Final Report
San Diego County Eye Gnat Research and Education Project 2011
Escondido

Biology and Control of the Eye Gnat
Liohippelates collusor

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RESEARCH PROJECT GOALS 2011- ESCONDIDO

- Determine the sources of the populations of eye gnats affecting the residents in Escondido
- Continue laboratory/greenhouse trials on the biology and control of eye gnats
- Initiate mass trapping in affected areas to determine if there is a consequential reduction in the eye gnat populations in the community
- Education by providing pertinent publications and information
- Provide additional services as needed on eye gnat related issues

BACKGROUND

Eye gnats are prevalent in the Southern United States, primarily in parts of California and Arizona. In San Diego County, especially in the Jacumba and Escondido areas, they have been a problem for many years and are the source of numerous citizen complaints to Departments of Environmental Health - Vector Control, and Agriculture Weights and Measures. Research has determined that local agriculture is the source of the problem, and the community residents are looking to the County for a solution. Eye gnats are problems in other agricultural areas in Southern California and have been extensively studied for more than a century. These nuisance problems have been successfully addressed by identifying the source, altering land management practices, implementing integrated pest management (IPM), and conducting a sound public outreach and education program.

Benefit to the County

In utilizing our technical and expert resources with UCCE, we can more efficiently offer the County's residents easier access to current and applicable information and educational opportunities to understand and manage the eye gnat problem. Increased awareness of this problem, its causes and possible solutions will assist county departments in dealing with citizen complaints.

Introduction

The eye gnat (*Liohippelates* and *Hippelates* spp.) has been a nuisance pest since the turn of the 20th century. *Liohippelates collusor* (Townsend), formerly known as *Hippelates collusor* in the scientific literature is the primary species in southern California and was implicated in an epidemic of bacterial conjunctivitis (pinkeye) in the Coachella Valley California and in the southern U.S. (Anonymous 1929, Buehler et al. 1983). There is no scientific evidence, however, to substantiate the inference. Eye gnats created problems in other cultivated areas, however, such as the Imperial and San Joaquin valleys of California. In addition, they are present in many desert areas of California, such as the Mojave Desert, and could create problems if and when such areas are intensively cultivated and irrigated.

Problems are heightened when irrigated agriculture is in close proximity to urban areas. Research has shown that irrigated agriculture provides good reproductive potential for eye gnat production (Mulla 1963). However, female gnats need a protein food source (mucus, blood, scabs, etc.) in order to produce their young and that protein source is largely unavailable in agriculture. Therefore, since eye gnats can disperse approximately 4 miles both upwind and downwind, humans and domesticated animals living in close proximity to eye gnat producing areas can become a food source.

EXECUTIVE SUMMARY

Introduction

A significant amount of research was conducted on the Be Wise Ranch property during 2011. Therefore some of our resources were diverted to that effort, but the benefits to the county and the residents will be evident in future research results.

A verbal confidentiality agreement with the owner of the Be Wise Ranch requires that data collected on that Ranch not be included in this report. The omission of those data has not affected the conclusions and recommendations in this report because emergence trapping and adult collar trapping in the surrounding area have implicated the farm as an eye gnat source in previous studies and in this report. Additionally, historical research has clearly demonstrated that irrigated agriculture using tilling is a significant source of eye gnats.

Additional research will be conducted at Be Wise Ranch in 2012 with the intention of having a negative impact on eye gnat production for the 2012 eye gnat season.

STUDIES ON THE IMPROVEMENT OF TRAP DESIGN

- Painting the interior and exterior of the collar traps flat black showed a significant increase in attracting gnats.

POTENTIAL EFFECTS OF DIFFERENT SOILBORNE FOOD SOURCES AND DEPTH ON EYE GNAT POPULATION DYNAMICS

- Composted steer manure does not provide a food source for larvae in the soil. Eye gnat larvae were able to travel up to one foot in sterile media to reach food and develop into adults.

EFFICACY OF DIFFERENT ORGANIC INSECTICIDES AND TIMING AGAINST EYE GNAT LARVAE

- Azadirachtin, Spinosad and Ecotec EC showed activity as a larvacide applied in the soil but at very high rates. The earlier the products are applied after egg deposition, the more effective treatments.

USE OF MASS TRAPPING AS AN EFFECTIVE MEANS OF REDUCING ADULT EYE GNAT MIGRATION IN ESCONDIDO

- There are statistically greater numbers of eye gnats captured in traps in close proximity to the farm, but with the present high levels of eye gnats and under the conditions of our study, we were unable to identify a significant decrease on the opposite side of a densely laid line of collar traps. Further study is needed, and the results are discussed.

ADULT EYE GNAT POPULATION DENSITY STUDY IN ESCONDIDO

- A baseline for eye gnat numbers was determined using an area wide grid sampling method. Eye gnat trap catches closely follow patterns seen in Jacumba, large numbers close to the farm and dwindling numbers further away.

EXTENSION ACTIVITY

- Meetings were attended and data shared to community leaders, the farm, and the county. Information was made available on the Internet.

Recommendations for the Eye Gnat Nuisance Prevention Plan for Be Wise Ranch in Escondido 2012 Based on Research Conducted During 2011

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The key to reducing huge eye gnat populations to background levels is finding the source and implementing all possible eye gnat abatement methods. The following recommendations are based on the current knowledge of the situation and the research conducted in Escondido in 2011 and in Jacumba during 2008-2010.

Preliminary Results 2011

- The results from one of our studies provide some indication that a line of traps can reduce eye gnat numbers migrating from the farm as they move into the community. This study needs repeating but coupled with the fact that this is one of the management tools used by the Coachella Valley Vector Control District, this method seems a way to, in part, reduce eye gnat populations reaching the community. Laboratory research this last year indicated that adult eye gnats could be killed by organic pesticides in glass vial trials. Glass vials are coated with diluted insecticides and the insects are exposed to the pesticides in the vials for 24 to 48-hours. Glass vial trials are typically used to detect insecticide resistance in insect populations. Although these results are conducted in the laboratory and manipulative, there is a good possibility that the use of organic pesticides, in part, will reduce eye gnat populations. Recent laboratory research has indicated that eye gnat larvae are exceptionally adept at moving through sandy soil. We have found that placing eye gnat eggs on sand surface and a food source at a depth of 24 inches, that eye gnat larvae are able to reach the food source, develop to the late instar, which can then migrate through the sand to the surface to pupate. Therefore, attempting to bury the eye gnat larvae by deep tilling or another method likely will not succeed.

Specific Recommendations for the 2012 Cropping Season in Escondido

Barriers

Barriers should still be an important part of any nuisance prevention plan, because they can reduce, in part, eye gnat populations. The current black shade cloth barrier that acts like an erosion or dust barrier is approximately 3 feet high and should be employed for the length of the farm. Since our data shows that a majority of the flies stay low to the ground on the farm due to the lack of refuge, that the barrier will still pose a hindrance to eye gnat movement between the farm and the community.

- The barrier between the farm and the community needs to be maintained for the entire length of crop production. Wherever crop production occurs, there needs to be an erosion or dust barrier of at least 36-inches in height and parallel with the border of the community.

Trapping

Removing the adult eye gnats from the population is a highly effective tactic in reducing eye gnat population numbers in Coachella Valley and in Jacumba.

- Traps need to be monitored on a weekly basis and maintained, i.e. addition of new solution, replace broken parts, etc.
- A double row of collar traps 10 feet apart and parallel with the community border should be employed. They should be 10 feet from the black erosion cloth barrier, and the second row that parallels the first should be staggered.
- In addition to the trap line, trapping should occur at a rate of 1 trap per 1000sqft in long-term vegetable production where appropriate or possible.
- To enhance the capture and removal of eye gnats from the population and provide further relief to the community, increased trapping should begin in the community.
- Since organic farming at Be Wise occurs year round, collar trapping at Be Wise Ranch should continue throughout the year.

Chemical Control

Laboratory studies conducted in small scale trials indicate that mortality to adults may occur with the use of organic pesticides. At present, applications of registered organic oils such as Ecotrol/Ecotec (rosemary oil and peppermint oil) or an application of Entrust (spinosad) should be applied every other week to production crops throughout the cropping cycle. Applications of Ecotec will reduce, in part, eye gnat adult populations. However, if further testing of other organic pesticides indicates an effective compound against one of the stages of this insect, pesticide applications against that stage may be recommended.

Cultural Control Methods

- Reduce organic matter production as much as possible. Crop residues should remain on the soil surface until they are completely dried out. They should be collected and removed from the production areas and never be tilled into the soil.
- Weed control needs to be by herbicides or by hand, not tilling.
- Research has not been conducted on the effects of composting of crop residues and eye gnat population dynamics. Therefore, until research has been conducted that answers those questions, crop residues can be properly composted.

STUDIES ON THE IMPROVEMENT OF TRAP DESIGN

Objective

A trial was designed to test whether painting collar trap either glossy black and flat black, would increase the efficiency of the traps.

Materials & Methods

Experimental Unit- Three collar trap modifications were tested. The first was the original UCCE 4-holed collar trap utilizing 1-pt mason jars. The second trap was constructed of: 1) a 6-inch section of 3-inch PVC drainage pipe capped at one end painted flat black, 2) 3-inch PVC coupler with four ¾–inch holes drilled below the center rib, 3) 4 oz. plastic champagne glass with the bottom stem cut at the bottom, 4) a 32 oz. clear, pinch grip plastic container (Figure 1 & 2). One set of the PVC couplers was painted flat black and the other gloss black.

