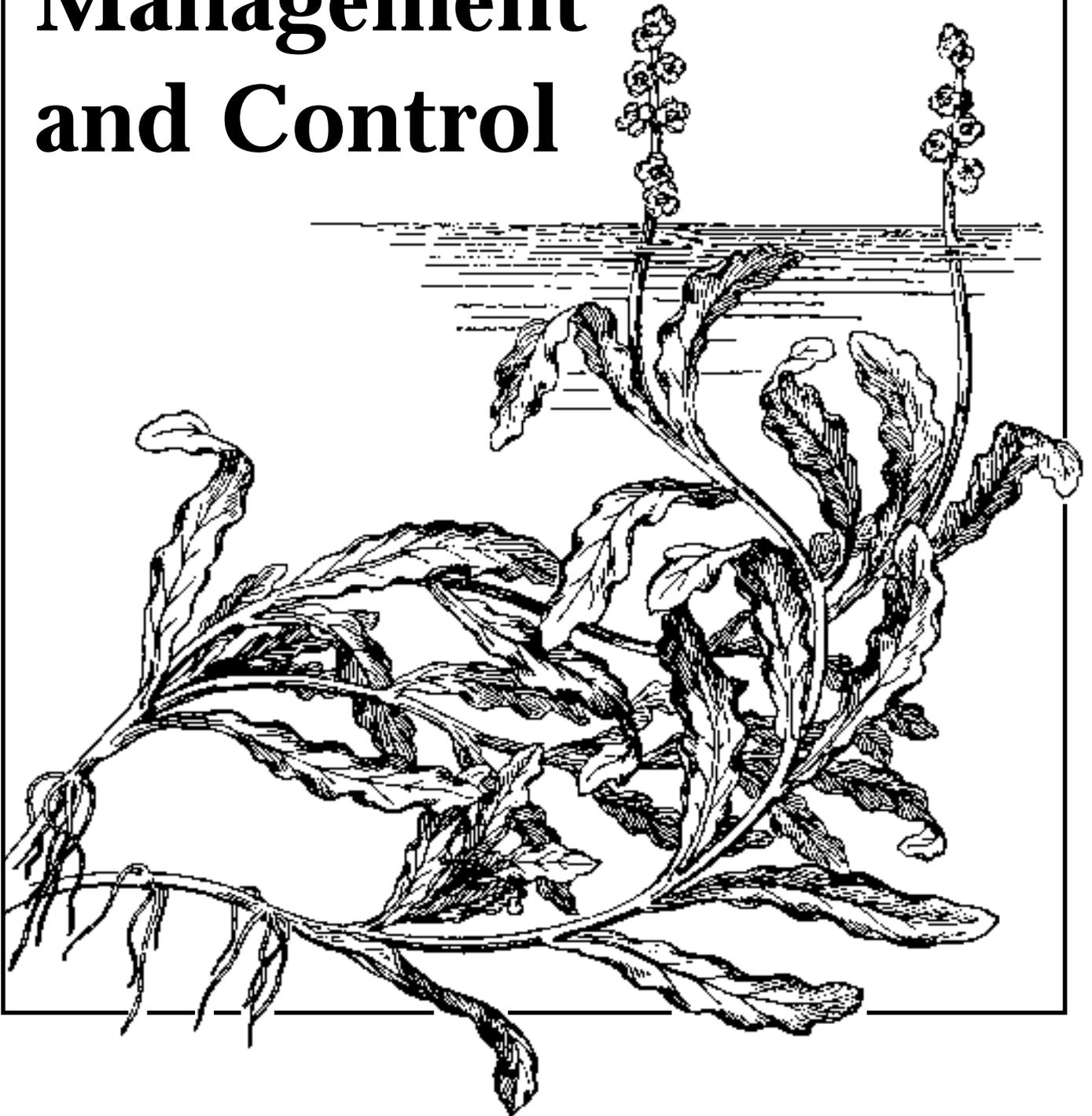


Aquatic Vegetation Management and Control



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AQUATIC VEGETATION MANAGEMENT AND CONTROL

There is an ever increasing demand upon water resources for recreational, agricultural, industrial, and numerous other purposes. Water areas, like land areas, support plant life. The kinds and amounts of plants vary within the different aquatic environments of streams, rivers, lakes, ponds, marshes, and other wetlands. Aquatic plants can be the dominant visible feature of some water areas. In other cases, they may occupy only the water margin, grow out of sight beneath the water surface, or grow as minute organisms suspended in the water. Aquatic plants belong to two groups: vascular plants and algae.

The planned uses for a body of water determine, to a large extent, the need for management or control of aquatic plants. A given body of water may be used for irrigation, fishing, boating, swimming, water skiing, or waterfowl hunting. Plant control may be required to meet the objectives of domestic, industrial, recreational, or agricultural consumption of water.

Many of the plants may be pests in some situations and desirable in others. The category into which they are placed depends on:

- their abundance.
- the use of the waters which they inhabit.
- personal values of people using or living near the water.

The information in this publication applies to control of plants in:

- recreational waters used for fishing, boating, and aquatic sports.
- agricultural reservoirs and water distribution channels used for stock watering, irrigation, and drainage.
- ornamental ponds.
- coastal bays, estuaries, and channels.
- drinking water reservoirs.
- ditchbanks.

CATEGORIES OF AQUATIC WEEDS

The first step toward prevention or control of aquatic weeds is to correctly identify them. Most control methods are aimed at specific plants or groups of plants with similar growth habits. Aquatic weeds are usually separated into four broad categories based on their life form. These are algae and emersed, submersed, and floating vascular plants.

Algae

Algae are the simplest plants in structure and organization as well as the most primitive. They are the most common and most uniformly distributed of all aquatic plants. The waters of the United States contain many species. Algae are simple aggregates of cells capable of carrying out all life processes without specialized tissue such as leaves, roots, or stems. They vary from microscopic forms to long, stringy mats. Under conditions of high nitrogen and phosphorus levels and during hot, calm, sunny weather, algae multiply rapidly and may accumulate in large masses. Algae reproduce by spores, cell division, or fragmentation. They are divided into two groups.

Filamentous algae consist of long, stringy hairlike filaments that form mats or "pond scums" during summer which can be seen without the aid of a microscope. Others may form a green, furlike coating on stones and other bottom objects. They grow on the bottom in early spring and rise to the surface during hot, calm, sunny weather. Stonewort algae or muskgrass, because of their size, growth, and attachment to the pond bottom, may be mistaken for vascular plants. Examples are chara and nitella. Chara has a strong, musty odor. It is sometimes encrusted with calcium deposits that give it a rough, gritty texture.

These plants consist of an erect central main stem with clusters of branches arising at

various intervals. They generally grow as tall as 2 or 3 feet, and can completely cover a pond or lake bottom.

Plankton algae are commonly single cell or small colonial groups, free-floating, and either green, blue-green, or brown. In large numbers, plankton algae may color the water brown, yellow, pea soup green, or even red during the warm seasons. When this occurs, the lake or pond is said to be “blooming.” These blooms may indirectly provide food for fish, but they may also make water undesirable for swimming or fishing, or for use as a domestic water supply. Each ounce of water in this condition contains millions of microscopic algae cells. Upon death, they may release foul odors and tastes to the water and, in some species, toxins capable of poisoning livestock. Complete chemical treatment for “water blooms” is not normally desirable or feasible. Treatment would be expensive and would only be effective for a few days. Also, serious oxygen depletion from sudden death of the “bloom” could cause extensive kills of fish.

Vascular Plants

Vascular plants are more complex in structure and organization and have specialized tissues such as roots, leaves, stems, and flowers. Vascular plants are annual and perennial. Many flower and produce seed; others propagate asexually (tubers, winter buds, turions, and fragments).

Emerged plants are rooted or anchored in the substratum with most of the leaf-stem tissue above the water surface and not lowering or rising with changes in the water level. Most plants are perennial with creeping rootstocks. The foliage is aerial. Examples are cattails, tules, purple loosestrife, and yellow waterlilies.

Submersed plants are adapted to grow with all or most of their vegetative tissue below the water surface. They are usually rooted in the bottom soils. Examples of submersed plants are pondweeds, coontail, elodea, and milfoil.

Floating plants are either free floating or anchored to the bottom and produce most of

their leaf-stem tissue or thalli at or above the water surface. Leaves or thalli of floating plants rise and lower with the water level. Examples of floating plants are duckweeds, azolla, white waterlily, and water hyacinth.

