# AQUATIC (SURFACE WATER) PEST CONTROL

**PESTICIDE APPLICATION**
**AND**
**SAFETY TRAINING**
**STUDY GUIDE**


**UTAH DEPARTMENT OF AGRICULTURE**
**DIVISION OF PLANT INDUSTRY**
350 NORTH REDWOOD ROAD
BOX 146500
SALT LAKE CITY, UTAH 84114-6500

Volume 1, October 1996

Format Revised by UDAF 11/2008

# STUDY GUIDE FOR
# AQUATIC (SURFACE WATER)
# PEST CONTROL

The educational material in this study guide is practical information to prepare you to meet the written test requirements. It doesn't include all the things you need to know about this pest-control subject or your pest-control profession. It will, however, help you prepare for your test.

Contributors include the Utah Department of Agriculture and Utah State University Extension Service. This study guide is based on a similar one published by the Colorado Department of Agriculture. Materials for that guide were prepared by Colorado State University Extension Service. Other contributors include: University Cooperative Extension Service personnel of California, Kansas, New York, Oregon, Pacific Northwest, Pennsylvania, and Wyoming. Other contributors were the U.S. Department of Agriculture -- Forest Service, the United States
Environmental Protection Agency (Region VIII), the Department of Interior -- Bureau of Reclamation, and Metro Pest Management.

The information and recommendations contained in this study guide are based on data believed to be correct. However, no endorsement, guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

Other topics that may be covered in your examinations include First Aid, Personal Protective Equipment (PPE), Protecting the Environment, Pesticide Movement, Groundwater, Endangered Species, Application Methods and Equipment, Equipment Calibration, Insecticide Use, Application, Area Measurements, and Weights and Measures. Information on these topics can be found in the following books:

1. **National Pesticide Applicator Certification Core Manual,** Published by the National Association of State Departments of Agriculture Research Foundation.

2. **The Workers Protection Standard for Agricultural Pesticides – How to Comply: What Employers Need to Know.** U.S. EPA, Revised September 2005, Publication EPA/735-B-05-002.

These books can be obtained from the Utah Department of Agriculture or Utah State University Extension Service. Please contact your local Utah Department of Agriculture Compliance Specialist or Utah State University extension agent.

**This page is intentionally blank**

# TABLE OF CONTENTS


| Section: | Page Number |
|---|---|
| INTRODUCTION . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 1 |
| ECOLOGY OF WATER . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 1 |
| BIOLOGY OF AQUATIC PLANTS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 2 |
| AQUATIC WEEDS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 2 |
| CULTURAL AND MECHANICAL CONTROL . . . . . . . . . . . . . . . . . . . . . | 3 |
| BIOLOGICAL CONTROL . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 4 |
| CHEMICAL CONTROL OF AQUATIC WEEDS . . . . . . . . . . . . . . . . . . . . | 5 |
| CHEMICAL FORMULATIONS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 5 |
| APPLICATION OF CHEMICALS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 7 |
|  APPLICATION TECHNIQUES ……………………………………. | 8 |
|  APPLICATIOIN EQUIPMENT ……………………………………. | 9 |
| WEED CONTROL IN STATIC WATER …………………………………. | 10 |
| WEED CONTROL IN LARGE IMPOUNDMENTS …………………….. | 10 |
| WEED CONTROL IN FLOWING WATER ……………………………… | 11 |
| CONSIDERATIONS BEFORE CHOOSING A HERBICIDE …………… | 11 |
| ENVIRONMENTAL CONSIDERATIONS AND RESTRICTIONS (Weed Control) | 12 |
| IRRIGATION DITCH BANK WEED CONTROL……………………….. | 13 |
| CONTROL OF VERTEBRATES ………………………………………. | 14 |
| ENVIRONMENTAL EFFECTS (Vertebrate Control) …………………… | 16 |
| CHEMICAL CONTROL FAILURE ……………………………………… | 16 |
| THREATENED AND ENDANGERED SPECIES . . . . . . . . . . . . . . . . . . . . | 17 |
| WORKER PROTECTION STANDARDS . . . . . . . . . . . . . . . . . . . . . . . . . . | 17 |
| GROUNDWATER CONTAMINATION BY PESTICIDES . . . . . . . . . . . . | 18 |
| APPENDIX I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 19 |
| CALIBRATION INFORMATION ………………………………………… | 21 |
| APPENDIX ……………………………………………………………… | 25 |
|   Algae and Weed Identification | |
|   Fish Control Information | |

# INTRODUCTION

Water is such a common natural resource that it's often taken for granted without much consideration for its proper management. The old adage "You never miss the water until the well goes dry" also applies to water storage ponds, lakes, streams, and irrigation ditches.

Most ponds, at least those that are man-made, have some reason for their existence. Aquatic weed growth is a major consideration in the management of ponds, lakes, and ditches. Control is important to maintain the quality and use of water for wildlife, drinking, recreation, agriculture, and transportation.

Aquatic weeds can cause serious agricultural problems. They interfere with irrigation, restricting water movement through canals by clogging siphons, trash racks, turnouts, pump filters, and sprinkler irrigation systems. In fact, some authorities say that half the land now irrigated in the western United States would not be irrigated during mid- and late-summer months if chemical control of aquatic weeds were prohibited. In some places, reed canary grass has increased rapidly along the water line of irrigation canals and laterals; this weedy grass reduces water flow in small canals and laterals by 75 percent or more. In other parts of the state, cattails and tules cause serious problems by reducing water flow in irrigation and drainage ditches. Also, weed beds offer a favorable environment for mosquito production.

Heavy growths of algae and submersed aquatic weeds often make many beautiful lakes and ponds become unsightly during the summer, so that they have no use other than for water storage. But with proper weed control techniques, these ponds can be made attractive and useful recreational facilities. The benefits of removing aquatic weeds are many. First, it will increase water-storage capacity, since heavy infestation of weeds may reduce the holding capacity of a pond 30 percent or more. Second, most fish will produce better and can be harvested better in clean water. Third, getting rid of weeds will add to the recreational use of water for better swimming, boating, and other uses. Removing weeds also enhances the shoreline area, which may be used for water-related recreational activities such as fishing and picnicking.

# ECOLOGY OF WATER

Having a basic understanding of the ecology of water, especially ponds and lakes, is helpful in understanding the aquatic weed problems that develop. What is a pond? A pond is usually described as a body of water that doesn't have large amounts of water flowing in and out of it continuously. This is a simple definition of a complex and dynamic ecosystem.

Ponds are more than static bodies of water. Whether they are natural or man-made, they are constantly changing. Change within the pond may be caused by fluctuations from season to season and even by day-to-day variations in the weather. Many of the life processes taking place in a pond are destructive, in that ultimately they lead to the pond's deterioration, at least from man's point of view. Without an outflow to clear it of accumulated silt and dead plant and animal materials, the pond gradually accumulates undesirable materials and weeds. The addition of sediment and nutrients from the pond's watershed area speeds up the process.

Ponds teem with life. Plants, especially algae, in the pond produce food, just as land plants do. They are the main source of food for simple animals, which in turn are eaten by larger animals and fish. These plants also give off oxygen, which is necessary for fish and animals to live. Large quantities of oxygen are also consumed in the decomposition of organic material -- dead plants and animals. This decomposition is a natural and basic part of the life of a pond.

The shallow waters of most ponds permit the penetration of sunlight throughout, so the sun's rays reach all the way to the bottom. This encourages the growth of both desirable and undesirable plant life.

Nutrient-rich water and relatively high water temperatures characterize many ponds. These factors also encourage excessive algae and higher plant growth. Some algae are desirable in that they serve as food for microscopic animals at the bottom of the food chain. Some algae, however, impart unpleasant odors, colors and tastes to water; others produce toxic substances that cause allergic reactions in people and are sometimes lethal to fish and wildlife. And later in the cycle, the accumulation of dying and decomposing plants and algae can deplete the dissolved oxygen supply. While fish-kills are often blamed on pesticides, more often they occur naturally. During decomposition, the bacteria and fungi carrying out this process deplete the water of dissolved oxygen, causing fish stress or, in extreme cases, fish-kills.

As stated earlier, water is a medium for complex interactions between many organisms in the pond, lake or stream. A good number of these interactions are interdependent and actually beneficial. The oxygen produced through photosynthesis by the submersed aquatic plants and algae is used by fish, bacteria and zooplankton for respiration. In turn, the carbon dioxide released by fish during respiration is used by the submersed aquatic plants and algae for photosynthesis. These plants provide the materials and energy that other aquatic organisms convert into food for fish.

The problem, then, is how to maintain a desirable balance -- how to maintain adequate algae and plant growth to supply the food chain, but at the same time to keep potentially destructive forces in check.

# BIOLOGY OF AQUATIC PLANTS

Aquatic plants don't differ profoundly from terrestrial plants, although their habits may differ. The medium in which the foliage of terrestrial and underwater plants grow is different.

However, both air and water serve as a medium for some aquatic plants, and practically all aquatics photosynthesize. Many bloom and produce seed -- some below the water surface, others above. Aquatic plants include annuals that reproduce by seed or spores; others are perennials that may reproduce by rhizomes, tubers, or other vegetative parts as well as by seed.