Experimental Design- Five areas were selected at The Vineyard Golf Course. In each area, one trap design of each trap type was taped to a three-foot wooden stake placed approximately 5 feet from each other. Thus, each design was replicated 5 times. The duct tape used to hold the trap on the stake was spray-painted flat black. Putrefied egg was used as bait.

Treatments- 1) UCCE 4 hole glass mason jar collar trap, 2) PVC collar trap with collar painted glossy black, 3) PVC collar trap with collar painted flat black.

Sampling- Collar tops were collected weekly from April 26- May 25, 2011. Tops were placed in the freezer overnight to kill any remaining live gnats. The following morning, the contents were emptied, sorted, counted and recorded.

Insect Source- Gnats caught in each trap type were naturally present at that location.

Table 1. Mean (± SE) adult eye gnat/trap captured collar traps with either flat black, gloss black or clear/glass bait containers.

Mean no. (N=5) of eye gnats/trap/day			**Analysis of Variance**[1]		
Flat	**Glossy**	**4-hole mason jar**	**df**	**F value**	**Prob.**
161.0 ± 36.1a	95.9 ± 23.0b	23.2 ± 6.3c	2,6	41.6	0.0003

[1] Data were log transformed prior to analysis of variance. Numbers followed by different letters are significantly different (p=0.05).

Results

Collar trap "glossiness" had a significant effect on the number of eye gnats captured (Table 1). There is a clear indication that the flat black color on trap parts increases trap catch approximately 85% over clear glass bait containers. Even with the same trap painted gloss black verses flat black, the flat black trap caught 40% more. It appears to be a major factor in determining the effectiveness of a collar trap.

POTENTIAL EFFECTS OF DIFFERENT FOOD SOURCES AND DEPTH ON EYE GNAT POPULATION DYNAMICS

Objective

This trial had two objectives. The first was to determine if the composted steer manure used by the farm was a food source. The second was to see if burying a food source (finely ground, rabbit pellets) deep under the surface of the soil would reduce the number of developing gnats.

Materials & Methods

Food Source

Experimental Unit- The trial was conducted using glass 1-pint mason jars (Figure 3). Each jar was filled with 450 grams of sandy soil collected from Bornt Farm, Jacumba, CA. The lettuce was collected from Bornt Farm and stored in a Ziploc bag in the freezer. The composted steer manure was taken from samples given by Be Wise Ranch.

Experimental Design- The trial utilized three jars per treatment. The trial took place between May 24- July 8, 2011.

Treatments- The products added to the sand as treatments were as follows: fresh lettuce @ 40 mls/jar, composted steer manure @ 40 mls/jar, and 20 mls of both composted steer manure and lettuce. An untreated control group was added that only contained farm soil.

Sampling- Funnels with a collection jar were added to the tops of the jars to collect the eye gnats that emerged. When all the gnats had emerged and died, the funnels were removed and the number of gnats was counted in the jars and on the soil surface.

Insect Source- Eye gnat eggs were obtained from a colony and added to the surface of the soil to simulate typical eye gnat laying behavior.

Food Depth

*Experimental Unit***-** Two foot sections of 3-inch PVC drainage pipe were filled with (Figure 4) silica sand that was devoid of any organic matter. Fifty grams of ground rabbit pellets was added at various depths as the food source. Water was added to the tubes until it was observed dripping from the bottom.

Experimental Design- The trial utilized four tubes per treatment. The trial took place from December 29, 2011- February 10, 2012.

Treatments- The trial contained four replicates where the average depth of the food was placed at 5.6, 14.0, 21.1, and 29.7 centimeters inverted below the soil surface.

Sampling- Funnels with a collection jar were added to the tops of the tubes to collect the eye gnats that emerged. When all the gnats had emerged and died, the funnels were removed and the number of gnats counted in the jars and on the soil surface. An untreated control group was added that only contained sand.

Insect Source- Eye gnat eggs were obtained from an existing colony and added to the surface of the soil to simulate typical eye gnat laying behavior.

Experimental Conditions- The jars and tubes were kept in an environmental chamber with constant temperature (25°C ± 1) and humidity (70%).

Table 2. Mean number (±SE) and percent survivorship of eye gnat adults emerging from the soil treated with selected types of food sources. N = the total number of eggs deposited into the soil of each treatment.

Food Source	N	Mean no. of emerged eye gnats	Mean Percent Survivorship[2]
Composted Steer Manure	131	0.0 ± 0.0	0.0 a
Lettuce	133	82.0 ± 18.3	61.7 b
Lettuce + Composted Steer Manure	167	102.7 ± 7.7	61.5 b
UTC Soil	125	0.0 ± 0.0	0.0 a

[2]Data were transformed arcsine √x prior to analysis. Means within a column followed by different letters are significantly different, LSD (p=0.05), ANOVA F=167.59; df=3; P<0.0001.

Table 3. Mean number (±SE) and percent survivorship of eye gnat larvae with various depths of a food source. N = the mean number of eggs deposited into the soil of each treatment.

Depth	N	Mean no. of emerged eye gnats	Mean Percent Survivorship[2]
UTC	122.3	0.0	0.0 a
5.6 cm	93.0	28.0 ± 9.0	30.0 b
14.0 cm	80.8	48.3 ± 9.9	60.0 cb
21.1 cm	91.5	43.3 ± 17.1	47.3 cb
29.7 cm	102.8	77.3 ± 15.1	75.2 c

[2]Data were transformed arcsine √x prior to analysis. Means within a column followed by different letters are significantly different, LSD (p=0.05), ANOVA F=8.37; df=4; P<0.0018.

Results

Food Source - The composted steer manure used by Be Wise Ranch does not appear to be a food source for eye gnats (Table 2). Eye gnats only developed and emerged in the presence of organic matter (lettuce debris).

Food Depth – Despite simulating the laying of eye gnat eggs on the surface of the soil, larvae were able to hatch, travel to a distance of nearly a foot in a sterile media to a food source (finely ground, rabbit pellets), develop and crawl back to the surface to pupate (Table 3). It is speculated that the higher mortality in the 2.2-inch depth is due to drying of the soil at that depth. Eye gnat larvae appear highly mobile in soil therefore; incorporating organic matter deep in the soil is not a viable solution. Pupae are also tough and appear to tolerate strenuous conditions.

EFFICACY OF DIFFERENT ORGANIC INSECTICIDES AND TIMING AGAINST EYE GNAT LARVAE

Objective

Determine the efficacy of selected organic insecticides on gnat larvae in sandy soil.

Materials & Methods

Jar Tests

Experimental Unit- The trials were conducted using glass mason jars (Figure 3). Sandy soil from Jacumba, CA was collected and transported to the Center for Applied Horticultural Research. The sand was sifted to remove as much organic matter and debris as possible. Jars were filled with 450 g soil and twenty-five grams of ground rabbit pellets. Jars were stored indoors at room temperature.

Experimental Design- There were three replicates (jars) per treatment. The amount of insecticide needed to treat the square footage of each jar was determined, mixed with 150 milliliters of water, and applied.

Treatments- See Table 4.

Insect Source- Eye gnat eggs obtained from a colony raised at the Center of Applied Horticultural Research were counted and placed into the treated jars.

Sampling- Funnels were attached to the jars that allowed the gnats to enter a container for counting. The gnats were allowed to develop to an adult and emerge. Gnats in the jars and on the soil surface were counted.

Tray Tests

Experimental Unit- Experiments were conducted in trays measuring 10” X 20” X 3”. Sandy soil from Jacumba, CA was collected and transported to the Center for Applied Horticultural Research. The sand was sifted to remove as much organic matter and debris as possible. Trays were filled with the 4500 g of soil and seventy-five grams of powdered rabbit pellets. The trays were then placed in a cage (BugDorm, supplied by

BioQuip, 2321 Gladwick Street, Rancho Dominguez, CA 90220) and placed in a greenhouse kept between 65-75°F (Figure 5). The trays were periodically watered and kept moist.

Experimental Design- Each treatment comprised of four trays. The amount of insecticide needed to treat the square footage of each tray was determined, mixed with 1500 milliliters of water, and applied.

Treatments- See Table 4.

Insect Source- Same as above.

Sampling- Following the emergence and death of all eye gnats in each cage (approximately 2 weeks), they were collected and counted. This number was compared to the number of eggs added to each tray or jar.

Timing Tests

Experimental Unit- Tests were conducted in either jars or trays as described above.

Experimental Design- Jars tests contained three replicates per treatment while the tray tests contained four replicates per treatment. Eye gnat eggs were added to all units at the same time. Chemical treatments were added at 0, 1, 2 and 3 weeks after the addition of the eggs (Table 9).

Treatments- See Table 4.

Insect Source- Same as above.

Sampling- Followed same procedure as mentioned above for either jar or tray.

