Suffolk County Vector Control & Wetlands Management Long Term Plan & Environmental Impact Statement

TASK 3B: DEMONSTRATION PROJECTS ALTERNATIVE MOSQUITO CONTROL

Prepared for:

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LIST OF ABBREVIATIONS AND ACRONYMS

ABDL	Suffolk County Arbovirus Detection Laboratory
CDC	Centers for Disease Control
CO_2	Carbon Dioxide
EEE	Eastern Equine Encephalitis
MMP	Mosquito Magnet Pro
MMLP	Mosquito Magnet Liberty Plus
SCVC	Suffolk County Vector Control
WNV	West Nile Virus

1. Goals

1.1. Repellants

These demonstration projects were designed to evaluate the efficacy of two commercially available liquid repellants. Mosquito Solution is a rosemary oil solution and Mosquito Barrier is a garlic oil solution. Mosquito populations in treated areas were compared to populations in untreated control areas for a three-week test period. Mosquitoes trapped in control and treatment areas were identified to species and counted. The repellants would be considered effective if test area traps contained, on average, fewer mosquitoes than control area traps.

1.2. Propane Powered Traps

Testing of the propane-powered traps was designed to examine their effectiveness when used as a barrier. These units have been demonstrated in academic studies to be effective tools for trapping mosquitoes in large quantities under certain circumstances. If the units were effective in intercepting mosquitoes that would have otherwise traveled from breeding areas to residential areas, they might reduce the need for aerial spraying.

1.3. Recharge Basins

Recharge basins have a reputation as mosquito breeding areas. That reputation may not be deserved for all basins under all conditions. Basins that hold water for periods long enough for mosquitoes to successfully breed may not necessarily support them. Examining County Vector Control complaint records may identify basins that do support mosquito breeding. Six recharge basins were sampled for mosquito larvae in areas where mosquito-related complaints had been filed with Suffolk County Vector Control. An examination of other environmental conditions in the basins can help explain the presence or absence of mosquito breeding.

1.4. Mosquito Species of Concern

The species believed to be the primary carriers of West Nile Virus (WNV) in Suffolk County are *Coquillettidia perturbans, Ochlerotatus candidensis, Culex salinarius, Oc. trivittatus, Oc. japonicus, Culex pipiens* and *Culex restuans*. These species breed in residential areas and are known to enter dwellings seeking hosts. They are the primary targets of the repellents.

2. Products

2.1. Rosemary Solution

Mosquito Solution contains rosemary oil to repel mosquitoes and guar gum to smother larvae. Rosemary (*Rosmarinus officinalis*) is an herb that has been used for medicinal purposes throughout history and is commonly used as a food seasoning. Gardeners routinely plant rosemary alongside cabbage, beans and carrots to deter cabbage moths, bean beetles and carrot flies (GardenGuides, 2004). Rosemary oil is typically obtained from the stem and leaves, before bloom development (Botanical.com, 2005). The manufacturer lists the product ingredients in its concentrated product as found in Table 2-1.

Table 2-1 – Rosemary Oil Solution Ingredients

Ingredient	Concentration
Active	
Rosemary Oil	1.62%
Table Salt	1.20%
Inert	97.18%
Vinegar	
Water	
Guar Gum	
Casein	

Once diluted with water, the product is applied to plants. According to the manufacturer, after a 60-minute drying period, the solution repels mosquitoes for up to two weeks. The manufacturer recommends it for low-lying water areas, ponds, rainwater collection areas and stagnant or standing water. Mosquito Solution ingredients are natural and exempt from EPA pesticide regulations.

Suffolk County Vector Control personnel applied the product according to the manufacturer's directions. The product was diluted 1:10 with water and loaded into a SCVC backpack mounted sprayer. As the manufacturer asserts that one (1) gallon of the diluted product will cover 4,000 square feet, approximately 2.5 gallons were applied per 100 x 100 foot test area. The product was sprayed on lower tree limbs and all grasses and shrubs in the test areas. The product was reapplied after two weeks, per the manufacturer's directions.

2.2. Garlic Oil Solution

Concentrated garlic oil has been reported to provide protection from biting mosquitoes for two to four weeks (Fiteni, 2002). Mosquito Barrier is a commercially available repellant that contains liquid garlic concentrate, which is diluted with water and mixed with canola oil or liquid soap.

The product is sprayed on outdoor plants. According to the manufacturer, plants absorb the oil through pores in their leaves, which open during early morning and evening hours for gas exchange. The oil travels throughout the plant, but does not alter the taste or smell of any part of the plant to humans. According to the manufacturer, the solution reportedly repels mosquitoes for up to two (2) weeks, but becomes odorless to humans within minutes.

Suffolk County Vector Control personnel applied the product according to the manufacturer's directions. The product was diluted 1:100 with water and three tablespoons of canola oil added per gallon of diluted product to aid in product adherence to foliage. The diluted product was applied by SCVC from a backpack-mounted sprayer. As the manufacturer asserts that one gallon of the diluted product will cover five acres, less than one gallon was used to cover the three 100 x 100 foot test areas. The product was sprayed on lower tree limbs and all grasses and shrubs in the test areas. It was reapplied after two (2) weeks, per the manufacturers directions. The manufacturer lists the ingredients in the concentrated product in Table 2-2.

Table 2-2 - Garlic Oil Solution Ingredients

Ingredient	Concentration
Active	
Garlic Juice	99.3%
Citric Acid	0.5%
Potassium Sorbate	0.2%

2.3. Propane Powered Mosquito Traps

Propane powered mosquito traps such as the Mosquito Magnet Liberty Plus (MMLP) and the Mosquito Magnet Pro (MMP) rely on the use of heat and carbon dioxide (CO_2) to attract mosquitoes (Photograph 1). A small fan located in the center of the unit emits an exhaust of carbon dioxide and the attractant Octenol, while a large fan at the top of the unit pulls air and mosquitoes into the trap. A thermoelectric generator uses the excess heat from the propane combustion process to generate electricity to run the trap's fan. Therefore, the device operates

without the need for batteries or external power. Carbon dioxide is catalytically produced by converting propane to CO_2, water vapor, and heat. Mosquitoes, attracted to the CO_2, heat, and octenol attractant, fly into a tube where they are sucked into a collection bag.

