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

Task 3 Literature Review
Book 2 Part 1: Diseases Transmitted by Mosquitoes

Prepared for:

Suffolk County Department of Public Works
Suffolk County Department of Health Services
Suffolk County, New York

CASHIN ASSOCIATES, P.C.

January 2005

SUFFOLK COUNTY LONG TERM PLAN	
The Consultant Team	
Cashin, Associates, P.C.	Hauppauge, NY
Subconsultants	
Cameron Engineering, L.L.P.	Syosset, NY
Integral Consulting	Annapolis, MD
Bowne Management Systems, Inc.	Mineola, NY
Kamazima Lwiza, PhD	University at Stony Brook, NY
Ducks Unlimited	Stony Brook, NY
Steven Goodbred, PhD & Laboratory	University at Stony Brook, NY
RTP Environmental	Westbury, NY
Sinnreich, Safar & Kosakoff	Central Islip, NY
Bruce Brownawell, PhD & Laboratory	University at Stony Brook, NY
Anne McElroy, PhD & Laboratory	University at Stony Brook, NY
Andrew Spielman, PhD	Harvard School of Public Health, Boston, MA
Richard Pollack, PhD	Harvard School of Public Health, Boston, MA
Wayne Crans, PhD	Rutgers University, New Brunswick, NJ
Susan Teitelbaum, PhD	Mount Sinai School of Medicine, NY
Zawicki Vector Management Consultants	Freehold, NY
Michael Bottini, Turtle Researcher	East Hampton, NY
Robert Turner, PhD & Laboratory	Southampton College, NY
Christopher Gobler, PhD & Laboratory	Southampton College, NY
Jerome Goddard, PhD	Mississippi Department of Health, Jackson, MS
Sergio Sanudo, PhD & Laboratory	University of Stony Brook, NY
Suffolk County Department of Health Services, Division of Environmental Quality	Hauppauge, NY
Project Management	
Richard LaValle, P.E., Chief Deputy Commissioner	Suffolk County Department of Public Works, Yaphank, NY
Vito Minei, P.E., Director, Division of Environmental Quality	Suffolk County Department of Health Services, Hauppauge, NY
Walter Dawydiak, Jr., P.E., J.D., Chief Engineer, Division of Environmental Quality	Suffolk County Department of Health Services, Hauppauge, NY
Dominick Ninivaggi, Superintendent, Division of Vector Control	Suffolk County Department of Public Works, Yaphank, NY

Primary research for this report was conducted by Cashin Associates (personnel including John Perrotta and David J. Tonjes, PhD). It was edited and revised in response to comments by Cashin Associates (personnel including David Tonjes, PhD). Review was provided by Suffolk County Department of Public Works, Division of Vector Control, and Suffolk County Department of Health Services (personnel including Erin Duffy). Additional comments have been received from _____.

Table of Contents

EXECUTIVE SUMMARY 1
1. INTRODUCTION..... 3
2. MOSQUITO-BORNE DISEASES WORLDWIDE 4
2.1 Malaria 5
2.2 Yellow Fever 6
2.3 Dengue Fever..... 7
2.4 Filariasis..... 8
2.5 Encephalitis..... 9
2.6 Other 11
3. SIGNIFICANT DISEASES, UNITED STATES.....12
3.1 Malaria 12
3.2 Yellow Fever.....13
3.3 Encephalitis.....13
4. Mosquito-borne Diseases in Suffolk County 15
4.1 Recent Incidence.....15
4.2 Vectors 15
REFERENCES.....18

TABLES
1. Important Mosquito-borne Arboviruses that Cause Disease 5
2. US Malaria Cases, 1991-2001 12

Abbreviations and Acronyms

CDC	Centers for Disease Control and Prevention
DHF	Dengue hemorrhagic fever
EEE	Eastern equine encephalitis
JE	Japanese encephalitis
LAC	LaCrosse encephalitis
MVE	Murray Valley encephalitis
SLE	St. Louis encephalitis
VEE	Venezuelan equine encephalitis
WEE	Western equine encephalitis
WHO	World Health Organization
WNV	West Nile virus

Executive Summary

Mosquito-borne disease, worldwide, is one of the greatest threats to human health. Malaria alone kills over one million people every year. Additionally, other mosquito-borne diseases either can, or have, wreaked havoc through epidemics and other disease events.