Table 4. Organically Labeled Chemicals Tested as Larvacides

Trade Name	Manufacturer	Active Ingredients	Max. label rate
Ecotec EC	Brandt Consolidated	Rosemary Oil 10% Peppermint Oil 2%	4 pts/a foliar
Entrust/Naturalyte	Dow AgroSciences	Spinosad 80%	3 oz/a foliar (max 9 oz/crop)
Neemix 4.5	Certis	Azadirachtin 4.5%	2 gal/ 4.5gal/a for subsurface pests
Matratec EC (Herbicide)	Brandt Consolidated	Clove Oil 50%	10% v/v
Pyrellin EC	Webb Wright	Pyrethrins .60% Rotenone .50% Other Resins .50%	2 pints/a
Gnatrol WDG	Valent	*Bacillus thuringiensis* subsp. *israelensis* 37.4%	26 oz/100 gallons

Results

The following is a summary of fifteen different studies using both the tray and jar technique. In the following tables, proportions were calculated by dividing the number of emerged gnats by the number of eggs added ([# emerged gnats ÷ # eggs added] ÷ # gnats emerged in control). *Any number greater or equal to one had the same effect as the untreated control (Abbott's correction, 1925). The smaller the number, the more effective the application*. Rates that are followed by numbers in parenthesis indicate how many times above the maximum labeled rate was used.

Jar Tests Results

It quickly became apparent that the chemical amounts had to be several times the maximum labeled rates to have any effect. Ecotec and Matratec became effective around 4 gallons/acre, which is eight times the labeled rate (Table 5). Neemix 4.5 becomes effective around 7 gallons/a or 56 times the maximum labeled rate. Combinations of chemicals were tested at lower rates to test for synergistic effects (Table 6). Each combination of Ecotec + Matratec, Neemix 4.5 + Matratec, and Neemix 4.5 + Ecotec had efficacy at 2 gallons/acre of each product. Gnatrol and Pyrellin EC were tested at the low, mid, and high labeled rates. They did not have a significant effect on eye gnats. Entrust looked to have efficacy at 18 oz/a or six times the labeled rate (Table 7).

Table 5. Mean proportion of gnats emerging adults as calculated by Abbott's correction. Testing of individual chemicals in jars.

Rate	Ecotec proportion	Matratec proportion	Neemix 4.5 proportion
UTC	1	1	1
2 gal/a	0.548	0.586	N/A
4 gal/a	0.117	0.035	N/A
6 gal/a	0.01	0.008	0.684
7 gal/a	N/A	N/A	0.076
8 gal/a	N/A	N/A	0.028

N/A= not available, not tested

Table 6. Mean proportion of gnats emerging adults as calculated by Abbott's correction. Testing of combinations of chemicals in jars.

Rate	Eco+Mat proportion	Neem+Mat proportion	Neem+Eco proportion
UTC	1	1	1
1 gal/a each	0.435	0.566	0.622
2 gal/a each	0.197	0.168	0.063
3 gal/a each	0.044	0	0.01

Table 7. Mean proportion of gnats emerging adults as calculated by Abbott's correction. Testing of individual chemicals in jars.

Chemical	Rate	Proportion
UTC	---	1
Pyrellin EC	1.0 pints/a	1.237
	1.5 pints/a	0.975
	2.0 pints/a	1.355
Entrust	18 oz/a (6X)	0.16
	24 oz/a (8X)	0.058
	30 oz/a (10X)	0.085
Gnatrol WG	13 oz/100 gallons	1.312
	19.5 oz/100 gallons	0.663
	26 oz/100 gallons	0.784

Tray Tests Results

Many of the tray tests confirmed what was happening in the jars. Entrust showed good control of gnat starting at 18 ounces per acre or six times the labeled rate (Table 8). Neemix 4.5 requires more product to have an effect at 8 gallons/acre. Ecotec showed good control at a rate of 8.3 gallons/acre.

Table 8. Mean proportion of gnats emerging adults as calculated by Abbott's correction. Testing of individual chemicals in trays.

Chemical	Rates	Proportion
UTC	---	1
Entrust	3 oz/a (1X)	1.32
	6 oz/a	0.929
	12 oz/a	0.874
	18 oz/a	0.339
	24 oz/a (8X)	0.164
Neemix 4.5	2.0 gal/a	1.258
	4.0 gal/a	0.991
	8.0 gal/a (16X)	0.354
Ecotec	8.3 gal/a	0.051
	16.6 gal/a	0.003
	24.9 gal/a (66.4X)	0

Timing Results

Results from these trials show that the organic pesticides tested have only an effect on newly hatched larvae (Table 9). They may have some activity up to one week after egg hatch. There is a slight effect on applications just prior to pupae emergence.

Table 9. Mean proportion of gnats emerged adults as calculated by Abbott's correction. Testing of individual chemicals and combinations in jars and trays.

Jar Test			Tray Test
Rate	Ecotec @ 6 gal/a	Eco+Mat @ 3 gal/a	Neemix 4.5 @ 2gal/a
UTC	1	1	1
0 week	N/A	0.259	N/A
1 week	0.5	0.804	0.699
2 weeks	0.831	0.85	0.866
3 weeks	0.789	0.76	0.846

N/A= not available, not tested

USE OF EYE GNAT MASS TRAPPING AS AN EFFECTIVE MEANS OF REDUCING MIGRATION

Objective

To determine if a line of collar traps would significantly reduce the number of gnats migrating into residential areas.

Materials & Methods

Location: In this study, we selected a neighborhood in close proximity to the western edge of the local organic farm in south Escondido (Figure 8). The residential neighborhood contained 15 homes on the west end and 17 homes on the eastern end, each group roughly two rows in parallel separated by a residential street. The white line in Figure 8 separates the two groups of homes. The homes closest to the farm were approximately 700 feet from the farm edge.

Eye Gnat Traps: The UCCE 4-hole collar traps used in previous studies (Bethke et al. 2010).

Area of Study: The area studied is bordered by the farm edge to the south and Beethoven Drive to the north, and the edges of the neighborhoods described above are considered the eastern and western outside edges. Therefore the area is approximately a rectangle 800 feet by 1400 feet. The study area was divided roughly into quadrants of 400 feet by 700 feet. The northwest and northeast corners contained residential homes and the southwest and southeast corners were located in coastal chaparral.

Experimental Design and Sampling: The experiment was designed to answer the question of whether a dense line of adult eye gnat traps would reduce migrating eye gnat populations in one direction with the assumption that the eye gnats were originating from the farm. In order to approach the question we needed to compare eye gnat populations originating from the farm side and migrating into the residential neighborhood with and without a trap line perpendicular to the farm and neighborhood. A reduction in trap capture is expected in this study due to the distance between farm and neighborhood traps.

The experiment was conducted two times, once with the trap line on the western side of the study area and repeated on the eastern side of the study area over time. Trapping data were collected on six dates for each of the two trap line sides studied. When the trap line was on the western quadrants, trapping data was collected six times from July 26 to Aug 3, and when the trap line was on the eastern quadrants, trapping data was collected six times from Aug 5 to Aug 12.

Ten UCCE eye gnat collar traps were placed approximately 100 feet apart in each quadrant, either close to the farm in the southern edge (20 total) or in the residential area in the northern edge (20 total). Traps in the residential neighborhood were approximately 450 feet from those placed next to the farm edge. These traps were from monitoring the populations in each quadrant, which will help determine reductions due to the treatment effect.

The treatment effect being tested is with or without a trapline between the monitoring traps. The trapline consisted of 125 traps approximately 5 feet apart within the 700 feet width between north and south quadrants (Figure 10).

Data were analyzed using ANOVA and data were transformed Log (x+1) to satisfy the assumptions for the analysis.

Results

As suspected, the farm is the likely source of the eye gnats. Data collected from this study demonstrate that the number of eye gnats captured in traps in close proximity to the farm are in greater number than those captured in traps in the neighboring community ($F = 24.37$; df = 1,407; $P < 00001$).

There was no difference in the number of gnats caught between the western quadrants verses the eastern quadrants ($F = 0.12$; df = 1,407; $P = 7250$). Again, this is as expected since there should be no difference between the east or west side of the study area in contrast to north verses south.

Unfortunately, there is no statistical difference in the number of eye gnats caught in traps in the neighborhood community in response to trap line capture ($F = 0.02$; df = 1,407; $P = 0.9582$). Figure 9 shows that the number of eye gnats caught in the northeastern quadrant is statistically different from other quadrants but it is always lowest regardless of the presence of the trapline. The percent reduction from the south farm side traps to the north community traps averages to essentially the same percentage.

Further study is needed to confirm that a trap line is an effective tool for eye gnat migration management. The great numbers of eye gnats present in the test area may be diluting the effect of a trap line. This suggests that the study should be conducted when there are fewer eye gnats in the area. Subsequently, we may be able to detect a significant treatment (trapline) effect. Additionally, greater replication may also be necessary.

Migration may not occur in a straight line directly away from the farm. We suspect that the eye gnats are attracted to volatiles from the community as directed by airflow. This means that there may be a directed migration from the farm along topographical pathways. In addition, the trapline itself may have an influence on the trap catch. If the volatiles from the trapline are a dominant factor, they may be drawing eye gnats from both directions, the community and the farm. If that were the case, then the farm side traps would have larger numbers due to the production of eye gnats, and the community traps would have fewer numbers due to the initial lower numbers and the migration away from the community towards the trapline.

A capture-mark-release study will help answer this question. We will conduct a preliminary study to determine the feasibility of a capture-mark-release study in 2012.

