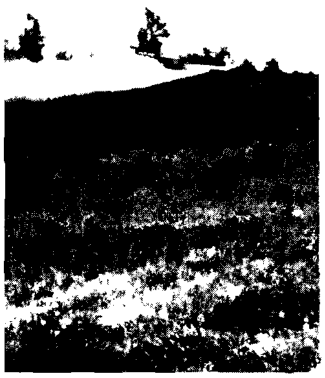
US Army Corps
of Engineers



AQUATIC PLANT CONTROL RESEARCH PROGRAM

MISCELLANEOUS PAPER A-84-5

FIELD EVALUATION OF GARLON 3A (TRICLOPYR) AND 14-ACE-B (2,4-D BEE) FOR THE CONTROL OF EURASIAN WATERMILFOIL

by

Kurt D. Getsinger, Howard E. Westerdahl

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

September 1984
Final Report

Prepared for

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Miscellaneous Paper A-84-5	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FIELD EVALUATION OF GARLON 3A (TRICLOPYR) AND 14-ACE-B (2,4-D BEE) FOR THE CONTROL OF EURASIAN WATERMILFOIL		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Kurt D. Getsinger Howard E. Westerdahl		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Engineer Waterways Experiment Station Environmental Laboratory PO Box 631, Vicksburg, Mississippi 39180-0631		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Aquatic Plant Control Research Program
11. CONTROLLING OFFICE NAME AND ADDRESS DEPARTMENT OF THE ARMY US Army Corps of Engineers Washington, DC 20314-1000		12. REPORT DATE September 1984 13. NUMBER OF PAGES 25
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aquatic plant control (WES)	Herbicides (LC)
Euraisian watermilfoil (WES)	Plants, Effects of herbicides on (LC)
14-ACE-B (WES)	Triclopyr (WES)
Garlon 3A (WES)	2,4-D BEE (WES)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The efficacy and residue persistence in water and sediment of triclopyr (Garlon 3A) and the controlled-release (CR) formulation of 2,4-D BEE (14-ACE-B) on 0.4-ha plots of Eurasian watermilfoil (*Myriophyllum spicatum* L.) in Lake Seminole, Ga., were evaluated through field application. Results showed that rapid dissipation of triclopyr occurred in water and sediment in both the 1.0-mg/ℓ active ingredient (a.i.) and 2.5-mg/ℓ a.i. treatment plots.

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

Triclopyr applied at these rates did not control watermilfoil as well as 2,4-D BEE applied at conventional rates. The CR elastomer formulation 14-ACE-B did not provide desired long-term 2,4-D concentrations in the water column, although watermilfoil was controlled for a short period of time. Triclopyr shows promise as an aquatic herbicide, but 14-ACE-B is unacceptable as a CR 2,4-D formulation.

PREFACE

This study was conducted by personnel of the U. S. Army Engineer Waterways Experiment Station (WES) as part of the U. S. Army Corps of Engineers Aquatic Plant Control Research Program (APCRP).

The work was initiated in June 1982 under the general supervision of Dr. John Harrison, Chief, Environmental Laboratory (EL), and under direct supervision of Mr. Donald L. Robey, Chief, Ecosystem Research and Simulation Division (ERSD), EL, and Dr. Thomas L. Hart, Chief, Aquatic Processes and Effects Group (APEG), ERSD. Mr. J. Lewis Decell was the Program Manager for the APCRP. Mr. E. Carl Brown, Office, Chief of Engineers (OCE), was Technical Monitor.

The principal investigators for this work were Dr. Kurt D. Getsinger and Dr. Howard E. Westerdahl of APEG, ERSD. They were assisted by Mr. Jerry M. Hall, APEG, ERSD. Messrs. Angus Gholson, Joe Kight, and Holmes Walters of the U. S. Army Engineer District, Mobile, provided additional field assistance. The Dow Chemical Company analyzed triclopyr residues in water and sediment samples, and the Tennessee Valley Authority, Laboratory Branch, Chattanooga, Tenn., analyzed 2,4-D residues in water and sediment samples under a cooperative agreement with WES.

Commander and Director of WES during this study was COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

This report should be cited as follows:

Getsinger, K. D., and Westerdahl, H. E. 1984. "Field Evaluation of Garlon 3A (triclopyr) and 14-ACE-B (2,4-D BEE) for the Control of Eurasian Watermilfoil," Miscellaneous Paper A-84-5, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

CONTENTS

FIELD EVALUATION OF GARLON 3A (TRICLOPYR) AND 14-ACE-B (2,4-D BEE) FOR THE CONTROL OF EURASIAN WATERMILFOIL

PART I: INTRODUCTION

1. During the winter of 1982, Dow Chemical Co. representatives requested assistance from the U. S. Army Engineer Waterways Experiment Station (WES) to cooperatively evaluate the efficacy of Garlon 3A (triclopyr) on Eurasian watermilfoil (*Myriophyllum spicatum* L.). Subsequently, research plots containing primarily Eurasian watermilfoil in Lake Seminole near Chattahoochee, Fla., were selected. Also, field evaluation of the controlled release (CR) natural rubber elastomer (14-ACE-B) containing butoxyethanol ester of 2,4-D (2,4-D BEE) was initiated in conjunction with the Garlon 3A tests. This CR formulation was developed by Creative Biology Laboratory, Inc., Barberton, Ohio.