Although some mosquito-borne diseases are spread by parasites, such as malaria and filiarsis, most of them are viral. These kinds of disease are classified as arboviruses, which stands for arthropod-borne disease. Ticks, for example, are another arthropod that carry arboviruses. .

Worldwide, malaria is the most important mosquito-borne disease, however, yellow fever, Dengue fever, filiarsis, and various encephalitises are also of concern. Malaria has been nearly eradicated in the US, and Dengue fever and filiarsis are not found here. Yellow fever, an important disease in this country at one time, has not occurred for over a hundred years. The diseases of greatest concern in the US at this time are five encephalitises:

- St. Louis encephalitis
- Eastern Equine encephalitis
- Western equine encephalitis
- La Crosse encephalitis
- West Nile virus.

Other than West Nile virus, these diseases appear to be cyclical in nature. There are indications that particular weather patterns foster more cases. Another suggestion is that these diseases are not native to many areas where they occur; the process of re-introduction of the disease to an area may require several years to cause an outbreak, and may be require particular weather conditions to become especially virulent. Typically, an outbreak of the non-West Nile virus encephalitises may account for hundreds of cases nationwide during an outbreak. West Nile virus is a novel disease to this country, being first diagnosed in 1999. In comparison to the hundreds of cases associated with the other four encephalitises, West Nile virus accounted for

nearly 10,000 cases in 2003. Research is being conducted in weather-dependent causation of West Nile virus, but, to date, there is little suggestion that is the case.

Suffolk County has declared public health emergencies due to mosquito-borne diseases in seven years of the decade from 1994 to 2003. Eastern equine encephalitis was responsible for the concerns in 1994 and 1996; malaria was a problem in 1999 - two cases apparently initiated in the county; and the outbreak of West Nile virus, beginning in 1999, has led to declared public health threats from 1999 through 2003.

Factors associated with the greater mobility of people, animals, and goods, and stresses leading to failures in formerly well-established public health services appear to be responsible for the greater number and wider range of mosquito-borne diseases afflicting people in this century. It is unlikely that the US and, perhaps, Suffolk County has experienced its last novel arbovirus event.

1. Introduction

Merriam-Webster Medical Dictionary (2002) defines a vector as an organism that transmits a pathogen from one organism or source to another. A female mosquito is well-suited to become a vector because it feeds on the blood of multiple hosts in its lifetime. When a mosquito feeds on an infected host the mosquito ingests microorganisms along with the host's blood. After gestating within the mosquito, the microorganisms are passed to a new host through the mosquito's saliva during subsequent feedings (Spielman and D'Antonio, 2001). Most mosquito-borne diseases are arboviruses, a contraction of **ar**thropod-**bo**rne **virus** (Gubler, 2001). A major exception being malaria, which is spread by protozoan parasites, chiefly *Plasmodium falciparum* (Joy et al., 2003).

2. Mosquito-borne Diseases Worldwide

As world travel increases, and populations expand into tropical areas, the incidences of vector borne diseases are increasing. The major arboviruses that cause human illness are listed in Table 1 (Gubler, 2001).

Arboviruses are reemerging and spreading throughout the world due to a variety of factors that define the modern world and its disfunctions (Gubler, 2001). These include:

- demographic changes (urbanization, population explosions, and emigration)
- societal changes (encroachment on hitherto unpopulated areas, transport of animals, commodities, and people, containerized shipping)
- modern agriculture (changes in land use, increased irrigation, deforestation)
- changes in pathogens caused by greater interactions between different human and animal populations (some pathogen changes may be genetic and unrelated to human causes)
- public health failures (mosquito control ineffectiveness, infrastructure fraying leading to inability to address vector-borne diseases, loss in disease surveillance and prevention programs)
- possible climate changes (increased temperature, changes in precipitation patterns, more extreme weather events leading to mosquito proliferation)