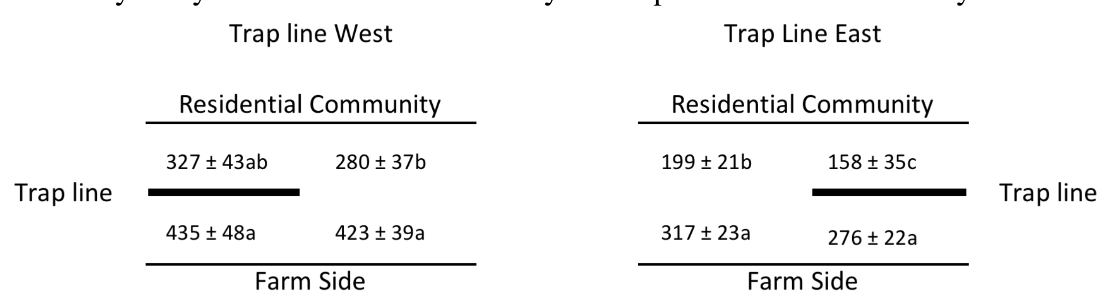

Figure 9. Mean number of eye gnats/trap (±SE) in 48 hours in the four quadrants with and without a trap line present. The trap line west represents the four quadrants and all traps when the trap line is on the west side of the study area. The trap line east represents the four quadrants and all traps when the trap line is on the east side of the study area.

ADULT EYE GNAT POPULATION DENSITY STUDY

Objective

This trial was designed to establish a baseline on the range of adult eye gnat populations using a GPS grid pattern.

Materials and Methods

Experimental Unit- Modified PVC based 4 hole collar traps were used for monitoring. The lower portions of the trap are painted flat black and the top portion is clear plastic (Figure 2). Traps were attached to 3' wooden stakes using electrical tape. Putrefied egg was added to the lower PVC container as bait.

Experimental Design- Twenty-four collar traps were placed on a 25-trap by 25-trap grid pattern approximately one-half mile apart (Figure 6) in south Escondido. Trap numbers in Table 10 correspond to the numbers on the pins in Figure 6. Trap #7 is not present in the study because Lake Hodges precluded its placement.

Sampling- Trap tops were collected each day for four consecutive days from October 17-21, 2011. Trap tops were removed and replaced by a clean trap top. The trap tops with the eye gnats were placed in a Ziploc bag to prevent any gnats from escaping, brought back to the laboratory, and placed in the freezer overnight. Eye gnats were separated from other fly species and all flies were counted and recorded.

Analysis – Data were analyzed using descriptive statistics. Selected data sets were pooled (elevation and location) in search of trends.

Results

Table 10 lists the average number of eye gnats captured/trap/day in traps located a half mile apart on a grid delineated by GPS coordinates (Figure 6). The area studied was south Escondido, an area plagued by eye gnats and in close proximity to an organic farm.

Topographic features and elevation may hinder or assist eye gnat migration, but there was no discernable trend in eye gnat trap capture based on the topographic elevation (Table 11) most likely due to the diversity of topographic features in the area, the variability in wind direction, and the attraction to harborage and food sources. The highest mean number of eye gnats/trap/day was observed in the 400-500ft elevations.

As was the case in Jacumba (Bethke et al. 2009) eye gnats are concentrated around the farm, and in areas of human activity such as residential areas, schools, parks, etc. (Table 12). The highest concentration of eye gnats (Mean no. 600.5, traps 13, 14, 18 and 19) was found in the vicinity of Sonata/San Pasquel Rd, the residential community in close proximity to and north and west of the organic farm. This is also one of the areas, which produces some of the greatest number of complaints from residents and homeowners associations. Traps within a "half mile of the farm" and "within residential areas" contained the next highest mean number of eye gnats (>300/trap/day).

There is an anomalous trap capture associated with trap #22. This trap is one of the furthest from the farm (>1-mile) and just north of Kit Carson Park and located in an area of chaparral. A greater density of traps in this area may allude to a source of eye gnats closer to this trap and is worth investigating.

All indications are that patterns of trap catch mimics what was observed in Jacumba in that eye gnats are concentrated in an area in close proximity to the farm and in residential areas. Traps #18 and #19 have the highest counts, and #19 is less that a half mile from the edge of the farm.

Table 10. Mean number of eye gnats/trap/day captured in traps placed a half-mile apart on a grid delineated by GPS coordinate.

Trap #	Mean no. of Gnats/Trap/Day	Mean no. of Other Flies/Trap/Day
1	86.5	17.5
2	25.0	31
3	183.3	163.25
4	417.0	112
5	50.0	6.25
6	15.0	60.75
8	130.5	23.5
9	44.0	19.25
10	283.0	49.25
11	289.8	29.5
12	63.0	19.5
13	317.3	19.75
14	271.7	51.5
15	354.0	23
16	4.3	6
17	167.8	54.25

18	763.3	17.25
19	1050.0	70
20	386.0	30.75
21	8.7	69.25
22	1083.0	40
23	119.3	4.25
24	384.0	26.25
25	81.0	26.75

Table 11. Mean number of eye gnats/trap/day by elevation. Trap catches were grouped by hundred or fifty foot delineations.

Elevation (feet)	Mean no. of Gnats/Trap/Day
300-399	249.2
400-499	364.5
500-599	185.4
599- 650	221.4
300-349	181.7
350-399	263.4
400-449	429.6
450-499	412.5
500-549	81
550-599	290
600-650	327.8

Table 12. Grouping of selected traps into areas of interest.

Description of Area	**Trap Numbers**	**# of Traps**	**Mean Gnats/Trap/Day**	**Importance**
Proximity to Organic Farm	8, 9, 10, 15, 20	5	239.5	Population potential near the farm
South of farm (Highland Valley Rd)	2, 3, 4, 5	4	168.8	Proximity to the farm but across open space
West of I-15	1, 6, 11, 16, 21	5	80.8	Furthest from the farm, across freeway
Traps within a half mile of the farm	3, 4, 5, 13, 14, 19, 25	7	338.6	Half mile proximity to farm
Traps greater than a mile of the farm	1, 16, 17, 21, 22, 23	6	216.9	Mile proximity to farm
Traps in open areas	2, 3, 4, 5, 6, 12, 17, 22	8	250.5	Natural environment
Traps within residential areas	11, 13, 14, 16, 19, 21, 24, 25	8	300.8	Residential landscaping

Extension Activity

ADDITIONS TO THE SAN DIEGO EYE GNAT RESEARCH AND EDUCATION PROJECT WEB SITE (http://ucanr.org/eyegnats)

2010 County Eye Gnat Report Research Report 2010
Eye Gnat Research and Education Symposium 2012

EYE GNAT PRESENTATIONS AND PUBLICATIONS

Bethke, J. A. 2011. New invasions of eye gnats in Southern California. UC Delivers Success Story. Feb 22, 2011. http://ucanr.org/delivers/impactview.cfm?impactnum=838
Vander Mey, B. and J. A. Bethke. 2011. Alternative Control Options Against Eye Gnats, *Liohippelates collusor* (Townsend), in Organic Production Agriculture. Reno, NV. Nov 13-17, 2011. Abstracts are available online: http://www.entsoc.org/Pacific/meetings/FINAL_PBESA_2011_Abstracts.pdf
Vander Mey, B. and J. A. Bethke. 2010. Conventionally sprayed crops reduce eye gnat, *Liohippelates collusor* (Townsend), populations in organic production. 58th Annual Meeting of the Entomological Society of America. Town and Country Resort, San Diego, CA. Dec. 12-16-2010. (Tuesday the 14th Poster) available online: http://esa.confex.com/esa/2010/webprogram/Paper51914.html
Bethke, J. A., Vander Mey, A., and I. DeBonis. Final Report: San Diego County Eye Gnat Research and Education Project 2010. In fulfillment of San Diego County Contract #532716. 35pgs. Available online: http://ucanr.org/eyegnats

San Diego County Eye Gnat Research and Education Symposium 2012

Sponsored by University of California Cooperative Extension, San Diego County Department of Environmental Health, and the Department of Entomology at UC Riverside
Presentations are available online: http://ucanr.org/eyegnats
Agenda - March 22 (Thurs.), 2012

7:20 AM – 7:55 **AM Registration**

7:55 AM - 8:00 AM
Introduction/Welcome/Housekeeping
Moderator – James A. Bethke, Nursery and Floriculture Farm Advisor, UCCE San Diego

8:00 AM – 8:45 AM (45min)
Nuisance Eye Gnats and Eye Flies: 50 Years Experience
Speaker: Dr. Mir Mulla, Department of Entomology, University of California Riverside

9:30 AM – 9:50 AM
Refreshment Break in the Exhibit Hall

9:50 AM – 10:30 AM (40min)
San Diego County Eye Gnat Research and Education Project
Speaker: James A. Bethke, Nursery and Floriculture Farm Advisor, UCCE San Diego

10:30 AM – 11:00 AM (30 min)
Other Nuisance Flies not to be confused with Eye Gnats
Speaker: Alec Gerry, Department of Entomology, UC Riverside

11:00 AM – 11:30 PM (30 min)
Eye gnat population control in Coachella Valley
Speaker: Gregory White, Vector Ecologist, Coachella Valley Mosquito and Vector Control District, Indio