Almost all aquatic plants require light for growth and survival. Those that grow beneath the water surface may require only one to six percent of full sunlight; different species require different amounts of light. Therefore, the amount of light that penetrates a body of water may determine the species present at different depths.

Water temperatures may determine which plants grow in a stream or body of water. Some species of algae may grow and thrive in near-freezing temperatures. Other plants begin growth at temperatures of about 45 degrees F., and still others grow best at 65 to 80 degrees F.

Aquatic plants require the same nutrients as terrestrial plants. Rooted underwater species are believed to obtain these nutrients from the soil as well as from the water. Aquatics that grow underwater are very efficient in extracting, concentrating and using nutrients from water in which these nutrients are very dilute.

# AQUATIC WEEDS

Regardless of the pest problem being considered for management/control, the correct identification of the target pest is critically important. Usually, aquatic weeds are separated into four broad categories. These are immersed, submersed, floating and algae.

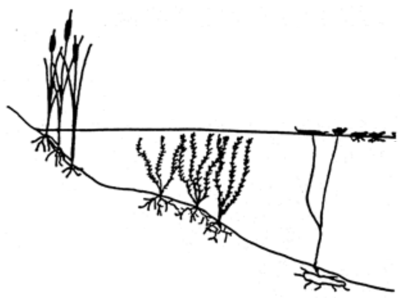
**Immersed** species are rooted or anchored beneath the water surface. They grow with most of their leaf-stem tissue above the water surface and don't lower or rise with the water level. Examples are cattails, purple loosestrife, and tules. Most of these species become established at or near the water lines of lakes, ponds, and irrigation systems and spread outward into the water.

**Submersed** species grow with all or most of their vegetative tissue below the water surface. They have shallow roots in the bottom of water channels and make most of their growth during the warm part of the summer. Plants of this type clog or reduce the carrying capacities or irrigation channels, collect silt and debris, and interfere with operation of sprinkler irrigation systems. Examples are sago pondweed, coontail, water milfoil, and elodea. These weeds are often referred to as "moss."

**Floating** species are those that are either free-floating or anchored and produce most of their foliage at or above the water surface, lowering or rising with the water level. Examples are the duckweeds and water lily.

**Algae** are also submersed and free-floating, or they may be anchored by "holdfasts" to rocks, ditch linings, etc. Algae don't have true roots or leaves and are often called "pond scums," "slime," or "floating mats." Algae are primitive plants that reproduce by spores. Where they become abundant, they give water a soupy green color often called "water bloom." Under some conditions, algae may cause odors and bad taste in municipal water supplies, and some species of blue-green algae are toxic to humans, livestock, and other warm-blooded animals.

Immersed and floating plants tend to have a thick outer layer on their leaves. This can cause a problem with herbicide absorption and make control difficult. Submersed aquatic plants have a thin outer layer on their stem and leaf surfaces. This is why they are able to absorb nutrients from the water so well. This characteristic makes them easier to control chemically,



because they will also absorb herbicides.

# CULTURAL AND MECHANICAL CONTROL

As stated previously, the first step in any control program is to identify the problem. Low-growing plants that don't produce problems or interfere with recreational uses should be left alone. If these are eliminated or reduced, it's possible that much more troublesome plants will replace them.

Excess growth of aquatic plants may be prevented by removing or limiting one of the environmental factors necessary for plant growth. These factors are water, light, nutrients, and a minimum temperature of about 10 degrees C. (50 degrees F.). Obviously, the first three factors may be controlled to some extent, but there is no practical way to control water temperature.

Weed prevention begins with pond design and construction. The following specifications will help in aquatic weed prevention:

Build the pond as deep as possible. Most algae grow only in sunlight; therefore, more water will become infested when the pond is shallow. Deep water discourages bottom-rooting plants whose leaves reach the surface, such as coontails and potomageton. Deep water also gives more protection to fish during long, hard winters and extremely hot weather.

Build the pond as large as possible. This allows more wave action to carry free-floating plant material to shore.

Have abruptly sloping sides (at least three feet deep within ten feet of shore). This is more treacherous for humans and livestock but is essential if cattails, bulrushes, sedges and willows are to be prevented.

Limit nutrient input. Sediment-rich nutrients may be removed by building a small settling basin just upstream from the pond's inlet.

To help prevent serious aquatic weed problems, you can take the following steps:

Maintain a good sod or grass cover around your pond to prevent runoff and erosion and to solidify banks. Don't fertilize turf directly around a pond.

Reduce soil erosion from cropped areas into your pond through the use of conservation tillage, contour farming, terraces, and grass waterways. Eutrophy is an increase in mineral and organic nutrients that favor plant over animal life. This will result from the fertilizer and agricultural chemicals that are carried in on the eroded soil.

Don't allow livestock access to a pond. Animals tear down banks and supply excessive nutrients to the water. If your pond is to be used for watering livestock, fence the pond, and water animals from a stock tank below and outside the fence.

Don't permit runoff from poultry or livestock operations to enter your pond. If this kind of runoff is occurring upstream from your pond, check with your county board of health to see if anything can be done about it.

Check septic tanks for possible leakage or seepage into the pond. Locate your septic drain fields so that the nutrient-rich effluent won't reach your pond.

Manipulation of the water level might be used to control weed growth. Some ponds, lakes, canals and ditches can be drained so aquatic weeds will dry out. The water levels in some large lakes and reservoirs can be lowered enough to expose weeds in shallow areas. Initial weed growth the following spring can be inhibited or stopped by lowering the water level enough to expose and dry or freeze the bottom sediments where plants root. If possible, weed debris and root stocks should be removed while the bottom is exposed. The hard-to- control plants such as cattails and other emergent with large, fleshy roots are especially well-controlled by root removal.

Drying periods of several months may be needed to control weeds in some ponds and lakes. In canals, it may not be practical to interrupt water flow for longer than three or four days. The season of year and species of plant present may determine whether this method will be useful in a particular situation.

Be sure to consider the resident fish species and their normal spawning times. Weed growth in late spring and early summer may be inhibited by raising the water level. This will cut off light from the new growing tips that are close to the bottom at this time of year.

Light reduction by shading during this same period can be effective for small areas. Black plastic sheeting over a floating 2 inches x 4 inches frame is effective. Black plastic may also be used as a bottom cover if held in place with rocks or three or four inches of sand. This method is most effective for small areas used for swimming or docking.

Making the water deeper by removing sediments is very effective, but this is impractical except when building the pond.

Fertilization with inorganic nutrients may be a convenient and inexpensive way to control weeds in ponds and small lakes. Fertilization stimulates a dense bloom of microscopic algae. The algae shade the pond bottom and prevent or reduce the growth of submersed weeds. Unless the fertilization is done correctly, however, the weed problem may become even more severe.

The fertilizer can be broadcast from a boat or dissolved in the water in other ways. Existing weeds either are not affected or their growth may be stimulated. You may need to remove them before fertilizing. Ponds that have a monthly water exchange greater than the capacity of the pond don’t respond well to fertilization. Fertilizers are more effective in deep water than in shallow water.  Cutting is another important technique that has several advantages. All types of aquatic vegetation, including filamentous algae and vascular plants, can be removed. No special equipment or protective clothing is needed. No operating experience or permits are required. The technique can be practiced under any conditions. And there are no restrictions on the use of the water during or following treatment.

Disadvantages include increased time involved, disposal of plant material, and the multiple yearly cuttings that are usually required. Underwater cutting using commercial machines, hand sickle or rake is effective if practiced regularly. Commercial machines cost from several hundred to many thousands of dollars, depending on their capacity. The cut stems should always be removed, because most aquatic plants spread vegetatively. Any small piece may become a new plant. A minimum of two cuttings is usually needed each summer. Better control, even into the next season, can be accomplished by more frequent cuttings. Because many rooted aquatics are perennial plants that remain alive but dormant during the winter, complete removal by cutting in late fall will slow the next spring's growth.

Several years of faithful cutting and removal will gradually deplete the sediment of its nutrients and result in less frequent cuttings. This technique is especially applicable to lilies and cattails, which must store leaf-produced starch in their roots for the next year's early growth.

Aquatic plant harvesters are large machines that cut five to eight feet below the surface and collect the weeds in a single, power-driven operation; however, these harvesters are usually too expensive for individuals.

Don't spread noxious aquatic weeds. Always check your boat, motor and trailer, and remove all plant material from them before moving to another body of water.

# BIOLOGICAL CONTROL

Biological controls for aquatic weed vegetation have received much interest but little actual use. They have been successful in a number of cases. Biological control agents include:

- Tilapia -- This plant-eating fish has only limited value. It will eat aquatic plants and reproduce rapidly, but it survives winter temperatures in a very few areas of this country.

- White amur -- The white amur is a large fish that eats large amounts of aquatic plants. It survives well in many areas of the United States. Because its environmental hazards are not fully known, only a few states permit its use.
- Insects -- Several insects have been brought into this country to control aquatic weeds. The most successful are a beetle and a moth that are parasitic on alligator-weed. They have provided good control of this weed in large areas of the South. Other insects are under study for control of other species of weeds.