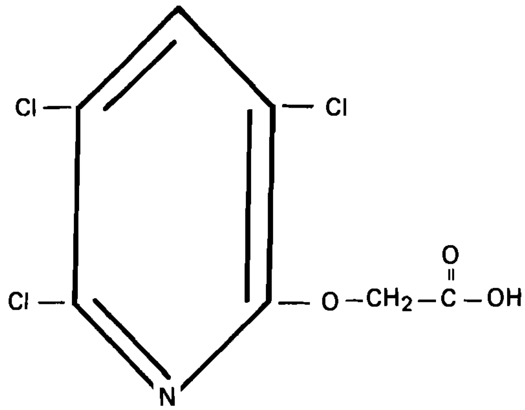
2. The objective of this field study was to evaluate the activity of Garlon 3A and the CR formulation of 2,4-D BEE, referred to as 14-ACE-B, against Eurasian watermilfoil in Lake Seminole. Specifically, the efficacy and residue persistence in water of Garlon 3A were to be determined whereas the 14-ACE-B plots were studied to identify residue persistence in water and sediment.

PART II: MATERIALS AND METHODS

Herbicides

Triclopyr

3. The empirical formula of triclopyr is $C_7H_4Cl_3NO_3$ and its structural formula is:

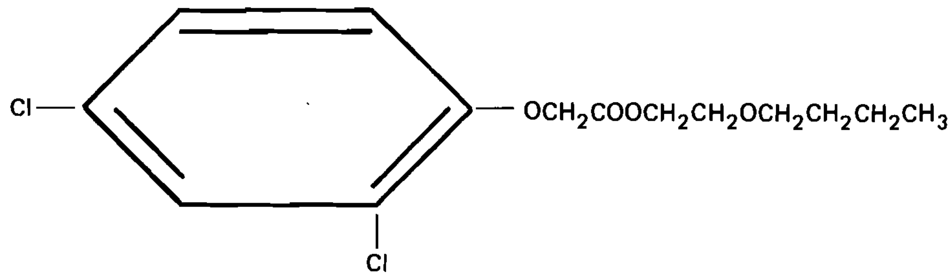


3, 5, 6 - Trichloro-2-pyridinyloxyacetic acid

4. Commercial formulations of triclopyr are available in a water-soluble triethylamine salt formulation (Garlon 3A) containing 0.37 kg of triclopyr acid equivalent (a.e.) per litre (3 lb/gal) and in an oil-soluble, water-emulsifiable butoxyethyl-ester formulation (Garlon 4) containing 0.48 kg of triclopyr a.e. per litre (4 lb/gal). Triclopyr-treated plants exhibit an auxin-type response. The chemical is readily absorbed by both leaves and roots in actively growing plants. Triclopyr, applied to woody plants, moves readily in the symplast; however, it has limited apoplastic mobility (Radosevich and Bayer 1977). Foliage applications of triclopyr typically show maximum plot damage soon after full-leaf development (Dow Chemical Co. 1981). Photodecomposition of triclopyr is rapid with a half-life of 10 hr in water at 25° C (Weed Science Society of America 1979). Generally, triclopyr behaves similarly to the phenoxy herbicides; however, published information describing its activity in water is limited.

2,4-D BEE

5. The empirical formula of the butoxyethanol ester of 2,4-D is $C_{14}H_{18}Cl_2O_4$ and its structural formula is:



2,4-D BEE

6. Commercial formulations of 2,4-D BEE for aquatic use are available on special heat-treated attaclay granules, e.g., Aqua-Kleen; these granules resist rapid decomposition in water, permitting release of the 2,4-D into the water near the sediment-water interface. This formulation is 19 percent a.e. by weight. Hoeppel and Westerdahl (1983) showed that most of the 2,4-D BEE is converted to the acid form within less than 24 hr following release from the attaclay granule. Zepp et al. (1975) and Bothwell and Daley (1981) showed that more than 95 percent of the 2,4-D BEE would be chemically hydrolyzed within 24 hr at the average temperature of 30° C and pH of 8.0; the hydrolysis half-life would be less than 5 hr. Photosensitization reactions with organic matter (Zepp et al. 1975), microbial enzymatic hydrolysis (Paris et al. 1981), and metabolic activities of aquatic organisms (Rodgers and Stallings 1972) have resulted in faster hydrolysis rates. The mode of action of 2,4-D has been investigated extensively over the past 40 years (Westerdahl et al. 1983, and Westerdahl and Hall 1983). However, the specific mode of action is still unclear.

