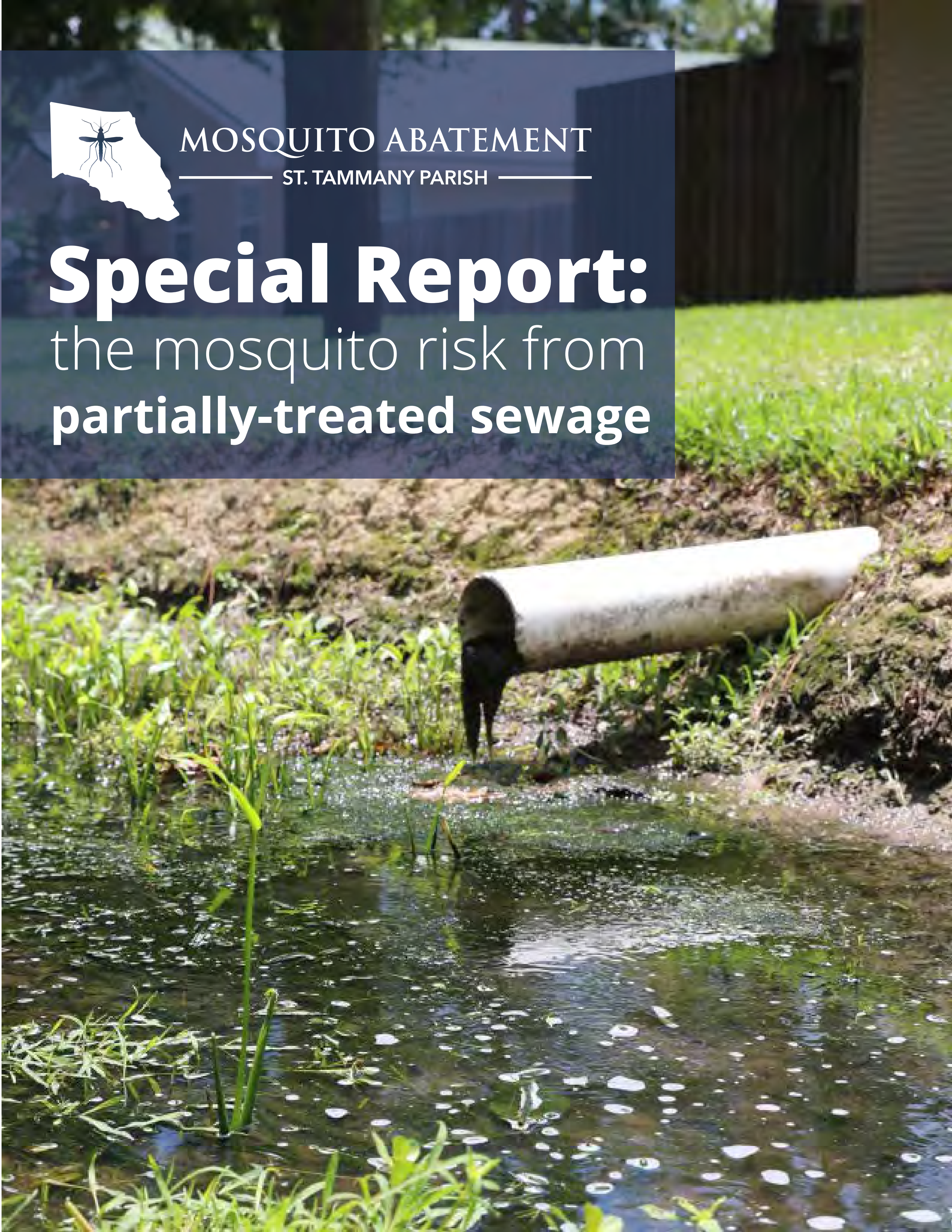
MOSQUITO ABATEMENT

ST. TAMMANY PARISH

Special Report:
the mosquito risk from **partially-treated sewage**



Foreword to this special report on the threat of sewage associated mosquito production

Dr. Kevin A. Caillouet
Director
St. Tammany Parish
Mosquito Abatement

The link between the primary vector of West Nile virus (WNV) in the Southern United States and sewage has been well established. Previous reports have documented increased risk of WNV at sites near combined sewer overflows in Atlanta due to the production of the southern house mosquito, *Culex quinquefasciatus*.

Of the 50 or so mosquito species in St. Tammany Parish only about a dozen are common and just a few of these are significant vectors of human pathogens. Of these, the southern house mosquito, *Culex quinquefasciatus*, accounts for most infected specimens collected in Louisiana for all three arboviruses found locally (Eastern equine encephalitis virus, St. Louis encephalitis virus, and WNV). This mosquito species' preference to feed on birds amplifies these arboviruses. It is our region's practice of discharging onsite wastewater treatment systems (OWTS), commonly known by the public as "septic systems", into drainage ditches that amplify the production of this dangerous vector mosquito.

With more OWTS than other parishes in Louisiana (as many as 65,000 by one estimate (see Figure 1; K.S. Irion 2018), St. Tammany also predominately has clay soils which prohibit the effective remediation of sewage discharges by percolating effluent through drain fields. Given the constraints of our local soil conditions, the Louisiana Sanitary Code, enforced by the Louisiana Department of Health, allows for the discharge of sewage effluent from OWTS that employ aerated treatment units (ATUs) into surface water drainages (see graphic on pages 5-6). By design, OWTS with functioning ATUs release "clean water" only. By practice, nearly 60% of OWTS are not maintained by homeowners or business owners (according to Dr. Brady Skaggs, Pontchartrain Conservancy, see report on page 3) -- releasing raw or partially treated sewage into drainage ditches and eventually into Lake Pontchartrain.

Traditional tools to manage mosquito populations including the use of insecticides to kill larval or adult mosquitoes are: 1) expensive; 2) not comprehensive (some sources can be missed); 3) can damage non-target organisms; 4) have risks to our applicators; and, 5) mosquito populations can develop resistance to these tools. **Spraying cannot be our only solution to this problem – it is simply a mitigation tool or band-aid.** Reducing the source of mosquito production by limiting the discharge of sewage effluent into open surface waters is our best tool for mitigating WNV vectors, because it addresses the root cause.

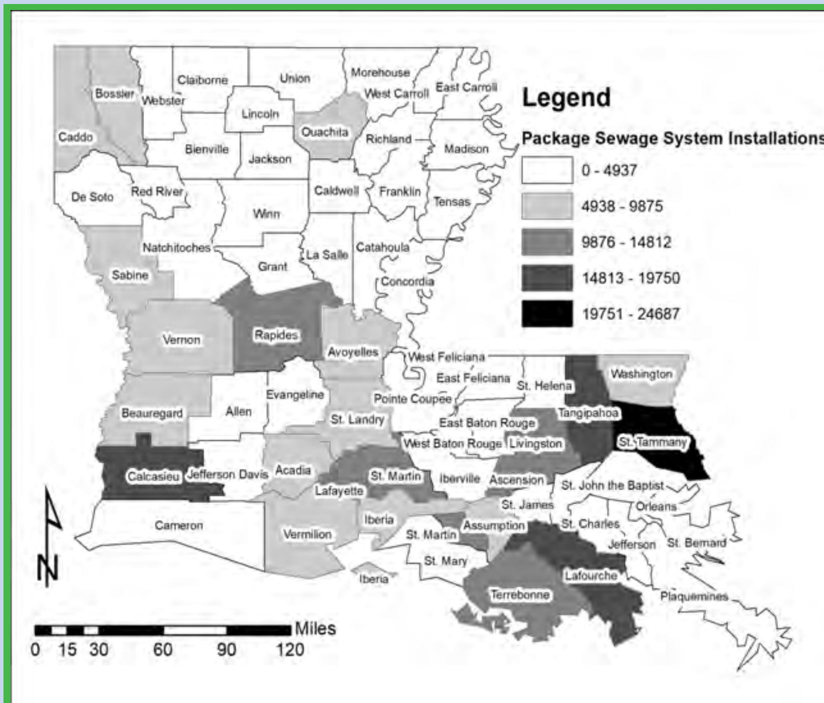


Figure 1. Estimated number of onsite wastewater treatment systems (OWTS) in Louisiana by parish. Data source: Karen S. Irion, Louisiana Department of Health, 2018.

Though the local practice of effluent discharge from OWTS to surface water is a significant threat to public health, it is not the only threat to the health of our community and environment. Exposure to human pathogens in partially treated sewage can cause a variety of gastrointestinal, skin, and eye infections. Excess nutrients in sewage also damages the environment by creating algal blooms and limiting oxygen in receiving waterways, both of which can lead to fish and other wildlife kills.

