



# 2011 Integrated Mosquito Management Program Report

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January 2012



# TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY .....</b>	<b>1</b>
<b>1.0 VECTOR MOSQUITO CONTROL PROGRAM.....</b>	<b>3</b>
1.1 INTRODUCTION .....	3
1.2 WEST NILE VIRUS UPDATE.....	3
1.3 2011 CLIMATOLOGICAL DATA AND MOSQUITO ACTIVITY OVERVIEW .....	6
1.4 LARVAL MOSQUITO SURVEILLANCE AND CONTROL.....	8
1.5 ADULT MOSQUITO SURVEILLANCE.....	10
1.5.1 Adult Surveillance Methodology .....	10
1.5.2 Adult Surveillance Results and Discussion .....	11
1.6 PUBLIC OUTREACH AND EDUCATION.....	13
<b>2.0 NUISANCE MOSQUITO CONTROL PROGRAM.....</b>	<b>14</b>
2.1 INTRODUCTION .....	14
2.2 LARVAL SURVEILLANCE AND CONTROL .....	14
2.3 ADULT MOSQUITO SURVEILLANCE.....	18
2.4 EVALUATION OF THE EFFECTS OF THE NUISANCE PROGRAM ON COMPLAINT NUMBERS .....	22
2.5 EVALUATION OF THE EFFECTS OF THE EXPANDED NUISANCE PROGRAM SITES ON THE GREENBELT MEADOWS AND SAN LAZARO NEIGHBORHOODS.....	22
2.5.1 Greenbelt Meadows Neighborhood .....	22
2.5.2 San Lázaro Neighborhood .....	24
2.6 EVALUATION OF THE EFFECT OF INCREASING THE SPRAY THRESHOLD ON ADULT SPRAYING FREQUENCY .....	25
2.7 EVALUATION OF POTENTIAL LONG-TERM IMPACTS OF BTI TREATMENTS ON BIOTA .....	25
<b>3.0 REFERENCES .....</b>	<b>27</b>

## FIGURES

Figure 1	2011 Monthly Mean Air Temperature and Historical Averages.....	7
Figure 2	2011 Monthly Total Precipitation and Historical Averages.....	7
Figure 3	Percentages of Site Visits with Nuisance and Culex Larvae per Month, 2011.....	9
Figure 4	Season-Wide Weekly Adult Trap Counts of All Trap Stations, 2011 .....	13
Figure 5	Percentages of Site Treatments for Nuisance and Culex Larvae per Month, 2011.....	16
Figure 6	Weekly Adult Trap Counts at Sombrero Marsh (Trap H2), 2011 and Historical Average ....	19
Figure 7	Weekly Adult Trap Counts at Sombrero Marsh (Trap BC-32), 2011 and Historical Average .....	19
Figure 8	Weekly Adult Trap Counts at Gapter Rd/Old Tale (Trap BC-01), 2011 and Historical Average .....	20
Figure 9	Weekly Adult Trap Counts at Stazio Ballfields (Trap C11), 2011 and Historical Average ...	20
Figure 10	Weekly Adult Trap Counts at EBCC (Trap C13), 2011 and Historical Average .....	21
Figure 11	Weekly Adult Trap Counts at Thorne Institute (Trap C12), 2011 and Historical Average ....	21
Figure 12	Weekly Adult Trap Counts at Greenbelt Meadows Temporary Trap, 2008-2011.....	23

## TABLES

Table 1	WNV Incidence, 2002-2011 .....	4
Table 2	Colorado WNV Cases and WNV Positive Mosquito Pools, 2011.....	5
Table 3	Boulder County WNV Cases and Crude Attack Rates, 2002-2011 .....	5
Table 4	Larval Surveillance Summary, 2011 and Historical Data.....	8
Table 5	Total Number of Adult Mosquitoes per Trap for the 2011 Season and Historical Data.....	11
Table 6	Average Numbers of Mosquitoes, 2003 - 2011 .....	12

Table 7	Total Number of Mosquitoes per Trap During the Sentinel Zone Extra Trap Nights of the 2011 Season and Historical Data.....	12
Table 8	Comparison of Larval Surveillance and Control During the Nuisance Program vs. What Would Have Been Performed With the Standard Vector Program, 2011 and Historical Averages.....	15
Table 9	Larval Treatment Summary by Month, 2011.....	16
Table 10	Comparison of Larval Populations Controlled During the Nuisance Program vs. What Would Have Been Controlled with the Standard Vector Program .....	17
Table 11	Number of Treatments for Nuisance-Only Species Mosquitoes by Property, 2007-2011.....	17
Table 12	Number of Adult Mosquitoes per Trap, 2011 .....	18
Table 13	Average Numbers of Mosquitoes of the Nuisance Program Area Traps, 2006-2011 .....	18
Table 14	Comparison of Larval Surveillance and Control Activities at Greenbelt Meadows Nuisance Program Sites vs. What Would Have Been Performed With the Standard Vector Program, 2011 and Historical Averages .....	23
Table 15	Comparison of Larval Surveillance and Control Activities at San Lazaro Nuisance Program Sites vs. What Would Have Been Performed With the Standard Vector Program, 2011 and Historical Averages.....	24
Table 16	Comparison of the Number of County ULV Spray Applications Using the Nuisance Program’s 250 Threshold vs. the Previous Pre-Nuisance Threshold of 100, 2011 and Historical Data .....	25

**APPENDIX A:**

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Map A-1	City of Boulder Larval Sites (Electronic file located at <a href="http://www.bouldercolorado.gov">www.bouldercolorado.gov</a> )
Map A-2	City of Boulder Adult Trap Locations (Electronic file located at <a href="http://www.bouldercolorado.gov">www.bouldercolorado.gov</a> )
Map A-3	Nuisance Program Larval Sites
Map A-4	Nuisance Program Adult Trap Locations

## EXECUTIVE SUMMARY

For the 2011 mosquito season, the City of Boulder contracted OtterTail Environmental, Inc. (OtterTail) to operate a comprehensive Integrated Mosquito Management (IMM) program to protect public health from the effects of West Nile Virus (WNV) and to help suppress nuisance mosquito populations in a limited number of areas in the city.

Since the spring of 2003, the City of Boulder has conducted a vector mosquito control program designed to protect public health and biological resources from the effects of WNV. Through surveillance of potential mosquito breeding sites, areas identified as containing larvae of the *Culex* (vector) species were identified and treated with *Bacillus thuringiensis israelensis* (*Bti*). This method of targeting prevents the mosquitoes from developing into adults and transmitting the virus, and is the most efficient and environmentally responsible way to reduce vector populations. The vector mosquito control program provided *Bti* treatments only on the areas where the target *Culex* species were found; areas with nuisance-only species were bypassed. This approach reduced the impact to many wetland environments from repeated applications of *Bti* because many of the mosquito breeding sites only bred *Culex* mosquitoes for a limited portion of the season.

Sites identified as breeding nuisance-only larvae were not treated in the vector mosquito control program which reduced control material costs as well as the time needed to apply them. More labor time was required to differentiate between vector and nuisance-only larvae as compared to nuisance-focused control. These costs were outweighed by the increase in early WNV detection that larval vector identification provides. A benefit of early identification of vector larvae can provide approximately two weeks advance notice before adult mosquitoes are identified. In addition, control of larvae reduces the possible future need for non-biological control of adult mosquitoes such as ultra-low volume (ULV) pesticide spraying.

The 2011 vector mosquito control program started in May with larval surveillance and the first *Culex* larval treatment occurred on May 26<sup>th</sup>. The project area included 495 sites totaling 3,015 acres consisting of City-owned lands within the city limits (approximately 573 acres) and City-owned lands outside of the city limits (approximately 2,435 acres). Approximately 2,706 acres were Open Space and Mountain Parks lands (**Appendix A, Map A-1**). OtterTail performed 327 treatments on 130 sites that were found to be breeding *Culex* mosquitoes. A total of 171 acres were treated for larvae during the 2011 season due to the vector mosquito control program.

Adult mosquito populations and WNV activity were monitored within the project area using 16 adult mosquito traps. These trap collections enabled OtterTail to monitor adult nuisance levels and provide adult mosquito samples to the Colorado Department of Public Health and Environment (CDPHE) which tested mosquitoes weekly for the presence of WNV.

The State of Colorado experienced its fourth consecutive year with low WNV activity in 2011. This year, human WNV case counts were at their lowest levels since it was first detected in the state in 2002. Similar to recent seasons, cooler early season temperatures and above average precipitation were less conducive for *Culex* mosquito breeding in 2011 and explain, in part, the lower WNV activity throughout the region. The City of Boulder's IMM program coupled with education and personal protection measures, also likely contributed to reduced mosquito populations and WNV activity in the city and county during 2011.

In addition to protecting public health with the vector mosquito control program, the City also wanted to help suppress the number of nuisance mosquitoes around several popular outdoor recreational areas and isolated neighborhoods. These were areas that had an unusually high number of visitor and residential complaints concerning nuisance mosquito bites in 2006. To address this issue, the City of Boulder started a nuisance mosquito control program during the 2007 season and continued it through the 2011 season. The program

allows the City of Boulder to treat a limited number of habitat sites for nuisance mosquito larvae with *Bti*. The habitat sites included were already a part of the City's vector mosquito control program, but since nuisance mosquitoes typically peak before the WNV season begins, OtterTail began monitoring the selected sites several weeks earlier in the season

The 2011 nuisance mosquito control program started in April with larval surveillance and the first larval treatment for nuisance mosquitoes occurred on April 21<sup>st</sup>. The project area included 120 sites totaling approximately 690 acres. OtterTail performed 30 treatments on 23 sites that were found to breeding nuisance-only mosquitoes. A total of 11 acres were treated for larvae during the 2011 season due to the nuisance mosquito control program.

Adult mosquito populations were monitored within the nuisance project area using 3 adult mosquito traps in addition to the 16 traps used in the vector mosquito control program. These trap collections enabled OtterTail to monitor adult nuisance levels around the nuisance mosquito control program to aid in determining the success of the nuisance mosquito treatments.

# 1.0 VECTOR MOSQUITO CONTROL PROGRAM

## 1.1 INTRODUCTION

For the 2011 mosquito season, the City of Boulder contracted OtterTail Environmental, Inc. to operate a vector mosquito control program (vector program) to protect public health and biological resources from the effects of West Nile Virus (WNV). For background information about WNV and mosquito control in Boulder, please refer to the *2006 City of Boulder West Nile Virus Mosquito Management Plan* (WNV MMP) and the *2010 West Nile Virus Season Report* ([www.bouldercolorado.gov](http://www.bouldercolorado.gov)). This report explains the methods used in the Integrated Mosquito Management (IMM) program and provides a detailed summary of the results of this year's effort.

The City's primary goal was the same as in previous seasons; to protect public health from the effects of WNV. To accomplish this goal, specific objectives have been established for the vector program. First, the City of Boulder wanted to continue to prioritize mosquito habitats by determining which ones had the highest potential for mosquito breeding and then monitor and treat those sites when *Culex* larvae were present. Second, since *Culex* larvae were being identified, they wanted to use this as a tool to provide an early warning of any upcoming adult *Culex* populations. Third, they wanted to monitor adult mosquito populations. Monitoring is done by speciation, population counts, and testing for WNV in trapped vector specimens and provides an early warning system for the occurrence and severity of WNV activity in the program area. The City also wanted to limit the effect on the environment from control materials and to be as cost-effective as possible.

## 1.2 WEST NILE VIRUS UPDATE

West Nile Virus is a mosquito-transmitted virus that can cause a wide range of effects, from an asymptomatic infection to a neuroinvasive disease termed West Nile meningitis or encephalitis. West Nile Virus was first detected in the United States during the summer of 1999 in New York City while conducting routine St. Louis Encephalitis (SLE) and Eastern Equine Encephalitis (EEE) surveillance. The virus has since spread across the U.S. and has been confirmed in all continental states. Bird populations act as a reservoir for the virus until a mosquito bites an infected bird. Only then can an infected mosquito pass the virus on to humans, horses, and other animals through their bite. While many people who contract WNV experience mild or no symptoms, the more severe cases of West Nile meningitis or encephalitis can result in severe illness and sometimes death.

There are over 50 mosquito species in Colorado, yet only species from the genus *Culex* are known to be effective transmitters of WNV. Mosquitoes and other insects that transmit disease are called vectors; mosquitoes that are not known to transmit a disease are often called nuisance mosquitoes. The most abundant mosquito in Boulder County, *Aedes vexans*, is an aggressive nuisance mosquito.

As of December 13, 2011, there were 667 WNV human cases and 42 WNV related deaths in 43 states (**Table 1**). During the 2003 WNV epidemic, Colorado led the U.S. in WNV cases and then experienced a significant decrease in WNV cases in 2004 and 2005. During the 2006 and 2007 mosquito seasons, Colorado had a resurgence of cases and once again led the U.S. human case count in 2007. WNV activity decreased throughout the U.S. and Colorado during 2008-2011 seasons, with 2011 having the lowest totals in the state and nation since it was first detected in Colorado in 2002.