Test Plots

7. Seven 0.4-ha (1-acre) plots were established in the Spring Creek arm of Lake Seminole, Ga., in heavy stands of Eurasian watermilfoil where water depth was approximately 1.5 m (Figure 1). Herbicide was applied to five plots on 22 July 1983. Plots 1, 2, and 3 were treated with the elastomer-based 14-ACE-B at 22 kg a.e./ha (20 lb/acre), 45 kg a.e./ha (40 lb/acre), and 90 kg a.e./ha (80 lb/acre), respectively. Plots 4 and 5 were treated with a liquid formulation of Garlon 3A at 1.0 mg a.e./ℓ and 2.5 mg a.e./ℓ, respectively. The 14-ACE-B formulation was broadcast from an airboat uniformly over the plots. Garlon 3A was tank mixed with water and sprayed from an airboat over the

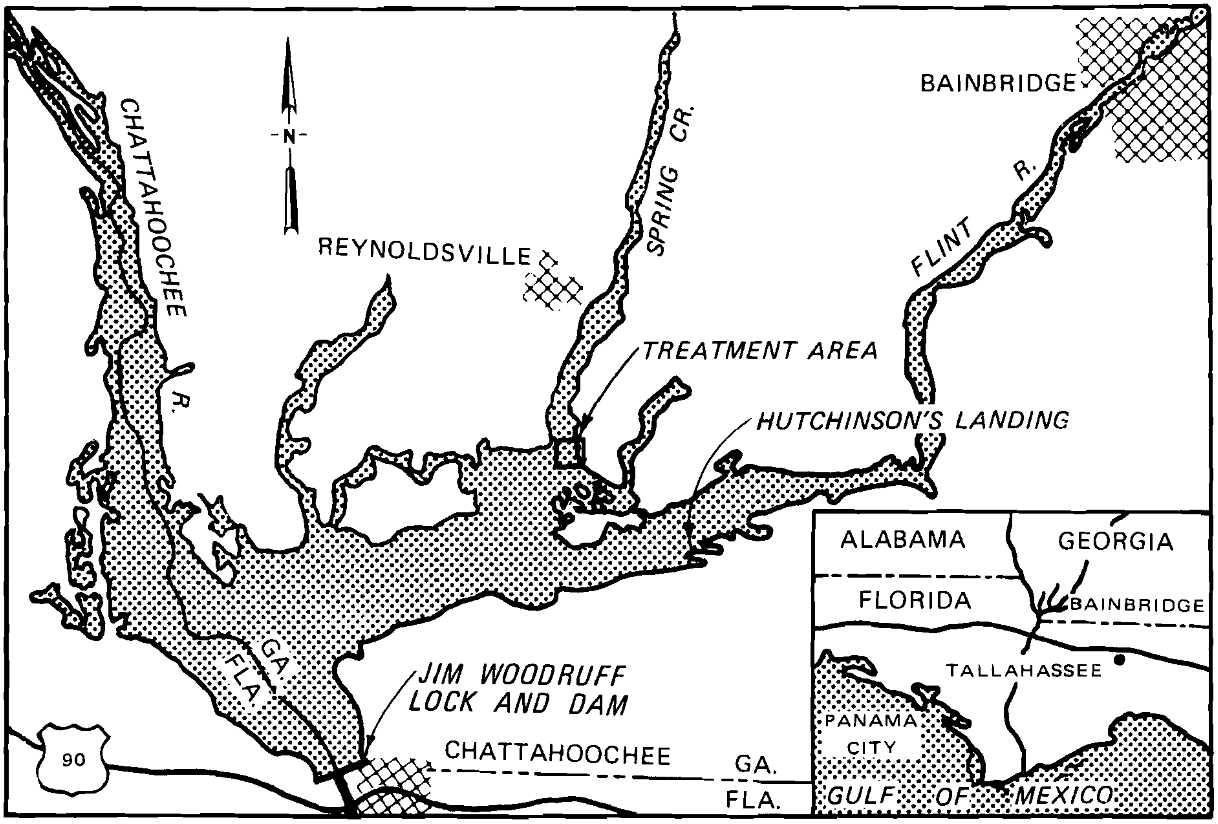


Figure 1. Location of the treatment plots in Lake Seminole, Georgia

surface area of the plots at or just below the surface of the water. Plots 6 and 7 located upstream of the treatment areas were designated as reference plots and were not treated. Plots were separated by a minimum distance of 250 m to minimize cross-contamination from herbicide drift.

8. Water and sediment samples were collected in all plots except plot 2 which was monitored for herbicide efficacy only. Water samples for herbicide residue analysis were collected with a 12V d-c Jabsco pump attached to a weighted, drinking-quality water hose with a screened inflow orifice. These samples were taken 1 day prior to treatment and on posttreatment days 1, 7, 14, 28, and 56. Water samples in plots 1, 3, 6, and 7 were taken at approximately 0.3 m above the bottom along three transects within each plot. Each residue sample represented a composite of four samples taken along each transect. Water samples in plots 4 and 5 were taken in the center of each plot and 50 m downstream from each plot at the water surface, middepth (approximately 0.7 m), and approximately 0.3 m above the sediment. Sediment samples for herbicide residue analysis were collected one day prior to treatment and on posttreatment days 28, 56, and 84 using a pole-mounted scoop-type

sampler with a cable-operated lid. Each sediment sample represented a composite of 10 to 15 samples taken within each plot.

9. Residues of 2,4-D in water were determined by high pressure liquid chromatography and in sediment by gas chromatography using approved, standard procedures (American Public Health Association 1976). The 2,4-D analyses were performed by the Laboratory Branch of the Tennessee Valley Authority. Residues of triclopyr in water were determined by ACR 76.8.S1* and in sediment by ACR 77.5.S1.* The triclopyr analyses were developed and performed by Dow Chemical Company.