# CHEMICAL CONTROL OF AQUATIC WEEDS

The use of chemical herbicides to control excess aquatic plant growth is often convenient, quick, effective and -- in some cases -- inexpensive. Of course, there are disadvantages such as the safety precautions necessary when storing, handling, applying or disposing of the chemical. There is no guarantee it will work in any specific situation. There is no long-lasting effect or carry-over to the next season. In fact, algae "blooms" are often stimulated by weed-kill. There is danger of killing too much weed material at one time and producing an oxygen deficiency for fish and other organisms as the weed mass decays. There is a restricted-use period after each application. Once the chemical is in the water, there is little control over its movement. And there is always the danger of poisoning the wrong organism when chemicals are used. This includes ourselves and various aquatic organisms.

Before beginning an aquatic weed-control program, one should analyze the problem. Considering the following factors may help to analyze the situation:

1. Identify the problem species and other species present; herbicides are not effective on all aquatic weed species. This can be done with the help of plant taxonomy books and other pertinent references. Good references are "Aquatic Pests on Irrigation Systems -- Identification Guide" and "Herbicide Manual, A Water Resources Technical Publication," both from the U.S. Department of the Interior -- Bureau of Reclamation.

2. Determine density, stand, and stage of growth of the weeds.
3. Determine what fish species are present, if any.
4. Determine whether the water is or will be used for human consumption, irrigation, recreation, fish production, livestock consumption, or wildlife habitat.

5. Determine the destination of outflow or tail water.

6. Determine the size of channel or pond to be treated.

7. Determine the depth and velocity of the water.

8. Determine the water temperature.

9. Determine which herbicides are registered for the intended usage.

10. Rate the herbicides according to efficacy and to selectivity desired.

11. Compare cost.

# CHEMICAL FORMULATIONS

Chemicals used in aquatic weed control are classified as herbicides. Herbicides used primarily for control of algae are called algaecides, even though they may also kill other aquatic plants. Aquatic herbicides are available in several formulations:

**Sprayable Formulations** -- Most herbicides are formulated to be mixed with a water carrier and sprayed. Some perform best as aquatic herbicides when applied into static or flowing water so that they disperse evenly and contact underwater surfaces of weeds. Kinds available are:

- Water-soluble powders or crystals that form true solutions in water
- Water-soluble liquid concentrates that form true solutions in water
- Wettable powders that can be suspended in water and applied
- 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. Kinds available are:

- Granulated pure chemical, such as crystalline copper sulfate
- Granules or larger-size pellets of clay and other materials impregnated with active ingredients
- Slow-release granules or pellets designed to release the active ingredient in small amounts over an extended period of time in the water.

**Solutions** -- Many herbicides come in solid forms (such as copper sulfate) or liquid forms that readily dissolve in water to form solutions. Solutions are stable in that the chemical material doesn't normally settle out readily over a period of time. When using a solution, fill the tank one-half full of water. Add the chemical slowly, and stir until completely dissolved. Next, bring the tank up to capacity. It may be necessary to add a surfactant, a soap-like material that tends to spread the water-soluble spray on the waxy leaves of emergent or floating vegetation. When applied under water, solutions disperse evenly and bathe submerged plants completely.

**Suspensions** -- A suspension is formulated by mixing a water-dispersible powder in water. This powder doesn't dissolve but is mixed or contained in the water. Continuous agitation is needed in order to maintain the material in suspension. There are two methods for mixing: (1) Add the powder to a tank containing water in which vigorous agitation is taking place. Never add the powder to an empty tank, and never add powder to a tank containing water in which there is little or no agitation. If this is done, the powder will settle on the bottom and possibly damage or clog the sprayer and the sprayer lines. It will also form caked material on the tank bottom. (2) A better way to mix dispersible powders is to make a thin water slurry of the required amount of material in a bucket or other container. Thoroughly mix the wettable powder in the water before adding it to the tank. Fill the tank one-half full of water, pour the slurry into the tank, and thoroughly agitate the water. When using suspensions, a sprayer with mechanical agitation is preferable to one having hydraulic agitation, because constant, vigorous mixing is needed in order to maintain the suspension.

**Emulsions** -- An emulsion is a preparation that doesn't truly dissolve in the solvent or carrier, but rather is dispersed throughout the carrier as almost microscopic globules barely visible to the eye. Unlike a true solution, if emulsions are given time; they will separate or settle out of the carrier. When preparing emulsions, if additional oil is needed, it should be added to the chemical first. Then add the oil-chemical mixture to a tank one-third full of water, and agitate as the tank is filled to capacity. For best results with an emulsion, constant agitation is needed. Most emulsions consist of oil globules surrounded by water. Invert emulsions are usually viscous and harder to apply; however, they settle or sink more rapidly, reduce drift, and adhere to plant surfaces.

**"Bivert" or Invert Spray System** -- The "bivert" system is a relatively new system of applying chemical spray. The system may be defined as a double invert. A simple invert usually produces spray droplets of oil surrounded by water or water drops surrounded by oil. The "bivert" is a system with oil in water in oil. That is, each spray droplet should have an oil center, an outer layer of water, and a third layer of oil. The herbicide may be included in either the oil, water, or in both the oil and water phases. The "bivert" system, along with simple inverts, has been used in the past to treat terrestrial or floating plants, but it may have a greater potential for aquatic weed control as a technique for chemical application to submerged plants.

The "bivert" spray enters below the water surface as small, almost microscopic, droplets with the consistency and adhesive texture of mayonnaise. It descends through the water column, lands on and adheres to the submerged vegetation, releasing the herbicides close to the plants. Preliminary results of this system indicate it has definite advantages over parts-per-million treatment in several ways: it's less expensive, less chemical is needed, the chemical is released near the plant, and the clinging property of the droplet makes treatment in moving waters feasible. Several herbicides are compatible to the system; others must be specifically formulated to invert, or a specific invert-additive must be mixed in the formulation.

The system has one distinct drawback. Since it's a form of invert, the mixing and application must be done with extreme care. All chemical components must be measured accurately, and the pressure and vacuum hoses on the invert machinery must be securely attached and airtight. Inverts are usually lighter than water and must be weighted using an inert material (sugar or molasses).

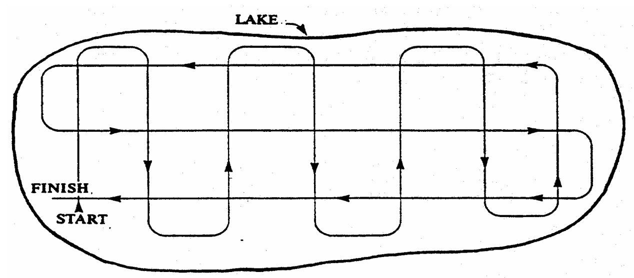
**Slow-Release Pellets** -- The slow-release pellet is a relatively new formulation for aquatic weed control and is designed especially for the control of submerged aquatics. When the pellet contacts the water, it begins to disintegrate, thus slowly releasing small quantities of the herbicide over an extended period of time. This system has a big advantage in that normally-fish-toxic compounds known to be good aquatic weed-control agents can be safely used. A good example of the slow-release pellet is "Hydout," the monoamine salt of endothall. It has long been known that this chemical is a good agent for control of aquatics, but the salt is normally toxic to fish at rates needed for weed control. When placed in a slow-release pellet and used with caution, good weed control can be obtained, and fish-kill won't result. With this system, treatment is usually confined to the lower water depths where the submerged weeds occur, leaving untreated surrounding water areas where fish can escape. This system has an advantage in that it's easy to apply the pellets in a uniform manner, and it's also adaptable to aerial application techniques. The system has two disadvantages. Often a fine dust may accompany the pellets, and when inhaled for prolonged periods, this dust may irritate the respiratory organs. Second, if the system isn't used cautiously (especially when fish-toxic chemicals are incorporated into the pellet), fish-kill may result.

**Granules** -- Granules consist of vermiculite, attaclay, or other similar carriers impregnated with an active chemical herbicide. Granules are easily used in spot treatments or places where liquids may be diluted away, such as in large lakes. The particles sink to the bottom, where the herbicide is released close to roots and the new plant shoots. Hazard to non-target organisms is reduced, because most of the herbicide stays near the bottom, and less total chemical is required.

# APPLICATION OF CHEMICALS

The application of chemicals to the water environment must always be approached with caution. Identify the plant, and be sure the chosen herbicide is appropriate. Apply the minimum amount only to those areas that really need treatment. Always consider the reasons for controlling excess growth and later uses of the water. To ensure uniform coverage, distribute half of the total chemical needed by making several passes across the area to be treated. Then repeat with the other half of the chemical in a direction at right angles to the first trips across the affected area.

It is best to split the treatment, doing one portion one day and the second portion ten days or two weeks later. This minimizes the danger to fish from oxygen depletion by decaying weeds. Application should be made when the plants are growing vigorously but before huge masses appear. This is in spring or early summer for most plants. The weather should be calm and sunny, with little prospect of rain for 24 hours




When using herbicides in water, it's of the utmost importance to calculate rates of application correctly. An error can be expensive, be disastrous to non-target organisms in the water and to the applicator himself, have adverse effects long distances from the application area, cause contamination of drinking water by the chemical itself, or decrease the general water quality with tastes and colors. As a result, the applicator may find a claim for damages filed against him. It pays to understand rate calculations and apply them correctly.

Although the correct chemicals must be selected for treating aquatic plants, using the proper application technique will determine whether or not this chemical will be effective in controlling the aquatic weed problem.

