Response to Eastern Equine Encephalitis Virus Mosquito Control Aerial Spray Events 2024: A Summary of the Surface Water Quality Sampling Operations

Massachusetts Department of Environmental Protection
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Background

The Massachusetts Department of Public Health's (DPH) Arbovirus Surveillance Program (Program) collects mosquito population data statewide on Eastern Equine Encephalitis virus (EEEv), West Nile Virus (WNV), and other mosquito-borne arboviruses from spring to fall of each year in order to predict trends in virus prevalence and subsequent potential for human infection. Throughout the state, positive surveillance findings for arbovirus infected mosquitos were fewer in 2023 than in 2024. There were fewer cases of EEEv and no aerial adulticide spraying in 2023. From the first report issued in May 2024, the Program warned that intense regional precipitation events and warm weather would support increased populations of WNV and EEE mosquito vectors. Based upon data collected in 2024, the Program issued a determination on August 24, 2024 that there was an elevated risk of EEEv in parts of southeastern Massachusetts. The final number of human EEEv cases in 2024 totaled four and WNV cases totaled fifteen.

On July 8, 2024, the Program reported the first positive samples of the season: 2 positive WNV mosquito samples in Norfolk County and 6 positive EEE mosquito samples in Plymouth County.

In late June, the southeastern communities of Carver and Middleborough in Plymouth County experienced increased mosquito activity, typical for that region due to its wetter geography, which provides favorable mosquito habitat. By early July, EEE-positive mosquito pools were found in these communities, prompting DPH to raise the EEEv risk level to moderate in these areas.

The first EEEv human case was identified in mid-August in southern Worcester County, and DPH raised the risk levels in towns in that area from low to high and critical. DPH conducted increased testing in Worcester County and results did not support the initiation of aerial spray in this area in the 2024 season.

Based on the elevated public health risk and a confirmed human case of EEEv on August 24, 2024, DPH issued a "*Certification of Public Health Hazard that Requires Pesticide Application to Protect Public Health"* for Plymouth County. The certification affirmed that aerial intervention application was necessary to protect the public, and the State Reclamation and Mosquito Control Board (SRMB) held an emergency meeting on the same day to approve aerial spray to reduce the abundance of adult mosquitoes infected with EEEv and other arboviruses.

Following DPH's certification of public health hazard, the SRMB, operating within the Massachusetts Department of Agricultural Resources, and in collaboration with regional Mosquito Control Districts and Projects, and the Massachusetts Department of Public Health, planned and implemented an aerial mosquito control spray operation and coordinated communication between agencies. The Massachusetts Department of Environmental Protection (MassDEP) conducted pre- and post-spray monitoring of public water supplies (PWS) as well as post-spray monitoring of non-PWS surface water bodies in conjunction with

the spraying, which was conducted on the evening of August 27-28, 2024.

The pesticide Anvil 10+10 ULV, currently used for aerial spraying in Massachusetts, contains the active ingredients d-phenothrin (sumithrin) and the synergist piperonyl butoxide (PBO).

Mosquito Control Aerial Spraying

Dynamic Aviation conducted the aerial spraying and MassDEP provided the associated GIS services. The emergency mosquito response began at 8 pm on August 27, 2024 and ended at approximately 2 am on August 28, 2024. One plane covered the entire spray area, which totaled 178,823 acres, in one night. The pilots were instructed to follow a 1,000 ft exclusion (no spray) zone around public water supplies that are surface waters as identified by GIS maps. In addition, other exclusion zones included the entirety and buffers of mapped organic farms and endangered species habitat. Eight towns in Plymouth County (Figure 1) were either fully or partially in the spray area, including: Carver, Halifax, Kingston, Middleborough, Plymouth, Plympton, Rochester and Wareham.