Testing of these units has demonstrated their effectiveness in capturing mosquitoes (Smith, 2003; Kline, 2002). The capture rates and efficacy of several trap models were tested by Florida A&M University, in Panama City, Florida. Results revealed that American Biophysics Corporation's MMLP captured the greatest number of species and three times more mosquitoes than several other manufacturers' units tested, but did not significantly reduce mosquito populations in residential settings. The tests conducted here were designed to determine if multiple units could be effectively operated as a barrier.

The MMLP and MMP traps operated continuously according to the manufacturers recommendations. The MMLP is designed for one-acre sites and the MMP for one and a quarter acre sites. The American Biophysics Corporation provided four (4) MMLP units for use in the project. Three (3) MMP units were provided by the Rutgers University Department of Entomology for use in the project.

3. Test Sites

3.1. Timber Point Golf Course – Garlic Oil

The Timber Point Golf Course is owned by Suffolk County and is located on the south shore of Suffolk County in West Sayville off Montauk Highway and adjacent to the Great South Bay. This site is surrounded on two sides by salt marsh and on another side by forest. The golf course is adjacent to salt marshes and regularly experiences problems with mosquitoes. To test the garlic oil repellant solution, three (3) test and three (3) control plots were located in one (1) area on the course (Map 1). The area is wooded, adjacent to a residential area and alongside the #4 fairway. Test and control sites were staked and measured 100 x 100 feet. All control sites were positioned upwind of the test sites. The six (6) plots were aligned in a row with 50 feet of untreated space between each of the test and control sites. Six (6) light traps were utilized to assess mosquito populations, one in each of the control and test areas. The first three plots were upwind and untreated. Plots four (4), five (5) and six (6) were sprayed with garlic oil solution.

3.2. West Sayville Golf Course – Rosemary Oil

The West Sayville Golf Course is owned by Suffolk County and is located on the south shore of Suffolk County in West Sayville off Montauk Highway and adjacent to the Great South Bay. There are ponds and a marsh within the golf course. The golf course tends to have standing water and regularly experiences problems with mosquitoes. To test the repellant solutions, three (3) test and three (3) control plots were located in different areas on the golf course (Map 2). Test and control sites were staked and measured 100 x 100 feet. All the control spots were upwind of the test sites. The test sites were sprayed with the rosemary solution. Six (6) light traps were utilized to assess mosquito populations, one in each of the control and test areas. The first area had a control area and a test area located on opposite sides of a mosquito ditch. The control area was located on fairway #1 and the test area was located on fairway #14. The second test area was located in between fairway #4 and fairway #13. The second and third control areas were located adjacent to each other with fifty feet between the two plots. They were located between fairway #11 and fairway #7. The last test area was parallel to the two controls, between fairway #7 and fairway #6. All test and control areas were in similar surroundings, located in the rough areas with some tree cover.

3.3. Blydenburgh County Park - Garlic Oil and Rosemary Oil

The Blydenburgh County Park is located in Smithtown. The park contains the headwaters of the Nissequogue River in Stump Pond. The park has been closed in the past due to the presence of Eastern Equine Encephalitis (EEE) virus in mosquitoes. Mosquitoes continue to be a problem.

Two (2) areas in the park were selected to test the repellant solutions. One is a large open field surrounded by a forest with a considerable shrub understory (Map 3). Three (3) 100 x 100 foot test sites were located along the northern edge of the field and three (3) control sites were located along the southern edge of the field. Each site was separated from the adjacent one by 50 feet. One half of each of the sites was in the forested area and one half in the field. This area was used for the garlic oil test.

The second Blydenburgh location was in the Historic Trust Area just north of Stump Pond (Map 4). Grassed fields surrounded by forest with dense shrub cover characterize this area of the park. Three (3) 100 x 100 foot test and three (3) control areas were located in the grassed areas and separated by at least 50 feet. This area was used for the rosemary oil test.

Six (6) light traps were utilized to assess mosquito populations, one in each of the control and test areas.

3.4. Connetquot State Park – Propane-Powered Traps

The propane-powered traps were deployed at Connetquot State Park in grassed fields surrounded by forest. Three (3) Mosquito Magnet Pro (MMP) units were set up in a triangular arrangement 111, 118, and 126 feet apart from one another (Map 5) and chained to trees. A light trap was placed in the center. A control area of equal size and type was selected upwind of the test area and a light trap placed in its center. The control light trap was 250 feet upwind of the test light trap.

A second test area was established in a nearby, grassed field surrounded by forest. Four (4) Mosquito Magnet Liberty Pro (MMLP) units were set up in a square (Map 6) with a light trap placed in the center of the square. The square was 150 feet on a side. Two (2) of the MMLP units were chained to trees at the edge of the field and the other two (2) were chained to trees in the field. A control area of equal size and type was selected upwind of the test area and a light trap placed in its center, 275 feet upwind of the test light trap.

3.5. Town of Huntington - Recharge Basins

Six (6) recharge basins in the Town of Huntington were selected that were located in close proximity to mosquito related complaints received by the Suffolk County Vector Control (Map 7). Basins were selected that retain water for relatively long periods and others for relatively short periods. Detailed descriptions of each of the basins are found in the results section in the following pages.

4. Mosquito Population Sampling

4.1. Schedule

All studies were conducted during the summer months of June, July and August. The table below shows the study schedule.

Location	Product/Study	Test Traps	Control Traps	Start Date	Finish Date
Timber Point	Garlic Oil	3	3	6/13/2005	7/8/2005
West Sayville	Rosemary Oil	3	3	6/13/2005	7/8/2005
Blydenburgh	Garlic Oil	3	3	7/11/2005	7/29/2005
Blydenburgh	Rosemary Oil	3	3	7/11/2005	7/29/2005
Connetquot	Propane Powered Trap	3	3	8/1/2005	8/19/2005
Recharge Basins	Larval Mosquito Study	N/A	N/A	8/1/2005	8/19/2005

4.2. Mosquito Traps

New Jersey Miniature Light Traps were used to recover adult mosquitoes to assess mosquito populations in the test and the control areas (Photograph 2). Light traps were baited with carbon dioxide supplied by dry ice. Traps were set to operate from dusk to dawn and were hung five (5) to six (6) feet off the ground from Shepard's hooks (USACHPPM, 2004, as adapted by McNelly, 1989) in the center of each of the treatment and control areas.