This year, Colorado ranked twentieth in the national case count with only 7 human WNV cases reported and no WNV related deaths as of December 15, 2011. WNV cases occurred in Colorado among the populous regions of the Front Range (Boulder, Denver, and Larimer Counties) as well as in the western slope counties of Archuleta, Delta, and La Plata. Boulder County reported the highest number of cases in Colorado with 2

cases reported (**Table 2**). No mosquito pools, horses, birds or humans tested positive for St. Louis Encephalitis or Western Equine Encephalitis in Colorado during the 2011 season.

As of December 15, 2011 there were 2 WNV related illnesses and no related deaths reported in Boulder County (**Table 2**). With widespread and frequent testing of mosquito pools, 9 of the 205 submitted pools of mosquitoes tested WNV positive in the county. The continued lower number of human infections and amounts of WNV activity in Colorado may be attributed to the temperature and precipitation patterns observed during the 2011 mosquito season and the affect they had on mosquito populations, as discussed further in **Section 1.3**.

**Table 1 WNV Incidence, 2002-2011**

Total WNV Human Cases	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cases in the United States <sup>1</sup>	4,156	9,862	2,539	3,000	4,269	3,630	1,356	720	1,021	667
Deaths in the United States <sup>1</sup>	284	264	100	119	177	124	44	32	57	42
Highest State Count in United States <sup>1</sup>	884	2,947	779	880	996	578	445	115	167	154
Cases in Colorado <sup>2</sup>	14	2,947	291	106	345	578	71	103	81	7
Deaths in Colorado <sup>2</sup>	0	63	4	2	7	7	1	3	4	0
Cases in Boulder County <sup>2</sup>	0	421	14	5	74	95	18	12	6	2
Deaths in Boulder County <sup>2</sup>	0	7	0	0	1	2	0	0	0	0
Total WNV Positive Results	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mosquito Pools in Boulder County <sup>2</sup>	0	118	8	0	107	55	3	4	1	9
Mosquito Pools in the City of Boulder <sup>2</sup>	0	43	0	0	12	7	0	0	0	3
Birds in Boulder County <sup>2</sup>	5	50	0	1	12	2	0	0	1	0
Horses in Boulder County <sup>2</sup>	3	18	0	0	1	0	0	0	0	0

1. Reported by the Center for Disease and Control (CDC); 2011 data reported as of December 13, 2011.

2. Reported by the Colorado Department of Public Health and Environment (CDPHE); 2011 data reported as of December 15, 2011.

The number of Boulder County cases and WNV positive mosquito pools comprised approximately twenty-nine percent and fifteen percent of the state totals, respectively (**Table 2**). Although Boulder County reported the most number of human WNV cases in Colorado in 2011, the WNV crude attack rate (cases per 100,000 individuals) was at the lowest level since the first case was reported in the county in 2003 (**Table 3**). The relatively low number of WNV positive mosquito pools, along with the minimal WNV crude attack rate, suggests that the viral activity in Boulder County was significantly less in 2011 than during the years with epidemic outbreaks. It is likely that the continued widespread larval control efforts to reduce mosquito populations combined with public education and personal protection measures helped reduce the exposure and consequently limited disease transmission within the City of Boulder and Boulder County.

**Table 2 Colorado WNV Cases and WNV Positive Mosquito Pools, 2011**

County	Human Cases <sup>1</sup>		Human Deaths <sup>1</sup>		Positive Mosquito Pools <sup>1</sup>	
	Number	% of State	Number	% of State	Number	% of State
Adams	0	0.0%	0	0.0%	3	5.1%
Alamosa	0	0.0%	0	0.0%	3	5.1%
Archuleta	1	14.3%	0	0.0%	0	0.0%
Boulder	2	28.6%	0	0.0%	9	15.3%
Delta	1	14.3%	0	0.0%	8	13.6%
Denver	1	14.3%	0	0.0%	0	0.0%
Jefferson	0	0.0%	0	0.0%	2	3.4%
La Plata	1	14.3%	0	0.0%	0	0.0%
Larimer	1	14.3%	0	0.0%	5	8.5%
Las Animas	0	0.0%	0	0.0%	1	1.7%
Logan	0	0.0%	0	0.0%	1	1.7%
Mesa	0	0.0%	0	0.0%	3	5.1%
Montrose	0	0.0%	0	0.0%	1	1.7%
Otero	0	0.0%	0	0.0%	8	13.6%
Prowers	0	0.0%	0	0.0%	1	1.7%
Pueblo	0	0.0%	0	0.0%	1	1.7%
Rio Grande	0	0.0%	0	0.0%	3	5.1%
Weld	0	0.0%	0	0.0%	10	16.9%
Colorado Totals	<b>7</b>		<b>0</b>		<b>59</b>	

1. Reported by CDPHE as of December 15, 2011.

**Table 3 Boulder County WNV Cases and Crude Attack Rates, 2002-2011**

Year	# of WNV Cases	% of Colorado Cases by # of Cases	Crude Attack Rates (per 100,000)
2002	0	0.0%	0.00
2003	421	14.3%	150.12
2004	14	4.8%	4.99
2005	5	4.7%	1.78
2006	74	21.4%	26.39
2007	95	16.4%	33.88
2008	18	25.4%	6.38
2009	12	11.7%	4.09
2010	6	7.4%	1.98
2011	2	28.6%	0.68

\* WNV human case information used for Crude Attack Rate calculations was obtained from CDPHE (CDPHE 2011); Population information for Crude Attack Rate calculations was obtained from U.S. Census Bureau 's 2010 Census of Population (USCB 2011); Crude Attack Rates are listed as cases per 100,000 people.

### 1.3 2011 CLIMATOLOGICAL DATA AND MOSQUITO ACTIVITY OVERVIEW

The weather patterns leading into and during the mosquito season are important factors that influence mosquito abundance and WNV activity. The following section describes the local climate in Boulder, the weather during the season, and how that may have affected the mosquito populations.

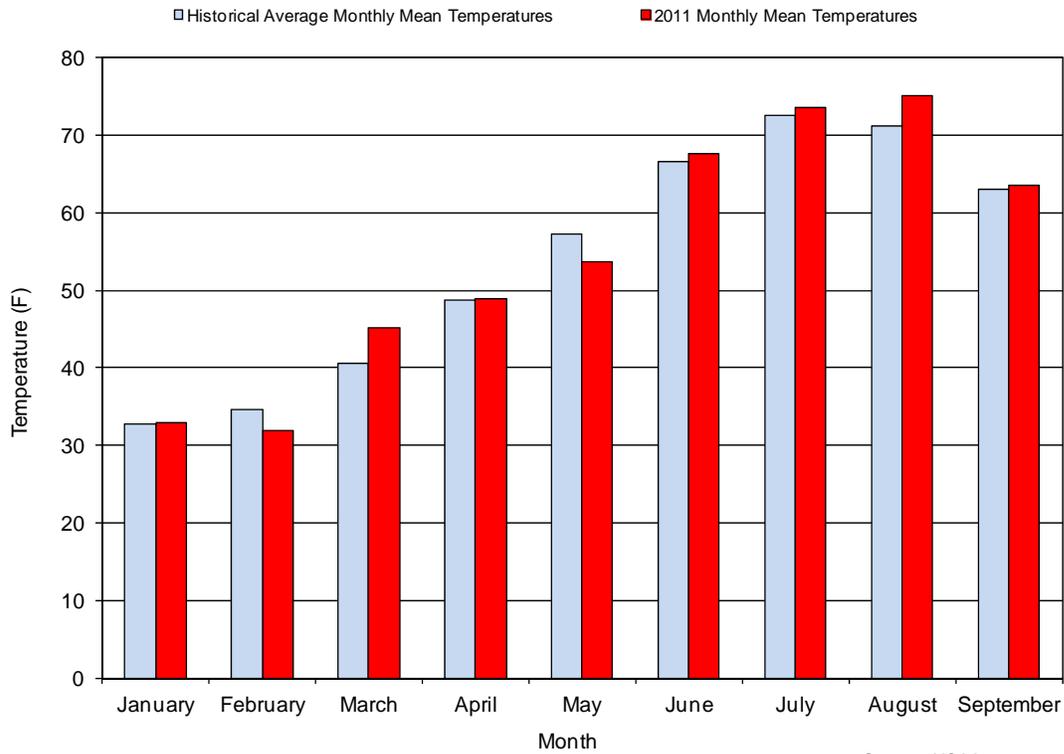
The City of Boulder is located in a semi-arid environment at an elevation of approximately 5,340 feet. The typical mosquito season for the City of Boulder is from April to September. Current and historical climate data from the National Oceanic Atmospheric Administration's (NOAA) Boulder, Colorado weather station were used for regional temperature and precipitation patterns.

Historical records for the mean monthly temperature at the station suggest that temperatures usually have a steady increase from April to July, making July, on average, the hottest month of the year. Typically the mean temperature steadily decreases into September. In 2011, the month of May had below normal temperatures, while June, July, August, and September had slightly above normal temperatures, with the average hottest month of 2011 being August. The month of March experienced the highest deviation from normal monthly mean temperature at almost five degrees above normal. May also had a high deviation from normal with its monthly mean temperature approximately three and a half degrees below normal (**Figure 1**).

Monthly mean precipitation for the period of record indicates that April, May and June are usually the wettest months of the year (**Figure 2**). During 2011, the accumulated precipitation from January through September was above the historical average of accumulated precipitation for the same period. During this time period in 2011, there was an accumulation of 17.5 inches. This is approximately 15 percent more than the normal accumulation for this time period when compared to the historical average, which is 15.4 inches. Five of the nine months received precipitation amounts higher than their normal averages. The most significant variations were the months of March, May, and July. March received 80 percent less precipitation than average making it the driest month of 2011. May and July received 73 percent and 66 percent more precipitation than average, making them the wettest months of the 2011 mosquito season (NOAA 2011).

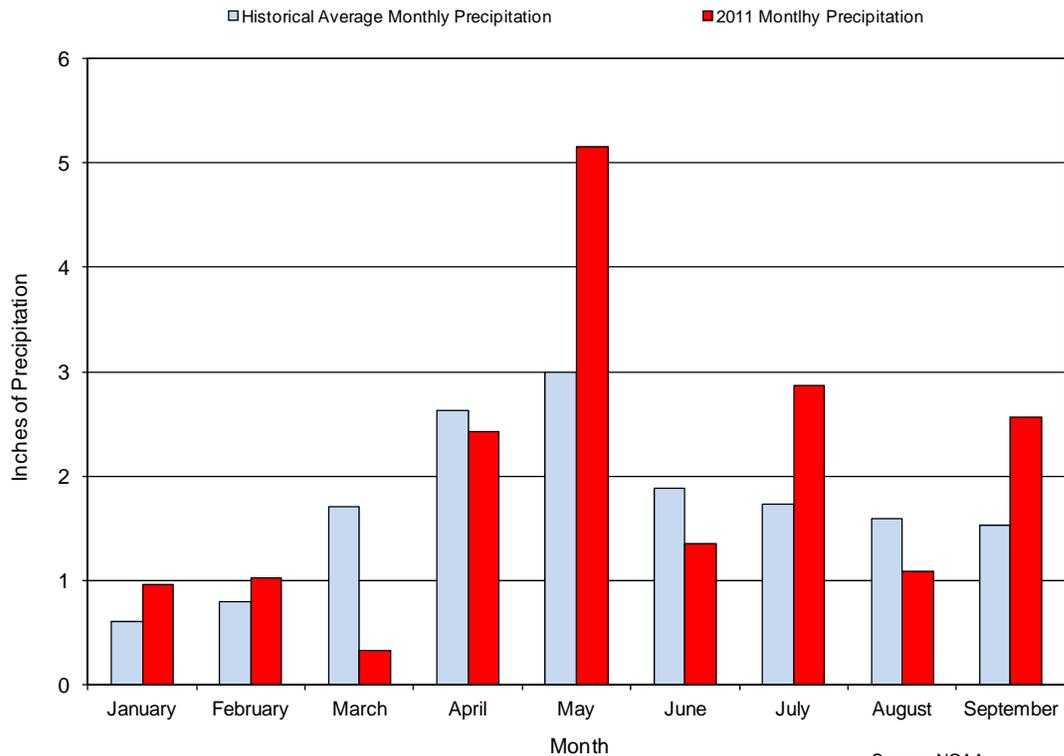
Temperatures and precipitation amounts varied throughout the 2011 mosquito season. High amounts of precipitation during May and early June caused many of the habitat sites to fluctuate in size throughout the early portion of the season. This early-season flooding of larval habitats, along with several more rainfall events throughout the summer, led to above average *Aedes/Ochlerotatus* (floodwater) mosquito populations in most areas during the 2011 season. In July, the entire Front Range region experienced monsoon rains followed by several days of 90 degree temperatures. This combination of weather caused the nuisance mosquito populations to increase exponentially to some of the highest recorded mosquito abundances for the region in late July. Nuisance populations remained higher than normal into mid-August and then decreased significantly as habitat sites dried up later in the month and into September with cooler nighttime temperatures. Although nuisance mosquito populations were above average during the 2011 season, *Culex* populations were lower than typically seen for much of the season. The especially low abundance of *Culex* mosquitoes during the first half of the season was the likely cause of the lower levels of WNV activity throughout the region during 2011. The lower temperatures and lesser *Culex* abundances early in the season likely caused the WNV cycle to start later and magnify at a much lower rate than during a year with large early-season *Culex* populations and higher summer temperatures.

