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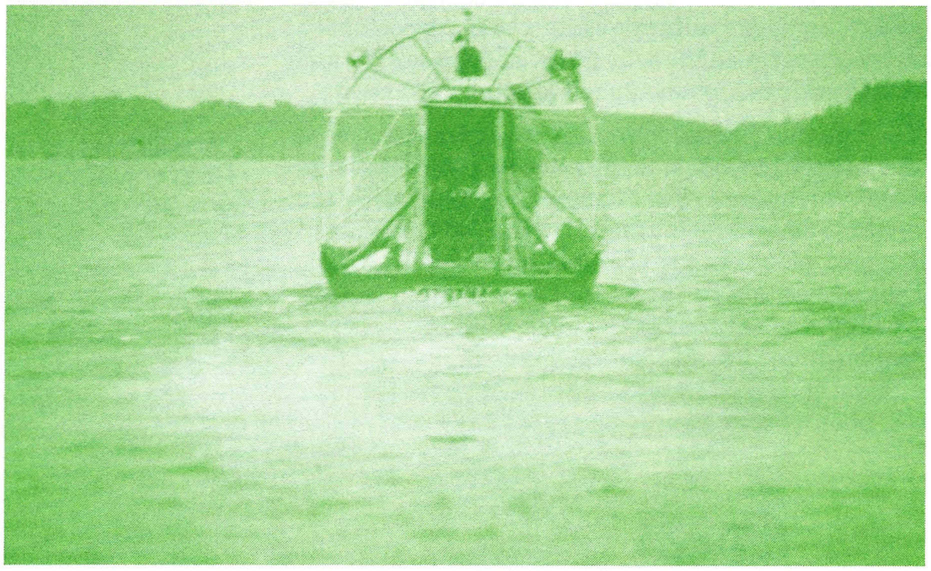

Submersed application of Rhodamine WT using airboat

Understanding Water Exchange Characteristics to Improve the Control of Submersed Plants

by
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The successful control of submersed aquatic plants using chemicals depends upon the concentration and exposure time of a herbicide with respect to the target plant. The movement of water—via flow, wind mixing, thermal regimes, or other hydrodynamic processes—can dramatically impact herbicide concentration/exposure time relationships. An understanding of water movement within submersed plant stands can be useful for improving herbicide efficacy. This understanding is particularly critical in systems with a potential of high water exchange, such as rivers, tidal areas, and large reservoirs.

Researchers at the US Army Engineer Waterways Experiment Station (WES) and the University of Florida's Center for Aquatic Plants are conducting dye studies in hydrilla- and Eurasian watermilfoil-infested lakes, reservoirs, rivers, and tidal areas around the nation using the fluorescent dye Rhodamine WT (Figure 1). The objectives of these studies are to characterize flow velocities and water exchange rates in submersed plant stands, evaluate various submersed application techniques to maximize herbicide contact time, and establish correlations between the behavior of Rhodamine WT and selected herbicides when applied to submersed plants.

The research focuses on several major problems faced by operational personnel responsible for controlling submersed vegetation. For instance, some studies are designed to determine the retention time of herbicides in submersed plant stands of inland rivers, such as the Withlacoochee and St. Johns Rivers in Florida, and the Pend Oreille and Columbia Rivers in Washington State. Retention time will also be studied in the submersed vegetation of tidal rivers and canals, such as the Potomac River, near Washington DC, and the Crystal River in Florida. Additional studies will determine herbicide distribution through the water column as influenced by thermal stratification, as well as various application techniques and formulations. Study results will provide information needed by aquatic plant managers to select the timing, formulation, and application technique(s) that will maximize herbicide efficacy on submersed plants.

Use and Measurement of Rhodamine WT

Hydraulic engineers have used tracer dyes for time-of-travel and dispersion studies in rivers and canals for many years (Hubbard and others 1982). The fluorescent dye, Rhodamine WT, is recommended by the US Geological Survey for typical water-tracing studies and has been approved for use in potable water at concentrations of up to 10 micrograms per litre (µg/L). This dye is practically inert, with a very low affinity for absorption by aquatic organisms, or adsorption by sediments or other submersed objects. Rhodamine WT has

