Wind-concentrated duckweed presents this unpleasant scene. The picture at left is the same area from a different side two weeks after treatment.

keep in contact weekly with our lakes and know what changes are occurring. This saves time. Some lakes will hold for more than a week, so we can eliminate a trip.

Any aquatic treatment success can be noticeably affected by wind. Chemical drift can occur rapidly, with the result being no control at all. Expense goes up, profits go down, and people are dissatisfied.

The Clear Lake Project

Clear Lake in northwestern Wisconsin is illustrative of a typical lake with several problems.

It's about 40 feet below the level of the village by the same name, which includes a large creamery. Below the creamery was a seven-acre pond infested with brush, a variety of submerged weeds, duck weed and filamentous algae.

This pond was treated three times successfully for control of all the above-mentioned problems. The pond's water drains into Clear Lake, covering about 100 acres.

When we first surveyed the problem, the lake was infested with elodea packed solid in the swimming area of six acres, plus scattered masses around the lake. Planktonic algae was heavy throughout.

My first impression was to forget it and concentrate on other jobs. However, the challenge spurred me to tackle it.

The elodea was controlled completely in two years. The first year, I supervised the job as a state biologist. The village crew treated with aquathol-plus pellets at 600 pounds per acre. In three weeks, the entire mass of elodea broke loose and rose to the surface, but eventually decayed.

The algae became worse.

Last year, we took on the maintenance problem, which consisted of elodea treatment, then a weekly routine algae treatment. We used diquat for complete elodea control in the treated areas and 50 pounds of copper sulfate for algae control on a once-around marginal basis. Each week we sprayed using the marginal plan. In three weeks, we had clear water throughout. Planktonic algae disappeared and clumps of clodophora, hydrodictyon and spiro gyra occurred. We then changed from marginal to spot spraying of filamentous algae.

The result was a clear, usable lake all summer long. The fishing was excellent, with northern pike, bluegills, perch, and largemouth bass being taken. We never used more than 50 pounds of copper sulfate per week and never spent more than 45 minutes a week on the lake. The rapid growth of filamentous algae was indicative of the high nutrient content of the water.

We skipped one week and a filamentous growth again started and would have gone completely out of control had we not been on call and informed of the condition.

This plan of total lake management has been very successful for us. We plan on using it on most of our jobs.

It is highly important to develop ethical practices on the water, develop a good understanding and working relationship with property owners, and to report failures and successes to chemical companies and state governing agencies.

It also is a feasible way to carry on a continual year-by-year research program of new techniques, chemical mixtures, new chemicals, and new equipment to better achieve a beneficial program for all concerned.