**Figure 1 2011 Monthly Mean Air Temperature and Historical Averages\***



Source: NOAA

**Figure 2 2011 Monthly Total Precipitation and Historical Averages\***



Source: NOAA

## 1.4 LARVAL MOSQUITO SURVEILLANCE AND CONTROL

The 2011 larval surveillance season began in May and ended in mid-September. Monitoring for larvae throughout the project area and larval species identification determined if mosquito control was needed. During the season, a total of 6,590 individual larval site visits and 327 larval site treatments were performed within the program area. Of the potential breeding sites, 25% bred vector mosquito larvae during the 2011 season (**Table 4**).

As the season progressed, the sites were categorized and inspected according to larval abundance and occurrence per the City of Boulder WNV MMP. Low priority mosquito sites were not producing mosquitoes, had poor habitat, or had the presence of aquatic predators. High priority mosquito sites typically had larvae when sampled and often produced mosquitoes every seven to ten days during the peak season. Approximately 171 acres of active vector breeding habitat were identified and treated within the entire project area in 2011. For a detailed explanation of the larval surveillance methodology used during the 2011 season, please see the *2006 City of Boulder West Nile Virus Mosquito Management Plan* ([www.bouldercolorado.gov](http://www.bouldercolorado.gov)).

**Table 4 Larval Surveillance Summary, 2011 and Historical Data**

Larval Site Surveillance Totals	2011	Historical Average <sup>1</sup>	Historical Range <sup>1</sup>
Site investigations	6,590	4,433	1,871 - 6,308
Percent of sites breeding (vector and/or nonvector)	34%	41%	28% - 50%
Percent of sites breeding vector	25%	24%	18% - 30%
Site treatments	327	326	196 - 558
Treated acreage	171	159	67 - 294

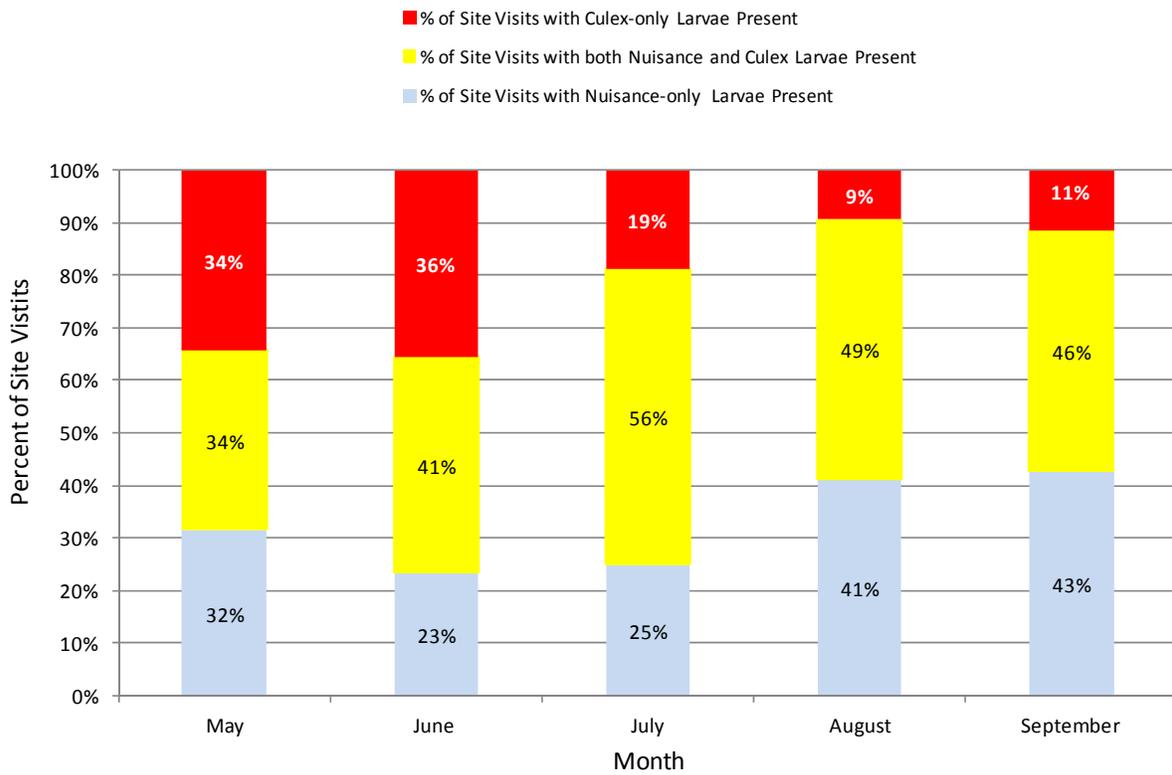
Notes: 1. Historical average and range based on 2003 - 2010 seasons.

To help understand patterns of larval species presence throughout the season, the numbers of site visits with larvae present were used to represent relative larval abundance during the season (**Figure 3**). The methodology used in the larval surveillance and control program, as previously discussed, targeted *Culex* larval habitat. Therefore, these numbers are biased towards finding a higher prevalence of *Culex* mosquito larvae and should only be used to compare the abundances between the months of the season and should not be used in determining the overall larval abundance of the City of Boulder mosquito populations.

The season's overall average representative larval collection resulted in site visits with both nuisance and *Culex* species present having the highest abundance at 48%, compared to site visits with nuisance-only species present at 32%, and site visits with only *Culex* species making up 20% of the seasonal larval abundance. When site visits that had both *Culex* and nuisance are combined with the *Culex*-only visits, this results in a larval abundance for *Culex* mosquitoes of 68% compared to 32% nuisance-only for the season.

The number of sites breeding *Culex* larvae or both *Culex* and nuisance larvae along with treatments suggest that a substantial number of adult vector mosquitoes would have become airborne, which would have likely increased WNV activity, had the larval control program not been implemented.

**Figure 3 Percentages of Site Visits with Nuisance and Culex Larvae per Month, 2011**



## 1.5 ADULT MOSQUITO SURVEILLANCE

### 1.5.1 Adult Surveillance Methodology

Adult mosquito population surveillance is a crucial component of any successful IMM program. Adult surveillance provides information on which types of mosquito species are in an area as well as information on their abundance. Mosquitoes collected from mosquito traps can be tested for a variety of mosquito-borne diseases and are critical for monitoring and forecasting vector threats, particularly WNV.

Adult mosquito traps were placed and monitored at 16 sites around the city starting the first week in June through mid-September. Traps were set in areas of suitable harborage for adult mosquitoes and were set in the same locations used during previous years of the program. OtterTail uses two different types of mosquito traps to monitor adult mosquito populations, the gravid trap and the carbon dioxide (CO<sub>2</sub>) baited light trap. The CO<sub>2</sub> baited light traps are based on the principle that most adult mosquitoes are attracted to light, CO<sub>2</sub> (via respiration), and heat. The CO<sub>2</sub> baited light trap collects adult female mosquitoes that are seeking a blood meal. The gravid trap mimics sources of mosquito breeding habitat and attracts gravid female mosquitoes that are seeking a spot to lay their eggs. Both types of traps are set overnight and on the following morning the nets are collected and returned to the lab to be identified and counted. Once identified, the mosquitoes were then sorted by species and samples of the vector mosquitoes were submitted to the Colorado Department of Public Health and Environment (CDPHE) for WNV testing. Refer to the *2006 City of Boulder West Nile Virus Mosquito Management Plan* ([www.bouldercolorado.gov](http://www.bouldercolorado.gov)) for details about site selection and trap methods.

To maximize the efficiency of their WNV testing resources, CDPHE developed a statewide protocol for the sentinel surveillance program in 2007, which continued into the 2011 season. There were two main changes implemented in the 2007 surveillance guidelines. The first part of the 2007 protocol was to change each county's sentinel testing location from a single sentinel sampling site into a sentinel zone. The sentinel zone is a system of five light traps at five different locations within a five mile radius. Culex mosquitoes collected from all five traps within the zone are then pooled together each week for WNV testing. It is thought that the use of five traps within the sentinel zone will give more reliable data over time as well as cut down on weeks with lost data (e.g. trap malfunction when only a single trap site was being used). Based on the high WNV activity in the past, CDPHE allowed Boulder County to continue to operate and submit mosquitoes from two separate sentinel zones. The City of Boulder area was one sentinel zone and the second sentinel zone was in a location of the county that included the Longmont area.

The second change to the CDPHE protocol was the monitoring schedule for the sentinel zones. After analyzing data from previous years, CDPHE found that the majority of all WNV activity occurred between June and August. In an effort to perform most of its WNV testing during this heightened transmission period, CDPHE requested that counties no longer perform early (May) or late (September) season monitoring for the sentinel program. Instead, they requested that counties run their sentinel zone traps once a week starting the first week of June, then run their sentinel zone traps for a second night each week from the first week of July until the first week of August, and run them once a week again until the end of August. This monitoring schedule would allow the vector mosquitoes collected from the traps within the sentinel zone to be submitted for WNV testing throughout the season, with extra samples being collected and tested during the height of the transmission period.

Beginning in June, 12 light traps and four gravid traps were set so that each would cover an approximately one-mile radius (**Appendix A, Map A-2**). The City cooperated with the University of Colorado (CU) and Boulder County Public Health Department (BCPH) in order to provide complete surveillance coverage of the city. The 16 City traps, in combination with Boulder County and CU traps, provided comprehensive surveillance of the Boulder urban area. Five of the City's traps were also used in Boulder County's CDPHE WNV sentinel surveillance program. All 16 traps were set on a weekly basis until mid-September, with the five sentinel zone traps having a second trap night from the first week of July until the first week of August.

The adult mosquito data were used to calculate potential WNV infection rates and to help City and County officials determine local areas of concern for public awareness and safety. These data could also be used to guide any potential adulticide efforts within the city, which was an important health and environmental issue to City officials and residents.

### 1.5.2 Adult Surveillance Results and Discussion

The City of Boulder’s adult mosquito surveillance began on June 7<sup>th</sup> and ended on September 20<sup>th</sup>. The 12 light traps collected a variety of mosquito species and the 4 gravid traps collected mostly Culex species throughout the season. A total of 14,064 mosquitoes were trapped in these 16 traps during the 2011 season. The total adults collected during the season resulted in Aedes and Ochlerotatus species being the most abundant, followed by Culex (vector) species, Coquillettidia species and finally Culiseta species as shown in **Table 5**. This resulted in approximately 85 percent nuisance vs. 15 percent Culex adults being collected over the entire season. As shown in **Table 6**, there was an average of 55 total adult mosquitoes per trap per night and an average of 8 adult Culex mosquitoes per trap per night in 2011.

**Table 5 Total Number of Adult Mosquitoes per Trap for the 2011 Season<sup>1</sup> and Historical Data**

Trap Name, (Type), and Location	Culex spp.		Ae./Oc. Spp.		Coquillettidia spp.		Culiseta spp.		Trap Total	Average per Trapnight	Trap %RA	Historical Avg. Per Trap Night <sup>2</sup>	Range of Historical Trap Nights <sup>2</sup>
	#	%RA	#	%RA	#	%RA	#	%RA					
HO (Light) Rolling Rock Ranch	43	2%	2,003	89.1%	177	7.9%	24	1.1%	2,247	140	16.0%	103	31-213
H2 (Light) Sombrero Marsh	153	8%	1,682	89.8%	0	0.0%	39	2.1%	1,874	117	13.3%	165	61-399
H4 (Light) Papini	117	31%	255	67.8%	0	0.0%	4	1.1%	376	24	2.7%	40	11-79
H5 (Light) Tom Watson Park	290	32%	573	64.1%	19	2.1%	12	1.3%	894	56	6.4%	57	30-89
H6 (Light) Sawhill Ponds	402	30%	888	66.3%	29	2.2%	21	1.6%	1,340	84	9.5%	184	53-397
C1 (Light) Locust/ 10th	91	18%	416	81.3%	1	0.2%	4	0.8%	512	32	3.6%	13	6-20
C2 (Light) 23rd/Meadow	42	25%	125	74.9%	0	0.0%	0	0.0%	167	10	1.2%	10	3-20
C3 (Light) Christensen Park	640	17%	3,004	82.1%	2	0.1%	12	0.3%	3,658	229	26.0%	112	22-246
C4 (Light) South Boulder Rec.Center	41	3%	1,147	95.9%	4	0.3%	4	0.3%	1,196	75	8.5%	33	7-76
C5 (Light) Broadway / Baseline	22	10%	190	89.6%	0	0.0%	0	0.0%	212	13	1.5%	6	1-11
C6 (Light) Broadway / Alpine	3	25%	9	75.0%	0	0.0%	0	0.0%	12	1	0.1%	6	0-19
C7 (Gravid) Table Mesa / Stevens	15	94%	1	6.3%	0	0.0%	0	0.0%	16	1	0.1%	12	3-28
C8 (Gravid) 7th / Pennsylvania	5	100%	0	0.0%	0	0.0%	0	0.0%	5	0	0.0%	7	2-18
C9 (Gravid) Columbine Park	5	100%	0	0.0%	0	0.0%	0	0.0%	5	0	0.0%	6	1-17
C10 (Gravid) Comanche / Mohawk Dr.	23	79%	6	20.7%	0	0.0%	0	0.0%	29	2	0.2%	16	3-35
C11 (Light) Stazio Ballfields	141	9%	1,373	90.3%	2	0.1%	5	0.3%	1,521	95	10.8%	142	78-213
<b>Total</b>	<b>2,033</b>	<b>14.5%</b>	<b>11,672</b>	<b>82.9%</b>	<b>234</b>	<b>1.7%</b>	<b>125</b>	<b>0.9%</b>	<b>14,064</b>	<b>879</b>	<b>100.0%</b>	<b>912</b>	---
Average	127	---	730	---	15	---	8	---	879	55	---	57	---

1. Season includes June 7 through September 20, 2011 for surveillance traps for a total of 256 trap nights. 2. Historical average per trapnight and range based on 2003-2010 data. %RA=Percent Relative Abundance.