The following basics must be considered in evaluating control methods. Floating and submersed plants can interfere with swimming or boating. In fact, dense plant growth can make swimming hazardous. Rooted emergent shoreline plants may make it difficult to launch boats and may limit the usefulness of beach areas. Good examples are reed canarygrass and cattails. Dense vegetation also interferes with fish propagation, hatchery operations, and fishery management. Aquatic plants may give water an off-flavor or fishy odor and make it unfit for drinking without treatment.

Free-floating aquatic vegetation and fragments of submersed plants often clog irrigation pipes and nozzles. In irrigation systems, aquatic plants reduce water-flow rates, increase evaporation and seepage rates, and increase the danger of breaks in canals because the water level is increased to maintain the water flow. Some aquatic plants may restrict industrial and agricultural withdrawals of water.

On the other hand, aquatic plants may be desirable for special purposes. Certain plants and their seeds are useful as cover and food to attract waterfowl for fall hunting. If fishing is a major interest, a limited number of aquatic plants, both floating and submerged, may be desirable. They provide fish with cover, food, and a spawning site. But when plants are overabundant, they interfere with fish life and fishing.

The desirability of aquatic plants depends on the point of view of the water user. Reservoir managers and swimmers want clean, clear water free of vascular plants, algae, and other organisms. Waterfowl hunters want an abundance of aquatic plants that attract ducks and geese. Anglers prefer to see lily pads, plant beds, and plankton that nurture fish and the organisms they feed upon, but only if they do not become widespread and spoil the fishing.

Conservationists strive for suitable plant cover on watersheds and banks of streams, lakes, and ponds to control erosion and to protect water quality. Irrigators want clean, free-flowing water. The owner or manager of a body of water must be knowledgeable about aquatic plants to choose procedures that meet management objectives. The application of science to management of water areas and aquatic environments offers the best solution to meeting the diverse interests of all water users.

CONTRIBUTION OF PLANTS TO THE AQUATIC ENVIRONMENT

Energy

Aquatic plants, like all other green plants, use energy from the sun to manufacture carbohydrates. Part of the energy obtained is essential for plant growth. Excess energy is stored as carbohydrates, oil, and other products. This stored energy supports most other organisms in aquatic environments. Submerged aquatic plants and algae contribute to the water environment by taking in carbon dioxide and releasing oxygen during photosynthesis.

Food Chain

Algae and flowering plants form the base of the food pyramid, or the first link in the food chain. These plants, called producers, support the aquatic animal population, termed the consumers. Organisms that feed directly on these plants are called primary consumers. Part of the energy transferred to the consumer through food is used in growth and the excess is stored. The primary consumer is in turn eaten by a secondary consumer, and so forth as the cycle of energy utilization and storage is repeated up the food pyramid. As the food pyramid becomes taller (or the food chain longer), it supports fewer individual organisms.

The stems and leaves of submersed sections of vascular plants serve as host for a whole community of microscopic organisms, all of which contribute to the food chain in a pond or lake. Bacteria, fungi, algae, diatoms, protozoans, insect larvae, thread worms, bristle worms,

rotifers, and small crustaceans are the principal members of the community of organisms that live on and around the larger plants. The populations of this community are spread over all leaf and stem surfaces, and increases in numbers until the end of the summer. This microscopic community provides support for the larger organisms, including fish.

Animal Habitat

The underwater plants contribute in another way to the ecological structure of the total pond or lake community. Many of the free swimming creatures, such as fish and amphibians, use plant beds as places to deposit eggs. The young of many fish use these beds for shelter from predators, or they seek the plants as a feeding area since a rich supply of food organisms is usually available there.

The game fish sought for fishing are found at the top of the food pyramid. Thus, the presence of green plants, especially plankton algae, is important to the success of sport fishing.

Pondweeds, arrowhead, bulrushes, and reeds are important foods for wildlife. The snapping turtle's diet consists of 90% vegetable matter; plants make up two-thirds of the food for the smaller painted turtle. Muskrats eat the rootstocks, tubers, and stems of emergent plants, including cattails, arrowheads, bulrushes, and waterlilies. They also use aquatic plants for building their houses and lining their dens. Aquatic plants are also important food sources for waterfowl, upland game birds, and shore birds.

Eutrophication

Over extended time, a pond or a lake will fill with decayed plant matter and become dry land. The deeper the lake, the longer the time required to fill it. This filling process is aided by the growth of aquatic plants in many ways. The continuous cycle of plant growth and decomposition creates a slow buildup of organic matter in the basin. Plants also retard the flow of water and cause suspended material to settle to the bottom. As the filling progresses, plants of the shallower zones

become established in the zones that were formerly deeper. Most bogs and swamps were lakes that are being filled by these processes.

Water Pollution

There are two types of pollution associated with aquatic plant growth—pollutants that *inhibit* growth and those that *stimulate* growth. Although both forms can be serious, the discussion below is centered around the growth-stimulating pollutants.

Chemicals that stimulate growth are primarily nitrogen and phosphorus compounds discharged from sewage plant effluents, home waste disposal systems, food producing plants, and well-fertilized agricultural watersheds. These nutrient materials stimulate profuse growth of both algae and vascular aquatic plants.

Depending on conditions, a polluted pond or lake may be either excessively turbid and scum-coated or clear and choked with plants. Either condition indicates water of relatively high fertility and optimum conditions for plant growth. Sewage treatment or disposal systems that meet governmental requirements may not circumvent the problem of increased fertility; nitrate and phosphate levels in treated sewage are still high enough to stimulate plant growth in receiving waters.

Fish Kills

Dense aquatic plant growth may deplete oxygen and subsequently kill fish. Warm, calm, and cloudy weather in summer and thick, opaque, or snow-covered ice in winter contribute to this hazard. Under these conditions, plants do not photosynthesize and produce oxygen. Instead, they consume oxygen through respiration, and some die and decompose. Toxic substances may be released into the water during decomposition of algae, especially blue-green algae.

Organic decomposition occurring throughout the year makes continuous demands on available oxygen. If oxygen is not continuously added to the water through wave action, inflowing water, or photosynthesis, oxygen

levels may be reduced to the extent that they become inadequate for survival of fish and many other organisms that provide fish food.

In deep lakes, the water below the photic zone may also have a very low level of oxygen. When the lake turns over or breathes (bottom water moving and mixing with the water in the upper layers over a short time period in response to seasonal temperature changes), fish may be distressed or killed because of the low oxygen levels that result in the upper layers.

MANAGEMENT AND CONTROL

Wise management of water is necessary if aquatic vegetation control is to be more than temporary. Management must begin with an evaluation of all uses of a given body of water. To benefit the greatest number of people, manipulate chemical, biological, and physical factors to obtain the maximum utilization of the water. However, before any control measures are initiated, determine if any permits are required from appropriate local, state, and/or federal agencies.

Management: Construction of Ponds, Reservoirs, Ditches

Proper design and construction of ponds and ditches are important factors in preventive control of aquatic plants. Shallow water at the margins of ponds and ditches provides an ideal habitat for emerged plants, such as cattail. Submersed plants can easily become established, then spread into deeper waters. Maintaining steep banks with a 1:1 to 1:1.5 slope until water depth reaches at least 3 feet will help prevent establishment of many emergent and bank weeds. Be aware that steep banks may create other problems. If small children frequent a pond, steep banks would be a safety hazard. Remove fertile topsoil from the pond or reservoir basin before filling. If a beach area for swimming and other recreational purposes is desired, remove the fertile topsoil and replace with sand. If possible, prevent waters heavily laden with silt and nutrients from entering an impoundment.

Constructing ponds, lakes, canals, and ditches so they can be drained is an effective means of controlling aquatic plants. The water levels in some large lakes and reservoirs may be lowered enough to expose plants in the shallow areas. Freezing or drying periods of several months may be necessary to control plants in some ponds and lakes. In most canals, it is not practical to interrupt water flow during the summer months when aquatic plants grow most rapidly. The species of plants and the seasonal growing period will generally determine whether this method is practical or not. A factor to consider when contemplating lowering reservoirs or drying up ponds will be the protection of fish populations and especially spawning habitats.

If grass is planted on ditchbanks, 2,4-D can be applied to keep out most undesirable broad-leaf plants. East of the Cascade Mountains, Redtop or other low-growing, adapted grasses should be seeded at the waterline and crested wheatgrass or other adapted grass on the shoulders and top of the ditchbank. Provide roadways on both ditchbanks for weed control and other operations.

Mechanical Control

Physical removal is effective for small quantities of plants near shorelines. Techniques include cutting, mowing, raking, digging, or pulling. In small ponds or lakes, emergent plants such as sedges, cattails, and rushes can be mowed, pulled by hand, or dug with a hoe.

