦ Effective against several difficult-to-control species ♦ Low toxicity to aquatic fauna ♦ Fast action	♦ Impacts on non-target plant species possible at higher doses ♦ Restrictions on use of treated water for supply or recreation not yet certain for MA ♦ Registration not complete in MA at time of table preparation

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
BIOLOGICAL CONTROLS			
7) Biological introductions	♦ Fish, insects or pathogens which feed on or parasitize plants are added to system to affect control ♦ The most commonly used organism is the grass carp, but the larvae of several insects have been used more recently, and viruses are being tested	♦ Provides potentially continuing control with one treatment ♦ Harnesses biological interactions to produce desired conditions ♦ May produce potentially useful fish biomass as an end product	♦ Typically involves introduction of non-native species ♦ Effects may not be controllable ♦ Plant selectivity may not match desired target species ♦ May adversely affect indigenous species
7.a) Herbivorous fish	♦ Sterile juveniles stocked at density which allows control over multiple years ♦ Growth of individuals offsets losses or may increase herbivorous pressure. Grass carp are illegal in Massachusetts.	♦ May greatly reduce plant biomass in single season ♦ May provide multiple years of control from single stocking ♦ Sterility intended to prevent population perpetuation and allow later adjustments	♦ May eliminate all plant biomass, or impact non-target species ♦ Funnels energy into algae ♦ Alters habitat ♦ May escape upstream or downstream ♦ Population control issues
7.b) Herbivorous insects	♦ Larvae or adults stocked at density intended to allow control with limited growth ♦ Intended to selectively control target species ♦ Milfoil weevil is best known, but still experimental	♦ Involves species native to region, or even targeted lake ♦ Expected to have no negative effect on non-target species ♦ May facilitate longer term control with limited management	♦ Population ecology suggests incomplete control likely ♦ Oscillating cycle of control and re-growth ♦ Predation by fish may complicate control ♦ Other lake management actions may interfere with success
7.c) Fungal/bacterial/viral pathogens	♦ Inoculum used to seed lake or target plant patch ♦ Growth of pathogen population expected to achieve control over target species	♦ May be highly species specific ♦ May provide substantial control after minimal inoculation effort	♦ Effectiveness and longevity of control not well known ♦ Infection ecology suggests incomplete control likely
7.d) Selective plantings	♦ Establishment of plant assemblage resistant to undesirable species ♦ Plants introduced as seeds, cuttings or whole plants	♦ Can restore native assemblage ♦ Can encourage assemblage most suitable to lake uses ♦ Supplements targeted species removal effort	♦ Largely experimental ♦ Nuisance species may eventually return assemblage ♦ Introduced species may become nuisances