10. A Hydrolab 8000 water-quality monitor was used to measure water depth, temperature, pH, dissolved oxygen (DO), and specific conductivity at the water surface, middepth, and 0.3 m above the sediment. These variables were monitored in the center of all of the plots as well as 50 m downstream from each Garlon 3A plot, between 0830 and 1200 hr on the same dates that water residue samples were collected.

11. Qualitative changes in the watermilfoil standing crop were monitored visually, and efficacy estimates were based on those observations.

---

* Proprietary analytical procedures. Code number provided by Dow Chemical Co., Midland, Mich.

PART III: RESULTS AND DISCUSSION

Garlon 3A

Efficacy

12. Watermilfoil in plot 4 (1.0-mg/ℓ treatment rate) began to decompose by posttreatment day 14; leaf abscission was noticeable and stems began to fold and sink to the sediment surface. Efficacy was estimated at 10 percent on posttreatment day 14. Large areas of open water were evident within the treatment plot by day 28 and efficacy was estimated at 50 to 60 percent. Watermilfoil was damaged up to 5 m outside the plot boundary. Regrowth of watermilfoil was observed by posttreatment day 56. New, healthy shoots were sprouting from root crowns and stems which survived the herbicide treatment. Watermilfoil control was estimated at 50 percent on posttreatment day 56.

13. Watermilfoil in plot 5 (2.5-mg/ℓ treatment rate) showed toxic symptoms by posttreatment day 7 when the apical meristem began to soften. Rapid watermilfoil deterioration was observed by posttreatment day 14. Stems throughout the plot were sinking, and leaf abscission was apparent. Holes several metres wide were present within the treated watermilfoil mat. Efficacy was estimated at 35 to 40 percent at this time. By posttreatment day 28, large areas of open water dominated the plot and efficacy was estimated at 60 to 70 percent. Plant toxicity was noted up to 20 m beyond the plot boundary. Regrowth from root crowns and stems was observed on posttreatment day 56, when watermilfoil control was estimated at 50 to 60 percent.

14. Toxicity symptoms appeared more slowly within the Garlon 3A plots, particularly at the low-level treatment, than what is typically observed in 2,4-D BEE-treated plots (Hoeppel and Westerdahl 1983). Also, Garlon 3A was less efficacious at the application rates used in this study than when compared with 2,4-D BEE treatments of milfoil.

Residue persistence

15. Triclopyr levels in the water column of plot 4 (1.0-mg/ℓ treatment rate) reached a maximum concentration of 28 μg/ℓ inside the plot and 25 μg/ℓ 50 m outside the plot on posttreatment day 1 (Table 1). Triclopyr declined to concentrations below the level of detection (<10 μg/ℓ) both inside and outside the plot by posttreatment day 7 and remained below detection through posttreatment day 14. Triclopyr concentrations in the sediment remained below

detection (<100 μg/kg) through posttreatment day 56 (Table 2).

16. Triclopyr concentrations in the water column of plot 5 (2.5-mg/ℓ treatment rate) peaked at 166 μg/ℓ inside the plot but reached only 26 μg/ℓ 50 m outside the plot on posttreatment day 1 (Table 3). Low levels of triclopyr, 14-16 μg/ℓ, were detected inside the plot on posttreatment day 7. Triclopyr levels decreased to concentrations below the level of detection inside and outside the plot by posttreatment day 14. Triclopyr concentrations in the sediment remained below detection through posttreatment day 56 (Table 4). This rapid dissipation and/or degradation of triclopyr in lake water and sediment was expected since photodecomposition of triclopyr is rapid in water and triclopyr degrades quite rapidly when exposed to temperature conditions favorable to microbial activity (Weed Science Society of America 1979).

17. Triclopyr was applied as a liquid formulation throughout heavy stands of milfoil in Spring Creek. Absorption of triclopyr by milfoil and dissipation by water currents contributed to the very low triclopyr concentrations found in the water and sediment.

18. Triclopyr levels detected on posttreatment day 1 approximately 50 m downstream from the treated plots were probably related to lateral dispersion via density gradients and water movement (Tables 1 and 2). The higher levels of triclopyr outside the low-level treatment plot may have been due to differences in water flow between the low-level and high-level plots.

14-ACE-B

Efficacy

19. Watermilfoil in all treated plots was beginning to show symptoms of 2,4-D treatment by posttreatment day 4. On posttreatment day 7, some watermilfoil plants in all treated plots were dropping out of the water column. Treatment efficacy was estimated at 40 to 50 percent in the 22- and 45-kg a.e./ha 2,4-D BEE treatments (plots 1 and 2) and at approximately 50 percent in the 90-kg a.e./ha 2,4-D BEE treatment (plot 3) on posttreatment day 14. Maximum watermilfoil control was observed on posttreatment day 28. An estimated 60 to 70 percent of the watermilfoil in the 22- and 45-kg a.e./ha plots was decomposing or had disintegrated and 75 to 85 percent control was estimated for the 90-kg a.e./ha plot. Watermilfoil more than 30 m outside the treated plots as well as within the reference plots (plots 6 and 7) was still healthy at this time and remained so throughout the study. Areal coverage of

watermilfoil had recovered with substantial regrowth evident in all of the treated plots by posttreatment day 56. At this point all treated plots had recovered to approximately 50 to 60 percent of the original watermilfoil standing crop.