**Table 6 Average Numbers of Mosquitoes, 2003 - 2011**

Year	2003 <sup>1</sup>	2004	2005	2006	2007	2008	2009	2010	2011
Average # of Total Mosquitoes (per Trap per Trap Night)	200	32	41	86	50	62	68	42	55
Average # of Total Vector Mosquitoes (per Trap per Trap Night)	60	4	9	10	14	12	19	8	8

1. The 2003 season-wide averages are based upon traps H0-H6 only; traps H0-H6 historically capture significantly more mosquitoes than traps C1-C11 which likely cause the overall 2003 average to be much higher than following years.

As shown in **Table 7**, an additional 4,230 mosquitoes were captured during the extra sentinel zone trap nights. Over the course of five weeks, from all five sentinel traps, there was an average of 169 total adult mosquitoes per trap per night and an average of 27 adult vector mosquitoes per trap per night. The total adults collected during the sentinel trap nights resulted in a trend similar to the regular trap nights with *Aedes* and *Ochlerotatus* species being the most abundant, followed by *Culex* (vector) species, *Coquillettidia* species, and finally *Culiseta* species. This resulted in approximately 84% nuisance adults vs. 16% *Culex* adults being collected over the five weeks of additional trap nights.

**Table 7 Total Number of Mosquitoes per Trap During the Sentinel Zone Extra Trap Nights of the 2011 Season<sup>1</sup> and Historical Data**

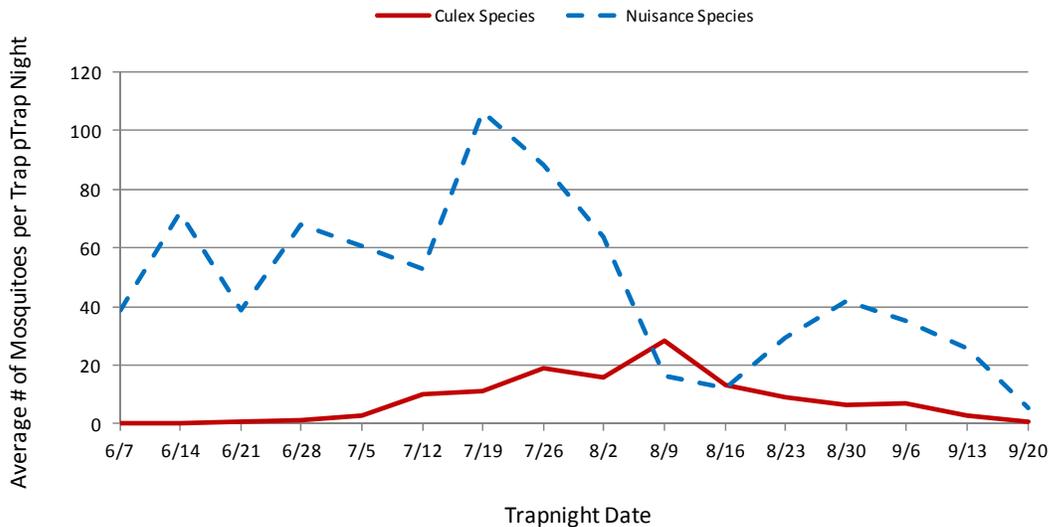
Trap Name, (Type), and Location	<i>Culex spp.</i>		<i>Ae./Oc. Spp.</i>		<i>Coquillettidia spp.</i>		<i>Culiseta spp.</i>		Trap Total	Average per Trapnight	Trap %RA	Historical Avg. Per Trap Night <sup>2</sup>	Range of Historical Trap Nights <sup>2</sup>
	#	%RA	#	%RA	#	%RA	#	%RA					
H5 (Light) Tom Watson Park	155	22.8%	429	63.2%	95	14.0%	0	0.0%	679	136	16.1%	73	32-109
C1 (Light) Locust/10th	32	21.1%	119	78.3%	1	0.7%	0	0.0%	152	30	3.6%	25	9-52
C3 (Light) Christensen Park	397	21.6%	1,439	78.3%	1	0.1%	1	0.1%	1,838	368	43.5%	198	142-264
C4 (Light) South Boulder Rec.Center	46	7.6%	553	91.9%	3	0.5%	0	0.0%	602	120	14.2%	66	44-78
C11 (Light) Stazio Ballfields	44	4.6%	911	95.0%	4	0.4%	0	0.0%	959	192	22.7%	224	141-353
<b>Total</b>	<b>674</b>	<b>15.9%</b>	<b>3,451</b>	<b>81.6%</b>	<b>104</b>	<b>2.5%</b>	<b>1</b>	<b>0.02%</b>	<b>4,230</b>	<b>846</b>	<b>100.0%</b>	<b>586</b>	<b>---</b>
Average	135	---	690	---	21	---	0	---	846	169	---	117	---

1. Sentinel Zone trap nights include one (extra) trap night a week from July 6 to August 3, 2011 for a total of 25 trapnights. 2. Historical average per trapnight and range based on 2007-2010 data. %RA = Percent Relative Abundance.

As described in **Section 3**, temperatures and precipitation amounts varied throughout the 2011 mosquito season. High amounts of precipitation during May and early June caused many of the habitat sites to fluctuate in size throughout the early portion of the season. This early-season flooding of larval habitats, along with several more rainfall events throughout the summer, led to above average *Aedes/Ochlerotatus* (nuisance) mosquito populations in most areas during the 2011 season (**Figure 4**).

In July, the entire Front Range region experienced numerous monsoon rains followed by several days of 90 degree temperatures. This combination likely caused the nuisance mosquito populations to exponentially increase into some of the highest recorded mosquito populations for the region in late July. As shown in **Figure 4**, the City of Boulder's nuisance mosquito population also reached its peak in late July. Nuisance populations remained higher than normal into mid-August and then decreased significantly as habitat sites dried up later in the month and into September. *Culex* and nuisance mosquito populations decreased in September as temperatures decreased.

**Figure 4 Season-Wide Weekly Adult Trap Counts of All Trap Stations, 2011**



Although nuisance mosquito populations were above average in most areas in 2011, Culex populations were lower than typically seen for much of the season. Similar to recent years, the especially low abundance of Culex mosquitoes during the first half of the season was the likely cause of the lower levels of WNV activity throughout the region during 2011. The low early-season Culex populations caused the WNV transmission to start later and magnify at a much lower rate than during a year with higher Culex populations and temperatures.

### 1.6 PUBLIC OUTREACH AND EDUCATION

Public education is an important component to any successful mosquito control program and is vital in combating West Nile Virus. As in previous years, the *One Bite* campaign, produced by Boulder County Public Health, provided the City of Boulder with posters and flyers for distribution to the general public. The campaign materials contained information about personal protection using the “4 D’s” (DEET, Dawn and Dusk, Dress, and Drain) and testimonials from local persons infected with WNV during previous outbreaks. Posters were displayed throughout the City of Boulder, at Open Space and Mountain Park trailheads, Parks and Recreation facilities, libraries, senior centers and the Municipal Building to raise awareness about WNV in the Boulder community.

The City of Boulder also provided an electronic notice to residents with their monthly online utility bill payments that provided information about WNV and their website contained sections for current WNV activity, the City’s mosquito control plan, program maps and links to email City staff with WNV questions. The City also continued to provide a WNV hotline for residents. Callers were given information from a menu service and could leave a message for City staff to report any WNV or mosquito related concerns as well as request to be added to the City’s no-spray list.

OtterTail also offered an extensive amount of information on its website, including sections on mosquito biology and control as well as actions residents and land users could take to help aid OtterTail and the City in our mosquito control efforts.

Educating residents on the need for property maintenance, source reduction, and the use of personal protection measures continued to be crucial in the fight against WNV in 2011. The resulting actions taken by the public likely helped reduce the mosquito populations in the area as well as decreasing the WNV activity levels and reported cases of infection in 2011.

## **2.0 NUISANCE MOSQUITO CONTROL PROGRAM**

### **2.1 INTRODUCTION**

Since the spring of 2003, the City of Boulder has conducted a vector management program designed to protect public health and biological resources from the effects of West Nile Virus (WNV). The design of the West Nile Virus Mosquito Management Plan (vector program) allows for mosquito control with the larvicide, *Bacillus thuringiensis israelensis* (*Bti*). This plan is only targets species of mosquitoes that are known to most effectively transmit WNV to humans (Culex or vector species). Habitats that only contain species of mosquito larvae that are a nuisance to people (nuisance or non-vector species) are bypassed. While the results of the vector program suggest that it has been highly effective at protecting the public against the threat of WNV, there were certain issues that developed with the Culex-only approach to mosquito control.

In May and June of 2006, mosquito breeding conditions were ideal, and the City of Boulder received hundreds of complaints about nuisance mosquito activity from softball players and attendees at Stazio Ballfields and golfers at Flatirons Golf Course. These Parks and Recreation (P&R) facilities began realizing decreased revenues from declining attendance associated with these complaints. The City also received a large number of complaints about high numbers of nuisance mosquitoes from city and county residents living adjacent to several Open Space and Mountain Parks (OSMP) properties.

After the 2006 mosquito season, the City conducted several meetings to develop a strategy to address these issues. As a result, the Nuisance Mosquito Control Program (nuisance program) was developed. The nuisance program allows the City of Boulder to treat a limited number of habitat sites for nuisance mosquito larvae with *Bti* when nuisance mosquito larvae are present in high numbers. The habitat sites included were already a part of the City's WNV program, but since nuisance mosquitoes typically peak before the WNV season begins, OtterTail began monitoring the selected sites several weeks earlier in the season. The nuisance program was started in 2007 and was intended to be a two-year trial program to reduce the nuisance mosquito populations within the areas of concern. The City has since extended the program through the 2011 season.

Fifty-seven sites were initially approved to be included in the nuisance program project area for nuisance mosquito larval control. However, over the course of the 2007- 2008 seasons, two areas near the nuisance program continued to experience nuisance mosquito complaints. The two areas were the Greenbelt Meadows and San Lazaro neighborhoods. These neighborhoods are located near the nuisance program area, but dozens of habitat sites that are located within a mile radius of them were not included in the 2007 nuisance program, and therefore, could not be treated for nuisance-only species. As discussed in more detail in the *Nuisance Mosquito Control Nuisance Program Report* (OtterTail 2009), uncontrolled nuisance mosquito populations from these nearby habitats likely increased the adult populations and consequently, the residential complaints of nuisance mosquitoes increased in each neighborhood. Due to the residents reporting a large number of complaints within the Greenbelt Meadows and San Lazaro neighborhoods, the City expanded the nuisance program during the 2009 season and again in the 2011 season to include 64 additional nuisance program sites, raising the total number of sites included in the nuisance program to 120 in 2011 (**Map A-3**). .

For detailed background information including methods, results and discussion of the nuisance program, please reference the *2010 Nuisance Mosquito Control Pilot Program Report* (Ottertail 2010).

### **2.2 LARVAL SURVEILLANCE AND CONTROL**

As shown in **Table 8**, a total of 3,009 individual larval site visits were performed on the 120 potential breeding sites during the 2011 season. Approximately 115 acres of active breeding habitat were identified and treated at 45 sites. There were a total of 41 site treatments performed for Culex-only species, 74 site

treatments performed when both *Culex* and nuisance species were present, and 30 site treatments for nuisance-only species over the course of the season (**Table 9**). Therefore the nuisance program increased the number of site treatments by 30 (21%), which increased the amount of acreage treated by 11 acres (10%), and the amount of *Bti* applied by 57 pounds (10%).

