Final Report

Impact of Malathion on Fish and Aquatic Invertebrate Communities and on Acetylcholinesterase Activity in Fishes within Stewart Creek, Fayette County, Alabama

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Introduction

A program coordinated by the United States Department of Agriculture (USDA) is currently underway to eradicate the boll weevil from cotton-growing areas in the United States. This program employs repeated treatment of cotton fields with the pesticide malathion. No-spray buffers are currently used around aquatic habitats as protective measures for federally endangered and threatened species inhabiting such areas. Laboratory experiments have shown malathion to be toxic to fishes (Macek & McAllister 1970, Domanik & Zar 1978, Beyers & Sikoski 1994) and even more so to freshwater invertebrates (Finlayson et al. 1982). This study was undertaken to assess any adverse effects on the aquatic fauna from a worst-case scenario application of malathion to cotton fields adjacent to a small stream in Alabama. This study specifically examined the negative impacts on fish and aquatic invertebrate communities, certain taxa within these communities, and/or any possible depression of acetylcholinesterase activity in fishes. The results of this study should provide insight into the efficiency of current protective buffers around aquatic habitats.

Study Locations

Our study sites were on Stewart Creek, located approximately 6 miles (9.7 kilometers) south of Winfield in Fayette County, west-central Alabama (Figure 1). Stewart Creek is a fourth order stream with a drainage area of approximately 11 square miles (28.5 square kilometers), and is located in the Coastal Plain physiographic province. It is a tributary to the upper Tombigbee River, a major system of the Mobile Basin

Drainage. Three locations were sampled during the first year (Year 1) of this study: one at the spray location (Spray), one downstream of the spray location (Downstream), and a control upstream of the spray location (Control). The last mile of Stewart Creek has been channelized; the Spray and Downstream locations were located in this portion of the stream. Only the Downstream and Control locations were sampled in the second (Year 2) and third year (Year 3) of the study due to fiscal constraints.

The Spray location was located just upstream of County Road 21 (Figure 1). It was bordered to the north and south by cotton fields measuring 11.6 and 7.6 acres (4.7 and 3.1 hectares), respectively. These fields came to within 25 feet (7.6 meters) of the creek. The eroding banks were covered only with kudzu, ragweed, and small amounts of grasses, offering no shade to the aquatic habitat. The lack of riparian vegetation also offered no obstructions to malathion drift; this plus the lack of any no-treatment buffers made Stewart Creek a worst-case scenario with respect to malathion application. The creek consisted mostly of long, slow flowing pools and occasional riffles. Beaver activity at the bridge during various sampling periods had deepened and slowed the water over a portion of the study area at times. The creek's substrate was mostly sand with small amounts of fine gravel in the riffles.

The Downstream location was in a pasture approximately 0.5 miles (0.8 kilometers) downstream of County Road 21 (Figure 1). Hardwood trees lined the north side of the creek; the south side was eroding banks with sparse vegetation. Here the creek was a series of pools and riffles. Substrate consisted of sand in the pools, gravel in riffles and runs, and concrete slabs in a riffle used as a ford in the creek. This location was more heterogeneous than the other two sites.

The Control location was just downstream of US/Alabama highways 43/171, where Stewart Creek was bordered on both sides by old overgrown fields (Figure 1). The banks were mostly stable and lined on both sides by hardwood trees shading most of the creek. The creek consisted of a series of pools and riffles; some beaver activity at the lower end of the location has slowed and deepened the water at times. The substrate was sand with some gravel in pools and various-sized gravel in riffles and runs. The substrate at this location appeared to be more stable relative to the experimental locations, probably due to the lack of channel modification here. Large, boulder-sized rip-rap was located just below the highway bridge. This rip-rap habitat was collected only when it was necessary to augment samples of fishes for the acetylcholinesterase study when appropriate numbers were not available in the "natural" habitat at the Control location.

Experimental Consideration

This field study was not without experimental complications. First, the experimental fields at Stewart Creek were treated with numerous chemicals prior to malathion application (Appendix 1), and malathion was applied in response to boll weevil populations and not to a rigorous experimental design. Second, an 11 acre (4.5 hectare) cotton field located 0.25 miles (0.4 kilometers) upstream of the experimental fields (Figure 1) was sprayed with malathion during the first two years of our study period, as well as on the day of our pre-spray invertebrate collection and the day before our pre-spray fish sample (Appendix 2). Fortunately, a wooded no-treatment buffer of 600 feet (183 meters) is present along Stewart Creek at this upstream field. Third, even without the above complication, only one sample was taken at each location before the first application of malathion to the study area. This single sample provided little information regarding the pre-spray biological variation within Stewart Creek, especially at the Spray and Downstream locations. Last, our Control location had moderately different physical stream characteristics (more stable substrate, more shade, slightly smaller stream bed) compared to the Spray and Downstream locations, although substrate type and flow parameters were similar. Many of these shortcomings in the experimental design of this field study were offset by three years of sampling, which included two years of sampling during malathion application and a third year of no application (a post-treatment "control").

The laboratory study to determine if malathion application reduces acetylcholinesterase activity in fishes also possessed some experimental complications. There are known factors, other than malathion, that can influence activity levels of acetylcholinesterase, including the size of the specimen and its physiological state. Acetylcholinesterase activity naturally decreases with increasing specimen size and brain weight (Weiss 1958, 1961, Gibson et al. 1969). Larger fishes, as well as those near death before being frozen, would demonstrate a depressed activity. Attempts were made in this study to collect similar-sized individuals at each location to control for this activity variation, but this was not always possible.

Several other factors can affect acetylcholinesterase activity in fishes. One series of factors includes the concentration of malathion and the time of exposure required to produce a reduction in acetylcholinesterase activity, and the time needed to recover from non-lethal doses, which may range from hours to days (Weiss 1961). A second factor involves prior exposure to malathion, which increases the sensitivity of fishes to subsequent exposures (Weiss 1961). Additionally, different species of fishes may vary in their sensitivity to malathion (Weiss 1961; Domanik & Zar 1978). Thus, acetylcholinesterase activity can depend upon (i) concentration of malathion necessary to produce a reduction in the test species, (ii) length of time the specimens were exposed to a sufficient concentration, (iii) length of time between a decrease in concentration and actual collection that could constitute a recovery period, and (iv) whether any of the specimens were previously exposed to a sufficient concentration of malathion for a sufficient length of time to increase their susceptibility to current malathion concentrations.

Methods

Sampling

Fishes and aquatic invertebrates were recorded from experimental and control locations using time-limited sampling efforts designated to effectively sample all available habitats. Fishes were sampled with a 10 by 6 foot by 1/8 inch (3 by 1.8 meter by 3.2 millimeter) mesh seine over a 30 minute period at each location. Collecting consisted of downstream hauls in pools and unobstructed runs, and "set and kick" collecting in riffles and along undercut banks. Fish specimens were preserved in formalin, except for a subsample of *Notropis baileyi,* the Rough Shiner, and *Etheostoma rupestre*, the Rock Darter, which were frozen in liquid nitrogen for acetylcholinesterase activity analyses (see below). Because of concerns about depleting the population of fishes in Stewart Creek over the three year period of this study, starting and continuing from 15 December 1993 we recorded and then released (after completion of sampling) all specimens except those too small to field identify to species or those specimens needed for the acetylcholinesterase analyses.

Aquatic invertebrates were sampled at each location with two D-frame aquatic dipnets using "kick sampling" (Merritt and Cummins 1984) over a 30 minute period at each location. This method allows a greater variety of stream habitats to be sampled under a full scale of stream-flow conditions. Removal of aquatic invertebrates from the detritus/substrate kicked into a dipnet was performed in the field and specimens were then preserved in 80% ethanol.

Identification

Fish specimens were identified to species. Aquatic macroinvertebrates (e.g., Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), Diptera (true flies), Decapoda (crayfishes) were identified to genus using Merritt and Cummins (1984) and Harris (1987). Aquatic microinvertebrates (some dipteran larvae (midges), microcrustaceans) were identified to the lowest taxonomic level feasible within a reasonable period of time (usually family).

Acetylcholinesterase activity analyses

Fish from each sampling location were assayed for acetylcholinesterase activity for each collection date. *Notropis baileyi* and *Etheostoma rupestre* were used in these analyses. These species were present at all locations for almost every date. Additional advantages in using these two species are that they represent groups that are not closely related and therefore may have different responses to malathion. They also occupy very different micro-habitats where concentrations of instream malathion may differ; *N. baileyi* typically occupies mid-water levels, whereas *E. rupestre* is a benthic fish. Brain tissue samples were removed from each specimen and analyzed separately. Samples were homogenized in 0.1 M sodium phosphate buffer (pH 8) and protein determined by the BCA assay (Smith et al. 1985) using bovine serum albumin as standard. Acetylcholinesterase activity was determined by the method of Ellman et al. (1961) as modified by Venturino et al. (1992).

Sampling period

A total of 39 representative samples from each experimental and the control location in Stewart Creek were taken over a 34 month period from August 1993 through May 1996. Due to the late start date of this study, only one pre-spray sample (August 1993) was taken at each location. A total of four samples (8, 16/17, 28 September, 13 October 1993) were taken during the Year 1 spray period either on the spray day or the following morning. Two of these samples followed ground spraying; two followed aerial applications. Year 1 also included no-spray monthly samples from November 1993 through June 1994.

Except for 12 July 1994, all samples for the Year 2 included only the Downstream and Control locations. Six samples were taken during the spray period, where all malathion applications were aerial. Those on 28 June, 6 and 12 July, 24 August, and 14 October were taken the day of or the morning following malathion application; the 16 September sample was taken three days following application. The sample of 12 August was not considered a spray sample because of the lack of malathion application for over two weeks prior to this date. All acute samples were coordinated, as best as possible, with advisement from USDA. Monthly no-spray samples from November 1994 though June 1995 concluded Year 2.

Because of the lack of boll weevil infestation during Year 3, no malathion was applied to the cotton fields at Stewart Creek. Eleven monthly samples were taken at the Downstream and Control locations from July 1995 through May 1996.

Malathion concentrations

Monitoring of malathion concentrations in Stewart Creek consisted of obtaining water samples downstream of the application area every 15 minutes, from one hour prior to four hours following malathion application. Water samples were obtained for all nine malathion applications in 1993 and for four of the 15 applications in 1994. Collection and analyses of water samples were performed by USDA personnel.

Data analysis

The null hypothesis with respect to the community structure and abundance of certain taxa was that the application of malathion to adjacent cotton fields did not alter the aquatic fauna in Stewart Creek. This was evaluated by comparing numbers of individuals, species, and the diversity index at each of the sampling locations: the Spray location within the experimental application area; the Downstream location, supposedly impacted from spraying malathion in the application area; and the Control location upstream of the cotton fields, outside the effects of spraying malathion in the application area.

A pre-spray baseline comparison of possible "natural" differences between these locations was not possible. Therefore, samples were grouped into spray and no-spray periods to examine how location variation (community structure or numbers of individuals of selected taxa) changed between these periods (Table 1 and 4). The one pre-spay sample (August 1993) was combined with the no-spray monthly samples from 12 November 1993 through 14 June 1994 for a total of nine no-spray samples for Year 1. There were four spray samples (8, 16/17, 28 September, 13 October 1993) for Year 1, and six spray sample (28 June, 6 and 12 July, 24 August, 16 September, and 14 October 1994) for Year 2. The second no-spray period covered 20 samples (12 August 1994 (see above), November 1994 - May 1996) due to the lack of malathion application in Year 3. To facilitate comparisons between spray and no-spray periods for all three years of the study, this second no-spray period was evaluated in three sections: nine samples of no-spray in Year 2 corresponding to the no-spray months of Year 1 (November 1994 - June 1995, 12 August 1994), four samples of no-spray Summer/Fall Year 3 corresponding to the spray period of Year 2 (July - October 1995), and seven samples of no-spray Winter/Spring Year 3, which again corresponding to the no-spray period of Year 1 (November 1995 - May 1996).

Species abundance at each sampling location was determined by the species captured during the sampling period. Diversity at each location was quantified using Margalef's diversity index (Ludwig and Reynolds 1988). Two species of fishes, *Notropis baileyi* and *Percina nigrofasciata*, the Blackbanded Darter, were common at all three locations throughout the study. This allowed an examination of differences in the numbers of specimens of these species between locations. Further advantages in using these two species include their non-relatedness and disparate micro-habitats (see above discussion of *N. baileyi* and *E. rupestre*). Additionally, *N. baileyi* happens to spawns during the Summer when malathion application occurs; therefore, it may be more sensitive to malathion than other non-breeding species due to possible adverse affects on its breeding behavior. Differences in numbers of individuals between locations in four orders of aquatic insects (Ephemeroptera, Plecoptera, Trichoptera, and Diptera) were also investigated. These taxa are commonly used as bio-indicators due to their sensitivity to pollutants (Norris and Georges 1993), thus they should be the most susceptible to any possible malathion impact. Additionally, these taxa make up a large percentage of the diet of bats. Because there are at least five species of insect-eating bats that are federally endangered in North America, there are concerns that any adverse affect of malathion on these orders of aquatic insects could impact the bats' food base.

Data analysis for Year 1 included an one-way ANOVA followed by the Tukey HSD test if significance was found for parametric data. Non-parametric data were tested with a Kruskal-Wallis one-way ANOVA followed by the Mann-Whitney U-Wilcoxon Rank Sum W test (Bonferroni adjusted) if significance occurred. Only two locations were studied in Year 2 and 3, therefore a T-test for independent samples was used for normally distributed data. A Mann-Whitney U-Wilcoxon Rank Sum W test was used to test significance for non-normal data. Statistical significance was inferred at $p < 0.05$. Data analyses were performed using SPSS Version 4.1 (SPSS 1990).

The null hypothesis tested with respect to the acetylcholinesterase study was that variation in acetylcholinesterase activity will not differ significantly between control and experimental locations. Rejection of this hypothesis followed if acetylcholinesterase activity was found to be reduced significantly ($p < 0.05$) in samples from the experimental locations relative to samples from the control. Variation in acetylcholinesterase activity in fishes was evaluated using a one-way ANOVA (Sokal and Rohlf 1969). Post-hoc tests included the T-method for samples of equal size and the GT2-method plus the Tukey-Kramer procedure for samples of unequal size (Sokal and Rohlf 1969).

Results

Below, we provide the final results of malathion concentrations in Stewart Creek, comparisons outlined above within the fish and aquatic invertebrate communities, and comparisons associated with acetylcholinesterase activity.

Malathion concentrations

The nine applications in 1993 (ground and aerial treatments) produced peak malathion concentrations that ranged from below detectable levels to 10.89 ppb ($\bar{x}$ = 3.49 ppb), and average concentration over the four hours of post-application sampling that ranged from below detectable levels to 1.89 ppb ($\bar{x}$ = 0.59 ppb) (Table 2 and 5). The four malathion treatments sampled in 1994 were all aerial applications that produced higher peak and average values of malathion in Stewart Creek. Peak concentrations ranged from 4.34 to 31.10 ppb ($\bar{x}$ = 18.67 ppb) and average concentrations from 0.88 to 3.69 ppb ($\bar{x}$ = 2.08 ppb) (Table 2 and 5).

Fish community

A total of 48 species were observed during the three year sampling period at all three locations in Stewart Creek, with a total of 11,921 individuals collected (Tables 3a-c). Larval lampreys (ammocoetes) not identifiable to species were assumed to represent one or both species of non-parasitic adult lampreys collected in Spring spawning runs. Fish species composition of Stewart Creek appears similar to other southeastern U.S. Coastal Plain streams, with Cyprinidae (minnows and shiners) the most diverse family with 16 species, followed by Percidae (darters) and Centrarchidae (sunfishes and black basses) with nine and eight species, respectively. Esocidae (pike), Aphredoderidae (pirate-perch), Fundulidae (topminnows), Poeciliidae (livebearers), and Elassomatidae (pygmy sunfish) were all represented by a single species (Tables 3a-c).

At any one location and date, the number of individual fish specimens varied from 58 to 186 for the Control, 43 to 231 for the Spray, and 51 to 365 for the Downstream location (Table 2). The number of species present at a location and sampling date ranged from 7 to 16 for the Control, 9 to 18 for the Spray, and 10 to 21 for the Downstream location (Table 2). At any one date and location, the diversity index ranged from 3.08 to 8.19 for the Control, 4.51 to 9.11 for the Spray, and 4.15 to 9.36 for the Downstream location (Table 2).

Thirty-one species of fishes and 4,449 individuals were collected at the Control location during the entire study; only the cyprinid *Notemigonus crysoleucas*, the Golden Shiner, was unique to this location (Table 3a). The most abundant fish species, in terms of total numbers of individuals collected, was *Notropis baileyi* (1,882 specimens); the least common species (one specimen each) were *Noturus funebris*, the Black Madtom, *Ambloplites ariommus*, the Shadow Bass, *Chaenobryttus gulosus*, the Warmouth, and *Lepomis macrochirus*, the Bluegill (Table 3a).

The Spray location yielded 32 species and 1,515 individuals in the single year of sampling; no species were unique to this location (Table 3b). *Notropis baileyi* (513) was again the most common species, while *Hybopsis ammophilus*, the Orangefin Shiner, *Notropis stilbius*, the Silverstripe Shiner, *Semotilus thoreauianus*, the Dixie Chub, *Moxostoma erythrurum*, the Golden Redhorse, *Ameiurus natalis*, the Yellow Bullhead, *Elassoma zonatum*, the Banded Pygmy Sunfish, *Ambloplites ariommus*, *Etheostoma nigrum*, the Johnny Darter, *Etheostoma parvipinne*, the Goldstripe Darter, and *Percina* *sciera*, the Dusky Darter, were the least common, with only one specimen collected during the study (Table 3b).

The Downstream location was by far the most diverse location with 47 species; 10 of these were unique to this location (Table 3c). This location also had the most individuals with 5,957 specimens collected during the study. *Notropis baileyi* (1,888) continued to be the most common species. The least common species (one specimen each) included *Opsopoeodus emiliae*, the Pugnose Minnow, *Pimephales notatus*, the Bluntnose Minnow, *Minytrema melanops*, the Spotted Sucker, *Moxostoma erythrurum*, *Aphredoderus sayanus*, the Pirate Perch, *Ambloplites ariommus*, and *Centrarchus macropterus*, the Flier (Table 3c).

Of the 48 species collected in Stewart Creek, 33 were absent from at least one location and one of the three years of the study (Tables 3a-c). Sixteen of these species were absent from the Control location in all three years, and 10 of these were also absent from the Spray location. Relative to the Control, the Spray location was missing only two species in Year 1. One of them, *Etheostoma swaini*, the Gulf Darter, was represented by only one specimen at the Control, and the appropriate habitat was not present at the Spray location for the other species, *Semotilus atromaculatus*, the Creek Chub. No species from the Downstream location were absent relative to the Control for Year 1 (Tables 3a-c). Similar results were seen for the last two years of the study; species missing from the Downstream location relative to the Control for Year 2 included *Notemigonus crysoleucas* and *Ambloplites ariommus*, both represented at the Control by only one specimen. In Year 3, three species of fishes (*Lythrurus bellus*, the Pretty Shiner, *Chaenobryttus gulosus*, and *Lepomis macrochirus*) and larval lampreys (ammocoetes) were missing from the Downstream location; again they were represented by at most two specimens at the Control location (Tables 3a-c). No species in any of the three years appear to have been substantially reduced in number of individuals at either experimental location relative to the Control location (Tables 3a-c).

Relationships between number of individuals (across all species and for *Notropis baileyi* and *Percina nigrofasciata*), number of species, and diversity index at each location and date (August 1993 - May 1996), along with average malathion water concentrations (ppb) for 13 of 24 spray dates, are graphed in Figures 2-6. There were no significant differences between the three locations based on the number of individuals, either during or after the spray period in Year 1, nor between the two locations during the spray period in Year 2 (Table 1). Numbers of individuals at each location appear to co-vary across time (Figure 2). Some variation can be attributed to collecting conditions; all three locations show a large decrease in April 1994 due to high water. The Downstream location was significantly larger than the Control location for the combined 20 no-spray samples in Year 2 and 3 ($\bar{x}$ = 176.40, SD = 80.94 vs. $\bar{x}$ = 116.80, SD = 31.74), but when evaluated separately, significance was found only in the Winter/Spring no-spray period of Year 3 (Downstream $\bar{x}$ = 153.14, SD = 12.62 vs. Control $\bar{x}$ = 107.86, SD = 28.65) (Table 1).

The Downstream location had consistently more species present than the other locations during this study (Figure 3). Significant differences between Downstream and Control locations occurred for the 20 no-spray samples in Year 2 and 3 ($\bar{x}$ = 14.30, SD =

2.56 vs. $\overline{x}$ = 11.40, SD = 1.76) (Table 1). When evaluated separately, significance was present at the Year 3 no-spray Summer/Fall (Downstream $\overline{x}$ = 17.50, SD = 2.08 vs. Control $\overline{x}$ = 12.25, SD = 1.26) and Winter/Spring ($\overline{x}$ = 13.14, SD = 1.86 vs. $\overline{x}$ = 10.71, SD = 0.76) periods. Although not as consistent as number of individuals, the number of species present at a given location and date did co-vary during parts of this study (Figure 3).

The Downstream location also had a higher diversity index throughout the entire study (Figure 4). Once again no significant differences were found in the spray period for Year 1 or 2, nor were any present for the no-spray period Year 1 (Table 1). The Downstream location had a significantly higher diversity index than the Control location for the 20 no-spray samples in Year 2 and 3 ($\overline{x}$ = 6.03, SD = 1.17 vs. $\overline{x}$ = 5.11, SD = 1.01), specifically for the no-spray Summer/Fall Year 3 period ($\overline{x}$ = 6.79, SD = 0.59 vs. $\overline{x}$ = 5.37, SD = 0.52) (Table 1).

Examination of the number of individuals over time for two common fish species in Stewart Creek revealed no significant differences between locations for either *Notropis baileyi* or *Percina nigrofasciata* (Table 1). No regular pattern of variation over sampling period was discernible for *N. baileyi* (Figure 5), and any increase or decrease in numbers of *P. nigrofasciata* associated with spray or no-spray periods occurred at both experimental and control locations (Figure 6).

Aquatic invertebrate community

A total of 87 taxa were collected at all three locations in Stewart Creek during the three year sampling period, with a total of 6,088 individuals collected (Tables 6a-c). The most diverse order of aquatic invertebrates in this community was Odonata (dragonflies) with 16 taxa, followed by Coleoptera (beetles) and Plecoptera (stoneflies) with 15 and 12 taxa, respectively. Only the order Amphipoda (scuds) was represented by a single taxon (Tables 6a-c). Specimens in the order Oligochaeta (earthworms) were only identified to this level, and chironomids were only identified to family. The assemblage of taxa present in Stewart Creek is similar to other small streams in the southeastern United States.

The number of individual aquatic invertebrates at any one location and date varied from 23 to 161 for the Control, 20 to 101 for the Spray, and 6 to 140 for the Downstream location (Table 5). The number of taxa present at a location and sampling date ranged from 9 to 30 for the Control, 2 to 19 for the Spray, and 1 to 20 for the Downstream location (Table 5). At any one date and location, the diversity index ranged from 5.88 to 13.46 for the Control, 0.73 to 9.60 for the Spray, and 0 to 10.97 for the Downstream location (Table 5).

Seventy-four taxa of aquatic invertebrates were collected at the Control location during the study, making it the most diverse locality. Thirteen of these taxa were unique to this location (see Table 6a). The Control also had the greatest total number of individuals (3,262) for the study. The taxon with the highest number of individuals (922) was Chironomidae, the midges. Not only was the Control location the most diverse, it also had the fewest taxa represented by only one specimen: one genus of crayfish

(*Procambarus*), two genera of dragonflies in the family Gomphidae (*Gomphus* and *Progomphus*), one genus of Plecoptera (*Clioperia*) in the family Perlodidae, two genera of Trichoptera in the families Leptoceridae (*Oecetis*) and Polycentropodidae (*Polycentropus*), and one specimen of Diptera in the family Tabanidae (Table 6a).

The Spray location had the lowest number of taxa and individuals, with only 44 and 752 collected, respectively, during the single year of sampling at this location. The only taxon unique to this location was the odonate genus *Helocordulia* (family Corduliidae) (Table 6b). This taxon was only represented by one specimen, as were three other genera in three different families of Odonata (*Gomphus* of Gomphidae, *Cordulegaster* of Cordulegasteridae, and *Macromia* of Macromiidae), one genus of Ephemeroptera in the family Baetidae (*Baetis*), one family (Capniidae) and one genus (*Sweltsa* of Chloroperidae) in Plecoptera, one genus of Hemiptera (true bugs) in the family Mesovelidae (*Mesovelia*), the genus *Neohermes* of Megaloptera in the family Corydalidae (dobsonflies), four genera in different coleopteran (beetle) families (*Dytiscus* in Dytiscidae, *Stenelmis* in Elmidae, *Hydrocanthus* in Noteridae, and *Peltodites* in Haliplidae), and one dipteran specimen in the family Tabanidae. Chironomidae (279) was again the most common taxon (Table 6b).