Residue persistence

20. Residue analyses indicated that concentrations of 2,4-D in the water column ranged from 40 to 66 μg/ℓ in plot 1 (22-kg a.e./ha treatment rate) and from 71 to 130 μg/ℓ in plot 3 (90-kg a.e./ha treatment rate) on posttreatment day 1 (Table 5). Herbicide concentrations decreased in both plots by posttreatment day 7 and remained low (<10 to 37 μg/ℓ) from posttreatment day 14 through posttreatment day 56. Concentrations of 2,4-D in the sediment reached a peak of 1300 μg/kg in the 90-kg/ha plot and 880 μg/kg in the 22-kg/ha plot on posttreatment day 28 (Table 6). Sediment levels of 2,4-D ranged from <100 to 230 μg/kg on posttreatment days 56 and 84.

21. Dissipation of 2,4-D in the water and sediment following release by the CR elastomer formulation in this study was similar to that observed in a study by Hoeppel and Westerdahl (1983). Sustained levels of 2,4-D in the water column of the 14-ACE-B plots were well below established threshold levels for watermilfoil control. Westerdahl and Hall (1983) determined that the minimum sustained 2,4-D concentrations required to control watermilfoil were between 40 and 100 μg/ℓ and that a period of 3-4 weeks with continuous exposure of 30 to 50 μg/ℓ 2,4-D was required to achieve 50 percent watermilfoil injury. The 14-ACE-B formulation used in this study essentially had released all of the 2,4-D BEE into the water column in less than 2 weeks, most of which was released during the first week. These results suggest that the CR elastomer was ineffective in governing the slow release of 2,4-D BEE.

Water Quality

22. No discernible changes in water quality parameters occurred between the 2,4-D BEE and Garlon 3A treatment and reference plots during the study (Tables 7-14). Likewise, no harmful effects were observed with respect to fauna in the treatment areas following 2,4-D BEE and Garlon 3A application and subsequent habitat changes.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

23. The following conclusions can be drawn concerning the use of Garlon 3A (triclopyr) and 14-ACE-B (2,4-D BEE) as potential herbicides for the control of Eurasian watermilfoil:

a. Garlon 3A (triclopyr).

(1) Rapid dissipation of triclopyr occurred in the water and sediment of both the low treatment rate (1.0 mg/ℓ) and high treatment rate (2.5 mg/ℓ) plots; hence, contact time with plants was reduced significantly and efficacy diminished.

(2) Garlon 3A at the 2.5-mg/ℓ application rate gave slightly better control of watermilfoil than did the 1.0-mg/ℓ application rate; however, Garlon applied at these rates did not control watermilfoil as well as 2,4-D BEE applied at conventional rates.

b. 14-ACE-B (2,4-D BEE).

(1) The CR formulation 14-ACE-B failed to provide desired long-term 2,4-D concentrations in the water column, although a majority of the watermilfoil population was controlled for a short time.

(2) The CR elastomer formulation 14-ACE-B is ineffective under the given field conditions as a CR 2,4-D BEE formulation. Behavior is similar to conventional 2,4-D BEE, i.e. Aqua-Kleen.

24. The following are recommendations based on this study:

a. Garlon 3A shows promise as an aquatic herbicide. Additional field testing at higher application rates should be performed to determine effective application rates.

b. The CR elastomer formulation 14-ACE-B as designed, should not be considered an appropriate carrier for long-term 2,4-D BEE delivery in aquatic environments.

REFERENCES

American Public Health Association. 1976. Standard Methods for the Examination of Water and Wastewater, 14th ed., APHA, Washington, D. C.

Bothwell, M. L., and Daley, R. J. 1981. "Selected Observations on the Persistence and Transport of Residues from Aqua-Kleen 20 (2,4-D) Treatments in Wood and Kalamalka Lakes, B. C.," The National Water Research Institute, Inland Waters Directorate, Pacific and Yukon Region, West Vancouver, B. C.

Dow Chemical. 1981. "Technical Information on Triclopyr, the Active Ingredient of Garlon Herbicides," Technical Data Sheet No. 137-859-81.

Hoeppel, R. E., and Westerdahl, H. E. 1983. "Dissipation of 2,4-D DMA and BEE from Water, Mud, and Fish at Lake Seminole, Georgia," Water Resources Bulletin, Vol 19, pp 197-204.

Paris, D. F., Steen, W. C., Baughman, G. L., and Barnett, J. T., Jr. 1981. "Second-Order Model to Predict Microbial Degradation of Organic Compounds in Natural Waters," Applied and Environmental Microbiology, Vol 41, pp 603-609.

Radosevich, S. R., and Bayer, D. E. 1977. "Effect of Temperature and Photoperiod on Triclopyr, Picloram, and 2,4,5-T Translocation," Weed Science, Vol 27, pp 22-27.

Rodgers, C. A., and Stallings, D. L. 1972. "Dynamics of an Ester of 2,4-D in Organs of Three Fish Species," Weed Science, Vol 20, pp 101-105.

Westerdahl, H. E., and Hall, J. F. 1983. "Threshold 2,4-D Concentrations for Control of Eurasian Watermilfoil and Sago Pondweed," Journal of Aquatic Plant Management, Vol 21, pp 22-25.