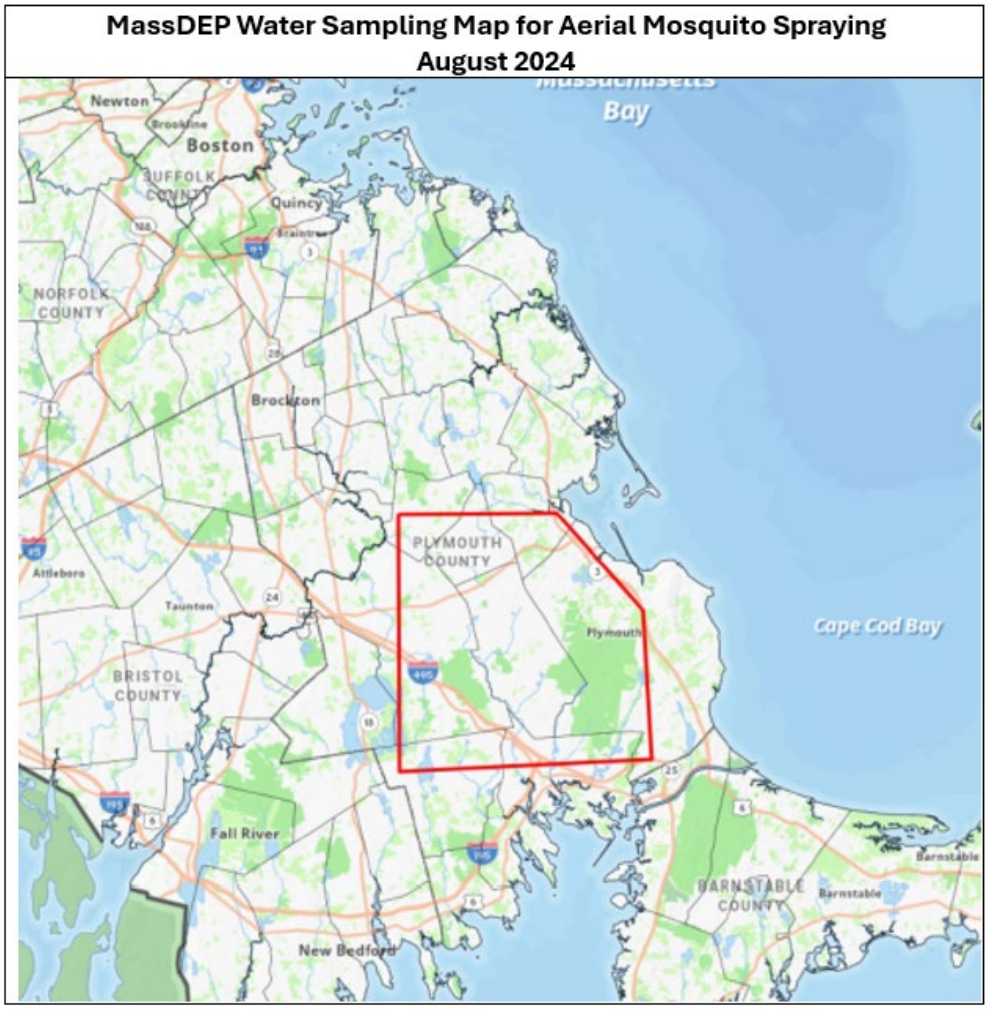

Figure 1: 2024 MassDEP Water Sampling Map for Aerial Mosquito Spraying

MassDEP's Water Quality Sampling Effort in 2024

In conjunction with the aerial spraying, MassDEP conducted a water monitoring study of all PWS using surface waters within the spray area as well as selected non-PWS surfaces waters within the spray area. MassDEP staff collected non-PWS surface water samples and were assisted by the public water suppliers who collected samples from their water systems. This study was undertaken, to ensure that public water supplies were safe for human consumption and that surface waters were safe for the ecological receptors, including both fish and invertebrates, that lived in them based on MassDEP Office of Research and Standard (ORS) and U.S. EPA benchmarks: the Human Health Drinking Water Criteria and the Aquatic Life Benchmark Concentrations for fish and invertebrates, respectively, for the short-lived sumithrin pesticide and piperonyl butoxide synergist.

Sampling was conducted as specified in the Office of Research and Standards' *Mosquitocide Aerial Spraying Water Resources Sampling Guidance* (updated 2024), which describes the sampling protocols developed by MassDEP staff and analytical methodologies recommended by MassDEP's Wall Experiment Station (WES). The samples were analyzed by the Massachusetts Pesticide Analysis Lab (MPAL) at the University of Massachusetts-Amherst.