**Table 8 Comparison of Larval Surveillance and Control During the Nuisance Program vs. What Would Have Been Performed With the Standard Vector Program, 2011 and Historical Averages**

Year	Nuisance Program (Nuisance) <sup>1</sup>	Standard Vector Program ( <i>Culex</i> ) <sup>2</sup>	Increase Due to Nuisance Program <sup>3</sup>	
			Number	Percent
<b>2011</b>				
Potential Breeding Site Locations	120	120	0	0%
Number of Site Investigations	3,009	2,565	444	15%
Number of Site Treatments	145	115	30	21%
Number of Site Locations Treated	45	41	4	9%
Total Treated Acreage	115	104	11	10%
Pounds of <i>Bti</i> Used <sup>4</sup>	575	519	57	10%
<b>Historical Average<sup>5</sup></b>				
Potential Breeding Site Locations	63	63	0	0%
Number of Site Investigations	1,104	929	176	16%
Number of Site Treatments	98	71	28	28%
Number of Site Locations Treated	27	21	6	23%
Total Treated Acreage	42	28	14	33%
Pounds of <i>Bti</i> Used <sup>4</sup>	211	142	69	33%

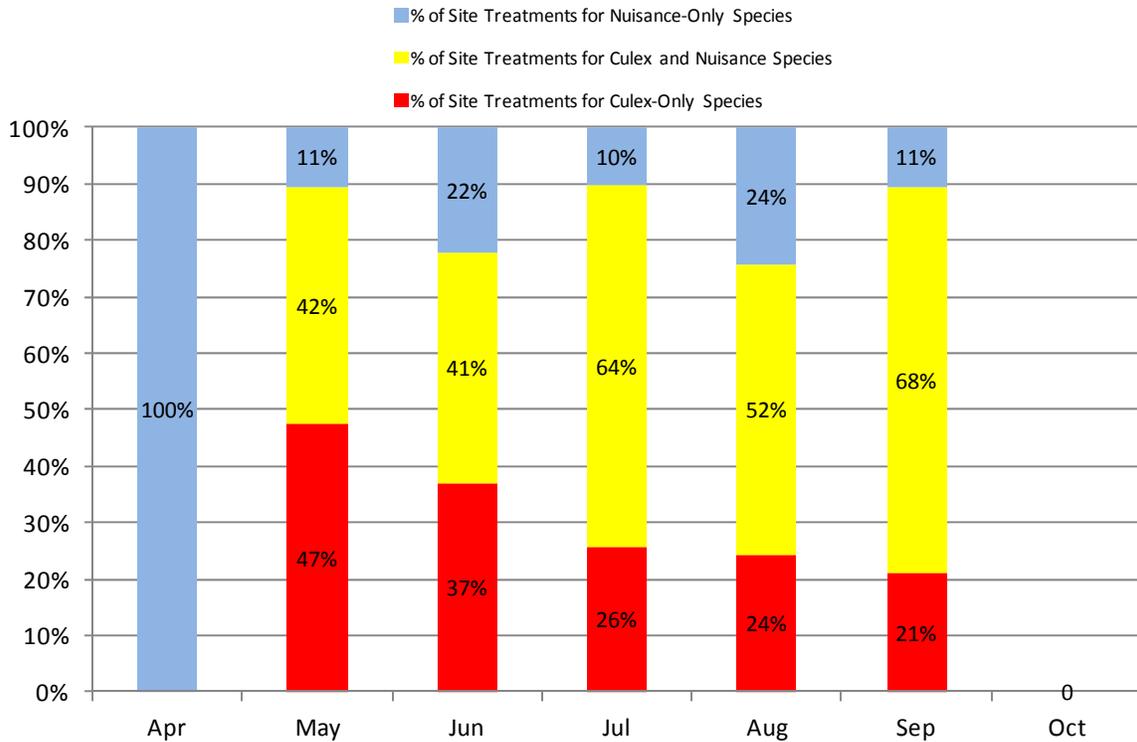
Notes:

- 1: The implemented program during 2007-2011 seasons.
- 2: Results if the standard vector program had been done instead of the nuisance program.
- 3: Difference between nuisance program and what would have occurred had the standard vector program been implemented instead.
- 4: Amount of *Bti* used when applied at the typical 5 lbs. per acre application rate.
- 5: Historical average based on 2007-2010 data.

The number of site locations receiving *Bti* treatments and the amount of *Bti* being used for mosquito control was a concern of several City staff members and residents. The results of the nuisance program show that the amount of *Bti* that was used and the total amount of acreage treated increased by 10%. The additional site treatments for nuisance mosquitoes increased the number of site locations treated by 4 locations (or 9%) during the 2011 season. The increase in site investigations (15% increase) and treatments (10% increase) due to the nuisance program also increased the overall labor and material costs associated with those activities.

To help understand patterns of larval species presence and treatments throughout the season, the number of 2011 site treatments is shown by each month (**Figure 5**). As expected, the majority of the early season treatments that were performed were for nuisance-only species. Of the 30 site treatments performed during the season, 51% were on sites when both *Culex* and nuisance species were present, 28% when *Culex* only species were present and 21% for nuisance-only species (**Table 9**).

**Figure 5 Percentages of Site Treatments for Nuisance and Culex Larvae per Month, 2011**



**Table 9 Larval Treatment Summary by Month, 2011**

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Total	Percent of Total
Number of Site Treatments for Culex-Only Species	0	9	10	10	8	4	0	41	28%
Number of Site Treatments for Culex and Nuisance Species	0	8	11	25	17	13	0	74	51%
Number of Site Treatments for Nuisance-Only Species Due to Nuisance Program	8	2	6	4	8	2	0	30	21%
<b>Total Site Treatments</b>	<b>8</b>	<b>19</b>	<b>27</b>	<b>39</b>	<b>33</b>	<b>19</b>	<b>0</b>	<b>145</b>	<b>100%</b>

The number of sites breeding mosquito larvae and their treatments suggest that more adult nuisance mosquitoes would have become airborne had the nuisance program not been implemented. The larval surveillance data were used to estimate larval populations controlled during the nuisance program vs. what would have been controlled with only the standard vector program. As shown in **Table 10**, the estimates suggest that a potential of over 28 million more mosquito larvae were controlled during the 2011 season due to the nuisance program. The properties where treatments for nuisance-only mosquitoes occurred over the course of the nuisance program can be found in **Table 11**.

**Table 10 Comparison of Larval Populations Controlled During the Nuisance Program vs. What Would Have Been Controlled with the Standard Vector Program**

Year	Nuisance Program <sup>1</sup>	Program (Culex) <sup>2</sup>	Increase Due to Nuisance Program	
			Number	Percent
2011 Estimated Larval Population Controlled <sup>3</sup>	140,282,424	112,209,458	28,072,966	20%
Historical Average <sup>4</sup>	123,314,181	70,935,012	52,379,169	42%

Notes:

- 1: The implemented program during 2007-2011 seasons.
- 2: The back-calculated population if the standard WNV program had been conducted instead of the nuisance program.
- 3: Estimated larval populations were calculated by multiplying # per dip by 10 (each dip is approx. 1/10 of a sq. ft) by the sq. ft. of breeding habitat; This is the theoretical maximum potential number of mosquitoes (including males and females) that would be produced with no mortality.
- 4: Historical average based on 2007-2010 data.

**Table 11 Number of Treatments for Nuisance-Only Species Mosquitoes by Property, 2007-2011**

Property Name (Managing Department)	# of Treated Sites on Property	Total # of Treatments in 2007 <sup>2</sup>	Total # of Treatments in 2008 <sup>2</sup>	Total # of Treatments in 2009 <sup>2</sup>	Total # of Treatments in 2010 <sup>2</sup>	Total # of Treatments in 2011 <sup>2</sup>	5-yr Total
Boulder Reservoir (P&R)	11	9	12	9	5	3	38
Burke I	2	n/a	n/a	n/a	n/a	4	4
Colorado Open Lands II (OSMP)	2	n/a	n/a	1	6	0	7
Colorado Open Lands III (OSMP)	3	n/a	n/a	1	2	0	3
East Boulder Recreation Center (P&R)	3	0	3	0	11	6	20
Flatirons Golf Course (P&R)	4	0	0	5	1	0	6
Gebhard (OSMP)	2	n/a	n/a	3	1	2	6
Kentucky Property (P&R)	1	0	1	n/a	n/a	n/a	1
Mary Clyncke (OSMP)	1	n/a	n/a	1	0	0	1
Pleasantview Soccer Fields (P&R)	1	1	1	0	0	0	2
Hogan/Pancost Area (Private)	3	0	0	1	5	0	6
Sombrero Marsh (OSMP)	1	1	1	0	5	1	8
Stazio Ballfields (P&R)	2	2	2	3	4	1	12
Van Vleet (OSMP)	10	n/a	n/a	6	8	13	27
<b>Total</b>	<b>46</b>	<b>13</b>	<b>20</b>	<b>30</b>	<b>48</b>	<b>30</b>	<b>141</b>

Notes:

- 1: Total number of separate sites on property that were treated
- 2: Total number of treatments was obtained by combining the treatments from all of the separate breeding sites on the property during the season  
n/a=sites that were not included in pilot program during corresponding year.

## 2.3 ADULT MOSQUITO SURVEILLANCE

The City of Boulder's 2011 adult mosquito nuisance surveillance program began on April 28<sup>th</sup> and ended on September 20<sup>th</sup>. The four nuisance program light traps collected a total of 7,493 mosquitoes during the 2011 season. The total adults collected during the nuisance program resulted in species within the genus *Aedes* and *Ochlerotatus* being the most abundant, followed by *Culex* (vector mosquitoes), *Culiseta*, and finally *Coquillettidia* (Table 12).

**Table 12 Number of Adult Mosquitoes per Trap, 2011**

Trap Location (Name)	<i>Culex spp.</i>		<i>Ae./Oc. spp.</i>		<i>Coquillettidia spp.</i>		<i>Culiseta spp.</i>		Total of All Trapnights	Average Total per Trapnight
	#	% RA <sup>2</sup>	#	% RA	#	% RA	#	% RA		
Sombrero Marsh (H2)	154	8.2%	1,686	89.6%	0	0.0%	41	2.2%	1,881	86
Stazio Ballfields (C11)	142	9.3%	1,377	90.2%	2	0.1%	5	0.3%	1,526	69
Thorne Institute (C12)	195	9.5%	1,850	89.8%	0	0.0%	16	0.8%	2,061	94
East Community Center (C13)	120	5.9%	1,889	93.3%	1	0.0%	15	0.7%	2,025	92
<b>Total of All Traps</b>	<b>611</b>	<b>8.2%</b>	<b>6,802</b>	<b>90.8%</b>	<b>3</b>	<b>0.04%</b>	<b>77</b>	<b>1.0%</b>	<b>7,493</b>	<b>341</b>
Average	153		1,701		1		19		1,873	85

Notes: 1: Season was April 28 to September 20 for a total of 88 trapnights. 2: % RA = Percent Relative Abundance

The season-long average numbers of mosquitoes for each of the nuisance program area traps are presented to help evaluate the success of the nuisance program's nuisance-larval control (Table 13). Each of the traps with 2006 data had lower total mosquito averages during the years of the nuisance program than their 2006 averages. Every trap except one (Boulder County Mosquito District's trap BC-01), also had counts lower than its nuisance program average during the 2011 season. Overall, there was an average of 96 adult mosquitoes per trap per night in 2011, which is considerably lower than the 128 per trap per night average of the 2007-2010 seasons and 258 per trap per night average in 2006.

**Table 13 Average Numbers of Mosquitoes of the Nuisance Program Area Traps, 2006-2011**

Trap Location (Name)	Season-Long Avg. # of Mosquitoes per Trapnight			
	2006 (Pre-Nuisance) <sup>1</sup>	2007-2010 Nuisance Program Average <sup>2</sup>	2007-2010 Nuisance Program Range <sup>2</sup>	2011 Nuisance Program <sup>2</sup>
Sombrero Marsh (H2)	399	98	53 - 145	86
Sombrero Marsh (BC-32) <sup>3</sup>	360	141	82 - 204	87
Stazio Ballfields (C11)	143	136	111 - 184	69
Thorne Insitute (C12)	N/A	112	32 - 240	94
East Community Center (C13)	N/A	153	57 - 350	92
Old Tale/ Gapter Rd. (BC-01) <sup>3</sup>	131	125	46 - 314	146
<b>Total</b>	<b>1,033</b>	<b>766</b>	<b>---</b>	<b>574</b>
<b>Average</b>	<b>258</b>	<b>128</b>	<b>---</b>	<b>96</b>

Notes:

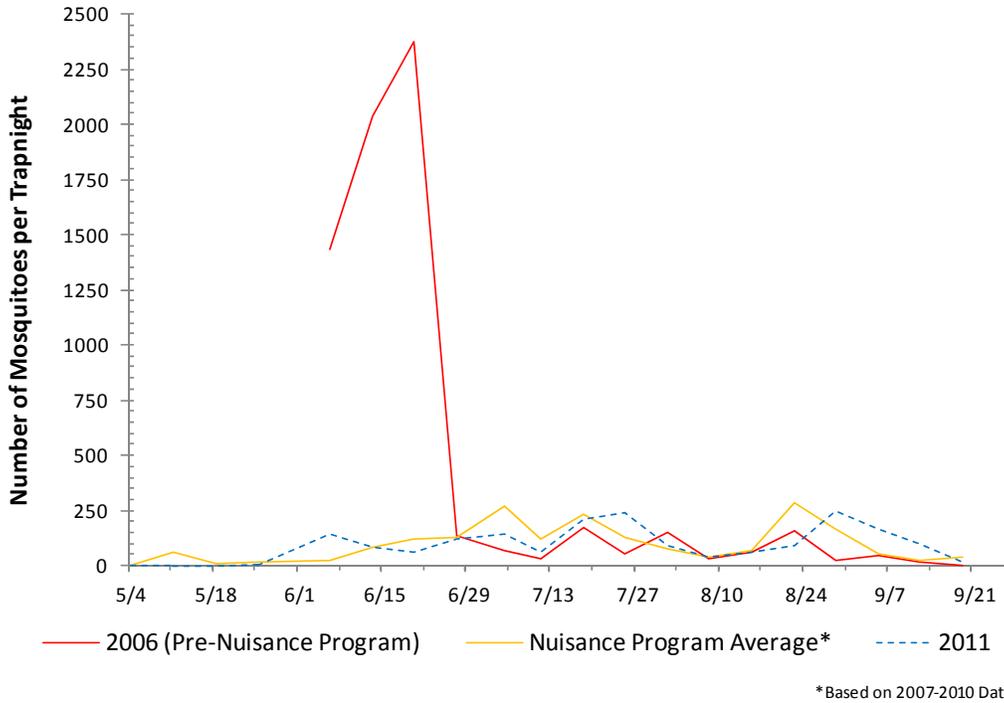
1: Pre-nuisance is without any larval nuisance-only control. 2: Nuisance program is with larval nuisance-only control in many of the breeding habitats near the adult traps. 3: Boulder County Mosquito Control District traps

To help show the possible effects of nuisance mosquito control within the nuisance program area throughout the season, season-wide weekly trap counts of the six associated traps are presented in Figures 6 through 11. All but the two new nuisance program traps (C12 and C13) have 2006 (pre-nuisance program) trap data included.