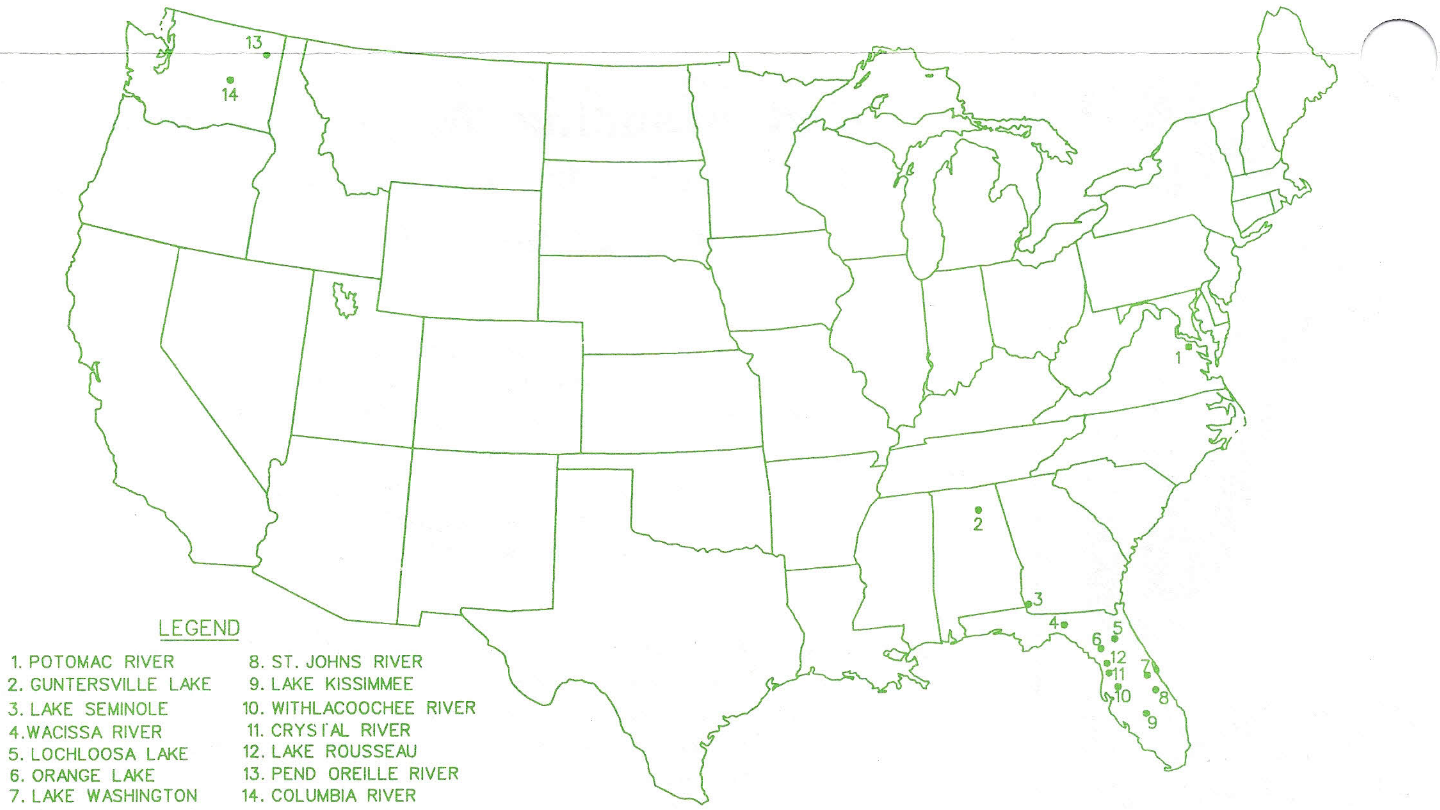

Figure 1. Locations of Rhodamine WT/submersed plant study sites

been shown to resist photochemical and microbial degradation in field situations, and exhibits negligible uptake by submersed aquatic vegetation (Fox and others 1988). These properties make the dye ideal for tracing water movement in submersed plant stands.

The concentration of Rhodamine WT can be measured directly in the water using a fluorometer equipped with a high-volume, continuous-flow cuvette system, and the appropriate filters and light source (Figure 2). Water to be measured is circulated through the fluorometer with a bilge pump attached to the end of a hose. The hose is lowered to desired depths in the water column and dye concentrations are immediately measured to levels as low as 0.01 µg/L. Water temperature must be recorded concurrently with each reading of the fluorometer. Fluorescence of Rhodamine WT decreases with an increase in temperature, so a correction with the fluorometer calibration temperature is necessary to determine actual dye concentrations (Smart and Laidlaw 1977). Fluorometric techniques used for tracing dyes through submersed plant stands are similar to dye tracing techniques developed for streams and reservoirs (Hubbard and others 1982, Johnson 1984).