Description of Water Quality Sampling Operation

The water quality sampling of the PWS was conducted by the water suppliers on August 27-28, 2024. An initial set of "pre-spray" samples, including one raw water (water that has not yet undergone treatment) sample and one finished (treated) sample was collected on the morning of August 27th prior to the evening spray and delivered to the MassDEP office. Another similar set of "post-spray" samples, including one raw and one finished sample, was also collected and delivered to MassDEP early in the morning after spraying was conducted.

The sampling of the non-PWS surface waters was conducted by MassDEP staff and involved collecting a "post-spray" sample from each waterbody on August 28th. In addition, MassDEP staff collected a "ControlSite" sample from a non-PWS waterbody that was outside of the aerial spray zone.

As specified in the sampling protocol, a sample duplicate was collected, and a field blank sample was prepared by both one PWS sampler and one non-PWS sampler on each sampling day as measures of quality control.

Though the bottles used to collect the samples were pre-filled with a number of preservatives to slow down the rapid degradation process of the pesticide and PBO once exposed to light and air, MassDEP staff and the water suppliers made every effort to mobilize quickly and collect samples by approximately 8:00 am after the previous night's aerial spray operation. Samples were then delivered to MPAL for analysis.

A total of 19 samples were collected from 7 locations, as shown in Figure 2.