Major emerging vector-borne diseases, not all of which are mosquito-borne, of the 21st century include:

- the Flaviviridae: Dengue hemorrhagic fever, yellow fever, Japanese encephalitis, West Nile virus, and Kyasanur Forest disease virus
- the Togaviridae: Venezuelan equine encephalitis, epidemic polyarthritis, Barmah Forest, and Mayaro
- the Bunyaviridae: Rift Valley fever, Oropouche, California encephalitis, and Crimean-Congo hemorrhagic fever

Table 1. Important Mosquito-borne Arboviruses that Cause Disease

Family/Virus	*Vertebrate Host*	*Geographic Distribution*	*Epidemics*
Gaviridae			
Chikungunya[α]	humans, primates	Africa, Asia	yes
Ross River[α]	humans, marsupials	Australia, So. Pacific	yes
Mayaro[α]	birds	South America	yes
O'nyong-nyong[α]	?	Africa	yes
Sinbis	birds	Asia, Africa, Australia, Europe, Americas	yes
Barmah Forest[α]	?	Australia	yes
Eastern equine encephalitis	birds	Americas	yes
Western equine encephalitis	birds, rabbits	Americas	yes
Venezuelan equine encephalitis[α]	rodents	Americas	yes
Viviridae			
Dengue 1-4	humans, primates	worldwide in tropics	yes
Yellow Fever	humans, primates	Africa, South America	yes
Japanese encephalitis	birds, pigs	Asia, Pacific	yes
Murray Valley encephalitis	birds	Australia	yes
Rocio	birds	South America	yes
St. Louis encephalitis	birds	Americas	yes
West Nile	birds	Africa, Asia, Europe, North America	yes
Nyaviridae			
Rift Valley Fever[α]	?	Africa, Middle East	Yes
La Crosse encephalitis	rodents	North America	No
California encephalitis	rodents	North America, Europe, Asia	Yes

2.1. Malaria

Malaria is a parasitic disease that can cause an array of symptoms and complications ranging from flu-like symptoms to anemia, jaundice, kidney failure, coma and death (CDC, 2000).

Malaria is found in over 100 countries, and more than 40 percent of the world's population is at risk from this disease. The World Health Organization (WHO) estimates that there are 300 to 500 million cases of malaria each year, with more than one million deaths (CDC, 2000). Most of those who die from malaria are young children. For those that survived childhood malaria, a malaria incidence as an adult is unlikely to be fatal (Spielman and D'Antonio, 2001).

Ninety percent of malaria cases occur in sub-Saharan Africa. The disease is also found in Central and South America, the Middle East, Southeast Asia and Oceania. Areas of limited risk include North America, Europe and Asia. Approximately 1,200 cases of malaria are diagnosed in the United States each year (CDC, 2000).

Malaria is caused by one of four parasites (*Plasmodium falciparum, P. vivax, P. ovale,* and *P. Malariae)*, each causing a different type of Malaria. *P. falciparum* is considered the worst, with a fatality rate of one to two percent (Joye et al., 2003).

Symptoms of *P. falciparum* include fever, headache and weakness. Complications include: cerebral malaria, infection of the brain; severe malaria, parasites reproduce in uncontrollable quantities; and placental malaria, causing complications with pregnancy. Each of these complications is often fatal. *P. falciparum* is the major strain found in sub-Saharan Africa, and is frequently resistant to drugs. Illness caused by the other strains is rarely fatal (MFI, 1999-2003).

Malaria parasites require both a human and mosquito host to live, and the mosquito must be of the genus *Anopheles*. When feeding on an infected person, mosquitoes ingest microscopic malaria parasites, which develop and reproduce in the mosquito's gut for about a week before they can be transmitted to a human. The parasites are transmitted to the human host through the salivary glands of the mosquito (Budiansky, 2002).