4.3. Daily Sampling Procedure

4.3.1. Mosquito Repellants

Mosquito traps were deployed Monday through Thursday evenings with newly charged batteries and new dry ice. Traps were collected within 14 hours of deployment as trap batteries and dry ice would have been depleted after 14 hours. Mosquito samples from the traps were emptied into sample bottles labeled with the location, trap identification number, and sampling date. Sample bottles were transported in coolers with dry ice to the Suffolk County Arbovirus Detection Laboratory (ABDL) in Yaphank for identification and counts. Seven (7) layers of newspaper separated the mosquito containers and dry ice. This created a temperature in the coolers that sedated the mosquitoes, but did not kill them.

4.3.2. Propane Powered Traps

Traps associated with the Mosquito Magnets were emptied daily from Monday through Friday mornings and stored in a cooler with ice. The Mosquito Magnets and trap carbon dioxide delivery were checked along with Mosquito Magnet fan operation and trap function. Here also,

weather conditions were recorded daily. Mosquito sample bottles were labeled with the location, trap identification number, and sampling date. Samples were stored in the cooler and transported the same day to the Suffolk County Department of Health Services laboratory for species identification and counts.

4.3.3. Recharge Basin Sampling

The following six (6) recharge basins were sampled: basin numbers 36, 88, 336, 338, 339, and 450. Larvae samples were collected three (3) times a week over a three (3) week period in all basins. The larvae samples were collected with a standard larval dipper in the shallower areas where mosquitoes would most likely breed. Six (6) dips were taken in each basin. Samples were placed into jars if larvae or pupae were present. The jars were transported at room temperature to the Suffolk County Department of Health Services laboratory for species identification. Basin conditions were also recorded each sampling day.

4.4. Statistical Analysis of Repellant and Propane Trap Tests

The F-test and an Analysis of Variance (ANOVA) were performed on mosquito counts from the light traps in each of the test and control areas for the garlic oil and rosemary oil evaluations and the propane powered trap tests.

A primary assumption of ANOVA is homogeneity of variances or that the variances display equal scatter among a normal distribution, or in the case of data consisting of counts, a Poisson distribution. The F-test is a way to determine if the data to be analyzed meets this assumption. Data not meeting this assumption must be transformed in order to normally distribute the variances and perform ANOVA.

Each location had at least one data point that had to be dropped due to equipment failure. Consequently, single-classification ANOVA with unequal sample sizes was performed on each of the four data sets. Significance was set at 95 percent or $p = 0.05$.

5. Garlic Oil Repellant Results and Conclusions

5.1. Timber Point Golf Course

The Timber Point testing was done at the beginning of the summer when few mosquitoes were present. An average of only 23 mosquitoes were present in the control traps and an average of only 27 mosquitoes in the test traps (see Appendix A for all data and Table 5-1 for data summary). The major species trapped in order of prevalence were:

- *Ochlerotatus cantator*
- *Ochlerotatus sollicitans*
- *Culex pipiens-restuans*
- *Aedes vexans*
- *Ochlerotatus taeniorhynchus*

An analysis of variance (ANOVA) was performed on the data to test its statistical significance. Since the data consisted of counts (*i.e.* the number of insects in a trap), the square root of each data point, plus 0.5, was determined. The addition of 0.5 was necessary to eliminate zero counts, since the square root function cannot be performed on zero values. Transforming the data points to square roots makes the variances of the data points independent of their means. The ANOVA revealed that the number of mosquitoes caught in the test area traps (27) was not significantly different than the number of mosquitoes caught in the control area traps (23) ($F = 1.31$, $df = 52$, $p = 0.25$) (Figure 1).

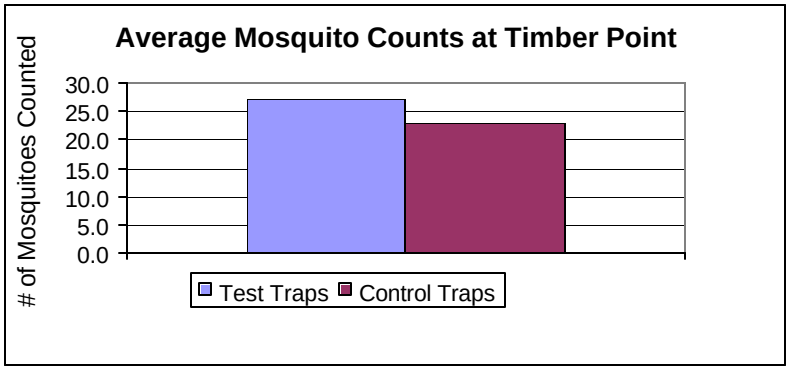

Figure 1. Average mosquito counts at Timber Point Golf Course.

The garlic oil may not be effective in repelling salt marsh mosquitoes, though few individuals were captured in the traps. Based on the positive results of the Blydenburgh County Park test of

the garlic oil, it may be advisable to conduct another test at Timber Point Golf Course during a period when mosquito populations are more abundant.