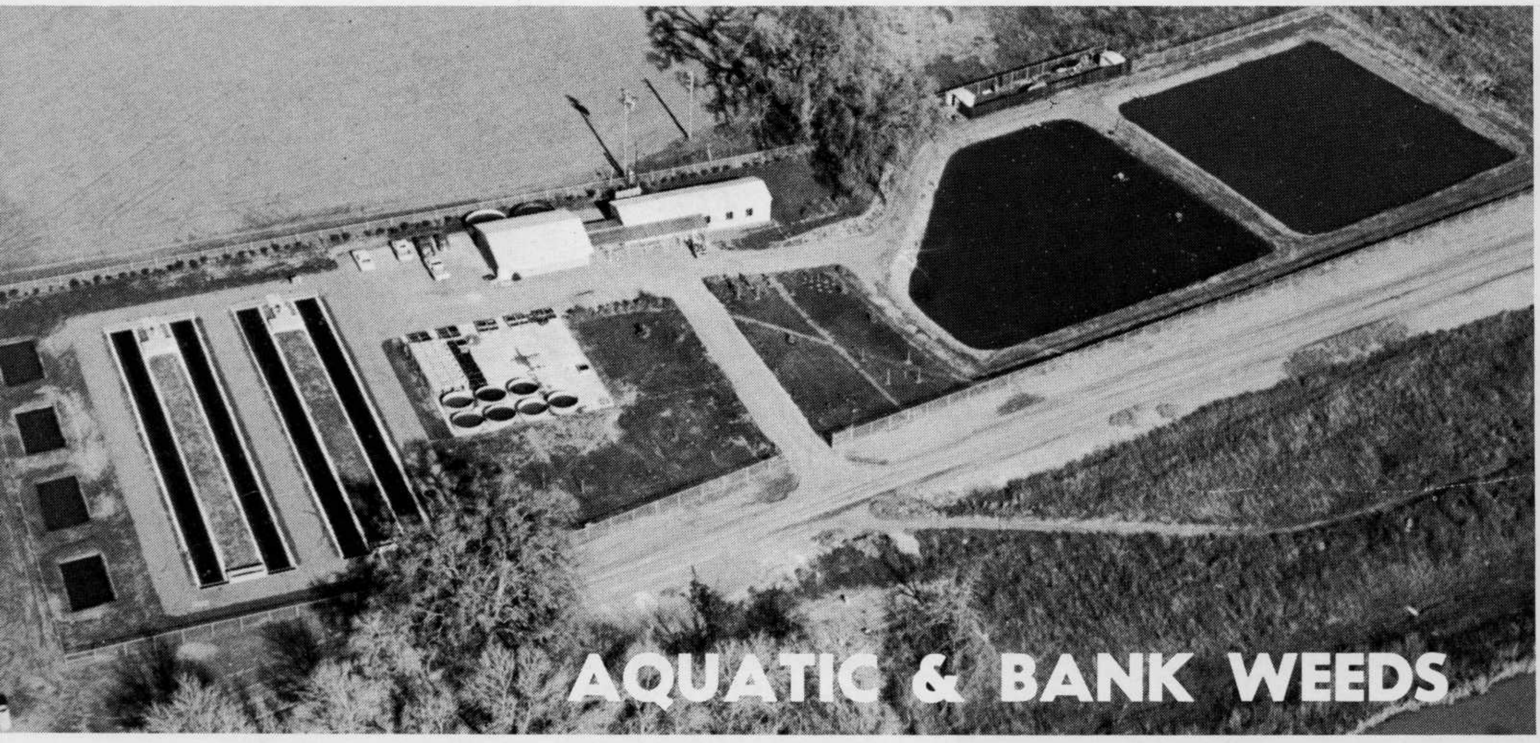
Book for Water Specialists

THE PRACTICE OF WATER POLLUTION BIOLOGY, Kenneth M. Mackenthun, U.S. Department of Interior. Single copies free from the Office of Public Information, Federal Water Pollution Control Administration, Washington, D.C. 20242. The book also is for sale at $1.50 per copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

This book presents some practical water pollution biological field investigative techniques and practices, procedures to solve problems, data analyses, interpretation and display, and the development and writing of the investigative report. It is written principally for the biologist inexperienced in these activities, and for sanitary engineers, chemists, attorneys, water pollution control administrators, and others who are interested in broadening their understanding of this discipline.

More than 20 years of biological field investigative experience are represented in the described field and laboratory methods, report writing, and data display. Methodology modifications presented may be of value to other professional biologists.


Who'd want this rotten job?
HELP WANTED
Weed-control crew
for industrial lawns
and landscaped grounds
* No weekends off
* No evenings off
* No vacations
* No sick leaves
* No days off
* No lunch hours
* No coffee breaks
* No benefits
And you'd better be good!



Research Techniques and Challenges Are Unique*

By F. L. TIMMONS**

RESEARCH on control of aquatic and bank weeds involves many challenging problems not encountered in research with terrestrial weeds. Equipment and techniques required are quite different, and often nonexistent.

Bank weeds, for example, along unlined earth irrigation canals, drainage channels, and pond and lake shorelines present situations and require research techniques much different from those on terrestrial weeds, but not nearly as unique as those with floating and submersed aquatic weeds.