The Downstream location yielded 71 taxa, nine of these were unique to this location (see Table 6c). A total of 2,074 specimens of aquatic invertebrates were collected, and chironomids continued to be the most common taxon with 684 individuals. As with the Spray location, numerous taxa were represented by only one specimen. They included the genus *Gammarus* in the order Amphipoda, one family and two genera of

Odonata (Lestidae, *Gomphus* in Gomphidae, and *Somatochlora* in Corduliidae), two genera of Hemiptera in the families Gerridae (*Trepobates*) and Nepidae (*Rinatra*), the genus *Trianodes* of Trichoptera in the family Leptoceridae, four genera in four different families of Coleoptera (*Stenelmis* in Elmidae, *Hydrocanthus* in Noteridae, *Helichus* in Dryopdidae, and *Sperchopsis* in Hydrophilidae), and the dipteran genus *Dixa* in the family Dixidae (Table 6c).

There were 59 total taxa of aquatic invertebrates collected in Year 1 at all three locations. As is the case for the entire study, the Control location was the most diverse with 44 taxa, followed by 38 taxa at the Spray location and 35 at the Downstream locality (Tables 6a-c). Only one collection was made at the Spray location in Year 2 (12 July 1994). Of the 19 taxa collected, six were new to the location (Table 6b). This collection was made after three malathion applications in two weeks, including one the day before sampling.

Only the Control and Downstream locations were sampled for Year 2 and 3. A total of 53 taxa were collected from these two locations in Year 1, which increased to 57 taxa in Year 2. Three taxa are missing from the Control location for Year 2, but eight new taxa were collected, for a total of 49. The Downstream location had a total of 48 taxa for Year 2, resulting from 17 new taxa and the loss of only four taxa from Year 1 (Table 6a and 6c).

This pattern of increased diversity continued in Year 3, where a total of 73 taxa were present for both locations. The Control had a total of 64 taxa, with 22 new taxa for the location, compared to a loss of eight taxa that were present in both Year 1 and 2.

Nineteen new taxa were collected at the Downstream location in Year 3, only six of the taxa present in both Year 1 and 2 disappeared, for a total of 54 taxa (Table 6a and 6c).

Relationships between number of individual aquatic invertebrates (across all taxa and for Ephemeroptera, Plecoptera, Trichoptera, and Diptera), number of taxa, and diversity index at each location and date (August 1993 - May 1996), along with average malathion water concentration (ppb) for 13 spray dates, are plotted in Figures 7-13. There were no significant differences in the number of individuals collected between the three locations either during or after the spray period in Year 1, although numbers at the Control were much higher than the Downstream location during the spray period (Table 4, Figure 7). Significantly higher numbers were present at the Control relative to the Downstream location for the spray period in Year 2 ($\bar{x}$ = 74.67, SD = 19.53 vs. $\bar{x}$ = 34.33, SD = 16.00) and for the combined 20 no-spray samples in Year 2 and 3 ($\bar{x}$ = 102.95, SD = 38.22 vs. $\bar{x}$ = 76.10, SD = 31.70), but this later significance was not present in any of the three narrower comparisons (Table 4). Numbers of individuals generally increased and co-varied across time throughout most of the study, with no obvious divergence between the Control and experimental locations (Figure 7).

The Control location had more taxa present than any other location for all periods of this study, and was significantly higher than the Downstream location for all time segments except spray period Year 1 (Table 4). As seen with number of individuals, the number of taxa collected across time tended to increase throughout the study and co-varied between locations, exclusive of the spray period Year 1 (Figure 8).

The diversity index for aquatic invertebrates was also highest for the Control location and lowest for the Downstream location. These differences were significant except for spray Year 1 and no-spray Year 2 periods (Table 4). Exclusive of the August Year 1 sample and Year 1 and 2 spray periods, the diversity index was relatively stable, and the Control location was consistently higher than the Downstream location for all samples after February 1995 (Figure 9).

Differences between locations over time for the number of individuals in four different orders of aquatic insects varied among taxa. Ephemeropteran individuals were significantly more numerous at the Control versus the Downstream location in all time periods except no-spray Year 1 and Summer/Fall Year 3 (Table 4). This contrasted with numbers of individual plecopterans ($\bar{x}$ = 3.25, SD = 2.22 vs. $\bar{x}$ = 0) and trichopterans ($\bar{x}$ = 2.75, SD = 0.96 vs. $\bar{x}$ = 0) that were significantly higher at the Control relative to the Downstream location only for the spray period Year 1, and dipterans that were only significantly greater during the no-spray Year 2 period (Control $\bar{x}$ = 26.11, SD = 7.03 vs. Downstream $\bar{x}$ = 15.44, SD = 7.28) (Table 4). An annual cycle of high numbers in Winter/Spring and low numbers in the Summer was present for ephemeropterans, plecopterans, and trichopterans, with dipterans showing a less cyclic pattern (Figures 10-13). As seen with other comparisons of the entire aquatic invertebrate community, variation between the Control and experimental locations co-varied. All orders showed an overall increase in numbers of individuals as the study progressed except for Plecoptera; numbers of individuals in this taxon were constant during the study (Figures 10-13).

Acetylcholinesterase activity

Notropis baileyi

The large number of individuals of *Notropis baileyi* present at all locations during this study provided both a fairly constant number of specimens between locations and similar-sized specimens within and between locations for any given date. Significant depression of acetylcholinesterase activity in this species was noted in specimens collected from experimental locations in Year 1 during the spray period (samples from 16 and 28 September were not analyzed due to early technical difficulties) (Table 7). Specimens from the Control location had significantly higher activity relative to both experimental locations on 8 September, even though the dissolved malathion in Stewart Creek was below level of detection (Table 2 and 5). Specimens from the Control and Spray locations had significantly higher activity compared to the Downstream location for 13 October. Here the levels of dissolved malathion averaged 1.13 ppb, with a peak of 4.52 ppb. Significantly higher activity at the Control relative to both experimental locations occurred on 12 July during the spray period in Year 2 (Table 7), with malathion values averaging 0.88 ppb, with a peak of 4.34. This sample was collected the morning after spraying, but rainfall before and during collecting may have caused run-off of malathion into Stewart Creek. Although collections were made in Year 2 on spray days with much higher levels of dissolved malathion detected (peak of 14.3 and 24.9) (Table 2 and 5), there were no significant reductions in activity at experimental locations on these dates (Table 7). Only one significant reduction in activity occurred during a no-spray period, on 15 August 1995. Although no malathion was sprayed in the experimental area in Year 3, this acetylcholinesterase reduction could have possibly been the result of other organophosphates being applied to the Stewart Creek fields. No spray data for Year 3 are currently available.

Etheostoma rupestre

Whereas number of specimens were consistent between locations for *Notropis baileyi*, this was not the case for *Etheostoma rupestre*, especially for the Spray location (Table 8), due to lack of appropriate habitat. The low numbers of *E. rupestre* at both the Spray and Control locations also contributed to specimen sizes not being consistent between or within locations. Because of these limitations, it is more difficult to assess the impact of malathion residue on acetylcholinesterase activity during spray periods. These difficulties may contribute to the mixed levels of significance between the control and experimental locations over the sampling period, not necessarily correlated with the application of malathion. The only significant reduction in activity relative to specimens from the Control location during the spray period in Year 1 was on 16 September (Table 8). Values of dissolved malathion averaged 1.89, with a peak of 8.37, which were the highest values of any spray dates for Year 1 (Table 2 and 5). During the Year 2 spray period, only the 14 October sample had significantly depressed activity at the Downstream location, and this significance was indicated by only one of two follow-up tests employed (Table 8). No values for concentrations of malathion residue in Stewart Creek were available for this date.

Several dates during the no-spray period showed significant depressed activity in specimens from experimental locations relative to the Control; November and December 1993 and March and April 1994 for Year 1, and February 1996 during Year 3 (Table 8). Based on treatment data for 1993 and 1994 of all applied chemicals to both the experimental fields along Stewart Creek and the upstream cotton field (Appendix 1 and 2), no correlations exist between any application of a non-malathion chemical and these depressed activities. Although no chemical data are available for Year 3, the depressed activity for the February 1996 sample occurred outside of any "normal" chemical application period for cotton fields in Alabama. One correlation with the depressed activity in the April 1994 sample is that one of the two specimens had greatly reduced activity, which may have been due to the specimen dying before freezing took place.

Conclusions

At the concentration of malathion present in Stewart Creek in a worst case scenario application, no adverse acute or long-term affects were obvious in either the fish or aquatic invertebrate communities based upon numbers of individuals, numbers of taxa, or diversity indices over the three years of this study.

Within the fish community, numbers of individuals did not show any depression in the experimental locations during spray periods relative to the Control; in fact numbers were greatest for the Downstream location for all time periods except for spray Year 1, where the Control location averaged just one more specimen (Table 1). The same pattern was also present for the no-spray periods, with the Downstream location always having the greatest number of individuals. Significant differences only occurred in the combined no-spray Year 2 and 3 and in the no-spray Winter/Spring Year 3 periods (Table 1). Similar patterns were present for numbers of species and diversity indices for fishes, with the Downstream location having the larger values for all time periods. Once again, significant differences were only found in no-spray periods of Year 2 and 3 (Table 1).

Although these differences in the fish community between the Downstream and Control locations became significant in various time periods following the last application of malathion to Stewart Creek, there was no strong evidence for these results indicating a recovery at the Downstream location. If this were the case, one would have expected significant differences between locations in all or at least a large part of the no-spray periods and that these trends would be evident in the plots of abundance and diversity data over time (Figures 2-4), but these scenarios were not realized. Rather, temporal changes in these variables tended to co-vary, especially for numbers of individuals (Figure 2), indicating that these changes were due to intrinsic factors (temperature, water levels, etc.).

As noted above, the Downstream location had the greatest number of individuals and species. It also had 10 unique species of fishes, compared to one and none for the Control and Spray locations, respectively. These data are likely due to the greater number of micro-habitats for fishes (riffles, pools, undercut banks) present at the Downstream location.

There were also no indications of malathion application affecting the abundance of *Notropis baileyi* or *Percina nigrofasciata* at experimental locations (Table 1, Figures 5 and 6), even though the acetylcholinesterase data showed significant lowering of activity in *N. baileyi* in several spray samples (Table 7). Perusal of fish data within the experimental locations also indicated no consequential reduction of individuals within any species relative to the Control. Likewise, at most only three species were absent from an experimental location for any given year compared to the Control; all of these missing species were represented at the Control location by just one or a few specimens (Tables 3a-c). These results do not demonstrate any adverse affects on the fish community in Stewart Creek from malathion application to bordering cotton fields.

Whereas the Downstream location had the greatest abundance and diversity of fishes, the Control location possessed these qualities for the aquatic invertebrates. Both number of taxa and diversity index had their greatest values at the Control location for all time periods, and the number of individuals was greatest at the Control for all but the no-spray Year 1 period (Table 4). Additionally, 13 unique taxa were present at this location compared to one and nine at the Spray and Downstream locations, respectively; the Control location also had the fewest taxa represented by only one individual, seven, compared to 13 and 11, respectively. These differences are most likely due to the relatively undisturbed nature of the Control location, which has never been channelized and has a more stable and silt-free substrate relative to the experimental locations.

The conclusion of habitat-related differences between locations rather than malathion-induced depression of the experimental parameters is based on these differences not showing any pattern related to spray or no-spray periods. Both number of taxa and diversity index were significantly higher at the Control for spray Year 2, but were also significant for all but one of the no-spray periods. The number of individuals was likewise significantly higher at the Control for the spray Year 2 period, but significance also occurred for the combined no-spray Year 2 and 3 (Table 4).

Evaluating these data and patterns across all three years of this study does not reveal any adverse affects on the experimental locations associated with malathion application (Figures 7-9). Although the variation in these parameters was greater than that seen in the fish community, aquatic invertebrates still showed a large degree of co-variation across time between the Control and experimental locations. This pattern of extreme variation was likely due to the life histories of aquatic invertebrates. Many taxa emerge as adults during the late Summer and early Fall, leaving only early instars present in the stream. This can result in the apparent disappearance of these taxa during the Fall and Winter months because these early instars are small and often not sampled using conventional techniques.

The overall increase in the abundance and diversity at both the Control and experimental locations over the course of this study appears to be due to either intrinsic components of the stream system or better sampling efficiency as the study progressed (Figures 7-9). If these trends had been due to malathion application, the Control location would not have been expected to increase along with the experimental locations.

As with the entire aquatic invertebrate community, no evidence of adverse affects from malathion application were evident between locations with respect to the number of individuals of the four orders of aquatic insects examined. Plecoptera and Trichoptera had significantly larger numbers at the Control relative to the experimental locations for the spray Year 1 period, but no significance was present in any other time period, including spray Year 2. Diptera only demonstrated significantly higher numbers at the Control for the no-spray Year 2 period, whereas Ephemeroptera showed significance at both spray periods (Year 1 and 2), but also at most of the no-spray periods (combined Year 2 and 3, Year 2, and Winter/Spring Year 3) (Table 4). None of these patterns could be attributed to malathion application. This is also the case when examining the plots of these orders' abundances over time (Figures 10-13). As with the entire invertebrate community, there were large fluctuations, but the Control location co-varied with the experimental locations, pointing to seasonal variations. The general increase in numbers of individuals was also evident in all orders except Plecoptera, once again occurring at all locations.

Examination of aquatic invertebrate data within the Downstream location gave no indication of any substantial loss of taxa during the study. Four taxa were missing in Year 2 relative to Year 1, and six were missing in Year 3 that were present in both Year 1 and 2. This loss compares closely with the Control location, which lost three taxa in Year 2 relative to Year 1 and eight taxa in Year 3 relative to both Year 1 and 2. As with the fishes, the aquatic invertebrate community in Stewart Creek does not show any adverse affects due to the application of malathion to the adjacent cotton fields.

Measurements of acetylcholinesterase activity in *Notropis baileyi* and *Etheostoma rupestre* showed mixed results. The mid-water *N. baileyi* had reduced activity for three of seven samples taken during spray dates in Year 1 and 2, compared to only one sample demonstrating significant reduction on a no-spray date. These data contrast with the benthic *E. rupestre*, which demonstrated reduced activity associated with malathion application for all statistical tests on only one of nine occasions, whereas five samples from no-spray dates showed significant reduction at experimental locations relative to the Control (Table 8).

Although *Notropis baileyi* did show a significant reduction in acetylcholinesterase activity for almost one-half of the spray samples, this reduction did not appear to have affected the success of this species based on the abundance data presented above. This is somewhat surprising in one regard because *N. baileyi* spawns during most of the spray period, and reduced activity has been shown to affect breeding behaviors of other animals. Conversely, the Rough Shiner is by far the most common fish in Stewart Creek, thus indicating it is an extremely successful species, and maybe one of the more tolerant fish species in the community.

The contradictory results for *Etheostoma rupestre* (reduced acetylcholinesterase activity relative to the Control in several instances when no malathion had been recently applied versus no reduction during malathion application periods) may be attributed to the low number of specimens, the low consistency of numbers of specimens between locations, and the lack of size-control between specimens for a given date due to their relative scarcity (Table 8). The lack of reduced acetylcholinesterase activity during malathion application may also be a result of the particular physiology of this species. Lastly, the Rock Darter is a benthic species that lives among rocks, and it may be protected from exposure to high concentrations of dissolved malathion in this micro-habitat where mixing with surface waters is at a minimum.

Based on these observations, it appears that malathion application to cotton fields bordering Stewart Creek did significantly affect the acetylcholinesterase activity of one of the two species examined, *Notropis baileyi*. But based on the abundance data of this species over the three years of this study, the populations of Rough Shiners at the experimental locations did not appear to have been adversely affected by this malathion treatment.

Caveats

The conclusions of this report are based on the detected malathion concentrations in Stewart Creek, Fayette County, Alabama between August 1993 and May 1996. These results cannot be directly extrapolated to any other concentrations, application methods, or duration of exposure of aquatic communities to this substance. Furthermore, these results are based on the fishes and aquatic invertebrate species observed at these study locations. It is difficult to predict, based on these data, whether other species or communities may be more or less sensitive to exposure of malathion for varied lengths of time.

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List of Tables

Table 7. Summary statistics for acetylcholinesterase activity for *Notropis baileyi* at three locations in Stewart Creek from August 1993 to May 1996.

Table 8. Summary statistics for acetylcholinesterase activity for *Etheostoma rupestre* at three locations in Stewart Creek from August 1993 to May 1996.

List of Figures

Figure 6. Plot of number of individual *Percina nigrofasciata* across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

Figure 7. Plot of number of individual aquatic invertebrates across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

Figure 8. Plot of number of aquatic invertebrate taxa across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

Figure 9. Plot of aquatic invertebrate diversity index across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

Figure 10. Plot of number of individual Ephemeropterans across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

Figure 11. Plot of number of individual Plecopterans across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

Figure 12. Plot of number of individual Trichopterans across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

Figure 13. Plot of number of individual Dipterans across time at three locations in Stewart Creek from August 1993 to May 1996. Levels of average malathion concentration in the stream are also provided for comparison.

List of Appendices

Table 1. Comparisons of sample size, mean, and standard deviation between sampling locations for numbers of individuals, species, and diversity index of fishes in Stewart Creek between August 1993 and May 1996. Statistical significance ($p < 0.05$) denoted by *.

NUMBER OF INDIVIDUAL FISHES

All Species

Spray Year 1 (8 Sept.-13 Oct. 93)			
Control	4	148.75	34.89
Spray	4	138.00	34.03
Downstream	4	147.75	18.46
No-Spray Year 1 (31 Aug. 93, 12 Nov.-14 June 94)			
Control	9	97.22	25.62
Spray	9	102.22	60.91
Downstream	9	117.88	44.94
Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)			
Control	6	107.17	30.18
Downstream	6	129.50	45.22
* No-Spray Year 2 & 3 (12 Aug. 94, 17 Nov. 94-8 May 96)			
Control	20	116.80	31.74
Downstream	20	176.40	80.94

No-Spray Year 2 (12 Aug. 94, 17 Nov. 94-13 June 95)			
Control	9	117.22	28.53
Downstream	9	146.56	66.58
No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)			
Control	4	131.50	45.74
Downstream	4	284.25	99.54
* No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)			
Control	7	107.86	28.65
Downstream	7	153.14	12.62
Notropis baileyi			
Spray Year 1 (8 Sept.-13 Oct. 93)			
Control	4	37.50	11.82
Spray	4	47.00	19.41
Downstream	4	46.50	11.09
No-Spray Year 1 (31 Aug. 93, 12 Nov.-14 June 94)			
Control	9	35.89	14.90
Spray	9	34.89	36.26
Downstream	9	25.22	17.22
Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)			
Control	6	45.67	15.14
Downstream	6	48.83	18.52

No-Spray Year 2 & 3 (12 Aug. 94, 17 Nov. 94–8 May 96)

Control	20	56.75	20.49
Downstream	20	59.10	46.04

No-Spray Year 2 (12 Aug. 94, 17 Nov. 94–13 June 95)

Control	9	59.56	21.29
Downstream	9	48.33	21.30

No-Spray Summer/Fall Year 3 (13 July–13 Oct. 95)

Control	4	64.75	29.07
Downstream	4	125.50	64.84

No-Spray Winter/Spring Year 3 (17 Nov. 95–8 May 96)

Control	7	48.57	13.06
Downstream	7	35.00	14.66

Percina nigrofasciata

Spray Year 1 (8 Sept.–13 Oct. 93)

Control	4	17.25	6.08
Spray	4	12.25	3.30
Downstream	4	11.25	9.54

No-Spray Year 1 (31 Aug. 93, 12 Nov.–14 June 94)

Control	9	8.11	3.72
Spray	9	7.89	4.14
Downstream	9	9.22	6.53

Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)			
Control	6	11.17	6.62
Downstream	6	8.00	4.65
No-Spray Year 2 & 3 (12 Aug. 94, 17 Nov. 94-8 May 96)			
Control	20	11.90	6.42
Downstream	20	9.45	4.75
No-Spray Year 2 (12 Aug. 94, 17 Nov. 94-13 June 95)			
Control	9	8.33	3.39
Downstream	9	8.00	4.64
No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)			
Control	4	10.25	7.50
Downstream	4	9.25	4.27
No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)			
Control	7	17.43	5.53
Downstream	7	11.43	5.09

NUMBER OF SPECIES OF FISHES

Spray Year 1 (8 Sept.-13 Oct. 93)			
Control	4	14.25	1.50
Spray	4	15.00	2.71
Downstream	4	19.75	1.89

No-Spray Year 1 (31 Aug. 93, 12 Nov.-14 June 94)

Control	9	13.56	2.35
Spray	9	13.00	2.78
Downstream	9	15.88	3.30

Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)

Control	6	13.50	1.38
Downstream	6	15.33	1.63

* No-Spray Year 2 & 3 (12 Aug. 94, 17 Nov. 94-8 May 96)

Control	20	11.40	1.76
Downstream	20	14.30	2.56

No-Spray Year 2 (12 Aug. 94, 17 Nov. 94-13 June 95)

Control	9	11.56	2.35
Downstream	9	13.78	2.17

* No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)

Control	4	12.25	1.26
Downstream	4	17.50	2.08

* No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	10.71	0.76
Downstream	7	13.14	1.86

DIVERSITY INDEX FOR FISHES

Spray Year 1 (8 Sept.-13 Oct. 93)			
Control	4	6.12	0.52
Spray	4	6.63	1.54
Downstream	4	8.65	0.87
No-Spray Year 1 (31 Aug. 93, 12 Nov.-14 June 94)			
Control	9	6.38	1.22
Spray	9	6.18	1.42
Downstream	9	7.27	1.29
Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)			
Control	6	6.25	0.99
Downstream	6	6.86	0.53
* **No-Spray Year 2 & 3 (12 Aug. 94, 17 Nov. 94-8 May 96)**			
Control	20	5.06	0.77
Downstream	20	6.02	1.03
No-Spray Year 2 (12 Aug. 94, 17 Nov. 94-13 June 95)			
Control	9	5.11	1.01
Downstream	9	6.03	1.17
* **No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)**			
Control	4	5.37	0.52
Downstream	4	6.79	0.59

No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	4.83	0.50
Downstream	7	5.56	0.85

Table 2
Summary Data Table - Fishes

SITES	31VIII 93	1 IX 93	8 IX 93	16 IX 93	21 IX 93	28 IX 93	2 X 93	7 X 93	13 X 93	25 X 93	12 XI 93	15 XII 93
CONTROL												
Total # of specimens	69	NC	102	147	NC	161	NC	NC	185	NC	105	112
Total # of species	15	NC	13	13	NC	16	NC	NC	15	NC	14	14
SPRAY												
Total # of specimens	231	NC	90	165	NC	138	NC	NC	159	NC	126	79
Total # of species	13	NC	17	11	NC	16	NC	NC	16	NC	11	13
DOWNSTREAM												
Total # of specimens	70	NC	133	147	NC	137	NC	NC	174	NC	170	185
Total # of species	16	NC	20	17	NC	21	NC	NC	21	NC	18	21
DIVERSITY INDEX												
Control	7.613458	NC	5.97431	5.536799	NC	6.797093	NC	NC	6.175095	NC	6.431857	6.343883
Spray	5.076975	NC	8.187316	4.509616	NC	7.009742	NC	NC	6.813855	NC	4.761065	6.323687
Downstream	8.129649	NC	8.946011	7.382398	NC	9.360138	NC	NC	8.926383	NC	7.621784	8.821564
TOXICITY DATA												
Spray average	NS	BDL	BDL	1.89	0.37538	0.1519	0.084667	BLQ	1.1292	1.523	NS	NS
Spray maximum	NS	BDL	BDL	8.37	3.16	0.38	10.89	BLQ	4.52	4.05	NS	NS

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 2 (continued)
Summary Data Table - Fishes

SITES	17 I 94	15 II 94	14 III 94	15 IV 94	19 V 94	14 VI 94	28 VI 94	5 VII 94	6 VII 94	11 VII 94	12 VII 94	12 VIII 94
CONTROL												
Total # of specimens	75	89	112	58	131	124	68	NC	111	NC	74	131
Total # of species	16	12	16	10	10	15	16	NC	14	NC	12	14
SPRAY												
Total num Total # of	49	57	163	52	86	77	NC	NC	NC	NC	43	NC
Total # of species	10	17	18	11	11	13	NC	NC	NC	NC	9	NC
DOWNSTREAM												
Total # of specimens	156	103	114	51	116	96	101	NC	163	NC	70	105
Total # of species	18	15	10	12	16	17	14	NC	17	NC	13	18
DIVERSITY INDEX												
Control	7.999739	5.642791	7.319865	5.103696	4.250754	6.687616	8.185499	NC	6.355964	NC	5.884771	6.139978
Spray	5.324826	9.112267	7.684701	5.827494	5.169299	6.361017	NC	NC	NC	NC	4.897554	NC
Downstream	7.751498	6.955356	4.375506	6.441902	7.26583	8.071549	6.485986	NC	7.23266	NC	6.503719	8.41089
TOXICITY DATA												
Spray average	NS	NS	NS	NS	NS	NS	1.11	2.65	NS	0.88	NS	NS
Spray maximum	NS	NS	NS	NS	NS	NS	14.3	31.1	NS	4.34	NS	NS