Table 5-1 - Garlic Oil Repellant Test Results from Timber Point Golf Course

TIMBER POINT	GARLIC OIL							
	Weeks							
	Test Traps				Control Traps			
Species	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*
Ochlerotatus abserratus (ABS)								
Oc. atropalpus (ATR)								
Oc. aurifer (AUR)								
Oc. canadensis (CAN)	0.2	0	0	***0.1***	0.3	0.1	0	***0.1***
Oc. cantator (CTT)	10	6	16.9	***11.0***	8.1	4	11.4	***7.8***
Oc. dorsalis (DOR)								
Oc. excrucians (EXC)								
Oc. fitchii (FIT)								
Oc. flavescens (FLA)								
Oc. intrudens (INT)								
Oc. japonicus (JAP)	0.5	0.2	0.2	***0.3***	0.5	0.1	0.4	***0.3***
Oc. sollicitans (SOL)	3.3	0.1	15.1	***6.2***	3.2	0.2	12.6	***5.3***
Oc. sticticus (STC)								
Oc. stimulans (STI)								
Oc. stimulans group (SEF)								
Oc. taeniorhynchus (TAE)	0.3	0	3.2	***1.2***	1.7	0.2	4.4	***2.1***
Oc. triseriatus (TRI)	0	0	0.2	***0.1***	0	0.2	0.1	***0.1***
Oc. trivittatus (TVT)	0	0	0.1	***0.0***	0	0	0.1	***0.0***
Aedes cinereus (CIN)								
Ae. vexans (VEX)	4.5	0.3	4	***2.9***	3.2	0.9	3.7	***2.6***
Anopheles barberi (BAR)								
An. crucians (CRU)								
An. punctipennis (PUN)	0.2	0.4	0	***0.2***				
An. quadrimaculatus (QUA)	0	0	0.2	***0.1***	0	0	0.1	***0.0***
An. walkeri (WAK)								
Coquillettidia perturbans (PER)	1.5	1	0.9	***1.1***	1.5	0.8	0	***0.8***
Culiseta inornata (INO)								
Cs. melanura (MEL)	0.2	0.1	1	***0.4***	0	0	0.3	***0.1***
Cs. minnesotae (MIN)								
Cs. morsitans (MOR)								
Culex pipiens-restuans (PRE)	5.2	1.7	3.7	***3.5***	6.3	0.9	2.1	***3.1***
Cx. salinarius (SAL)								
Cx. territans (TER)								
Orthopodomyia sp. (OAS)								
Or. alba (OAL)	0	0	0.2	***0.1***				
Or. signifera (SIG)								
Psorophora ciliata (PCI)								
Ps. confinnis (PCO)								
Ps. ferox (PFR)								
Ps. howardi (PHO)								
Toxorhynchites (TOX)								
Uranotaenia sapphirina (USA)								
Wyeomyia smithii (WYS)								
Unidentified (UFM)								
Total Mosquitoes:	25.9	9.8	45.7	***27.1***	24.8	7.4	35.2	***22.5***

5.2. Blydenburgh County Park

A large number of mosquitoes were trapped in Blydenburgh County Park (see Appendix B for all data and Table 5-2 for data summary). The average number of mosquitoes in the control traps was 158, whereas, on average, only 72 mosquitoes were present in the test traps. On average, there were less than half the numbers of mosquitoes in the garlic oil treated areas as compared to the untreated control areas. An analysis of variance (ANOVA) was performed on the mosquito counts. As the counts demonstrated homogeneous variances, they did not need to be transformed. An analysis of variance revealed that the number of mosquitoes caught in garlic oil test area traps (72) was significantly lower than the number of mosquitoes caught in control areas traps (158) ($F = 16.7$, $df = 52$, $p = .0001$) (Figure 2).

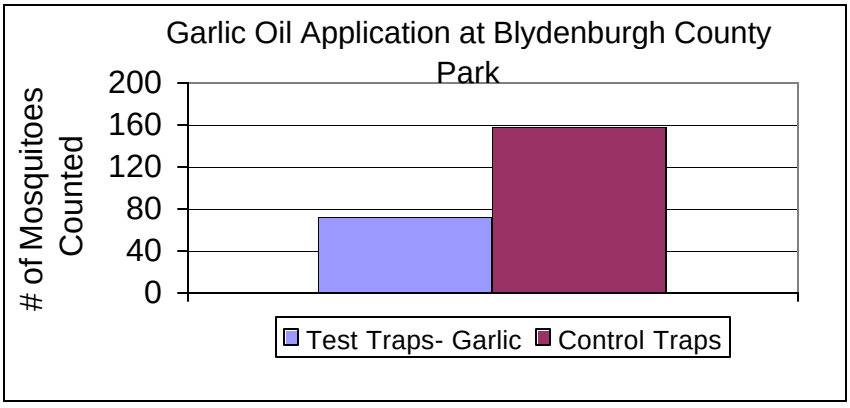

Figure 2 - Average mosquito counts at Blydenburgh County Park, garlic oil applications.

The major species trapped in order of prevalence were:

- *Anopheles quadrimaculatus*
- *Aedes vexans*
- *Coquillettidia perturbans*
- *Culex pipiens-restuans*
- *Ochlerotatus japonicus*
- *Ochlerotatus canadensis*
- *Ochlerotatus trivittatus*
- *Ochlerotatus triseriatus*
- *Anopheles punctipennis*
- *Culiseta melanura*

The garlic oil demonstrated little or no repellant activity with the following species, although the number of these species trapped was low:

- *Culex pipiens-restuans*
- *Anopheles punctipennis*
- *Culiseta melanura*

The efficacy of the garlic oil seemed to decline over time. In the first week following its application there were an average of 181 mosquitoes in the control traps from the untreated areas and 95 in the traps from the treated areas, a 48 percent reduction in mosquito numbers. In the second week, an average of 99 mosquitoes were found in the control traps and 70 in the test traps, or a 29 percent reduction. The test areas were re-sprayed after two weeks. In the third week of the study there were an average of 194 mosquitoes in the control traps and 72 in the test traps, or a 63 percent reduction in areas treated with the garlic oil solution.

The garlic oil is marketed as a repellant (it is not designed to kill mosquitoes). It was effective in repelling mosquitoes, with twice as many mosquitoes found in the control areas as in the test areas. Some species in fact were controlled more completely than the overall rate. There was no evidence that this product repelled *Cx. pipiens/Cx. restuans*. However, there were few individuals of this species present in both the test and control traps. *Cx. pipiens* is arguably the most important mosquito vector to repel in sites such as Blydenburgh Park, if theories regarding WNV transmission in uplands are correct in identifying it as the primary vector. Even if the product is not, in fact, effective in repelling this disease-bearing species, it may still be a viable product for repelling other biting mosquitoes. Its use may be appropriate in areas where mosquito control measures are inadequate or not permitted and measures are required to reduce quality of life impacts from mosquitoes on residential and recreational outdoor activities.