Chaining may be practical in some instances, particularly in canals. Draglines are useful for deepening and cleaning canals and margins of lakes and ponds. Underwater mowers are often used in both lakes and canals for cutting plants.

There can be problems associated with these mechanical control methods. Pulling or cutting usually must be repeated several times to eliminate new growth as it appears. Single cutting treatments usually are not effective because most submersed and emergent vegetation is perennial and the underground portion of the plants is unharmed by such a treatment. Attempts to remove submersed plants by

cutting or dragging a chain or cable over the bottom are not effective and actually may spread the infestation because the plants can regenerate from plant fragments. Also, plant fragments and other debris dislodged by such devices plug irrigation sprinklers and pumps. Mechanical control may be slower and more costly than other methods of control.

Burning ditchbank weeds may increase the flow of water in a ditch and help prevent seed from infesting new land. Sear green vegetation the first time and then thoroughly burn 7 to 10 days later. Control by burning also is only temporary.

Biological Control

Biological control employs plant or animal agents to eliminate or reduce growth of vegetation or to alter the habitat to favorably change plant growth. Insects, mites, snails, pathogenic microorganisms, fish, ducks, geese, manatees, and competitive plants have all been tried as biological controls for aquatic weeds. Biological control is not new, but practical and safe means of controlling aquatic plants by these methods are extremely limited.

Muskrats may cut considerable quantities of plants, but in doing so they leave fragments that may act as sources for plant propagation. Domestic waterfowl may feed on certain floating and submersed plants; however, the fertility resulting from their excrement may create excessive algal blooms that are more undesirable than the original problem. Some exotic species of fish, such as the white amur or grass carp, are being promoted to control aquatic vegetation. However, the impact of these organisms on all aquatic ecosystems is not fully known, and so their release is controlled in many states.

Control with Herbicides

Unlike terrestrial herbicides, which are applied to a stationary, two-dimensional area, aquatic herbicides are applied to an area that has a third dimension—depth—and often has some degree of motion.

Responsible use of aquatic herbicides requires careful consideration of many factors. The most important consideration is the safety of the people using the treated water. Contamination of domestic water supplies, or failure to observe the proper precautions regarding water-use restrictions, may result in health hazards. Most waters are managed for multiple use. Game fish, waterfowl, and aquatic mammals share water usage with swimmers, boaters, irrigation, and domestic uses.

Pesticides often are blamed for a phenomenon called swimmers' itch, but in fact it is caused by a parasite associated with snails and water birds. A brief summary of swimmers' itch follows:

Through their feces, birds deposit a blood fluke in the water. This fluke deposits eggs in the water. When hatched, the small organisms (called miracidia) must find a snail to use as an intermediate host for a short time or they will die. In the snail, the miracidia develop into cercaria, which leave the snail as free-swimming organisms that can penetrate human skin. After penetration, the cercaria cause an itching, burning sensation. Small red spots appear at the point of entry into the skin. These symptoms are noticed soon after the bather leaves the water. For additional information on swimmers' itch, visit: http://www.cdc.gov/ncidod/dpd/parasites/schistosomiasis/factsht_cardmermatitis.htm.

Environmental Consideration and Restrictions

Incorrect application of herbicides to water may involve serious hazards to people, wildlife, fish, and desirable plant life. It is important to analyze the biological, water-use, and physical factors.

Biological:

- Identify the problem species.
- Identify other species present.
- Determine density, stand, or scope of problem and stage of weed growth.

Water use:

- Irrigation, potable, recreational, fish production, livestock, wildlife.
- Length of time water can be quarantined from each use.
- Amount of and destination of outflow. Can outflow be regulated? If so, for how long?

Physical:

- Size of channel or pond to be treated.
- Water depth and movement or velocity.
- Water turbidity.
- Water temperature.
- Water quality.

After analyzing all these factors carefully, choose the herbicide labeled for that use, considering safety, effectiveness and selectivity, residues, and cost. Obtain permission or permits, if necessary, from appropriate state or federal agencies.

The control of aquatic vegetation presents special problems because:

- the water often has multiple uses.
- herbicides do not always remain where they are placed.

Consider all the uses of the water to be treated, including those far downstream. Read the label to determine that the herbicide you choose is compatible with these uses.

Types of water uses to consider before applying herbicides include:

- Human use, such as drinking, cooking, and swimming. Few tolerances have been established for herbicide residues in such water. Copper sulfate has been used for control of algae in drinking water for many years and is permitted in raw drinking water. However, you must avoid contamination of any drinking water with any level of herbicide which is not registered for that use.
- Livestock and wild animal use.
- Irrigation.
- Industrial uses.
- Fish production—most aquatic herbicides are not toxic to fish or other animal life at the concentrations recommended for plant control. Notable exceptions are Grade B xylene, acrolein, and some solvents and

emulsifiers in certain formulations of normally nontoxic herbicides. Do not use these in fisheries or where the water treated with these herbicides could enter fishery waters. Trout are especially susceptible to copper sulfate. Do not treat trout waters with copper sulfate without consulting fish biologists.

Application Rates

Correct application of herbicides in aquatic areas involves equipment calibration and calculation of appropriate water volumes or areas. Environmental hazard can result from incorrect application rates.

Excessive application can cause:

- Damage to fish, either from direct toxicity or from lack of oxygen caused by excessively rapid kill of plants. Bacterial contamination resulting from decay of killed fish might further contaminate downstream water supplies.
- The need for exclusion of livestock from use of the water for a longer time than necessary.
- Water unfit for irrigation use.

State and Federal Regulations

Many states have regulations that govern the use of pesticides in water. Check with the appropriate agency when in doubt. There also are stringent federal and state regulations controlling the importation of exotic fish and plants.

Treatment Techniques

Lower lakes and ponds should have a high rate of inflow prior to treatment to ensure adequate contact time for the herbicide. Close the spillway and retain the treated water for at least the minimum period specified on the label before overflow occurs. The amount of draw-down will vary according to the situation. Avoid excessive exposure of bottom areas.

Most herbicides should be applied to submersed aquatic plants in late spring or early summer growing season when the plants are young. Treatment at this time usually gives

the best control with a minimum of chemical. Applications in late summer or early fall require more chemical and usually give slow, erratic control. Furthermore, access to often-dense aquatic vegetation is best in the spring or early summer before the plants reach the surface.

Points to Remember

The applicator should:

- Be certain of the identity of the vegetation to be treated and the capability of the chemical to control it.
- Obtain any permits necessary before treating any body of water, whether for plant control, cleaning, or other purposes.
- Never use more chemical than suggested on the label. Fish and other valuable aquatic life may be harmed or killed.
- Use treated water only as suggested on the label.

Environmental Changes Caused by Aquatic Plant Control

The sudden elimination of a dense growth of vegetation from an aquatic environment often causes side effects that can produce significant changes in the biological and physical makeup of a lake, pond, or stream.

Following the death of large quantities of vascular plants in a pond or lake, a greenish or yellowish brown turbid condition may occur. This condition is due to the presence of billions of microscopic algal cells which have used the nutrients released from the decaying vascular plants for their growth and reproduction. The green or blue-green algae are often responsible for a pea soup appearance. Other algae and various one-celled organisms cause yellowish-brown colors in water.

When conditions are optimal for development of algae, a dense bloom can quickly develop. These dense blooms of plankton algae reduce light penetration and inhibit the regrowth of those species defoliated by the treatment. The algae may turn out to be more objectionable than the original plant infestation.

Chemical Formulations

Aquatic herbicides are available in several formulations.

Sprayable formulations. Most herbicides are formulated to be mixed with water and sprayed.

Types available:

- water-soluble powders or crystals that form true solutions in water.
- wettable powders that can be dispersed in water.
- water-soluble liquid concentrates that form true solutions in water.
- emulsifiable liquid concentrates that form ordinary “oil-in-water” emulsions in water.
- special liquid concentrates that form “water-in-oil” emulsions (called invert emulsions) when mixed with water and oil in the spray tank or when applied through special mixing nozzles.

Granular formulations. Many aquatic herbicides are used as dry granules of various sizes.

Types available:

- granulated pure chemical, such as crystalline copper sulfate.
- granules or larger pellets of clay and other materials impregnated with the parent herbicide.
- slow-release granules or pellets designed to release the chemical into the water over an extended period.