Westerdahl, H. E., Hoeppel, R. E., Hummert, E., and Williams, L. 1983. "Determination of Chemical Threshold Concentrations Using 2,4-D to Control Selected Aquatic Macrophytes--A Pilot Study to Evaluate a Laboratory System," Technical Report A-83-4, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Weed Science Society of America. 1979. Herbicide Handbook of the Weed Science Society of America, 4th ed.

Zepp, R. G., Wolfe, N. L., Gordon, J. A., and Baughman, G. L. 1975. "Dynamics of 2,4-D Esters in Surface Waters--Hydrolysis, Photolysis, and Vaporization," Environmental Science and Technology, Vol 9, No. 13, pp 1144-1150.

Table 1

Analysis of Water for Triclopyr in Plot 4

Treatment Rate mg/ℓ	Day	Sampling Depth	Sampling Location*	Triclopyr, μg/ℓ**
0	Pretreatment	Surface	1	ND†
		Middle	1	ND
		Bottom	1	ND
		Surface	0	ND
		Middle	0	ND
		Bottom	0	ND
1.0	Posttreatment-1	Surface	1	24
		Middle	1	23
		Bottom	1	28
		Surface	0	20
		Middle	0	23
		Bottom	0	25
	Posttreatment-7	Surface	1	ND
		Middle	1	ND
		Bottom	1	ND
		Surface	0	ND
		Middle	0	ND
		Bottom	0	ND
	Posttreatment-14	Surface	1	ND
		Middle	1	ND
		Bottom	1	ND
		Surface	0	ND
		Middle	0	ND
		Bottom	0	ND

* 1 = inside plot, 0 = outside plot.

** Percent recovery = 94.

† ND = nondetectable (<10 μg/ℓ).

Table 2

Analysis of Bottom Sediment for Triclopyr in Plot 4*

Treatment Rate mg/ℓ	Day	Sampling Location**	Triclopyr, μg/kg†
0	Pretreatment	1	ND††
		1	ND
		0	ND
		0	ND
1.0	Posttreatment-14	1	ND
		1	ND
		0	ND
		0	ND
	Posttreatment-28	1	ND
		1	ND
		0	ND
		0	ND
	Posttreatment-56	1	ND
		1	ND
		0	ND
		0	ND

* Values represent 10-15 samples taken within each plot and composited.
** 1 = inside plot, 0 = outside plot.
† Percent recovery = 80.
†† ND = nondetectable (<100 μg/kg).

Table 3

Analysis of Water for Triclopyr in Plot 5

Treatment Rate mg/ℓ	Day	Sampling Depth	Sampling Location*	Triclopyr, μg/ℓ**
0	Pretreatment	Surface	1	ND†
		Middle	1	ND
		Bottom	1	ND
		Surface	0	ND
		Middle	0	ND
		Bottom	0	ND
2.5	Posttreatment-1	Surface	1	155
		Middle	1	166
		Bottom	1	114
		Surface	0	15
		Middle	0	26
		Bottom	0	18
	Posttreatment-7	Surface	1	14
		Middle	1	16
		Bottom	1	16
		Surface	0	12
		Middle	0	12
		Bottom	0	12
	Posttreatment-14	Surface	1	ND
		Middle	1	ND
		Bottom	1	ND
		Surface	0	ND
		Middle	0	ND
		Bottom	0	ND

* 1 = inside plot, 0 = outside plot.
** Percent recovery = 94.
† ND = nondetectable (<10 μg/ℓ).

Table 4

Analysis of Bottom Sediment for Triclopyr in Plot 5*

Treatment Rate mg/ℓ	Day	Sampling Location**	Triclopyr, μg/kg†
0	Pretreatment	1	ND††
		1	ND
		0	ND
		0	ND
2.5	Posttreatment-14	1	ND
		1	ND
		0	ND
		0	ND
	Posttreatment-28	1	ND
		1	ND
		0	ND
		0	ND
	Posttreatment-56	1	ND
		1	ND
		0	ND
		0	ND

* Values represent 10-15 samples taken within each plot and composited.
** 1 = inside plot, 0 = outside plot.
† Percent recovery = 80.
†† ND = nondetectable (<100 μg/kg).

Table 5

Analysis of Water for 2,4-D BEE (μg/ℓ) in Plots 1, 3, 6, and 7*,**

Day	Plot 1 (22-kg/ha Treatment)	Plot 3 (90-kg/ha Treatment)	Plot 6 (Reference 1)	Plot 7 (Reference 2)
Pretreatment	19	36	31	48
	ND†	ND	23	ND
	--	ND	14	11
Posttreatment-1	56	130	31	42
	66	71	12	20
	40	130	ND	12
Posttreatment-7	14	53	65	22
	24	36	ND	ND
	33	28	ND	ND
Posttreatment-14	ND	ND	ND	ND
	ND	ND	ND	ND
	ND	ND	ND	ND
Posttreatment-28	37	ND	34	32
	ND	ND	ND	ND
	ND	ND	ND	ND
Posttreatment-56	17	22	44	ND
	14	ND	ND	ND
	34	ND	ND	ND

* Values represent four samples taken along a transect and composited.
** Percent recovery = 86-103.
† ND = nondetectable (<10 μg/ℓ).