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 2 (continued)
Summary Data Table - Fishes

SITES	24 VIII 94	16 IX 94	14 X 94	17 XI 94	15 XII 94	13 I 95	20 II 95	14 III 95	14 IV 95	15 V 95	13 VI 95	13 VII 95
CONTROL												
Total # of specimens	145	121	124	138	82	81	157	104	141	132	89	75
Total # of species	13	13	13	14	9	11	12	13	13	11	7	12
SPRAY												
Total # of specimens	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Total # of species	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
DOWNSTREAM												
Total # of specimens	98	178	167	288	107	144	74	112	217	120	152	139
Total # of species	16	15	17	15	13	12	15	11	15	12	13	15
DIVERSITY INDEX												
Control	5.552039	5.761515	5.732242	6.07511	4.180135	5.239758	5.009336	5.949332	5.583423	4.715704	3.077886	5.866475
Spray	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Downstream	7.533047	6.221061	7.198399	5.692463	5.913125	5.096456	7.489708	4.87991	5.991971	5.290544	5.499936	6.532853

TOXICITY DATA	
Spray average	3.69
Spray maximum	24.92

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 2 (continued)
Summary Data Table - Fishes

SITES	15 VIII 95	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	14 II 96	15 III 96	10 IV 96	8 V 96
CONTROL										
Total # of specimens	125	140	186	149	79	63	120	116	107	121
Total # of species	11	12	14	12	11	11	10	10	11	10
SPRAY										
Total # of specimens	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Total # of species	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
DOWNSTREAM										
Total # of specimens	313	320	365	166	150	160	147	169	147	133
Total # of species	20	18	17	12	15	15	12	14	10	14
DIVERSITY INDEX										
Control	4.768922	5.12551	5.728101	5.061692	5.269739	5.557592	4.328627	4.359498	4.927604	4.321137
Spray	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Downstream	7.613569	6.786021	6.244407	4.954714	6.433554	6.351741	5.075399	5.835126	4.152599	6.120955

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 3a

Control site - Fishes

* indicates species unique to this site

Scientific Names	31VIII 93	8 IX 93	16 IX 93	28 IX 93	13 X 93	12 XI 93	15 XII 93	17 I 94	15 II 94	14 III 94
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei										
Lampetra aepyptera					1		1	1	7	3
Ammocoete							1	2	1	1
CYPRINIDAE										
Campostoma oligolepis	2	2	4		2	2	1	4		8
Cyprinella venusta										
Ericymba buccata	1	1	16	6	1	8	23	6	17	5
Hybopsis winchelli	3			2	1					
Luxilus chrysocephalus	6	8	17	23	16	7	10	4	5	6
Lythrurus bellus	1			2	11	3	1			
Nocomis leptocephalus	2	13	12	12	12	4	7	15	1	2
**Notemigonus crysoleucas*										
Notropis baileyi	23	21	45	37	47	31	42	20	33	46
Notropis texanus	1	1	3	12	4	5				
Semotilus atromaculatus	1	5	1	2					1	1
Semotilus thoreauianus	1	1		1						
CATOSTOMIDAE										
Hypentelium etowanum	3	4	6	7	8	5	2	2	8	8
Moxostoma poecilurum	1									
ICTALURIDAE										
Noturus funebris								1		
Noturus leptacanthus				1		1				1
ELASSOMATIDAE										
Elassoma zonatum			1					1		
CENTRARCHIDAE										
Ambloplites ariommus										
Chaenobryttus gulosus										
Lepomis macrochirus										
Lepomis megalotis						1		1		
PERCIDAE										
Etheostoma lachneri	12	24	16	26	43	18	6	9	8	3
Etheostoma nigrum				3	3		1			
Etheostoma rupestre	4	2	6	6	6	2	3	3	3	6
Etheostoma stigmaeum		5	4	9	4	6	3	1	3	7
Etheostoma swaini										1
Percina maculata								1		
Percina nigrofasciata	8	15	16	12	26	12	11	4	2	12
Percina sciera										2
Total # of individuals	69	102	147	161	185	105	112	75	89	112
Total # of species	15	13	13	16	15	14	14	16	12	16
Diversity Index	7.6135	5.9743	5.5368	6.7971	6.1751	6.4319	6.3439	7.9997	5.6428	7.3199

Table 3a (continued)
Control site - Fishes
* indicates species unique to this site

Scientific Names	15 IV 94	19 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei				1						
Lampetra aepyptera										
Ammocoete										
CYPRINIDAE										
Campostoma oligolepis	8	5	1	5	2	1				1
Cyprinella venusta										
Ericymba buccata			3	2	16	2	21	18	7	1
Hybopsis winchelli					1		3	1		
Luxilus chrysocephalus	2	9	3	9	6	4	38	16	10	13
Lythrurus bellus				2						1
Nocomis leptocephalus	7	9	9	2		4	4	4	4	5
**Notemigonus crysoleucas*										
Notropis baileyi	17	50	61	16	46	50	39	59	52	51
Notropis texanus			1	2	3	2	6	5	6	
Semotilus atromaculatus				3	1		1		1	
Semotilus thoreauianus	1		1					1	3	2
CATOSTOMIDAE										
Hypentelium etowanum	3	2	5	4	8	2	2	3	3	6
Moxostoma poecilurum				1						1
ICTALURIDAE										
Noturus funebris										
Noturus leptacanthus			1				1			
ELASSOMATIDAE										
Elassoma zonatum										
CENTRARCHIDAE										
Ambloplites ariommus									1	
Chaenobryttus gulosus										
Lepomis macrochirus										
Lepomis megalotis				2	1					
PERCIDAE										
Etheostoma lachneri	5	9	10	5	4	1	7	12	9	9
Etheostoma nigrum			2					1		
Etheostoma rupestre	5	8	4	4	4	2	2	5	4	6
Etheostoma stigmaeum	5	27	14	6	8	2	2	7	5	9
Etheostoma swaini										
Percina maculata		1	1				2			
Percina nigrofasciata	5	11	8	4	10	3	3	15	16	19
Percina sciera					1	1				
Total # of individuals	58	131	124	68	111	74	131	145	121	124
Total # of species	10	10	15	16	14	12	14	13	13	13
Diversity Index	5.1037	4.2508	6.6876	8.1855	6.356	5.8848	6.14	5.552	5.7615	5.7322

Table 3a (continued)
Control site - Fishes
* indicates species unique to this site

Scientific Names	17 XI 94	15 XII 94	13 I 95	20 II 95	14 III 95	14 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei										
Lampetra aepyptera		1		18	5					
Ammocoete										
CYPRINIDAE										
Campostoma oligolepis	5		3	7	8	4	3			1
Cyprinella venusta			3							
Ericymba buccata	2		1						2	10
Hybopsis winchelli										
Luxilus chrysocephalus	3	3	8	8	5	2	19	3	5	21
Lythrurus bellus	1		3		1	1				
Nocomis leptocephalus	6		2	2	8	1	2	1	1	10
**Notemigonus crysoleucas*					2					
Notropis baileyi	82	50	39	88	32	83	67	56	47	42
Notropis texanus	2								2	9
Semotilus atromaculatus				1					1	
Semotilus thoreauianus	2					7	2			
CATOSTOMIDAE										
Hypentelium etowanum	5	1	2	2	3	5	1			2
Moxostoma poecilurum				1						
ICTALURIDAE										
Noturus funebris										
Noturus leptacanthus										
ELASSOMATIDAE										
Elassoma zonatum										
CENTRARCHIDAE										
Ambloplites ariommus										
Chaenobryttus gulosus										
Lepomis macrochirus										
Lepomis megalotis										
PERCIDAE										
Etheostoma lachneri	10	13	10	6	10	14	12	9	2	13
Etheostoma nigrum						3	3		1	
Etheostoma rupestre	5	4	2	2	4	7	8	7	8	3
Etheostoma stigmaeum	3	3		8	14	8	7	4	3	6
Etheostoma swaini	1									
Percina maculata									1	
Percina nigrofasciata	11	6	8	14	11	5	8	9	2	8
Percina sciera		1			1	1				
Total # of individuals	138	82	81	157	104	141	132	89	75	125
Total # of species	14	9	11	12	13	13	11	7	12	11
Diversity Index	6.0751	4.1801	5.2398	5.0093	5.9493	5.5834	4.7157	3.0779	5.8665	4.7689

Table 3a (continued)
Control site - Fishes
* indicates species unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	14 II 96	15 III 96	10 IV 96	8 V 96	Total # of indiv.
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei									1	2
Lampetra aepyptera					2	4	10	1		54
Ammocoete				1						6
CYPRINIDAE										
Campostoma oligolepis	2		6	5	5	7	10	1	4	119
Cyprinella venusta										3
Ericymba buccata	12	10	18	2		2				211
Hybopsis winchelli										11
Luxilus chrysocephalus	5	16	14	4	2	12	1	3	1	347
Lythrurus bellus		1	1							29
Nocomis leptocephalus	13	1	1	3	1		4	2	3	189
**Notemigonus crysoleucas*										2
Notropis baileyi	64	106	64	40	24	56	52	49	55	1882
Notropis texanus		5								69
Semotilus atromaculatus										19
Semotilus thoreauianus										22
CATOSTOMIDAE										
Hypentelium etowanum	2	2			4	1	3	1	1	126
Moxostoma poecilurum										4
ICTALURIDAE										
Noturus funebris										1
Noturus leptacanthus		1								6
ELASSOMATIDAE										
Elassoma zonatum										2
CENTRARCHIDAE										
Ambloplites ariommus										1
Chaenobryttus gulosus	1									1
Lepomis macrochirus				1						1
Lepomis megalotis		1	1		1	2				10
PERCIDAE										
Etheostoma lachneri	18	8	13	7	8	6	3	2	3	403
Etheostoma nigrum	1	1	1					3		23
Etheostoma rupestre	9	12	7	4	6	11	8	9	4	205
Etheostoma stigmaeum	2	2	2	1	1		8	12	28	239
Etheostoma swaini										2
Percina maculata										6
Percina nigrofasciata	11	20	21	11	9	19	17	24	21	447
Percina sciera										7
Total # of individuals	140	186	149	79	63	120	116	107	121	4449
Total # of species	12	14	12	11	11	10	10	11	10	
Diversity Index	5.1255	5.7281	5.0617	5.2697	5.5576	4.3286	4.3595	4.9276	4.3211	

Table 3b
Spray site - Fishes

Scientific Names	31 VIII 93	8 IX 93	16 IX 93	28 IX 93	13 X 93	12 XI 93	15 XII 93	17 I 94	15 II 94	14 III 94
ICHTHYOMYZONDITAE										
Lampetra aepyptera							1		2	
Ammocoete		2		1	1		1	2	1	1
CYPRINIDAE										
Campostoma oligolepis	8	6	14	10	27	27	16	18	7	37
Cyprinella venusta					1		1			
Ericymba buccata	63	15	28	43	19	31	2	2	1	10
Hybopsis ammophilus	1									
Hybopsis winchelli					1					1
Luxilus chrysocephalus	9	6	19	9	9	3	9	7	6	21
Lythrurus bellus									1	1
Nocomis leptocephalus	2	4	6	6	14		5	8	10	7
Notropis baileyi	122	31	74	35	48	51	25	5	9	42
Notropis stilbius				1						
Notropis texanus		1		7	15			2	2	5
Semotilus thoreauianus									1	
CATOSTOMIDAE										
Hypentelium etowanum	4	6		1	3	1	3		1	10
Moxostoma erythrurum					1					
Moxostoma poecilurum							1			2
ICTALURIDAE										
Ameiurus natalis		1								
Noturus funebris		1	1		2			1	1	
Noturus leptacanthus				1	1	1			3	1
ESOCIDAE										
Esox americanus	1					1				
ELASSOMATIDAE										
Elassoma zonatum			1							
CENTRARCHIDAE										
Ambloplites ariommus								1		
Lepomis megalotis	1	1		1						
Micropterus punctulatus		1		1						
PERCIDAE										
Etheostoma lachneri	9	2	4	4	3	1	2		3	4
Etheostoma nigrum										1
Etheostoma parvipinne		1								
Etheostoma rupestre	1	3	2	1	1	2				2
Etheostoma stigmaeum	3	1	4	1			2		1	12
Percina maculata									1	1
Percina nigrofasciata	7	8	12	16	13	7	11	3	7	5
Percina sciera						1				
Total # of specimens	231	90	165	138	159	126	79	49	57	163
Total # of species	13	17	11	16	16	11	13	10	17	18
Diversity Index	5.077	8.1873	4.5096	7.0097	6.8138	4.7611	6.3237	5.3248	9.1123	7.6847

Table 3b (continued)
Spray site - Fishes

Scientific Names	15 IV 94	19 V 94	14 VI 94	12 VII 94	Total # of indiv.
ICHTHYOMYZONDITAE					
Lampetra aepyptera					3
Ammocoete					9
CYPRINIDAE					
Campostoma oligolepis	11	5	6	11	203
Cyprinella venusta			1		3
Ericymba buccata		1	1	1	217
Hybopsis ammophilus					1
Hybopsis winchelli			1		3
Luxilus chrysocephalus	2	11	4	5	120
Lythrurus bellus					2
Nocomis leptocephalus	8	5	3	4	82
Notropis baileyi	6	28	26	11	513
Notropis stilbius					1
Notropis texanus					32
Semotilus thoreauianus					1
CATOSTOMIDAE					
Hypentelium etowanum	11	5	8	4	57
Moxostoma erythrurum					1
Moxostoma poecilurum	1				4
ICTALURIDAE					
Ameiurus natalis					1
Noturus funebris					6
Noturus leptacanthus	2	5		2	16
ESOCIDAE					
Esox americanus					2
ELASSOMATIDAE					
Elassoma zonatum					1
CENTRARCHIDAE					
Ambloplites ariommus					1
Lepomis megalotis	2				5
Micropterus punctulatus					2
PERCIDAE					
Etheostoma lachneri		4	3	1	40
Etheostoma nigrum					1
Etheostoma parvipinne					1
Etheostoma rupestre	1	2	1		16
Etheostoma stigmaeum	3	11	4		42
Percina maculata			2		4
Percina nigrofasciata	5	9	17	4	124
Percina sciera					1
Total # of specimens	52	86	77	43	1515
Total # of species	11	11	13	9	
Diversity Index	5.8275	5.1693	6.361	4.8976	

Table 3c
Downstream site - Fishes
* indicates species unique to this site

Scientific Names	31 VIII 93	8 IX 93	16 IX 93	28 IX 93	13 X 93	12 XI 93	15 XII 93	17 I 94	15 II 94	14 III 94
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei										
Lampetra aepyptera								1	1	2
Ammocoete		1		1			2	4		
CYPRINIDAE										
Campostoma oligolepis	7	3	25	5	3	7	12	9	12	45
Cyprinella venusta										
Ericymba buccata		5	5	3	13	9	1	5	5	1
Hybopsis ammophilus		1								
Hybopsis winchelli					2	1				
Luxilus chrysocephalus	11	6	7	14	5	4	10	10	4	
Lythrurus bellus	2		4	4	12		3	12		
Nocomis leptocephalus	5	11	14	12	19	20	45	25	4	6
Notropis baileyi	27	61	46	34	45	57	40	30	9	12
Notropis stilbius										
Notropis texanus	2	1	5	3	8		3	5		
**Opsopoeodus emiliae*			1							
**Pimephales notatus*					1					
Semotilus atromaculatus	1	1	1		1		1	1		
Semotilus thoreauianus							2			
CATOSTOMIDAE										
**Erimyzon oblongus*										
Hypentelium etowanum	2	3	7	4	2	6	4	1	9	
**Minytrema melanops*										
Moxostoma erythrurum										
Moxostoma poecilurum			2	1						
ICTALURIDAE										
Ameiurus natalis		3								
Noturus funebris		2	2	1	2	2	1			
Noturus leptacanthus	2	2		9	6	8	9	3	1	3
APHREDODERIDAE										
**Aphredoderus sayanus*										
ESOCIDAE										
Esox americanus										
FUNDULIDAE										
**Fundulus olivaceus*		1	1	4	4	1	1	1		
POECILIIDAE										
**Gambusia affinis*							1			
ELASSOMATIDAE										
Elassoma zonatum		1		1	2	1				
CENTRARCHIDAE										
Ambloplites ariommus										
**Centrarchus macropterus*										
Chaenobryttus gulosus										
**Lepomis cyanellus*	1									
Lepomis macrochirus										
Lepomis megalotis					1					
Micropterus punctulatus	1	1								
**Micropterus salmoides*										

Table 3c (continued)
Downstream site - Fishes
* Indicates species unique to this site

Scientific Names	31 VIII 93	8 IX 93	16 IX 93	28 IX 93	13 X 93	12 XI 93	15 XII 93	17 I 94	15 II 94	14 III 94
PERCIDAE										
Etheostoma lachneri	1	10	3	2	3	10	1	2	4	5
Etheostoma nigrum	1			1		1			1	
Etheostoma parvipinne				1					1	
Etheostoma rupestre	2	9	17	10	19	16	16	21	31	26
Etheostoma stigmaeum	3	8	4	5	5	8	8	12	11	7
Etheostoma swaini				3		2				
Percina maculata							2		1	
Percina nigrofasciata	2	3	3	19	20	16	22	12	9	7
Percina sciera					1	1	1	2		
Total # of specimens	70	133	147	137	174	170	185	156	103	114
Total # of species	16	20	17	21	21	18	21	18	15	10
Diversity Index	8.1296	8.946	7.3824	9.3601	8.9263	7.6218	8.8216	7.7515	6.9554	4.3755

Table 3c (continued)
Downstream site - Fishes
* indicates species unique to this site

Scientific Names	15 IV 94	19 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	18 IX 94	14 X 94
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei	1									
Lampetra aepyptera		2								
Ammocoete										
CYPRINIDAE										
Campostoma oligolepis	15	12	12	14	18	6	1	2	12	8
Cyprinella venusta			1							
Ericymba buccata		1	6	2	9		3	1	8	10
Hybopsis ammophilus						1				
Hybopsis winchelli							1			
Luxilus chrysocephalus	2	11	12	12	7	10	5	8	6	15
Lythrurus bellus					1			1		
Nocomis leptocephalus	5	10	11	10	9	8	8	7	29	16
Notropis baileyi	5	35	12	38	64	21	39	41	60	69
Notropis stilbius										
Notropis texanus					17		2			
**Opsopoeodus emiliae*										
**Pimephales notatus*										
Semotilus atromaculatus			1		2	1			2	3
Semotilus thoreauianus										
CATOSTOMIDAE										
**Erimyzon oblongus*			2							
Hypentelium etowanum			2		2	1	1	1	4	1
**Minytrema melanops*										
Moxostoma erythrurum										
Moxostoma poecilurum										
ICTALURIDAE										
Ameiurus natalis										
Noturus funebris		1								1
Noturus leptacanthus		1		1			2	2	3	2
APHREDODERIDAE										
**Aphredoderus sayanus*				1						
ESOCIDAE										
Esox americanus			1			1				
FUNDULIDAE										
**Fundulus olivaceus*		1			1					
POECILIIDAE										
**Gambusia affinis*	1			1	2		5	4	6	7
ELASSOMATIDAE										
Elassoma zonatum								1		1
CENTRARCHIDAE										
Ambloplites ariommus	1									
**Centrarchus macropterus*							1			
Chaenobryttus gulosus	1							1		
**Lepomis cyanellus*	1	1	1		1	1	6			
Lepomis macrochirus		1	1							
Lepomis megalotis			1	1			2		1	
Micropterus punctulatus							1			
**Micropterus salmoides*										

Table 3c (continued)
Downstream site - Fishes
* indicates species unique to this site

Scientific Names	15 IV 94	19 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
PERCIDAE										
Etheostoma lachneri		3	5	3	1	3	3	3	12	2
Etheostoma nigrum									1	3
Etheostoma parvipinne		4		3						1
Etheostoma rupestre	13	22	15	11	18	8	13	13	11	7
Etheostoma stigmaeum	4	5	6	1	4	6	4	2	10	8
Etheostoma swaini					1					
Percina maculata										
Percina nigrofasciata	2	6	7	3	6	3	8	10	13	13
Percina sciera								1		
Total # of specimens	51	116	96	101	163	70	105	98	178	167
Total # of species	12	16	17	14	17	13	18	16	15	17
Diversity index	6.4419	7.2658	8.0715	6.486	7.2327	6.5037	8.4109	7.533	6.221	7.1984

Table 3c (continued)
Downstream site - Fishes
* indicates species unique to this site

Scientific Names	17 XI 94	15 XII 94	13 I 95	20 II 95	14 III 95	14 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei				1	1					
Lampetra aepyptera		2		2						
Ammocoete				1						
CYPRINIDAE										
Campostoma oligolepis	137	23	35	12	32	66	13	9	7	4
Cyprinella venusta	2									
Ericymba buccata	1				1	3		4	35	27
Hybopsis ammophilus										
Hybopsis winchelli										
Luxilus chrysocephalus	10		4	1	1	10	18	2	8	14
Lythrurus bellus		6	1	1		1				
Nocomis leptocephalus	29	1	5	4	9	19	12	7	13	22
Notropis baileyi	70	40	60	23	16	68	43	76	30	167
Notropis stilbius										
Notropis texanus	1	6							1	12
**Opsopoeodus emiliae*										
**Pimephales notatus*										
Semotilus atromaculatus										1
Semotilus thoreauianus								1		
CATOSTOMIDAE										
**Erimyzon oblongus*				2						
Hypentelium etowanum	2	1				1	1	3	2	2
**Minytrema melanops*										1
Moxostoma erythrurum							1			
Moxostoma poecilurum			1			1	2			
ICTALURIDAE										
Ameiurus natalis										
Noturus funebris						1				2
Noturus leptacanthus	1	3	1	2	1	1			2	1
APHREDODERIDAE										
**Aphredoderus sayanus*										
ESOCIDAE										
Esox americanus										1
FUNDULIDAE										
**Fundulus olivaceus*										
POECILIIDAE										
**Gambusia affinis*	9	1								
ELASSOMATIDAE										
Elassoma zonatum		1								
CENTRARCHIDAE										
Ambloplites ariommus										
**Centrarchus macropterus*										
Chaenobryttus gulosus	1						1			
**Lepomis cyanellus*				1		1		1		
Lepomis macrochirus		1						1		
Lepomis megalotis			1							1
Micropterus punctulatus									1	2
**Micropterus salmoides*									2	

Table 3c (continued)
Downstream site - Fishes
* indicates species unique to this site

Scientific Names	17 XI 94	15 XII 94	13 I 95	20 II 95	14 III 95	14 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
PERCIDAE										
Etheostoma lachneri	1		1		1	2	1	8	7	5
Etheostoma nigrum										1
Etheostoma parvipinne										1
Etheostoma rupestre	5	16	22	17	39	32	18	31	16	19
Etheostoma stigmaeum			2		2	2	7	5	10	19
Etheostoma swaini									1	
Percina maculata	1			2						
Percina nigrofasciata	18	6	11	4	9	9	3	4	4	11
Percina sciera				1						
Total # of specimens	288	107	144	74	112	217	120	152	139	313
Total # of species	15	13	12	15	11	15	12	13	15	20
Diversity Index	5.6925	5.9131	5.0965	7.4897	4.88	5.992	5.2905	5.5	6.5329	7.6136

Table 3c (continued)
Downstream site - Fishes
* indicates species unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	14 II 96	15 III 96	10 IV 96	8 V 96	Total # of indiv.
ICHTHYOMYZONTIDAE										
Ichthyomyzon gagei										3
Lampetra aepyptera						2	1	1		14
Ammocoete										9
CYPRINIDAE										
Campostoma oligolepis	3	53	10	1	16	22	20	29	17	737
Cyprinella venusta										3
Ericymba buccata	44	37	2	2	1	3	2	1	1	251
Hybopsis ammophilus	1		1							4
Hybopsis winchelli	3									7
Luxilus chrysocephalus	11	18	1	1	6		4		10	278
Lythrurus bellus										48
Nocomis leptocephalus	29	26	8	3	3		2	2	8	476
Notropis baileyi	165	140	60	22	23	39	19	43	39	1888
Notropis stilbius					1				1	2
Notropis texanus	3	12								81
**Opsopoeodus emiliae*										1
**Pimephales notatus*										1
Semotilus atromaculatus	1									17
Semotilus thoreauianus					1					4
CATOSTOMIDAE										
**Erimyzon oblongus*										4
Hypentelium etowanum		5	1	2	3	2	1	4	1	81
**Minytrema melanops*										1
Moxostoma erythrurum										1
Moxostoma poecilurum										7
ICTALURIDAE										
Ameiurus natalis										3
Noturus funebris	5	2		3	3				1	29
Noturus leptacanthus		2	3	6		3	4			84
APHREDODERIDAE										
**Aphredoderus sayanus*										1
ESOCIDAE										
Esox americanus										3
FUNDULIDAE										
**Fundulus olivaceus*	1			1						17
POECILIIDAE										
**Gambusia affinis*										37
ELASSOMATIDAE										
Elassoma zonatum	1									9
CENTRARCHIDAE										
Ambloplites ariommus										1
**Centrarchus macropterus*										1
Chaenobryttus gulosus										4
**Lepomis cyanellus*									2	17
Lepomis macrochirus										4
Lepomis megalotis		1								9
Micropterus punctulatus		1					1	1		9
**Micropterus salmoides*										2

Table 3c (continued)
Downstream site - Fishes
* Indicates species unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	14 II 96	15 III 96	10 IV 96	8 V 96	Total # of indiv.
PERCIDAE										
Etheostoma lachneri	13	6	1	1	1	3	3		2	132
Etheostoma nigrum	1	2					2		1	15
Etheostoma parvipinne	1					1				13
Etheostoma rupestre	20	20	37	73	72	52	84	49	35	955
Etheostoma stigmaeum	10	24	33	13	14	6	15	6	12	301
Etheostoma swaini				1						8
Percina maculata		2			2	1				11
Percina nigrofasciata	8	14	9	20	13	13	11	11	3	365
Percina sciera				1	1					9
Total # of specimens	320	365	166	150	160	147	169	147	133	5957
Total # of species	18	17	12	15	15	12	14	10	14	
Diversity Index	6.786	6.2444	4.9547	6.4336	6.3517	5.0754	5.8351	4.1526	6.121	

Table 4. Comparisons of sample size, mean, and standard deviation between sampling locations for numbers of individuals, taxa, and diversity index of aquatic invertebrates in Stewart Creek between August 1993 and May 1996. Statistical significance ($p < 0.05$) denoted by *. When significance occurs among three comparisons (Year 1), differences are always between Control and Downstream.