Once transmitted to a new human host, the parasites travel to the liver, where they continue to develop and reproduce before entering the bloodstream. Once in the bloodstream, they take up residence in red blood cells, where they continue to grow and multiply. During this time, the red blood cells burst releasing the parasites to other red blood cells, as well as toxins, which make the human host develop fever and flu-like symptoms including shaking, chills, anemia, headache, muscle ache and exhaustion. Nausea, vomiting and diarrhea can also occur. Illness generally lasts from 10 to 14 days (Spielman and D'Antonio, 2001).

Various drugs are used to treat the disease. The most widely used are quinine, chloroquine, and sulfadoxone/pyrimethamine. These drugs form complexes in the blood, which are toxic to the malaria parasite (MFI, 1999-2003).

2.2. Yellow Fever

Yellow fever, transmitted primarily between non-human primates and mosquitoes, is caused by a zoonotic virus, a disease of animals. When a human becomes the host, the disease is considered urban yellow fever (CDC, 2003a).

The yellow fever virus enters the host and incubates from three to six days. After the incubation period, the disease develops in two phases, and may be transmitted by mosquitoes to other humans. The first, which lasts three to four days, may result in fever, muscle pain, headache, shivers, loss of appetite and nausea (WHO, 2001).

In 85 percent of those infected, symptoms disappear after the first phase. The remaining 15 percent, however, enter a second phase within 24 hours of the first. The second phase is characterized by fever, jaundice, abdominal pain, and bleeding from the mouth, nose, eyes and/or stomach and kidney failure. The disease is fatal for approximately half of those who experience the second phase of the virus (WHO, 2001).

WHO estimates that approximately 200,000 cases occur per year, resulting in about 30,000 deaths. The disease is primarily found in sub-Saharan Africa and tropical regions of South America, but has occurred in Europe and North America (WHO, 2001).

The disease places infants and children at greatest risk for infection and there is no treatment for the virus. Afflicted people are often treated for the side effects of the disease, such as dehydration and pain (WHO, 2001).

Yellow fever is one of the few diseases worldwide that some countries require travelers visiting affected areas receive vaccinations. The vaccination provides up to 10 years of immunity from the disease, which is a key feature of the prevention of yellow fever. There is no cure for the disease; any treatment is only symptomatic (WHO, 2001).

2.3. Dengue Fever

Dengue fever is a virus nicknamed “bone break fever”, which can cause sudden and severe incapacitating illness including headache, high fever, and extreme muscle and joint pain. It can lead to Dengue hemorrhagic fever (DHF), which is frequently fatal (Budiansky, 2002).

The disease is found in approximately 100 countries in tropical and subtropical regions throughout the world and places about 2.5 billion people at risk. WHO estimates approximately 50 million cases of Dengue infection occur worldwide annually. The geographic area affected by Dengue is increasing with time, and, thus, the incidence of Dengue is increasing each year (WHO, 2002).

The disease is caused by one of four serotypes of *Flavivirus* (DEN-1, DEN-2, DEN-3, and DEN-4), and is transmitted primarily by the *Aedes aegypti* mosquito. Infection from one serotype offers lifetime immunity; however, there is no cross-immunity between serotypes (WHO, 2002).

Once in the bloodstream, the virus circulates for two to seven days, causing fever and flu-like symptoms in the host. DHF, a complication of Dengue fever, includes hemorrhaging, high fever, enlargement of the liver, and, frequently, failure of the circulatory system. The afflicted either die from shock within 12 to 24 hours, or recover with proper medical treatment (Spielman and D'Antonio, 2001).

The fatality rate is approximately two and a half percent for Dengue fever and over 20 percent for DHF. Treatment can reduce the fatality rate for DHF to approximately one percent (WHO, 2002).

During the two to seven days that the virus circulates throughout the bloodstream, a mosquito feeding on the host may contract the disease. The disease must develop in the mosquito for eight to ten days before the mosquito can transmit the disease. Once infected, the mosquito can transmit the disease for the rest of its life. In addition, the mosquito can pass the virus to its offspring through eggs (CDC, 2003b).

There is no specific medical treatment or vaccine for Dengue fever. Prevention is crucial to fighting the disease. Combating the vector mosquito, *Aedes aegypti*, has been determined to be the most effective means of prevention (CDC, 2003b).