Although garlic oil may be a useful repellant in certain applications, mosquito control by the County remains essential to protecting public health and quality of life. Source control by SCVC remains the best method for eliminating mosquitoes before they become a problem. Progressive water management provides up to 100 percent larval control according to practitioners in the northeast. County records indicate that reductions of 90 percent or more in larval mosquito populations can be achieved with Bti, Bs, and methoprene. Mosquito population densities can be

reduced by 90-95 percent by adulticiding with modern pesticides when mosquito-borne disease threatens public health.

Table 5-2 - Garlic Oil Repellant Test Results from Blydenburgh County Park

BLYDENBURGH	**GARLIC**							
	Weeks							
	Test Traps				**Control Traps**			
Species	**1st Avg**	**2nd Avg**	**3rd Avg**	***Tot. Avg***	**1st Avg**	**2nd Avg**	**3rd Avg**	***Tot. Avg***
Ochlerotatus abserratus (ABS)								
Oc. atropalpus (ATR)								
Oc. aurifer (AUR)								
Oc. canadensis (CAN)	1.3	2.2	1.2	***1.6***	6.5	6.3	7.1	***6.6***
Oc. cantator (CTT)	0.5	0.2	0.2	***0.3***	0.2	0.3	0.6	***0.4***
Oc. dorsalis (DOR)								
Oc. excrucians (EXC)								
Oc. fitchii (FIT)								
Oc. flavescens (FLA)								
Oc. intrudens (INT)								
Oc. japonicus (JAP)	1.5	5	0.9	***2.5***	4.2	9.8	12.3	***8.8***
Oc. sollicitans (SOL)								
Oc. sticticus (STC)								
Oc. stimulans (STI)								
Oc. stimulans group (SEF)								
Oc. taeniorhynchus (TAE)	0	0.2	0	***0.1***				
Oc. triseriatus (TRI)	0.2	0.8	0.3	***0.4***	0.2	1.2	3.4	***1.6***
Oc. trivittatus (TVT)	2.5	0.7	0.3	***1.2***	4.7	1.8	1.3	***2.6***
Aedes cinereus (CIN)								
Ae. vexans (VEX)	38	15	5.4	***19.5***	58.3	15.8	16.4	***30.2***
Anopheles barberi (BAR)								
An. crucians (CRU)	0.2	0	0	***0.1***				
An. punctipennis (PUN)	1.2	1.2	1.9	***1.4***	0	2	2	***1.3***
An. quadrimaculatus (QUA)	8.7	12.5	22.8	***14.7***	44.8	28	127	***66.6***
An. walkeri (WAK)								
Coquillettidia perturbans (PER)	32.3	17.2	7.8	***19.1***	49	25.3	12.9	***29.1***
Culiseta inornata (INO)								
Cs. melanura (MEL)	1.5	2.3	1.2	***1.7***	2	0.8	0.8	***1.2***
Cs. minnesotae (MIN)								
Cs. morsitans (MOR)								
Culex pipiens-restuans (PRE)	6.8	12.7	9.9	***9.8***	10.7	6.7	9.7	***9.0***
Cx. salinarius (SAL)								
Cx. territans (TER)								
Orthopodomyia sp. (OAS)								
Or. alba (OAL)								
Or. signifera (SIG)								
Psorophora ciliata (PCI)								
Ps. confinnis (PCO)								
Ps. ferox (PFR)	0	0.2	0		0.2	0.3	0.4	***0.3***
Ps. howardi (PHO)								
Toxorhynchites (TOX)					0	0	0.1	***0.0***
Uranotaenia sapphirina (USA)								
Wyeomyia smithii (WYS)								
Unidentified (UFM)								
Total Mosquitoes:	**94.7**	**70.2**	**51.9**	***72.2***	**180.8**	**98.3**	**194**	***157.7***

6. Rosemary Oil Repellant Results and Conclusions

6.1. Blydenburgh County Park

The rosemary oil solution was tested in the historic section of Blydenburgh County Park (see Appendix C for test results and Table 6-1 for a summary). The average number of mosquitoes in the control traps was 60, while the test traps had an average of 69 mosquitoes. An ANOVA revealed that the difference between the test and control area counts was not statistically significant ($F = 3.28$, $df = 48$, $p = 0.17$) (see Figure 3). This solution proved ineffective in repelling adult mosquitoes.

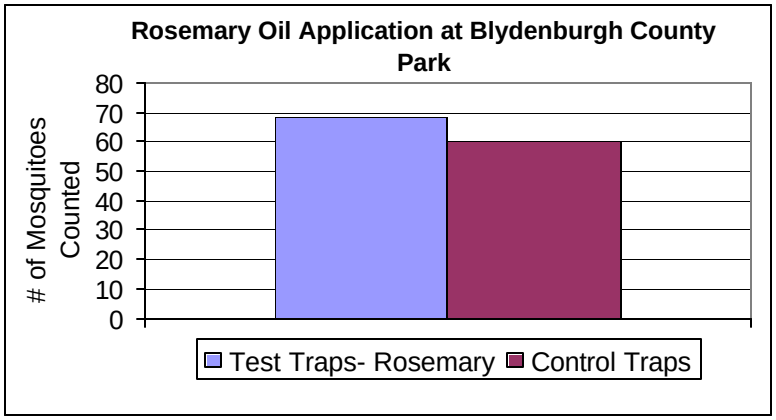

Figure 3. Average mosquito counts at Blydenburgh County Park, rosemary oil applications.

The major species trapped in order of prevalence were:

- *Aedes vexans*
- *Culex pipiens-restuans*
- *Coquillettidia perturbans*
- *Anopheles quadrimaculatus*
- *Culex pipiens-restuans*
- *Ochlerotatus trivittatus*
- *Culiseta melanura*
- *Anopheles punctipennis*
- *Ochlerotatus canadensis*

6.2. West Sayville Golf Course

The rosemary oil solution was tested on the West Sayville Golf Course (see Appendix D for test results and Table 6-2 for a summary). The average number of mosquitoes in the control traps was 25, while the test traps had an average of 30 mosquitoes. An ANOVA revealed that the number of mosquitoes caught in test area traps was not significantly different from the number of mosquitoes caught in control area traps ($F = 1.34$, $df = 46$, $p = 0.25$) (Figure 4). For each of the three (3) study weeks, the traps in the treated areas had more mosquitoes then those in the untreated areas, even after re-spraying. This solution proved ineffective in repelling adult mosquitoes.