NUMBER OF INDIVIDUAL AQUATIC INVERTEBRATES

All Taxa

Spray Year 1 (8 Sept.-13 Oct. 93)			
Control	4	67.25	7.27
Spray	4	35.50	12.37
Downstream	4	13.25	8.14
No-Spray Year 1 (30 Aug. 93, 12 Nov.-14 June 94)			
Control	9	54.00	15.35
Spray	9	59.44	32.60
Downstream	9	32.56	14.55
* Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)			
Control	6	74.67	19.53
Downstream	6	34.33	16.00

* No-Spray Year 2 & 3 (12 Aug. 94, 16 Nov. 94-8 May 96)

Control	20	102.95	38.22
Downstream	20	76.10	31.70

No-Spray Year 2 (12 Aug. 94, 16 Nov. 94-13 June 95)

Control	9	102.56	38.94
Downstream	9	69.22	25.19

No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)

Control	4	98.50	51.50
Downstream	4	91.25	53.93

No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	106.00	35.42
Downstream	7	76.29	25.63

Ephemeroptera

* Spray Year 1 (8 Sept.-13 Oct. 93)

Control	4	3.50	1.73
Spray	4	0.25	0.50
Downstream	4	0.00	0.00

No-Spray Year 1 (30 Aug. 93, 12 Nov.-14 June 94)

Control	9	7.44	4.10
Spray	9	6.33	6.20
Downstream	9	3.33	3.46

* Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)

Control	6	6.67	3.72
Downstream	6	1.83	1.60

* No-Spray Year 2 & 3 (12 Aug. 94, 16 Nov. 94-8 May 96)

Control	20	13.40	6.76
Downstream	20	6.40	5.45

* No-Spray Year 2 (12 Aug. 94, 16 Nov. 94-13 June 95)

Control	9	15.11	6.68
Downstream	9	10.56	4.56

No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)

Control	4	9.25	5.91
Downstream	4	3.25	5.19

* No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	13.57	7.21
Downstream	7	2.86	2.41

Plecoptera

* Spray Year 1 (8 Sept.-13 Oct. 93)

Control	4	3.25	2.22
Spray	4	0.50	0.58
Downstream	4	0.00	0.00

No-Spray Year 1 (30 Aug. 93, 12 Nov.-14 June 94)			
Control	9	7.89	8.99
Spray	9	14.56	13.72
Downstream	9	11.56	11.31
Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)			
Control	6	11.67	10.01
Downstream	6	4.33	10.13
No-Spray Year 2 & 3 (12 Aug. 94, 16 Nov. 94-8 May 96)			
Control	20	11.45	9.50
Downstream	20	9.10	8.83
No-Spray Year 2 (12 Aug. 94, 16 Nov. 94-13 June 95)			
Control	9	15.11	11.62
Downstream	9	9.56	7.92
No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)			
Control	4	6.00	10.03
Downstream	4	2.25	4.50
No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)			
Control	7	9.86	3.53
Downstream	7	12.43	10.41

Trichoptera

* Spray Year 1 (8 Sept.-13 Oct. 93)

Control	4	2.75	0.96
Spray	4	0.25	0.50
Downstream	4	0.00	0.00

No-Spray Year 1 (30 Aug. 93, 12 Nov.-14 June 94)

Control	9	4.44	3.64
Spray	9	3.78	3.27
Downstream	9	1.89	2.85

Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)

Control	6	4.83	4.96
Downstream	6	3.67	2.73

No-Spray Year 2 & 3 (12 Aug. 94, 16 Nov. 94-8 May 96)

Control	20	8.05	7.80
Downstream	20	4.70	5.57

No-Spray Year 2 (12 Aug. 94, 16 Nov. 94-13 June 95)

Control	9	12.89	7.98
Downstream	9	8.44	6.21

No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)

Control	4	4.25	7.18
Downstream	4	1.50	2.38

No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	4.00	4.24
Downstream	7	1.71	2.43

Diptera

Spray Year 1 (8 Sept.-13 Oct. 93)

Control	4	31.00	12.19
Spray	4	29.25	10.90
Downstream	4	9.75	8.54

No-Spray Year 1 (30 Aug. 93, 12 Nov.-14 June 94)

Control	9	14.11	9.27
Spray	9	19.44	10.49
Downstream	9	7.78	6.55

Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)

Control	6	15.67	13.71
Downstream	6	8.50	11.24

No-Spray Year 2 & 3 (12 Aug. 94, 16 Nov. 94-8 May 96)

Control	20	35.25	22.52
Downstream	20	34.45	34.71

* No-Spray Year 2 (12 Aug. 94, 16 Nov. 94-13 June 95)

Control	9	26.11	7.03
Downstream	9	15.44	7.28

No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)

Control	4	28.00	25.81
Downstream	4	66.50	63.51

No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	51.14	27.43
Downstream	7	40.57	21.36

NUMBER OF TAXA OF AQUATIC INVERTEBRATES

Spray Year 1 (8 Sept.-13 Oct. 93)

Control	4	16.00	1.41
Spray	4	6.25	2.06
Downstream	4	3.75	1.89

* No-Spray Year 1 (30 Aug. 93, 12 Nov.-14 June 94)

Control	9	15.11	3.18
Spray	9	11.56	5.68
Downstream	9	8.89	3.10

* Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)

Control	6	19.67	2.94
Downstream	6	12.83	3.97

* No-Spray Year 2 & 3 (12 Aug. 94, 16 Nov. 94-8 May 96)

Control	20	21.20	3.93
Downstream	20	14.40	3.28

* No-Spray Year 2 (12 Aug. 94, 16 Nov. 94-13 June 95)

Control	9	20.11	5.28
Downstream	9	15.22	2.64

* No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)

Control	4	22.25	3.40
Downstream	4	14.00	3.37

* No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	22.00	1.63
Downstream	7	13.57	4.16

DIVERSITY INDEX FOR AQUATIC INVERTEBRATES

Spray Year 1 (8 Sept.-13 Oct. 93)

Control	4	8.21	0.64
Spray	4	3.36	1.00
Downstream	4	2.50	1.91

* No-Spray Year 1 (30 Aug. 93, 12 Nov.-14 June 94)

Control	9	8.20	1.55
Spray	9	5.88	2.76
Downstream	9	5.23	1.38

* Spray Year 2 (28 June-12 July, 24 Aug.-14 Oct. 94)

Control	6	10.00	1.10
Downstream	6	7.84	1.59

* No-Spray Year 2 & 3 (12 Aug. 94, 16 Nov. 94-8 May 96)

Control	20	10.19	1.71
Downstream	20	7.35	1.79

No-Spray Year 2 (12 Aug. 94, 16 Nov. 94-13 June 95)

Control	9	9.59	2.04
Downstream	9	7.94	1.54

* No-Spray Summer/Fall Year 3 (13 July-13 Oct. 95)

Control	4	10.99	1.90
Downstream	4	7.09	2.26

* No-Spray Winter/Spring Year 3 (17 Nov. 95-8 May 96)

Control	7	10.51	0.88
Downstream	7	6.73	1.85

Table 5
Summary Data Table - Aquatic Invertebrates

SITES	30 VIII 93	1 IX 93	7 IX 93	8 IX 93	16 IX 93	17 IX 93	21 IX 93	28 IX 93	2 X 93	7 X 93	13 X 93	25 X 93
CONTROL												
Total # of specimens	60	NC	58	NC	NC	65	NC	74	NC	NC	72	NC
Total # of taxa	19	NC	15	NC	NC	15	NC	16	NC	NC	18	NC
SPRAY												
Total # of specimens	24	NC	38	NC	NC	20	NC	34	NC	NC	50	NC
Total # of taxa	2	NC	6	NC	NC	4	NC	6	NC	NC	9	NC
DOWNSTREAM												
Total # of specimens	18	NC	15	NC	NC	6	NC	8	NC	NC	24	NC
Total # of taxa	6	NC	5	NC	NC	1	NC	5	NC	NC	4	NC
DIVERSITY INDEX												
Control	10.123	NC	7.939	NC	NC	7.722	NC	8.025	NC	NC	9.153	NC
Spray	0.725	NC	3.165	NC	NC	2.306	NC	3.265	NC	NC	4.709	NC
Downstream	3.983	NC	3.401	NC	NC	0	NC	4.429	NC	NC	2.174	NC
TOXICITY DATA												
Spray average	NS	BDL	NS	BDL	1.89	NS	0.37538	0.1519	0.084667	BLQ	1.1292	1.523
Spray maximum	NS	BDL	NS	BDL	8.37	NS	3.16	0.38	10.89	BLQ	4.52	4.05

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 5 (continued)
Summary Data Table - Aquatic Invertebrates

SITES	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94	15 IV 94	17 V 94	14 VI 94	28 VI 94	5 VII 94	6 VII 94	11 VII 94
CONTROL												
Total # of specimens	57	76	23	38	56	63	52	61	91	NC	87	NC
Total # of taxa	16	13	9	13	18	14	18	16	21	NC	24	NC
SPRAY												
Total # of specimens	23	56	20	95	101	92	50	74	NC	NC	NC	NC
Total # of taxa	4	14	7	17	15	14	14	17	NC	NC	NC	NC
DOWNSTREAM												
Total # of specimens	9	40	34	21	39	39	35	58	54	NC	31	NC
Total # of taxa	4	11	8	8	9	9	10	15	20	NC	12	NC
DIVERSITY INDEX												
Control	8.543	6.38	5.875	7.596	9.724	7.225	9.907	8.402	10.209	NC	11.859	NC
Spray	2.203	7.436	4.612	8.09	6.985	6.62	7.652	8.56	NC	NC	NC	NC
Downstream	3.144	6.242	4.571	5.294	5.028	5.028	5.829	7.939	10.968	NC	7.376	NC
TOXICITY DATA												
Spray average	NS	NS	NS	NS	NS	NS	NS	NS	1.11	2.65	NS	0.88
Spray maximum	NS	NS	NS	NS	NS	NS	NS	NS	14.3	31.1	NS	4.34

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 5 (continued)
Summary Data Table - Aquatic Invertebrates

SITES	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94	16 XI 94	15 XII 94	15 I 95	20 II 95	14 III 95	12 IV 95	15 V 95
CONTROL												
Total # of specimens	68	45	48	58	96	53	69	105	136	97	139	136
Total # of taxa	19	17	17	16	21	14	18	20	21	14	21	26
SPRAY												
Total # of specimens	75	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Total # of taxa	19	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
DOWNSTREAM												
Total # of specimens	32	22	11	27	51	52	96	65	59	94	86	94
Total # of taxa	13	15	8	11	13	12	20	15	17	14	13	18
DIVERSITY INDEX												
Control	9.823	9.678	9.517	8.506	10.089	7.539	9.245	9.4	9.374	6.543	9.333	11.718
Spray	9.6	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Downstream	7.973	10.429	6.722	6.986	7.028	6.41	9.585	7.722	9.035	6.589	6.203	8.616
TOXICITY DATA												
Spray average	NS	NS	3.69									
Spray maximum	NS	NS	24.92									

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 5 (continued)
Summary Data Table - Aquatic Invertebrates

SITES	13 VI 95	13 VII 95	15 VIII 95	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	15 II 96	15 III 96	11 IV 96	8 V 96
CONTROL												
Total # of specimens	143	120	161	62	51	81	111	157	70	118	140	65
Total # of taxa	30	25	21	25	18	20	25	23	22	22	21	21
SPRAY												
Total # of specimens	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Total # of taxa	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
DOWNSTREAM												
Total # of specimens	55	62	133	140	30	29	86	114	66	83	74	82
Total # of taxa	13	18	10	15	13	10	17	19	13	17	8	11
DIVERSITY INDEX												
Control	13.455	11.543	9.063	13.39	9.956	9.956	11.734	10.019	11.382	10.136	9.319	11.032
Spray	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Downstream	6.9	9.485	4.238	6.523	8.124	6.154	8.271	8.751	6.595	8.337	3.745	5.225

NC = No Collections
NS = No Spray
BDL = Below Detectable Level
BLQ = Below Level of Quantification

Table 6a
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
DECAPODA										
Cambaridae										
Hobbseus sp.										
Orconectes sp.	1	4	1	2	3	7	6	4	5	9
**Procambrus sp.*										
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.	1				2	3	3			
Heptagenlidae										
Stenonema sp.	5	5	3	1	2	6	11	2	5	8
Caenidae										
Caenis sp.			1							
Baetidae										
Baetiscidae										
**Baetisca sp.*										1
Leptophlebiidae										
Leptophlebia sp.										
Oligoneuridae										
Isonychia sp.										
ODONATA										
Coenagrionidae										
Argia sp.	2		4	7	1	7	1	1		1
Calopterygidae										
Calopteryx sp.	2					1	2	3	6	1
Gomphidae										
Dromogomphus sp.		2								1
Gomphus sp.										
Haganius sp.										
Progomphus sp.	1	2	2	4	1	2			1	1
Stylurus sp.	1		2	3	3	2		2		
Cordulegastridae										
Cordulegaster sp.				1	1					1
Aeshnidae										
Boyeria sp.									1	5
Lestidae					3					
Macromiidae										
Macromia sp.					1				1	
Libellulidae										
**Perithimes sp.*									1	
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.	1	1		2					2	
Perlidae										
Acroneuria sp.		1								2
**Eccoptura sp.*									1	7
Perlesta sp.					1	1				
**Perlinella sp.*										
Periodidae										
Isoperla sp.										
**Clioperla sp.*										

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
Leuctridae										
Leuctra sp.			6	2			3			
Taeniopterygidae										
Taeniopteryx sp.										
Capniidae										
Allocapnia sp.										
Chloroperlidae										
Sweltsa sp.										
HEMIPTERA										
Gerridae										
**Rheumatobates sp.*										
Trepobates sp.										
Mesoveliidae										
Mesovelia sp.	2	1	2			1				
Notonectidae	1	2								
Corixidae	1	7	15	6	5	7	8	2		
Nepidae										
Rinatra sp.			1							
Veliidae										
Rhagovelia sp.					1					
**Microvelia sp.*										
Saldidae										
MEGALOPTERA										
Corydalidae										
Corydalus sp.	2	4		1	1	1	1			1
Nigronia sp.	2		1		2					
Sialidae										
Sialis sp.										
TRICHOPTERA										
Hydropsychidae										
Cheumatopsyche sp.										
Diplonectra sp.									1	
Hydropsyche sp.	4	2	4	1	2	4	11	2		2
Limnephilidae										
Pycnopsyche sp.	1			1					7	3
Leptoceridae										
**Oecetis sp.*										
Trienodes sp.		1								
Philopotamidae										
Chimarra sp.							1			
Phryganeidae										
Ptilostomis sp.										
Polycentropodidae										
**Polycentropus sp.*										
COLEOPTERA										
Elmidae										
Ancyronyx sp.										
**Dubiraphia sp.*										
Macronychus sp.	1						1			

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
Noteridae										
Hydrocanthus sp.	1			1						
Gyrinidae										
Dineutus sp.	1	3	4		1					1
Gyrinus sp.										
Haliplidae										
Peltodites sp.		1		1		1				1
Hydrophilidae									1	
Dytiscidae										
Dytiscus sp.										
**Hydroporus sp.*										
**Uvarus sp.*										
Ptilodactylidae										
OLIGOCHAETA										
DIPTERA										
Tipulidae										
Tipula sp.					1	1	10	1	6	3
Hexatoma sp.										
Chironomidae	30	22	18	40	41	12	18	6		8
Ceratopogonidae										
Simuliidae			1	1		1				
Tabanidae										
Dixidae										
Dixa sp.										
Total # of individuals	60	58	65	74	72	57	76	23	38	56
Total # of taxa	19	15	15	16	18	16	13	9	13	18
Diversity Index	10.1229	7.93908	7.72238	8.02469	9.15291	8.54275	6.38022	5.87489	7.59598	9.72435

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
DECOPODA										
Cambaridae										
Hobbseus sp.										
Orconectes sp.	5	5	5	6	6	1	3	5	1	3
Procambrus sp.										
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.										
Heptageniidae										
Stenonema sp.	13	4	5	6	3	2	1	12	10	6
Caenidae										
Caenis sp.										
Baetidae					1					
Baetiscidae										
Baetisca sp.										
Leptophlebiidae										
Leptophlebia sp.										
Oligoneuridae										
Isonychia sp.										
ODONATA										
Coenagrionidae										
Argia sp.				1	1					1
Calopterygidae										
Calopteryx sp.	1	2		1	1			1		
Gomphidae										
Dromogomphus sp.		4		2	3	3	3	1	3	3
Gomphus sp.										
Hagenius sp.										
Progomphus sp.		2								2
Stylurus sp.		1								1
Cordulegastridae										
Cordulegaster sp.	1	1	2				1	2		
Aeshnidae										
Boyeria sp.	6	2	1	8	8	5	1	1	2	5
Lestidae										
Macromiidae										
Macromia sp.		1	1	1	1	1		2		3
Libellulidae										
Perithimis sp.										
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.										
Perlidae										
Acroneuria sp.	25	7	16	18	17	18		3		1
Eccoptura sp.										
Perlesta sp.		2	4	3		1				1
Perlinella sp.										
Perlodidae										
Isoperla sp.					1	4	2			
Clioperla sp.										

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
Leuctridae										
Leuctra sp.							3	1	2	
Taeniopterygidae										
Taeniopteryx sp.										
Capniidae										
Allocapnia sp.										
Chloroperlidae										
Sweltsa sp.										
HEMIPTERA										
Gerridae										
Rheumatobates sp.										
Trepobates sp.				1	2					
Mesoveliidae										
Mesovelia sp.			3	5	2			1		4
Notonectidae							1			
Corixidae				3	5					2
Nepidae										
Rinatra sp.										
Veliidae										
Rhagovelia sp.	1	1			1	1	1			6
Microvelia sp.	1	5			1	3	1		7	2
Saldidae										
MEGALOPTERA										
Corydalidae										
Corydalus sp.			1							1
Nigronia sp.	1				1	1			1	
Sialidae										
Sialis sp.			3		2					
TRICHOPTERA										
Hydropsychidae										
Cheumatopsyche sp.										
Diplonectra sp.										
Hydropsyche sp.		1	1	8	2	1	1		1	8
Limnephilidae										
Pycnopsyche sp.	2							1	1	1
Leptoceridae										
Oecetis sp.										
Trianodes sp.						1	1			1
Philopotamidae										
Chimarra sp.				1						3
Phryganeidae										
Ptilostomis sp.										
Polycentropodidae										
Polycentropus sp.										
COLEOPTERA										
Elmidae										
Ancyronyx sp.					8	6	1		1	
Dubiraphia sp.										
Macronychus sp.	2	1	1	3	2	7	1	3	6	

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
Noteridae					2					
Hydrocanthus sp.								1	5	
Gyrinidae										
Dineutus sp.	1			3	5	2	2	3	8	
Gyrinus sp.						3			5	
Haliplidae										
Peltodites sp.				1						
Hydrophilidae		1							1	
Dytiscidae										
Dytiscus sp.		1	1	1				1		
Hydroporus sp.										
Uvarus sp.										
Ptilodactylidae			1	1						
OLIGOCHAETA										
DIPTERA										
Tipulidae										
Tipula sp.	2		1	3	2	1	2	1	4	9
Hexatoma sp.										
Chironomidae	2	11	15	15	10	7	20	9		33
Ceratopogonidae										
Simuliidae										
Tabanidae										
Dixidae										
Dixa sp.										
Total # of individuals	63	52	61	91	87	68	45	48	58	96
Total # of taxa	14	18	16	21	24	19	17	17	16	21
Diversity Index	7.22487	9.90674	8.40181	10.2091	11.8586	9.8226	9.67813	9.51678	8.50616	10.0894

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	16 XI 94	15 XII 94	15 I 95	20 II 95	14 III 95	12 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
DECAPOPDA										
Cambaridae										
Hobbsaus sp.							1			
Orconectes sp.	4	4	8	16	10	7	8	5	6	1
Procambrus sp.										
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.					1					
Heptagenlidae										
Stenonema sp.	10	13	14	20	19	24	16	14	18	5
Caenidae										
Caenis sp.	1									
Baetidae		1								2
Baetiscidae										
Baetisca sp.					1			1		
Leptophlibiidae										
Leptophlebia sp.										
Oligoneuridae										
Isonychia sp.										
ODONATA										
Coenagrionidae										
Argia sp.										
Calopterygidae										
Calopteryx sp.	7	6	16	6	5	6	7	7	5	4
Gomphidae										
Dromogomphus sp.	2	1	9	8	4	3	5	4	3	3
Gomphus sp.										
Hagenius sp.										
Progomphus sp.	1		2	3	1	3	3	2	2	1
Stylurus sp.				1						
Cordulegastridae										
Cordulegaster sp.										1
Aeshnidae										
Boyeria sp.			4	4	1	7	5	6	4	2
Lestidae										
Macromiidae										
Macromia sp.		1	2	6		2	1	1	3	
Libellulidae										
Perithimis sp.				1			1	1		
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.		1	1							
Perlidae										
Acroneuria sp.			2	12	20	29	22	20	18	
Eccoptura sp.										
Perlesta sp.		1		3		1	2	1	1	
Perlinella sp.										
Perlodidae										
Isoperla sp.	1	1	2			1	3	2	1	
Clioperla sp.										