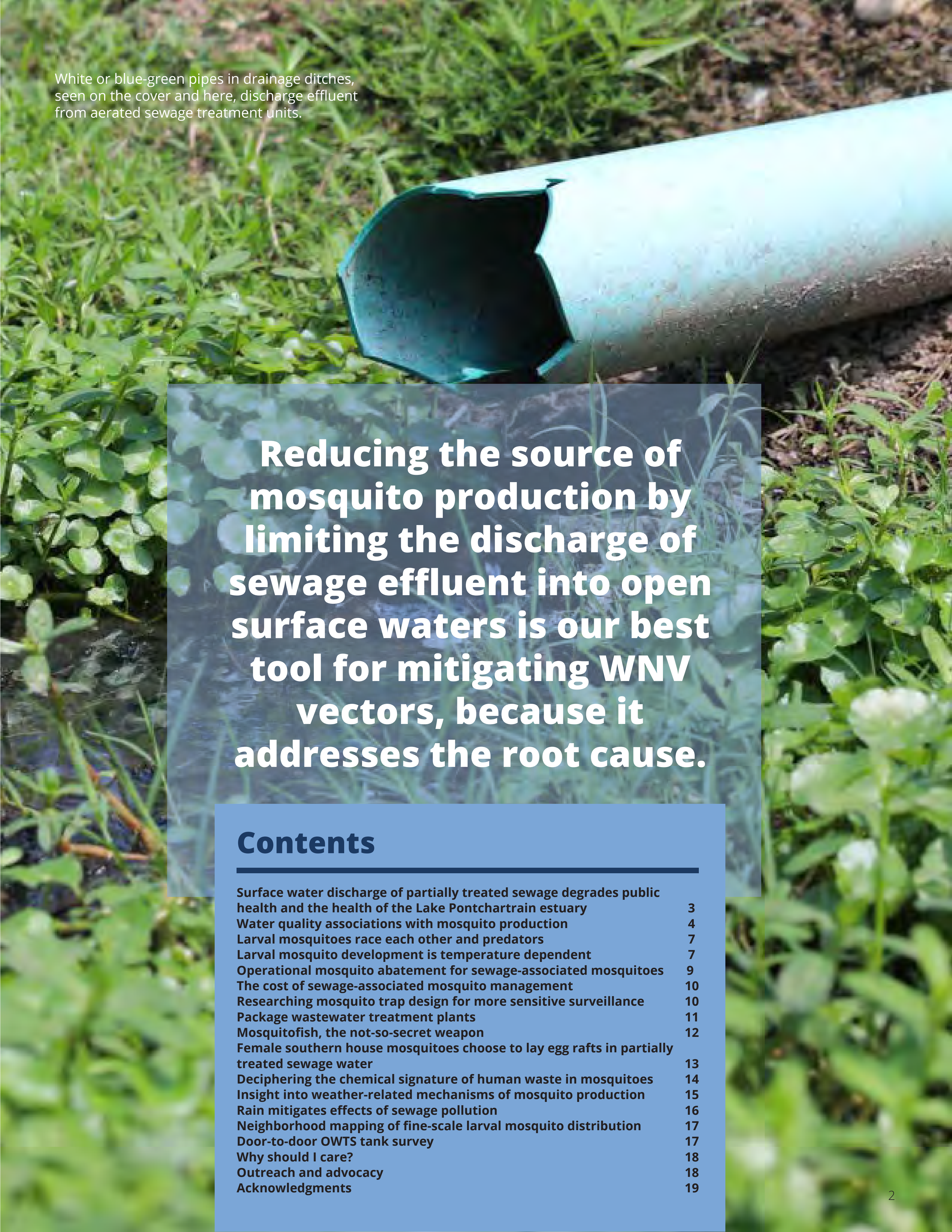
The **threat** from partially treated sewage to public health is real. The **scale** of the problem is significant with more than 600 miles of roadside ditches in St. Tammany Parish contaminated with sewage. The **urgency** of the problem is immediate, as each year we watch to see if St. Tammany will again be the canary in the West Nile coal mine. These are the reasons St. Tammany Parish Mosquito Abatement (STPMAD) is committed to better understand how best to mitigate the effects of sewage discharge and why we are advocating for community change to implement solutions.

The following pages of this special report document the work to date that Mosquito Abatement has conducted to:

1) understand the impact and ecology of sewage-associated mosquito production,

2) develop effective mosquito management tactics to mitigate these mosquitoes, and

3) focus advocacy efforts to develop solutions.



White or blue-green pipes in drainage ditches, seen on the cover and here, discharge effluent from aerated sewage treatment units.

Reducing the source of mosquito production by limiting the discharge of sewage effluent into open surface waters is our best tool for mitigating WNV vectors, because it addresses the root cause.

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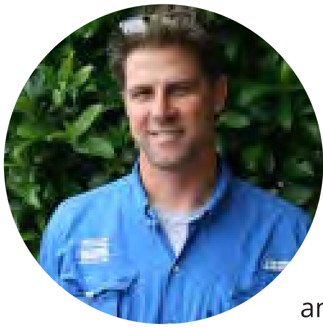
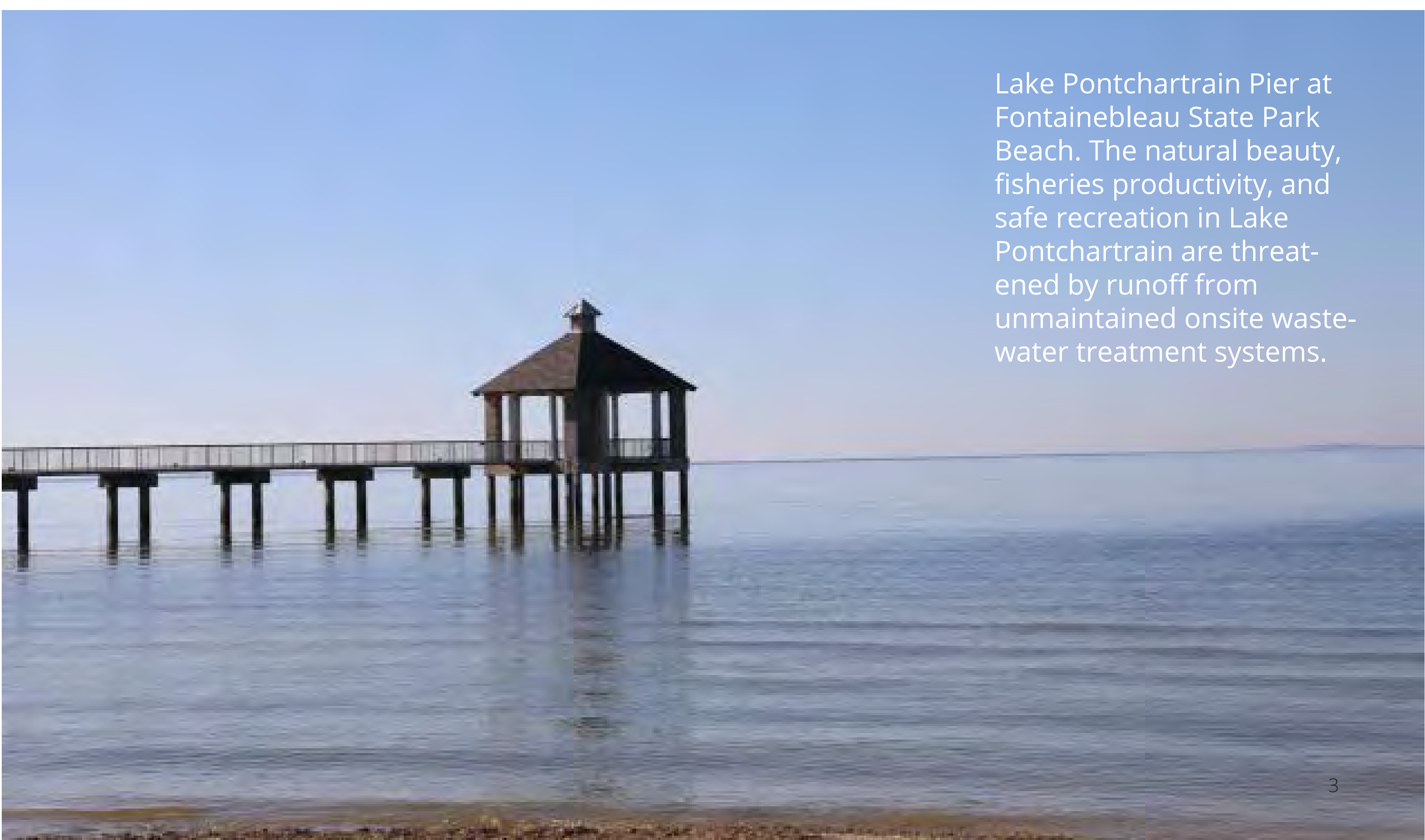
Surface water discharge of partially treated sewage degrades public health and the health of the Lake Pontchartrain estuary



By: Dr. Brady Skaggs
Water Quality Program Director
Pontchartrain Conservancy

Sanitary wastewater treatment in St. Tammany has special considerations for the treatment and disposal of wastewater. First, rapid development has occurred since 2000, and has largely outpaced the infrastructure for wastewater treatment. Most areas in south Louisiana have poor soil drainage, and make the use of septic systems unfeasible. Therefore, aerated treatment units (ATUs) are utilized onsite preferentially where connection to municipal wastewater systems are unpractical. ATU systems are mechanized and provide oxygen to provide both primary and secondary sewage treatment. These systems also differ from septic systems by directly discharging to surface water conveyance rather than groundwater (see pages 5-6). ATU systems installed at individual homes are not regulated by the US Environmental Protection Agency (US EPA) or the Louisiana Department of Environmental Quality (LDEQ) for the discharge of pollutants to receiving waters.