11:30 AM – 12:00 PM (30min)
Eye Gnats in Jacumba: The Communities Perspective
Speaker: Danielle Cook, Resident, Member of Jacumba Against Gnats (JAG)

12:00 PM – 1:00 PM
Lunch/Exhibit Hall Open

1:00 PM – 1:30 PM (30min)
Cooperative Extension's Role in solving Urban and Agriculture Issues
Speaker: Valerie Mellano, County Director, University of California Cooperative Extension, San Diego County

1:30 PM – 2:00 PM (30min)
Impact of Eye Gnats on Farming in San Diego County
Speaker: Eric Larson, Executive Director, San Diego County Farm Bureau

2:00 PM – 2:30 PM (30min)
Eye gnats: San Diego County Department of Environmental Health Perspective
Speaker: Jack Miller, Director, San Diego County Department of Environmental Health

2:30 PM – 3:00 PM
Improvements in Eye Gnat Mass Trapping in San Diego County
Speaker: Bryan Vander Mey, Staff Research Associate, UCCE San Diego

3:00 PM – 3:20 PM Break

3:20 PM – 4:15PM (50min)
Eye Gnat Population Reduction in San Diego County and Future Research
Speaker: James A. Bethke, Nursery and Floriculture Farm Advisor, UCCE San Diego

4:15 PM – 5:00 PM
OPEN DISCUSSION – ALL SPEAKER PANEL

SELECTED REFERENCES

Anonymous. 1929. The California eye gnat. Science 69:14.

Bethke, J. A., B. Vander Mey, T. P. Salmon, & V. J. Mellano. 2008. Biology and Control of the Eye Gnat *Liohippelates collusor*. Final Report San Diego County Eye Gnat Research and Education Project 2008, County Contract #523836. 29pp.

Bethke, J. A., B. Vander Mey and I. DeBonis. 2009. Biology and Control of the Eye Gnat *Liohippelates collusor*. Final Report: San Diego County Eye Gnat Research and Education Project 2009. County Contract #532716. Also available online.

Bethke, J. A., B. Vander Mey and I. DeBonis. 2010. Biology and Control of the Eye Gnat *Liohippelates collusor*. Final Report: San Diego County Eye Gnat Research and Education Project 2010. County Contract #532716 Amendment #1. Also available online.

Buehler J. W., J. T. Holloway, R. A. Goodman, and R. K. Sikes. 1983. Gnat sore eyes - seasonal, acute conjunctivitis in a southern state. Southern Medical Journal. 76(5):587-589.

Mulla, M. S. 1963. An ecological basis for suppression of *Hippelates* eye gnats. Journal of Economic Entomology. 56(6): 768

APPENDIX I
Photo Images

Figure 1. Components used to make improved collar traps. Bait jar, 3-inch PVC collar with ¾ inch holes, plastic champagne glass, 3-inch drainage pipe used to connect 32 ounce pinch grip plastic container.

Figure 2. Assembled collar trap

Figure 3. 1 pint mason jar used to test food sources or chemicals on larvae

Figure 4. 3-inch drainage tubes used to measure the depth at which eye gnat larvae would travel to food.

Figure 5. Chemical emergence test conducted at the Center of Applied Hort. Research

Figure 6. Grid showing location and trap ID# of collar traps. The colors represent the average number of gnats per trap per 24 hours. Green = 1-270, yellow = 271-542, orange = 543-814, red = 815-1085.

Figure 7. Red and yellow lines show the location of the row of collar traps. Numbers of gnats were tracked when the trap line was located either in the red line or yellow line. White line represents separation between two test units.

Figure 8. Line trial showing traps used to intercept gnats

APPENDIX II

2011 VISITS TO ESCONDIDO

Jan. 3 – Scouting and planning trip for upcoming season
April 26 – Set up collar traps at The Vineyard Golf Course
May 3 – Collect gnats from traps
May 10 – Collect gnats from traps
May 18 – Collect gnats and meet with Bill B. at BeWise farms
May 25 – Set up traps at Be Wise and collect gnats at golf course
May 31 – Collect gnats at farm and golf course
June 7 – Collect gnats at farm and golf course
June 14 – Collect gnats and set perimeter traps at farm
June 21 – Collect gnats at farm and golf course
June 28 – Set up more perimeter traps and collect gnats
July 6 – Collect gnats at farm and golf course
July 13 – Collect gnats at farm and golf course
July 19 – Collect gnats and begin setting up collar traps for line trial
July 20 – Continue setting up line trial
July 21 – Continue setting up line trial
July 25 – Start collecting data from line trial
July 26 – Collect line trial and gnats from farm and golf course
July 27 – Collect gnats from line trial
July 28 – Collect gnats from line trial
July 29 – Collect gnats from line trial
August 1 – Collect gnats from line trial
August 2 – Collect gnats from line trial and farm and golf course
August 3 – Collect gnats from line trial and move line trial
August 4 – Collect gnats from line trial
August 5 – Collect gnats from line trial
August 8 – Set up line trial
August 9 – Collect gnats from line trial and farm and golf course
August 10 – Collect gnats from line trial
August 11 – Collect gnat from line trial
August 12 – Collect gnats from line trial
August 16 – Collect gnats from farm and golf course
August 23 – Collect gnats from farm and golf course
August 30 – Collect gnats from farm and golf course, set up compost emergence traps
September 6 – Collect gnats at farm and golf course
September 13 – Collect gnats from farm and golf course and set up Malaise trap
September 21 – Collect gnats from farm and golf course and set up Malaise trap
September 27 – Collect gnats from farm and golf course
October 4 – Collect gnats from farm and golf course
October 11 – Collect gnats from farm and golf course

APPENDIX III

Weather for Escondido, CA

CIMIS (California Irrigation Management Information System)

Daily Report

Rendered in English Units.
April 1, 2011 - October 31, 2011
Printed on April 3, 2012

Escondido SPV - South Coast Valleys - Station 153

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
04/01/2011	0.20	0.00	584	14.6	87.4	47.4	65.4	94	41	68	54.7	3.0	71.4	67.4
04/02/2011	0.11	0.00	380	14.1	73.2	45.2	58.1	96	66	86	53.7	3.5	84.7	66.8
04/03/2011	0.15	0.00	502	13.1	70.8	45.8	58.9	91	57	77	51.7	3.4	83.3	66.8
04/04/2011	0.19	0.00	601	12.7	82.5	40.2	60.2	95	34	71	50.9	3.9	93.6	66.5
04/05/2011	0.17	0.00	570	12.9	77.5	42.9	57.9	96	44	78	51.2	3.8	91.8	66.7
04/06/2011	0.08	0.00	305	13.6	71.9	50.1	58.0	94	56	83	52.8	3.1	75.0	66.1
04/07/2011	0.11	0.16	380	11.8	66.1	45.6	55.4	95	64	78	48.8	5.6	134.1	65.6
04/08/2011	0.13	0.18	503	8.6	58.4	40.5	47.9	96	47	76	40.6	4.7	113.8	63.9
04/09/2011	0.14	0.44	552	8.0	59.0	33.4 Y	45.4	96	53	77	38.8	4.3	104.0	60.7
04/10/2011	0.17	0.00	620	9.4	67.6	36.8	51.1	92	48	73	42.9	3.9	93.3	59.9
04/11/2011	0.18	0.00	600	10.7	72.0	37.2	53.3	95	51	77	46.3	3.7	89.2	60.9
04/12/2011	0.18	0.00	615	11.7	73.1	36.1	54.7	95	48	80	48.8	3.7	89.3	61.7
04/13/2011	0.16	0.00	534	11.4	65.9	43.9	55.9	91	54	75	48.0	4.3	104.9	63.5
04/14/2011	0.19	0.00	595	10.1	76.5	38.1	56.6	94	32	65	44.9	3.6	86.2	63.3
04/15/2011	0.22	0.00	613	9.1	88.6	40.9	63.3	93	16	46	42.0	3.3	80.1	63.9
04/16/2011	0.24	0.00	623	10.4	93.7 Y	51.3	69.1	77	19	43	45.6	4.1	99.6	65.5
04/17/2011	0.21	0.00	613	13.0	84.5	42.0	62.0	93	35	69	51.5	4.4	106.6	66.2
04/18/2011	0.03	0.00	158	14.3	66.3	55.8	59.8	89	66	81	54.0	3.4	82.8	66.1
04/19/2011	0.13	0.01	433	14.3	72.6	54.3	60.9	94	57	78	54.0	4.5	109.0	65.5
04/20/2011	0.16	0.00	533	14.2	72.8	56.0	62.0	90	57	75	54.0	4.6	111.9	66.7
04/21/2011	0.09	0.00	308	13.9	71.9	53.9	60.5	88	54	77	53.3	3.9	93.6	66.8
04/22/2011	0.18	0.00	560	12.6	72.4	49.7	59.2	92	51	73	50.7	4.4	106.3	66.5
04/23/2011	0.20	0.00	616	11.8	71.5	47.7	59.3	89	43	68	48.9	4.6	112.1	67.2
04/24/2011	0.11	0.00	360	13.0	71.4	52.0	59.0	88	58	76	51.5	5.2	126.5	66.6
04/25/2011	0.20	0.00	605	12.4	76.5	45.6	60.3	91	45	69	50.2	3.9	93.0	66.8
04/26/2011	0.20	0.00	620	13.1	75.0	48.8	61.9	93	48	69	51.8	3.9	93.7	67.8