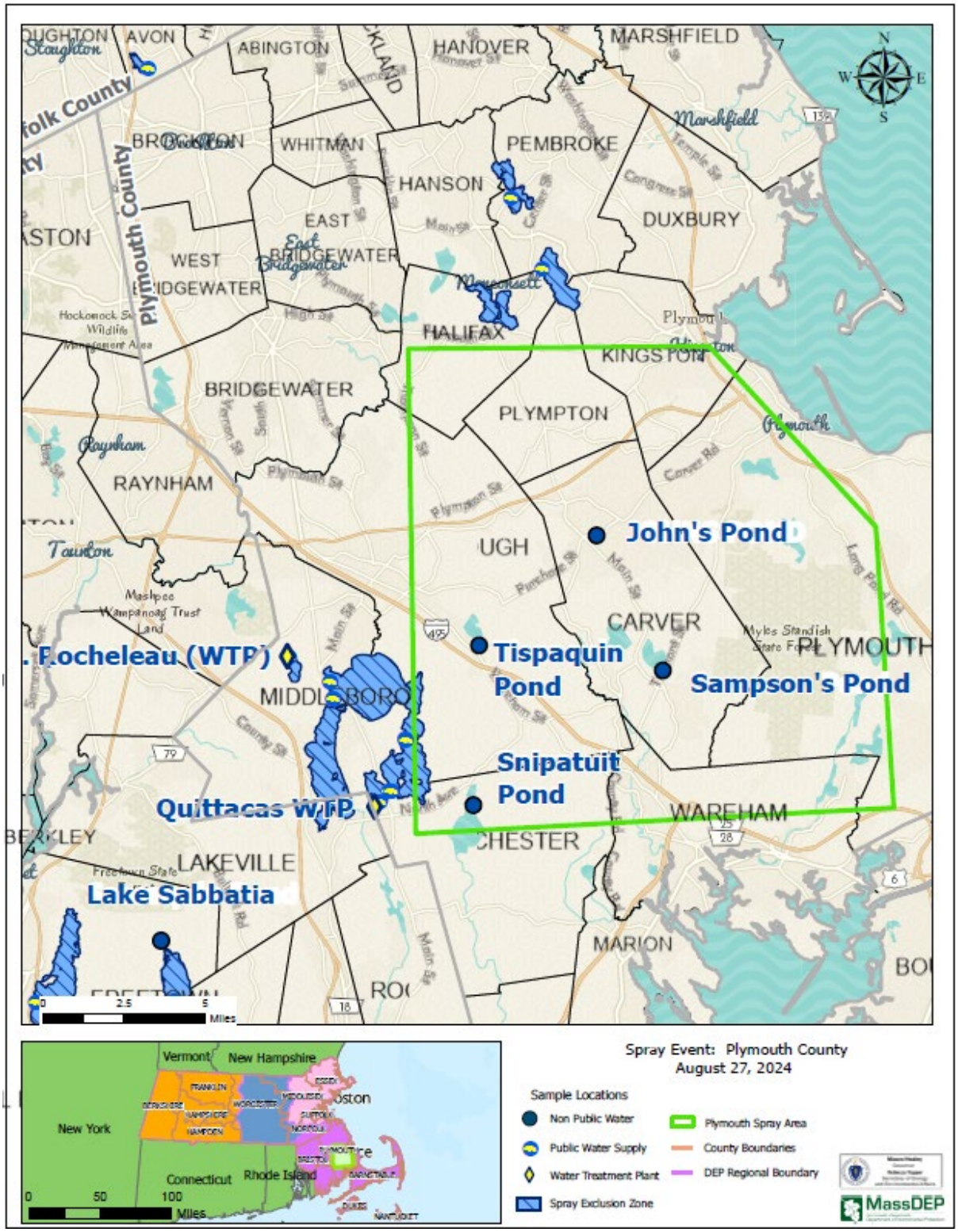

Figure 2: Sampling Locations for August 27-28, 2024 Spray Event

Two public water suppliers collected eight raw and finished water samples at their water treatment plants and one of them also collected a duplicate sample and prepared a field blank sample on each sampling day (thus, four quality control samples) for a total of twelve samples collected by water suppliers.

They were:

1. Taunton Water Division's Charles J. Rocheleau Water Treatment Plant (WTP) at Elders Pond
2. New Bedford Department of Public Infrastructure (DPI) Water Division's Quittacas WTP

MassDEP's field sampling staff collected samples from four non-PWS waterbodies within the spray area, one non-PWS sample outside the spray area (ControlSite sample), one duplicate sample and prepared one field blank sample for a total of seven samples. These samples were collected from the following water bodies:

1. Lake Sabbatia, Taunton (Control Site)
2. Snipatuit Pond, Rochester
3. Sampson's Pond, Carver
4. John's Pond, Carver
5. Tispaquin Pond, Middleborough

Summary of the Anvil® 10+10 Water Sampling Results

Post-spray samples were analyzed by MPAL in Amherst and the resulting data were forwarded to ORS for assessment of potential human and ecological risks. (See Appendix 2 for detailed information about samples analyzed by MPAL as well as sample results.) ORS evaluated the analytical data to determine if any concentrations of sumithrin (the pesticide active ingredient) and piperonyl butoxide (PBO, the synergist that amplifies its effectiveness) were of public health concern or posed risks to aquatic animals based on U.S. EPA benchmarks as noted earlier, the Human Health Drinking Water Criteria and the Aquatic Life Benchmark Concentrations for fish and invertebrates, respectively.

Neither sumithrin nor PBO were detected in any of the raw and finished samples collected from the public water systems. If present, PWSs participating in the sampling would have been required to provide information on any detects in their Drinking Water Consumer Confidence Report. More information is available at https://www.mass.gov/info-details/consumer-confidence-reports.

Table 1. PBO and Sumithrin Detections by Water Treatment Plant (ug/L)[1]

Public Water System/ Location	PBO		SUMITHRIN	
	RAW	FINISH	RAW	FINISH
Taunton Water Department/ Charles J. Rocheleau WTP @ Elders Pond	<LOQ[2]	<LOQ	<LOQ	<LOQ
New Bedford Water Division/ Quittacas WTP	<LOQ	<LOQ	<LOQ	<LOQ

[1] ug/L means micrograms per liter (also equal to parts per billion (ppb)).
[2] LOQ = Limit of Quantitation; The LOQ for both Sumithrin and PBO is 0.004 ug/L (ppb).

Table 2. U.S. EPA Guidance Levels for Human Health

COMPOUND	Chronic Criteria (ug/L)[1]			Acute Criteria (ug/L)[1]		
	general population	child[3]	lactating woman[3]	child	female (13-49 years)	lactating woman[3]
Sumithrin	40[2]	9.3	30		800[2]	640
Piperonyl Butoxide	950	213	682	30,000		106,000

[1] ug/L =micrograms per liter (also equal to parts per billion, or ppb).
[2] Sumithrin is undergoing reregistration review by US EPA, which has proposed human health toxicity values that will result in acute and chronic sumithrin values that are ten times less restrictive than the values currently being used by MassDEP. For additional information, see EPA's risk assessment at EPA-HQ-OPP-2011-0539-0047_content (4).pdf and EPA's Interim Registration Decision at US EPA - d-Phenothrin Interim Registration Review Decision - Case Number 0426. MassDEP will update these values once EPA issues a final reregistration decision.
[3] Criteria for the lactating woman and chronic exposure for the child were derived by the MassDEP Office of Research and Standards.