Application Techniques

Four zones of a body of water may be treated:

- water surface
- total water volume
- bottom 1- to 3-foot layer of water
- bottom substrate surface

Surface Treatment

Generally, treat only one-fourth to one-third of the surface area of the water at a time. This helps protect fish from a possible shortage of oxygen from vegetative decomposition. Surface acreage of a rectangular body of water equals length in feet times width in feet divided by 43,560.

Total Water Volume Treatment

The whole body of water (from surface to the bottom) can be treated but more frequently, one-fourth or one-third of the total water volume is treated at a time. Calculate the volume of the body of water and add the correct amount of chemicals to obtain the required dilution in the water.

The concentration of chemical needed to kill aquatic plants is often very small and is stated in “parts per million” (ppm).

If the toxicity level of a certain chemical for a particular aquatic plant is 2 ppm of active ingredient (ai), for example, the chemical should be applied at a rate of 2 parts of “ai” to one million parts of water in the area to be treated.

First, calculate the acre-feet of the body of water to be treated. Multiply surface acres by the average depth in feet. An acre-foot of water weighs 2.7 million pounds. If one dissolves 2.7 pounds of any material in 1 acre-foot of water, the concentration will be 1 ppm by weight (ppmw). Use the following formula to determine the material needed to obtain a desired ppm concentration:

$$2.7 \times \text{ppm wanted} \times \text{acre-feet} = \text{pounds required}$$

Assume one wants to treat a pond containing 10 acre-feet. The concentration of active ingredient required is 0.5 ppm. Using the formula above, we would calculate:

$$2.7 \times 0.5 \times 10 = 13.5 \text{ pounds of active ingredient}$$

Bottom Layer Treatment

Treating the deepest 1 to 3 feet of water is especially useful in deep lakes where it is impractical and too costly to treat the entire volume of water. Such treatments are generally made by attaching several flexible hoses at 3- to 5-foot intervals on a rigid boom. Each hose is usually equipped with a nozzle at the end. Hoses may be weighted to reach the depth desired. The length of hose and speed of the boat carrying the application equipment also affect the depth of application. Successful bottom treatments apply the herbicide as a “blanket” in the lower 1 to 3 feet of water.

Bottom Soil Treatment

Herbicide applications may be made to the bottom soil of a drained pond, lake, or channel to control certain submersed and emersed species. The interval between treatment and reintroducing water varies up to three weeks, depending on the herbicide used.

VEGETATION MANAGEMENT IN STATIC WATER

Floating and Emersed Weeds

Sprayable formulations are almost always preferred for floating and emersed plants. These plants are killed by direct foliage applications of the spray mixture:

- by aircraft.
- by ground equipment-operated from the bank of small ponds or if plants occur only around the margin.
- from a boat, using various types of booms or spray guns.

Submersed Plants

The herbicide formulations for the control of submerged plants and algae in static water may be in the form of sprays or granules.

Sprayable formulations are most often applied as water-surface treatments, particularly in shallow water. The herbicide is dispersed throughout the water by diffusion, thermal currents, and wave action. Sprayable herbicides can be applied under the surface by:

- injection through a hose pulled along behind a boat.
- injection into the water by booms.

Sprayable herbicides are sometimes used for bottom soil treatments. Some sprays may be applied from aircraft at low volumes, e.g., 5 to 10 gallons per acre. Both surface and injection treatments made by boat or ground equipment are more effective and are easier to apply when large volumes of liquid carrier are used. A handy sprayer for making applications by boat uses a special pumping system that draws water from the lake or pond as the boat

moves along. Concentrated herbicide is metered into the pumped water to achieve the concentration required. This avoids both frequent interruptions to prepare spray solutions and the need to carry water on board.

Granular formulations are most often used for control of algae or submersed plants, although some are effective on certain emersed plants. Because granules sink to the substrate, they perform in a similar manner as herbicides applied as bottom soil treatments. Application rates for granular herbicides may be based on:

- amount of herbicide per unit of surface area.
- the concentration (ppm) that would be achieved if the same amount of herbicide were dissolved and totally dispersed in the water (total water volume treatment).

Granular herbicides perform best when distributed evenly over the water surface. They may be broadcast by hand or manual spreader over small areas. Special granule spreaders mounted on aircraft or boats are used for large-scale applications. Advantages of granular herbicides are:

- treatment is usually confined to the bottom where the submersed plants are located.
- they can provide a long contact time with plants (slow-release granules).
- the herbicide concentration can be held to a low level.
- they make it possible to use chemicals that in other formulations would be toxic to fish.

Plant Control in Large Impoundments

Herbicide applications that are successful in smaller bodies of water often perform poorly in large impoundments, where water movement caused by thermal currents or the wind can be substantial. Plant control may sometimes be improved in these sites by:

- using the maximum recommended application rates.
- treating relatively large water areas at one time.
- applying herbicides only during periods of minimum wind.
- using bottom treatment in deep water.
- using granular formulations when possible.
- selecting herbicides that are absorbed quickly by the plants.

VEGETATION MANAGEMENT IN FLOWING WATER

Aquatic plants in flowing water are the most difficult to control. Because the water is moving from one location to another, the potential for negative impacts of herbicide use to occur is greater.

Herbicides are sometimes used to control plant in natural streams. Control of aquatic plants in engineered water distribution and drainage systems is more common, but most of these carry irrigation water. Do not irrigate crops with treated water unless permitted by the pesticide label. Some systems also carry domestic, industrial, and recreational water. As the number of water uses increases, more restrictions may apply and more precautions are required.

Floating and Emerged Plants

When control of floating and emerged plants found in flowing water becomes necessary, procedures for using herbicides will be the same as when applied in static waters. Precautions are especially important for flowing waters. What are the flowing waters used for? Do they support fish life? Are they used for recreation? Much concern for the environment is in order when applying pesticides to flowing water.

Submersed Plants and Algae

Submersed plants and algae can only be effectively controlled in flowing water by continuously applying enough herbicide at a given spot to maintain the needed concentration and contact time.

The greater the cross-sectional area and the depth of the stream and the greater the speed of flow, the larger the volume of water that must be treated.

The large volume of water that must be treated makes the use of herbicides in flowing water costly, particularly when:

- the plant infestation covers only a small area.
- the herbicides are effective for only a short distance downstream.

Few herbicides are available for control of submersed plants in flowing water. The more common ones are:

- copper sulfate, used for control of algae. It is toxic to trout at recommended treatment rates, but only moderately toxic to most other fish species. The toxicity of copper to fish increases with decreased total alkalinity of the water.
- Grade B xylene and acrolein. These are highly toxic to fish and many other forms of aquatic life. They are used primarily in water delivery systems that contain no fish, or where the water delivery is far more important than the value of the few fish that might be present. These products are usually injected below the flowing water surface. This enhances distribution in the water, reduces volatilization, and increases the stability of Grade B xylene emulsions.

Be certain that the residues in the treated water and runoff water are at or below the levels permitted for all subsequent uses.

PLANT CONTROL IN LIMITED FLOW WATERWAYS

Flood drainage canals, sloughs, and drains are examples of limited flow waterways. Plant control methods in these kinds of systems with little water movement are very similar to those used in static water. Consider the possible contamination of water that will be used for other purposes when you plan the application of herbicides in limited flow water. In some areas, drainage water may flow directly onto cropland and be used for irrigation or it may enter a fishery or drinking water supply.

VEGETATION MANAGEMENT ON DITCHBANKS

Weeds on ditchbanks are a major obstacle to irrigation of crops and subsequent drainage. They reduce the flow of water and cause flooding, seepage, breaks in ditchbanks, increased evaporation and transpiration loss, decreased water delivery, and decreased drainage of water. They obstruct inspection

and maintenance of the irrigation systems and facilitate silt deposits in the irrigation channels. Also, seeds and other propagules produced by weeds on ditchbanks can infest croplands.

Ditchbanks provide a variable plant habitat, primarily because soil moisture varies greatly within a short distance on an irrigation ditchbank.

Emergent aquatic species often appear at the waterline. Within a few feet of this area, up over the top of the bank, the soil may be very dry with drought-tolerant species predominant.

Plant control methods will depend on which plants are to be controlled in relation to the water level, intended water use, and the subsequent use of the water downstream.

When spraying ditchbanks, the sprayer should travel upstream to avoid the possibility of concentrating any herbicide that may get into the water.

SELECTED HERBICIDES USED IN AQUATIC SITES

The following brief description of herbicides used to control weeds growing in aquatic situations does not include specific recommendations for control of aquatic and ditchbank weeds. Current recommendations can be obtained within your state from Extension, the current Pacific Northwest Weed Management Handbook, or by consulting appropriate product labels for specific rates, timing, and registered uses.