The root of the surface water problem is a permissive state policy allowing high density developments of single-family residences equipped with ATUs for sanitary wastewater management. Home ATU systems have a high failure rate nationally, and PC has observed neighborhood failure rates exceeding the national average at greater than 60% of the installed systems. Louisiana's topography and geological conditions, when coupled with failed systems, can lead to stagnating, untreated wastewater in drainage ditches in homeowners' front yards. Effluent produced by improperly maintained ATUs discharging into drainage ditches enhances mosquito production, and therefore, the possibility of increased pathogen transmission by mosquitoes.



Lake Pontchartrain Pier at Fontainebleau State Park Beach. The natural beauty, fisheries productivity, and safe recreation in Lake Pontchartrain are threatened by runoff from unmaintained onsite wastewater treatment systems.

Water quality associations with mosquito production

A four-year collaboration between the Pontchartrain Conservancy (PC) and St. Tammany Mosquito Abatement (STPMAD) on an EPA funded project has yielded important findings for our understanding of sewage-associated mosquitoes.

The project area, Ponchitolawa Creek Watershed, drains approximately 9,441 acres in St. Tammany Parish and is a tributary of the Lower Tchefuncte River, which flows into Lake Pontchartrain. The project watershed is within St. Tammany Parish, which has a watershed management plan developed by the Louisiana Coastal Protection and Restoration Authority that identified:

- **20 subdivisions not connected to community or centralized wastewater treatment systems;**
- **More than 1,686 residences that have septic tanks or Aerated Treatment Units (ATUs),**

Water quality measurements taken by STPMAD staff at 311 sites in 2019 and 2021 demonstrated that failing OWTS are associated with more acidic aquatic habitats in ditches receiving effluent ($P = 0.008$). In addition, mosquito larvae are 3.8 times more likely to be found in failing OWTS effluent than in ditches receiving partially-treated effluent from properly functioning systems. The probability of finding mosquito larvae was **3.5 times lower when fish were present,** potentially due to predation or oviposition deterrence. Mosquitofish absence was correlated with worsening water quality indicators such as higher total dissolved solids (TDS) ($P = 0.003$), and lower oxidation reduction potential (ORP) ($P = 0.027$). Despite these relationships, we did not find a statistical relationship between OWTS functioning status and fish presence ($P = 0.488$).

Unfortunately, we were not able to determine whether repaired or remediated OWTS reduced mosquito populations in a direct pre-to-post intervention study. However, correlative data suggesting that mosquito larvae are less likely to be found at OWTS that pass inspection indicate that remediating OWTS may limit mosquito production.

This study also determined that water depth is an important predictor of mosquitofish presence and mosquito absence as well. Mosquitoes were significantly more likely to be found in water less than three inches of depth (see Figure 2). By contrast mosquitofish are 6.8 times more likely to be found in water greater than six inches than in water between 0-3 in. Water depth may play several roles -- as a refuge during drought for water-bound fish, accessibility for fish to find mosquito prey, and as additional assimilative capacity for sewage pollutants.

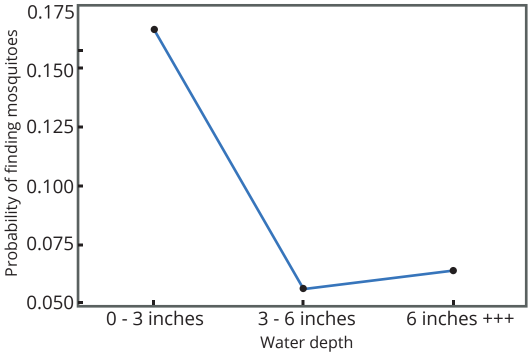


Figure 2. The relationship between water depth and the likelihood of finding larval mosquitoes.

The probability of **finding mosquito larvae** was **3.5 times lower when fish were present**

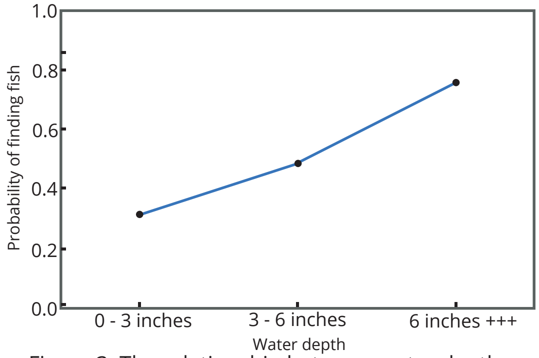
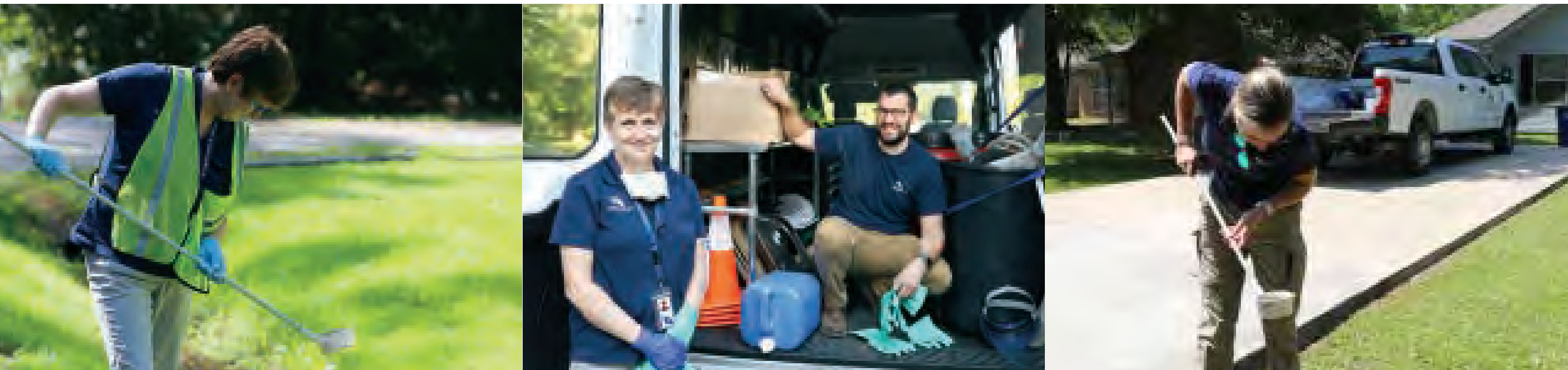


Figure 3. The relationship between water depth and the likelihood of finding predatory mosquitofish.

The Mosquito Abatement water quality team (seen here: Nick DeLisi, Lisa Rowley, and Shannon O'Meara) collect samples for an EPA funded project that is providing insight into the ecology of sewage associated mosquitoes.



Types of On-site Wastewater Treatment Systems in Louisiana

What steps should you take to maintain your OWTS?

- **CHECK THE AERATOR!** Is it running? Did it come unplugged or the GFI tripped?
- **GET AN ANNUAL INSPECTION!**
- **BE MINDFUL OF WHAT IS ENTERING YOUR SYSTEM.**
- **HAVE YOUR SYSTEM PUMPED OUT EVERY THREE TO FIVE YEARS.**
- **IF THE LIDS OR CAPS ARE CRACKED - GET THEM REPLACED!**
- **CALL US TO TREAT THOSE MOSQUITOES!**

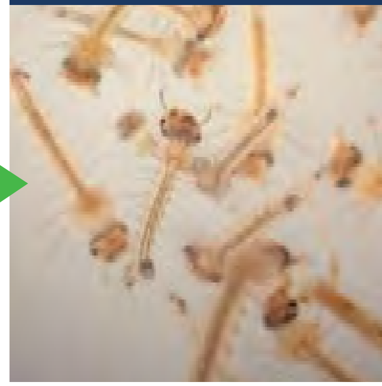
Field Biologist, Chad Kirkley inspects a settling tank for mosquito production.

Aerated Treatment Unit with Effluent Pipe Discharge into Surface Water

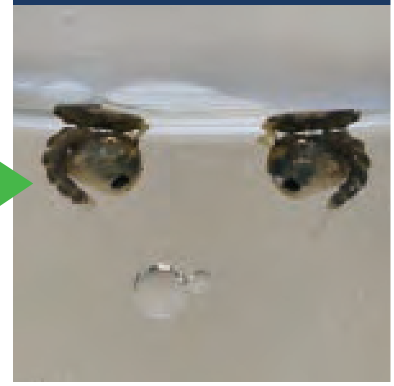
Various images: Mosquitoes can infiltrate tanks and OWTS equipment that is broken or cracked. Discharge of effluent into drainage ditches by aerated treatment units, often in dense neighborhoods, provides ample predator-free habitat for the southern house mosquito—more than 600 miles worth in St. Tammany alone.

Egg raft clusters collected from one ditch in Mandeville - each raft can contain as many as 250 larvae.