When treating aquatic plants in situations where fishing is valued, two or more partial treatments are recommended instead of total treatment of the body of water in one operation. In highly nutritive waters especially, a complete treatment may reduce the lake or pond recovery capacity, and often the nutrients released by the decaying plants after treatment are

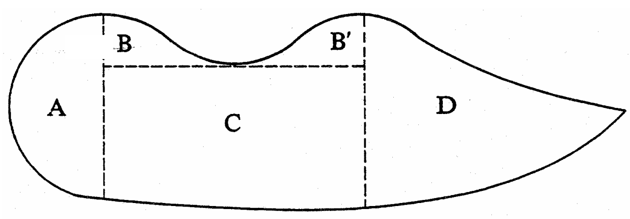
recycled into undesirable types of algal growth. Specific application
techniques are available for different situations and should be used according to the particular type of aquatic weed problem that exists.

# APPLICATION TECHNIQUES

There are four zones in a body of water that may be treated to control aquatic weeds:

- The water surface
- The total water volume
- The bottom one to three feet of water
- The bottom soil surface.

### SURFACE TREATMENT




Generally only a fourth to a third of the surface area of the water should be treated at a time. This helps protect fish from a possible shortage of oxygen. Surface acreage of a rectangular body of water equals length in feet times width in feet divided by 43,560. For areas of unusual shape, divide the pond into recognizable shapes, calculate the area for each, and total it up.

A = semicircle — B, B', D = triangles

Area = $\frac{3.14 \times \text{radius2}}{2}$ — Area = ½ x base x height

C = rectangle area

**Area = length x width**

Liquid formulations are almost always recommended for floating and emergent weeds. These weeds require surface applications with the spray mixture applied directly to the plants.

Use the following formula when making spray solution for a particular number of pounds per acre of acid equivalent (or active ingredient) using liquid herbicide:

Pints needed per 100 gallons of solution

$$= \frac{\text{wanted lb. acid equiv. (or act. ingr.) per acre x 834}}{\text{gal. spray per acre x lb. acid equiv. (or act ingr.) in 1 gal.}}$$

(100 gallons of water weigh about 834 pounds)

Example: If a 2,4-D formulation containing four pounds acid equivalent per gallon is to be applied at five pounds acid equivalent in 120 gallons of solution per acre, the pints needed per 100 gallons of solution are:

$$\frac{5 \times 834}{120 \times 4} = 8.7 \text{ pints}$$

When using solid (dry) herbicide:

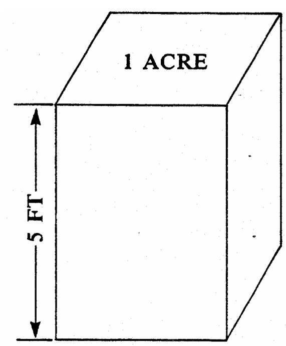
Pounds needed per 100 gallons of solution =

$$\frac{\text{wanted lb. acid equiv. (or act. ingr.) per acre x 100}}{\text{gal. spray per acre x \% acid equiv. (or act. ingr.)}}$$

### TOTAL WATER VOLUME TREATMENT

The whole body of water (from the surface to the bottom) is treated. You can also treat one-fourth to one-third of the total water volume (base on surface area) at a time. Calculate the volume of the body of water and add chemical to obtain the required dilution in the water.

The chemical can be metered or injected into the water from booms trailing behind the boat or from a boat bailer tied into a tank of chemicals. It can also be applied as a spray over the water surface.




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

If the toxicity level of a certain chemical for a particular aquatic weed is two ppm of active ingredient, for example, the chemical should be applied at a ratio of two parts of active ingredient 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.

For average depth in smaller lakes and ponds, divide the maximum depth by two. In larger bodies of water, areas of similar depth should be marked and treated as a unit. Then change application rate accordingly for other depths.

An acre-foot of water weighs 2.7 million pounds. If one dissolves 2.7 pounds of any material in one acre-foot of water, there will be a concentration of one ppm by weight (ppmw).

1 acre = 43,560 square feet

1 acre-foot = l acre of water 1 foot deep = 43,560 cubic feet

l cubic foot of water = 62.4 pounds

1 acre-foot = 2.7 lbs. chemical (active ingredient) per acre-foot of water.

Use the following formula to determine the material needed to obtain a desired ppm concentration: 2.7 x ppm wanted x acre-feet = lbs. required.

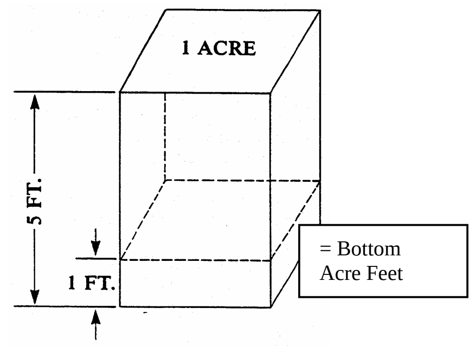
Example:
Assume one wants to treat a pond containing ten acre-feet. The concentration of active ingredient required is 1.5 ppm. Using the formula:

2.7 x 1.5 x 10 = 40.5 lbs. of active ingredient

### BOTTOM-LAYER TREATMENT

Treating the deepest one to three feet of water is especially useful in deep lakes where it's impractical to treat the entire volume of water. Such treatments are generally made by attaching several flexible hoses at three- to five-foot intervals on a rigid boom. Each hose is usually equipped with some type of nozzle at the end. They 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 one to three feet of water.

This technique of application works well in lake or static- water conditions that have sandy, firm bottoms, and it's much cheaper and safer than treating the entire water column. It isn't recommended for flowing water conditions or where water usage leads to turbulent water, or in areas where mud is deep. It is recommended especially where chemicals toxic to fish are used. By applying the material to the bottom foot, upper waters where fish can escape the effects of the chemical and decaying vegetation are left untreated.




### BOTTOM SOIL TREATMENT

Herbicide applications may be made to the bottom soil of a drained pond, lake or channel.

## APPLICATION EQUIPMENT

Applications of liquid formulations are usually made with sprayers, which come in a variety of sizes and types. To treat small areas, a compressed-air sprayer with a hand-operated pump or sprinkler can may be all that is needed. Higher-quality compressed-air sprayers with $CO_2$ gas for constant pressure are available but are more expensive.

For larger areas, a boat-mounted pump-and-tank rig with one or several booms available would be used. If submergents are being treated, it's best to place the nozzle(s) under the surface of the water. If emergent plants are being sprayed, apply only under still wind conditions and with the necessary protective clothing and equipment as indicated on the label.

Application of granules and slow-release pellets isn't as troublesome because the treatment is usually on an area basis. The chemical is released slowly from the inert granules in the treatment area only; less chemical is needed to get the job done, and toxicity effects to applicators and non-target organisms are decreased. Application can be made in the early spring with a cyclone spreader or even by hand (wearing gloves) from a boat. The granules sink to the bottom, where the chemical is slowly released in the relatively small volume of water where the new shoots are beginning to grow.

## WEED CONTROL IN STATIC WATER

Static water is water in ponds, lakes or reservoirs that has little or no inflow and outflow. Even totally enclosed bodies of water often have appreciable water movement because of wind and other factors. Weeds commonly grow in static water up to 12 feet deep. In very clear water, however, weeds sometimes grow in water 20 feet or more in depth.

Floating and immersed weeds are usually controlled with sprayable formulations. These weeds are killed by direct foliage applications of the spray mixture:

- By aircraft.
- With ground equipment, operated from the bank if the pond is small or if weeds occur only around the margins.
- From a boat, using various types of booms or spray guns.

Submersed weeds and algae can be controlled with either sprays or granules. Sprayable formulations are most often applied as water-surface treatments, especially 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.

In all instances, control of weeds depends on good dispersion of the chemical in the water. Sprayable herbicides sometimes are used for bottom-soil treatments. Some sprayable herbicides may be applied from aircraft at low volumes of five to ten gallons per acre.

Both surface and injection treatments made by boat or ground equipment are more effective and are easier when larger 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 solution and the need to carry water on board.

Granular formulations are generally used to control algae or submersed weeds, although some are effective on certain immersed weeds. Because granules sink to the soil surface, they perform about the same way 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 weeds are.
- They can be made to provide a long contact time with weeds (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.

## WEED CONTROL IN LARGE IMPOUNDMENTS

Herbicide applications that are successful in smaller bodies of water often perform poorly in large impoundments. These impoundments often have much water movement caused by thermal currents or the wind. Weed 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 treatments in deep water.
- Using granular formulations when possible.
- Selecting herbicides that are absorbed quickly by the weeds.

## WEED CONTROL IN FLOWING WATER

Aquatic weeds in flowing water are the hardest to control. Because the water is moving from one location to another, the possible hazards of herbicide use are greater.

Herbicides are sometimes used to control weeds in natural streams. Control of aquatic weeds in man-made water distribution and drainage systems is more common. Most of these carry irrigation water. Don't irrigate crops with treated water unless permitted by the herbicide label. Some systems also carry domestic, industrial and recreational water. As the number of water uses increases, more restrictions and precautions are required.

Floating and immersed weeds, when in flowing water, require the same herbicides and treatment techniques as they do in static water. Precautions and restrictions are the same as those for control of submersed weeds in flowing water.