Table 6

Concentration of 2,4-D BEE (μg/kg) in Bottom Sediment from Plots 1, 3, 6, and 7*,**

Day	Plot 1 (22-kg/ha Treatment)	Plot 3 (90-kg/ha Treatment)	Plot 6 (Reference 1)	Plot 7 (Reference 2)
Pretreatment	ND†	ND	ND	ND
Posttreatment-28	880	1300	ND	140
Posttreatment-56	ND	190	130	140
Posttreatment-84	230	ND	ND	180

* Values represent 10-15 samples taken within each plot and composited.
** Percent recovery = 81.
† ND = nondetectable (<100 μg/kg).

Table 7

Water Quality Measurements in Plot 1

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity μmho/cm	pH
Pretreatment	Surface	28.6	7.4	152	8.6
	Middle	28.2	4.8	168	8.0
	Bottom	28.1	2.6	181	7.8
Posttreatment-1	Surface	28.9	7.4	157	8.3
	Middle	28.9	7.2	160	8.3
	Bottom	28.9	4.1	167	7.9
Posttreatment-4	Surface	29.3	6.5	174	8.1
	Middle	29.3	6.4	175	8.1
	Bottom	28.8	3.1	162	7.9
Posttreatment-7	Surface	27.8	4.5	180	7.8
	Middle	27.8	4.5	179	7.8
	Bottom	27.7	4.3	178	7.8
Posttreatment-14	Surface	28.7	8.5	148	8.6
	Middle	28.4	7.8	159	8.3
	Bottom	27.4	4.6	163	7.8
Posttreatment-28	Surface	27.3	6.5	185	8.0
	Middle	27.3	6.3	188	8.0
	Bottom	27.3	5.5	192	7.8
Posttreatment-56	Surface	27.9	7.6	215	8.3
	Middle	27.2	8.0	217	8.4
	Bottom	26.2	7.4	220	8.2

Table 8

Water Quality Measurements in Plot 3

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity μmho/cm	pH
Pretreatment	Surface	28.4	7.7	148	8.6
	Middle	28.4	5.4	156	8.1
	Bottom	28.2	2.4	167	7.9
Posttreatment-1	Surface	28.9	6.2	138	8.2
	Middle	28.9	5.5	141	7.9
	Bottom	28.7	2.6	160	7.6
Posttreatment-4	Surface	29.3	5.6	133	8.3
	Middle	29.2	5.3	133	8.1
	Bottom	28.1	1.8	153	7.4
Posttreatment-7	Surface	27.7	3.6	159	7.8
	Middle	27.7	3.4	160	7.8
	Bottom	27.7	2.9	162	7.8
Posttreatment-14	Surface	28.6	3.1	174	7.8
	Middle	28.5	2.2	178	7.7
	Bottom	27.4	0.3	203	7.4
Posttreatment-28	Surface	27.5	3.1	202	7.6
	Middle	27.4	2.4	203	7.5
	Bottom	27.3	1.6	208	7.4
Posttreatment-56	Surface	28.1	7.7	207	8.2
	Middle	27.7	6.6	211	8.1
	Bottom	27.1	3.5	221	7.7

Table 9

Water Quality Measurements in Plot 6

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity μmho/cm	pH
Pretreatment	Surface	28.2	8.1	172	8.4
	Middle	28.2	7.9	172	8.3
	Bottom	28.0	5.8	190	8.1
Posttreatment-1	Surface	28.7	8.6	154	8.4
	Middle	28.7	8.5	154	8.4
	Bottom	28.5	5.6	177	7.9
Posttreatment-4	Surface	29.1	8.7	165	8.5
	Middle	29.1	8.5	167	8.3
	Bottom	28.3	4.4	191	7.6
Posttreatment-7	Surface	27.4	3.6	173	7.8
	Middle	27.4	3.4	175	7.8
	Bottom	27.4	3.2	177	7.8
Posttreatment-14	Surface	28.3	7.6	166	8.6
	Middle	28.2	7.2	169	8.5
	Bottom	27.2	2.0	214	7.7
Posttreatment-28	Surface	27.2	3.9	199	7.9
	Middle	27.1	3.6	197	7.8
	Bottom	27.1	2.3	203	7.7
Posttreatment-56	Surface	27.5	8.9	181	8.5
	Middle	27.3	7.5	188	8.3
	Bottom	26.5	3.0	216	7.8

Table 10

Water Quality Measurements in Plot 7

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity μmho/cm	pH
Pretreatment	Surface	28.5	6.9	191	8.2
	Middle	28.4	6.4	191	8.1
	Bottom	28.4	5.6	195	8.0
Posttreatment-1	Surface	28.8	7.1	180	8.1
	Middle	28.8	6.4	186	8.0
	Bottom	28.8	6.0	189	8.0
Posttreatment-4	Surface	29.4	8.9	160	8.2
	Middle	29.4	8.5	160	8.1
	Bottom	28.8	5.4	177	7.9
Posttreatment-7	Surface	27.4	3.8	180	7.8
	Middle	27.4	3.6	181	7.8
	Bottom	27.4	3.3	182	7.8
Posttreatment-14	Surface	28.6	8.8	155	8.8
	Middle	28.3	6.2	165	8.2
	Bottom	27.9	1.3	193	7.7
Posttreatment-28	Surface	27.3	6.4	187	8.1
	Middle	27.3	5.8	188	8.0
	Bottom	27.2	4.9	193	7.8
Posttreatment-56	Surface	27.7	8.5	194	8.4
	Middle	27.2	7.3	208	8.1
	Bottom	26.7	2.0	238	7.7