04/27/2011	0.24	0.00	651	11.1	86.3	44.5	64.4	93	25	54	47.2	4.2	102.3	67.9
04/28/2011	0.25	0.00	657	11.0	84.7	43.3	63.8	92	29	54	46.9	4.7	113.6	68.5
04/29/2011	0.20	0.00	591	12.3	76.3	46.4	60.0	91	45	70	50.0	4.7	112.8	68.8
04/30/2011	0.24	0.00	662	7.7	82.1	42.0	61.6	94	12	41	37.8	4.1	98.0	68.3
Tots/Avgs	5.06	0.79	531	11.9	75.0	45.2	58.9	92	45	70	48.8	4.1	98.6	65.6

Escondido SPV - South Coast Valleys - Station 153

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
05/01/2011	0.26	0.00	686	5.3 Y	84.3	35.0 R	62.9	74	10	27 Y	28.3 Y	4.5	109.6	68.2
05/02/2011	0.29	0.00	683	4.9 R	87.1	36.1 Y	64.4	78	8	-- R	-- I	5.4	130.2	68.3
05/03/2011	0.28 R	0.00	693	6.1 Y	95.5 Y	35.6 Y	67.8	80	6	26 Y	31.8 Y	4.5	108.0	68.6
05/04/2011	0.27	0.00	681	9.0	91.1	42.8	67.1	83	15	40	41.7	4.0	96.9	69.9
05/05/2011	0.24	0.00	665	11.7	87.7	42.5	63.1	97	23	60	48.8	3.9	93.6	69.3
05/06/2011	0.21 R	0.00	653	13.3	79.6	46.0	60.5	98	44	74	52.1	4.1	100.1	67.9
05/07/2011	0.21	0.00	612	13.8	73.5	54.9	62.4	92	54	72	53.2	6.0 Y	143.9 Y	68.5
05/08/2011	0.10	0.02	319	12.3	67.7	52.5	58.9	90	58	72	50.0	5.2	125.8	67.6
05/09/2011	0.12	0.01	364	10.3	64.4	51.4	55.9	84	50	68	45.4	6.4 Y	154.0 Y	66.1
05/10/2011	0.21	0.00	675	10.5	71.3	46.6	57.3	91	42	66	45.9	4.1	98.7	65.7
05/11/2011	0.20	0.00	616	12.2	74.5	45.2	59.3	93	48	71	49.9	3.8	92.8	66.7
05/12/2011	0.22	0.00	662	14.1	79.1	48.6	63.3	94	47	71	53.7	4.2	100.9	68.0
05/13/2011	0.21	0.00	644	14.1	77.6	46.0	60.5	96	49	78	53.6	4.6	111.7	68.8
05/14/2011	0.15	0.00	505	13.2	69.4	53.5	60.1	90	59	74	51.9	4.1	99.1	69.0
05/15/2011	0.14	0.00	445	10.6	66.1	43.4	56.6	85	42	68	46.1	5.2	124.7	68.3
05/16/2011	0.19	0.00	619	9.3	67.3	41.3	54.2	88	41	65	42.7	4.9	117.9	66.8
05/17/2011	0.09	0.08	366	12.5	64.9	50.8	55.9	93	64	82	50.4	4.0	96.7	66.5
05/18/2011	0.10	0.28	351	12.2	63.2	46.9	55.7	95	59	80	49.8	6.2 Y	150.8 Y	65.9
05/19/2011	0.19	0.00	603	12.1	69.9	44.4	57.5	95	53	75	49.6	4.0	97.7	65.6
05/20/2011	0.20	0.00	608	13.4	73.8	47.3	60.6	93	55	74	52.4	3.8	91.6	66.8
05/21/2011	0.18	0.00	544	14.0	80.6	49.3	61.1	93	45	76	53.6	4.0	96.5	68.1
05/22/2011	0.14	0.00	445	13.8	72.2	53.0	60.4	93	56	77	53.1	3.9	94.3	68.3
05/23/2011	0.14	0.00	433	12.6	70.2	50.8	59.5	87	54	73	50.7	4.9	119.3	68.3
05/24/2011	0.21	0.00	611	11.6	75.2	45.7	59.9	90	43	66	48.4	4.0	97.2	68.4
05/25/2011	0.22	0.00	637	13.0	80.4	43.6	61.5	94	43	69	51.4	4.2	101.7	69.1
05/26/2011	0.21	0.00	599	12.8	76.3	46.4	60.5	93	44	71	51.0	4.5	108.3	69.9
05/27/2011	0.24	0.00	659	12.5	83.2	45.0	63.2	94	34	63	50.5	3.9	93.4	70.2
05/28/2011	0.22	0.00	652	12.8	74.6	45.1	60.4	94	50	71	51.1	5.3	128.1	70.6
05/29/2011	0.18	0.07	579	11.1	66.4	46.9	56.9	93	47	70	47.3	6.4 Y	154.8 Y	70.3
05/30/2011	0.24	0.00	710	9.6	81.5	41.6	60.4	88	25	53	43.4	4.4	105.0	69.0
05/31/2011	0.24	0.00	685	10.6	81.1	38.7 Y	60.7	93	26	58	46.0	4.0	96.4	69.5
Tots/Avgs	6.10	0.46	581	11.5	75.8	45.7	60.3	90	42	66	48.1	4.6	111.0	68.2

Escondido SPV - South Coast Valleys - Station 153

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)

06/01/2011	0.22	0.00	665	10.4	76.1	39.8 Y	57.1	93	35	65	45.5	4.4	106.1	69.7
06/02/2011	0.23	0.00	696	10.2	76.7	39.0 Y	58.4	93	37	61	45.0	4.0	96.5	69.5
06/03/2011	0.24	0.00	692	11.2	81.8	37.4 R	59.5	93	28	64	47.5	4.2	102.2	69.5
06/04/2011	0.22	0.00	646	11.9	76.4	45.4	60.7	89	41	66	49.2	4.5	108.4	70.4
06/05/2011	0.25	0.01	693	11.6	80.8	42.0 Y	61.6	94	32	62	48.5	4.0	97.3	70.3
06/06/2011	0.23	0.07	723	12.7	75.6	48.8	61.6	95	40	68	50.8	4.2	101.0	71.1
06/07/2011	0.24	0.00	706	13.3	76.0	44.7	61.9	93	45	70	52.1	4.7	114.2	70.7
06/08/2011	0.21	0.00	611	13.6	75.0	57.8	64.0	83	46	67	52.8	5.3	126.8	71.7
06/09/2011	0.14	0.00	434	14.6	74.6	57.8	63.2	87	53	74	54.7	4.8	115.8	72.0
06/10/2011	0.13	0.00	432	15.2	75.0	56.6	62.7	93	55	78	55.8	4.4	105.7	71.7
06/11/2011	0.22	0.00	637	14.7	75.9	56.8	64.2	87	51	71	54.8	5.4	129.7	72.5
06/12/2011	0.21	0.00	630	14.4	74.4	53.9	62.8	96	51	74	54.3	5.5 Y	133.3 Y	73.1
06/13/2011	0.22	0.00	641	14.9	78.8	47.9	63.0	98	49	76	55.2	5.1	122.0	70.2
06/14/2011	0.25	0.00	684	15.6	84.6	51.7	67.1	93	44	69	56.6	4.9	119.2	71.8
06/15/2011	0.24	0.00	666	15.8	82.5	55.8	66.3	92	47	72	56.9	5.5	131.6	72.9
06/16/2011	0.23	0.00	645	15.5	78.6	57.9	65.7	87	51	72	56.3	5.6 Y	135.6 Y	73.5
06/17/2011	0.22	0.00	613	14.8	78.0	57.7	65.3	85	47	69	55.0	5.6 Y	134.0 Y	74.2
06/18/2011	0.24	0.00	685	14.5	79.2	58.4	66.5	83	43	65	54.5	5.2	125.9	74.9
06/19/2011	0.22	0.00	622	14.6	77.1	53.2	65.0	91	51	69	54.7	5.2	126.0	75.4
06/20/2011	0.25	0.00	694	15.4	83.9	55.0	67.2	90	43	67	56.1	4.8	115.5	75.7
06/21/2011	0.23	0.00	627	16.3	92.3	51.0	67.9	95	35	70	57.7	3.9	93.5	76.0
06/22/2011	0.25	0.00	663	17.5	90.5	57.5	69.5	93	41	71	59.8	4.7	113.8	77.1
06/23/2011	0.24	0.00	661	17.0	85.8	55.2	68.0	93	49	73	58.9	4.8	116.9	77.6
06/24/2011	0.24	0.00	666	16.0	82.3	53.3	67.0	93	49	71	57.2	4.7	114.2	77.7
06/25/2011	0.26	0.00	698	15.3	85.8	51.5	67.5	92	41	67	56.0	4.7	112.9	77.9
06/26/2011	0.25	0.00	672	14.2	87.7	46.6	66.8	96	31	63	53.9	3.8	92.0	77.5
06/27/2011	0.26	0.00	692	15.2	88.5	46.7	67.9	96	38	65	55.8	4.3	102.6	77.5
06/28/2011	0.23	0.00	626	16.3	84.3	52.1	66.1	95	48	74	57.7	4.6	109.9	77.8
06/29/2011	0.21	0.00	596	16.7	82.3	58.0	67.8	91	48	72	58.4	4.2	100.3	77.8
06/30/2011	0.26	0.00	711	14.9	85.7	50.9	67.6	97	34	65	55.2	3.9	95.3	77.6
Tots/Avgs	6.84	0.08	648	14.5	80.9	51.3	64.7	92	43	69	54.2	4.7	113.3	73.8