Sumithrin was detected in one of the samples collected from the surface water bodies that do not serve as drinking water sources (non-PWS water samples). It was detected outside the treated area at Lake Sabbatia, the Control Site waterbody, at a level of 0.01 ug/L. The source(s) of the sumithrin and PBO found in this waterbody is unknown. The sumithrin concentration was far below the U.S. EPA Aquatic Life Benchmark Concentrations for fish and invertebrates (Table 4). The synergist PBO was detected and quantified in all five non-PWS surface water bodies sampled (Table 3). The highest concentration of PBO in a non-PWS water body was 0.15 ug/L, reported in a sample from Snipatuit Pond in Rochester, MA. This concentration was far below the U.S. EPA Aquatic Life Benchmark Concentrations for fish and invertebrates (Table 4). Thus, the concentrations of sumithrin and PBO found in these water bodies would not be expected to present a significant risk to fish and invertebrates.

Table 3. PBO and Sumithrin Detections by Non-PWS Waterbody (ug/L)[1]

Non-PWS Waterbody	PBO	Sumithrin
Lake Sabbatia, Taunton (Control Site)	0.09	0.01
Snipatuit Pond, Rochester	0.15	<LOQ
Sampson's Pond, Carver	0.08	<LOQ
John's Pond, Carver	0.02	<LOQ
Tispaquin Pond, Middleborough	0.08	<LOQ
AVERAGE	**0.084**	**.01**
MINIMUM	**0.02**	**.01**
MAXIMUM	**0.15**	**.01**

[1]ug/L means micrograms per liter (also equal to parts per billion (ppb)).
[2]LOQ = Limit of Quantitation; The LOQ for both Sumithrin and PBO is 0.004 ug/L (ppb).

Table 4. U.S. EPA Aquatic Life Benchmark Concentrations

COMPOUND	Chronic Criteria (ug/L)[1]		Acute Criteria (ug/L)[1]	
	Fish	Invertebrates	Fish	Invertebrates
Sumithrin	1.1	0.47	7.9	2.2
Piperonyl Butoxide	7.8	30	1450	21.1

[1]ug/L means micrograms per liter (also equal to parts per billion (ppb)).

References

Massachusetts Department of Environmental Protection, 2021, Response to Eastern Equine Encephalitis Virus Mosquito Control Aerial Spray Events 2020: A Summary of the Surface Water Quality Sampling Operations

Massachusetts Department of Environmental Protection, 2023, Mosquitocide Aerial Spraying Water Resources Sampling Guidance

Appendix 1:
Highlights of MassDEP's 2023 Mosquitocide Aerial Spraying Water Resources Sampling Guidance

Summary of Sample Collection Procedure for Mosquitocide Aerial Spraying
Water Resources Sampling Guidance

Water Quality Samples Within Aerial Spray Zone	PRE-SPRAY: Day Before Aerial Spraying	POST-SPRAY: Morning After Aerial Spraying
PWS Drinking Water Manager	• 1 Raw Water Intake; • 1 Finished Water Intake; • 1 Duplicate Finished Water Intake, as requested of one supplier per sampling day • One Field Blank, as requested of one supplier per sampling day	• 1 Raw Water Intake; • 1 Finished Water Intake; • Duplicate Finished Water Intake, as requested of one supplier per sampling day • One Field Blank, as requested of one supplier per sampling day
MassDEP Regional Sampling Staff		• Surface Water sample from up to six[1] non-PWS waterbodies; • 1 Duplicate water sample, as requested, of one field sampler per sampling day taken at one of their sampling locations • 1 Field Blank, as requested of one field sampler per sampling day; • 1 Control Site sample, as requested of one field sampler per sampling day.