Larvae viewed under microscope in the STPMAD laboratory.



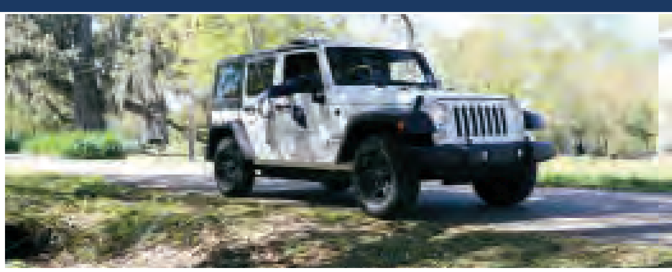
After approximately 24 hours in the pupa stage of development, the adult mosquito will emerge.



Larval mosquitoes race each other and predators

Many mosquitoes exploit newly wetted and/or ephemeral habitats that are prone to dry up. This is likely due to the lack of competition from other organisms with which they compete for nutrients. Alternatively, ephemeral habitats offer a lower risk of predation from natural enemies that may have not had time to invade these habitats. In nutrient-rich habitats, such as those influenced by sewage discharges, competitive effects presumably are not as important as predatory effects. Instead, immature mosquitoes race to complete their aquatic development (egg—larvae—pupae) before they are eaten by aquatic predators—most notably the mosquitofish.

Larval mosquito development is temperature-dependent



Right-hand drive Jeep treats roadside ditches polluted with sewage for the suppression of immature southern house mosquitoes.

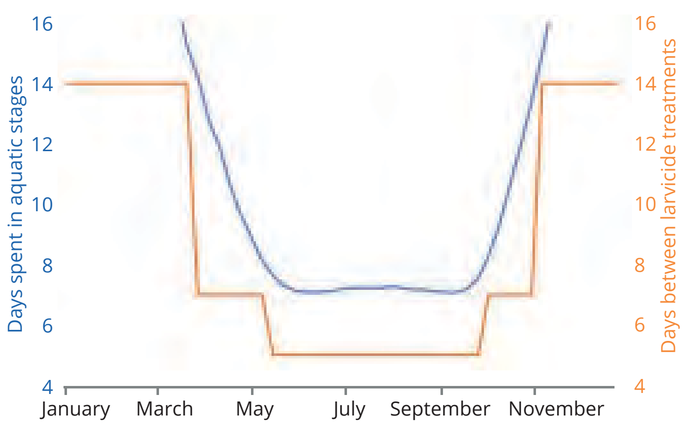


Figure 4. Mosquito larval development (blue line) speeds up in the hot summer months. Accordingly, the application of insecticides to manage these populations (orange line) must keep pace with mosquito development.

Temperature and nutrients are the fuel for larval mosquito development. As ectotherms—relying upon ambient temperatures—the mosquito life cycle is dominated by temperature. Though the role of ambient temperature in mosquito development has likely been known to the scientific community for a half century or more, it was only recently that this knowledge led to a change in our larvicide operations to enhance control efficiency. A semi-field project in 2017 led by then newly hired **STPMAD Entomologist, Nick DeLisi** modeled the number of degree hours (time at certain temperatures) necessary for the southern house mosquito to develop from egg to adult. This experiment demonstrated that a larval management regime that applied larvicides at the same frequency across a mosquito season, as had been the standard practice, was over-applying insecticides during colder months and failing to control larvae in the hotter months when mosquitoes develop quicker. As a result, larviciding operations now target re-treatment intervals that are dictated by the modeled development time of the southern house mosquito (see Figure 4).

600 linear miles of sewage-polluted ditches in St. Tammany are larvicided **each week**

Larval mosquito control

The temperature-dependent operations to kill larval mosquitoes are the frontline of our war on the southern house mosquito. Since larval and pupal mosquitoes can swim but not fly, eliminating mosquitoes from aquatic habitats is easier to target, less expensive, and more environmentally sensitive than killing adult mosquitoes. Also, a dead immature mosquito is one less biting adult mosquito that can potentially transmit a human pathogen.

With more than 600 miles of sewage-polluted roadside ditches, most of the labor hours STPMAD expends on inspection and treatment of this habitat far exceeds other habitats (see Figure 5). Inspections of sewage-influenced habitats accounted for 78% of all immature mosquito inspections in 2021. Larvicide operations in 2021 completed 2,987 missions covering 11,973 miles of roadside ditches treated.

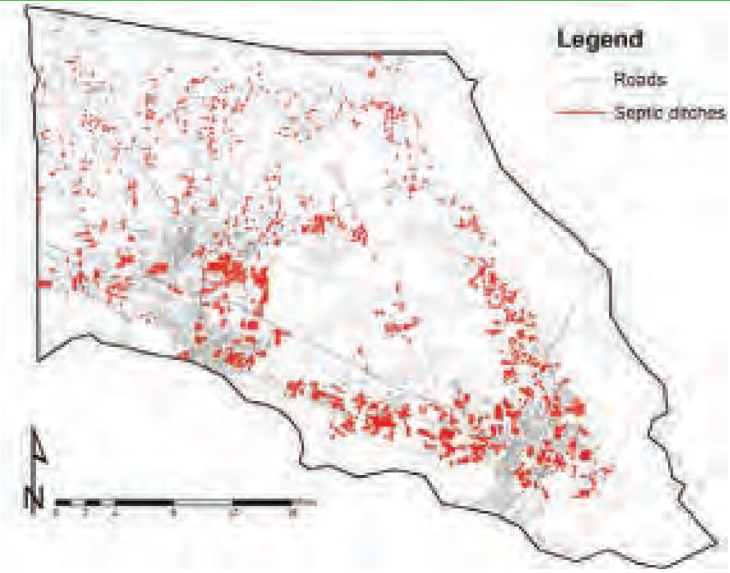
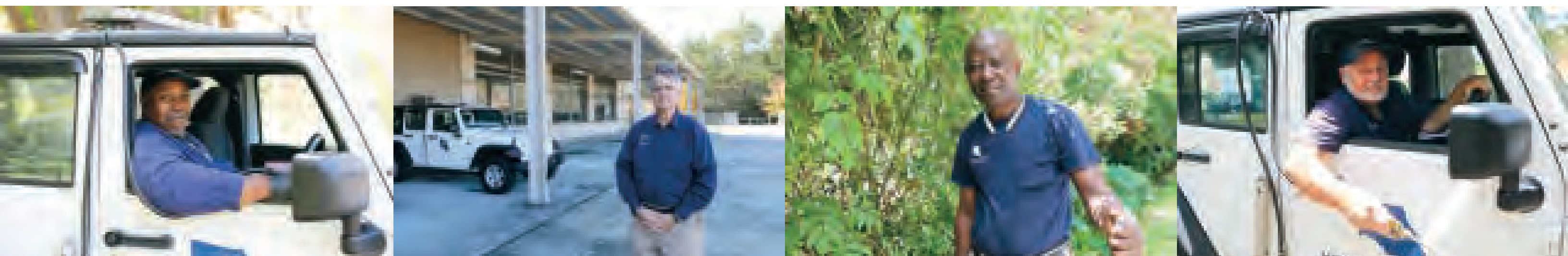


Figure 5. More than 600 miles of sewage-polluted ditches are found throughout unincorporated St. Tammany Parish.



The larvicide team (pictured here: Earnest Jones, Don Graff, Femi Jimoh, and Paul Burke) treat sewage-polluted ditches daily.

The adulticide crew (pictured here: Richard Sipes, Joe Harris [also below], David Glass, Kyle Swan, Dave McGregor, Scott Craddock, & Joey Harris) treats St. Tammany Parish at night by truck.

Adult mosquito control

If larviciding is the frontline of our war on mosquitoes, adulticiding (use of insecticides to manage adult mosquito populations) is our last resort of defense. Unfortunately, it is a costly defense that we must rely on frequently, given the total quantity of mosquito-producing sources parish-wide. Adult mosquito control operations are triggered by mosquito abundances in traps that exceed certain thresholds set for each species of concern. Thirty-two percent of trap-triggered treatments were caused by an excessive abundance of the southern house mosquito. This amounts to an estimated 380 truck treatment missions covering 296,103 acres.

Additionally, we treat for adult mosquitoes by airplane and helicopter. An estimated 18 aerial application missions covering 333,090 acres were conducted to manage sewage-associated mosquitoes in 2021.

The cost of sewage-associated mosquito management

Larvicide and adulticide operations targeting sewage-associated mosquitoes cost St. Tammany taxpayers more than $1.2 million* in 2021. *This does not include agency-wide administrative costs (insurance, software, administrative labor costs, or labor costs associated with surveillance and inspection).

This amounts to 17.3% of the 2021 actual operating expenses.