Escondido SPV - South Coast Valleys - Station 153

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
07/01/2011	0.26	0.00	699	15.7	90.9	48.8	69.2	97	37	65	56.7	3.7	89.5	72.1
07/02/2011	0.27	0.00	698	17.0	92.8	52.0	72.4	94	36	63	58.9	3.5	84.0	74.2
07/03/2011	0.21	0.00	564	18.6	88.1	54.6	70.9	96	51	72	61.5	3.7	88.2	75.3
07/04/2011	0.25	0.00	638	19.3	88.6	60.7	75.2	92	43	65	62.5	4.0	97.4	76.8
07/05/2011	0.22 R	0.00	576	21.1	91.0	64.3	77.3	91	44	66	65.0	4.0	96.9	78.3
07/06/2011	0.24 R	0.00	619	20.6	91.7	64.8	77.2	92	48	65	64.3	3.9	94.7	79.6
07/07/2011	0.26	0.00	638	18.6	93.7	62.6	77.5	86	34	58	61.4	3.6	87.5	80.2
07/08/2011	0.25 R	0.00	648	18.8	87.7	60.1	73.6	93	41	66	61.7	4.1	100.0	80.3
07/09/2011	0.25	0.00	666	18.0	88.5	56.6	71.5	95	42	68	60.5	3.8	90.8	80.1
07/10/2011	0.24	0.00	655	17.3	86.0	55.8	69.0	94	47	72	59.5	4.5	107.8	79.8
07/11/2011	0.24	0.00	659	16.2	82.4	57.2	68.1	91	48	69	57.5	4.6	110.2	79.4
07/12/2011	0.24	0.00	666	15.8	80.8	59.9	68.1	83	47	68	56.9	4.7	114.3	79.3
07/13/2011	0.23	0.00	647	15.0	81.6	57.5	67.7	86	42	65	55.3	4.4	107.4	79.1
07/14/2011	0.21	0.00	600	15.8	79.8	56.7	67.3	89	50	69	56.9	4.1	100.0	78.8

07/15/2011	0.22	0.00	629	15.5	81.0	53.7	65.8	97	41	72	56.3	4.0	97.6	78.6
07/16/2011	0.21	0.00	615	15.8	79.7	51.0	64.4	97	51	77	56.9	3.6	86.3	75.0
07/17/2011	0.24	0.00	675	16.2	84.5	51.5	67.7	94	48	70	57.5	4.0	95.4	74.8
07/18/2011	0.26	0.00	674	15.9	90.9	49.2	69.8	96	35	64	57.0	4.2	100.4	75.1
07/19/2011	0.27	0.00	571	15.8	91.2	-- S	77.4	94	30	49	56.9	5.4 Y	129.7 Y	77.9
07/20/2011	0.27	0.00	687	15.6	90.5	53.9	70.3	93	29	62	56.6	4.7	112.8	77.7
07/21/2011	0.25	0.00	663	15.9	88.2	54.3	68.4	93	35	67	57.1	5.1	122.6	78.4
07/22/2011	0.25	0.00	656	16.2	84.2	57.3	68.8	89	44	67	57.5	5.6 Y	135.1 Y	79.0
07/23/2011	0.24	0.00	644	16.2	86.0	59.3	69.3	86	41	66	57.5	5.2	125.6	79.4
07/24/2011	0.19	0.00	501	17.1	86.4	54.2	69.7	93	44	69	59.0	4.0	96.3	79.5
07/25/2011	0.26	0.00	618	17.2	92.9	60.3	74.7	90	38	59	59.3	4.4	106.6	80.1
07/26/2011	0.24	0.00	632	17.4	85.1	54.6	68.3	96	50	74	59.6	5.5 Y	131.7 Y	80.3
07/27/2011	0.20	0.00	576	16.4	78.6	54.5	64.8	96	54	78	57.9	5.1	123.8	78.0
07/28/2011	0.22	0.00	615	16.6	83.0	54.0	66.8	97	48	74	58.2	4.9	117.9	75.2
07/29/2011	0.21	0.00	585	17.8	83.0	57.4	68.9	93	52	74	60.2	4.4	106.0	76.0
07/30/2011	0.20	0.00	566	18.9	83.4	64.3	71.5	88	53	72	61.9	4.9	117.2	77.2
07/31/2011	0.19	0.07	527	20.1	86.5	63.2	72.2	93	53	74	63.6	3.9	94.4	78.5
Tots/Avgs	7.29	0.07	626	17.2	86.4	56.8	70.4	92	44	68	59.1	4.4	105.4	77.9

Escondido SPV - South Coast Valleys - Station 153

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
08/01/2011	0.25 R	0.00	633	18.9	92.0	60.7	75.3	93	42	63	61.9	3.6	87.8	79.7
08/02/2011	0.27	0.00	635	16.5	95.8	62.3	77.8	84	26	51	58.1	3.7	90.1	81.2
08/03/2011	0.26	0.00	649	15.1	93.4	55.5	73.8	90	27	53	55.7	3.5	84.8	81.5
08/04/2011	0.27	0.00	679	13.7	92.6	47.7	69.0	93	21	56	52.9	4.2	102.1	80.9
08/05/2011	0.24	0.00	662	15.3	85.8	50.1	66.8	93	42	68	56.0	4.5	109.4	80.5
08/06/2011	0.24	0.00	654	15.2	86.9	53.3	68.5	92	33	64	55.8	4.2	102.5	80.7
08/07/2011	0.24	0.00	656	16.3	87.7	53.4	68.6	93	40	68	57.7	4.2	101.6	80.9
08/08/2011	0.22	0.00	607	16.4	85.9	52.8	67.2	92	44	72	57.8	4.2	102.1	81.0
08/09/2011	0.21	0.00	590	16.2	83.2	53.0	66.1	93	49	74	57.5	4.3	104.2	80.7
08/10/2011	0.21	0.00	579	16.1	81.0	56.8	66.5	92	48	72	57.4	4.5	109.3	80.4
08/11/2011	0.20	0.00	573	16.3	79.8	59.8	67.6	87	51	71	57.7	4.3	103.3	80.4
08/12/2011	0.16	0.00	473	17.0	81.1	60.7	67.9	87	55	73	58.9	4.0	97.1	80.2
08/13/2011	0.22	0.00	600	17.3	83.1	56.3	68.0	92	53	74	59.4	4.0	97.5	80.1
08/14/2011	0.22	0.00	593	17.7	90.0	55.1	69.3	94	44	72	60.0	3.6	86.2	80.2
08/15/2011	0.24	0.00	624	17.3	90.6	52.8	70.6	92	35	68	59.5	4.1	98.1	80.7
08/16/2011	0.25	0.00	636	15.8	94.0	52.7	71.0	94	29	61	56.8	3.9	94.3	80.7
08/17/2011	0.23	0.00	557	15.3	95.3	51.6	70.8	95	26	59	56.0	3.9	93.0	80.7
08/18/2011	0.24	0.00	614	16.3	89.1	49.2	67.9	97	42	70	57.8	4.7	113.9	80.4
08/19/2011	0.22	0.00	596	16.6	84.5	53.0	66.1	97	46	76	58.3	5.2 Y	125.1 Y	78.5
08/20/2011	0.19 R	0.00	564	15.9	83.5	49.0	64.2	97	46	78	57.1	5.2 Y	126.0 Y	74.2
08/21/2011	0.21	0.00	582	16.1	83.4	56.0	67.1	90	47	71	57.4	4.9	117.6	74.4
08/22/2011	0.23	0.00	605	16.4	88.9	51.7	69.7	95	37	66	57.9	3.9	94.9	75.0
08/23/2011	0.24	0.00	597	16.9	92.8	53.0	73.1	94	32	61	58.7	3.6	87.0	76.2
08/24/2011	0.23	0.00	587	17.6	94.1	55.5	73.6	94	32	62	59.9	3.8	90.8	77.2
08/25/2011	0.24	0.00	583	17.9	97.0	56.1	75.5	94	30	59	60.4	3.7	88.1	78.0
08/26/2011	0.23	0.00	553	19.8	96.6	63.1	78.7	89	34	59	63.3	3.6	86.6	79.1
08/27/2011	0.24	0.00	565	20.4	98.3	62.8	78.4	90	36	61	64.1	4.3	104.5	79.9

08/28/2011	0.23	0.00	561	20.6	96.3	63.9	77.7	91	39	64	64.3	4.0	95.9	80.4
08/29/2011	0.24 R	0.00	580	18.4	97.7	57.7	73.6	94	29	65	61.1	3.9	93.9	80.2
08/30/2011	0.22	0.00	568	17.6	91.1	55.6	70.0	94	39	70	59.9	4.2	100.3	79.5
08/31/2011	0.21	0.00	560	16.7	87.7	53.3	68.8	94	42	69	58.4	3.9	93.7	78.8
Tots/Avgs	7.10	0.00	597	16.9	89.7	55.3	70.6	92	39	66	58.6	4.1	99.4	79.4