Appendix 2:
Samples Collected and Analytical Results

Summary Tables of the Water Samples Analyzed

Nineteen samples were collected by MassDEP and analyzed for sumithrin and the synergist piperonyl butoxide (PBO) by the Massachusetts Pesticide Analysis Lab (MPAL) at UMASS-Amherst. Details about these samples and their results are presented in Tables 2-1 through 2-5. Table 2-3 presents results of all samples collected.

Table 2-1. Number of Water Samples of Each Type Analyzed

SAMPLE TYPE	# ANALYZED
RAW[1] Water from PWS	4
FINISHED[1] Water from PWS	4
FINISHED DUPLICATE[2] Water from PWS	2
FIELD BLANK[3]	2
non-PWS	4
non-PWS DUPLICATE[2]	1
Control Site[4]	1
FIELD BLANK[3]	1
TOTAL SAMPLES	19

[1]RAW Water – water that has not been processed on a water treatment;
FINISHED Water – water that has been processed in a water treatment plant and is ready to be delivered to consumers.
[2]DUPLICATE – a second water sample collected concurrently with a first sample;
[3]FIELD BLANK– a clean, unopened sample bottle that accompanies the sample bottles to the "field" and back to the analytical laboratory, to which clean deionized water is added in the field and capped.
[4]Control Site – a waterbody outside of the spray area used as a reference to compare to data from within the spray area;

Table 2-2. Number of Detections of PBO and Sumithrin of Each Sample Type

SAMPLE TYPE DETECTIONS	PBO	Sumithrin
TOTAL detections	6	1
RAW[1] WATER detections	---	---
FINISHED[1] WATER detections	---	---
FINISHED WATER DUPLICATE[2] detections	---	---
Non-PWS detections	4	---
Non-PWS DUPLICATE[2] detections	1	---
Control Site[3] detections	1	1
FIELD BLANK[4] detections	---	---

[1]RAW Water – water that has not been processed on a water treatment;
FINISHED Water – water that has been processed in a water treatment plant and is ready to be delivered to consumers.
[2]DUPLICATE – a second water sample collected concurrently with a first sample;
[3]Control Site – a waterbody outside of the spray area used as a reference to compare to data from within the spray area;
[4]FIELD BLANK – a clean, unopened sample bottle that accompanies the sample bottles to the "field" and back to the analytical lab.

Table 2-3. 2024 Water Sampling Data for August 27-28, 2024 Anvil 10+10 Spraying Event

EventID[1]	Chain Of Custody ID[2]	PBO > LOQ[3] (ug/L)[4]	Sumithrin > LOQ[2] (ug/L)[4]	Surrogate Recovery[5] (%)	Sample Type	Geographic Town	SOURCE_ID	Water Body Name
BP1-2024	SN-S-1	.15	---	73.9	Non-PWS	Rochester	No SOURCE_ID	Snipatuit Pond
BP1-2024	SN-S-1-B	---	---	70.1	Non-PWS – Field Blank	Rochester	No SOURCE_ID	Snipatuit Pond
BP1-2024	TQ-S-1	.03	---	80.3	Non-PWS	Middleborough	No SOURCE_ID	Tispaquin Pond
BP1-2024	JP-S-1	.02	---	77.0	Non-PWS	Carver	No SOURCE_ID	John's Pond
BP1-2024	SP-S-1-D	.08	---	70.1	Non-PWS - Duplicate	Carver	No SOURCE_ID	Sampson's Pond
BP1-2024	SP-S-1	.08	---	74.9	Non-PWS	Carver	No SOURCE_ID	Sampson's Pond
BP1-2024	LS-S-1-CS	0.09	.01	86.0	Non-PWS Control Site	Taunton	No SOURCE_ID	Lake Sabbatia
BP1-2024	LQ-D-0-R	---	---	82.0	PWS, Raw, Pre-Spray	Rochester	4201000-02S	Little Quittacas Pond
BP1-2024	LQ-D-0-F	---	---	74.6	PWS, Finished, Pre-Spray	Rochester	4201000-02S	Little Quittacas Pond
BP1-2024	LQ-D-0-FD	---	---	76.6	PWS Duplicate - Finished, Pre-Spray	Rochester	4201000-02S	Little Quittacas Pond
BP1-2024	LQ-D-1-R	---	---	77.4	PWS, Raw, Post-Spray	Rochester	4201000-02S	Little Quittacas Pond
BP1-2024	LQ-D-1-F	---	---	77.5	PWS - Finished, Post-Spray	Rochester	4201000-02S	Little Quittacas Pond
BP1-2024	LQ-D-1-FD	---	---	78.3	PWS, Duplicate - Finished, Pre-Spray	Rochester	4201000-02S	Little Quittacas Pond
BP1-2024	LT-D-0-R	---	---	74.1	PWS Raw, Pre-Spray	Lakeville	4293000-02S	Elder's Pond
BP1-2024	LT-D-0-F	---	---	75.3	PWS- Finished, Pre-Spray	Lakeville	4293000-02S	Elder's Pond
BP1-2024	LT-D-0-FB	---	---	85.3	PWS, Field Blank - Finished, Pre-Spray	Lakeville	4293000-02S	Elder's Pond
BP1-2024	LT-D-1-R		---	76.8	PWS, Raw, Post-Spray	Lakeville	4293000-02S	Elder's Pond
BP1-2024	LT-D-1-F	---	---	75.0	PWS, Finished, Post-Spray	Lakeville	4293000-02S	Elder's Pond
BP1-2024	LT-D-1-FB		---	82.3	PWS, Field Blank - Finished, Post-Spray	Lakeville	4293000-02S	Elder's Pond