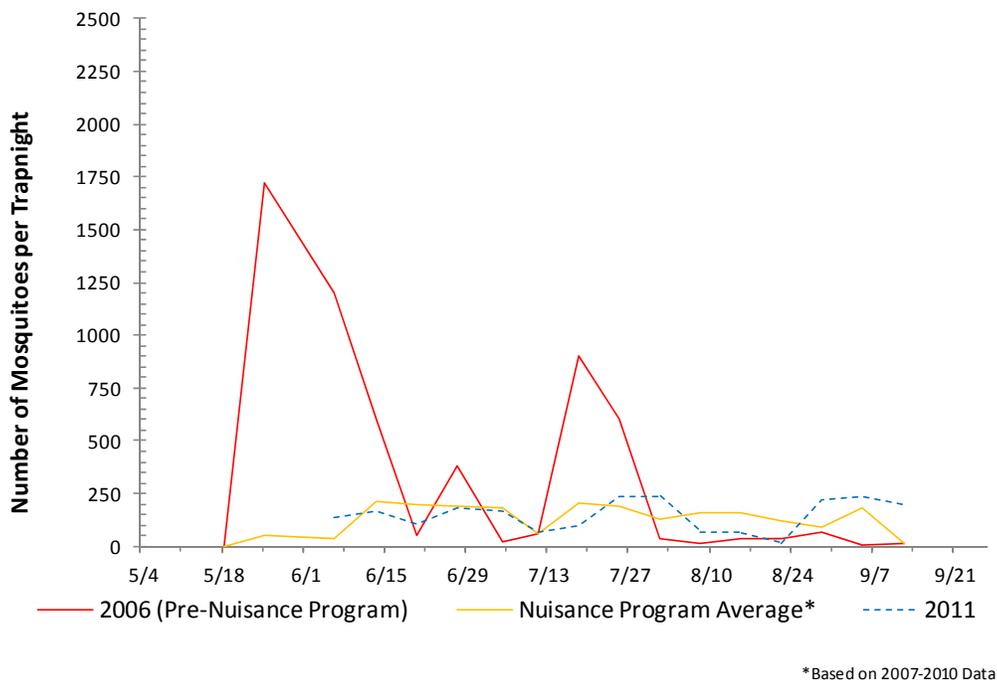
The traps in operation during 2006 (Figures 6 through 9) were examined to find any potential mosquito population trends that differed from before and after the implementation of the nuisance program's mosquito control. Each trap had high mosquito counts with significant population peaks during portions of the 2006 season

when there was no nuisance control. Although each trap had varying counts compared to 2006, trap results suggest that the nuisance-controlled seasons of 2007-2011 had lower averages and weekly population peaks during the full seasons of each year of the nuisance program.

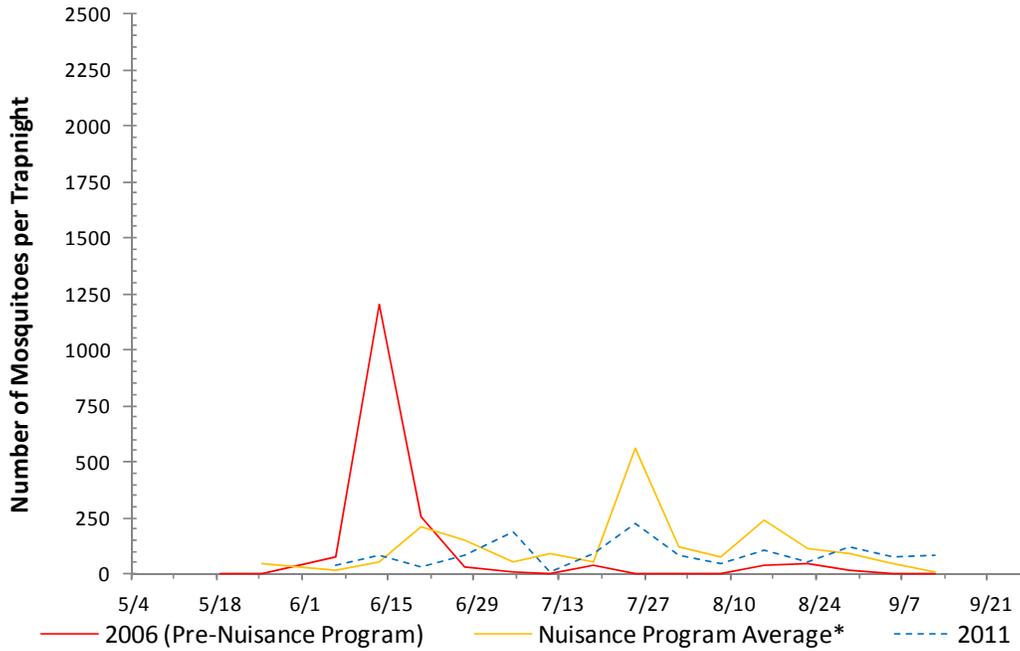
**Figure 6 Weekly Adult Trap Counts at Sombrero Marsh (Trap H2), 2011 and Historical Average**



**Figure 7 Weekly Adult Trap Counts at Sombrero Marsh (Trap BC-32), 2011 and Historical Average**

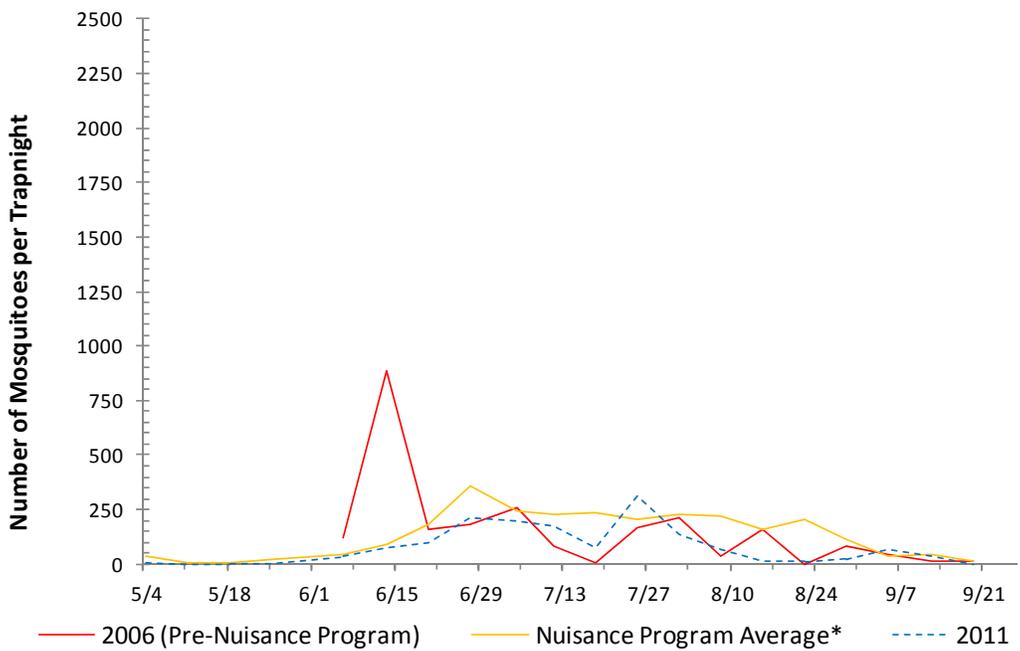


**Figure 8 Weekly Adult Trap Counts at Gapter Rd/Old Tale (Trap BC-01), 2011 and Historical Average**



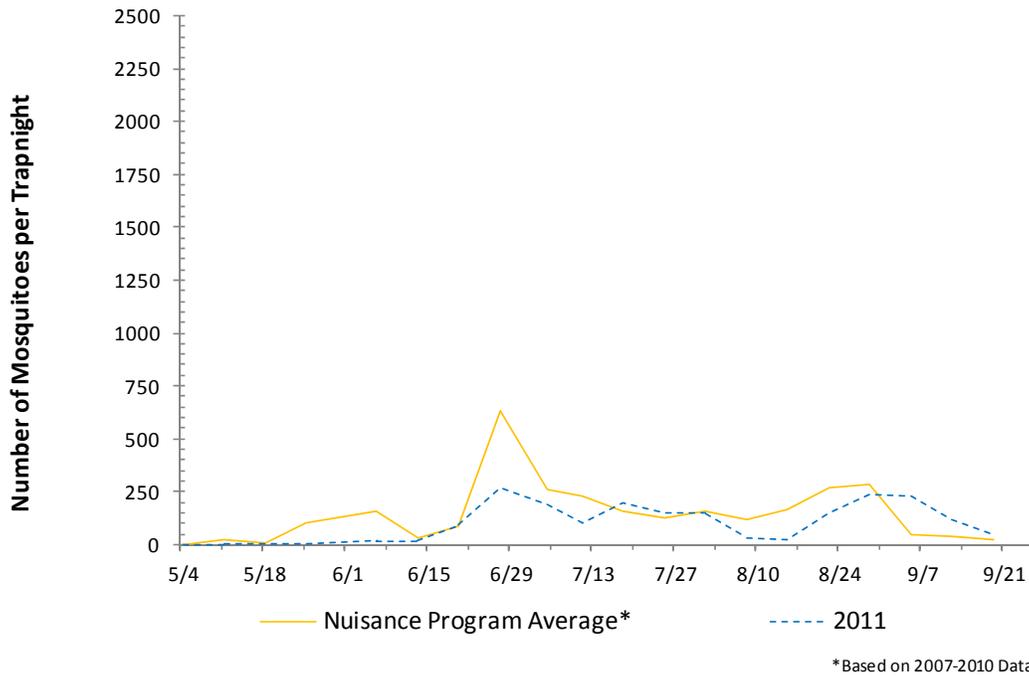
\*Based on 2007-2010 Data

**Figure 9 Weekly Adult Trap Counts at Stazio Ballfields (Trap C11), 2011 and Historical Average**

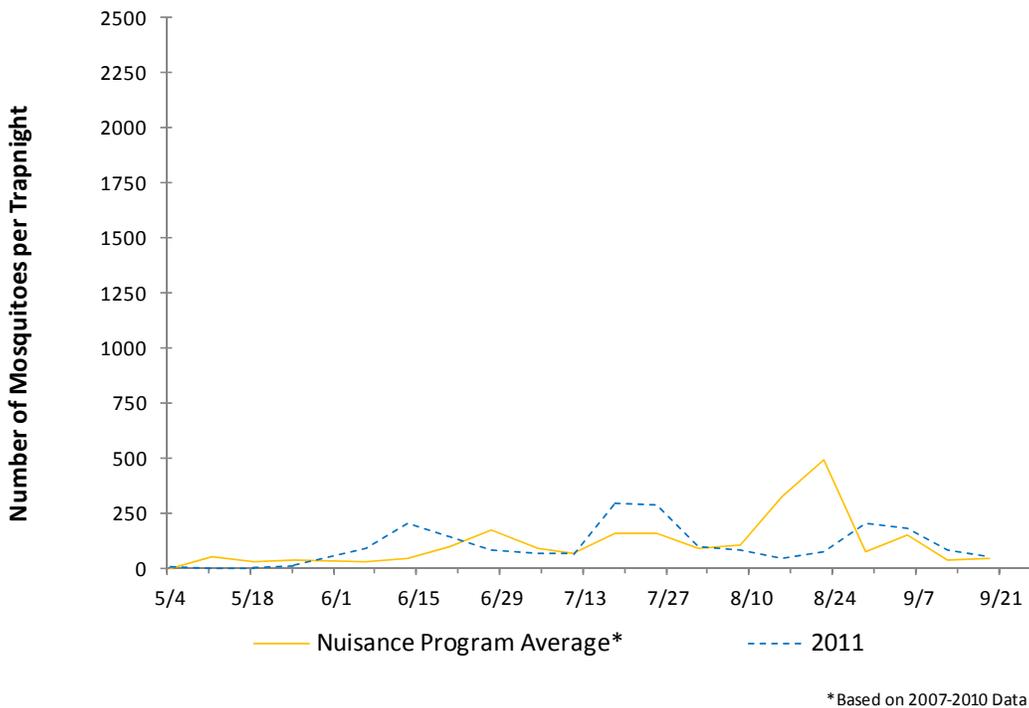


\*Based on 2007-2010 Data

**Figure 10 Weekly Adult Trap Counts at EBCC (Trap C13), 2011 and Historical Average**



**Figure 11 Weekly Adult Trap Counts at Thorne Institute (Trap C12), 2011 and Historical Average**



## 2.4 EVALUATION OF THE EFFECTS OF THE NUISANCE PROGRAM ON COMPLAINT NUMBERS

The high number of complaints from the City-owned revenue generating areas was one of the primary reasons for the establishment of the nuisance program. These complaints substantially decreased since the 2007 implementation of the nuisance program. Although numbers weren't formally tracked before the 2007 season, City P&R staff reported that there was a substantial decrease in complaints. City staff estimated that the number of complaints went from an estimate of hundreds of complaints during the summer of 2006 to approximately one to two dozen during each of the 2007-2011 seasons. In 2006 (before the nuisance program), The Flatirons Golf Course received over 50 written complaints and staff reported receiving dozens of verbal complaints on a daily basis during May and June. Flatirons staff reported no written complaints and minimal verbal complaints during the 2007-2011 seasons. There was a brief period of increased complaints in the 2011 season during the period of high nuisance mosquito populations that were reported across the region, but they did not reach the numbers reported in 2006. Parks staff reported a similar decrease in complaints reported at the Stazio ballfields.