Table 11

Water Quality Measurements Inside Plot 4

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity µmho/cm	pH
Pretreatment	Surface	28.3	5.4	148	8.1
	Middle	28.3	5.1	157	8.0
	Bottom	28.2	5.0	168	7.9
Posttreatment-1	Surface	29.2	6.3	147	8.0
	Middle	29.2	6.2	146	8.1
	Bottom	29.0	6.1	147	8.0
Posttreatment-4	Surface	30.1	8.0	135	8.0
	Middle	29.7	6.4	138	6.4
	Bottom	28.5	6.4	140	6.4
Posttreatment-7	Surface	28.2	4.7	137	8.0
	Middle	28.2	4.5	137	8.0
	Bottom	28.1	4.6	136	8.0
Posttreatment-14	Surface	28.6	7.0	149	8.2
	Middle	28.6	6.7	150	8.2
	Bottom	28.0	4.6	165	7.9
Posttreatment-28	Surface	27.8	5.5	181	8.0
	Middle	27.8	5.4	182	8.0
	Bottom	27.7	5.5	180	8.0
Posttreatment-56	Surface	27.6	8.7	193	8.3
	Middle	27.6	8.4	192	8.3
	Bottom	26.6	3.1	216	7.8

Table 12

Water Quality Measurements Outside Plot 4

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity μmho/cm	pH
Pretreatment	Surface	28.3	6.7	151	8.2
	Middle	28.3	6.2	154	8.2
	Bottom	28.2	6.0	155	8.1
Posttreatment-1	Surface	28.9	7.2	144	8.3
	Middle	28.9	6.9	145	8.2
	Bottom	28.8	5.5	149	7.8
Posttreatment-4	Surface	30.3	9.9	124	9.0
	Middle	29.6	6.9	135	8.4
	Bottom	28.5	5.2	146	8.1
Posttreatment-7	Surface	28.2	5.7	137	8.1
	Middle	28.2	5.3	136	8.0
	Bottom	28.0	4.8	135	7.9
Posttreatment-14	Surface	28.5	7.0	144	8.3
	Middle	28.4	6.5	148	8.1
	Bottom	26.9	0.4	205	7.5
Posttreatment-28	Surface	27.7	3.5	190	7.8
	Middle	27.7	2.9	191	7.8
	Bottom	27.6	2.2	193	7.6
Posttreatment-56	Surface	27.8	7.4	185	8.3
	Middle	27.4	5.6	199	8.0
	Bottom	26.6	2.7	212	7.8

Table 13

Water Quality Measurements Inside Plot 5

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity µmho/cm	pH
Pretreatment	Surface	28.3	5.7	148	8.1
	Middle	28.3	5.6	147	8.1
	Bottom	28.3	5.4	149	8.1
Posttreatment-1	Surface	29.0	6.3	140	8.1
	Middle	28.9	6.0	140	8.0
	Bottom	28.8	4.6	141	7.8
Posttreatment-4	Surface	30.2	9.2	129	8.9
	Middle	29.5	6.1	136	8.2
	Bottom	28.0	3.4	148	7.8
Posttreatment-7	Surface	28.1	3.2	154	7.9
	Middle	28.1	3.2	153	7.9
	Bottom	28.1	3.2	154	7.9
Posttreatment-14	Surface	28.7	4.8	158	8.1
	Middle	28.7	4.4	160	8.0
	Bottom	28.7	0.3	179	7.6
Posttreatment-28	Surface	27.6	3.8	198	7.7
	Middle	27.6	3.5	199	7.7
	Bottom	27.6	3.2	203	7.6
Posttreatment-56	Surface	27.7	8.5	207	8.3
	Middle	27.3	6.0	214	8.0
	Bottom	26.0	0.9	223	7.7

Table 14

Water Quality Measurements Outside Plot 5

Day	Sampling Depth	Temperature °C	DO mg/ℓ	Conductivity µmho/cm	pH
Pretreatment	Surface	28.3	6.2	143	8.2
	Middle	28.3	5.6	151	8.0
	Bottom	28.3	1.8	170	7.6
Posttreatment-1	Surface	28.9	7.1	126	8.3
	Middle	28.9	6.5	127	8.2
	Bottom	28.9	6.5	129	8.2
Posttreatment-4	Surface	30.3	10.9	116	9.2
	Middle	29.5	8.0	124	8.5
	Bottom	28.1	4.7	137	7.9
Posttreatment-7	Surface	28.1	3.3	154	7.9
	Middle	28.1	2.8	163	7.8
	Bottom	28.1	2.9	165	7.8
Posttreatment-14	Surface	28.8	4.6	153	8.2
	Middle	28.7	3.7	156	7.9
	Bottom	27.5	0.4	182	7.5
Posttreatment-28	Surface	27.6	5.5	189	8.0
	Middle	27.6	5.4	190	7.9
	Bottom	27.5	5.0	193	7.8
Posttreatment-56	Surface	27.9	6.8	210	8.1
	Middle	27.5	5.9	211	8.0
	Bottom	26.8	2.9	222	7.8