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

The greater the cross-sectional area 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, especially when the weed infestation covers only a small area or the herbicides are effective for only a short distance downstream.

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

## WEED CONTROL IN LIMITED-FLOW WATERWAYS

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

## CONSIDERATIONS BEFORE CHOOSING A HERBICIDE

Use of herbicides to control aquatic vegetation is complicated by water entering and leaving the impoundment because of springs, streams, runoff, overflow pipes, and emergency spillways. Fresh water entering the impoundment may dilute the chemical to a point where it won't be effective, while overflow of treated water may kill plants in non-target areas or pollute streams and other ponds or lakes. Ponds with a high influx and outflux of water should be treated only with copper sulfate, which poses little environmental threat.

Projected use of treated water is another important consideration influencing chemical selection. Restrictions on the use of treated water for human and livestock consumption; swimming; irrigation of turf, food and forage crops; and also the consumption of fish from treated water are specific for the herbicide used.

Herbicide control may be longer lasting than other methods, but a weed-free condition should not be expected the following year. Retreatment the same year may be necessary for hard-to-control aquatic plants such as duckweed, and brittle and slender naiads. Also, herbicide application may result in the removal of predominant species, releasing other tolerant species from competition that consequently flourish in the open environment. The quality of the water can have an effect on the herbicidal activity of the chemical. If the water temperature is too low, the chemical may stop working. Suspended matter in the water may absorb the chemical and render it inactive. The alkalinity of the water can be a principal factor. High- bicarbonate alkalinity affects most chemicals. In copper-sulfate treatments, the copper ions can react with bicarbonate and carbonate ions in the water to form insoluble complexes that precipitate from solution and reduce the amount of biologically active copper. Diquat and other chemicals are subject to hydrolysis in alkaline waters, and this reduces their effectiveness. (Diquat also quits working at low temperatures and is readily absorbed by soil particles in muddy or murky water.) Emulsifiers that ionize in solution are affected by alkaline water. When treating alkaline water with Xylene, a blend of non-ionic-anionic emulsifiers should be used, because they won't react with mineral salts in hard waters since they don't ionize in solution.

One interesting aspect of water alkalinity is that fish can tolerate higher concentrations of copper ion in alkaline waters than they can in acid waters. For reasons not clearly understood, higher alkalinity in treated waters reduces toxicity of the copper ion to fish.

Aquatic weeds are not affected by herbicides when water is cold and weed growth is slow. Treatment should not be made until the water temperature has risen to at least 65 degrees F. Treatment for algae control should be made before vegetative growth is great, when about five to ten percent of the water surface is covered with algae. Treat immersed and submersed plants when they are growing rapidly up to early bud stage. Optimum application dates for most immersed and submersed plants and algae lie between May 1 and July 1, depending on the year.

Cattails should be sprayed when they are about three feet tall and before they begin to form heads.

Bodies of water should be treated before weed growth is excessive for another important reason. Many fish-kills following chemical treatment have resulted from the depletion of water oxygen by the massive decay of dying vegetation. If the weed infestation is severe and covers much of the pond, treat only one-fourth to one-half of the vegetation or pond area at a time, and wait ten to 14 days before continuing treatment. Applying one-third of the total chemical to be used over one-third of the pond area followed by a second and third treatment at ten- to 14-day intervals over the rest of the pond is a good application program. In the spring, vegetation is often limited to the edges of the lake, and sufficient open water is available so treatment of all vegetation should not result in a fish-kill.

The sudden elimination of a dense growth of vegetation from an aquatic environment very 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 larger weed-plants in a pond or lake, a greenish or yellowish-brown turbid condition may be noticed. This condition is due to the presence of billions of microscopic algae cells that have used the released nutrients for growth and reproduction. The blue-green algae are often responsible for a green, pea-soup appearance, whereas other algae and various one-celled organisms cause the yellowish-brown colors in water. When conditions are optimal for development of algae, a dense bloom can develop quickly. These dense blooms of plankton algae cut down light penetration and thereby inhibit the reestablishment of those species killed in treatment, but the algae may turn out to be more objectionable than the original weed infestation.

Some aquatic vegetation is necessary for the reproduction and survival of certain fish (pickerel, golden shiners, and others). It follows that where desirable fish are dependent on aquatic vegetation, portions of water should be left untreated.

## ENVIRONMENTAL CONSIDERATIONS AND RESTRICTIONS

Incorrect application of herbicides in water may involve serious hazards to man, wildlife, fish, and desirable plant life. Consequently, you must:

- Select the correct herbicide for a specific aquatic site and particular weed infestation.
- Apply it correctly at recommended rates.
- Observe the restrictions on use of the treated water.
- Be aware of the adverse effects of incorrect use.
- Obtain permission, if necessary, from appropriate state or federal agencies.

The control of aquatic vegetation presents special problems, because the water often has multiple uses, and herbicides won't 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 use to consider before applying herbicides include:

Types of water use 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 at the

- 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 weed control. Notable exceptions are Grade B xylene, acrolein, and some solvents and emulsifiers in certain formulations of normally non-toxic herbicides. These should not be used in fisheries or where the water treated with these herbicides could enter fishery waters.

It is possible to use these herbicides for treatment of small plots, or for treatment of weed-infested marginal areas, with little hazard to fish. If given an avenue of escape, fish will leave areas where the herbicide is used.

Herbicides are rapidly accumulated by fish. Most appear to concentrate in various organs and tissues of the body, with least accumulation in muscle tissue. The rate at which pesticide levels in fish decline varies according to the chemical. The pesticide label will state the time which must pass before fish are free of the chemical and fit for human consumption. Pesticides are obviously lethal to fish when used as directed.

When considering the toxicity of pesticides to fish, it should again be pointed out that the kind of chemical, species of fish, and nature of the water all play a role in the ultimate reaction of the fish to a toxicant. The fry are at the most susceptible stage of the life of a fish. This is significant, since it’s usually recommended that aquatic herbicides be applied during the spring, when recently hatched fish are plentiful.

The acute toxicity of herbicides to fish and fish eggs is usually small when used at the recommended dosage. However, each herbicide should be evaluated on an individual basis, depending on the treatment levels, species of fish, and chemical characteristic of the water. For example, copper sulphate is highly toxic to trout at very low concentrations, much lower than the level recommended to treat algae. The toxicity of copper sulphate is also greatly affected by water hardness, being more toxic as hardness decreases.

Fish can feed on a number of different food organisms but generally restrict their feeding to a preferred group. However, most fishes will take whatever food is available in greatest quantities. Because of their adaptability to varying conditions and ability to change foods within limits, a temporary alteration in the food chain may not have an adverse effect. If the number of food organisms is reduced by the action of a pesticide when food is scarce, fish may exhibit reduced growth rates and fish populations may suffer.

In summary, most herbicides are non-toxic to fishes when used at the recommended rates and properly applied. Improper application rates, incorrect formulation, or faulty application of herbicides may result in a fish-kill or may seriously alter the food chain, slowing the growth rate.

## IRRIGATION DITCH-BANK WEED CONTROL

Extreme care should be taken when choosing a herbicide for the control of terrestrial weeds on the inside of ditch banks. It is essential to determine what crops the water irrigates. Irrigation ditch banks should not be treated if the water is used to irrigate crops susceptible to the herbicide.

The application of excessive amounts of non-selective weed oils (petroleum oils) beyond that necessary to cover target weeds should be avoided. If the dead vegetation remaining after treatment with weed oil is to be burned off, the necessary permits must be obtained from local governments beforehand.

Foliar herbicide sprays should be applied with low-pressure (ten to 40 psi), and spraying should be done when the air is fairly calm (no more than seven miles per hours) to minimize drift. No matter what type of sprayer, boom or handgun is used, spraying onto an irrigation-water surface should be held to an absolute minimum, and no cross-stream spraying to opposite banks should be done. The spray should be applied while traveling upstream to avoid accidental concentration of too much herbicide in the water.

A Rope-wick application of glyphosate (Roundup) may be made to control taller-growing species while allowing the growth of desirable grasses, such as red fescue or redtop, to stabilize banks. The principle of rope-wick application is to wipe the herbicide onto taller-growing weeds. This would be a preferred application technique where the water is used to irrigate susceptible crops.

Rope-wick applicators usually consist of a supporting slotted, horizontal boom through which a rope or cloth wick about one-half inch in diameter has been inserted. The wick is connected to a feed manifold that feeds the chemical into the wick along its entire length. The boom can be set at the proper height to contact the taller weeds and miss the desirable lower growth.

Clumps of weeds on a ditch bank may make it necessary to make two passes along the ditch bank in opposite directions. If only one pass were made, only one side of the clump would contact the herbicide.

Rope-wick application can be an economical and selective application method, where it can be used. For treatment of the densest ditch-bank weeds, rope-wick application may not be as economical as more conventional methods. Faster-feeding ropes may improve the treatment of plants in dense stands. Besides the flow resistance in the rope-wicks, the lack of consistent success in some cases has been attributed to hot temperatures and low humidity in the treatment areas.