$1.2 million per year

Researching mosquito trap design for more sensitive surveillance

All mosquito control operations in St. Tammany Parish are **evidence-based**. This means that each mission is driven by inspection, trap, or complaint data. Efficient service to reduce biting rates of adult mosquitoes is reliant on the **sensitive detection** of where and when mosquitoes and the pathogens they transmit require treatment. In 2015, we began experimenting with mosquito traps to enhance the collection of host-seeking southern house mosquitoes and other arbovirus vectors. At that time and to this day, the CDC gravid trap (see image below) is considered the "gold standard" mosquito trap for the collection of *Culex quinquefasciatus* and its close relative *Cx. pipiens*. This trap employs organically-enriched water (mimicking sewage pollutants) to attract gravid female mosquitoes to lay their eggs. This trap efficiently collects mosquitoes almost exclusively of species attracted to polluted water. Even more specifically, the CDC gravid trap primarily collects females in the egg-laying life stage only. Since most of our adult mosquito treatments require flying mosquitoes to contact airborne droplets, these treatments mostly target host-seeking mosquitoes. The specificity of the CDC gravid trap is simultaneously its best asset (limiting sorting time and occasionally more efficiently collecting arbovirus-infected mosquitoes) and its primary limitation (lack of host-seeking mosquitoes and poor representation by other vectors).

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Given these limitations, we began a collaboration with Dr. Kristen Healy's lab at LSU to compare the CDC gravid trap collections with CDC no-light CO_2-baited traps. This work resulted in the publication of a research article in the Journal of Medical Entomology in May 2021. This manuscript describes how the CDC no-light CO_2-baited traps collect more diverse life stages and the same number of *Cx. quinquefasciatus* mosquitoes while collecting many other species in the same trap. The result is a **more sensitive and accurate** representation of the species involved in arbovirus transmission and a **better ability to assess the efficacy** of adult mosquito treatments.

CDC gravid trap selectively collects southern house mosquitoes by using organically-enriched water (mimicking sewage) to lure female egg-laying mosquitoes.


Field Biologist Sydney Johnson sets a CO_2-baited No light CDC trap.

Though any sewage-polluted water source can produce mosquitoes, the total area of ditches polluted by effluent from OWTS dwarfs the production potential from municipal or package treatment facilities in St. Tammany.

Assistant Field Operations Supervisor Briana Hornsby inspects a package sewage treatment facility.

Package wastewater treatment plants

The southern house mosquito doesn't distinguish one source of sewage-polluted habitat from another. **Wherever organically enriched water remains for more than seven days it could be producing vector mosquitoes.** Sewage treatment facilities including those that treat large municipalities can be sources of southern house mosquito production. Though up to two-thirds of St. Tammany Parish relies on onsite wastewater treatment at each individual household or business, each of the eight municipalities treat sewage at centralized facilities. Additionally, many subdivisions treat sewage in medium-sized facilities (called package plants). Many of these package facilities are owned and managed by the Tammany Utilities public agency, but others are privately owned and operated by contracted utility providers.

Beginning in 2016, STPMAD started to surveil package treatment facilities for the production of southern house mosquitoes. Though most package plants kept water circulating inhibiting oviposition and development of mosquitoes, several became local sources of vector production. At these sites we initiated larval treatments to manage these populations until facilities managers could resolve the physical problems with the plants.

A collaboration began amongst STPMAD, Tammany Utilities, and other sewage treatment operators to educate their personnel to prevent mosquito production. Over the subsequent years we have given many presentations to educate sewage and water operators across Louisiana about the threat of sewage to produce mosquitoes.

In addition, **Laboratory Manager/Entomologist Nick DeLisi** performed a series of experiments to evaluate the efficacy of larvicides that can be used in package plants to manage both the treatment of mosquitoes and wastewater. Plant operators were concerned that insecticide application would cause their plants to fail an inspection. However, none of the three treated plants were negatively impacted by our treatments. All insecticides were briquet formulations, and were suspended on the water surface by pool tablet dispensers. *Bti* killed approximately 85% of larvae after 24 hours, but efficacy dwindled after one week. Spinosad killed approximately 80% of larvae after 24 hours, but also declined rapidly after the first week. Methoprene failed to inhibit eclosion at any point. Considering efficacy, non-target concerns, and cost, we decided to use *Bti* for spot treatments when larvae are found in package plants.

Though any sewage-polluted water source can produce mosquitoes, the total area of ditches polluted by effluent from OWTS dwarfs the production potential from municipal or package treatment facilities in St. Tammany.

Mosquitofish, the not-so-secret weapon

The Western Mosquitofish, *Gambusia affinis*, is the most widely distributed fish in the world and likely the single biggest mosquito predator. Undoubtedly, this diminutive fish, no larger than a few inches, has saved more human and animal lives from mosquito-transmitted diseases than any other organism -- doctors included. For this reason, the mosquitofish is humanity's not-so-secret, but often overlooked weapon.

Native to the Mississippi River Valley, the mosquitofish has an upturned mouth and upward-facing eyes allowing it to scan the surface of the water where its prey suspend themselves from their air siphons. Another predatory advantage is that mosquitofish are viviparous -- bearing live young instead of egg-laying. This allows mosquitofish to quickly invade new aquatic habitat and expand its population as rain expands its footprint. Its mosquito prey are often specialists at being the first organisms to infiltrate ephemeral aquatic habitat. When these newly wetted habitats begin to connect with others including those that harbor mosquitofish, mosquito larvae's days or hours are likely numbered. It then becomes a race for the mosquito to emerge as a flying adult before the hungry mosquitofish consume all of the immature mosquitoes in the habitat.

Mosquitofish are viviparous, giving birth to live young. This allows them to quickly invade newly flooded habitats and begin preying on mosquito larvae.

Mosquitofish cannot survive very long outside of water and cannot survive in water with low dissolved oxygen (DO). These two requirements limit this weapon in the fight against the southern house mosquito. In natural conditions, shallow water habitats, such as those found in roadside ditches, characteristically have low dissolved oxygen levels made worse by extreme heat and drought which further limits the capacity of water to carry oxygen. With the addition of nutrients from partially treated OWTS discharges, mosquitofish survivorship is even more limited.

The addition of human sewage tips the balance in favor of the southern house mosquito and away from its primary predator. As a rule, more is needed to promote healthy aquatic environments, which in turn provides tools to naturally regulate mosquito vectors. St. Tammany Parish Mosquito Abatement breeds mosquitofish and distributes them to the public upon request.

Lack of rainfall dries shallow ditches and kills mosquitofish for lack of water. Aquatic habitats become disconnected in dry conditions segregating fish predators from their prey. Conversely excess rainfall can create continuous habitats where mosquitofish flourish unless sewage fouls the habitat.

Female southern house mosquitoes choose to lay egg rafts in partially treated sewage water