2.4. Filariasis

Filariasis is caused by the Filaria worm and causes inflammation of the lymph nodes occasionally leading to elephantiasis, a build up of lymphatic fluid which causes swelling in parts of the body, particularly the arms, legs and genitals (GAELF, 2004).

According to the Centers for Disease Control and Prevention (CDC), lymphatic filariasis is a leading cause of permanent and long-term disability worldwide. People with the disease can suffer pain, disfigurement, and sexual disability. The disease affects over 120 million people, in over 80 countries; 1.1 billion people are at risk of contracting the disease. Filariasis is found in

Asia, Africa, Oceania, and Central and South America, including parts of Caribbean (CDC, 2003c).

Mosquitoes act as vectors for filariasis when they ingest microfilariae, newly born worms, during a bloodmeal, which then partly develop in the mosquito before being passed to humans. The microfilariae complete development in the human body (GAELF, 2004).

Male and female worms settle in lymph nodes, where they live and reproduce. Eggs are fertilized, and hatch within the female worm's uterus. Microfilariae are then distributed in lymphatic circulation and pass into bloodstream, where they can be ingested by mosquitoes and passed to another host (GAELF, 2004).

The limited function of affected lymph system makes it difficult for the body to fight germs, which lead to bacterial infections in the skin. The preferred course of treatment is to clean affected areas and use anti-bacterial treatments on wounds. In some cases, surgery is necessary to alleviate problems associated with elephantiasis (GAELF, 2004).

Prevention of the disease can be achieved through the use of drugs, such as mefloquine, which is 90 percent effective, and avoiding mosquito bites (GAELF, 2004).

2.5. Encephalitis

Encephalitis is virus that causes an inflammation of the brain, which may result in headache and fever, and can progress to paralysis, seizures, coma and death.

There are many types of encephalitis. The major mosquito vector transmitted strains are:

- Eastern equine encephalitis (EEE)
- Japanese encephalitis (JE)
- LaCrosse encephalitis (LAC)
- Murray Valley encephalitis (MVE)
- St. Louis encephalitis (SLE)

- Venezuelan equine encephalitis (VEE)
- Western equine encephalitis (WEE)
- West Nile encephalitis (WNV)

Encephalitis is found in the temperate zones throughout the world, with SLE, EEE, WEE, LAC and WNV in North America, VEE, EEE, WEE, and SLE in South America, WNV in Africa, Europe and the Middle East, JE in Asia, India and Oceania, and MVE in Australia (CDC, 2003d).

WNV is an inflammation of the brain, which affects humans, horses, birds and other mammals. The disease, which is closely related to SLE, is divided into several categories:

- West Nile virus
- West Nile fever
- West Nile encephalitis
- West Nile meningitis
- West Nile meningoencephalitis.

West Nile fever is characterized by mild fever and flu-like symptoms. West Nile encephalitis is an inflammation of the brain. West Nile meningitis is an in inflammation of the membrane around the brain and spinal cord, and West Nile meningoencephalitis is an inflammation of the brain and membrane surrounding it (CDC, 2004).

Risk of contracting WNV is low; approximately one percent of those bitten will experience symptoms. Approximately 80 percent of those affected with WNV show no symptoms; those that do have symptoms show them within three to 14 days of infection. These symptoms include headache, fever, nausea, and body aches, and generally last a few days (CDC, 2004).

However, approximately one in 150 of those infected will be seriously affected with symptoms including high fever, severe pain, paralysis and coma. Symptoms may last several weeks and neurological effects may be permanent (CDC, 2004).

EEE causes symptoms ranging from fever and flu to encephalitis, coma and death. EEE has a fatality rate of 35 percent, and 35 percent of survivors suffer permanent neurological damage. EEE particularly affects people younger than 15 and older than 50 (CDC, 2003d).

JE, though typically mild, can cause paralysis, coma and death. The fatality rate is 30 percent, with 30 percent of survivors suffering permanent neurological damage (CDC, 2003d).

LAC and SLE are similar in that they are rarely fatal, with the infection producing mild symptoms that can progress to seizures and coma. WEE can range from mild fever and flu-like symptoms to severe encephalitis and death (CDC, 2003d).