Escondido SPV - South Coast Valleys - Station 153

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
09/01/2011	0.20	0.00	542	15.8	90.3	52.4	68.4	94	33	67	56.9	3.3	80.5	78.1
09/02/2011	0.20	0.00	536	15.8	88.4	50.1	67.6	95	38	68	56.8	3.1	76.0	77.6
09/03/2011	0.21	0.00	559	16.4	88.2	52.1	69.2	95	39	67	57.9	3.3	78.8	77.5
09/04/2011	0.20 R	0.00	543	16.0	93.1	51.4	69.6	95	32	65	57.2	3.1	74.0	77.4
09/05/2011	0.06	0.01	185	20.2	85.8	60.1	71.9	90	52	76	63.8	3.3	80.0	77.2
09/06/2011	0.15	0.01	396	21.8	102.9	67.8	80.8	93	27	61	65.9	2.6	61.8	77.2
09/07/2011	0.23	0.00	545	19.0	103.4	62.6	80.6	94	28	53	62.1	2.9	69.2	78.4
09/08/2011	0.24	0.00	554	15.1	101.9	53.8	76.9	92	18	48	55.5	3.3	79.4	79.1
09/09/2011	0.19	0.00	537	15.6	86.4	48.5	66.3	94	44	70	56.4	3.8	92.6	78.3
09/10/2011	0.15	0.00	458	15.8	80.0	58.6	66.2	88	49	72	56.9	3.4	83.2	77.5
09/11/2011	0.19	0.00	549	15.0	82.9	49.5	66.8	91	43	67	55.5	3.4	83.2	76.8
09/12/2011	0.17	0.00	490	14.8	88.5	45.0 Y	63.4	97	32	74	55.1	2.7	64.6	75.3
09/13/2011	0.17	0.00	501	17.0	83.4	55.3	65.9	97	53	78	58.9	3.4	81.9	72.1
09/14/2011	0.15	0.00	452	16.6	82.8	54.2	65.4	95	51	78	58.3	2.9	69.0	72.6
09/15/2011	0.16	0.00	481	17.3	82.8	55.1	66.5	95	52	78	59.5	3.2	78.1	73.0
09/16/2011	0.14	0.00	440	17.2	77.4	61.3	66.3	89	60	78	59.2	3.5	83.4	73.3
09/17/2011	0.16	0.00	482	15.6	80.1	49.8	64.9	93	51	74	56.4	3.1	74.9	73.2
09/18/2011	0.17	0.00	510	15.5	88.1	46.7	63.8	96	46	77	56.4	2.5	61.5	72.4
09/19/2011	0.17	0.00	506	16.1	85.9	48.1	64.9	97	49	77	57.4	2.6	62.3	72.4
09/20/2011	0.15	0.00	454	16.4	86.6	50.9	65.3	96	48	77	57.8	2.3	55.5	72.5
09/21/2011	0.17	0.00	494	15.8	87.4	49.1	65.5	95	42	74	56.8	2.2	53.4	72.6
09/22/2011	0.14	0.00	411	16.2	89.5	47.8	66.1	96	45	74	57.6	2.3	55.4	72.2
09/23/2011	0.12	0.01	383	17.1	87.7	49.8	64.5	96	50	83	59.1	2.0	48.4	72.1
09/24/2011	0.10	0.01	347	17.2	79.4	55.7	64.9	95	54	82	59.2	1.9	46.0	72.1
09/25/2011	0.14	0.00	445	16.1	78.6	60.1	66.4	90	51	72	57.3	2.4	58.3	71.9
09/26/2011	0.14	0.00	427	15.9	82.7	52.0	67.0	92	45	70	57.0	2.4	58.6	72.2
09/27/2011	0.16	0.00	476	15.2	90.0	46.7	64.2	96	38	74	55.7	3.0	71.2	71.7
09/28/2011	0.13	0.00	383	15.9	85.4	51.7	64.1	96	44	78	57.0	3.1	74.8	71.5
09/29/2011	0.17	0.00	470	14.7	87.4	49.3	65.8	96	36	68	54.9	3.2	77.0	71.3
09/30/2011	0.15	0.00	421	15.1	90.7	50.5	66.5	96	31	68	55.7	3.0	71.6	71.3
Tots/Avgs	4.88	0.04	466	16.4	87.3	52.9	67.5	94	43	72	57.8	2.9	70.2	74.4

Escondido SPV - South Coast Valleys - Station 153

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
10/01/2011	0.18	0.00	456	14.6	90.5	53.1	68.0	97	29	63	54.8	3.4	83.2	71.7

10/02/2011	0.17	0.00	439	14.1	91.3	50.2	67.0	98	28	62	53.8	3.4	82.1	68.7
10/03/2011	0.15	0.00	402	13.9	84.0	51.2	64.7	93	38	67	53.4	3.8	90.9	68.5
10/04/2011	0.05	0.02	204	14.9	69.0	53.2	59.3	94	67	86	55.2	3.8	91.3	67.7
10/05/2011	0.02	0.00	109	14.5	64.4	51.7	57.8	97	71	89	54.5	4.2	100.4	66.7
10/06/2011	0.12	0.01	406	12.0	68.0	47.0	55.8	97	53	79	49.4	3.8	92.1	65.6
10/07/2011	0.15	0.00	461	10.7	75.2	44.0	57.4	92	34	67	46.4	3.7	88.6	64.6
10/08/2011	0.16	0.00	463	9.9	82.5	40.5	60.0	95	23	56	44.2	3.4	82.6	64.3
10/09/2011	0.18	0.00	458	9.7	85.0	44.5	63.6	90	21	48	43.7	3.8	92.6	64.7
10/10/2011	0.16	0.00	450	10.8	83.8	43.1	61.4	93	24	58	46.5	3.2	78.3	64.8
10/11/2011	0.16	0.00	443	12.1	86.2	45.0	63.9	94	28	60	49.6	2.8	66.9	65.2
10/12/2011	0.18 R	0.00	447	12.3	103.0 Y	46.9	71.8	97	13	46	50.1	3.0	73.1	66.0
10/13/2011	0.19	0.00	447	11.4	98.9 Y	51.5	71.2	87	15	44	47.9	3.3	79.5	67.2
10/14/2011	0.16	0.00	424	13.7	89.3	49.7	66.2	93	28	63	53.0	3.6	87.2	67.4
10/15/2011	0.14	0.00	417	15.7	82.2	53.7	64.7	94	49	75	56.6	3.7	88.3	67.8
10/16/2011	0.12	0.00	379	15.2	82.7	52.1	63.7	94	45	75	55.8	3.0	73.1	67.9
10/17/2011	0.15	0.00	426	13.8	86.9	44.2	64.4	96	34	67	53.1	3.0	71.8	67.6
10/18/2011	0.11	0.00	350	15.2	84.2	52.3	62.2	96	44	80	55.8	2.9	69.1	67.7
10/19/2011	0.08	0.00	299	15.1	74.2	53.3	60.7	94	60	83	55.6	3.5	84.2	67.6
10/20/2011	0.12	0.00	379	14.8	75.6	54.8	62.4	90	53	77	55.0	4.4	105.9	67.4
10/21/2011	0.11	0.00	370	14.7	76.2	48.5	62.6	93	55	76	54.8	3.1	74.7	67.8
10/22/2011	0.13	0.00	395	13.7	87.4	44.8	61.1	95	40	75	53.0	2.4	57.5	67.1
10/23/2011	0.12	0.00	380	14.4	85.3	50.7	60.3	96	39	81	54.3	3.1	75.4	67.2
10/24/2011	0.06	0.00	258	15.7	73.0	52.8	59.6	97	64	90	56.7	3.6	86.5	66.8
10/25/2011	0.06	0.00	247	14.6	67.7	54.6	59.8	97	60	83	54.7	3.3	79.3	65.0
10/26/2011	0.10	0.00	333	13.2	72.2	43.9	58.5	95	57	79	52.0	2.8	68.7	64.9
10/27/2011	0.13	0.00	402	8.0	78.1	33.3 Y	54.6	96	25	55	38.8	3.1	75.7	63.3
10/28/2011	0.12	0.00	381	7.8	81.7	32.1 Y	53.8	92	23	55	38.1	2.6	63.9	61.8
10/29/2011	0.13	0.00	395	8.6	84.2	36.2 Y	56.8	93	25	54	40.5	2.5	60.0	61.3
10/30/2011	0.13	0.00	391	8.6	88.1	34.9 Y	56.9	91	22	54	40.5	2.6	62.9	61.0
10/31/2011	0.12	0.00	384	9.4	84.5	36.6 Y	56.3	94	27	61	42.9	2.3	55.0	60.8
Tots/Avgs	3.96	0.03	380	12.7	81.8	46.8	61.5	94	39	68	50.3	3.3	78.7	66.0

Flag Legend		
A - Historical Average	I - Ignore	R - Far out of normal range
C or N - Not Collected	M - Missing Data	S - Not in service
H - Hourly Missing or Flagged Data	Q - Related Sensor Missing	Y - Moderately out of range
Conversion Factors		
Ly/day/2.065=W/sq.m	inches * 25.4 = mm	(F-32) * 5/9 = c
mph * 0.447 = m/s	mBars * 0.1 = kPa	--