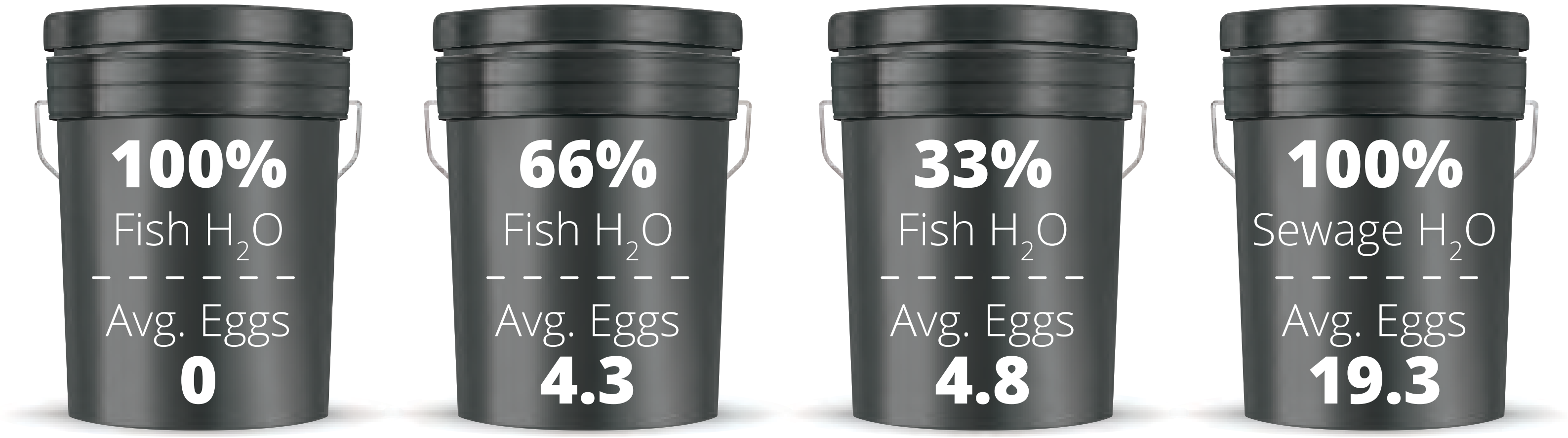
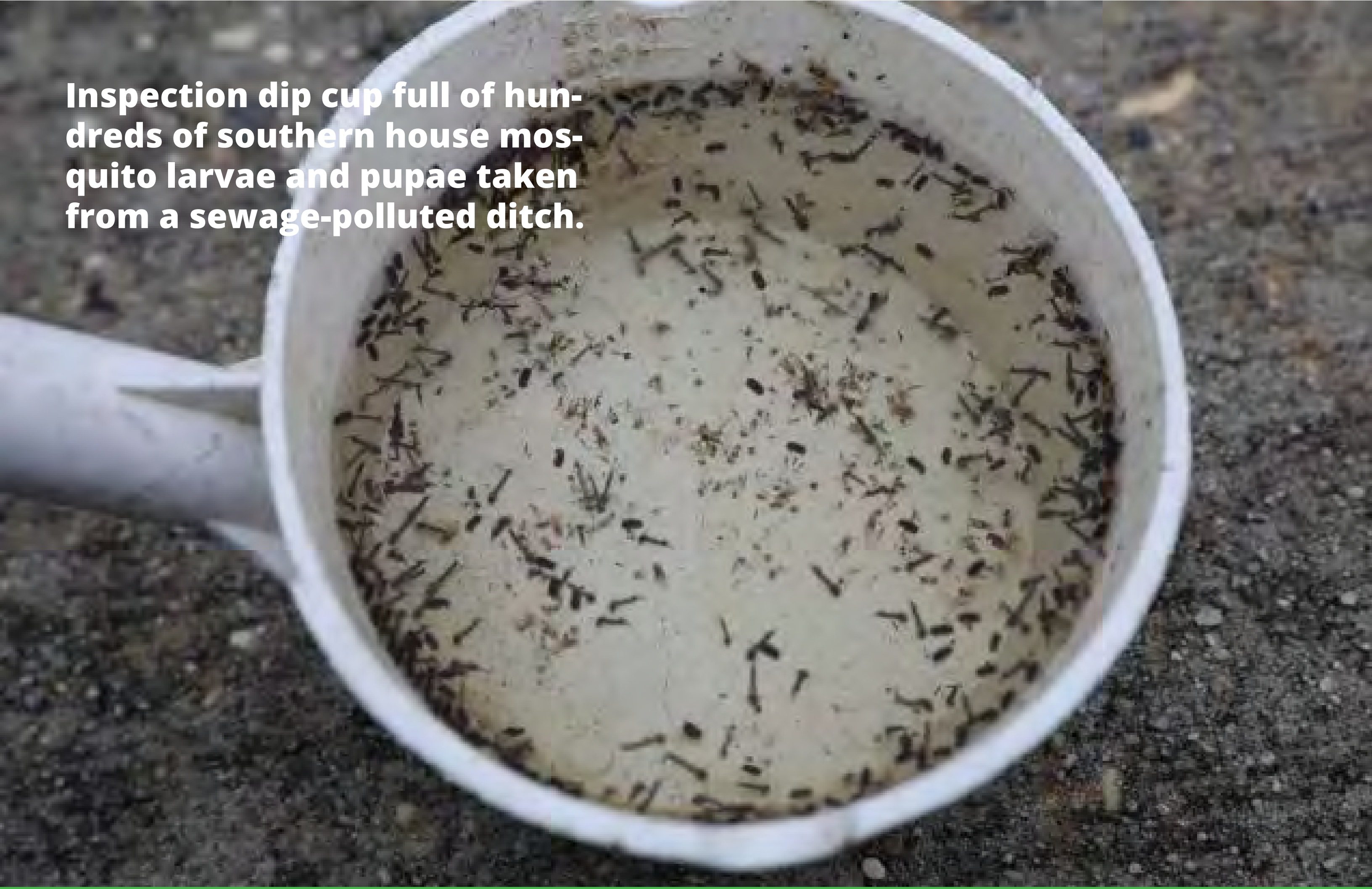


Figure 6. Egg-laying choice experiment shows the southern house mosquito prefers to lay her eggs in undiluted sewage effluent from OWTS either to avoid predators, due to chemical cues from other mosquitoes, or because of an abundance of nutrients.

Where mosquito larvae are found is not just a function of where their predators are not. Female mosquitoes selectively choose habitats to promote survivorship of their offspring. To better understand the habitat choices of the southern house mosquito, STPMAD has performed egg-laying choice experiments with 5-gallon buckets. By counting egg rafts deposited overnight in various manipulations of water type, we've confirmed that these mosquitoes cannot distinguish buckets with larvicide products that will kill their offspring compared to water without those products. We've also confirmed that these mosquitoes prefer water that is heavily polluted with sewage from unmaintained or not properly functioning OWTS. Diluting water from these treatment systems results in at least six-fold fewer egg rafts and replicates the effect of rain diluting pollutants.

In a separate study during the summer of 2021, **STPMAD Taxonomist Lisa Rowley** setup an egg laying choice experiment using a continuum of sewage strength and mosquitofish water (fish chemical cues only) (see figure above). No egg rafts were deposited in 100% mosquitofish water. Four-fold more eggs (119 in total) were laid in water collected from a polluted ditch than in any other treatment. Why mosquitoes prefer to oviposit in sewage-polluted water remains unknown and could be due to the lack of fish presence, presence of chemical cues from other mosquitoes, or due to the quality of nutrients in this habitat. Future manipulations of these choice experiments may shed light on why female southern house mosquitoes bet their offspring on and in sewage-polluted habitats.

The southern house mosquito lays 100-250 eggs at a time in a raft. Eggs when laid are creamy white but darken in a few hours. Egg rafts are the size of small grains of rice.



Inspection dip cup full of hundreds of southern house mosquito larvae and pupae taken from a sewage-polluted ditch.

Deciphering the chemical signature of human waste in mosquitoes

Under the guidance of Dr. Don Yee in collaboration with STPMAD, Catherine Dean Bermond, a University of Southern Mississippi graduate student is completing her Masters thesis on the sewage influence on the southern house mosquito life-history traits (development time and body size). As well, Ms. Bermond is investigating carbon (C) to nitrogen (N) ratios in mosquitoes reared in sewage-polluted water compared to clean water from natural ground pools. This technique uses stable isotope analysis to identify C to N ratios that are indicative of human waste. In the summer of 2021, Ms. Bermond collected samples from field sites in St. Tammany for her project. If successful, Ms. Bermond hopes to collect adult mosquitoes and determine whether they were reared as larvae in sewage-influenced or clean water habitats. The research will allow STPMAD to know what total proportion of southern house mosquitoes are the product of sewage-polluted habitats.

University of Southern Mississippi graduate student Catherine Bermond.

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MOSQUITO LAB

Insight into weather-related mechanisms of mosquito production

Mosquito Abatement is fortunate that the National Weather Service (NWS) and Lower Mississippi River Forecast Center office is immediately next door. This proximity has led to a valuable collaboration with meteorologists Jared Klein and David Schlotzhauer. Though we've known that the abundance of southern house mosquitoes was associated with drought conditions, precipitation data provided by the NWS is helping to understand why. The NWS utilizes doppler radar-indicated rainfall, rain gauge data, and forecaster expertise to provide daily estimates of precipitation at ~10 mi_2 resolution across the Continental United States (see Figure 7).

The importance of this relationship will grow as STPMAD aims to create real-time models to predict mosquito production for multiple species, as described in the STPMAD five-year strategic plan. Stay tuned for more updates on the relationships of mosquito populations with weather and other environmental variables as we learn them. Thanks to our next-door neighbors at the NWS for their service to our community and for the collaboration!

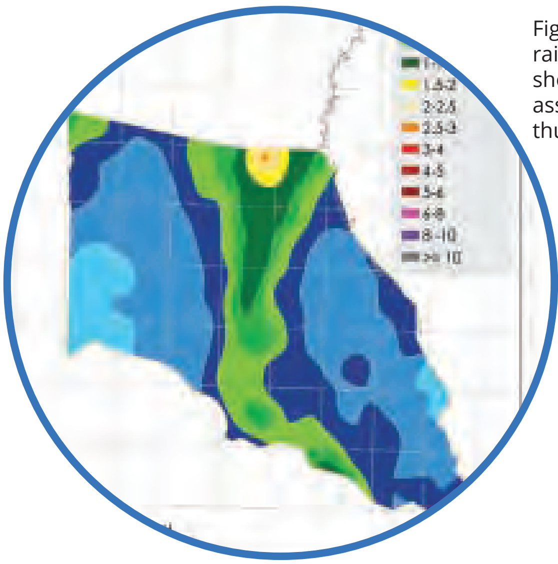


Figure 7. Surface map of a one-day rain total generated from NWS data shows highly focal precipitation associated with summertime thunderstorms.