Acrolein (Magnacide-H)

Acrolein is a contact herbicide used to control submersed and floating weeds and algae in irrigation canals and ditches. It is not toxic to common field crops irrigated with treated water when used as directed by the product label. Acrolein is volatile, flammable, and very toxic to mammals, birds, fish, and many other aquatic organisms.

Apply acrolein before weed growth is 4- to 6-inches tall. Specialized equipment is required for application. Acrolein is injected directly into the water using oxygen-free nitrogen as a propellant.

Repeat treatment every three to four weeks during the remainder of the season. There is no potable (drinking) water tolerance for acrolein, and it must not be applied in potable waters. Do not permit treated water to return to water courses containing desirable fish, vegetation, or other organisms until the herbicide has completely dissipated from the water.

Copper sulfate (Various Trade Names)

Copper sulfate can be used to control most algae in most waters, except in streams and rivers. It is an inorganic herbicide formulated as various-sized crystals. Dissolution rates in the water vary according to crystal size, water quality, flow rate, and other factors. The effectiveness of the product is influenced by light intensity, water hardness, organic matter content, and algal density. Make the first treatment before a severe algae problem develops; repeat treatments at two- to three-week intervals may be required for continued control. The herbicide can be applied by:

- suspending the crystals in porous bags beneath the water surface or dragging the bags through the water.
- pouring directly into water of irrigation channels if the channel is concrete lined.
- applying over the water surface of impoundments.
- using a specially-designed continuous feeder.

When applying to fish-containing waters, note label cautions for application and rates due to different fish sensitivities. Potable water has a tolerance of 1 ppm of copper.

Copper sulfate will not eliminate established growths of submersed vascular weeds. However, continuously maintained concentrations, begun in early spring for control of algae in municipal-water canals and reservoirs, also inhibit the growth of rooted submersed plants.

Diquat (Reward)

Diquat is a contact herbicide. It will control the top growth of most species of submersed weeds in clear-water ponds and lakes when injected below the water surface. Apply before submersed weeds reach the water surface.

Diquat is readily adsorbed by silt or other suspended material in water; its effectiveness is greatly reduced when mixed with dirty water. It is also an effective herbicide for control of free-floating species such as duckweed. Apply diquat on floating weeds as a foliage spray with surface equipment. When making this type of application, use a suitable nonionic surfactant in the spray solution as recommended by the manufacturer. Diquat is effective on free-floating aquatic weeds because the chemical is quickly absorbed by roots and stems, leading to the rapid desiccation of the above-water leaves and stems. Diquat only temporarily affects floating-leaf or emersed species rooted in the hydrosol. It is not effective on chara or attached algae.

Use restrictions for treated water vary depending on the rate of application. Restrictions on treated drinking water for animal consumption is one day, on drinking water for human consumption is one to three days, and for irrigation one to five days after treatment. Observe all other label restrictions.

Endothall (Hydrothol, Aquathol)

Endothall is a contact herbicide and, depending on formulation, is used to control algae and submersed weeds. For algae control in irrigation systems, lakes, ponds, and reservoirs, the dimethylamine salt (Hydrothol) formulations are sprayed on the water or injected below the water surface when growth appears.

Submersed weeds in lakes and ponds can be controlled with either the dipotassium salt or dimethylamine salt of endothall (Aquathol and Hydrothol, respectively). Apply either material by spraying on the water or injecting below the water surface after growth has developed in the late spring or early summer.

The dipotassium salt formulation works best when water temperatures reach a consistent 62°F to 65°F.

Endothall is not effective on chara or elodea. Several restrictions exist on the use of water following treatment with endothall, depending on product used and rates applied. The Hydrothol formulations may be toxic to fish at the concentrations required for control of submersed weeds. Consult and observe the restrictions on the appropriate label.

Fluridone (Sonar)

Fluridone controls most submersed and emersed aquatic plants. It has little effect on algae and provides only partial control of cattails. In addition, most floating aquatic weeds are only partially affected by this herbicide.

Fluridone is labeled for use in lakes, reservoirs, ponds, canals, and rivers depending on formulation. It should be applied to quiescent waters where little water movement occurs and little or no outflow follows treatment. It may be applied prior to active plant growth or anytime during the spring or summer when weeds are visible. The aqueous suspension can be applied as a spray to the water surface, under the water surface, or placed along the bottom of the body of water by using specialized equipment. The pellet formulations can be spread on the water surface.

The application rate of fluridone will depend on the type of water treated, water depth, and density of vegetation to be controlled.

Do not apply at rates greater than 20 ppb within one quarter mile of any potable water intake.

Do not irrigate established trees with treated water for at least seven days or other established crops for at least 30 days after treatment. Newly seeded crops or overseeding should not be irrigated with treated water until the manufacturers' FasTEST assay has determined the fluridone concentration is 5 ppb or less. Application of fluridone to bodies of water may injure vegetation growing along the shoreline.

Glyphosate (Various trade names)

Glyphosate is a nonselective, translocated, foliage-applied herbicide used for the control of many weed species. Some glyphosate formulations can be applied to the inside of ditches and canals only if they **do not** contain water. Applications to and along ditches and canals containing water must be done with aquatic-approved formulations. These formulations may also be used to control emerged and floating weeds in lakes and ponds. The aquatic approved formulations require the addition of an approved nonionic surfactant to the spray solution. Best weed control is obtained when the herbicide is applied to vigorously growing weeds at the labeled growth stage. It is especially effective against perennial grasses such as reed canarygrass and johnsongrass. The herbicide rate and timing depend on the target weed species.

Since glyphosate is not selective, occasionally all the vegetation may be killed, and erosion of banks may then occur. If this happens, make provisions to establish a desirable low-growing grass, such as redtop, or east of the Cascade Mountains, creeping red fescue.

Glyphosate also may be applied using selective equipment. Do not apply the aquatic labeled glyphosates directly to water upstream within one half mile of active potable water intakes in flowing water (i.e., river, stream) or within one half mile of an active potable water intake in a standing body of water such as a lake, pond, or reservoir. When making aquatic applications around and within one half mile of active potable water intakes, you must turn the water intake off for a minimum period of 48 hours after the applications. You may turn the water intake on prior to 48 hours if the glyphosate level in the intake water is below 0.7 parts per million, as determined by laboratory analysis. These aquatic applications may be made only in those cases where alternative water sources or holding ponds exist that would permit the turning off of an active potable water intake for a minimum period of 48 hours after the application. This restriction does not apply to intermittent inadvertent overspray of water in terrestrial use sites. Consult the label for any

restrictions that apply following treatment with glyphosate.

Imazapyr (Habitat)

Imazapyr is applied to emergent and floating aquatic vegetation growing in and around standing and flowing water including estuaries and marine sites. When applied to the foliage, it will control many annual and perennial grasses and broadleaf plants in addition to several brush and vine species. Imazapyr will not control plants that are submerged or when the majority of foliage is under water. An adjuvant is required for postemergence applications. Only spray adjuvants that are approved or appropriate for aquatic use must be used.

Application of Habitat can only be made by federal or state agency personnel, such as water management district personnel, municipal officials, U.S. Army Corp of Engineers, or those applicators who are licensed or certified as aquatic pest control applicators and are authorized by the state or local government. Treatment of other than non-native invasive species is limited to only those plants that have been determined to be a nuisance by a federal or state government entity.

Do not apply imazapyr within one half mile upstream of an active potable water intake in flowing water or within one half mile of an active potable water intake in a standing body of water. To make aquatic applications within one half mile of active potable water intakes, the intake must be turned off during application and for a minimum of 48 hours after application. Treated water may not be used for irrigation purposes for 120 days or until imazapyr residue levels are determined by laboratory analysis, or other appropriate means of analysis, to be 1.0 ppb or less. Do not apply to dry canals or ditches. Treated water may be used for recreational purposes including swimming and fishing. There are no restrictions on livestock consumption of treated water.

Do not treat more than one-half of the surface area of water in a single application and wait at least 10 to 14 days between treatments to avoid oxygen depletion in the water. Begin

treatment along the shore and proceed outward in bands to allow aquatic organisms to move into untreated areas. Avoid spray drift.

2,4-D (Various Trade Names)

2,4-D is a selective, foliage-applied herbicide used to control broadleaf weeds. When selecting a formulation of 2,4-D for a particular situation, be sure it is registered for that use. Some formulations of 2,4-D are registered for use in controlling broadleaf weeds on the inside perimeter of irrigation channels in the western United States. The use of other products for this purpose is an illegal application.