The major species trapped in order of prevalence were:

- *Ochlerotatus cantator*
- *Ochlerotatus sollicitans*
- *Culex pipiens-restuans*
- *Aedes vexans*

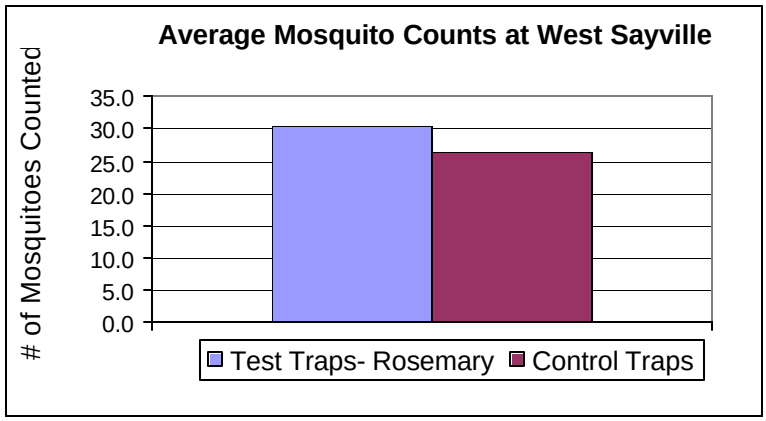

Figure 4. Average mosquito counts at West Sayville Golf Course.

Table 6-1 - Rosemary Oil Repellant Test Results from Blydenburgh County Park

BLYDENBURGH	**ROSEMARY**							
	Weeks							
	Test Traps				**Control Traps**			
Species	**1st Avg**	**2nd Avg**	**3rd Avg**	***Tot. Avg***	**1st Avg**	**2nd Avg**	**3rd Avg**	***Tot. Avg***
Ochlerotatus abserratus (ABS)								
Oc. atropalpus (ATR)								
Oc. aurifer (AUR)								
Oc. canadensis (CAN)	2.7	0.5	0.5	***1.2***	1.3	0.5	1.3	***1.0***
Oc. cantator (CTT)	1	0.3	0.2	***0.5***	0	0	0.2	***0.1***
Oc. dorsalis (DOR)								
Oc. excrucians (EXC)								
Oc. fitchii (FIT)								
Oc. flavescens (FLA)								
Oc. intrudens (INT)								
Oc. japonicus (JAP)	1.3	0	0.2	***0.5***	0.3	0.2	0.7	***0.4***
Oc. sollicitans (SOL)					0	0	0.5	***0.2***
Oc. sticticus (STC)								
Oc. stimulans (STI)								
Oc. stimulans group (SEF)								
Oc. taeniorhynchus (TAE)								
Oc. triseriatus (TRI)	0.7	0	0	***0.2***				
Oc. trivittatus (TVT)	2	0.83	1	***1.3***	1.7	0.8	1.7	***1.4***
Aedes cinereus (CIN)								
Ae. vexans (VEX)	29.3	14.7	19	***21.0***	39.3	13.7	16.3	***23.1***
Anopheles barberi (BAR)								
An. crucians (CRU)								
An. punctipennis (PUN)	2.3	1.5	1.7	***1.8***	0.3	1.7	0.5	***0.8***
An. quadrimaculatus (QUA)	3.3	22.3	14.8	***13.5***	0.7	5	15.5	***7.1***
An. walkeri (WAK)								
Coquillettidia perturbans (PER)	25	8.5	5.3	***12.9***	16.7	7	6.2	***10.0***
Culiseta inornata (INO)								
Cs. melanura (MEL)	4.7	1.7	0	***2.1***	2	0.2	0.5	***0.9***
Cs. minnesotae (MIN)								
Cs. morsitans (MOR)								
Culex pipiens-restuans (PRE)	17	9.7	13.7	***13.5***	17.3	13.2	14.9	***15.1***
Cx. salinarius (SAL)								
Cx. territans (TER)								
Orthopodomyia sp. (OAS)								
Or. alba (OAL)								
Or. signifera (SIG)								
Psorophora ciliata (PCI)								
Ps. confinnis (PCO)								
Ps. ferox (PFR)	0.3	0	0	***0.1***				
Ps. howardi (PHO)								
Toxorhynchites (TOX)								
Uranotaenia sapphirina (USA)								
Wyeomyia smithii (WYS)								
Unidentified (UFM)								
Total Mosquitoes:	**89.6**	**60.0**	**56.4**	***68.7***	**79.6**	**42.3**	**58.3**	***60.1***

Table 6-2 - Rosemary Oil Repellant Test Results from West Sayville Golf Course

WEST SAYVILLE	ROSEMARY OIL							
	Weeks							
	Test Traps				Control Traps			
Species	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*
Ochlerotatus abserratus (ABS)					0	0.1	0	***0.0***
Oc. atropalpus (ATR)								
Oc. aurifer (AUR)								
Oc. canadensis (CAN)	0.3	0.1	0	***0.1***				
Oc. cantator (CTT)	18.7	6.9	11.1	***12.2***	16	1.9	15.2	***11.0***
Oc. dorsalis (DOR)								
Oc. excrucians (EXC)								
Oc. fitchii (FIT)								
Oc. flavescens (FLA)								
Oc. intrudens (INT)								
Oc. japonicus (JAP)	0	0	0.1	***0.0***	0	0	0.1	***0.0***
Oc. sollicitans (SOL)	3	3	14.8	***6.9***	7.7	1.1	10	***6.3***
Oc. sticticus (STC)								
Oc. stimulans (STI)								
Oc. stimulans group (SEF)								
Oc. taeniorhynchus (TAE)	0	0.1	0.1	***0.1***	0.3	0	0.2	***0.2***
Oc. triseriatus (TRI)								
Oc. trivittatus (TVT)	0	0	0.1	***0.0***				
Aedes cinereus (CIN)	0	0.1	0	***0.0***	0	0.1	0	***0.0***
Ae. vexans (VEX)	7.7	0.8	4	***4.2***	3	0.3	4.7	***2.7***
Anopheles barberi (BAR)								
An. crucians (CRU)								
An. punctipennis (PUN)					0	0.1	0	***0.0***
An. quadrimaculatus (QUA)	0	0	0.1	***0.0***	0	0	0.1	***0.0***
An. walkeri (WAK)								
Coquillettidia perturbans (PER)	0	0.3	0.7	***0.3***	0	0	0.3	***0.1***
Culiseta inornata (INO)								
Cs. melanura (MEL)	0	1.2	0	***0.4***	0	0.6	0.1	***0.2***
Cs. minnesotae (MIN)								
Cs. morsitans (MOR)								
Culex pipiens-restuans (PRE)	6.3	3.2	8.2	***5.9***	5.3	1.7	6.6	***4.5***
Cx. salinarius (SAL)								
Cx. territans (TER)								
Orthopodomyia sp. (OAS)								
Or. alba (OAL)								
Or. signifera (SIG)								
Psorophora ciliata (PCI)								
Ps. confinnis (PCO)								
Ps. ferox (PFR)								
Ps. howardi (PHO)								
Toxorhynchites (TOX)								
Uranotaenia sapphirina (USA)								
Wyeomyia smithii (WYS)								
Unidentified (UFM)								
Total Mosquitoes:	36	15.7	39.2	***30.3***	32.3	5.9	37.3	***25.2***