## 2.5 EVALUATION OF THE EFFECTS OF THE EXPANDED NUISANCE PROGRAM SITES ON THE GREENBELT MEADOWS AND SAN LAZARO NEIGHBORHOODS

Over the course of the 2007 and 2008 seasons, two areas near the nuisance program reportedly experienced excessive nuisance mosquito related problems. The two areas were the Greenbelt Meadows and San Lazaro neighborhoods. These neighborhoods are located near the nuisance program area, but dozens of habitat sites that are located within a mile radius of them were not included in the first two years of the nuisance program, and therefore, could not be treated for nuisance-only species. As discussed in more detail in the *Nuisance Mosquito Control Pilot Program Report* (OtterTail 2009), uncontrolled nuisance mosquito populations from these nearby habitats likely increased the adult populations and consequently, the residential complaints of nuisance mosquitoes in each neighborhood.

Due to mosquito activity complaints from residents within the Greenbelt Meadows and San Lazaro neighborhoods, the City expanded the nuisance program during the 2009 season and again in the 2011 season to include 64 additional nuisance program sites located near these neighborhoods.

### 2.5.1 Greenbelt Meadows Neighborhood

OtterTail analyzed the site data from the 2007 and 2008 seasons of larval habitat sites within a mile radius of Greenbelt Meadows that were not included in the first two years of the nuisance program. The detailed results of the analysis can be found in the *Nuisance Mosquito Control Pilot Program Report* (OtterTail 2009). In summary, the analysis suggested that if these habitat sites were added to the nuisance program, mosquito populations affecting the Greenbelt Meadows neighborhood could potentially be lowered. In response to the number of residential complaints of high mosquito activity and based on the data from the nuisance mosquito control report, the City expanded the nuisance program in 2009 and again in 2011 to include a total of 59 additional habitat sites near Greenbelt Meadows.

As shown in **Table 14**, during 2011 season, a total of 81 individual larval site treatments were performed on 31 of the 64 potential breeding sites, treating approximately 36 acres of active breeding habitat. Of these, 24 treatments were performed for nuisance-only mosquitoes. Therefore, the Greenbelt Meadows sites added to the nuisance program increased the number of site treatments by 30%, which increased the amount of acreage treated by approximately 9 acres (25%) and the amount of *Bti* applied by 45 pounds (25%).

**Table 14 Comparison of Larval Surveillance and Control Activities at Greenbelt Meadows Nuisance Program Sites vs. What Would Have Been Performed With the Standard Vector Program, 2011 and Historical Averages**

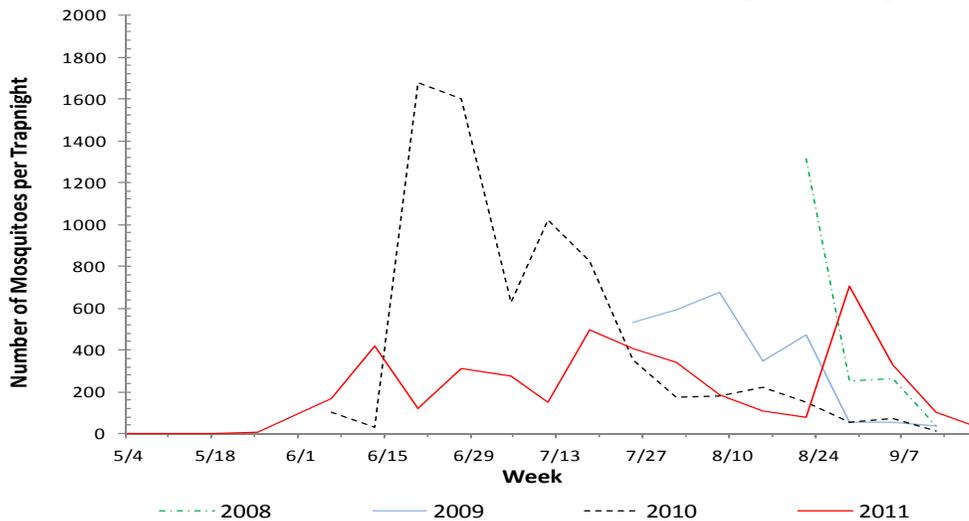
Year	Expanded Nuisance Program <sup>1</sup>	Standard Vector Program (Culex) <sup>2</sup>	Increase due to the Expanded Nuisance Program Sites <sup>3</sup>	
			Number	Percent
<b>2011</b>				
Number of Site Treatments	81	57	24	30%
Number of Site Locations Treated	31	31	0	0%
Total Treated Acreage	36	27	9	25%
Pounds of <i>Bti</i> Used <sup>4</sup>	180	136	45	25%
Estimated Number of Larvae Controlled <sup>5</sup>	76,082,656	52,839,042	14,152,765	19%
<b>Historical Average<sup>6</sup></b>				
Number of Site Treatments	41	31	10	24%
Number of Site Locations Treated	16	14	2	13%
Total Treated Acreage	17	14	4	18%
Pounds of <i>Bti</i> Used <sup>4</sup>	85	68	18	20%
Estimated Number of Larvae Controlled <sup>5</sup>	64,745,181	49,061,441	15,683,740	24%

Notes:

- 1: Results from the 59 sites being added to the nuisance program during the 2009 and 2011 seasons, allowing larval control for nuisance-only mosquitoes at these 59 sites.
- 2: Results if the standard vector program had been done instead of the expanded nuisance program.
- 3: Difference between nuisance program and what would have occurred had the standard vector program been implemented instead.
- 4: Amount of *Bti* used when applied at the typical 5 lbs. per acre application rate.
- 5: Estimated larval populations were calculated by multiplying # per dip by 10 (each dip is approx. 1/10 of a sq. ft) by the sq. ft. of breeding potential number of mosquitoes (including males and females) that would be produced with no mortality.
- 6: Historical average based on 2009 Nuisance Program expansion (8 of the 2011 season's 59 sites were added).

The City also had OtterTail continue to set an additional adult mosquito trap in the Greenbelt Meadows neighborhood during 2011 mosquito season in an attempt to evaluate the neighborhood mosquito populations. As shown in **Figure 12**, the additional trap captured varying numbers of nuisance mosquitoes throughout the 2011 season. Although the trap had several weeks with high counts, the population peaks remained lower than those seen in the 2008 and 2010 season.

**Figure 12 Weekly Adult Trap Counts at Greenbelt Meadows Temporary Trap, 2008-2011\***



\*Temporary trap was set for differing time periods during each season; results are shown for available data for each season.

## 2.5.2 San Lazaro Neighborhood

OtterTail analyzed the site data from the 2007 and 2008 seasons of larval habitat sites within a mile radius of San Lazaro which were not included in the nuisance program. The detailed results of the analysis can be found in the *Nuisance Mosquito Control Pilot Program Report* (OtterTail 2009). In summary, the analysis suggested that if these habitat sites were added to the nuisance program, mosquito populations affecting the San Lazaro neighborhood could potentially be lowered. In response to the number of residential complaints of high mosquito activity and based on the data from the nuisance mosquito control report, the City expanded the nuisance program to include 5 additional sites near San Lazaro in 2009 and then expanded the program again to provide more intense site monitoring on an additional 25 sites within the area in 2011.

As shown in **Table 15**, during the 2011 season, a total of 7 individual larval site treatments were performed on 2 of the potential breeding sites, treating approximately 5.3 acres of active breeding habitat. Of these, no treatments were performed for nuisance-only mosquitoes on sites that were added to the nuisance program.

**Table 15 Comparison of Larval Surveillance and Control Activities at San Lazaro Nuisance Program Sites vs. What Would Have Been Performed With the Standard Vector Program, 2011 and Historical Averages**

Year	Expanded Nuisance Program Sites (5 Sites) <sup>1</sup>	Standard Vector Program (Culex) <sup>2</sup>	Increase due to the Expanded Nuisance Program <sup>3</sup>	
			Number	Percent
<b>2011</b>				
Number of Site Treatments	7	7	0	0%
Number of Site Locations Treated	2	2	0	0%
Total Treated Acreage	5.3	5.3	0.0	0%
Pounds of <i>Bti</i> Used <sup>4</sup>	27	27	0.0	0%
Estimated Number of Larvae Controlled <sup>5</sup>	13,744,131	13,744,131	0	0%
<b>Historical Average<sup>6</sup></b>				
Number of Site Treatments	22	17	5	23%
Number of Site Locations Treated	7	5	2	29%
Total Treated Acreage	7.1	3.8	3.3	47%
Pounds of <i>Bti</i> Used <sup>4</sup>	35	19	16.5	47%
Estimated Number of Larvae Controlled <sup>5</sup>	56,291,356	24,295,401	31,995,955	57%

Notes:

- 1: Results from the 5 sites added during the 2009 season, allowing larval control for nuisance-only mosquitoes at these 5 sites.
- 2: Results if the standard vector program had been done instead of the expanded nuisance program.
- 3: Difference between nuisance program and what would have occurred had the standard vector program been implemented instead.
- 4: Amount of *Bti* used when applied at the typical 5 lbs. per acre application rate.
- 5: Estimated larval populations were calculated by multiplying # per dip by 10 (each dip is approx. 1/10 of a sq. ft) by the sq. ft. of breeding potential number of mosquitoes (including males and females) that would be produced with no mortality.
- 6: Historical average based on nuisance program expansion (5 sites added).

## 2.6 EVALUATION OF THE EFFECT OF INCREASING THE SPRAY THRESHOLD ON ADULT SPRAYING FREQUENCY

One of the goals for doing larval nuisance control in the nuisance program area was to reduce the potential for pesticides to drift onto City property from the County’s adult ULV adulticide applications. As part of the negotiations which enabled the approval of the nuisance program, the Boulder County commissioners and BCPH agreed to raise the thresholds that trigger an adult spray event surrounding the nuisance program from the historical threshold of 100 mosquitoes per trap night to 250.

Three County traps that were in or near the nuisance program were assigned a higher threshold (**Map A-4**). The data from traps BC-01 and BC-32 were used in combination by BCPH to aid in the weekly decision whether or not to spray the Gapter Road/Baseline Heights neighborhood of Boulder. If either trap were above the threshold during a given week, then areas of the neighborhood would be sprayed. The data from trap BC-34 were used by BCPH to aid in the weekly decision to spray the San Lazaro Mobile Home Park neighborhood of Boulder.

**Table 16 Comparison of the Number of County ULV Spray Applications Using the Nuisance Program’s 250 Threshold vs. the Previous Pre-Nuisance Threshold of 100, 2011 and Historical Data**

Year	250 Threshold (Nuisance Program) <sup>1</sup>	100 Threshold (Previous) <sup>2</sup>	Decrease Due to Increase to 250 Threshold			
			Spray Events	Linear Miles Sprayed <sup>3</sup>	Pesticide Gallons <sup>4</sup>	Percentage
<b>2011</b>					0.0	
Baseline Heights Area Traps (BC-01 and BC-32)	0	10	10	127.6	9.4	100%
San Lazaro Area Trap (BC-34)	6	12	6	9.6	0.7	50%
Areas Combined	6	22	16	137.2	10.1	73%
<b>Historical Average<sup>5</sup></b>					0.0	
Baseline Heights Area Traps (BC-01 and BC-32)	3	9	5	67.0	4.9	62%
San Lazaro Area Trap (BC-34)	6	12	6	9.6	0.7	51%
Areas Combined	9	20	11	52.7	3.9	56%

Notes:

- 1: The number of spray events occurring if spraying occurred each time the 250 mosquitoes per trap per trap night threshold was reached due to the nuisance program threshold
- 2: The number of spray events occurring if spraying occurred each time the 100 mosquitoes per trap per trap night threshold was reached without the nuisance program threshold
- 3: Calculated by multiplying the number of spray events not conducted by the average route distance; average route distance was calculated from 2007-2010 BCPH spray events data
- 4: Pesticide gallons were estimated using a typical application rate of 2.35 ounces per minute applied at 15 MPH for an undiluted adulticide
- 5: Historical average based on 2007 - 2010 data.