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	16 XI 94	15 XII 94	15 I 95	20 II 95	14 III 95	12 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
Leuctridae										
Leuctra sp.										
Taeniopterygidae										
Taeniopteryx sp.		1	1			1	1	2	1	
Capniidae										
Allocapnia sp.										
Chloroperlidae										
Sweltsa sp.										
HEMIPTERA										
Gerridae										
Rheumatobates sp.										4
Trepobates sp.										8
Mesoveliidae										
Mesovelia sp.	1					1	1	1	1	
Notonectidae										
Corixidae	2	1				2	1	2	1	2
Nepidae										
Rinatra sp.								3		
Veliidae										
Rhagovelia sp.							1	2	1	2
Microvelia sp.										3
Saldidae										
MEGALOPTERA										
Corydalidae										
Corydalus sp.										
Nigronia sp.				1			2	1		
Sialidae										
Sialis sp.		1	3					1	1	
TRICHOPTERA										
Hydropsychidae										
Cheumatopsyche										
Diplonectra sp.		1		2		1	2	3	1	
Hydropsyche sp.	1	3	3	5	4	10	9	12	7	
Limnephilidae										
Pycnopsyche sp.		10	5	4	7	6	4	4	4	
Leptoceridae										
Oecetis sp.										1
Trianodes sp.										
Philopotamidae										
Chimarra sp.						2	1	2	1	
Phryganeidae										
Ptilostomis sp.		4		3		2	2	2	2	
Polycentropodidae										
Polycentropus sp.										
COLEOPTERA										
Elmidae										
Ancyronyx sp.	1							1	1	4
Dubiraphia sp.										2
Macronychus sp.			4					2	2	

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	16 XI 94	15 XII 94	15 I 95	20 II 95	14 III 95	12 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
Noteridae										
Hydrocanthus sp.	2	1	2	2			1	1		
Gyrinidae										
Dineutus sp.			5	3	1	4	5	2	3	1
Gyrinus sp.										51
Halipiidae										
Peltodites sp.				2						
Hydrophilidae										
Dytiscidae										
Dytiscus sp.										
Hydroporus sp.										3
Uvarus sp.										
Ptilodactylidae			1							
OLIGOCHAETA										
Diptera										
Tipulidae										
Tipula sp.	5		3	2	11	7	5	5	3	
Hexatoma sp.										1
Chironomidae	15	18	18	32	12	20	27	33	30	60
Ceratopogonidae										
Simuliidae										
Tabanidae										
Dixidae										
Dixa sp.										
Total # of individuals	53	69	105	136	97	139	136	143	120	161
Total # of taxa	14	18	20	21	14	21	26	30	25	21
Diversity Index	7.5394	9.24491	9.40041	9.3741	6.54328	9.33265	11.7176	13.455	11.543	9.06279

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	15 II 96	15 III 96	11 IV 96	8 V 96	Total # of indiv.
DECAPODA										
Cambaridae										
Hobbseus sp.						1			3	5
Orconectes sp.	2		3	4	2	2	4	8	1	177
Procambrus sp.						1				1
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.										10
Heptagenlidae										
Stenonema sp.	3	7	9	18	19	10	11	9	4	353
Caenidae										
Caenis sp.	1									3
Baetidae	1			2						7
Baetiscidae										
Baetisca sp.										3
Leptophlibiidae										
Leptophlebia sp.			3	6				2		11
Oligoneuridae										
Isonychia sp.					1			1		2
ODONATA										
Coenagrionidae										
Argia sp.	1	3	1	1			1			34
Calopterygidae										
Calopteryx sp.	2	6	4	4	1	2	2	2		113
Gomphidae										
Dromogomphus sp.	6	1	2	6	7	3	11	3	3	109
Gomphus sp.									1	1
Haganius sp.						1				1
Progomphus sp.			7							43
Stylurus sp.						1		1		18
Cordulegastridae										
Cordulegaster sp.	1			1		1		2	1	17
Aeshnidae										
Boyeria sp.	1	3		1	1	2				86
Lestidae										3
Macromiidae										
Macromia sp.	1		2		1		1		1	34
Libellulidae										
Perithimis sp.										4
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.			1	3	1	2				15
Perlidae										
Acroneuria sp.			1		4	1		4		241
Eccoptura sp.			2	3		3				16
Perlesta sp.							7	7	3	39
Perlinella sp.					2	2				4
Perlodidae										
Isoperla sp.					4	1				23
Clioperla sp.							1			1

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	15 II 96	15 III 96	11 IV 96	8 V 96	Total # of indiv.
Leuctridae										
Leuctra sp.	1	2		1				1		22
Taeniopterygidae										
Taeniopteryx sp.				1						8
Capniidae										
Allocapnia sp.			5	2	1					8
Chloroperlidae										
Sweltsa sp.							4	2		6
HEMIPTERA										
Gerridae										
Rheumatobates sp.	2									6
Trepobates sp.	1	1								13
Mesoveliidae										
Mesovelia sp.										26
Notonectidae	1									5
Corixidae	3	2	1	1	8	1	1	4		93
Nepidae										
Rinatra sp.										4
Veliidae										
Rhagovelia sp.	7	12							4	41
Microvelia sp.	2								1	26
Saldidae	2	2					1			5
MEGALOPTERA										
Corydalidae										
Corydalus sp.				1						14
Nigronia sp.					1		1	1		16
Sialidae										
Sialis sp.										11
TRICHOPTERA										
Hydropsychidae										
Cheumatopsyche sp.		1			10			1		12
Diplonectra sp.					1					12
Hydropsyche sp.			1				2			112
Limnephilidae										
Pycnopsyche sp.				1	2	1	2	4	2	73
Leptoceridae										
Oecetis sp.										1
Trianodes sp.										4
Philopotamidae										
Chimarra sp.										11
Phryganeidae										
Ptilostomis sp.										15
Polycentropodidae										
Polycentropus sp.				1						1
COLEOPTERA										
Elmidae										
Ancyronyx sp.	1	2								26
Dubiraphia sp.		1		1					1	5
Macronychus sp.		1		2						39

Table 6a (continued)
Control site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	15 II 96	15 III 96	11 IV 96	8 V 96	Total # of indiv.
Noteridae										2
Hydrocanthus sp.										17
Gyrinidae										
Dineutus sp.	2		5		1	2	3		5	76
Gyrinus sp.	1	3	5	5			4		2	79
Haliplidae										
Peltodites sp.										7
Hydrophilidae	1	1					1		2	8
Dytiscidae										
Dytiscus sp.										4
Hydroporus sp.	1								3	7
Uvarus sp.		2	2			2	1	1	4	12
Ptilodactylidae		1								4
OLIGOCHAETA				4	2		1			7
DIPTERA										
Tipulidae										
Tipula sp.				1	5	5	3	1	1	104
Hexatoma sp.	3				2			5	1	12
Chironomidae	15		25	40	80	25	55	80	20	922
Ceratopogonidae						1	1	1	2	5
Simuliidae										3
Tabanidae			1							1
Dixidae										
Dixe sp.			1	1	1					3
Total # of individuals	62	51	81	111	157	70	118	140	65	3262
Total # of taxa	25	18	20	25	23	22	22	21	21	
Diversity Index	13.3899	9.95567	9.95554	11.7341	10.0187	11.3815	10.1357	9.31911	11.032	

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
Gyrinidae				1			2			
Dineutus sp.										
Gyrinus sp.										
Haliplidae								1	5	
Peltodites sp.										
Dryopidae										
Helichus sp.					1					
Hydrophilidae			3							
Sperchopsis sp.										
Tropisternus sp.							2			
Dytiscidae										
Dytiscus sp.		2		1						
Ptilodactylidae										
Ptilodactylus sp.										
OLIGOCHAETA										
DIPTERA										
Tipulidae										
Tipula sp.	3	2		1		1	1		7	6
Hexatoma sp.										
Chironomidae		11		3		9				24
Simuliidae										
Tabanidae										
Ceratopogonidae										
Bezzia sp.										
Dixidae										
Dixa sp.										
Total # of individuals	39	35	58	54	31	32	22	11	27	51
Total # of taxa	9	10	15	20	12	13	15	8	11	13
Diversity Index	5.02808	5.82876	7.93908	10.9675	7.37581	7.97263	10.4289	6.72177	6.98634	7.02753

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	16 XI 94	15 XII 94	15 I 95	20 II 95	14 III 95	12 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
DECAPODA										
Cambaridae										
Hobbseus sp.										
Orconectes sp.	10	20	13	6	13	7	9	4	13	
Palemonidae										
Cambarus sp.										
AMPHIPODA										
Gammarus sp.										
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.										
Heptagenlidae										
Stenonema sp.	10	10	11	12	14	10	14	9	11	
Caenidae										
Caenis sp.			1							
Baetidae										
Baetis sp.										1
Leptophlebiidae										
Leptophlebia sp.										
Oligoneuriidae										
Isonychia sp.					2		1	1		
ODONATA										
Coenagrionidae										
Argia sp.			2							
Calopterygidae										
Calopteryx sp.	6	8	2	2	4	6	4	2	2	
Gomphidae										
Dromogomphus sp.	1	2		1	6	3	7	2	5	4
Gomphus sp.										
Hagenius sp.										
Progomphus sp.										
Stylurus sp.		1								
Cordulegastridae										
Cordulegaster sp.	2		1				1	3	1	1
Aeshnidae										
Boyeria sp.	1	2				1	2		1	
Lestidae										
Macromiidae										
Macromia sp.		1	1				1			
Macrothemis sp.										2
Corduliidae										
Somatochlora sp.										
Libellulidae										
Celithemis sp.		1	3							
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.		1		3					3	
Perlidae										
Acroneuria sp.		2		7	14	16	10	8	4	
Perlesta sp.				2	6	2	3	1	1	

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	16 XI 94	15 XII 94	15 I 95	20 II 95	14 III 95	12 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
Perlodidae										
Isoperla sp.		5	2	1	2		2		1	
Taeniopterygidae										
Strophopteryx sp.										
Taeniopteryx sp.		1								
Capniidae										
Allocapnia sp.										
HEMIPTERA										
Gerridae										
Trepobates sp.										
Belostomatidae										
Belostoma sp.										
Mesoveliidae										
Mesovelia sp.										
Notonectidae										
Corixidae										
Nepidae										
Rinatra sp.										
Veliidae										
Rhagovelia sp.										2
Saldidae										
MEGALOPTERA										
Corydalidae										
Corydalus sp.	1	1					2	1	1	
Neohermes concolor										
Nigronia sp.				1	1		1		1	
Sialidae										
Sialis sp.										
TRICHOPTERA										
Hydropsychidae										
Chematopsyche sp.			2							
Diplonectra sp.		1								
Hydropsyche sp.	2	2	4	6		8	4	1	3	
Macrostemum sp.										
Limnephilidae										
Pycnopsyche sp.		3		3	14	9	9	4	1	
Leptoceridae										
Trianodes sp.										
Philopotamidae										
Chimarra sp.				2						
Phryganeidae										
Ptilostomis sp.				1		1	1		1	
COLEOPTERA										
Elmidae										
Ancyronyx sp.										
Macronychus sp.	1									
Stenelmis sp.										
Noteridae										
Hydrocanthus sp.										

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	16 XI 94	15 XII 94	15 I 95	20 II 95	14 III 95	12 IV 95	15 V 95	13 VI 95	13 VII 95	15 VIII 95
Gyrinidae										
Dineutus sp.	3	8	5	1	2	4			2	
Gyrinus sp.										
Haliplidae										
Peltodites sp.										1
Dryopidae										
Helichus sp.										
Hydrophilidae										
Sperchopsis sp.										
Tropisternus sp.										
Dytiscidae										
Dytiscus sp.										
Ptilodactylidae										
Ptilodactylus sp.		1			1					
OLIGOCHAETA										
DIPTERA										
Tipulidae										
Tipula sp.	7	8	2	1	3	2	4	1	1	2
Hexatoma sp.										4
Chironomidae	8	18	14	8	12	17	19	18	10	115
Simuliidae										
Tabanidae			2	2						
Ceratopogonidae										
Bezzia sp.										1
Dixidae										
Dixa sp.										
Total # of individuals	52	96	65	59	94	86	94	55	62	133
Total # of taxa	12	20	15	17	14	13	18	13	18	10
Diversity Index	6.41024	9.58496	7.72238	9.0352	6.58852	6.20316	8.61576	6.89511	9.48453	4.23758

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	15 II 96	15 III 96	11 IV 96	8 V 96	Total # of indiv.
DECAPODA										
Cambaridae										
Hobbseus sp.	2	2	6		1	11		13	7	42
Orconectes sp.				10	9		1			169
Palemonidae										3
Cambarus sp.			2	3						5
AMPHIPODA							2			2
Gammarus sp.					1					1
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.										2
Heptageniidae										
Stenonema sp.		1	3	1		1	5		1	148
Caenidae										
Caenis sp.										3
Baetidae										
Baetis sp.										2
Leptophlebiidae										
Leptophlebia sp.				1	7					8
Oligoneuriidae										
Isonychia sp.						1				6
ODONATA										
Coenagrionidae										
Argia sp.	1									8
Calopterygidae										
Calopteryx sp.	1	2	1	1	1	4	2		1	54
Gomphidae										
Dromogomphus sp.	1	1	3		4	3	2	1	1	60
Gomphus sp.					1					1
Hagenius sp.			1							2
Progomphus sp.				1						2
Stylurus sp.						2				10
Cordulegastridae										
Cordulegaster sp.					3	1	1	1		18
Aeshnidae										
Boyeria sp.	1									30
Lestidae		1								1
Macromiidae										
Macromia sp.							1			16
Macrothemis sp.										2
Corduliidae										
Somatochlora sp.	1									1
Libellulidae										
Celithemis sp.										5
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.										13
Perlidae										
Acroneuria sp.										150
Perlesta sp.						1	11	11	31	75

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	15 II 96	15 III 96	11 IV 96	8 V 96	Total # of indiv.
Periodidae										
Isoperla sp.			1		3	16	7			67
Taeniopterygidae										
Strophopteryx sp.										2
Taeniopteryx sp.				1	1					6
Capniidae										
Allocapnia			3	1						4
HEMIPTERA										
Gerridae										
Trepobates sp.	1									1
Belostomatidae										
Belostoma sp.		1								2
Mesoveliidae										
Mesovelia sp.										3
Notonectidae										2
Corixidae				4	1			1		25
Nepidae										2
Rinatra sp.										1
Veliidae										
Rhagovelia sp.		5								7
Saldidae		3			1					4
MEGALOPTERA										
Corydalidae										
Corydalus sp.				1	2	1				14
Neohermes concolor										2
Nigronia sp.										5
Sialidae										
Sialis sp.										4
TRICHOPTERA										
Hydropsychidae	1									1
Chematopsyche sp.							1	1	1	10
Diplonectra sp.										2
Hydropsyche sp.				1	6					58
Macrostemum sp.										2
Limnephilidae										
Pycnopsyche sp.					1					44
Leptoceridae										
Trianodes sp.										1
Philopotamidae										
Chimarra sp.							1			8
Phryganeidae										
Ptilostomis sp.										8
COLEOPTERA										
Elmidae										
Ancyronyx sp.	2	1								8
Macronychus sp.							1			10
Stenelmis sp.									1	1
Noteridae										1
Hydrocanthus sp.										1

Table 6c (continued)
Downstream site - Aquatic Invertebrates
 * indicates taxa unique to this site

Scientific Names	15 IX 95	13 X 95	17 XI 95	13 XII 95	12 I 96	15 II 96	15 III 96	11 IV 96	8 V 96	Total # of indiv.
Gyrinidae										3
Dineutus sp.		1		2			1		1	31
Gyrinus sp.	3						2		1	6
Haliplidae										6
Peltodites sp.	4								2	7
Dryopidae										
Helichus sp.										1
Hydrophilidae										3
Sperchopsis sp.	1									1
Tropisternus sp.										2
Dytiscidae										
Dytiscus sp.										3
Ptilodactylidae										
Ptilodactylus sp.										2
OLIGOCHAETA				1		4	2			7
DIPTERA										
Tipulidae										
Tipula sp.	1	1	7	3	9	6	3	1		100
Hexatoma sp.								45		49
Chironomidae	108	10	2	52	60	15	40		35	684
Simulidae	12				2					14
Tabanidae		1			1					6
Ceratopogonidae										
Bezzia sp.				2						3
Dixidae										
Dixa sp.				1						1
Total # of individuals	140	30	29	86	114	66	83	74	82	2074
Total # of taxa	15	13	10	17	19	13	17	8	11	
Diversity Index	6.52338	8.12391	6.15428	8.27088	8.75101	6.59506	8.33734	3.74485	5.22517	

Table 7. Acetylcholinesterase activity in *Notropis baileyi.*

Collection Date	% Reduction in Activity Compared to Control Site		Sample Size			Statistical Comparisons[1]		
	Spray Site	Downstream	Control Site	Spray Site	Downstream	Control vs. Spray	Control vs. Downstream	Spray vs. Downstream
Aug. 31, 1993	~	15.6	10	0	10	~	NSIG	~
**Sept. 8, 1993	9.1	14.2	20	20	20	SIGN	SIGN	NSIG
**Oct. 13, 1993	5.2	36.3	15	15	15	NSIG	SIGN	SIGN
Nov. 12, 1993	0.0[2]	14.3	6	6	6	~	NSIG	NSIG
Dec. 15, 1993	1.8	4.2	0[3]	5	5	NSIG	NSIG	NSIG
Jan. 17, 1994	0.0[2]	9.9	6	5	5	NSIG	NSIG	NSIG
Feb. 15, 1994	20.4	12.9	5	5	5	NSIG	NSIG	NSIG
Mar. 14, 1994	0.0[2]	9.9	6	5	5	~	NSIG	NSIG
Apr. 15, 1994	2.7	5.1	5	5	5	NSIG	NSIG	NSIG
May 19, 1994	0.0[2]	0.0[2]	5	5	5	~	~	~
June 14, 1994	1.4	19.3	5	5	5	NSIG	NSIG	NSIG
**June 28, 1994		0.0[2]	4		5		~	
*July 12, 1994	26.0	22.1	8	8	4	SIGN	SIGN	NSIG
Aug. 12, 1994		2.8	5		5		NSIG	
**Aug. 24, 1994		3.0	5		5		NSIG	
*Sept. 16, 1994		0.0[2]	5		5		~	
**Oct. 14, 1994		0.0[2]	5		5		~	
Nov. 17, 1994		0.0[2]	5		5		~	
Dec. 15 1994		9.5	5		4		NSIG	
Jan. 13, 1995		3.2	5		5		NSIG	

Table 7 (continued).

Feb. 17, 1995	3.2	5	5	NSIG
Mar. 14, 1995	9.6	4	5	NSIG
Apr. 14, 1995	0.0[2]	5	5	~
May 15, 1995	0.0[2]	5	5	~
July 13, 1995	0.0[2]	5	5	~
Aug. 15, 1995	13.2	5	5	SIGN
Sept. 15, 1995	15.1	5	4	NSIG
Oct. 13, 1995	0.1	5	5	~
Nov. 17, 1995	0.0[2]	5	5	~
Dec. 13, 1995	0.0[2]	5	5	NSIG
Jan. 12, 1996	0.0[2]	5	5	~
Feb. 14, 1996	16.7	5	4	NSIG
Mar. 14, 1996	14.5	5	4	NSIG
Apr. 10, 1996	0.0[2]	5	5	NSIG
May 8, 1996	0.0[2]	5	5	~

[1]NSIG = reduction not significant, SIGN = reduction significant at 0.05 level, ~ = no reduction.

[2]Mean specific activity ≥ that for sample from Control location.

[3]Sample for Control thawed. Activities for Spray and Downstream locations compared to Control sample collected Nov. 12, 1993.

*Malathion application within three days of sampling.

**Malathion application same day as sampling.

Table 8. Acetylcholinesterase activity in *Etheostoma rupestre.*

Collection Date	% Reduction in Activity Compared to Control Site		Sample Size			Statistical Comparisons [1]		
	Spray Site	Downstream	Control Site	Spray Site	Downstream	Control vs. Spray	Control vs. Downstream	Spray vs. Downstream
**Sept. 8, 1993	0.2	6.1	2	3	10	NSIG	NSIG	NSIG
**Sept. 16, 1993	14.3	28.4	6	2	10	NSIG	SIGN	NSIG
**Sept. 28, 1993	20.7	11.5	6	1	10	NSIG	NSIG	NSIG
**Oct. 13, 1993	0.0[2]	0.0[2]	6	1	10	~	~	~
Nov. 12, 1993	0.0[2]	25.8	2	2	10	~	B[3]	SIGN
Dec. 15, 1993	~	17.0	3	0	5	~	SIGN	~
Jan. 17, 1994	~	0.0	3	0	5	~	~	~
Feb. 15, 1994	~	0.0	3	0	5	~	~	~
Mar. 14, 1994	0.0[2]	29.7	4	2	4	~	SIGN	SIGN
Apr. 15, 1994	46.7	18.8	5	2	5	B[4]	NSIG	NSIG
May 19, 1994	0.0[2]	0.0[2]	5	5	2	~	~	~
June 14, 1994	0.0[2]	0.0[2]	5	1	3	~	~	~
**June 28, 1994		11.4	4		5		NSIG	
*July 12, 1994	2.6	15.5	5	5	5	NSIG	NSIG	NSIG
Aug. 12, 1994		0.0[2]	2		5		NSIG	
**Aug. 24, 1994		5.2	5		5		NSIG	
*Sept. 9, 1994		1.4	3		5		NSIG	
**Oct. 14, 1994		17.3	5		4		B[4]	
Nov. 17, 1994		16.2	5		5		NSIG	
Dec.15, 1994		6.3	4		5		NSIG	

Table 8 (continued).

Jan. 13, 1995	2.1	2	4	NSIG
Feb. 13, 1995	16.2	2	4	NSIG
Mar. 14, 1995	26.8	3	5	NSIG
Apr. 14, 1995	15.4	2	5	NSIG
May 15, 1995	0.0[2]	3	4	~
July 13, 1995	0.0[2]	4	5	~
Aug. 15, 1995	4.7	5	5	NSIG
Sept. 15, 1995	0.0[2]	3	5	~
Oct. 13, 1995	19.4	5	3	NSIG
Nov. 17, 1995	7.9	3	4	NSIG
Dec. 13, 1995	10.1	3	5	NSIG
Jan. 12, 1996	27.2	3	5T	NSIG
Feb. 14, 1996	20.0	5	5	SIGN
Mar.14, 1996	0.0[2]	5	5	~
Apr. 10, 1996	0.0[2]	5	5	~
May 8, 1996	7.4	4	5	NSIG

[1]NSIG = reduction not significant, SIGN = reduction significant at 0.05 level, ~ = no reduction, B = borderline.

[2]Mean specific activity ≥ that of sample from Control location.

[3]Significant by GT2-method for comparisons of means but not significant by Tukey-Kramer method.

[4]Significant by Tukey-Kramer method for comparisons of means but not significant by GT2-method.

*Malathion application within three days of sampling.

**Malathion application same day as sampling.

Figure 1. Stewart Creek in Fayette Co., Alabama, the malathion-treated cotton fields (1 = experimental fields; 2 = upstream field), and the sample locations (A = Control site; B = Spray site; C = Downstream site).