Bank weeds range in type from semi-aquatic species at the waterline to drought-resistant species high on the bank. Even the same species grows much more vigorously at the waterline, and it often responds differently to herbicide treatments than it does several feet higher on the bank. The spectrum of bank weeds includes most weeds that grow on cropland and the semi-aquatic species, such as canarygrass *(Phalaris arundinacea)* and smartweeds *(Polygonum* spp.*)* in the West and paragrass *(Panicum purpurascens)*, torpedograss *(Panicum repens)*, Johnsongrass *(Sorghum halepense)*, and phragmites *(Phragmites communis)* in the South. Woody plants such as saltcedar *(Tamarix pentandra)*, willows *(Salix* spp.*)*, and wild rose *(Rosa* spp.) are also common bank weeds.

The full width of canal bank must be included in each experimental plot. Canals run in all directions, so that the incidence of sunlight affects bank weed growth. The response to herbicides is different on north, south, east, and west bank slopes. These narrow bands of weeds grow immediately beside water on one side and, frequently, close to herbicide-sensitive irrigated crops on the other side. That raises the problem of herbicide residues in the water on one side, and of spray drift onto sensitive crops on the other.

In experiments to determine effectiveness of herbicides on bank weeds, the plots must be located where there are uniform stands of weeds. To obtain reliable results, each plot must include both banks; or different replicate blocks must be located on opposite sides of the canal.

Because banks are usually steep, and often uneven, wheel-mounted sprayers can seldom be used. Hand-spray booms and guns usually work best. A single-nozzle wand boom is ideal for following the bank contour. Sometimes a wind board must be carried by a second man, walking beside the man who carries the sprayer to prevent spray drift onto the adjacent crop, or elsewhere off the target plot.

When you are evaluating results of herbicide treatments on bank weeds, it usually is necessary to make the determinations on each plot, one at the waterline and one higher on the bank, beginning two or three feet above the waterline. Extreme care is necessary in selecting replicate blocks of plots to reduce within-block error. Variation in results from the same treatment is often considerable between blocks of plots under different conditions. Thus, many repetitions of the experiment are necessary for conclusive results, whether for average conditions or for each condition along the same type of canal.

Emersed Aquatic Weeds

With some exceptions, emersed aquatic weeds present research difficulties similar to those with bank weeds. Emersed weeds such as cattails *(Typha* spp.*)*, tules *(Scirpus* spp.*)*, smartweeds, and watercress *(Nasturtium officinale)* in the West,