## CONTROL OF VERTEBRATES

**Fish --** Programs to control fish populations usually are initiated for one of two reasons: (1) to remove undesirable species or (2) to attempt to establish a desirable balance of game fish. The control techniques used include fishing regulations, mechanical control, biological control, chemical control, and various combinations of techniques. Control of fish is regulated by federal and state laws; therefore, the Utah Division of Wildlife Resources and U.S. Fish and Wildlife Services should be contacted before control programs are initiated.

**Types of Problems --** The introduction of various species of fish into new environments (such as, common carp and grass carp) is an old practice. Quite often, there is an adverse impact on the environment or on more desirable native species already present. Under such circumstances, the offending species should be eliminated, or at least controlled.

Control is also desirable when one or more species overpopulate an aquatic environment. Such over-populations may outstrip their food supply, leading to large numbers of small, stunted fish, or they may interfere with the reproduction and survival of other species. Where predator (game) fish populations are not large enough to control panfish or forage fish populations (such as, bullheads, perch, suckers and sunfish), or if these fish are not harvested, they may reproduce to the point of being overpopulated. In such situations, control is essential to maintain desirable population balance and to obtain optimum production from the system.

### TYPES OF CONTROL

**Regulations --** The goals of fishing regulations include limiting the total harvest of fish, protecting spawning fish, and distributing the total catch among more people. Techniques employed include size and creel limits, restricted seasons, and fishing-gear restrictions. If predator (game) fish are harvested in too great numbers or at too small a size, panfish or forage fish may overpopulate. Carefully planned and managed regulations on the size and numbers of game fish that can be harvested from a given body of water can maintain more and larger predators, thus providing a better-balanced fish population and also better fishing.

**Environmental Manipulation --** Undesirable species and unbalanced populations can be removed from drainable ponds, lakes and reservoirs by simply draining the body of water. After refilling, desirable species can be stocked in appropriate numbers and combinations. Water levels can be increased to provide better spawning areas for predators such as northern pike. Carp can sometimes be controlled by dropping water levels rapidly after they have spawned in shallow areas. A partial drawdown is sometimes used to force small forage fish to leave the protection of shallow, weedy areas and, thus, become vulnerable to predators. Removal of the vegetation without a drawdown sometimes produces a similar effect.

**Mechanical Control --** Mechanical methods are often effective in reducing the numbers of fish in overcrowded situations. Mechanical barriers may also be used to reduce the movement of undesirable species into new environments or to control normal migrations. Mechanical devices include seines, nets and traps, as well as weirs and other barriers. Mechanical devices have the advantage of selectivity, since desirable species or size classes can be returned to the water, while undesirable fish can be removed.

Mechanical devices are seldom effective in completely eliminating undesirable species. Some individuals of the undesirable species invariably escape mechanical devices, grow and reproduce, thereby maintaining their presence in the particular body of water. If complete eradication rather than partial control is desired, draining or chemical toxicants will be more effective.

**Chemical Control** – Un-drainable ponds and lakes sometimes require the use of chemicals to kill all fish present before restocking with desired species or combinations of species. Chemicals may also be used to eliminate fish from isolated pockets, backwater areas, or inflowing streams where drainage is the principal method of control.

A wide variety of chemicals have been used to control fish populations. Insecticides that have been used include copper sulfate, anhydrous ammonia, sodium cyanide, cresol, sodium hydrozide, rotenone, antimycin, squozin, Bayluscide (Bayer 73), and TFM (3-trifluoromethyl- 4-nitrophenol). At present, only antimycin, rotenone, Bayluscide and TFM are registered for use as fish poisons, and Bayluscide and TFM can be used only by federal or selected state personnel. No chemical toxicants can be used if the fish are to be used for human consumption. Rotenone is normally the toxicant of choice when chemicals are used to control fish populations.

When chemicals are used, it's desirable to lower the level of the pond or lake if at all possible. This will reduce the volume of water to be treated and also the possibility of an outflow of the toxicant into the downstream area. As the pond or lake refills, the fish toxicant will be diluted. The combination of dilution and decomposition should make the toxicant harmless by the time the pond or lake has filled. It should be remembered, however, which water temperature and quality influence the decomposition rate of the chemicals used as fish toxicants, and that any downstream fish-kills are the legal responsibility of those who applied the chemical. If outflow can't be controlled, chemical neutralization may be required. Rotenone can be neutralized by potassium permanganate.

The volume of water to be treated must be accurately calculated. Procedures described in the section on aquatic plant control may be used. If areas deeper than 25 feet are to be treated, it may be necessary to use a weighted hose to pump the toxicant directly to the deep area. The depth to which winds mix the surface waters determines whether or not pumping to deep areas is needed. In all cases, complete mixing of the toxicant throughout the body of water is essential if a total kill is to be accomplished.

In some situations involving overpopulations of forage fish or panfish, it's possible to treat selected areas only and still accomplish sufficient control to establish a desirable balance of forage fish and game fish. When partial treatments are used, it's important to start application at the point farthest from shore and seal off the area to be treated with a curtain of the fish toxicant. For example, if a cove is to be treated, seal off the mouth of the cove and then work toward shore. Escape of fish into deeper, untreated water is minimized in this way.

When liquid fish toxicants are used, the chemicals must be diluted sufficiently to assure complete and uniform coverage of the area. Various types of sprayers can be used. Powdered toxicants are normally mixed with water to form a paste, which is placed in a cloth sack and towed behind a boat until even coverage is achieved. Backpack sprayers can be used for liquids if the treatment area is remote or inaccessible by boat. In all cases, use only enough toxicant to kill the target species. An overdose isn't only inefficient and uneconomical, but it may lead to unforeseen side effects.

**Other Vertebrates** -- Rodents, including beaver, nutria, muskrats and rats, are of the most concern. They can structurally weaken earthen dikes, levees and dams by burrowing. This can cause water loss or flooding and increases the erosion of banks. They also can increase suspended sediment in water, clog culverts or water-pipe intakes with vegetation cut during feeding or nest-building activities, and block stream flow.

Non-chemical control methods include modifying or controlling habitat, such as controlling weeds to reduce cover and food supplies; installing dike protectors or barriers; trapping; and shooting.

Chemical control methods include the use of repellents, fumigants and baits.

## ENVIRONMENTAL EFFECTS

Pesticides may affect aquatic life immediately, on a long-term basis, or indirectly. As chemicals are applied, they may be directly toxic to aquatic plants or animals. By accumulating in the environment and being passed up the food chain, pesticides may also be important from an ecological and human-health standpoint.

Pesticides are most effectively used when they act only on the target pest and don't affect non-target organisms. Knowledge of the potential effect on plants, fish, birds, insects, and other organisms in aquatic environments is essential for safe and effective aquatic pest control. In addition, a knowledge of the secondary effects that can be caused by improper application, incorrect formulations, and incorrect application rates of pesticides is necessary.

Herbicides and pesticides have a direct effect on aquatic life but don't cause environmental catastrophes, when they are used properly. However, they may cause subtle changes and indirectly modify an aquatic ecosystem. Indirect effects are just as important as the direct effects in many cases.

Aquatic plants provide cover, protection, attachment substrate and food for many aquatic animals. Plants contribute to and affect the chemical and physical nature of the aquatic ecosystem. Any reduction in quantity and quality of aquatic plants would affect the chemical and physical environment and thus the animal community structure. These changes are indirect, in that they don't involve the pesticide itself by acute or chronic toxicity, accumulation or irritation.

Fish, mammals, amphibians and reptiles living and feeding in water may be directly affected by herbicides and pesticides. Treatment of an aquatic ecosystem with herbicides and pesticides won't cause serious problems to these animals if the pesticides are used at the recommended rates and applied properly. When rates higher than those recommended are used or the pesticides are improperly applied, toxicity levels may reach a point that can be harmful to vertebrates. Fish killed by pesticides are not harmful to other forms of wildlife.

Most herbicides and fish toxicants or pesticides are not harmful to aquatic invertebrates when used at the recommended dosages. When toxic effects are found, they are usually short-lived. The high reproductive potential of most invertebrates allow population levels to return to normal relatively rapidly. However, improper application rates, incorrect formulation, or faulty application of herbicides or pesticides may reduce invertebrate populations to extremely low levels or eliminate them entirely.

The application of pesticides will also have a direct effect on many animals, including man. Almost all herbicides and pesticides used in aquatic resource management will be a potential hazard to man for a period of time. Treated water may be unsafe for swimming or irrigation, and the fish may be unfit for human consumption. Man's activities or use of water must be restricted for the period of time when dangerous conditions exist. This period of time is printed on the pesticide label. Improper use of herbicides and pesticides may cause serious problems. If application rates higher than those recommended are used, the danger from the chemical may exceed the time limit printed on the label.

In general, herbicides and pesticides are not a contamination problem in the environment, nor do they accumulate in the food chain to any great degree, as do some insecticides.

## CHEMICAL CONTROL FAILURE

In some situations, a pesticide application won't control the target pest. Some common reasons for pesticide failure are:

1. Not reading the label.
2. Misidentification of pest species.
3. Rate miscalculation.
4. Adverse weather -- rainstorms or high winds that dilute the chemical.
5. Water conditions -- high turbidity, low water temperature, and high alkalinity can chemically or physically interfere with pesticide action.
6. Weed regrowth or appearance of new pest.
7. Improper timing of application.
8. Rapid water exchange, causing chemical dilution. If used correctly in accordance with label restrictions, aquatic pesticides pose little threat to the environment or the public. However, these materials may become toxic to humans, livestock, and non-target organisms if applied at excessive rates.