2.6. Other

Mosquitoes are responsible for transmitting various other diseases, which are not significant on a global scale. Some of these diseases include Jamestown Canyon virus and Cache Valley fever in the US, Rift Valley Virus in Africa, and Murray Valley Virus and Ross River Virus in Australia (Spielman and D'Antonio, 2001).

3. Significant Diseases - United States

Of the major, world-wide mosquito-borne diseases, malaria and yellow fever have historically been found in the US, carried by local mosquitoes. Although dengue fever-like illnesses have been reported throughout the Americas for 200 years, it is not thought to have been transmitted by US mosquitoes. Neither has filariasis. Encephalitis has attracted more attention with the control of malaria and yellow fever.

3.1. Malaria

Malaria cases in the US now result from visitors or travelers returning from affected parts of the world, and introducing the disease here. Table 2 lists cases of malaria in the US and its territories from 1991-2001 (CDC, 1995; CDC, 1997a, b; CDC, 1999; CDC, 2001a, b; CDC, 2002a, b; CDC, 2003e).

Table 2. US Malaria Cases, 1991-2001

YEAR	REPORTED CASES	PERCENT CHANGE FROM PREV. YEAR	REPORTED DEATHS	NUMBER INFECTED IN U.S.
2001	1,383	-1.4	11	2
2000	1,402	-9.0	6	4
1999	1,540	+25.5	5	3
1998	1,227	-20.5	4	5
1997	1,544	+10.9	6	5
1996	1,392	+19.3	NOT AVAIL.	NOT AVAIL.
1995	1,167	+15.0	6	9
1994	1,014	-20.0	4	5
1993	1,275	+40.0	8	11
1992	910	-13.0	7	7
1991	1,046	NOT AVAIL.	NOT AVAIL.	NOT AVAIL.

The data show large fluctuations for the overall number of cases in the US. However, the number of people shown to have become infected with malaria in the US has continued to be very low, remaining less than 10 per year every year except 1993. Fatalities from malaria in the US have remained below 1 percent of the infected due to the high level of treatment available here.

3.2. Yellow Fever

It is believed that yellow fever was brought to the US from Africa via the slave trade. Notable outbreaks in the 18th and 19th Century included:

- Philadelphia, Pennsylvania (1793) killing about 10 percent of Philadelphia's population;
- New Orleans, Louisiana (1800s) killing over 1,000 in thirty five years;
- Mobile, Alabama (1850) killing about seven percent of the population;
- Norfolk and Portsmouth, Virginia (1855) killing about 10 percent of the population; and,
- Memphis, Tennessee (1878), killing about 15 percent of the population.

(Spielman and D'Antonio, 2001)

New York City has had several outbreaks of yellow fever, the first of which occurred in 1668. In 1702, yellow fever killed about 500 people in New York City. Bellevue Hospital was founded following an outbreak in 1795 that killed 732 people. A major outbreak in 1798 killed 2,086 and other outbreaks occurred in 1803, 1805, 1819 and 1822 (Spielman and D'Antonio, 2001).

Public sanitation efforts, including sanitary sewage systems and public water distribution systems, led to the demise of yellow fever in the US.

3.3. Encephalitis

Encephalitis is the most widely transmitted mosquito-borne disease in the US. There are five main encephalitis viruses in the US: EEE, WEE, SLE, LAC, WNV.

Between 1964 and 2000, the average number of cases in the US per year were:

- 121 cases of SLE per year
- 75 cases of LAC per year

- 18 cases of WEE per year
- 5 cases of EEE per year.

The number of cases follows a somewhat cyclical pattern with highs and lows generally occurring about the same time for the four diseases. (CDC, 2003d).

Until the advent of WNV, SLE was the most common form of mosquito-borne encephalitis in the United States. Major outbreaks occurred in:

- 1964 with 470 cases
- 1966 with 325 cases
- 1975 with 1,967 cases
- 1976 with 379 cases
- 1977 with 161 cases
- 1990 with 247 cases

(CDC, 2003d)

WNV now infects more people each year, for example, there were nearly 10,000 cases in 2003. As a novel infection in the US, WNV does not seem to follow the cyclical pattern of the other forms of encephalitis. It is not clear whether it eventually will (CDC, 2004).