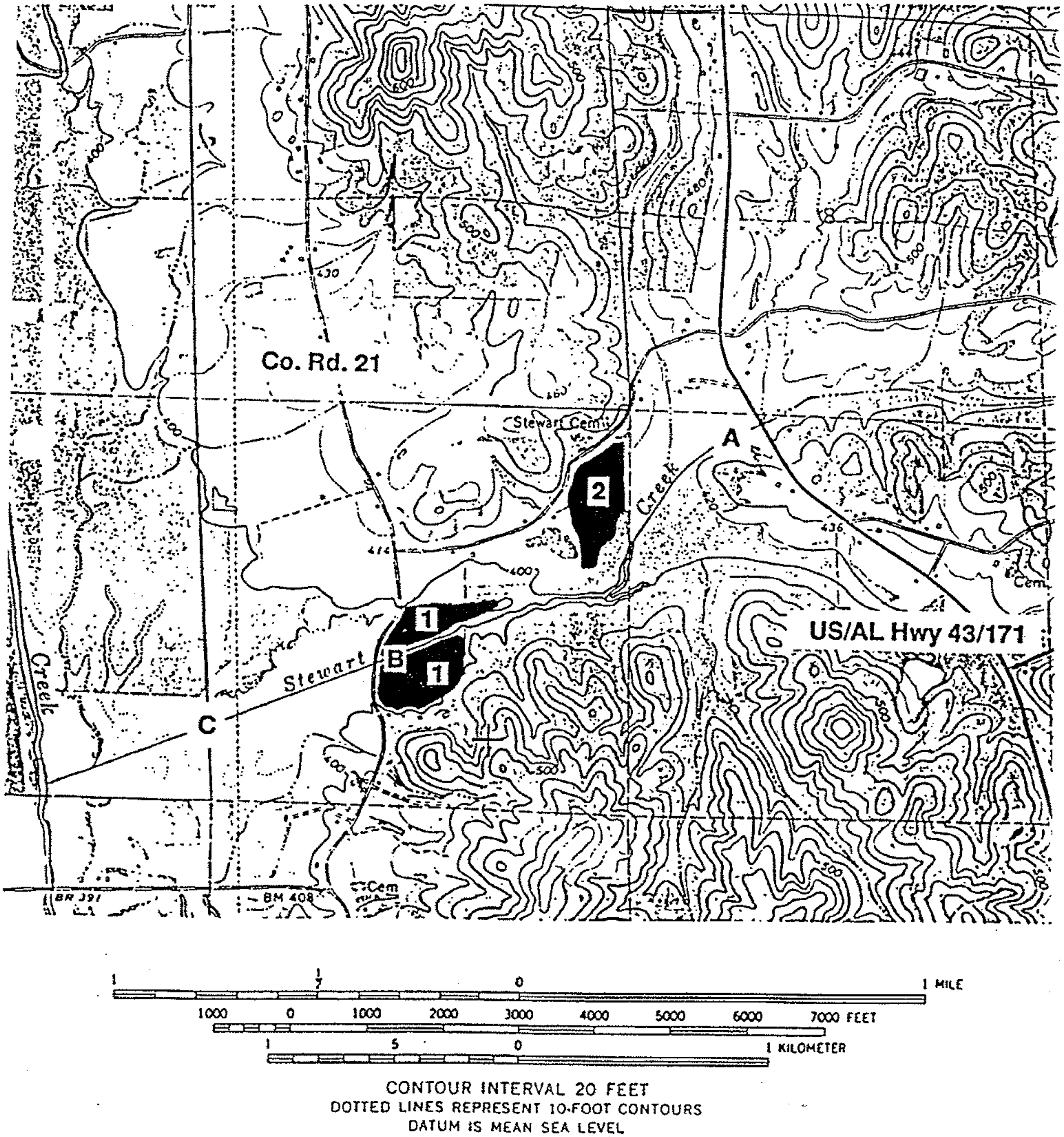


Figure 2

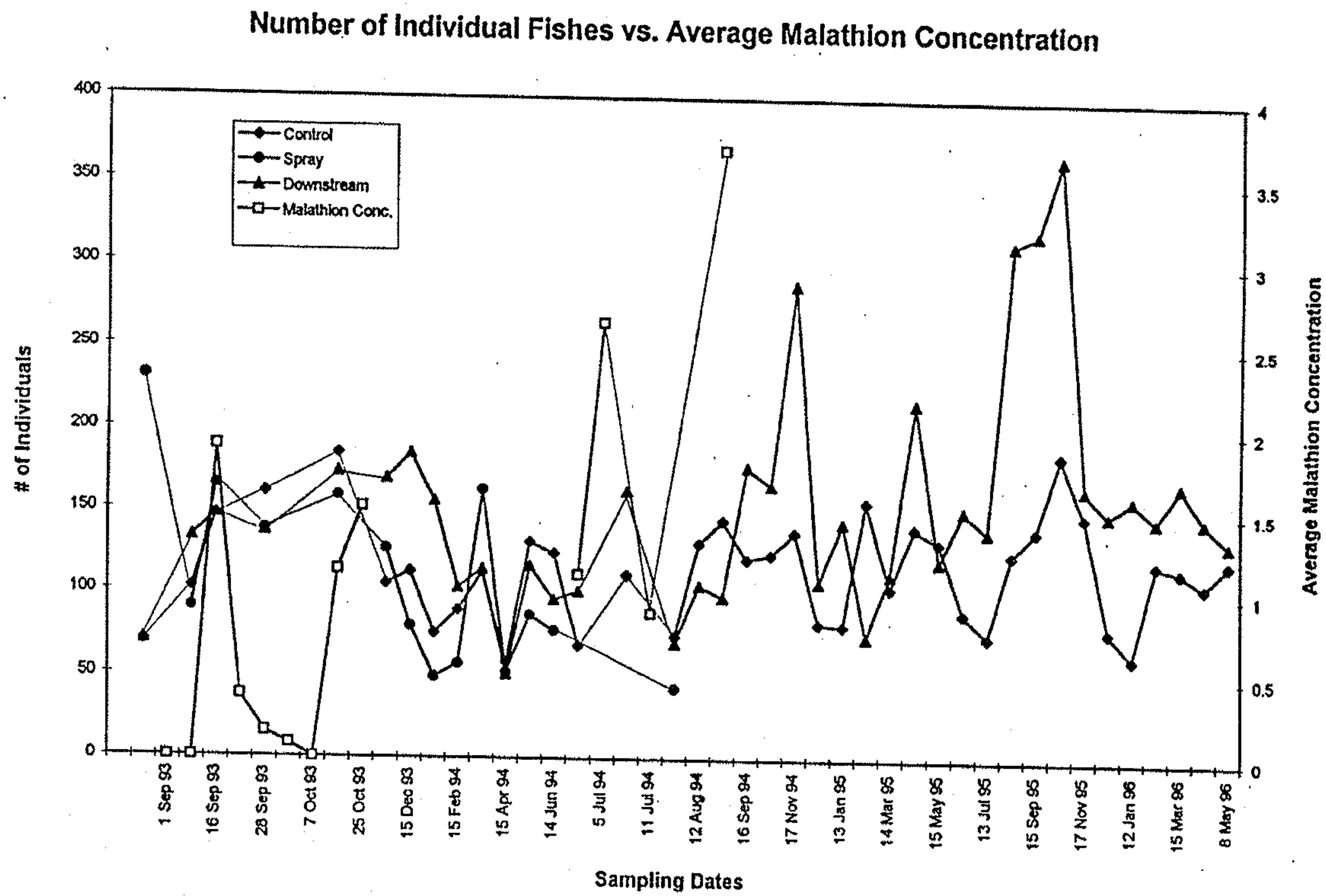

Number of Individual Fishes vs. Average Malathion Concentration
Control
Spray
Downstream
Malathion Conc.
# of Individuals
Average Malathion Concentration
Sampling Dates
1 Sep 93
16 Sep 93
28 Sep 93
7 Oct 93
25 Oct 93
15 Dec 93
15 Feb 94
15 Apr 94
14 Jun 94
5 Jul 94
11 Jul 94
12 Aug 94
16 Sep 94
17 Nov 94
13 Jan 95
14 Mar 95
15 May 95
13 Jul 95
15 Sep 95
17 Nov 95
12 Jan 96
15 Mar 96
8 May 96

Figure 3

Number of Fish Species vs. Average Malathion Concentration

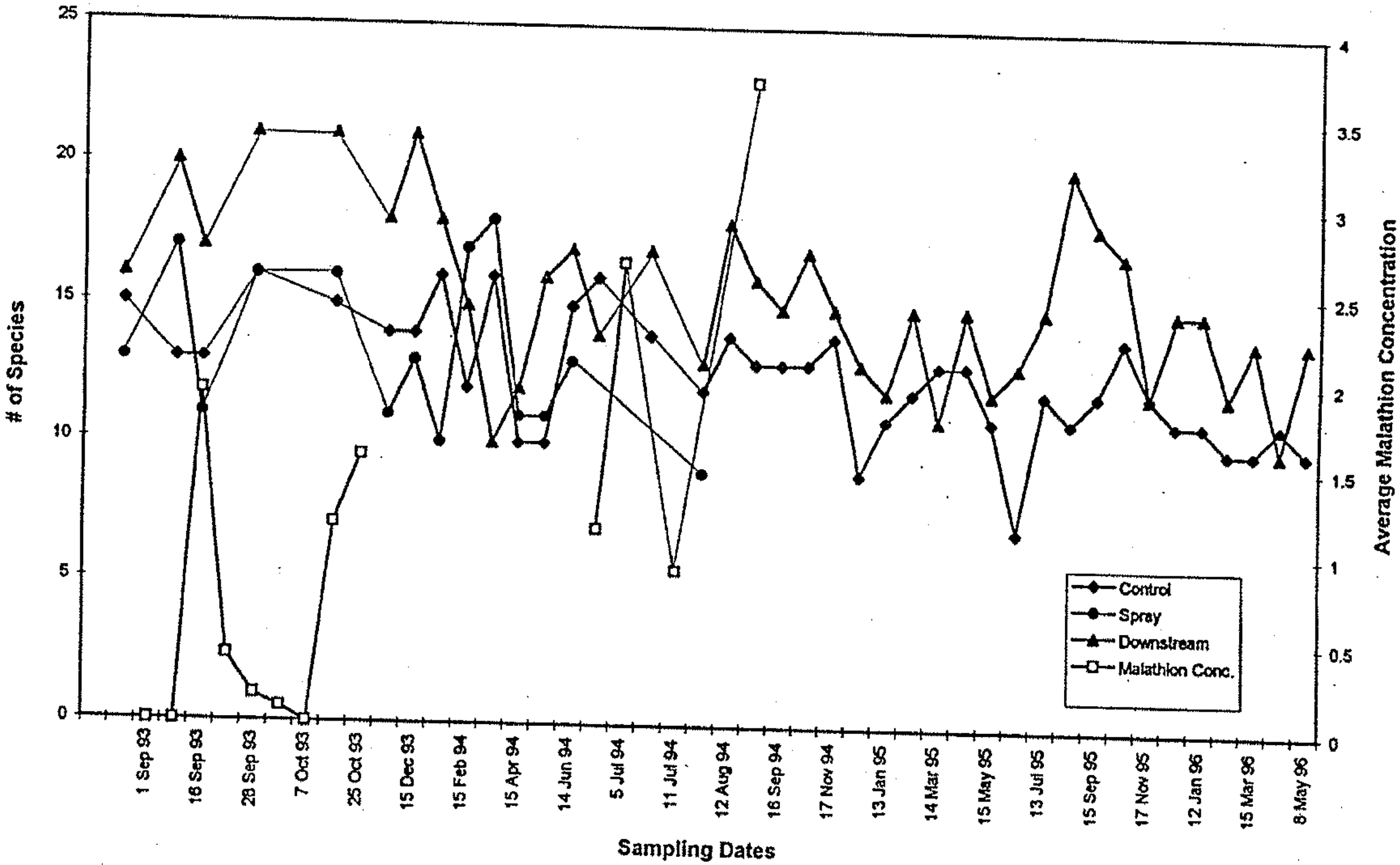
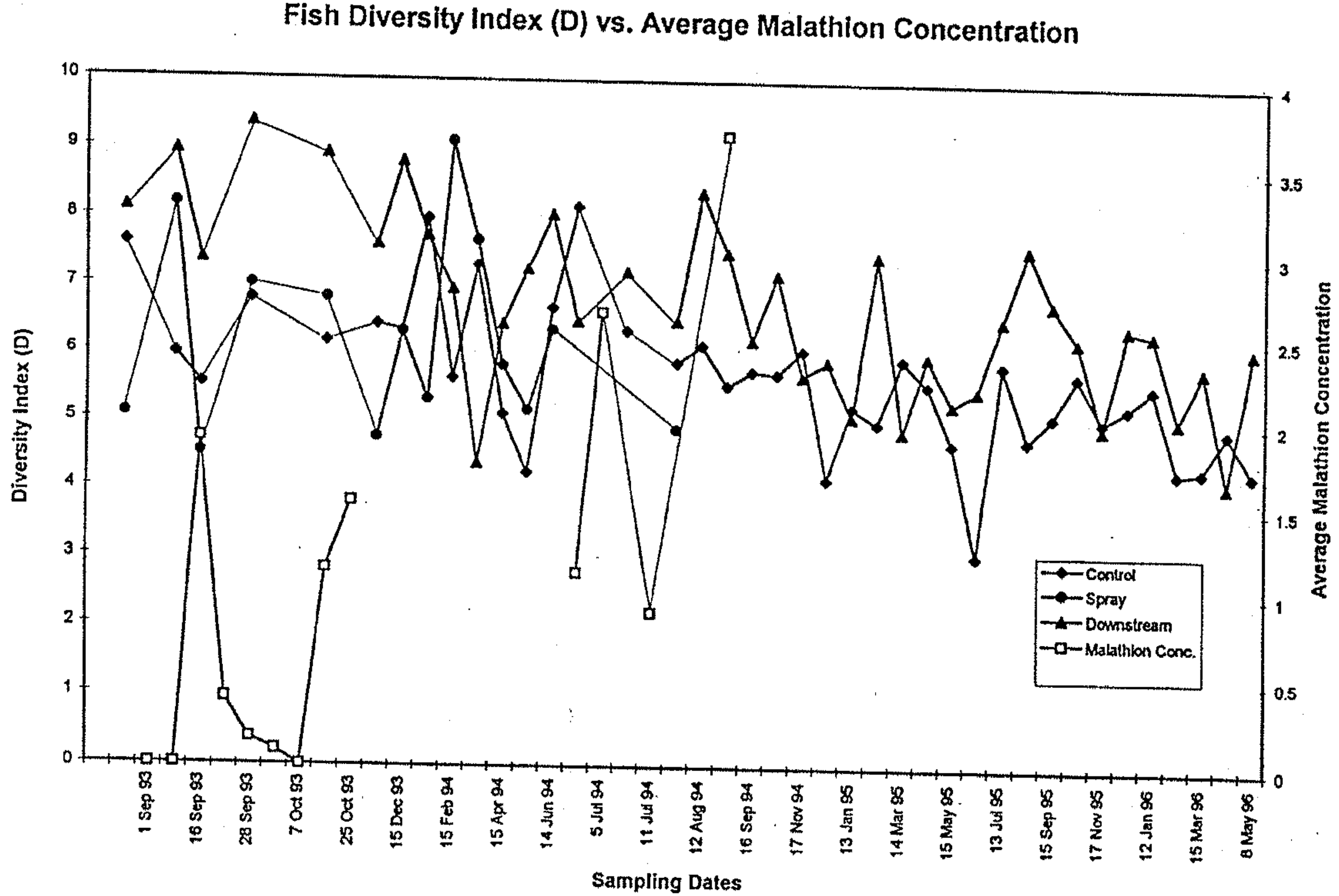


Figure 4



Fish Diversity Index (D) vs. Average Malathion Concentration
Diversity Index (D)
Average Malathion Concentration
Sampling Dates
1 Sep 93
16 Sep 93
28 Sep 93
7 Oct 93
25 Oct 93
15 Dec 93
15 Feb 94
15 Apr 94
14 Jun 94
5 Jul 94
11 Jul 94
12 Aug 94
16 Sep 94
17 Nov 94
13 Jan 95
14 Mar 95
15 May 95
13 Jul 95
15 Sep 95
17 Nov 95
12 Jan 96
15 Mar 96
8 May 96
Control
Spray
Downstream
Malathion Conc.

Figure 5

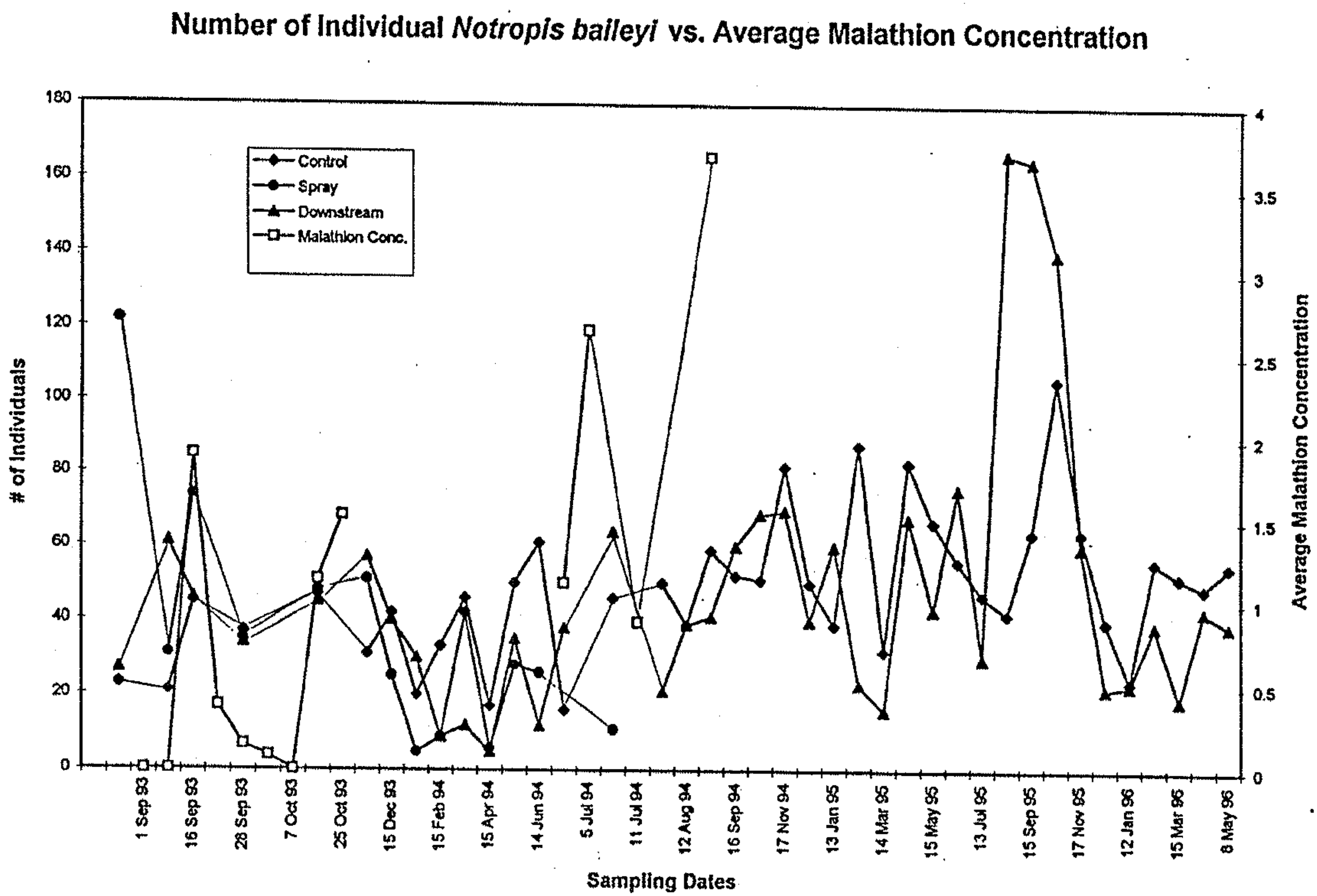
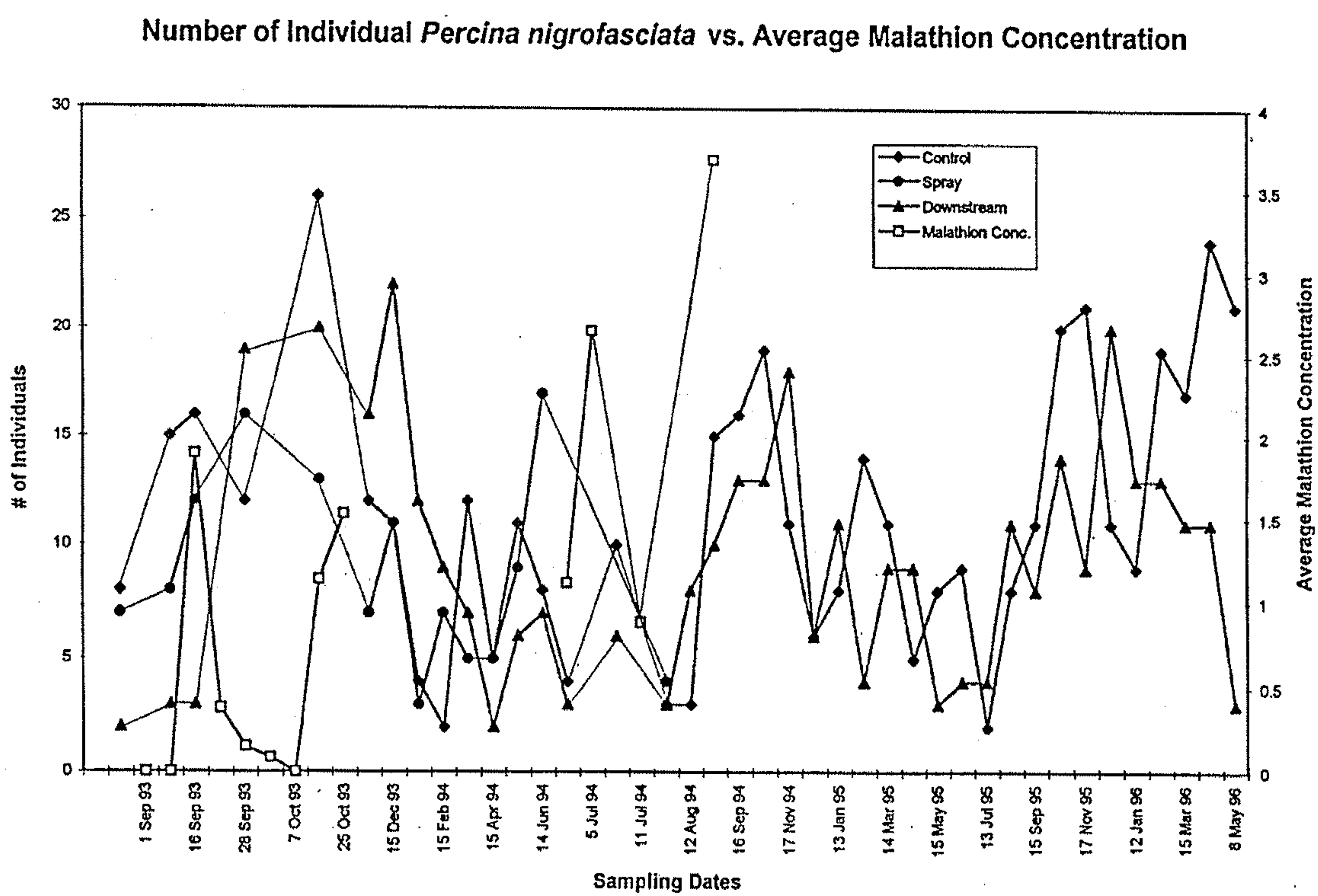
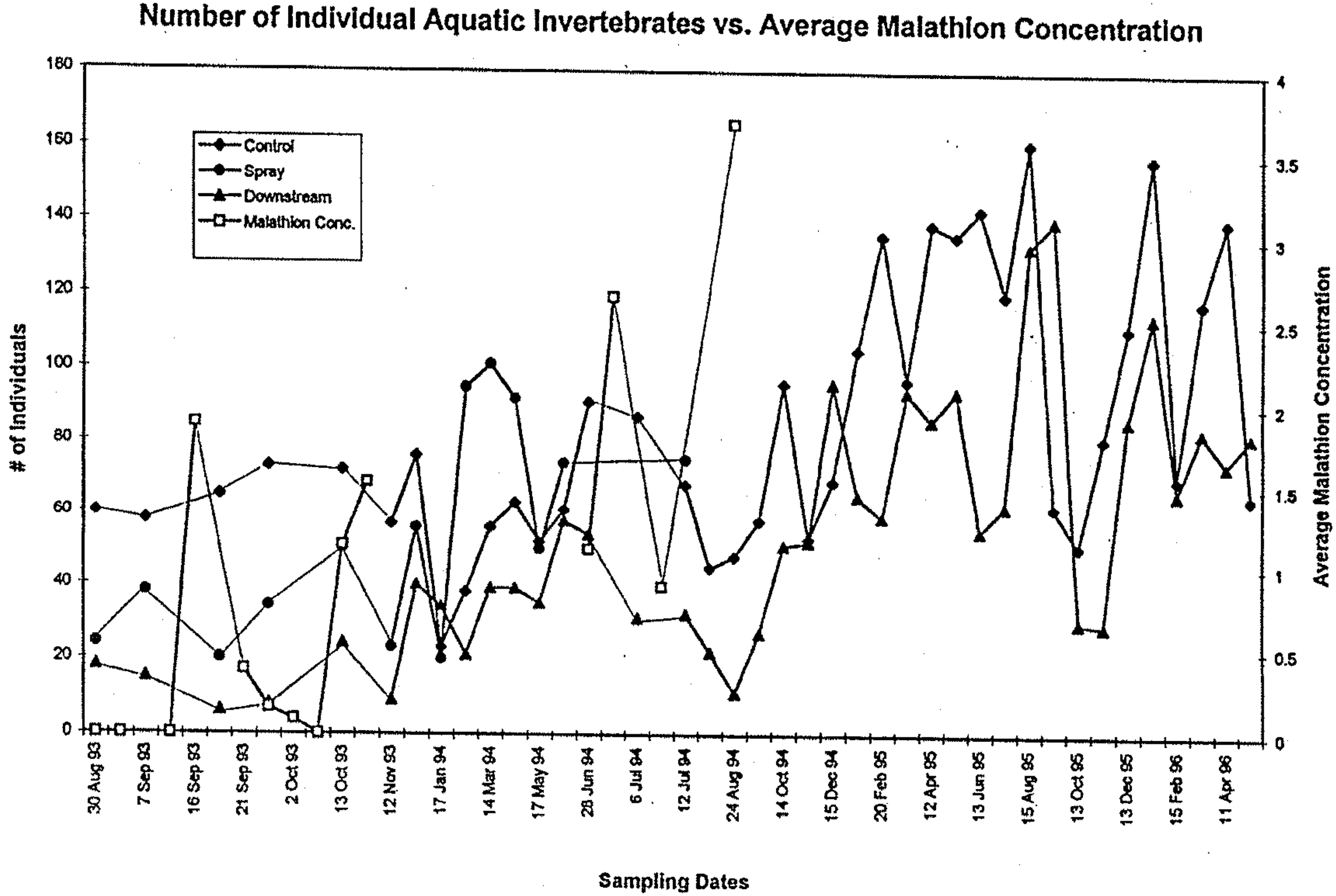

Number of Individual Notropis baileyi vs. Average Malathion Concentration
Control
Spray
Downstream
Malathion Conc.
# of Individuals
0
20
40
60
80
100
120
140
160
180
Average Malathion Concentration
0
0.5
1
1.5
2
2.5
3
3.5
4
1 Sep 93
16 Sep 93
28 Sep 93
7 Oct 93
25 Oct 93
15 Dec 93
15 Feb 94
15 Apr 94
14 Jun 94
5 Jul 94
11 Jul 94
12 Aug 94
16 Sep 94
17 Nov 94
13 Jan 95
14 Mar 95
15 May 95
13 Jul 95
15 Sep 95
17 Nov 95
12 Jan 96
15 Mar 96
8 May 96
Sampling Dates