# WORKER PROTECTION STANDARDS

The U.S. Environmental Protection Agency's Worker Protection Standard (WPS), as revised in 1992, must be complied with when pesticides are used on agricultural establishments, including farms, forests, nurseries, and greenhouses, for the commercial or research production of agricultural plants. The WPS requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides. Persons who must comply with these instructions include owners or operators of agricultural establishments and owners or operators of commercial businesses that are hired to apply pesticides on the agricultural establishment or to perform crop-advising tasks on such establishments. Family members who work on an agricultural or commercial pesticide establishment are considered employees in some situations.

WPS requirements for employers include:

- **Displaying information** about pesticide safety, emergency procedures, and recent pesticide applications on agricultural sites.
- **Training** workers and handlers about pesticide safety.
- Helping employees get **medical assistance** in case of a pesticide related emergency.
- Providing **decontamination sites** to wash pesticide residues off hands and body.
- Compliance with **restricted entry intervals** (REI)– the time after a pesticide application when workers may not enter the area.
- **Notifying** workers through posted and/or oral warnings about areas where pesticide applications are taking place and areas where REI are in effect.
- Allowing only **trained and equipped workers** to be present during a pesticide application.
- Providing **personal protective equipment** (PPE) for pesticide handlers and also for workers who enter pesticide treated areas before expiration of the REI.
- **Protecting pesticide handlers** by giving them safety instructions about the correct use of pesticide application equipment and PPE and monitoring workers and handlers in hazardous situations.

One of the provisions of the WPS is the requirement that employers provide handlers and workers with ample water, soap, and single use towels for washing and decontamination from pesticides and that emergency transportation be made available in the event of a pesticide poisoning or injury. The WPS also establishes REI and the requirements for PPE. PPE requirements are specified for all pesticides used on farms and in forests, greenhouses, and nurseries. Some pesticide products already carried REI and PPE directions. This rule raised the level of protection and requirements for all pesticide products.

Other major provisions require that employers inform workers and handlers about pesticide hazards through safety training. Handlers must have easy access to pesticide label safety information and a listing of treatment sites must be centrally located at the agricultural facility. Handlers are prohibited from applying a pesticide in a way that could expose workers or other people.

References: ***The Worker Protection Standard for Agricultural Pesticides–How to Comply: What Employers Need to Know***. Web site: www.usda.gov/oce/oce/labor-affairs/wpspage.htm

# PROTECTING GROUNDWATER AND ENDANGERED SPECIES

## INTRODUCTION

Federal and state efforts to protect groundwater and endangered species have resulted in special requirements and restrictions for pesticide handlers and applicators. Pesticides that are incorrectly or accidentally released into the environment can pose a threat to groundwater and endangered species. Whether pesticides are applied indoors or outdoors, in an urban area or in a rural area, the endangered species and groundwater must be protected and state and federal agencies rigidly enforce this requirement.

The need for special action by the pesticide handler/applicator depends on site location. Groundwater contamination is of special concern in release sites where groundwater is close to the surface or where the soil type or the geology allows contaminants to reach groundwater easily. In the case of endangered species, special action is normally required in locations where the species currently live or in locations where species are being reintroduced. The product labeling is the best source to determine if pesticide use is subject to groundwater or endangered species limitations.

The U.S. Environmental Protection Agency (EPA) establishes the specific limitations or instructions for pesticide users in locations where groundwater or endangered species are most at risk. These limitations and instructions may be too detailed for inclusion in pesticide labeling. In such cases the labeling will direct the applicator or handler to another source for instructions and restrictions. The legal responsibility for following instructions that are distributed separately is the same as it is for instructions that appear on the pesticide labeling.

### PROTECTING GROUNDWATER

Groundwater is water located beneath the earth's surface. Many people think that groundwater occurs in vast underground lakes, rivers, or streams. Usually, however, it is located in rock and soil. It moves very slowly through irregular spaces within otherwise solid rock or seeps between particles of sand, clay, and gravel. An exception is in limestone areas, where groundwater may flow through large underground channels or caverns. Surface water may move several feet in a second or a minute. Groundwater may move only a few feet in a month or a year. If the groundwater is capable of providing significant quantities of water to a well or spring, it is called an aquifer. Pesticide contamination of aquifers is very troubling, because these are sources of drinking, washing, and irrigation water.

Utah has implemented a comprehensive and coordinated approach to protect groundwater from pesticide contamination. Formulation of the Utah Groundwater and Pesticide State Management Plan is a cooperative effort between federal, state, private agencies, producers, and user groups. It provides a basis for continuing future efforts to protect groundwater from contamination whenever possible. Furthermore, this plan provides agencies with direction for management policies, regulations, enforcement, and implementation of groundwater strategies.

Utah recognizes that the responsible and wise use of pesticides can have a positive economic impact, yield a higher quality of life, enhance outdoor activities, and give relief from annoying pests. The EPA has authorized the Utah Department of Agriculture and Food (UDAF) to enforce the protection of groundwater from pesticides.

The UDAF, in concert with cooperating agencies and entities, demands strict compliance with all pesticide labels, handling procedures, and usage to protect groundwater in the state.

Prevention of groundwater contamination is important, because once the water is polluted, it is very difficult and costly to correct the damage and in some instances impossible. City and urban areas contribute to pollution because water runoff can contain pesticides. Shallow aquifers or water tables are more susceptible to contamination than deeper aquifers or water tables. Sandy soils allow more pollution to move than clay or organic soils, because clays and organic matter adsorb many of the contaminants. For more information about what groundwater is and where it comes from, read the study manual Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, establish a policy for determining the acceptability of a pesticide use or the continuation of that use, according to a risk/benefit assessment. As long as benefits outweigh adverse effects, the EPA can continue to register the pesticide. Although the intent of a pesticide application is to apply the pesticide to the target or pest, part of the pesticide will fall on the area around the target or pest. Rain or irrigation water then can pick up the part that is not degraded or broken down and carry it to the groundwater via leaching.

There are many factors that influence the amount of pesticide contamination that can get into groundwater. The major factors are the soil type, soil moisture, persistence in soil, placement of the pesticide, frequency of application, pesticide concentration and formulation, pesticide water solubility, and precipitation. Each of these factors will influence the amount of pesticide that can penetrate the soil surface, leave the root zone, and percolate into groundwater.

Although some pesticides may have a high adsorption quality, when they are applied to sandy soil, they may still migrate to the water table because there are few clay particles or little organic matter to bind them. The management and use of pesticides is up to the individual applicator and/or landowner as to whether safe practices are used. Groundwater is a very valuable resource and it must be protected from pesticide contamination.

## PROTECTING ENDANGERED SPECIES

The Federal Endangered Species Act lists the three classifications as endangered, threatened, and experimental. Endangered has the highest level of protection. The phrase “endangered species” is used when referring to these classifications. This Act was passed by Congress to protect certain plants and wildlife that are in danger of becoming extinct. A portion of this Act requires EPA to ensure that these species are protected from pesticides.

EPA’s goal is to remove or reduce the threat to endangered species that pesticides pose. Achieving this goal is a portion of the larger continuing effort to protect species at risk. Normally these restrictions apply to the habitat or range currently occupied by the species at risk. Occasionally the restrictions apply where endangered species are being reintroduced into a habitat previously occupied.

Habitats are the areas of land, water, and air space that an endangered species needs for survival. Such areas include breeding sites, sources of food, cover, and shelter, and the surrounding territory that provides space for normal population growth and behavior.

Utah's endangered species plan is a cooperative effort between federal, state, private agencies, producers, and user groups. This plan provides agency direction for regulations, enforcement, management policies, and implementation of threatened and endangered species protection strategies.

EPA launched a major project known as Endangered Species Labeling (ESL). The goal is to remove or reduce the threat to endangered species from pesticides. EPA has the responsibility to protect wildlife and the environment against hazards posed by pesticides. The ESL program is administered by the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of Interior. The FWS reports to EPA concerning endangered species. EPA and FWS work cooperatively to ensure that there is consistency in the pesticide restriction information provided to agencies and pesticide users.