4. Mosquito-borne Diseases in Suffolk County

4.1. Recent Incidence

Public health emergencies due to mosquito-borne diseases have been declared in seven of the past ten years. These health threats occurred in 1994, 1996, 1999, 2000, 2001, 2002 and 2003 (Graham and Harper, 2004).

The health threats prior to 1999 were due to EEE. Despite the fact that conditions appeared to constitute a risk of transmission of EEE from bird reservoirs to people, there were no resulting cases. In 1999, human health threats were declared due to malaria and the initial outbreak of WNV. The human health emergencies declared from 2000 to 2003 were all due to WNV (S. Campbell, SCDHS, personal communication, 2004).

From 1999 through 2003, 18 human cases of WNV meningitis or encephalitis occurred, and two human cases of malaria occurred. The cases occurred as follows:

- Two young children contracted malaria in 1999;
- One person contracted WNV meningitis in 2001;
- Eight people contracted WNV meningitis or encephalitis in 2002, two of which resulted in death;
- Nine people contracted WNV meningitis or encephalitis in 2003, two of which resulted in death.

(S. Campbell, SCDHS, personal communication, 2004)

Of the 18 human cases of WNV meningitis or encephalitis in Suffolk County, 11 resulted in neurological complications lasting months (P. Dillon, SCDHS, personal communication, 2004).

4.2. Vectors

Certain species of mosquitoes are recognized, or suspected, vectors for EEE, WNV and other mosquito-borne diseases by Suffolk County Vector Control and Suffolk County Department of Health Services (D. Ninivaggi, SCVC, personal communication, 2003). *Aedes vexans,*

Ochlerotatus sollicitans, Oc. taeniorhynch and *Oc. cantator* are salt marsh mosquitoes, and are considered to be aggressive feeders (CA-CE, 2004). Salt marsh mosquitoes present a particular worry as a vector threat because of their agressive biting, and their large populations in areas of Suffolk County.

Ae. vexans and *Oc. sollicitans* are known vectors for EEE, whereas *Oc. taeniorhynch* and *Oc. cantator* are unlikely, or are not capable, vectors for EEE. *Ae. vexans* and *Oc. cantator* are considered poor transmitters of WNV, while *Oc. sollicitans* and *Oc. taeniorhynch* are considered moderate transmitters of WNV. All of these salt marsh mosquitoes have tested field positive for WNV on Long Island (CA-CE, 2004).

Oc. trivittatus, and *Coquillettidia perturbans* are both freshwater mosquitoes, which are aggressive feeders. Both have tested field positive for WNV in Suffolk County. While *Oc. trivittatus* is an unlikely transmitter of EEE, it is a likely transmitter of WNV. *Co. perturbans* is a known vector for EEE, and is a poor transmitter of WNV (CA-CE, 2004).

Suffolk County's container breeding mosquitoes are *Oc. japonicus*, *Oc. triseriatus*, *Culex pipiens*, and *Cx. restuans*. *Oc. japonicus* and *Oc. triseriatus* are moderately aggressive to aggressive feeders which breed in containers and tree holes. They are not known, or are unlikely, to transmit EEE. However, they have tested field positive for WNV and are considered moderate to good transmitters of the disease (CA-CE, 2004).

Cx. pipiens and *Cx. restuans* breed in fresh, permanent water and in containers. They have both tested field positive for EEE and WNV in Suffolk County. *C. restuans* is a moderate transmitter of WNV; however, it is a bird biter. This mosquito may be considered a vector that transmits disease to a host, which is known as a bridge vector, from which another vector may transmit the disease to further hosts. *Cx. pipiens* is not very aggressive, but is considered to be the prime vector for West Nile virus in the north-east US (CA-CE, 2004).