Some granular formulations of 2,4-D are registered to control Eurasian watermilfoil and other weeds in lakes and ponds. Other formulations of 2,4-D are available for control of floating, emerged, marginal, and bank weeds of ponds and lakes.

The WSU Pesticide Information Center On-Line (PICOL) will direct you to the 2,4-D products registered for use in or near aquatic sites. You may access this site directly at <http://picol.cahe.wsu.edu/labels/Labels.php> or from the Washington State Pest Management Resource Service (WSPRS) site at <http://wsprs.wsu.edu/index.html>.

Triclopyr (Renovate)

Triclopyr is a selective, foliage-applied herbicide used to control submersed, floating, and emerged broadleaf weeds. It is registered for use in ponds, lakes, and reservoirs. Triclopyr is also registered for nonirrigation canals and ditches having little or no continuous outflow, and for marshes and wetlands, including broadleaf and woody vegetation on banks and shores within or adjacent to these and other aquatic sites. Make treatments when submerged, floating, and emerged plants are actively growing. For control of purple loosestrife, apply when the plants are at the bud to mid-flowering stage of growth. Treat woody plants when they are actively growing, or late in the season if they are hard-to-control

species. Match the type of application to the type of plant you are working to control.

Minimum setbacks from potable water intakes in lakes, ponds, and reservoirs vary with the acreage treated and the rate of triclopyr applied. No restrictions exist for livestock consumption of water from treated areas, or for recreational use of water, including swimming or fishing. Do not use treated water for irrigation for 120 days following application. Shorter restrictions for irrigation may be allowed once the triclopyr level in the intake water is determined to be nondetectable by a laboratory analysis (immunoassay). Use of water from the treatment area to irrigate established grass is not restricted. Do not apply triclopyr directly to unimpounded rivers, streams, ditches, canals, or ditchbanks of canals carrying irrigation water. Avoid spray drift.

Xylene (Aquatic Weed Killer)

Xylene is a nonselective, contact herbicide used to control submersed weeds in flowing canals. Apply this product after weed growth is well established, but before it becomes matted at the surface or causes channeling of the water. When applying xylene, mix with an emulsifier and inject under pressure near the bottom of the channel, preferably in turbulent water. The emulsifier will help the xylene form a stable emulsion with the water. Without the emulsifier, xylene will float on the water surface and evaporate.

Xylene is flammable, volatile, and very toxic to fish and many other aquatic organisms. There is no potable water tolerance for xylene, and it must not be applied to potable waters. Do not allow the treated water to return to water containing desirable fish, vegetation, or other organisms until the herbicide has completely dissipated from the water.

Repeat treatments as required during the remainder of the season. Do not allow people or animals to drink the treated water, and do not flood irrigate seedling crop plants with treated water. Xylene can be used only in programs of the Bureau of Reclamation and cooperating user organizations.

EQUIVALENTS AND EQUATIONS

Liquid Measurements

1/4 cup	=	2 ounces	0.1 gallon	=	12.8 ounces
1/2 cup	=	4 ounces	0.2 gallon	=	25.6 ounces
1 cup	=	8 ounces	0.25 gallon	=	32.0 ounces (1 qt)
1 tablespoon	=	1/2 ounce	0.3 gallon	=	38.4 ounces
8 tablespoons	=	4 ounces	0.4 gallon	=	51.2 ounces
16 tablespoons	=	8 ounces	0.5 gallon	=	64.0 ounces
1 pint	=	16 ounces	0.6 gallon	=	76.8 ounces
1 gallon	=	4 quarts	0.7 gallon	=	89.6 ounces
1 gallon	=	8 pints	0.8 gallon	=	102.4 ounces
			0.9 gallon	=	115.2 ounces
			1.0 gallon	=	128.0 ounces

Solid Measurements

0.1 pound	=	1.6 ounces	0.6 pound	=	9.6 ounces
0.2 pound	=	3.2 ounces	0.7 pound	=	11.2 ounces
0.3 pound	=	4.8 ounces	0.8 pound	=	12.8 ounces
0.4 pound	=	6.4 ounces	0.9 pound	=	14.4 ounces
0.5 pound	=	8.0 ounces	1.0 pound	=	16.0 ounces

Units and Conversion Equivalents

1 ac ft = 43,560 sq ft

1 ac ft (ac ft) = 43,560 cu ft = 325,762 gal = 2,720,000 lb of water

1 cu ft/second (cfs) = 450 gal/minute (gpm)

1 cu ft = 7.48 gal = 62.4 lb of water

1 gal = 128 fl oz = 8.33 lb of water

1 ppm by volume (ppmv) = 1 gal/million gal of water

1 ppm by weight (ppmw) = 8.33 lb of chemical/million gal of water

1 ppmw = 2.72 lb of chemical/ac ft of water

gal of liquid formulation required = $\frac{\text{lb ai required}}{\text{lb ai/gal of concentrate}}$

lb of dry formulation required = $\frac{\text{lb ai required} \times 100}{\% \text{ ai in formulation by weight}}$

(ai = active ingredient)

Formulas for Herbicide Application to Ponds or Lakes

Volume of pond in cu ft = surface area in sq ft × average depth in ft

Volume of pond in ac ft = surface area in ac × average depth in ft

Volume of pond in ac ft = $\frac{\text{volume of pond in cu ft}}{43,560}$

ppmv = $\frac{\text{gal of 100\% ai}}{\text{volume in ac ft} \times 0.33}$

Total gal of chem required = ac ft × ppmv × 0.33

ppmw = $\frac{\text{lb ai of chem applied}}{\text{volume in ac ft} \times 2.72}$

Total lb ai required = ac ft × 2.72 × ppmw desired

Total gal of liquid formulation required = $\frac{\text{ac ft} \times 2.72 \times \text{ppmw desired}}{\text{lb ai/gal of concentrate}}$

Formulas for Herbicide Application to Channels

cfs = cross section area in sq ft × average velocity in ft/second (fps)

cross section area of rectangular channel in sq ft = average width in ft × the average depth in ft

ppmv = $\frac{\text{gal of chemical} \times 1,000,000}{\text{cfs} \times 450 \times \text{minutes applied}}$

gal of chemical/cfs = $\frac{\text{ppmv} \times 450 \times \text{minutes applied}}{1,000,000}$

total gal of chemical required = $\frac{\text{ppmv} \times 450 \times \text{cfs} \times \text{minutes applied}}{1,000,000}$

ppmw = $\frac{\text{lb of chemical} \times 1,000,000}{\text{cfs} \times 3,744 \times \text{minutes applied}}$

ppmw = $\frac{\text{gal of formulation} \times \text{lb ai/gal} \times 1,000,000}{\text{cfs} \times 3,744 \times \text{minutes applied}}$

lb of chemical/cfs = $\frac{\text{ppmw} \times 3,744 \times \text{minutes applied}}{1,000,000}$

gal of formulation/cfs = $\frac{\text{ppmw} \times 3,744 \times \text{minutes applied}}{\text{lb ai/gal} \times 1,000,000}$

DEFINITION OF TERMS USED IN WEED CONTROL

Abscission—The formation of a layer of cells which cause the fruit, leaf, or stem to fall off the plant.

Absorption—Penetration of a substance from the surface to below the surface.

Acid Equivalent (ae)—The theoretical yield of parent acid from an active ingredient content of a formulation.

Activator—Materials used in a pesticide formulation to increase the effectiveness of the toxic materials towards the target pest.

Active Ingredient (ai)—The chemical(s) in a formulated product that is/are principally responsible for the herbicidal effects and that is/are shown as active ingredient(s) on herbicide labels.

Acute Oral LD₅₀—The dosage required to kill 50% of the test animals when given in a single oral dose in toxicity studies.

Acute Toxicity—The amount of a substance, as a single dose, to cause poisoning in a test animal.

Adhesive—A substance that will cause a spray material to stick to the sprayed surface, often referred to as a sticking agent.

Adjuvant—Any substance in a herbicide formulation which enhances the effectiveness of the herbicide.

Adsorption—Adherence of a substance to a surface.

Aerobic—Living in the air; opposite to anaerobic.

Aesthetic—Producing a pleasant or satisfying feeling to an exposure; enjoy seeing a beautiful flower or handsome animal.

Agitate—Keeping a mixture stirred up.

Algae—Nonvascular chlorophyll-containing plants, usually aquatic.

Alkalinity—Containing sodium and potassium carbonate salts. (Calcareous: Containing an excess of calcium usually in the form of the compound calcium carbonate-Limy.)