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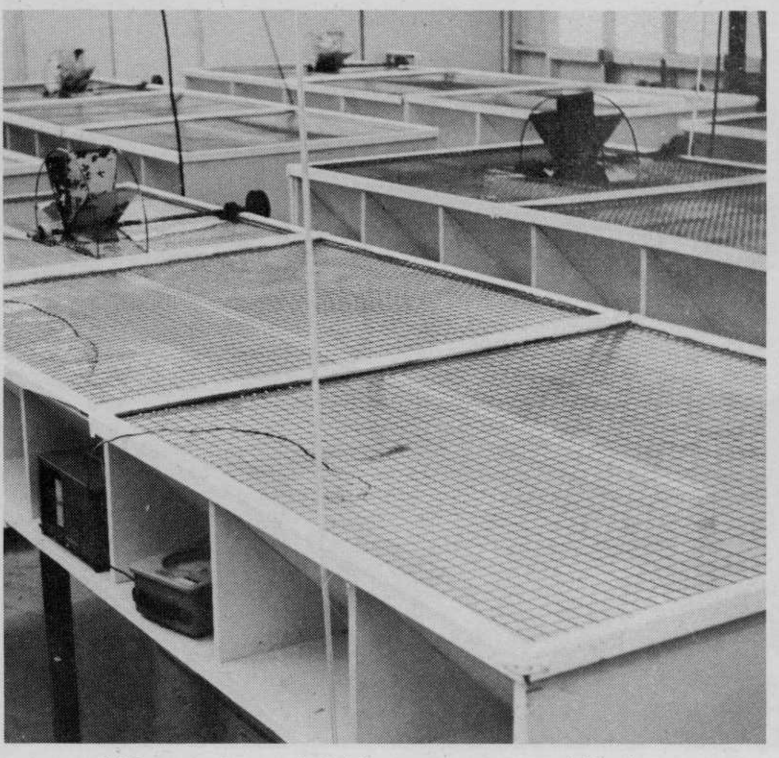
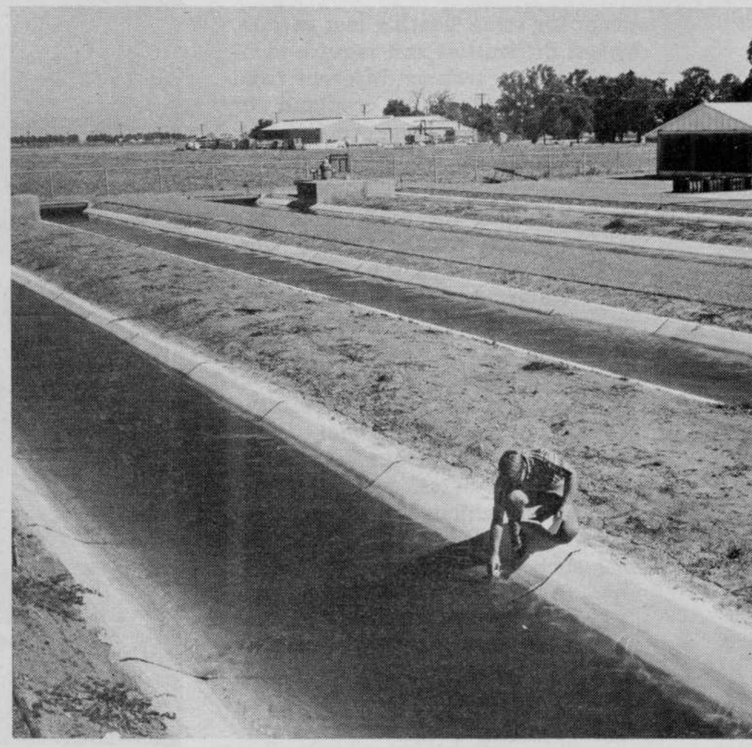
** Leader, Weed Investigations - Aquatic and Noncrop Areas, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Laramie, Wyo.





With aquatic weed field experimentation difficult to carry out in California, an elaborate and unique research facility has been constructed (aerial view, left) at the Davis campus of the University of California. Six two-part "mini" canals (above, left) in a greenhouse are used for preliminary flowing water experiments with herbicides and algicides that have shown promise for control of submersed weeds or algae in static water tests. Then initial field tests are conducted in four concrete-lined, 150x15x3-foot canals. The experiments determine the effects of herbicides on different species of submersed weeds, and on fish and Asiatic clams. Photos by California Department of Water Resources.

and all of these plus alligatorweed *(Alternanthera philoxeroides)*, waterprimrose *(Jussiaea* spp.), and others in the South, grow under less variable conditions of water supply. All are rooted in mud, usually below the waterline.

When the water is less than three feet deep for a considerable distance from shore, the bands of emersed weeds around ponds or lakes are often much wider than those in canals. The broader bands permit use of wider plots and, sometimes, two or more rows of adjacent plots.

When two or more rows of plots are present, herbicide applications of granules, pellets, or spray must be made from a boat or by wading in water or walking on water shoes, instead of from a sprayer or broadcaster moving on land.

If the emersed weeds are tall, like cattail, this often requires underwater mowing or otherwise removing plants to provide access passageways to and between the plots. Airboats are useful and often necessary for making herbicide applications and determining results in extensive areas of emersed weeds.

Growth conditions and vigor of emersed aquatic weeds usually are uniform within experimental plots. Except where water depth varies greatly, variability of results from control treatments within experiments is much less than it is with bank weeds. Results are particularly uniform from herbicide applications made on emersed or floating leaf weeds such as waterlilies *(Nymphaea* spp.), lotus *(Nelumbo lutea)*, spatterdock *(Nuphar advena)*, or watershield *(Brasenia screberi)*, which grow in water two to six or more feet deep.

Uniform applications of 2,6-dichlorobenzonitrile (dichlobenil) granules applied in early spring gave spectacularly effective, uniform, and long-lasting control of white waterlily *(N. tuberosa)* in Washington and Florida. Granular applications of dichlobenil or (2,4-dichloropenoxy)-acetic acid (2,4-D) were also effective on emersed alligatorweed in southeastern states.