The UDAF acts under the direction and authority of EPA to carry out the ESL project as it relates to the use of pesticides in Utah. Utah's web sites with maps designating the habitat boundaries and listings of endangered plants and wildlife is: www.utahcdc.usu.edu

# CALIBRATION INFORMATION

**Conversion:**

## Units

**One acre = 43,560 square feet** | **Example: ½ acre = 21,780 square feet**

| | |
|---|---|
| One mile = 5,280 feet | Example: ¼ mile = 1320 feet |
| One gallon = 128 fluid ounces | Example: ½ gallon = 64 fluid ounces |
| One quart = 2 pints = 4 cups = 32 fluid ounces | Example: 2 quarts = 64 fluid ounces |
| One pint = 2 cups = 16 fluid ounces | Example: ½ pint = 1 cup = 8 fluid ounces |
| One tablespoon = 3 teaspoons = 0.5 fluid ounces | Example: 2 tablespoons = 1 fluid ounce |
| One pound = 16 ounces | Example: ¼ pound = 4 ounces |
| One gallon = 231 cubic inches | Example: 2 gallons = 462 cubic inches |

## Weights

1 ounce = 28.35 grams
16 ounces = 1 pound = 453.59 grams
1 gallon water = 8.34 pounds = 3.785 liters = 3.78 kilograms

## Liquid Measures

1 fluid ounce = 2 tablespoons = 29.573 milliliters
16 fluid ounces = 1 pint = 0.473 liters
2 pints = 1 quart = 0.946 liters
8 pints = 4 quarts = 1 gallon = 3.785 liters

## Lengths

1 foot = 30.48 centimeters
3 feet = 1 yard = 0.9144 meters
16 1/2 feet = 1 rod = 5.029 meters
5280 feet = 320 rods = 1 mile = 1.6 kilometers

## Areas

1 square foot = 929.03 square centimeters
9 square feet = 1 square yard = 0.836 square meters
43560 square feet = 160 square rods = 1 acre = 0.405 hectares

## Speeds

1.466 feet per second = 88 feet per minute = 1 mph = 1.6 kilometers per hour (kph)

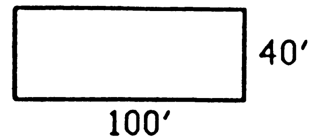
### Volumes

27 cubic feet = 1 cubic yard = 0.765 cubic meters
1 cubic foot = 7.5 gallons = 28.317 cubic decimeters

## **Area and Volume Calculations:**

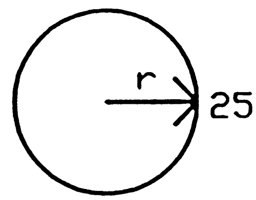
### Area of Rectangular or Square Shapes

The area of a rectangle is found by multiplying the length (L) times the width (W).
(Length) x (Width) = Area
Example: (100 feet) x (40 feet) = 4000 square feet



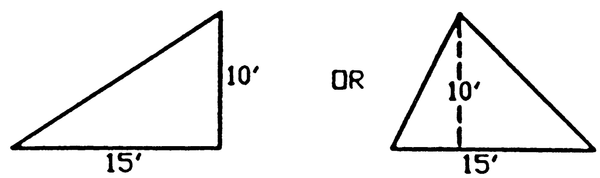

### Area of Circles

The area of a circle is the radius (radius = one-half the diameter), times the radius, times 3.14.
(Radius) x (radius) x (3.14) = Area
Example: (25 feet) x (25 feet) x (3.14) = 1962.5 square feet



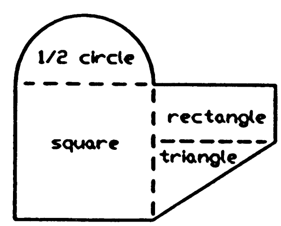

### Area of Triangular Shapes

To find the area of a triangle, multiply ½ times the width of the triangle's base, times the height of the triangle.
(½) x (base width) x (height) = Area
Example: (½) x (15 feet) x (10 feet) = 75 square feet

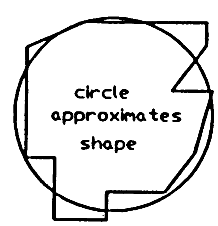



### Area of Irregular Shapes

Irregularly shaped sites can often be reduced to a combination of rectangles, circles, and triangles. Calculate the area of each shape and add the values together to obtain the total area.
Example: Calculate the area of the rectangle, triangle,
square and one-half of a circle.



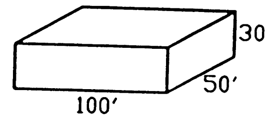

Another method is to convert the site into a circle. From a center point, measure the distance to the edge of the area in 10 or more increments. Average these measurements to find the radius, then calculate the area using the formula for a circle.
Example: Approximate the area by calculating
the area of a similarly sized circle.



## Volume of Cube and Box Shapes

The volume of a cube or box is found by multiplying the length, times the width, times the height.
(Length) x (Width) x (Height) = Volume

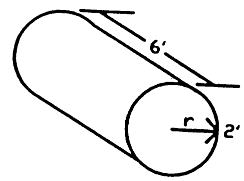
Example: (100 feet) x (50 feet) x (30 feet) = 150,000 cubic feet




## Volume of Cylindrical Shapes

The volume of a cylinder is found by calculating the area of the round end (see formula for circle) and multiplying this area times the length or height.

Example: (radius) x (radius) x (3.14) = Area of Circle
(Area of Circle) x (Length) = Volume of Cylinder
(2 feet) x (2 feet) x (3.14) x (6 feet) = 75.36 cubic feet




## Sprayer Calibration Formulas:

**To Calculate Travel Speed in Miles Per Hour**

The travel speed of a sprayer is determined by measuring the time (seconds) required to travel a know distance (such as 200 feet). Insert the values in the following formula to determine the miles per hour.

$$\frac{\text{Distance in Feet} \times 60}{\text{Time in Seconds} \times 88} = \text{Miles Per Hour}$$

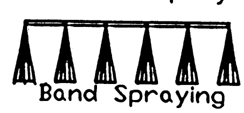
Example: $$\frac{(200 \text{ feet}) \times (60)}{(30 \text{ seconds}) \times (88)} = \frac{12{,}000}{2640} = 4.55 \text{ mph}$$

**To Calculate the Gallons Per Minute Applied During Broadcast Spraying**

The application rate in gallons per minute (GPM) for each nozzle is calculated by multiplying the gallons per acre (GPA), times the miles per hour (MPH), times the nozzle spacing in inches (W); then dividing the answer by 5940. For small adjustments in GPM sprayed, operating pressure is changed. For large adjustments in GPM sprayed, travel speed (miles per hour) is changed or nozzle size is changed.

$$\frac{\text{GPA} \times \text{MPH} \times \text{W}}{5940} = \text{GPM}$$


Example: $$\frac{(12 \text{ GPA}) \times (4.5 \text{ MPH}) \times (24\text{''})}{5940} = \frac{1296}{5940} = 0.22 \text{ GPM}$$




**To Calculate the Gallons Per Minute Applied During Band Spraying**

Broadcast spraying applies chemicals to the entire area. Band spraying reduces the amount of area and chemicals sprayed per acre. To use the above formulas for band sprayer applications, use the band width (measured in inches) rather than nozzle spacing for the “W” value.

## Pesticide Mixing:

### Terminology

The ***active ingredients*** of a pesticide are the chemicals in a formulation that control the target pests. The ***formulation*** is the pesticide product as sold, usually a mixture of concentrated active ingredients and an inert material. Restricted use pesticides are purchased in formulations requiring ***dilution prior to application***. Formulations are diluted with inert substances such as water. The ***percentage of active ingredients*** in a pesticide formulation directly affects dilution and application rates. Given two pesticides, A = 50% active ingredients, B = 100% active ingredients; twice as much pesticide A formulation is required to equal pesticide B formulation.

**To Determine the Total Amount of Pesticide Formulation Required Per Tank**

To calculate the total amount of pesticide formulation needed per spray tank, multiply the recommended dilution, ounces/pints/cups/teaspoons/tablespoons/etc. of pesticide per gallon of liquid, times the total number of gallons to be mixed in the sprayer. A full or partial tank of pesticide spray may be mixed.
(Dilution Per Gallon) x (Number of Gallons Mixed) = Required Amount of Pesticide Formulation
Example: (3 ounces per gallon) x (75 gallons) = 225 ounces
Note: 1 gallon = 128 ounces; through unit conversion 225 ounces = 1.76 gallons

**To Calculate the Amount of Pesticide Formulation Sprayed Per Acre**

The calculate the total amount of pesticide formulation sprayed per acre is determined by multiplying the quantity of formulation (ounces/pounds/pints/cups/teaspoons/tablespoons/etc.) mixed per gallon of water, times the number of gallons sprayed per acre.

(Quantity of Formulation Per Gallon) x (Gallons Sprayed Per Acre) = Formulation Sprayed Per Acre
Example: (1/2 pound per gallon) x (12 gallons per acre) = 6 pounds per acre

**To Calculate the Amount of Active Ingredients Sprayed Per Acre**

The total amount of active ingredients (AI) applied per acre, multiply the amount (pounds, gallons, ounces, etc) of pesticide formulation required per acre, times the percentage of active ingredients in the formulation (100%, 75%, 50%, 25%, etc.), and divide the value by 100.

$$\frac{\text{(Amount of Formulation Required Per Acre) x (Percentage of AI)}}{100} = \text{Active Ingredients Per Acre}$$

Example: $$\frac{\text{(4 pounds formulation sprayed per acre) x (75\% AI)}}{100} = \text{3 pounds of AI sprayed per acre}$$

*Note: 75 % = 0.75*

**To Calculate the Gallons of Pesticide Mixture Sprayed Per Acre**

The total amount of pesticide mixture sprayed per acre is determined by dividing the number of gallons sprayed by the number of acres sprayed.

$$\frac{\text{Gallons Sprayed}}{\text{Acres Sprayed}} = \text{Gallons Sprayed Per Acre}$$

Example: $$\frac{\text{200 Gallons Sprayed}}{\text{10 Acres Sprayed}} = \text{20 gallons of pesticide mixture sprayed per acre}$$

For APPENDIX information

http://wildlife.utah.gov/invasivespecies/aisplan/