Anaerobic—Living in the absence of air; opposite to aerobic.

Anionic Surfactant—A surface-active additive to a herbicide having a negative charge.

Annual Plant—A plant that completes its life cycle in one year.

Antagonism—Opposing action of different chemicals such that the action of one is impaired, or the total effect is less than that of one component used separately.

Antidote—A practical immediate treatment, including first aid, in case of poisoning.

Aquatic Plants—A plant that grows in water. There are three types: submergent, grow beneath the surface; emergent, root below the surface but foliage above the water; and floating.

At Emergence—Treatment applied during the visible emerging phase of the specified crop or weed.

Band or Row Application—An application to a continuous restricted area, such as in or along a crop row, rather than over the entire field area.

Basal Treatment—A treatment applied to the stems of woody plants at and just above the ground.

Bed-Up—To build up beds or ridges with a tillage implement.

Berm—Narrow shelf typically along the water's edge of canals formed by deposited silt.

Biennial—A plant that completes its life cycle in two years. The first year the seed germinates and the plant produces leaves, roots, and stores food. The second year it flowers and produces fruits and seeds.

Bioassay—The qualitative or quantitative determination of a substance by response measurements of treated living organisms as compared to measurement on nontreated, check, or standard living organisms.

Biological Control or Biocontrol—Controlling a pest by its natural enemies, including competitive plants; these may already occur in the area or be introduced.

Broadleaf Plants—Basically classified as dicotyledons. Plants have two cotyledon leaves in the seedling stage; true leaves are broad and have netlike or reticulate veins.

Brush Control—Control of woody plants.

Carcinogen—A substance capable of producing cancer.

Carrier—A gas, liquid, or solid substance used to dilute, propel, or suspend a herbicide during its application.

Cfs—Cubic feet per second.

Chlorosis—Loss of green color in foliage followed by yellowing of the tissue.

Chronic Toxicity—Results produced in test animals exposed for long periods to chemicals.

Combustible—Will burn when near an open flame or spark.

Compatible—Mixable in the formulation or in the spray tank for application together in the same carrier without undesirably altering the separate effects of components.

Concentration—The amount of active ingredient or herbicide in a quantity of diluent expressed as percent, lb/gal, etc.

Contact Herbicide—A herbicide that is phytotoxic by contact with plant tissue rather than as a result of translocation.

Contaminate—To alter or render a material unfit for a specified use by allowing the pesticide to come into contact with it.

Control—May not mean eradication, but reduction of the weed problem to a point where it does not cause economic damage.

Crown—The point where the stem and root join in a seed plant.

Cuticle—Waxy, fatty material that covers plant surfaces such as leaves.

Cut-Surface Application—Treatments applied to frills or girdles that have been made through the bark into the wood of a tree.

Deciduous Plants—Those plants which are perennial in habit but lose their leaves during winter.

Deflocculating Agent—A material added to suspension to prevent particles from clumping together and settling out of spray tanks.

Defoliant or Defoliator—Any substance or mixture of substances for which the primary use is to cause the leaves or foliage to drop from a plant.

Degradation—The process by which a chemical is decomposed or broken down into less complex compounds or elements.

Deoxygenation—Depletion of oxygen.

Dermal Toxicity—Measures the amount of a pesticide or poisonous material that can be absorbed through the skin of animals to produce toxic symptoms.

Desiccant—Any substance or mixture of substances used to accelerate the drying of plant tissue.

Detergent—Primarily used as a cleaning agent. It is often used as a wetting agent to reduce surface tension of spray droplets.

Dewatered Ditch—A drained ditch.

Dicot (Dicotyledon)—A plant that has two seed leaves or cotyledons; broadleaf plants.

Diluent—Any gas, liquid or solid material used to reduce the concentration of an active ingredient in a formulation.

Directed Application—Precise application to a specific area or plant organ such as to a row or bed or to the lower leaves and stems of plants.

Dispersing Agent—A material that reduces the cohesive forces between similar particles.

Dissolve—Refers to getting solids into solutions.

Dormancy—State of inhibited germination of seeds or growth of plant organs. A state of suspended development.

Dose (Rate)—The terms are the same; however, rate is preferred. Refers to the amount of active ingredient applied to a unit area regardless of percentage of chemical in the carrier.

Drift—The movement of airborne particles by air motion or wind away from the intended target area.

Early Postemergence—Applied after emergence during the cotyledonary growth phase of crop or weed seedlings.

Efficacy—Capacity for serving to produce effects; effectiveness.

Emergence—The act by germinating seedlings of breaking through the soil surface.

Emersed Plant—A rooted or anchored aquatic plant adapted to grow with most of its leafstem tissue above the water surface and not lowering or rising with the water level.

Emetic—A material used to cause vomiting to rid stomach of poisonous compounds.

Emulsifiable Concentrate (ec)—A concentrated herbicide formulation containing organic solvents and adjuvants to facilitate emulsification with water.

Emulsifier—A surface active substance that promotes the suspension of one liquid in another.

Emulsion—The suspension of one liquid as a minute globule in another liquid (for example, oil dispersed in water).

Epidermis—The outer cellular tissue of an animal or plant.

Epinasty—More rapid growth on the upper surface of a plant organ or part (especially leaves) causing it to bend downward.

Erosion—Wear away by wind or water.

Ester—A compound formed by reaction of an acid and an alcohol accompanied by the loss of water formed during the reaction.

Filler—A diluent in the powdered form.

Flag Stage—Stage of growth of cereals and other grasses at which the sheath and leaf have been produced from which the head will emerge.

Floating Plant—A free-floating or anchored aquatic plant adapted to growth with most of its vegetative tissue at or above the water surface and lowering or rising with the water level.

Foliar Application—Application of a herbicide to the leaves or foliage of plants.

Formulation—A mixture containing the active pesticide, the carrier, diluents, and other additives required to make the material ready for application.

Freeboard—Distance above water level.

gpa—Gallons per acre.

Gradient—Steps or progress in the rate of growth (plant) or development (seed).

Granule or Granular—A dry formulation of herbicide in which the active ingredient is impregnated on small particles of carrier such as clay or ground-up corncobs.

Grass—Botanically, any plant of the Gramineae family. Grasses are characterized by narrow leaves with parallel veins; by leaves composed of blade, sheath, and ligule; by jointed stems and fibrous roots; and by inconspicuous flowers usually arranged in spikelets.

Growth Regulator—A substance used for controlling or modifying plant growth processes without appreciable phytotoxic effect at the dosage applied.

Habitat—Environment (place) where plant grows naturally.

Hard Water—Generally defined as water containing 332 ppm of calcium carbonate. Water that contains certain minerals, usually calcium and magnesium sulfates, chlorides, or carbonates, in solution in sufficient amounts to cause a curd or precipitate instead of a lather when soap is added. Very hard water may cause precipitates in some herbicide sprays.

Hazard—The probability that injury or detrimental effects will result if a substance is not used properly.

Hazard Ratio—The relationship of the degree of risk.

Herbaceous Plant—A vascular plant that does not develop persistent woody tissue above ground.

Herbicide—A chemical used for killing plants or severely interrupting their normal growth processes.

High Volume Sprays—Spray applications of more than 60 gallons per acre volume.

Hormone—A naturally occurring substance in plants that controls growth or other physiological processes. It is used with reference to certain manufactured chemicals that regulate or affect growth activity.

Hydrosoil—Soil at bottom of the body of water. Soil-water interface at the bottom of the body of water.

Incorporate Into Soil—The mixing of a herbicide into the soil, generally by mechanical means.

Inert Ingredient—That part of compound without toxic or killing properties, sometimes called the carrier.

Inhibit—To hold in check or stop.

Integrated Control—Utilizes multiple approaches for pest control, giving consideration to minimum pesticide usage.

Invert Emulsion—The suspension of minute water droplets in a continuous oil phase.

Ionic Surfactant—One that ionizes or dissociates in water.

Jointing Stage—When the internodes of grass stems are elongating.

Label—All written, printed, or graphic matter on or attached to pesticide containers as required by law.

Lactation—To secrete milk.

Late Postemergence—Applied after the specified crop or weeds are well established.

Lateral Movement—Chemical movement in a plant or in a soil to the side or horizontal movement in the roots or soil layer.

Layby Application—Applied with or after the last cultivation of a crop.

LC₅₀—Means of expressing the lethal concentrations of a compound. It is a statistical estimate of the dosage necessary to kill 50% of a test animal population, usually expressed in ppm.