Figure 6



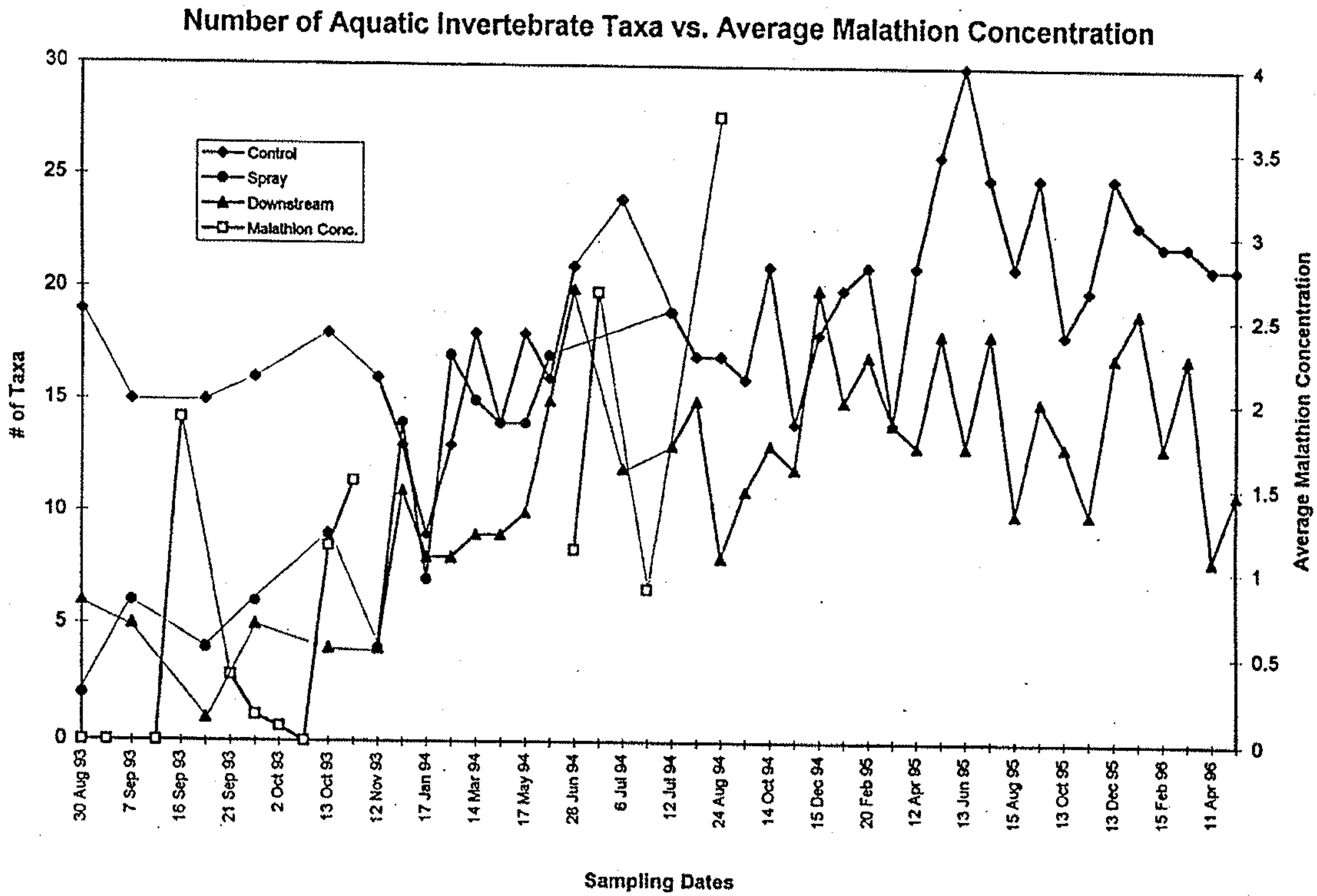
Number of Individual *Percina nigrofasciata* vs. Average Malathion Concentration
# of Individuals
Average Malathion Concentration
Sampling Dates
Control
Spray
Downstream
Malathion Conc.
1 Sep 93
16 Sep 93
28 Sep 93
7 Oct 93
25 Oct 93
15 Dec 93
15 Feb 94
15 Apr 94
14 Jun 94
5 Jul 94
11 Jul 94
12 Aug 94
16 Sep 94
17 Nov 94
13 Jan 95
14 Mar 95
15 May 95
13 Jul 95
15 Sep 95
17 Nov 95
12 Jan 96
15 Mar 96
8 May 96

Figure 7



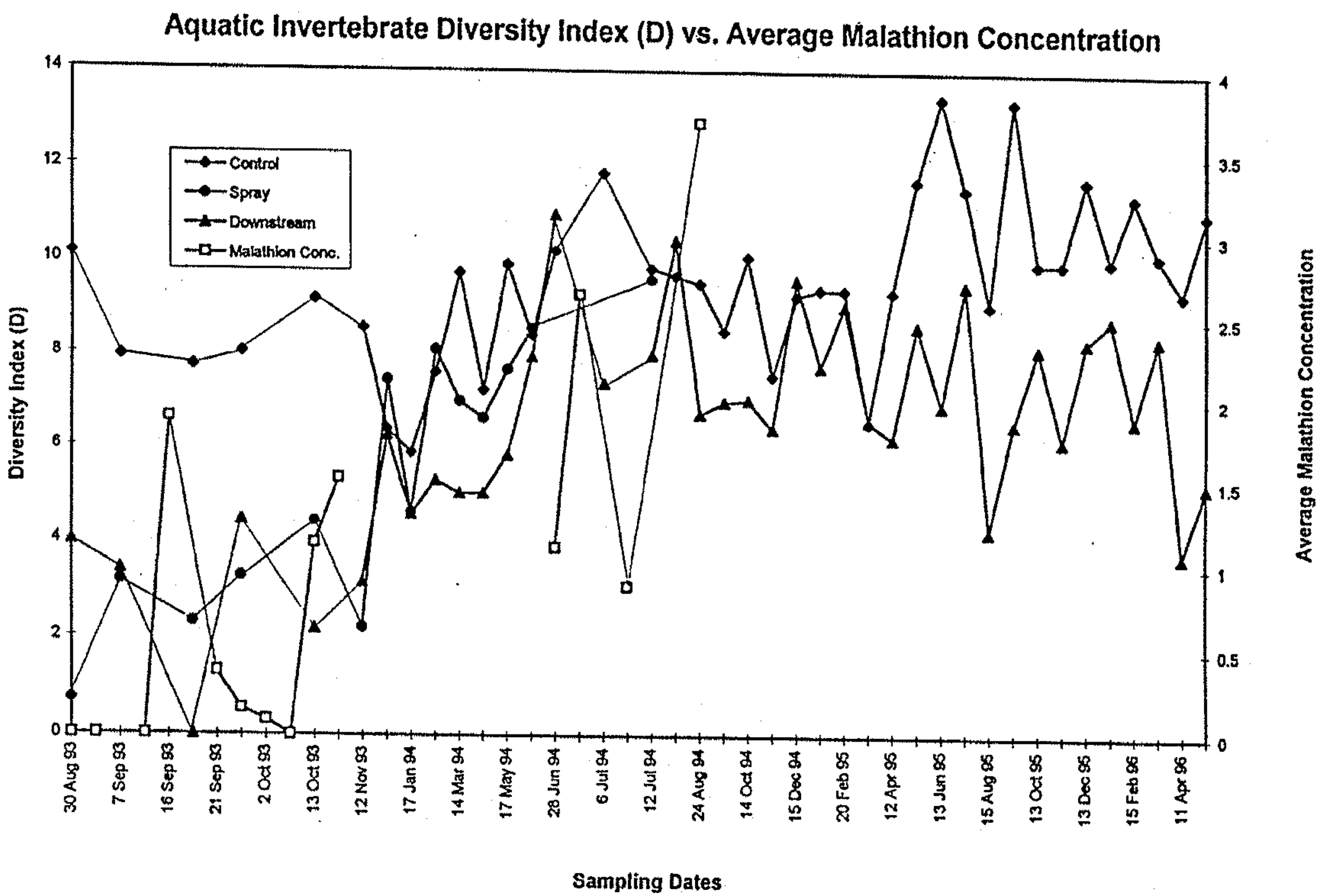
Number of Individual Aquatic Invertebrates vs. Average Malathion Concentration
Control
Spray
Downstream
Malathion Conc.
# of Individuals
0
20
40
60
80
100
120
140
160
180
Average Malathion Concentration
0
0.5
1
1.5
2
2.5
3
3.5
4
30 Aug 93
7 Sep 93
16 Sep 93
21 Sep 93
2 Oct 93
13 Oct 93
12 Nov 93
17 Jan 94
14 Mar 94
17 May 94
28 Jun 94
6 Jul 94
12 Jul 94
24 Aug 94
14 Oct 94
15 Dec 94
20 Feb 95
12 Apr 95
13 Jun 95
15 Aug 95
13 Oct 95
13 Dec 95
15 Feb 96
11 Apr 96
Sampling Dates

Figure 8



Number of Aquatic Invertebrate Taxa vs. Average Malathion Concentration
Control
Spray
Downstream
Malathion Conc.
# of Taxa
Average Malathion Concentration
Sampling Dates
30 Aug 93
7 Sep 93
16 Sep 93
21 Sep 93
2 Oct 93
13 Oct 93
12 Nov 93
17 Jan 94
14 Mar 94
17 May 94
28 Jun 94
6 Jul 94
12 Jul 94
24 Aug 94
14 Oct 94
15 Dec 94
20 Feb 95
12 Apr 95
13 Jun 95
15 Aug 95
13 Oct 95
13 Dec 95
15 Feb 96
11 Apr 96

Figure 9



Aquatic Invertebrate Diversity Index (D) vs. Average Malathion Concentration
Control
Spray
Downstream
Malathion Conc.
Diversity Index (D)
0
2
4
6
8
10
12
14
Average Malathion Concentration
0
0.5
1
1.5
2
2.5
3
3.5
4
30 Aug 93
7 Sep 93
16 Sep 93
21 Sep 93
2 Oct 93
13 Oct 93
12 Nov 93
17 Jan 94
14 Mar 94
17 May 94
28 Jun 94
6 Jul 94
12 Jul 94
24 Aug 94
14 Oct 94
15 Dec 94
20 Feb 95
12 Apr 95
13 Jun 95
15 Aug 95
13 Oct 95
13 Dec 95
15 Feb 96
11 Apr 96
Sampling Dates

Figure 10

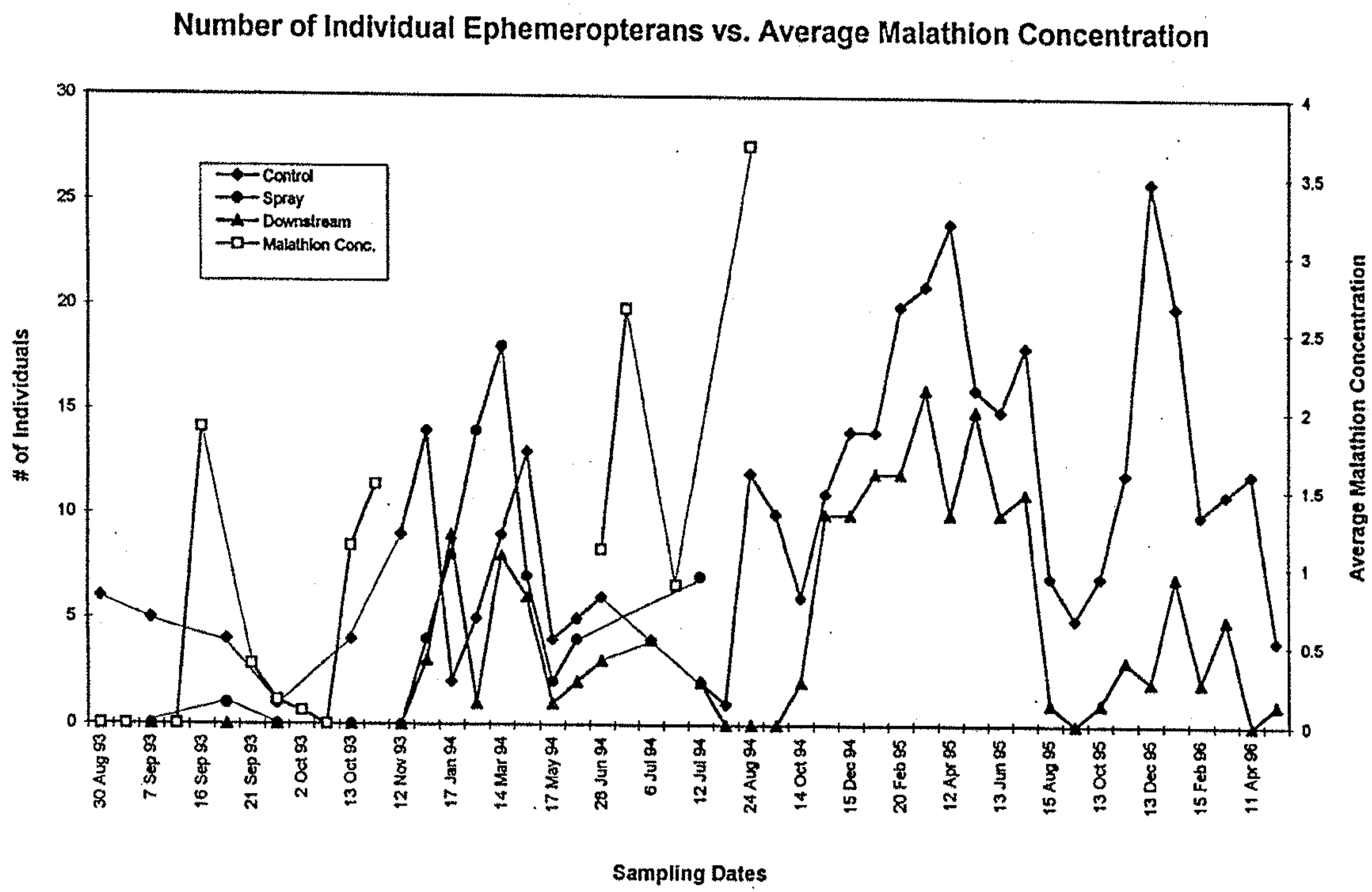
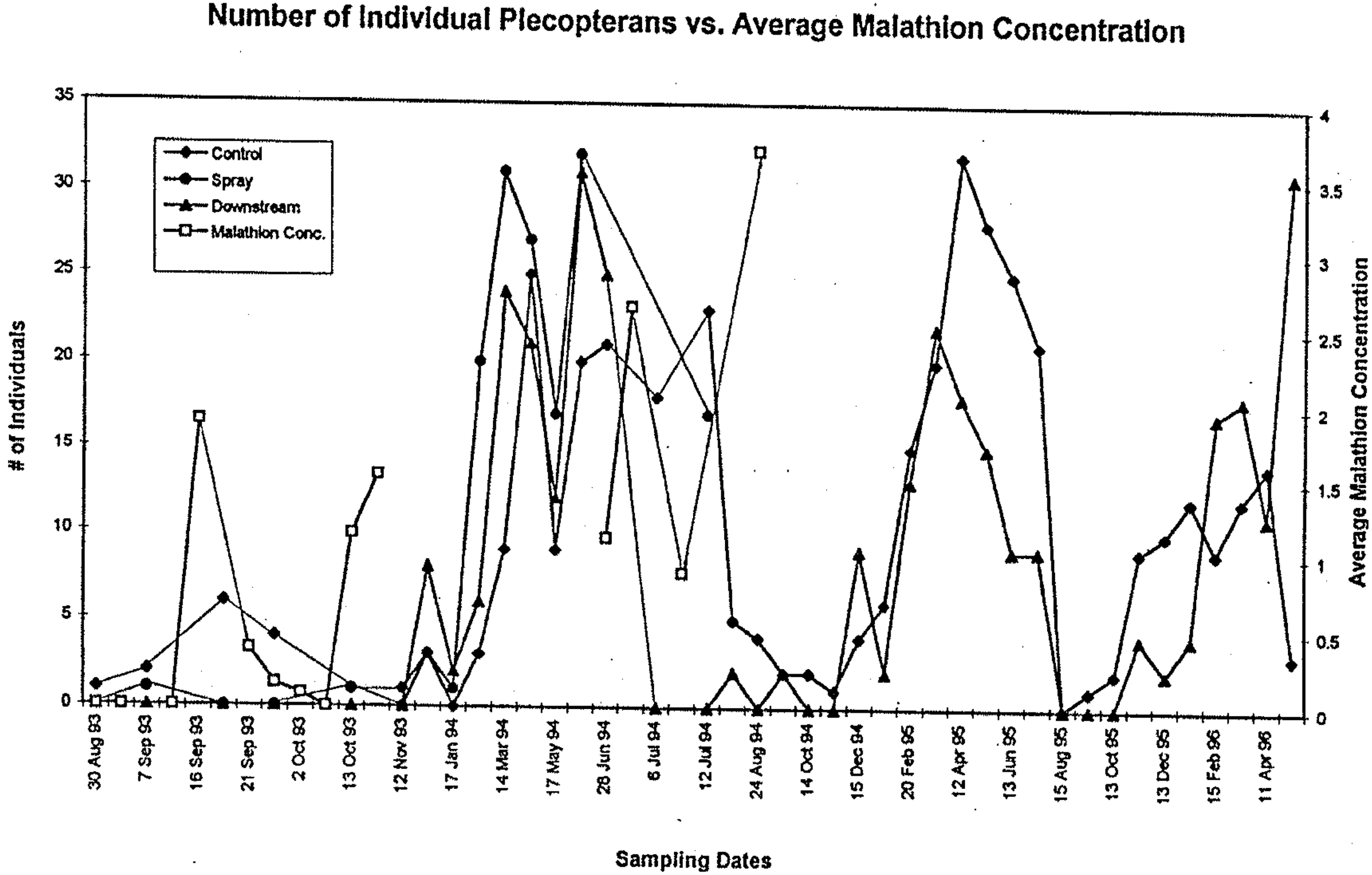

Number of Individual Ephemeropterans vs. Average Malathion Concentration
Control
Spray
Downstream
Malathion Conc.
# of Individuals
Average Malathion Concentration
Sampling Dates
0
5
10
15
20
25
30
0
0.5
1
1.5
2
2.5
3
3.5
4
30 Aug 93
7 Sep 93
16 Sep 93
21 Sep 93
2 Oct 93
13 Oct 93
12 Nov 93
17 Jan 94
14 Mar 94
17 May 94
28 Jun 94
6 Jul 94
12 Jul 94
24 Aug 94
14 Oct 94
15 Dec 94
20 Feb 95
12 Apr 95
13 Jun 95
15 Aug 95
13 Oct 95
13 Dec 95
15 Feb 96
11 Apr 96

Figure 11



Number of Individual Plecopterans vs. Average Malathion Concentration
Control
Spray
Downstream
Malathion Conc.
# of Individuals
0
5
10
15
20
25
30
35
Average Malathion Concentration
0
0.5
1
1.5
2
2.5
3
3.5
4
30 Aug 93
7 Sep 93
16 Sep 93
21 Sep 93
2 Oct 93
13 Oct 93
12 Nov 93
17 Jan 94
14 Mar 94
17 May 94
28 Jun 94
6 Jul 94
12 Jul 94
24 Aug 94
14 Oct 94
15 Dec 94
20 Feb 95
12 Apr 95
13 Jun 95
15 Aug 95
13 Oct 95
13 Dec 95
15 Feb 96
11 Apr 96
Sampling Dates

Figure 12

Number of Individual Trichopterans vs. Average Malathion Concentration

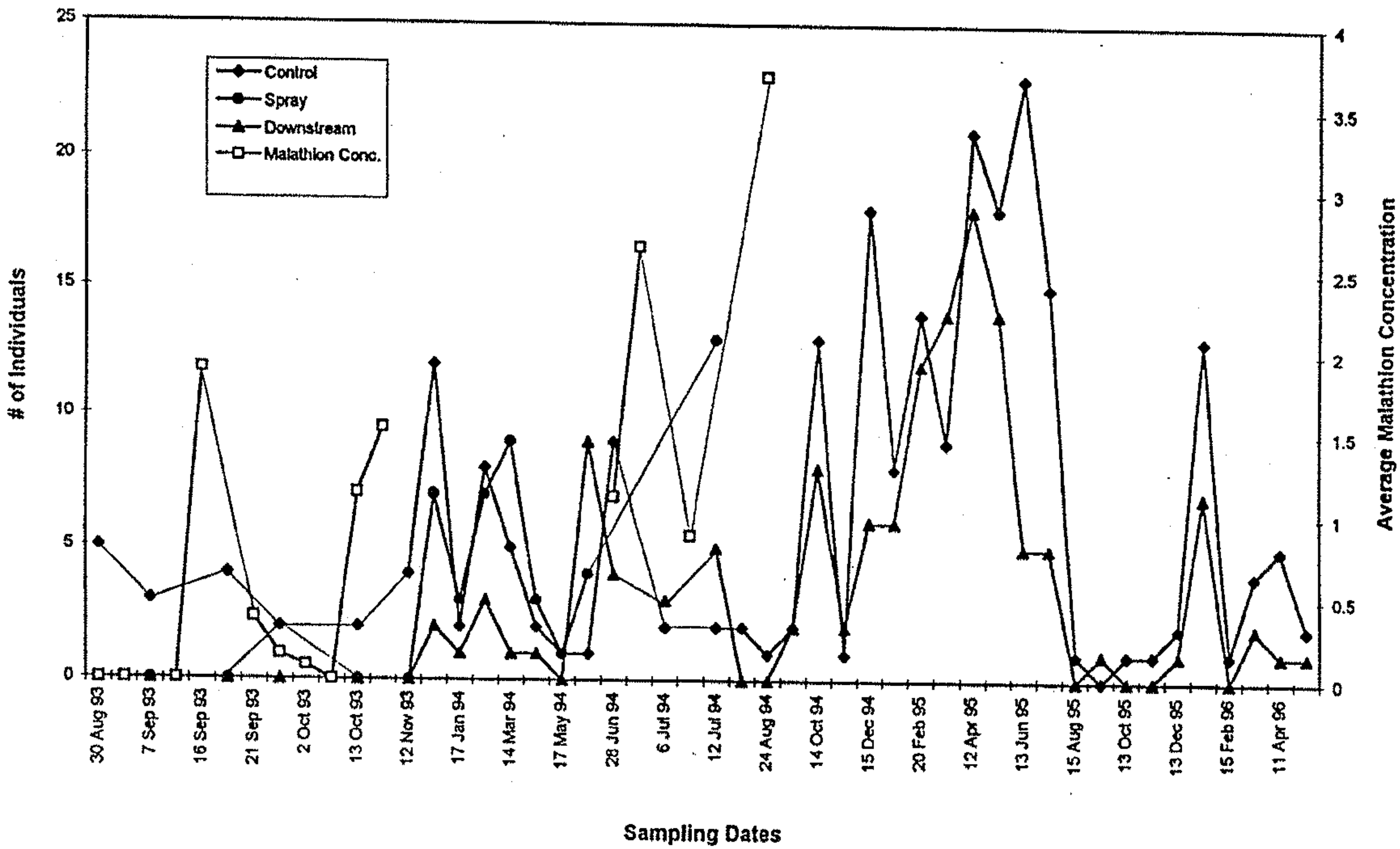
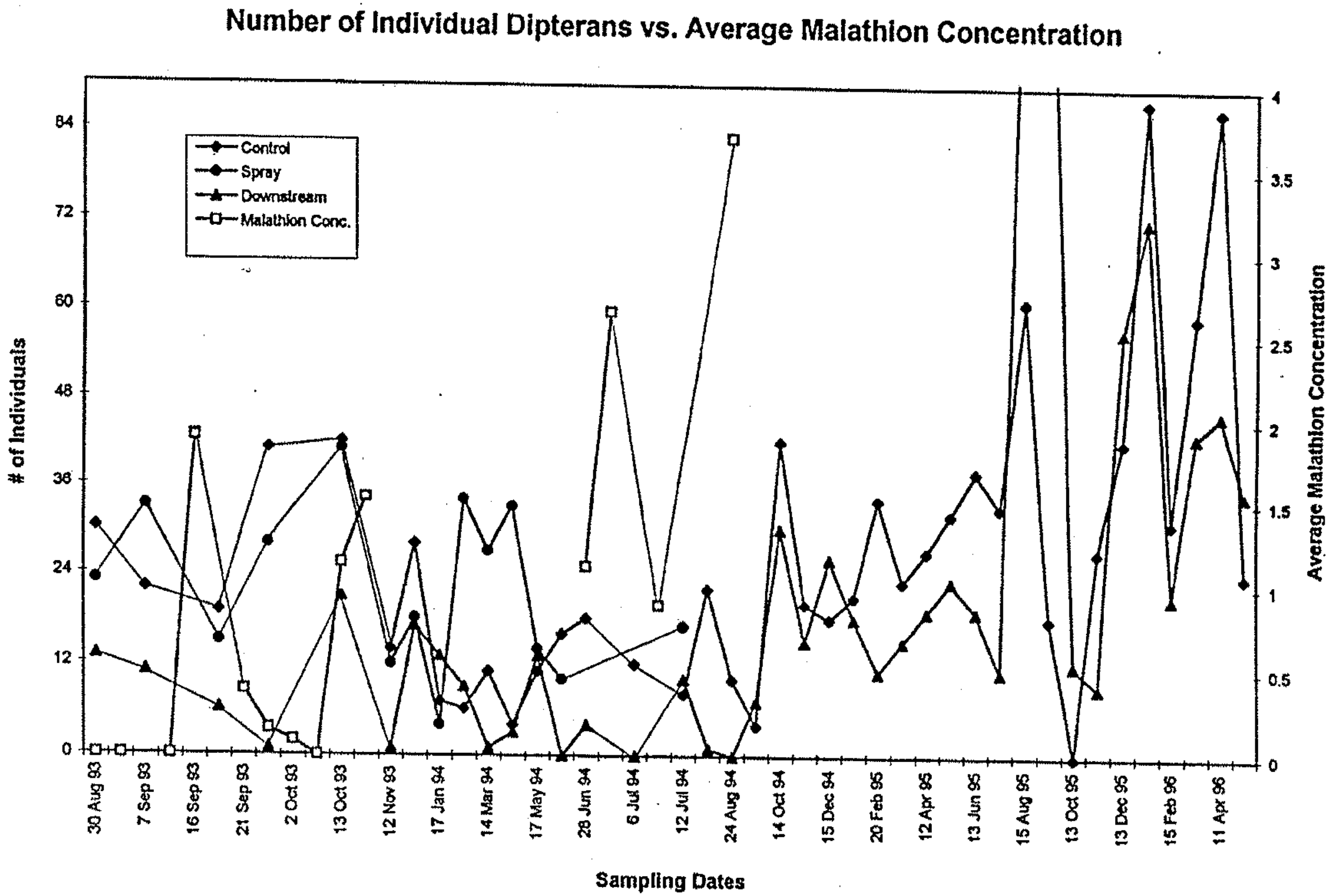


Figure 13



Number of Individual Dipterans vs. Average Malathion Concentration
# of Individuals
0
12
24
36
48
60
72
84
Average Malathion Concentration
0
0.5
1
1.5
2
2.5
3
3.5
4
Control
Spray
Downstream
Malathion Conc.
30 Aug 93
7 Sep 93
16 Sep 93
21 Sep 93
2 Oct 93
13 Oct 93
12 Nov 93
17 Jan 94
14 Mar 94
17 May 94
28 Jun 94
6 Jul 94
12 Jul 94
24 Aug 94
14 Oct 94
15 Dec 94
20 Feb 95
12 Apr 95
13 Jun 95
15 Aug 95
13 Oct 95
13 Dec 95
15 Feb 96
11 Apr 96
Sampling Dates

Appendix 1

Treatment history of both north and south cotton fields (19.2 acres) (7.8 hectares) along Stewart Creek, 1992. RA = rate applied (ounces/acre); TAA = total amount applied (ounces).