Based on the trap results, the County sprayed these areas 6 times during the 2011 season compared to the 22 times that they would have sprayed without the nuisance program threshold (see **Table 16**). This represents an average reduction of approximately 73% less adulticide spraying during the 2011 season. The average amount of linear miles sprayed and the amount of pesticides used also decreased by approximately 73%, with estimated amounts shown in **Table 16**. Although the majority of these spray events were likely avoided simply due to the increased threshold, it can be assumed that *Bti* treatments for nearby nuisance larvae potentially helped reduce the area adult populations and the corresponding trap counts (as discussed in **Section 2.3**).

## 2.7 EVALUATION OF POTENTIAL LONG-TERM IMPACTS OF BTI TREATMENTS ON BIOTA

As part of the nuisance program, the City wanted to perform studies to find the potential long term impacts of treating area wetlands with *Bti* for mosquito control. In 2007, the working group developed a plan to conduct a macroinvertebrate biodiversity study of all the wetland breeding habitats within the City’s WNV program. This would consist of a taxa gathering effort at 3 different times of the year to determine the diversity value of each habitat to assess what the true impact is on habitats being treated with *Bti*. However, after receiving cost estimates, the studies were deemed to be cost prohibitive during the 2007 - 2008 seasons.

As part of the nuisance program extension, the City agreed to appropriate funds to perform studies on the populations of invertebrates, amphibians, and birds occurring in local wetlands during 2009 - 2010 seasons. The studies were designed to use paired habitat sites with similar habitat characteristics. Each pair of sites consisted of one site that was within the nuisance program area (nuisance-only *Bti* treatments allowed) and one site that was in the WNV program (nuisance-only *Bti* treatments not allowed). This would allow for a comparison of possible affects the extra *Bti* treatments for nuisance only mosquitoes had on the nuisance program sites. A total of 5 habitat site pairs, or 10 habitats sites, were used in the studies.

Detailed results of the studies can be found in the *Red-winged Blackbird Survey for the Nuisance Mosquito Control Pilot Program - 2010*, (Andrews, Bob 2010), *Report: 2010, City of Boulder, Colorado Invertebrate Survey of Bti- Treated Wetlands* (Durfee, R.S. and B.C. Kondratieff 2010), and *Amphibian Surveys on City of Boulder Bti-Treated Wetlands* (Herasimtschuk, David A. and Johnson, Pieter T. J. 2010).

### **3.0 REFERENCES**

Andrews, Bob. 2010. "Red-winged Blackbird Survey for the Nuisance Mosquito Control Pilot Program - 2010". Boulder, Colorado. December 2010.

CDC 2011. Centers for Disease Control and Prevention (CDC). West Nile Virus, 2011. Centers for Disease Control and Prevention, Atlanta, Georgia. [Web page]. Accessed December 28, 2011. Located at <http://www.cdc.gov/ncidod/dvbid/westnile/index.htm>.

CDPHE 2011. Colorado Department of Public Health and the Environment (CDPHE). West Nile Virus, 2011. [Web page]. Accessed December 28, 2011. Located at <http://www.cdphe.state.co.us/dc/zoonosis/wnv/wnvhom.html>.

Durfee, R.S. and B.C. Kondratieff. 2010. "Report: 2010, City of Boulder, Colorado Invertebrate Survey of Bti- Treated Wetlands". Boulder, Colorado, December 2010.

Herasimtschuk, David A. and Johnson, Pieter T. J. 2010. "Amphibian Surveys on City of Boulder Bti-Treated Wetlands". Boulder, Colorado, December 2010.

NOAA 2011. National Oceanic Atmospheric Administration (NOAA). [Web page]. Accessed October 14, 2011. Located at <http://www.esrl.noaa.gov/psd/boulder/index.html#climo>

Ottertail. 2009. "Nuisance Mosquito Control Pilot Program Report." OtterTail Environmental, Inc. Colorado, January 2009.

Ottertail. 2010. "Nuisance Mosquito Control Pilot Program Report." OtterTail Environmental, Inc. Colorado, January 2010.

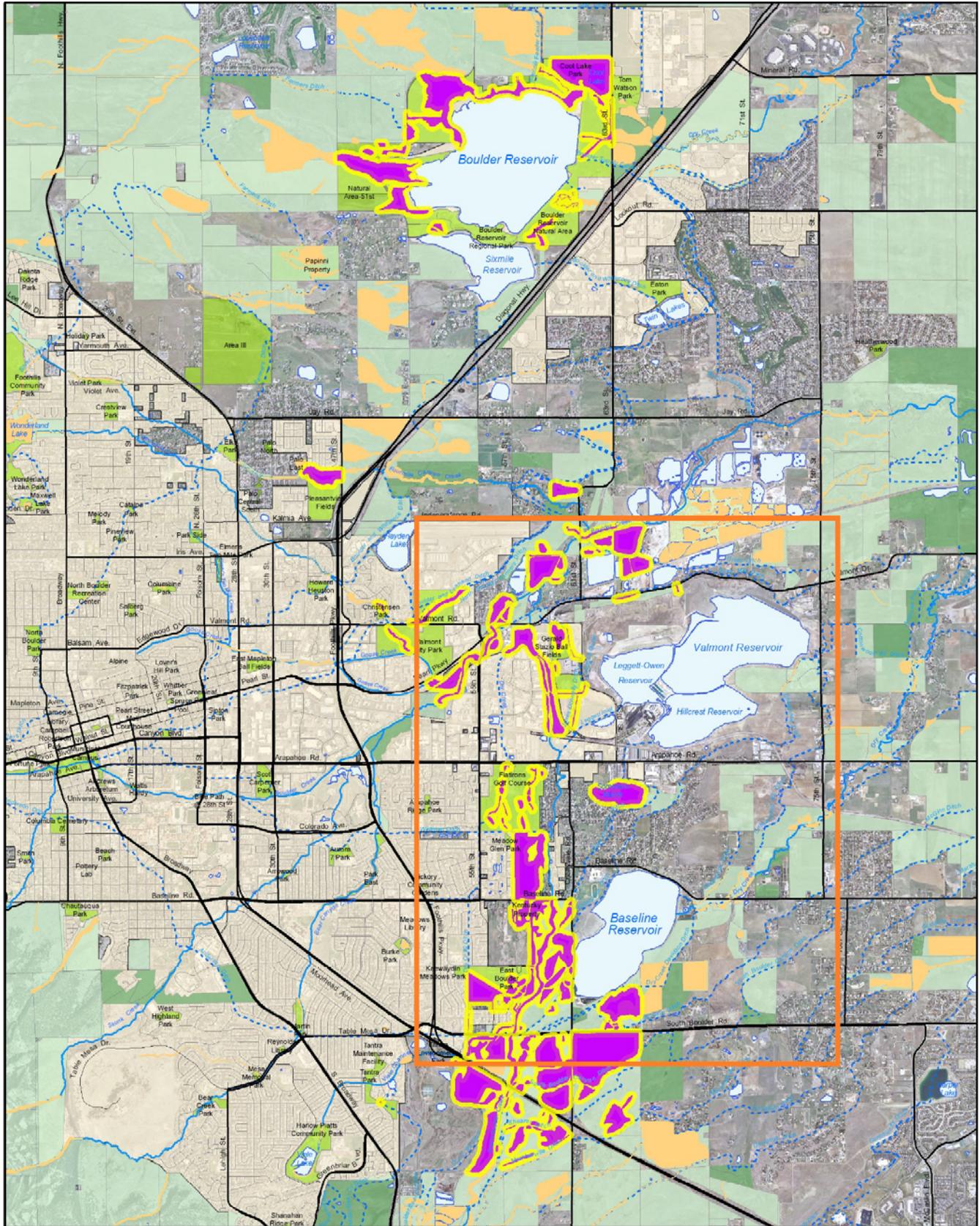
USCB 2010. United States Census Bureau. [Web Page]. Accessed September 29, 2010. Located at <http://quickfacts.census.gov>.



## Appendix A: Maps



# Map A-3: Nuisance Program Larval Site Locations

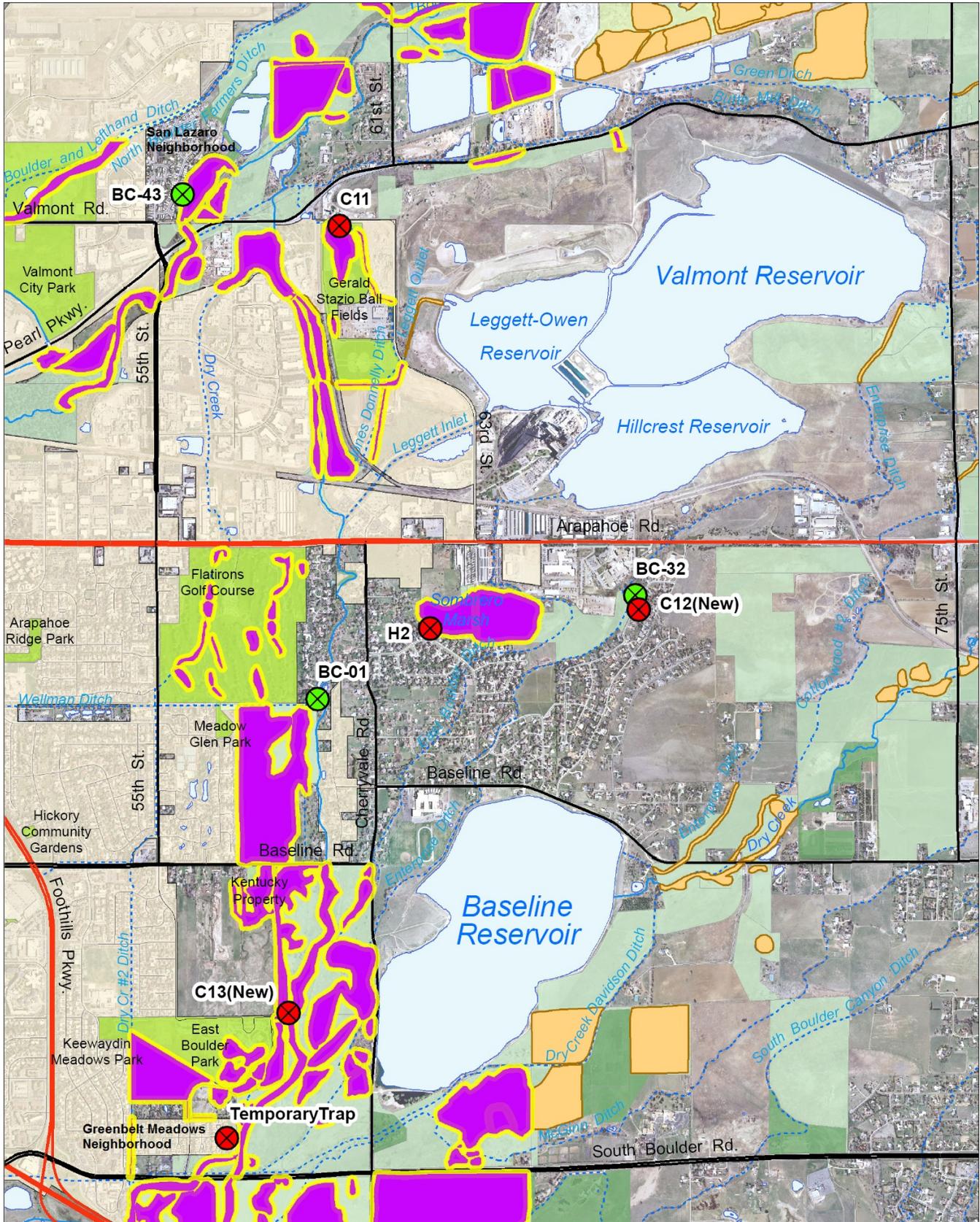


- |  |  |             |
|--|--|-------------|
| Nuisance Mosquito Program Larval Sites | Open Space and Mountain Parks Property | Urban Parks |
| WNV Program Larval Sites               | Conservation Easement                  | City Limits |
| Map A-4 Inset Area                     | Fee Property                           |             |
|  | Miscellaneous Easement                 |             |

0 1 Miles

Aerial Photography: Spring, 2010

# Map A-4: Nuisance Program Adult Trap Locations



- |   |   |   |
|---|---|---|
| Nuisance Mosquito Program Adult Traps   | Open Space and Mountain Parks Property  | Urban Parks   |
| <ul style="list-style-type: none"> <li><span style="color: green;">X</span> County Traps</li> <li><span style="color: red;">X</span> City Traps</li> </ul>  | <ul style="list-style-type: none"> <li><span style="background-color: #90EE90; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> Conservation Easement</li> <li><span style="background-color: #90EE90; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> Fee Property</li> <li><span style="background-color: #90EE90; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> Miscellaneous Easement</li> </ul> | <ul style="list-style-type: none"> <li><span style="background-color: #90EE90; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> City Limits</li> </ul> |
| <ul style="list-style-type: none"> <li><span style="background-color: purple; border: 1px solid yellow; display: inline-block; width: 15px; height: 10px;"></span> Nuisance Mosquito Program Larval Sites</li> <li><span style="background-color: orange; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> WNV Program Larval Sites</li> </ul> |   |   |

0 0.25 0.5 0.75 Miles