Weeds, Algae in Irrigation Systems

Submersed weeds and algae, which grow entirely under water

Two scuba divers inspect submersed weeds in a large irrigation canal. Two divers following safety regulations are indispensible to safe and accurate surveys and test evaluations in lakes and large canals. Photo by V. F. Bruns, research agronomist.

except for some floating leaf species, present difficulties and require techniques in research as different from those involved with cropland or rangeland weeds as one can imagine.

Because of the flowing water in irrigation and drain canals, only one treatment can be applied to the water in each canal. Canals vary widely in flow capacity, velocity of flow, water quality, temperature, and turbidity. Canals also vary in length. The size and volume of flow becomes increasingly less down an irrigation canal, but increasingly more down a drain canal. Some canals have numerous structures such as check dams, drops, siphons, and flumes, which often drastically reduce the effectiveness of herbicides such as acrolein and oxylene.

The difficulty in obtaining permission to use irrigation canals for experimental control treatments on submersed weeds or algae is even greater than that for experiments on control of bank weeds. The herbicide has to be applied directly in the flowing water at a concentration high enough to kill the pondweeds or algae for several miles down the canal.

Before the researcher introduces the herbicide into the water, he must know whether the treated water will kill or injure fish, livestock that drink the water, or irrigated crops. Frequently, the water from a single long canal is used to irrigate 10 to 30 different crop species. If there are hazards, the irrigation company or district board and farmers along the canal must be convinced that results will justify the hazards.

In order for a researcher to know that much about a herbicide before it is field tested in a commercial canal or drain, the herbicide must successfully pass a series of increasingly rigorous tests in greenhouse or growth room aquaria, outdoor bins or pools, and small closed system flowing "mini-canals." In addition, the effects that the herbicide in the water may have on irrigated crops must be ascertained.

Davis Research Stations

Equipment for all, or several, of these preliminary tests are in use at our research stations at Davis, Calif., Denver, Colo., Prosser, Wash.; and Fort Lauderdale, Fla. These include glass aquaria for submersed weeds at Fort Lauderdale and Denver, plastic aquaria for floating weeds at Fort Lauderdale, 4x4 plastic pools for submersed weeds, fish, and Asiatic clams at Davis, outdoor plastic pools at Fort Lauderdale and Davis, and the experimental plots at Prosser for research on crop tolerance to herbicides in irrigation water and on herbicide residues in crops.

Herbicides that are soluble or

Watershoes come in handy when working near weed infested shorelines. The footgear facilitates getting samples, making herbicide applications, and checking results. Dr. Lyle Weldon is the man at far left. In the picture above, Weldon is spraying an experimental plot of Carex on an irrigation ditchbank in Wyoming. The windboard prevents spray drift off of test plot.

emulsifiable in water are applied under water in a canal at one location or at a series of locations several miles apart. Application equipment depends upon the size of the canal and type and amount of herbicides to be applied. For xylene, they range from small one- or two-nozzle sprayers, usually located above a weir drop, to large many-nozzle booms, spray guns, or open hoses with high pressure for larger canals.

Concentrations of only 0.1 to 0.6 ppm of acrolein over long exposure periods of 8 to 48 hours will control most submersed weeds. Because acrolein creates an explosive mixture with air in a tank and polymerizes at small jet openings into air, the herbicide must be stored in pressure-resistant cylinders and delivered beneath the water surface under nitrogen gas pressure. Small plastic tubs with a screw clamp or regulator valve will deliver enough acrolein from a nitrogen gas pressurized cylinder to treat canals carrying from 200 to 2,000 cfs. The small tank holds 50 gallons of acrolein. Large tanks hold 250 gallons each. A small plastic tube delivers 0.1 ppm into a canal carrying 2000 cfs of water. The acrolein applied from one bank dispersed entirely across that large canal within about 200 ft. The treatment gave complete control of submersed weeds from there down the canal 20 miles and gave adequate control for 50 miles.