Estimation of Water Velocity and Retention Time

Estimation of frequency and rates of herbicide applications in flowing-water systems requires a knowledge of water velocity through submersed plants stands. Flowmeters are of little value in very slow velocities often found in dense submersed weeds (Getsinger 1987, 1988). In these systems, the maximum and mean water velocities can be estimated by timing the downstream movement of a slug-injection of Rhodamine WT. Studies of this nature have been conducted in hydrilla-infested portions of the upper St. Johns River and in Lake Rousseau, Florida.

Rhodamine WT is also being used in reservoirs (Lake Rousseau in Florida, Lake Seminole in Georgia, and Guntersville Lake in Alabama), rivers (the Potomac in Maryland and Virginia and the Pend Oreille and Columbia in Washington), and tidal canals (Three Sisters Canals/Crystal River in Florida) to estimate the maximum retention time of water in plots where herbicide applications, used to control hydrilla or Eurasian watermilfoil, may be required. An example of data obtained from these types of studies is presented in Table 1. This information is particularly important in systems subject to variable rates and directions of water movement. Such estimates of maximum potential herbicide persistence can be compared with herbicide concentration/exposure time relationships (being developed at WES and the Center for Aquatic Plants for all registered and experimental use aquatic herbicides) to aid operational personnel in selecting an appropriate herbicide and application method.

In weed-infested systems that have shown inconsistent efficacy after herbicide treatments, long-term dye studies are being conducted to compare water retention times under a variety of pertinent environmental conditions. If the most significant environmental factors and their influence on water retention time can be

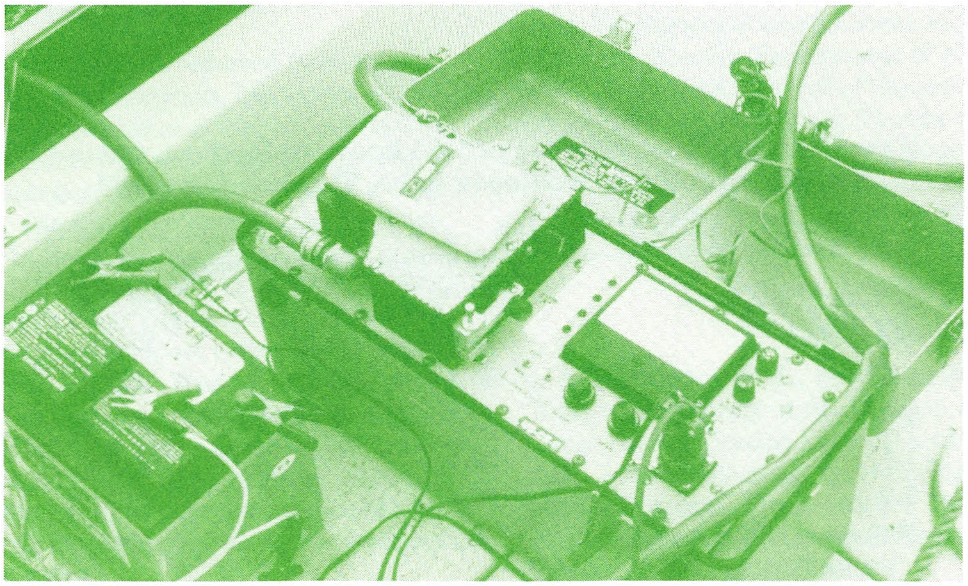

Figure 2. Turner Designs fluorometer equipped with continuous flow cuvette, pump system, and temperature monitor

Table 1

Half-Lives of Dye from 0.5-hectare Eurasian Watermilfoil Plots in the Pend Oreille River, Washington, August 1988

Type of Plant Stand	*Treatment*	*Half-life, hours*
Open shoreline	Surface injection	2.0
Open shoreline	Deep injection	2.3
Protected cove	Deep injection	16.0
Mid-channel island	Deep injection	0.3

quantified, then the optimum conditions and times for herbicide use (that is, when the period of plant exposure to the chemical is maximized) may be identified. Ideally a manager would be able to predict these optimum conditions from routinely collected environmental data, such as water flow or stage.