LD₅₀—Means of expressing the dosage necessary to kill 50% of a test animal population. It is expressed in weight of the chemical (mg) per unit of body weight (kg).

Leaching—The downward movement of a substance in solution through the soil.

Leaf Blade—The flat portion of a leaf.

Low-Volatile Ester—An ester compound with a high molecular weight and a low vapor pressure such as butoxy-ethanol, iso-octyl, or propylene glycol butyl ether ester.

Low-volume Spray—A spray application of 5 to 20 gallons per acre.

Marginal Plants—Those plants growing near shoreline.

Marl—A calcium carbonate deposit on algae.

Miscible Liquids—Two or more liquids capable of being mixed, which will remain mixed under normal conditions.

Monocot—A seed plant having a single cotyledon (monocotyledon) or leaf; includes grasses, corn, and lilies.

Mutagen—A compound having the property to induce mutations.

Necrosis—Localized death of living tissue (as, for example, following desiccation, browning, and loss of function).

Node—Region of plant stem where leaf or leaves are attached.

Nonionic Surfactant—Chemically inert.

Nonselective Herbicide—A chemical that is generally toxic to plants without regard to species (may be a function of dosage, method of application, etc.).

Noxious Weed—A weed specified by law as being especially undesirable, troublesome, and difficult to control. Definition will vary according to legal interpretations.

Oral Toxicity—Poisonous effect of a compound when it is ingested.

Overall Treatment—Uniform application over the entire area.

Overtop Application—Uniform over the top of transplanted or growing plants such as by airplane or raised spray boom of ground rigs. A broadcast application above the plant canopy.

Pellet—A dry formulation of herbicide and other components in discrete particles usually larger than 10 cubic millimeters.

Penetrant—Wetting agents that enhance the ability of a liquid to enter into the pores of a substrate.

Perennial—A plant that lives for more than two years.

Persistent Herbicide—A plant-killing chemical, which applied at the recommended rate, remains in the soil to harm susceptible crops planted in normal rotation after harvesting of the treated crop. Also can interfere with regrowth of native vegetation in noncrop sites.

Pesticide—Any substance or mixtures of substances used to control or kill insects, rodents, weeds, fungi, and other pests.

Pesticide Tolerance—The amount of pesticide residue which may legally remain in or on a food or feed crop.

Photic Zone—Zone where light is sufficient for plant growth.

Photosynthesis—The manufacture of simple sugars by green plants utilizing light as the energy source.

Phylogenetic—Origin and evolutionary developments of plants.

Phytoplankton—Microscopic plant life living suspended in water.

Phytotoxic—Injurious or toxic to plants.

Postemergence (poe)—After emergence of the specified weed or planted crop.

Postharvest—Application of a pesticide to the soil or plant after crops have been harvested.

Potable Water—Drinkable water.

Preemergence (pre)—Prior to the emergence of the specified weed or planted crop.

Preemergence Incorporated—Applied after seeding and incorporated into the soil above the seed.

Preplanting Application—Applied on the soil surface before seeding or transplanting.

Preplanting Soil Incorporated (ppi)—Applied and tilled into the soil before seeding or transplanting.

psi—Pounds per square inch.

Pubescent—In reference to hair on plants.

Quiescent—Quiet, still, inactive.

Rate—The amount of active ingredient or acid equivalent applied per unit area or other treatment unit.

Registered—Pesticides that have been approved for use by the Environmental Protection Agency.

Residual—To have continued killing effect over a period of time.

Residue—The amount of pesticide on or in the crop at the time an analysis is made.

Residue Tolerance—The amount of pesticide residue which may legally remain in or on a food or feed crop.

Resistance—The ability of an organism to suppress or retard the injurious effects of a pesticide.

Rhizome—Underground rootlike stem that produces roots and leafy shoots.

Seed—The part of a flowering plant that typically contains the embryo with its protective coat and stored food and will develop into a new plant if sown.

Seedling Stage—Early stage of plant growth, within a few days to a few weeks after seed germination and emergence.

Selective Herbicide—A chemical that is more toxic to some plant species than to others (may be a function of dosage or mode of application).

Silty Water—Water clouded with very small particles of clay, silt, and sand.

Soil Application—Applied primarily to the soil surface rather than to vegetation.

Soil Injection—Placement of the herbicide beneath the soil surface with minimal mixing or stirring of the soil—as with an injection blade, knife, or tine.

Soil Layered—Placement of the herbicide in a discrete horizontal zone under a lifted or tilled layer of soil.

Soil Persistence—Refers to the length of time that a herbicide application on or in the soil remains effective.

Soil Residual—A herbicide that prevents the growth of plants when present in the soil. Soil residual effects may be temporary or relatively permanent.

Soil Sterilant—See Soil Residual.

Solubility—The amount of a substance that will dissolve in a given amount of liquid at a specific temperature.

Soluble Solid—A dry herbicide formulation that is soluble in the carrier liquid.

Solvent—A liquid, usually water or oil, used to dissolve other material such as herbicides.

Spore—A reproductive body of bacteria; algae, mosses, and ferns.

Spot Treatment—The application of a herbicide to a selected individual area; usually defined as less than 10% of a field or given area.

Spray Drift—The movement of airborne spray particles from the intended area of application.

Spreading Agent—A substance to improve the wetting, spreading, or possibly the adhesive properties of a spray.

Static Water—Pond, lake, or reservoir water that has little or no inflow or outflow.

Stolon—The above-ground runners or slender stems that develop roots, shoots, and new plants at the tips or nodes.

Stunting—In reference to plant, the retarding effect on growth and development.

Subacute Toxicity—Results produced in test animals by long-term exposure to repeated doses or concentrations of a substance.

Submersed Plant—An aquatic plant adapted to grow with most all of its vegetative tissue below the water surface.

Surface Tension—A property of liquids related to surface molecular forces, a drop of liquid tends to form an apparent membrane that causes it to ball up rather than spread as a film.

Surfactant—A material that favors or improves the emulsifying, dispersing, spreading, wetting, or other surface modifying properties of liquids.

Surveillance—To keep watch on change in activity, growth, or performance.

Susceptibility—Lack of capacity to tolerate herbicide treatment.

Suspension—Finely divided solid particles dispersed in a solid, liquid, or gas.

Synergism—Complementary action of different chemicals such that the total effect is greater than the sum of the independent effects.

Systemic—A compound that moves freely within a plant. Application to one area will reach all areas of the plant to exert its effect.

Taxonomy—Science of classification: arrangement according to characteristics.

Teratogen—A compound having the property of causing congenital malformations in the fetus (birth defects).

Terrestrial Plant—A land plant.

Thallus—A nonvascular plant body with distinguishable roots, stems, or leaves.

Tolerance—Capacity to withstand herbicide treatment without marked deviation from normal growth or function.

Topical Application—Treatment of a localized surface site such as a single leaf blade, petiole, or growing point.

Transient—Not permanent; lasting for a short time.

Translocated Herbicide—A plant-damaging chemical that is moved within the plant. Translocated herbicides may be either phloem mobile or xylem mobile, but the term is frequently used in a more restrictive sense to refer to herbicides moved in the phloem.

Translocation—Transfer of food or other materials such as 2,4-D from one part of a plant to another (see Systemic).

Tuber—An underground plant storage stem of reserve food; may also be a reproductive organ.

Turbidity—Suspended material in water preventing light penetration.

Turion—A scaly, often thick and fleshy, detached winter bud, by means of which many water plants survive winter.

Vapor Drift—The movement of chemical vapors from the area of application.

Vascular plant—Plants which have specialized food and water conducting cells.

Vigilance—Staying watchful and alert.

Volatile—A compound is volatile when it evaporates or vaporizes (changes from liquid to a gas) at ordinary temperatures on exposure to the air.

Water Dispersible Slurry—A two-phase concentrate that contains solid herbicide suspended in liquid which is capable of suspension in water.

Water Soluble Powder—A finely ground herbicide powder that will dissolve in water.

Weed—A plant growing where it is not desired. Any plant that is a nuisance, hazard, or causes injury to people, animals, or the desired crop.

Weed Control—The process of limiting weed infestations or killing weeds for aesthetic, economic, public health, or other reasons.

Weed Eradication—The elimination of all live plant parts and seeds of a weed from a site.

Wettable Powder (wp)—A finely divided, dry herbicide formulation that can be suspended readily in water.

Wetting Agent—Substance which serves to reduce interfacial tensions and causes spray solutions or suspensions to make better contact with treated surfaces.

Zooplankton—Microscopic animal life living suspended in water.

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