[1]Bristol/Plymouth County: 2024 1st spray (completed August 28, 2024)

[2]Chain of Custody ID = Unique sample identifier from Field Sample Collection Datasheet for tracking purposes

[3]LOQ = Limit of Quantitation; The LOQ for both sumithrin and PBO is 0.004 ug/L (ppb).

[4]ug/L means micrograms per liter (also equal to parts per billion (ppb)).

[5]Surrogate Recovery measures the % recovery of surrogate standards added to each sample. These are compounds similar in physical and chemical properties to the method compounds that are not expected to be present in the environment, which are added to each environmental and QA/AC sample in known amount(s) and used to monitor matrix effects and overall method performance. Acceptance criteria are 60-140% recovery

Appendix 3:
Lab Results as Received from
Massachusetts Pesticide Analysis Laboratory
9/9/2024

Massachusetts Pesticide Analysis Laboratory

Morrill 1 N441
637 North Pleasant Street
University of Massachusetts
Amherst, MA 01003-0230
Phone: 413-545-4369

Massachusetts Department of Environmental Protection

Report of Analysis

Sumithrin/PBO Water Analysis

Reviewed and Approved by:

Jeffery J. Doherty
Laboratory Manager

Report Date: 8/30/24
Project: DEP
Container: 1 L amber glass
Preservation: 4°C storage
Matrix: water

Sampled: 8/27-28/24
Received: 8/28/224
Extracted: 8/28/24
Analyzed: 8/29/24
Analysts: JL/SNS

RESULTS (µg/L)

Sample	PBO	Sumithrin	Surrogate recovery%
LT-D-0-FB	<LOD	<LOD	85.3%
LT-D-0-R	<LOD	<LOD	74.1%
LT-D-0-F	<LOD	<LOD	75.3%
LT-D-1-FB	<LOD	<LOD	82.3%
LT-D-1-R	<LOD	<LOD	76.8%
LT-D-1-F	<LOD	<LOD	75.0%
LQ-D-0-FD	<LOD	<LOD	76.6%
LQ-D-0-R	<LOD	<LOD	82.0%
LQ-D-0-F	<LOD	<LOD	74.6%
LQ-D-1-FD	<LOD	<LOD	78.3%
LQ-D-1-R	<LOD	<LOD	77.4%
LQ-D-1-F	<LOD	<LOD	77.5%
LS-S-1-CS	**0.09 µg/L**	**0.01 µg/L**	86.0%
JP-S-1	**0.02 µg/L**	<LOD	77.0%
SP-S-1	**0.08 µg/L**	<LOD	74.9%
SN-S-1B	<LOD	<LOD	70.1
SN-S-1	**0.15 µg/L**	<LOD	73.9%
TQ-S-1	**0.03 µg/L**	<LOD	80.3%
SP-S-1-D	**0.08 µg/L**	<LOD	70.1%

Notes:

µg/L= ppb
ND = not detected.