Comparison of Submersed Application Techniques

Submersed application technique studies are being conducted in hydrilla stands of Lochloosa Lake and Lake Kissimmee, Florida. Various application techniques and formulations are being evaluated (using Rhodamine WT) for their potential to distribute herbicide through the water column under different vegetation and water temperature conditions. The techniques and dye formulations being evaluated include long- and short-hose applications of liquids, polymers, and inverts, as well as application of granules. The vegetation and water temperature conditions include tall and short stands of plants, and isothermal and stratified temperatures.

Thermal stratification, with warm water at the surface and cool water at the bottom, is common in surface-matted submersed plants. This type of stratification can reach extreme proportions on sunny days in Florida hydrilla stands (Table 2). However, on overcast days the degree of stratification can be minimized. Thermal stratification creates a physical barrier, isolating layers of the water column. In some cases, this barrier may prevent surface-applied herbicides from mixing below the thermocline and reduces the distribution of the chemical on the target vegetation. Figure 3 shows a comparison of vertical dye distribution, when using liquid, polymer, and granular application techniques. In this evaluation, the granular material provided the most complete vertical distribution of dye in the surface-matted hydrilla stands of Lochloosa Lake, Florida.

Table 2

Water Temperature Profiles at 1100 hours in Surface-matted Hydrilla Stands in Lochloosa Lake, Florida, June 1989

	Water Temperature, degrees Celsius	
Depth, metres	*Sunny*	*Overcast*
Subsurface	33.1	27.7
0.5	30.5	27.6
1.0	29.5	27.5
1.5	28.4	27.4
2.0	27.4	27.3
Difference, Top to Bottom	5.7	0.4

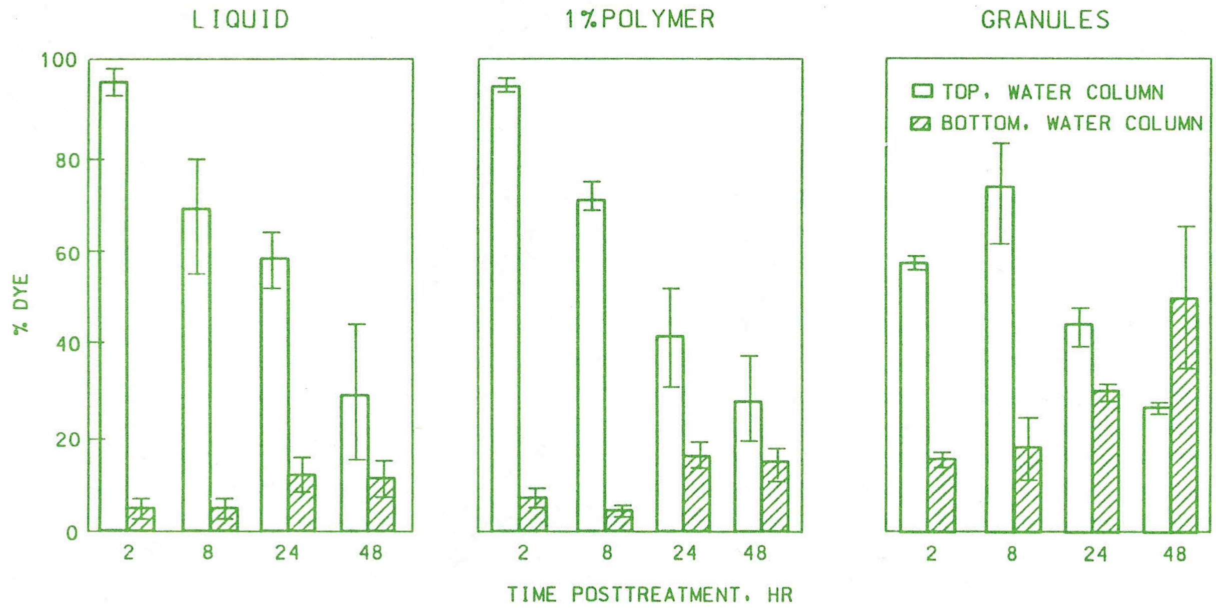

Figure 3. Percent distribution of dye in the top and bottom half of the water column over time, following liquid, polymer, and granular applications in hydrilla stands in Lochloosa Lake, Florida, June 1989 (Bars represent 3 replications ± 1 SE.)

Results from the application technique dye studies will provide insight into the herbicide mixing potential of the most frequently used chemical application methods. This information will allow operational personnel to choose the most effective application method based on plant and water temperature conditions.