Date	Chemical	Class	RA	TAA
11 Jun	Bidrin	Organophosphate	3.40	65.30
8 Jul	Methyl Parathion 6.0	Organophosphate	8.23	158.05
13 Jul	Methyl Parathion 4.0	Organophosphate	10.29	201.67
18 Jul	Methyl Parathion 6.0	Organophosphate	10.29	201.67
24 Jul	Baythroid	Pyrethroid	1.65	31.68
1 Aug	Baythroid	Pyrethroid	1.65	31.68
3 Aug	Methyl Parathion 7.5	Organophosphate	8.23	158.02
10 Aug	Asana	Pyrethroid	4.94	94.85
10 Aug	Methyl Parathion 6.0	Organophosphate	8.23	158.02
15 Aug	Asana	Pyrethroid	4.94	94.85
15 Aug	Methyl Parathion 6.0	Organophosphate	8.23	158.02
22 Aug	Methyl Parathion 7.5	Organophosphate	8.23	158.02
29 Aug	Asana	Pyrethroid	--	--
29 Aug	Methyl Parathion	Organophosphate	--	--
5 Sep	Methyl Parathion 7.5	Organophosphate	8.24	158.02
14 Sep	Karate	Pyrethroid	4.94	94.85
21 Sep	Methyl Parathion 4.0	Organophosphate	16.46	316.09
25 Sep	Guthion 2L	Organophosphate	16.46	316.09
22 Oct	Def	Organophosphate	18.55	356.17
22 Oct	Methyl Parathion 4.0	Organophosphate	11.13	213.70
22 Oct	Prep	Phosphonic acid	11.13	213.70

Appendix 1 (continued)

Treatment history of both north and south cotton fields (19.2 acres) (7.8 hectares) along Stewart Creek, 1993. RA = rate applied (ounces/acre); TAA = total amount applied (ounces).

Date	Chemical	Class	RA	TAA
6 Jul	Methyl Parathion 7.5	Organophosphate	8.47	162.62
12 Jul	Methyl Parathion 7.5	Organophosphate	16.95	325.51
17 Jul	Asana	Pyrethroid	6.79	130.37
17 Jul	Larvin	Carbamate	5.30	101.76
21 Jul	Bolstar 6	Organophosphate	29.63	568.90
21 Jul	Guthion	Organophosphate	14.81	284.35
28 Jul	Baythroid	Pyrethroid	2.12	40.73
5 Aug	Asana	Pyrethroid	2.12	40.73
12 Aug	Dimilin	Urea	1.88	36.10
12 Aug	Bolstar 6	Organophosphate	5.00	96.00
12 Aug	Baythroid	Pyrethroid	2.00	38.40
20 Aug	Asana or Karate	Pyrethroid	--	--
1 Sep	Malathion	Organophosphate	16.00	307.20
8 Sep	Malathion	Organophosphate	16.00	307.20
16 Sep	Malathion	Organophosphate	16.00	307.20
21 Sep	Malathion	Organophosphate	16.00	307.20
28 Sep	Malathion	Organophosphate	16.00	307.20
2 Oct	Malathion	Organophosphate	16.00	307.20
7 Oct	Malathion	Organophosphate	16.00	307.20
13 Oct	Malathion	Organophosphate	16.00	307.20
13 Oct	Def	Organophosphate	23.97	460.22

Appendix 1 (continued)

Treatment history of north cotton field (11.6 acres) (4.7 hectares) along Stewart Creek, 1994. RA = rate applied (ounces/acre); TAA = total amount applied (ounces).

Date	Chemical	Class	RA	TAA
28 Jun	Malathion	Organophosphate	16.00	185.60
5 Jul	Malathion	Organophosphate	16.00	185.60
11 Jul	Malathion	Organophosphate	16.00	185.6
15 Jul	Baythroid	Pyrethroid	3.15	36.54
30 Jul	Amno	Pyrethroid	3.37	39.09
6 Aug	Larvin	Carbamate	20.00	232.00
19 Aug	Malathion	Organophosphate	16.00	185.60
24 Aug	Malathion	Organophosphate	16.00	185.60
26 Aug	Larvin	Carbamate	20.00	232.00
30 Aug	Malathion	Organophosphate	16.00	185.60
7 Sep	Malathion	Organophosphate	16.00	185.60
13 Sep	Malathion	Organophosphate	16.00	185.60
20 Sep	Malathion	Organophosphate	16.00	185.60
28 Sep	Malathion	Organophosphate	16.00	185.60
1 Oct	Def	Organophosphate	22.54	261.46
1 Oct	Prep	Phosphonic Acid	15.02	174.27
5 Oct	Malathion	Organophosphate	16.00	185.60
14 Oct	Malathion	Organophosphate	16.00	185.60
18 Oct	Def	Organophoshate	15.88	184.22
25 Oct	Malathion	Organophosphate	16.00	185.60
2 Nov	Malathion	Organophosphate	16.00	185.60

Appendix 1 (continued)

Treatment history of south cotton field (7.6 acres) (3.1 hectares) along Stewart Creek, 1994. RA = rate applied (ounces/acre); TAA = total amount applied (ounces).

Date	Chemical	Class	RA	TAA
28 Jun	Malathion	Organophosphate	16.00	121.60
5 Jul	Malathion	Organophosphate	16.00	121.60
11 Jul	Malathion	Organophosphate	16.00	121.60
15 Jul	Baythroid	Pyrethroid	3.15	23.94
27 Jul	Malathion	Organophosphate	16.00	121.60
30 Jul	Amno	Pyrethroid	3.37	25.61
6 Aug	Larvin	Carbamate	20.00	152.00
24 Aug	Malathion	Organophosphate	16.00	121.60
26 Aug	Larvin	Carbamate	20.00	152.00
7 Sep	Malathion	Organophosphate	16.00	121.60
13 Sep	Malathion	Organophosphate	16.00	121.60
20 Sep	Malathion	Organophosphate	16.00	121.60
28 Sep	Malathion	Organophosphate	16.00	121.60
1 Oct	Def	Organophosphate	22.54	171.30
1 Oct	Prep	Phosphonic Acid	15.02	114.15
5 Oct	Malathion	Organophosphate	16.00	121.60
14 Oct	Malathion	Organophosphate	16.00	121.60
18 Oct	Def	Organophoshate	15.88	120.69
25 Oct	Malathion	Organophosphate	16.00	121.60
2 Nov	Malathion	Organophosphate	16.00	121.60

Appendix 2

Treatment history of 11 acre (4.5 hectare) cotton field located 0.25 miles (0.4 kilometers) upstream of Spray location, 1993. RA = rate applied (ounces/acre); TAA = total amount applied (ounces).

Date	Chemical	Class	RA	TAA
2 Jul	Methyl Parathion 7.5	Organophosphate	5.68	62.48
13 Jul	Asana	Pyrethroid	4.11	45.26
13 Jul	Methyl Parathion 7.5	Organophosphate	4.57	50.29
17 Jul	Asana	Pyrethroid	7.62	83.81
17 Jul	Methyl Parathion 7.5	Organophosphate	0.81	8.92
22 Jul	Asana	Pyrethroid	4.26	46.86
22 Jul	Methyl Parathion 7.5	Organophosphate	4.26	46.86
27 Jul	Asana	Pyrethroid	4.26	46.86
27 Jul	Methyl Parathion 7.5	Organophosphate	4.26	46.86
7 Aug	Karate	Pyrethroid	3.66	40.26
7 Aug	Methyl Parathion 7.5	Organophosphate	6.48	71.28
11 Aug	Methyl Parathion 7.5	Organophosphate	6.40	70.40
14 Aug	Methyl Parathion 7.5	Organophosphate	6.40	70.40
19 Aug	Larvin	Carbamate	8.84	97.24
19 Aug	Methyl Parathion 7.5	Organophosphate	4.27	46.93
19 Aug	Asana	Pyrethroid	2.90	31.85
19 Aug	Larnate	Carbamate	4.57	50.29
23 Aug	Malathion	Organophosphate	16.00	176.00
27 Aug	Asana	Pyrethroid	3.66	40.26
27 Aug	Methyl Parathion 7.5	Organophosphate	4.27	46.93
30 Aug	Malathion	Organophosphate	16.00	176.00

6 Sep	Malathion	Organophosphate	16.00	176.00
13 Sep	Malathion	Organophosphate	16.00	176.00
20 Sep	Malathion	Organophosphate	16.00	176.00
28 Sep	Malathion	Organophosphate	16.00	176.00
5 Oct	Malathion	Organophosphate	16.00	176.00
7 Oct	Def	Organophosphate	21.20	233.20
11 Oct	Malathion	Organophosphate	16.00	176.00
22 Oct	Malathion	Organophosphate	16.00	176.00

Appendix 2 (continued)

Treatment history of 11 acre (4.5 hectare) cotton field located 0.25 miles (0.4 kilometers) upstream of Spray location, 1994. RA = rate applied (ounces/acre); TAA = total amount applied (ounces).

Date	Chemical	Class	RA	TAA
20 Jun	Malathion	Organophosphate	16.00	176.00
29 Jun	Malathion	Organophosphate	16.00	176.00
5 Jul	Malathion	Organophosphate	16.00	176.00
11 Jul	Malathion	Organophosphate	16.00	176.00
14 Jul	Baythroid	Pyrethroid	2.13	23.47
14 Jul	Dimilin	Urea	2.00	22.00
23 Jul	Amno	Pyrethroid	3.20	35.20
27 Jul	Malathion	Organophosphate	16.00	176.00
1 Aug	Asana	Pyrethroid	1.60	17.60
9 Aug	Malathion	Organophosphate	16.00	176.00
11 Aug	Baythroid	Pyrethroid	2.13	23.47
25 Aug	Malathion	Organophosphate	16.00	176.00
30 Aug	Malathion	Organophosphate	16.00	176.00
7 Sep	Malathion	Organophosphate	16.00	176.00
13 Sep	Malathion	Organophosphate	16.00	176.00
20 Sep	Malathion	Organophosphate	16.00	176.00
28 Sep	Malathion	Organophosphate	16.00	176.00
14 Oct	Malathion	Organophosphate	16.00	176.00
24 Oct	Def	Organophosphate	8.00	88.00
24 Oct	Prep	Phosphonic acid	21.30	234.30
2 Nov	Malathion	Organophosphate	16.00	176.00

Table 6b

Spray site - Aquatic Invertebrates

* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
DECAPODA										
Cambaridae										
Orconectes sp.							5	1	11	4
EPHEMEROPTERA										
Heptageniidae										
Stenonema sp.			1				3	8	13	17
Baetidae										
Baetis sp.							1			
Oligoneuridae										
Isonychia sp.									1	1
ODONATA										
Coenagrionidae										
Argia sp.	1						3			
Calopterygidae										
Calopteryx sp.							5		2	6
Gomphidae										
Dromogomphus sp.										
Gomphus sp.									1	
Progomphus sp.						1	3		1	1
Stylurus sp.		1	2	1	3	5				1
Cordulegastridae										
Cordulegaster sp.										
Aeshnidae										
Boyeria sp.					1			2	4	2
Macromiidae										
Macromia sp.										
Corduliidae										
**Helocordulia sp.*		1								
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.							1		1	
Perlidae										
Acroneuria sp.									8	
Perlesta sp.										
Perlodidae										
Isoperla									11	31
Leuctridae										
Leuctra sp.							2	1		
Capniidae (adult)					1					
Chloroperlidae										
Sweltsa mediana		1								
HEMIPTERA										
Mesoveliidae										
Mesovelia sp.										
Corixidae		1	2	2	2	5	5			1
Nepidae										
Rinatra sp.					1		3			
Veliidae										
Rhagovelia sp.										

Table 6b (continued)
Spray site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
MEGALOPTERA										
Corydalidae										
Corydalus sp.				1	1			1		
Neohermes concolor										
Nigronia sp.				1						1
TRICHOPTERA										
Hydropsychidae										
Chematopsyche sp.									1	
Hydropsyche sp.							3		4	5
Limnephilidae										
Pycnopsyche sp.				1					1	3
Philopotamidae										
Chimarra sp.										1
Phryganeidae										
Ptilostomis sp.							4	3	1	
COLEOPTERA										
Elmidae										
Ancyronyx sp.										
Macronychus sp.										
Stenelmis sp.										
Noteridae										
Hydrocanthus sp.										
Gyrinidae										
Dineutus sp.		1							1	
Haliplidae										
Peltodites sp.										
Dryopidae										
Helichus sp.										
Dytiscidae										
Dytiscus sp.										
DIPTERA										
Tipulidae										
Tipula sp.					3		3		9	9
Chironomidae	23	33	15	28	37	12	15	4	25	18
Tabanidae					1					
Total # of individuals	24	38	20	34	50	23	56	20	95	101
Total # of taxa	2	6	4	6	9	4	14	7	17	15
Diversity Index	0.72453	3.16499	2.30587	3.26482	4.70874	2.20308	7.43627	4.61173	8.09011	6.98491

Table 6b (continued)
Spray site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	12 VII 94	Total # of indiv.
DECAPODA					
Cambaridae					
Orconectes sp.	4	4	8	1	38
EPHEMEROPTERA					
Heptageniidae					
Stenonema sp.	7	2	4	7	62
Baetidae					
Baetis sp.					1
Oligoneuridae					
Isonychia sp.					2
ODONATA					
Coenagrionidae					
Argia sp.					4
Calopterygidae					
Calopteryx sp.	1	1	2		17
Gomphidae					
Dromogomphus sp.	4		3	1	8
Gomphus sp.					1
Progomphus sp.		1		1	8
Stylurus sp.					13
Cordulegastridae					
Cordulegaster sp.			1		1
Aeshnidae					
Boyeria sp.	4	5	4	2	24
Macromiidae					
Macromia sp.				1	1
Corduliidae					
**Helocordulia sp.*					1
PLECOPTERA					
Pteronarcyidae					
Pteronarcys sp.		1	2		5
Perlidae					
Acroneuria sp.	27	15	22	13	85
Perlesta sp.		1	8		9
Perlodidae					
Isoperla				4	46
Leuctridae					
Leuctra sp.					3
Capniidae (adult)					1
Chloroperlidae					
Sweltsa mediana					1
HEMIPTERA					
Mesoveliidae					
Mesovelia sp.		1			1
Corixidae	8			1	27
Nepidae					
Ranatra sp.					4
Veliidae					
Rhagovelia sp.		1	1		2

Table 6b (continued)
Spray site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	12 VII 94	Total # of indiv.
MEGALOPTERA					
Corydalidae					
Corydalus sp.			2		5
Neohermes concolor				1	1
Nigronia sp.	1			2	5
TRICHOPTERA					
Hydropsychidae					
Chematopsyche sp.	1				2
Hydropsyche sp.	2	1	3	8	26
Limnephilidae					
Pycnopsyche sp.					5
Philopotamidae					
Chimarra sp.			1	5	7
Phryganeidae					
Ptilostomis sp.					8
COLEOPTERA					
Elmidae					
Ancyronyx sp.				4	4
Macronychus sp.		2	1		3
Stenelmis sp.				1	1
Noteridae					
Hydrocanthus sp.			1		1
Gyrinidae					
Dineutus sp.			1		3
Haliplidae					
Peltodites sp.		1			1
Dryopidae					
Helichus sp.				5	5
Dytiscidae					
Dytiscus sp.				1	1
DIPTERA					
Tipulidae					
Tipula sp.	3			2	29
Chironomidae	30	14	10	15	279
Tabanidae					1
Total # of individuals	92	50	74	75	752
Total # of taxa	14	14	17	19	
Diversity Index	6.61986	7.65169	8.55967	9.59969	

Table 6c
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
DECAPODA										
Cambaridae										
Hobbseus sp.										
Orconectes sp.				2			9	8	2	2
Palemonidae				3						
**Cambarus sp.*										
AMPHIPODA										
**Gammarus sp.*										
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.									1	
Heptagenlidae										
Stenonema sp.							3	9		8
Caenidae										
Caenis sp.										
Baetidae										
Baetis sp.										
Leptophlebiidae										
Leptophlebia sp.										
Oligoneuriidae										
Isonychia sp.										
ODONATA										
Coenagrionidae										
Argia sp.		1				3				1
Calopterygidae										
Calopteryx sp.										
Gomphidae										
Dromogomphus sp.										
Gomphus sp.										
Hagenius sp.										1
Progomphus sp.										
Stylurus sp.	2				1	2				
Cordulegastridae										
Cordulegaster sp.	1									
Aeshnidae										
Boyeria sp.	1									
Lestidae										
Macromiidae										
Macromia sp.		1		1			1			
**Macrothemis sp.*										
Corduliidae										
**Somatochlora sp.*										
Libellulidae										
**Celithemis sp.*		1								
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.							2			
Perlidae										
Acroneuria sp.							3		2	1
Perlesta sp.										

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
Perlodidae										
Isoperla sp.									4	23
Taeniopterygidae										
**Strophopteryx sp.*							1	1		
Taeniopteryx sp.							2	1		
Capniidae										
Allocapnia sp.										
HEMIPTERA										
Gerridae										
Trepobates sp.										
Belostomatidae										
**Belostoma sp.*										
Mesoveliidae										
Mesovelia sp.										
Notonectidae				1						
Corixidae		1			2	3				
Nepidae										
Rinatra sp.										
Veliidae										
Rhagovelia sp.										
Saldidae										
MEGALOPTERA										
Corydalidae										
Corydalus sp.										1
Neohermes concolor										
Nigronia sp.										
Sialidae										
Sialis sp.										
TRICHOPTERA										
Hydropsychidae										
Chematopsyche sp.										
Diplonectra sp.										
Hydropsyche sp.							1		1	1
**Macrostemum sp.*										
Limnephilidae										
Pycnopsyche sp.										
Leptoceridae										
Trianodes sp.										
Philopotamidae										
Chimarra sp.								1		
Phryganeidae										
Ptilostomis							1		2	
COLEOPTERA										
Elmidae										
Ancyronyx sp.										
Macronychus sp.	1									
Stenelmis sp.										
Noteridae										
Hydrocanthus sp.										

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	30 VIII 93	7 IX 93	17 IX 93	28 IX 93	13 X 93	12 XI 93	14 XII 93	17 I 94	15 II 94	14 III 94
Gyrinidae										
Dineutus sp.										
Gyrinus sp.								1		
Haliplidae										
Peltodites sp.										
Dryopidae										
Helichus sp.										
Hydrophilidae										
**Sperchopsis sp.*										
**Tropisternus sp.*										
Dytiscidae										
Dytiscus sp.										
Ptilodactylidae										
Ptilodactylus sp.										
OLIGOCHAETA										
DIPTERA										
Tipulidae										
Tipula sp.	1			1	4	1	7	1	1	1
Hexatoma sp.										
Chironomidae	12	11	6		17		10	12	8	
Simuliidae										
Tabanidae										
Ceratopogonidae										
Bezzia sp.										
Dixidae										
Dixa sp.										
Total # of individuals	18	15	6	8	24	9	40	34	21	39
Total # of taxa	6	5	1	5	4	4	11	8	8	9
Diversity Index	3.9832	3.4011	0	4.42924	2.17358	3.14385	6.24196	4.57075	5.29413	5.02808

Table 6c (continued)
Downstream site - Aquatic Invertebrates
* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
DECAPODA										
Cambaridae										
Hobbseus sp.										
Orconectes sp.	4	2	3	5	2	2	5	2	4	2
Palemonidae										
Cambarus sp.										
AMPHIPODA										
Gammarus sp.										
EPHEMEROPTERA										
Ephemeridae										
Hexagenia sp.		1								
Heptagenlidae										
Stenonema sp.	5		2	2	2	2				2
Caenidae										
Caenis sp.					2					
Baetidae										
Baetis sp.				1						
Leptophlebiidae										
Leptophlebia sp.										
Oligoneuriidae										
Isonychia sp.	1									
ODONATA										
Coenagrionidae										
Argia sp.										
Calopterygidae										
Calopteryx sp.	1	2	1	1						
Gomphidae										
Dromogomphus sp.	2	1	1	1	1	1		2	1	3
Gomphus sp.										
Hagenius sp.										
Progomphus sp.										1
Stylurus sp.						1	1			
Cordulegastridae										
Cordulegaster sp.							1			1
Aeshnidae										
Boyeria sp.			2	1	6	5	2	1	1	3
Lestidae										
Macromiidae										
Macromia sp.			2		3	2		1		1
Macrothemis sp.										
Corduliidae										
Somatochlora sp.										
Libellulidae										
Celithemis sp.										
PLECOPTERA										
Pteronarcyidae										
Pteronarcys sp.				1			1		2	
Perlidae										
Acroneuria sp.	21	12	27	22			1			
Perlesta sp.			4	2						

Table 6c (continued)

Downstream site - Aquatic invertebrates

* indicates taxa unique to this site

Scientific Names	15 IV 94	17 V 94	14 VI 94	28 VI 94	6 VII 94	12 VII 94	12 VIII 94	24 VIII 94	16 IX 94	14 X 94
Periodidae										
Isoperla sp.										
Taeniopterygidae										
Strophopteryx sp.										
Taeniopteryx sp.										
Capniidae										
Allocapnia sp.										
HEMIPTERA										
Gerridae										
Trepobates sp.										
Belostomatidae										
Belostoma sp.							1			
Mesovellidae										
Mesovelia sp.				3						
Notonectidae							1			
Corixidae		1	1	3	7			1		
Nepidae						2				
Rinatra sp.				1						
Vellidae										
Rhagovelia sp.										
Saldidae										
MEGALOPTERA										
Corydalidae										
Corydalus sp.	1	1							1	
Neohermes concolor						1	1			
Nigronia sp.									1	
Sialidae										
Sialis sp.			2		1	1				
TRICHOPTERA										
Hydropsychidae										
Chematopsyche sp.			4	1						
Diplonectra sp.	1									
Hydropsyche sp.			4	2	2	4			2	4
Macrostemum sp.					1	1				
Limnephilidae										
Pycnopsyche sp.										
Leptoceridae										
Trianodes sp.										1
Philopotamidae										
Chimarra sp.			1	1						2
Phryganeidae										
Ptilostomis sp.										1
COLEOPTERA										
Elmidae										
Ancyronyx sp.					3		1		1	
Macronychus sp.			1	1			1	2	2	
Stenelmis sp.										
Noteridae								1		
Hydrocanthus sp.							1			