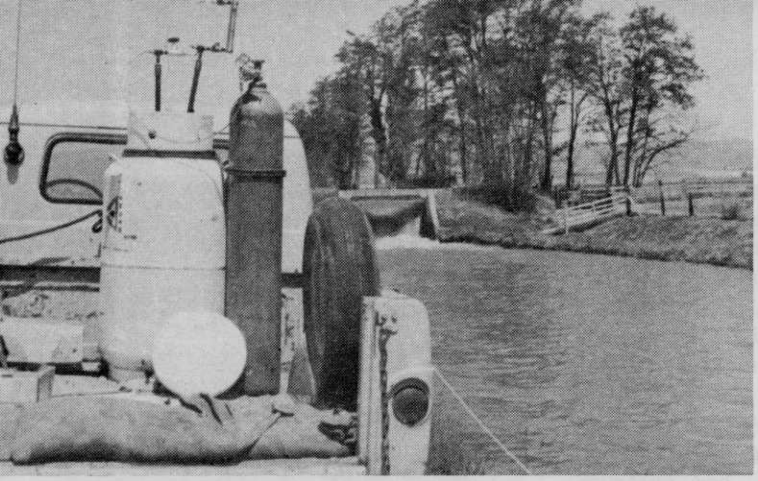
Herbicide Evaluation

Evaluating the results of herbicide treatments is simple in small canals with clear water. The degree of collapsing of weeds, of increased water flow at several day intervals after treatment, and, finally, sloughing of the leaves and stems are good criteria. Later, at intervals of one to several weeks, the degree of sloughing of wood leaves and stems, and, finally, the beginning and rapidity of regrowth, are observed and recorded. In large deeper canals or in small canals with turbid water, surface observations are not reliable. Dragging a long handle rake through small canals or many pronged gadgets on the end of a long nylon rope through large canals were techniques used for several years.

We are now much more sophisticated and use scuba diving in large canals and in lakes to evaluate results of herbicide treatments and make weed surveys and ecological studies of submersed weeds. Scuba diving equipment and techniques are efficient and essential for weed studies in deep water. All safety rules of scuba diving must be scrupulously followed without exception, just as safety belts must always be fastened in moving cars and trucks to greatly reduce the chances of serious or fatal injury.

Only one treatment can be made in each canal at one time. It is difficult to get permission to use several similar canals for identical treatments on the same day or during a span of several days. Therefore, it is almost impossible to replicate treatments that are applied in flowing water. For that reason, and because of the variability, repetitions of the treatment must be made in as many existing canals as possible at each of our field stations each year. Usually, these applications must be repeated at all stations for several years before conclusive results are obtained.

Fortunately, it is still possible to obtain permission to use existing canals and ponds or lakes for testing promising new herbicides in Washington, Montana, Wyoming, Colorado, and even in Florida. In highly urbanized California, it is much more difficult, and almost impossible. Because of that situation, and the urgent need for information on control of the critical submersed weed and algae problems in California, four federal and state agencies have constructed, on the experiment station campus at Davis, an



To treat this Washington irrigation canal, an experiment was set up to apply 1 ppm of acrolein during a 48-hour period. The acrolein was metered through the plastic tube from the high pressure tank under nitrogen gas pressure from the adjacent cylinder. Acrolein applied from the opposite bank eliminated the submersed weeds from a widening swath that reached across the canal 100 yards below. From there it gave excellent weed control for 20 miles and adequate control for 50 miles. Photos by V. F. Bruns, research agronomist.

aquatic weed research center at a total cost of nearly $250,000. The cooperating agencies are the Bureau of Reclamation, the California Department of Water Resources, the Agricultural Research Service, and the California Agricultural Experiment Station.

The center consists of four 15x30x-3-ft, ponds for biological control studies, four concrete-lined canals 150-15x3 ft. with an enclosed flowing water system, a well-drained concrete platform with space for ten 10-ft.-diameter plastic bins and eighty 4-sq. ft. plastic bins, a 30x40-ft. greenhouse, a 28x70-ft. headhouse-shop complex, and two lined ¾-acre holding and evaporation ponds which receive all herbicide-treated water and prevent it from getting into the underground water table.