7. Propane-Powered Trap Results and Conclusions

The propane-powered traps (Mosquito Magnets) were tested in Connetquot State Park (see Appendix E for test results and Table 7-1 for a summary). The results for the two (2) test sites were similar. In one site, the light trap within the mosquito magnet array collected an average of 150 mosquitoes, whereas the control trap collected 138 mosquitoes. In the other location, the light trap within the mosquito magnet array collected an average of 101 mosquitoes, whereas the control trap collected 83 mosquitoes. On average, for both test sites, 126 mosquitoes were found in the light traps placed in the middle of the propane-powered trap array. On average, for both test sites, 110 mosquitoes were found in the control light traps. The test area trap averaged 218 mosquitoes in week one (1) whereas the control area trap contained 181 mosquitoes on average. In week two (2) the traps collected similar numbers of mosquitoes: 89 and 98 respectively. In week three (3) the test area trap collected more mosquitoes (70) than the control area trap (52).

An ANOVA performed on the average data for the three week test revealed that the number of mosquitoes caught in test area traps did not differ significantly from the number of mosquitoes caught in control area traps ($F = 0.21$, $df = 38$, $p = 0.65$) (Figure 5).

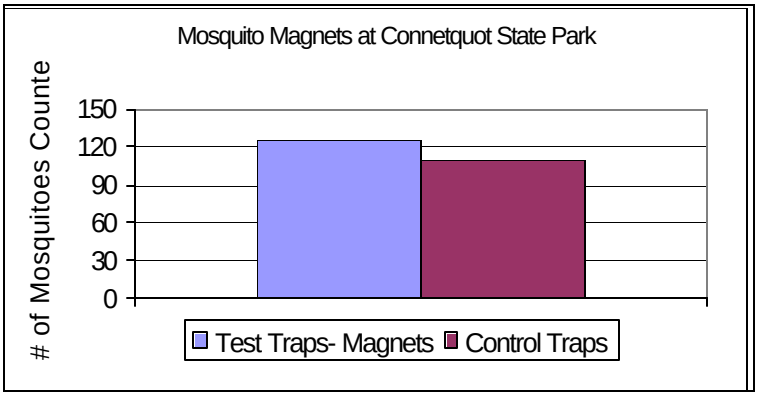

Figure 5. Average mosquito counts obtained using propane powered traps at Connetquot State Park.

The mosquitoes trapped by the propane-powered traps themselves were collected and counted halfway thru the experiment and at the end of the experiment. The propane powered traps also proved less effective than the light traps in collecting mosquitoes. The light traps were set up at night, while the propane-powered traps ran all day. Yet one light trap caught more then six (6) times the number of mosquitoes than one propane-powered trap. The propane-powered traps proved to be ineffective as a barrier against mosquitoes.

Table 7-1 - Mosquito Magnet Test Results from Connetquot State Park

CONNETQUOT	MOSQUITO MAGNETS							
	Weeks							
	Test Traps				Control Traps			
Species	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*
Ochlerotatus abserratus (ABS)								
Oc. atropalpus (ATR)								
Oc. aurifer (AUR)								
Oc. canadensis (CAN)								
Oc. cantator (CTT)	97.25	33.2	14.8	***48.4***	57.1	33.3	7	***32.5***
Oc. dorsalis (DOR)								
Oc. excrucians (EXC)								
Oc. fitchii (FIT)								
Oc. flavescens (FLA)								
Oc. intrudens (INT)								
Oc. japonicus (JAP)	0	0.5	0	***0.2***	0.3	0	0	***0.1***
Oc. sollicitans (SOL)	21.2	2.5	0.3	***8.0***	18.6	4.5	0	***7.7***
Oc. sticticus (STC)								
Oc. stimulans (STI)								
Oc. stimulans group (SEF)								
Oc. taeniorhynchus (TAE)	0.5	0	0	***0.2***	0.4	0	0	***0.1***
Oc. triseriatus (TRI)								
Oc. trivittatus (TVT)	0.1	0	0	***0.0***				
Aedes cinereus (CIN)	0.1	0	0	***0.0***	0	0.2	0.3	***0.2***
Ae. vexans (VEX)	7.9	5.2	0.3	***4.5***	7.1	3.2	0.8	***3.7***
Anopheles barberi (BAR)								
An. crucians (CRU)								
An. punctipennis (PUN)	33.5	30.8	40.3	***34.9***	29	30	31	***30.0***
An. quadrimaculatus (QUA)	1	0.2	4	***1.7***	0.5	0.7	3.5	***1.6***
An. walkeri (WAK)								
Coquillettidia perturbans (PER)	1.9	0.8	0.5	***1.1***	2	0.7	0.3	***1.0***
Culiseta inornata (INO)								
Cs. melanura (MEL)	0.5	1.3	1	***0.9***	0.8	1.7	1.5	***1.3***
Cs. minnesotae (MIN)								
Cs. morsitans (MOR)								
Culex pipiens-restuans (PRE)	54.3	14.8	8.5	***25.9***	65.1	24	7.8	***32.3***
Cx. salinarius (SAL)								
Cx. territans (TER)								
Orthopodomyia sp. (OAS)								
Or. alba (OAL)								
Or. signifera (SIG)								
Psorophora ciliata (PCI)								
Ps. confinnis (PCO)								
Ps. ferox (PFR)								
Ps. howardi (PHO)								
Toxorhynchites (TOX)								
Uranotaenia sapphirina (USA)								
Wyeomyia smithii (WYS)								
Unidentified (UFM)								
Total Mosquitoes:	**218.3**	**89.3**	**69.7**	***125.8***	**180.9**	**98.3**	**52.2**	***110.5***

8. Recharge Basins Results and Conclusions

8.1. Recharge Basin Characteristics

The recharge basins exhibited the following characteristics and biota. Photographs of each of the basins are found at the end of this document.