Simulation of Herbicide Residues

Since herbicide residues are removed from aquatic systems by processes of adsorption, degradation, and plant uptake, it cannot be assumed that a conservative dye, such as Rhodamine WT, will precisely mimic the movement and changes in concentration of a herbicide. However, establishing correlations between dye and herbicide residue concentrations would validate the use of Rhodamine WT to test application methods and to predict the approximate half-lives of herbicides in moving water (from estimates of retention time as described earlier). This would significantly reduce the time and expense associated with typical herbicide residue field studies. In addition, establishing these correlations will be of great value to herbicide registration studies that are concerned with the persistence and movement of herbicide residues applied to moving water.

Dye/herbicide correlation studies are being conducted in the Three Sister Canals of the Crystal River (endothall and fluridone), St. Johns River (fluridone), Lake Washington (endothall), Orange Lake (diquat), and Wacissa River (endothall) in Florida, and Lake Seminole (bensulfuron methyl) in Georgia.

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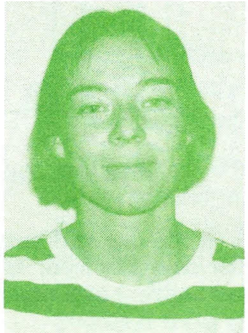

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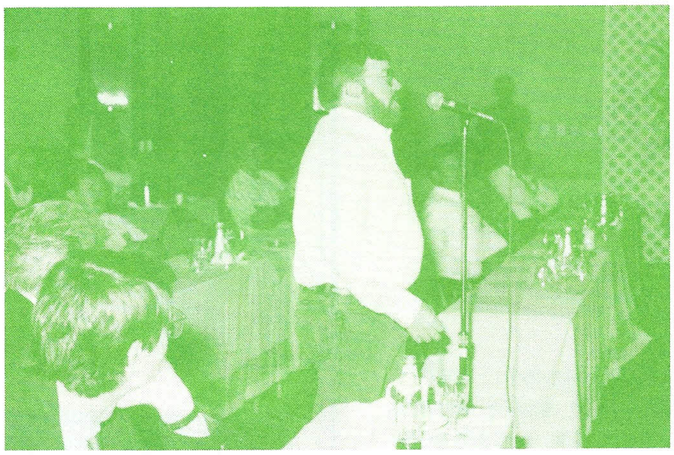
25th Annual Meeting
Aquatic Plant Control Research Program

The Aquatic Plant Control Research Program held its 25th Annual Meeting in Orlando, Florida, November 26-30. The meeting examined the past, present, and future of aquatic plant control research. Representatives from US Army Corps of Engineers Headquarters, Divisions, and Districts; other Federal, State, and local organizations; universities; and private industry were among the 140 attendees.

Jim Wolcott—current Technical Monitor—and Carl Brown, Dwight Quarles, and Roger Hamilton—former Technical Monitors—provided a historical perspective of significant accomplishments during their tenures. The silver anniversary meeting also included technical presentations, a poster session, and a computer demonstration.



Understanding water movement within submersed plant stands, particularly in rivers, tidal areas, and large reservoirs, can be useful for improving herbicide efficacy. Controlling submersed aquatic plants using chemicals depends on the concentration and exposure time relationships of a herbicide with the target plant. Water movement, whether by flow, wind mixing, thermal regimes, or other process, affects these relationships. This issue reports on dye studies being conducted in hydrilla- and Eurasian watermilfoil-infested lakes, reservoirs, rivers, and tidal areas around the nation by the US Army Engineer Waterways Experiment Station and the University of Florida's Center for Aquatic Plants.

US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

AQUATIC PLANT CONTROL RESEARCH PROGRAM

This bulletin is published in accordance with AR 25-30. It has been prepared and distributed as one of the information dissemination functions of the Environmental Laboratory of the Waterways Experiment Station. It is principally intended to be a forum whereby information pertaining to and resulting from the Corps of Engineers' nationwide Aquatic Plant Control Research Program (APCRP) can be rapidly and widely disseminated to Corps District and Division offices as well as other Federal agencies, State agencies, universities, research institutes, corporations, and individuals. Contributions are solicited and will be considered for publication so long as they are relevant to the management of aquatic plants as set forth in the objectives of the APCRP, which are, in general, to provide tools and techniques for the control of problem aquatic plant infestations in the Nation's waterways. These management methods must be effective, economical, and environmentally compatible. The contents of this bulletin are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products. This bulletin will be issued on an irregular basis as dictated by the quantity and importance of information to be disseminated. Communications are welcomed and should be addressed to the Environmental Laboratory, ATTN: J.L. Decell, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call AC 601/634-3494.

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