Limits of Detection (LOD)

The limit of detection for **PBO** and **Sumithrin** is 0.002 µg/L (ppb).

Limits of Quantitation (LOQ)

The limit of quantitation for **PBO** and **Sumithrin** is 0.004 µg/L (ppb).

QA/QC

Lab Spikes:	Surrogate, %	PBO, %	Sumithrin, %
Spike 1 (0.02ug/L)	80.3	127.9	75.8
Spike 2 (0.02ug/L)	83.3	107.1	94.0
Spike 3 (0.02ug/L)	79.0	104.4	121.2
Lab Blank	86.2	nd	nd

Duplicate Spikes:	Surrogate, %	PBO, %	Sumithrin, %
SP-S-1	78.3	-	72.1
SP-S-1-D	70.1	-	77.0
LQ-D-0-F	85.1	-	85.9
LQ-D-0-FD	82.5	-	81.0
LQ-D-1-F	83.1	-	83.7
LQ-D-1-FD	77.5	-	81.0

Laboratory Fortified Blank: Average of three replicates

PBO	
Mean	**SD**
113.1	12.89

Sumithrin	
Mean	**SD**
97.0	27.45

$^{13}C_6$ Permethrin (surrrogate)	
Mean	**SD**
80.8	0.027

Lab fortified Sample Matrix Recovery

LT-D-1-F

PBO
88.9%

Sumithrin
99.2%

$^{13}C_6$ Permethrin (surrrogate)
81.1%

Relative Percent Difference Comparison of Matrix Spikes

Field samples were not spiked with PBO since it is commonly found in the samples (see Method validation).

PBO

Sample	RPD
SP-S-1	0.0
SP-S-1-D	
LQ-D-0-F	0.0
LQ-D-0-FD	
LQ-D-1-F	0.0
LQ-D-1-FD	

Sumithrin

Sample	RPD
SP-S-1	7.7
SP-S-1-D	
LQ-D-0-F	3.8
LQ-D-0-FD	
LQ-D-1-F	3.3
LQ-D-1-FD	

Relative Percent Difference Comparison to unspiked Samples

Field samples were not spiked with PBO since it is commonly found in the samples (see Method validation).

Sumithrin

Sample	RPD
LQD1RA	10.5
LQD1RB	
LQD1FA	14.3
LQD1FB	
SPS1A	23.8
SPS1B	

PBO

Sample	RPD
LQD1RA	NA
LQD1RB	
LQD1FA	NA
LQD1FB	
SPS1A	0%
SPS1B	

Limit of Detection

Limit of detection was determined by making three spikes at the detection limit. Acceptable range 55-130%.

Continuing Calibration Curve

Full calibration curve is run between each set of 8 samples. Areas must be within 70-140% of the most recent calibration check.

Laboratory Reagent Blank

No peaks in a retention window of blanks. Any baseline noise less than 1/3 the MRL.

Percent Recovery

Sample concentration is calculated using linear regression against the average of the two bracketing standard curves. This is then normalized to the internal standard response and compared to the expected concentration. Recoveries between 50-150% acceptable when spiking at 2x the LOD.

Internal Standard

Variation in response must be between 70-140% of the latest calibration standard.

Surrogate Recovery

Surrogate recovery is calculated by dividing the calculated concentration of the surrogate in the sample by the fortified concentration of the surrogate x 100. Recovery must be in the range of 60-130%.

Lab Fortified Sample Matrix

Field samples selected by the client will be fortified with a spiking concentration on the low end of the standard curve. Recovery is calculated by subtracting the measured concentration in the unfortified sample, divided by the expected concentration x 100. Acceptable recoveries between 50-150%.

Field Blank

No analytes detected above 1/3 the LOD.

Relative Percent Difference (RPD) Comparison of Matrix Spikes

Concentration of Sample1 minus the concentration of Sample 2 divided by the average of the two concentrations.

$$\frac{S1-S2}{S1+S2/2} \quad X\ 100$$

Relative Percent Difference (RPD) Comparison to Unspiked Samples

Sample 1 is the Concentration of the matrix sample. Sample 2 is the matrix spike minus the added concentration. This is divided by the concentration in the sample.

$$\left| \frac{S1-S2}{S1} \right| \quad X\ 100$$