Cx. salinarius and *Culiseta melanura* are the final key mosquito species in Suffolk County. *Cx. salinarius* breeds in fresh and brackish water habitats, and is an unlikely transmitter of EEE. It has tested field positive for WNV. Although it is a moderate transmitter of WNV, it is only considered a bridge vector. This mosquito is an aggressive biter, but is not a major pest species in Suffolk County. *Cs. melanura* breeds in maple and cedar swamps, and is a bird biter. It is an

epiornitic vector for EEE, transmitting the disease between bird species, which amplifies the incidence of the disease. *Cs. melanura* has tested field positive for WNV, but is not considered a transmitter of the disease (CA-CE, 2004).

REFERENCES

Budiansky, S. 2002. Creatures of our own making. Science 298:80-86.

CA-CE. 2004. Task 3 Literature Review, Book 1 Long Island Mosquitoes. Suffolk County Department of Health Services, Riverhead, NY. 58 pp.

CDC. 1995. Malaria Surveillance -- United States, 1992. http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00039398.htm

CDC. 1997a. Malaria Surveillance -- United States, 1993. http://www.cdc.gov/mmwr/preview/mmwrhtml/00046488.htm

CDC. 1997b. Malaria Surveillance -- United States, 1994. http://www.cdc.gov/mmwr/preview/mmwrhtml/00049647.htm

CDC. 1999. Malaria Surveillance -- United States, 1995. http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00056518.htm

CDC. 2000. Malaria: General Information. http://www.cdc.gov/travel/malinfo.htm.

CDC. 2001a. Malaria Surveillance -- United States, 1997. http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5001a2.htm

CDC. 2001b. Malaria Surveillance -- United States, 1998. http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5005a1.htm

CDC. 2002a. Malaria Surveillance -- United States, 1999. http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5101a2.htm

CDC. 2002b. Malaria Surveillance -- United States, 2000. http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5105a2.htm

CDC. 2003a. *Yellow Fever*. www.cdc.gov/travel/diseases/yellowfever.htm>.

CDC. 2003b. *CDC Dengue Fever Home Page*. http://www.cdc.gov/ncidod/dvbid/Dengue/

CDC. 2003c. *Fact Sheet: Lymphatic Filariasis*. http://www.cdc.gov/ncidod/dpd/parasites/lymphaticfilariasis/factsht_lymphatic_filar.htm>.

CDC. 2003d. *Arboviral Encephalitides*. http://www.cdc.gov/ncidod/dvbid/arbor/

CDC. 2003e. Malaria Surveillance -- United States, 2001. http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5205a1.htm

CDC. 2004. *West Nile Virus*. http://www.cdc.gov/ncidod/dvbid/westnile/index.htm

GAELF. 2004. *The Global Alliance to Eliminate Lymphatic Filariasis*. http://www.filariasis.org/index.pl.

Graham, DG, and BL Harper. 2004. The potential threat of mosquito-borne disease in Suffolk County. *The Suffolk County Medical Society-Suffolk County Academy of Medicine*, July. Public Health Page.

Gubler, DJ. 2001. Human arbovirus infections worldwide. pp. 13-24. In: White, DJ, and DL Morse (eds.). *West Nile Virus: Detection, Surveillance, and Control*. Annals of the New York Academy of Science, V. 951. New York, NY. 374 pp.

Joy, DA, X. Feng, J. Mu, T. Furuya, K. Chotianich, AU Krettli, M. Ho, A. Wang, NJ White, E. Suh, P. Beerli, and X-Z Su. 2003. Early origin and recent expansion of *Plasmodium falciparum*. *Science* 300:318-321.

Merriam-Webster Medical Dictionary. 2002. Merriam-Webster, Inc. New York, NY.

MFI. 1999-2003. *Malaria Foundation International*. http://www.Malaria.org/.

Spielman, A., and M. D'Antonio. 2001. *Mosquito*. Hyperion, New York, NY. 247 pp.

WHO. 2001. *Yellow Fever*. http://www.who.int/inf-fs/en/fact100.html.

WHO. 2002. *Dengue and Dengue Hemorrhagic Fever*. http://www.who.int/inf-fs/en/fact117.html