Weeds in Lakes and Ponds

Field research on control of submersed weed problems in lakes and ponds is conducted by two main techniques:

1. metal or plastic enclosures 5 to 12 sq. ft., which separate the water and weeds within each enclosure from the remainder of the lake during the desired period of treatment exposure; and

2. large open-water plots 50 to 100 ft. square with untreated borders of about equal widths between plots.

The first technique is used for

preliminary tests of promising herbicides and mixtures. The large open-water plots are used for final replicated plot tests before the herbicide is used for total or partial area lake or pond treatments.

In "Winderful," Wyo., or anywhere the wind blows, it is very difficult to stake out open water plots from a boat. It is much more accurate and easier to cut holes in the ice in winter and insert a concrete block weighted plastic bottle float with a black metal shield for each plot corner marker.

Metal enclosures, 12 sq. ft., have been used for preliminary lake treatments in Wyoming. Each enclosure can be lifted by inflating the rubber tube that is attached near the bottom, the enclosure moved to a new location, and settled into place by deflating the rubber tube. The enclosure can be quickly dismantled into four metal sheets 4x12 ft. for hauling long distances.

Inexpensive, and quickly set up or dismantled plastic enclosures were developed by John Gallagher of Amchem Products, Inc., for preliminary test of herbicides on submersed weeds in lakes and marshes. These plastic enclosures are being extensively used by our Agricultural Research Service team at Fort Lauderdale. They are being used in several other eastern states by other investigators.

Space does not permit my discussing in detail the unique difficulties and research techniques involved in working with floating weeds like waterhyacinth *(Eichhornia crassipes)*, waterlettuce *(Pistia stratiotes)*, and alligatorweed. The most difficult problem is holding the treated plots in place long enough after treatment to determine results of the treatment. This has been successfully accomplished in some situations by inserting bamboo or other poles two to four feet apart around each plot, a tedious and time-consuming, but necessary, procedure.

Herbicide Residues in Water

In recent years, the need for information on concentrations of herbicides in water and the rate of dissipation from water after treatments for control of aquatic or bank weeds has necessitated the development of reliable sampling techniques and effective methods of preserving the water samples against deteriorations prior to chemical analysis.

The sampling technique finally established for both aquatic and bank weed treatments in or along canals is to begin by marking the beginning and end of the treatment with a slug of dye in the flowing water. Water samples are taken at pre-selected locations down the canal below the lower end of the bank treatment, or beginning half-mile below the point of introducing the aquatic weed treatment.