8.1.1. Basin Number 36

Basin 36 was covered with duckweed (*Lemna* sp.), which made observations of its depth or turbidity impossible. Amphibians, dragonflies, water striders, and swimmers were observed in the basin. Few or no larvae were observed in this basin except when the water level had dropped sufficiently to create shallower areas.

8.1.2. Basin Number 88

Basin 88 holds a relatively large quantity of water. The water was clear, very light brown with 2-3 inch visibility. Frogs, dragonflies, and fish were observed in the pond. The basin has steep, sandy sides with aquatic vegetation visible at the bottom. No shallow areas were present in the basin. No larvae or adult mosquitoes were found.

8.1.3. Basin Number 336

The water level in Basin 336 changed substantially with rain events. At its shallowest, the basin separated into two pools of brown water with 8-12 inch visibility. Dragonflies and fish were observed, but no amphibians. Mosquito larvae were present.

8.1.4. Basin Number 338

Basin 338 contained clear, light brown water with 2-3 inch visibility. Amphibians, dragonflies, water striders, and other small aquatic organisms were observed. The basin has steep sides and vegetation that consisted of trees and shrubs, with no grasses. There were no shallow areas. No larvae or adult mosquitoes were found here.

8.1.5. Basin Number 339

Basin 339 contains brown water with 2-inch visibility. Amphibians, dragonflies, water striders, and other aquatic organisms were observed in the basin. This basin has steep sides with no shallow areas. No larvae or adult mosquitoes were found here.

8.1.6. Basin Number 450

Of all the basins, Basin 450 changed the most with the precipitation. During dry weather, small puddles or no water was present. The basin did fill to the vegetation level (about 6 inches deep) after a rain event. No amphibians, water striders, or fish were observed in the basin. Dragonflies did appear when the basin had filled. Many adult mosquitoes and larvae were found in this basin.

8.2. Recharge Basin Conclusions

The recharge basins chosen differed in the amount of water they held over time and in the presence of mosquito larvae. Mosquito larvae were present in only three (3) of the basins. *Culex pipiens* larvae were present in basin 36 on two (2) occasions. On both occasions, water levels in the basin were low and the area where samples were taken was shallow. Adult mosquitoes were never seen here. Amphibians and dragonflies were observed in this basin.

Culex pipiens larvae were present in basin 336 on two (2) occasions. On both days, basin water levels were such that shallow areas were present. This basin had dragonflies and fish in it. Adult mosquitoes were never found here.

Basin 450 supported the most mosquito breeding. It filled and emptied with the weather. During dry weather no water was present or at best, stagnant shallow puddles. At its wettest (during the study period) it held about six (6) inches of water with especially shallow areas. This basin had *Culex pipiens* larvae and *C. restuans* larvae on seven (7) of the nine (9) days sampled. A significant number of adult mosquitoes and larvae were present when water levels were low. No amphibians, dragonflies, or fish were present in this basin.

Results demonstrate that mosquitoes will breed in shallow, stagnant areas, and will survive when there are few or no predators. Basins with steep sides and no shallow areas that retain water are unlikely to support mosquito breeding. Those that drain completely in a short time will support mosquito breeding only if shallow waters are present for a sufficient period of time. Basins that support fish, amphibians, and dragonflies, which are all mosquito larvae predators, are generally deeper with permanent water and do not support mosquito breeding.

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Maps

Map 1 - Timber Point Golf Course Study Areas

Map 2 - West Sayville Golf Course Study Areas

Map 3 - Blydenburgh County Park Study Area One

Map 4 - Blydenburgh County Park Study Area Two

Map 5 - Connetquot State Park Study Area One

Map 6 - Connetquot State Park Study Area Two

Map 7 - Town of Huntington Recharge Basin Study Areas

PHOTOGRAPHS

Photograph 1 - Mosquito Magnet Liberty Plus and Pro propane powered traps

(from American Biophysics Corporation).

Photograph 2. New Standard Miniature Light Trap with CO_2 release

(from J.W. Hock Company, 2005).

Photograph 3 - Timber Point Golf Course Photographs

Photograph 4 - West Sayville Golf Course Photographs

Photograph 5 - Blydenburgh County Park Photographs

Photograph 6 - Recharge Basin Photographs

APPENDICES

Appendix A – Timber Point Golf Course Garlic Oil Sampling Results

Appendix B - Blydenburgh County Park Garlic Oil Sampling Results

Appendix C - Blydenburgh County Park Rosemary Oil Sampling Results

Appendix D – West Sayville Golf Course Rosemary Oil Sampling Results

Appendix E – Propane Powered Trap Sampling Results

Appendix F – Stormwater Basin Sampling Results

APPENDIX A
BLYDENBURGH COUNTY PARK
GARLIC OIL SAMPLING RESULTS

APPENDIX B
TIMBER POINT GOLF COURSE
GARLIC OIL SAMPLING RESULTS

APPENDIX C
BLYDENBURGH COUNTY PARK
ROSEMARY OIL SAMPLING RESULTS

APPENDIX D
WEST SAYVILLE GOLF COURSE
ROSEMARY OIL SAMPLING RESULTS

APPENDIX E
PROPANE POWERED TRAP SAMPLING RESULTS

APPENDIX F
STORMWATER BASIN SAMPLING RESULTS