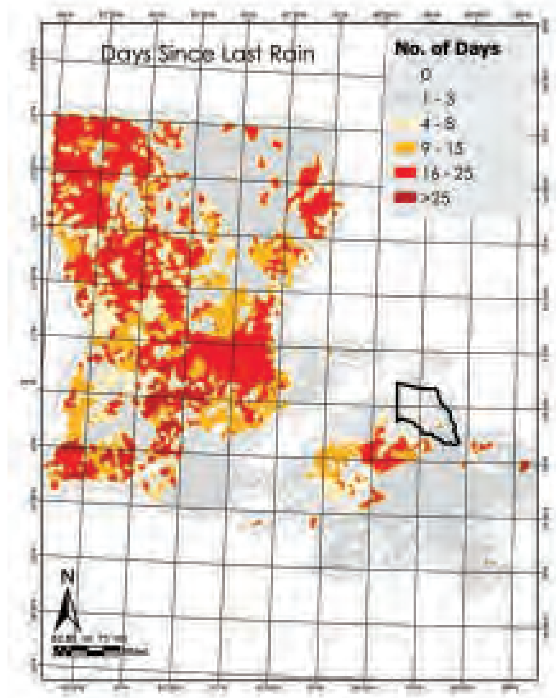
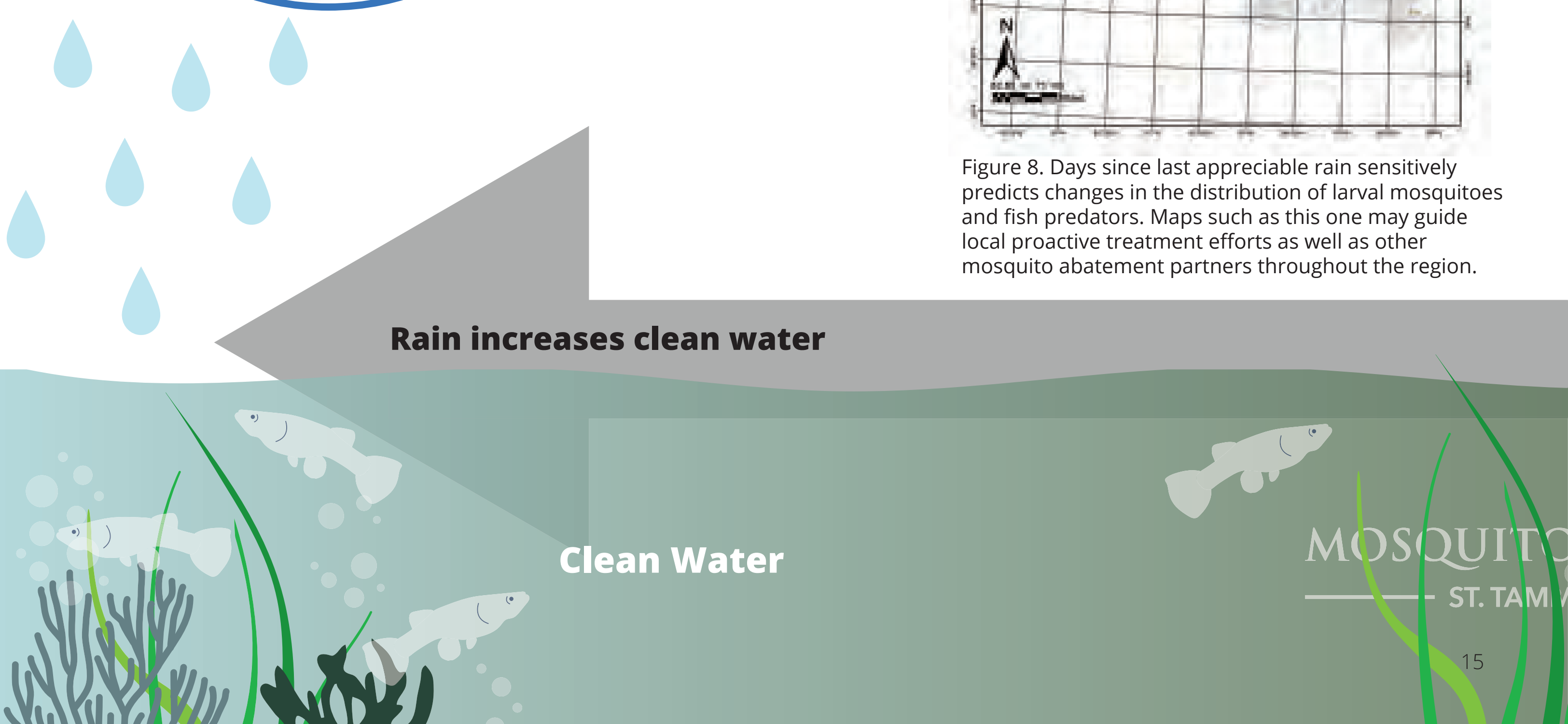


Figure 8. Days since last appreciable rain sensitively predicts changes in the distribution of larval mosquitoes and fish predators. Maps such as this one may guide local proactive treatment efforts as well as other mosquito abatement partners throughout the region.



Rain mitigates effects of sewage pollution

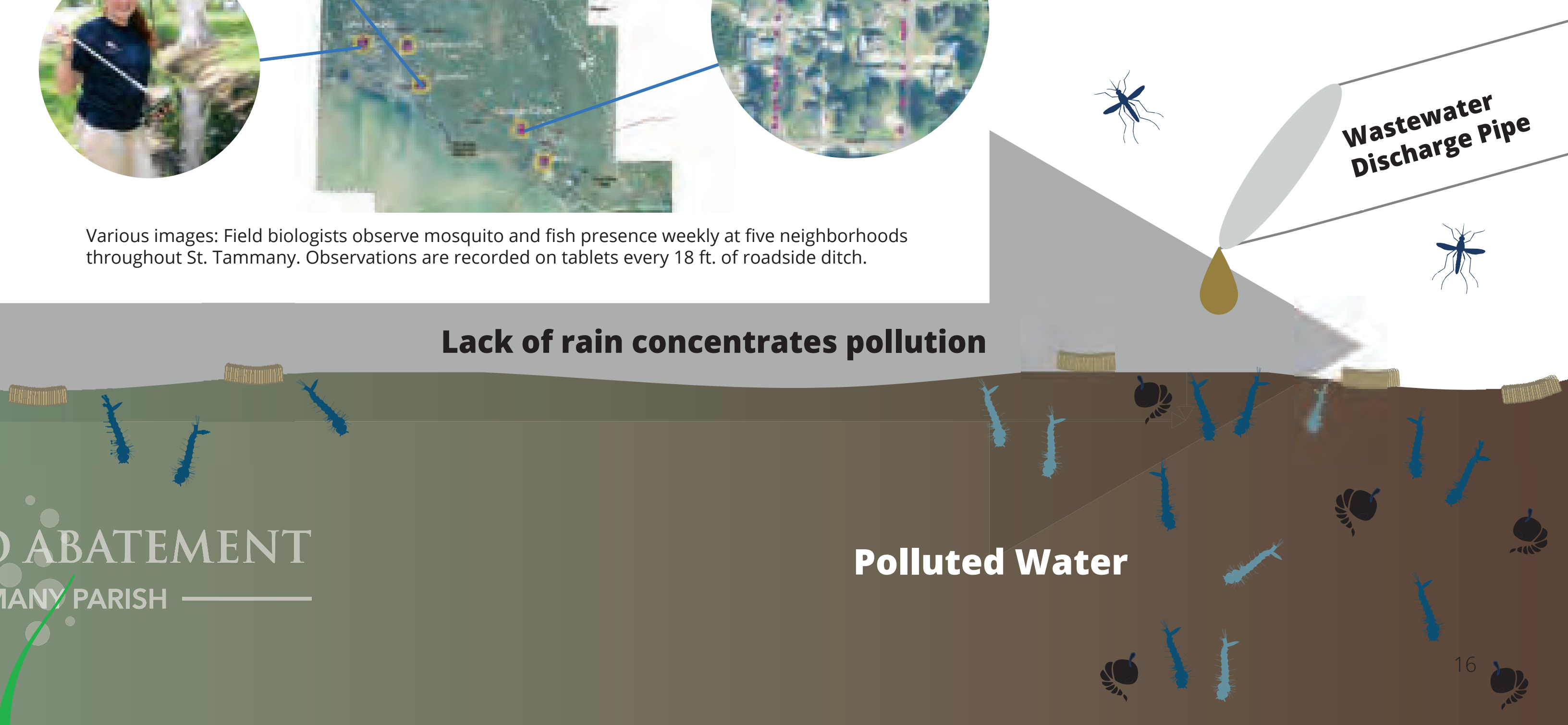
It rains a lot in South Louisiana. Intuitively, rain creates standing water where most mosquitoes lay their eggs and rear their offspring as larvae and pupae. Most mosquito species' populations demonstrate a positive association with increasing amount or frequency of rainfall. Counterintuitively, the southern house mosquito bucks this trend -- this West Nile vector is associated with the lack of rainfall. Additionally, since rain dilutes nutrient pollution from OWTS, the impact of rainfall on sewage discharge is also critical to understanding sewage-mediated determinants of mosquitoes. Research studies launched this year aim to understand the relationship between rainfall and the southern house mosquito and are yielding some exciting insights into population triggers.

Beginning in early May, **STPMAD Field Biologists Briana Hornsby, David Giron, Sydney Ferguson, Eric Martin, and Haley Marquette** began observing the presence of mosquito larvae and mosquitofish weekly at 60 precise locations. Locations were chosen throughout St. Tammany as transects of 20 sites within three residential blocks for each biologist (a total of 15 block transects across all five biologists-300 observations weekly). Individual observation sites were established every 18 ft. and marked on the pavement for weekly visits (see images below). This systematic approach allows us to control static environmental circumstances (such as ditch elevation) and to evaluate changes in the distribution of mosquitoes and mosquitofish that are the result of time, such as rainfall.