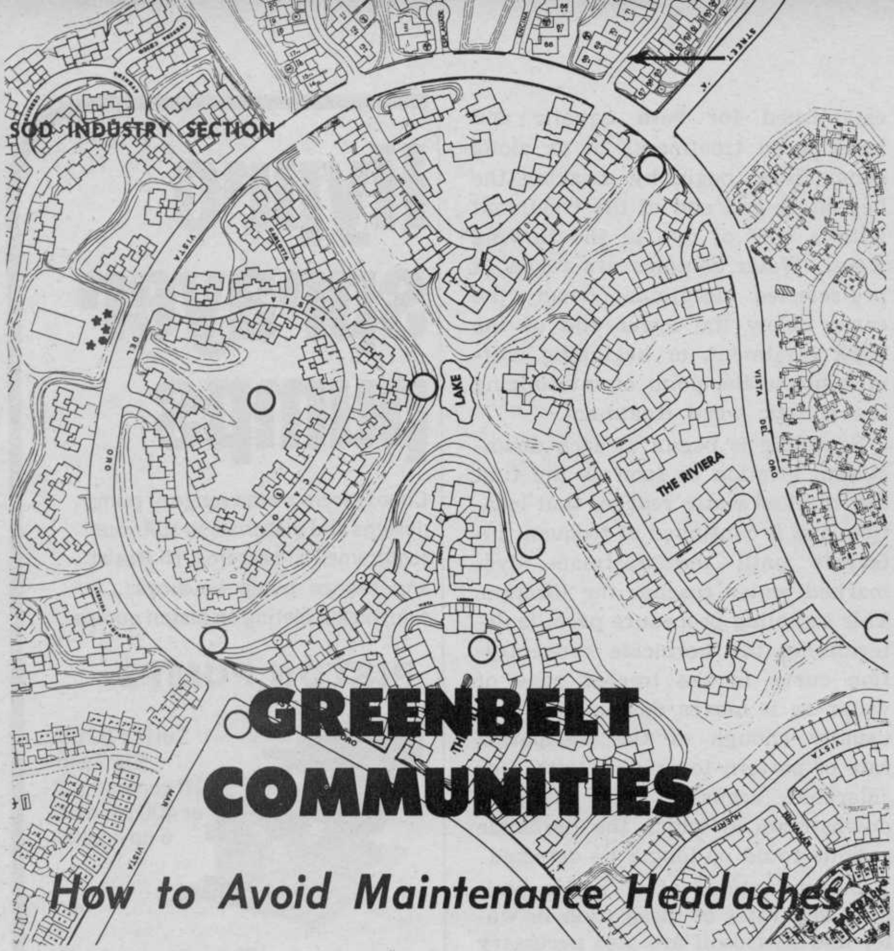
Sampling is begun at each downstream location as soon as the first dye-marked water reaches that location, and is continued at frequent intervals until the upstream dye-marked water reaches the location. This sampling procedure permits determining the herbicide concentration curve in the treated zone of water as it moves downstream and usually enough of the dissipation rate of pattern to predict, with considerable accuracy, the distance downstream at which the herbicide residue could no longer be detected.

Determinations of herbicide residues and rates of dissipation in water and hydrosoil are also necessary following applications for control of aquatic weeds in ponds.

Studies were initiated several years ago in ponds and small reservoirs in Colorado and California following total area application. Sampling of water or hydrosoil following total area treatments is not complicated, but care must be used to obtain a sufficient number of samples on each sampling date to accurately represent the water and hydrosoil throughout the treated area.

In bodies of water six feet or more deep, water samples should be taken near the surface and near the bottom to determine whether a thermocline exists and is affecting the concentration of herbicide at different depths. Samplings of water and hydrosoil are continued for a sufficient period after treatment to measure the trends of dissipation and, when possible, until residues are no longer found.

Studies are now under way in Washington and Florida to determine herbicide residues and rates of dissipation following isolated plot treatments with a granular formulation of dichlobenil. In these situations, samples are taken periodically in the treated area and also at various distances from the treated area in at least two directions to measure lateral dispersion of the herbicide in the water, and subsequent absorption by the hydrosoil.



GREENBELT COMMUNITIES

How to Avoid Maintenance Headaches

Greenbelt neighborhoods, though a boon to residents and to developers, sometimes become maintenance monsters. City and county park officials are seeking a greater voice in design plans in an effort to avert maintenance problems later. Planned communities with strip parks are fast rising in popularity. Landscaped parkways between homes, as shown below and on plat map above, are tremendous selling points to families with children. In this greenbelt development in Orange County, Calif., broad paths shuttle residents through an inter-community of walks that glide past a variety of pleasing landscaped pockets.

By LOU SPEER
El Toro, Calif.

RECENTLY, in Simi Valley, Calif., the park department narrowly escaped the attempts of a subdivision developer to foist the maintenance of his projected greenbelt neighborhood onto the park's already over-crowded general budget.

Further south, in Fountain Valley, the Homeowner's Association of a five-year-old greenbelt neighborhood approached that city's park director asking: Would the city be interested in assuming title to the Association's strip parks? The spiraling maintenance costs were too high for them.

In an unincorporated South Coast section of Orange County, residents of a highly touted "hillside with a view" retreat complained to county maintenance officials that the hillside was just their trouble: Architects of their planned community had given them nothing for their maintenance money but landscaped slopes. Where were their children to play?

"These problems do happen," stated Kenneth Sampson, Orange County park director, who received the South Coast community's complaint. A husky man with a number of year's planning experience as well as park work behind him, he thoughtfully considers these and