We analyzed the effect of the total rainfall (provided by the NWS) from the seven days prior to these observations and found that fish and mosquito larvae are more likely to be found together when sites experience greater rain totals. Further, we evaluated how the number of days since the last appreciable rain event (>0.25 in. of rain) effects the distribution of these organisms. This analysis sensitively predicts the presence of all three conditions – mosquito only, fish only, and both fish and mosquitoes. The greater number of days without appreciable rainfall prior to an observation, the more likely fish will be absent and mosquitoes will be present. This model is further improved when controlling for the static characteristics of the ditch being observed.

Why is it important to understand both the natural rain-mediated triggers and man-made sewage-mediated triggers of the southern house mosquito? The answer is simply *prediction.* The more we know about the precursors of mosquito production, the more likely we will be able to predict *where* and *when* problems may exist. Figure 8 demonstrates a map of the "where"-- drier conditions that may be conducive to mosquito production. The "where" and "when" are necessary for proactive larviciding and environmental management, so that we may minimize vector populations and thereby reduce human risk from arboviruses.

Various images: Field biologists observe mosquito and fish presence weekly at five neighborhoods throughout St. Tammany. Observations are recorded on tablets every 18 ft. of roadside ditch.



Neighborhood mapping of fine-scale larval mosquito distribution

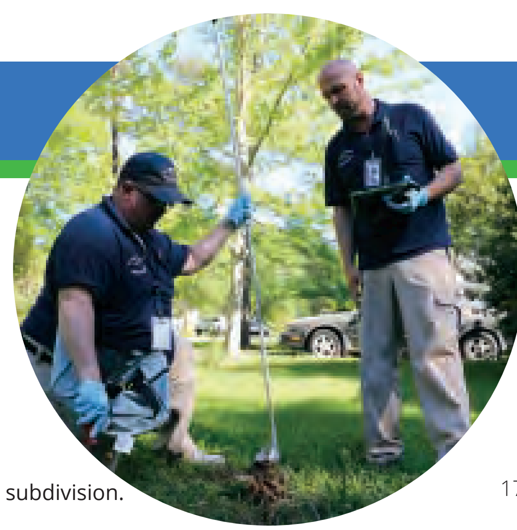
Routine inspection for mosquito larvae involves counting larvae in water samples taken by a pint-sized "dipper" on a yard-long stick. Mosquito control personnel take hundreds of such samples per day in a haphazard fashion—dipping wherever they suspect larvae may inhabit. Using this approach, field biologists find hotspots effectively, cover a lot of ground, and treat these habitats for larvae as they go.

Where standard larval surveillance provides area-wide treatment of larvae, it fails to describe detailed geographic patterns within neighborhoods. To address this lack of microhabitat mapping, starting in August 2019 we created a systematic approach to mosquito larvae and their mosquitofish predator presence. Field biologists surveyed the entirety of the Tammany Hills neighborhood south of Covington for two days by observing the ditch for the presence of "mosquitoes, fish, both, neither or dry condition" at every tenth pace (see Figure 9).

The result is a mosaic map of mosquito larval habitat (see Figure 9). This data allowed visiting researcher Mark Meyer to assess the relationship of various geographic variables with observed mosquito and predator presence. As a result, increasing slope was significantly negatively correlated with fish presence (P = 0.009), while total ditch depth was positively correlated with fish presence (P = 0.001). Additionally, TDS was again verified to negatively (P = 0.04) influence the likelihood of encountering fish.

Figure 9. Detailed neighborhood map of the distribution of mosquito larvae (red) and mosquitofish (blue) reveals hotspots and patterns that help predict where these populations are found at other sites.

Door-to-door OWTS tank survey



Effluent discharged into ditches is not the only source conducive for mosquito production associated with OWTS. Mosquitoes can infiltrate OWTS settling tanks if lids are broken, missing, or other access points allow entry. In 2019, field biologists performed inspections door-to-door in the Tammany Hills neighborhood to understand whether mosquito production was occurring within OWTS tanks. Nearly 10% of OWTS inspected had cracked lids or other entry ports for mosquitoes to lay eggs and rear their offspring directly within the treatment systems.

Field Biologists Richard Frazier and Chad Kirkley inspect OWTS tanks in the Tammany Hills subdivision.

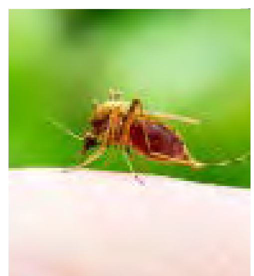
Why should I care?

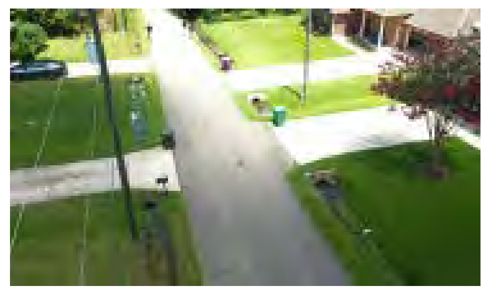
Q. **I keep my "septic" system (OWTS) maintained all the time, why should I care about mosquitoes these systems may produce?**

A. **The answer is that because mosquitoes can fly, even if you keep your OWTS working, your neighbor's unmaintained system may be producing mosquitoes that can transmit WNV. In fact, according to our partners at the Pontchartrain Conservancy, more than half of OWTS in St. Tammany are not being maintained—potentially every other house on your block!**

A collaboration with scientists from the Centers for Disease Control and Prevention has determined that St. Tammany residents that live within a half mile from a sewage-polluted ditch experience 5.9 times more WNV vector mosquitoes than those that live farther. Given the pervasiveness of OWTS in St. Tammany Parish most residents (~87%) live within a half mile – the flight range of the southern house mosquito—of a sewage-polluted ditch that may produce these mosquitoes.

CDC researchers analyzed St. Tammany mosquito trap data from 2017-2018 to assess the spatial relationships of sewage-polluted ditches, southern house mosquitoes and WNV. An ongoing collaboration with these researchers promises a more detailed description of the mechanisms underlying the sewage-southern house mosquito connections. Stay tuned for future updates on this project.





No matter where you live in St. Tammany Parish you are likely to experience mosquitoes produced from sewage-polluted ditches. Southern house mosquitoes can fly up to a half mile. Figure 5 on page 9 shows the distribution of sewage-polluted ditches throughout the parish.

Outreach and advocacy to address the root cause

Knowing there is a problem and providing temporary mitigation to limit mosquito populations does not address the root cause of the sewage-associated mosquito production. In 2015, STPMAD joined an informal Water Quality Taskforce consisting of St. Tammany Parish Departments of Planning and Environmental Services, LA Department of Environmental Quality, LA Department of Health, LA Sea Grant, and Pontchartrain Conservancy personnel. This group sought solutions and collaborated on projects to focal water quality issues in the parish including OWTS. This task force dissolved in early 2020 when grant funding ran out for support of the group.

Meanwhile, external advocacy at STPMAD regarding the mosquito threat of OWTS began in earnest in 2017 with a presentation to the Parish Council and letters to former Parish President Patricia Brister and Council leaders. To encourage progress by community leaders, STPMAD has continued to promote messaging to inform the public about the need to maintain OWTS for WNV prevention in traditional media outlets and via social media.

The change of administration at Parish Government brought a different perspective on the issue. Parish President Michael Cooper has demonstrated his concern over sewage pollution caused by OWTS. Earlier this year, President Cooper ordered a new task force to review the problem and to present potential solutions and a plan for improving water quality. We are grateful for his leadership and support in addressing this community problem. Stay tuned for future developments resulting from this new group led by the LA Sea Grant program.

Sea Grant LOUISIANA

ST. TAMMANY PARISH GOVERNMENT

Acknowledgements

We wish to thank our research partners and collaborators that have helped us with funding, support, and data to achieve a greater understanding of the ecology of sewage-associated mosquitoes. These include the Pontchartrain Conservancy, St. Tammany Parish Department of Environmental Services and Planning, LA Sea Grant, the National Weather Service, and the Centers for Disease Control and Prevention. Thanks to Dr. Brady Skaggs, Pontchartrain Conservancy, for writing a background on the local problem with OWTS (page 3).

Thanks to our dedicated Board of Commissioners, field and administrative employees who work every day to manage the threat of mosquito-transmitted arboviruses. Special thanks to the men and women who day in and day out inspect sewage-polluted ditches for the production of the southern house mosquito. Nobody necessarily enjoys that job, but performs it as a service to our community – we see the good work you do!

This report was written by Dr. Kevin Caillouet, Director, with analysis from Nick DeLisi, Entomologist/Laboratory Manager, and maps from Dr. Hieu Duong, GIS Manager. Jennifer Bushnell, Public Information Officer, was responsible for the layout and graphical content. Susan Lowrie, Office Manager, edited this document. Dr. A.J. Englande, STPMAD Commissioner, provided valuable insight and advice.

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