MOSQUITO CONTROL IN STORMWATER BMPS

BMP GUIDANCE HANDBOOK

Orange County Mosquito and Vector Control District

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INTRODUCTION

The Orange County Mosquito and Vector Control District (OCMVCD) is a public health agency whose mission is to protect the public from disease vectors and pests throughout Orange County. Mosquito control forms the largest portion of the District's work. There are over 20 species of mosquitoes present in Orange County. While each species varies in habitat, behavior, and capability in carrying disease, all share the common need of requiring standing water in order to complete their life cycle. In addition to being a nuisance, these mosquitoes are vectors capable of transmitting pathogens to humans such as West Nile, Saint Louis encephalitis, Zika, dengue viruses, and more.

The California Health and Safety Code, Division 3 authorizes the District to take any and all necessary or proper actions to abate or control vectors and vector-borne diseases. The District takes an Integrated Vector Management (IVM) approach using cultural, biological, chemical and physical controls. Physical controls typically involve the use of equipment or structures designed to eliminate shallow, standing water, where possible. Sources of standing water include basins, ponds, wetlands, local depressions on streets and lots, flood control structures, vernal pools, and water quality best management practices (BMPs).

The Porter-Cologne Act of 1970 established the nine California Regional Water Quality Control Boards. The Boards became responsible for implementing the National Pollutant Discharge Elimination System (NPDES) that brought changes to the fundamentals of stormwater drainage. The Water Boards goals and requirements have become increasingly stringent over time; as a result, more and more Best Management Practices (BMPs) are being implemented to comply with these regulations.

BMPs, as opposed to traditional drainage inlets and storm drains, reduce flow and provide barriers to drainage in order to treat water and remove pollutants. As a result, BMPs can create or exacerbate local mosquito breeding issues when not planned, designed, constructed, or maintained correctly. A BMP that is implemented properly should drain water in a timely fashion and prevent mosquitoes from breeding within.

For more information, contact:

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PURPOSE OF THIS HANDBOOK

This handbook is intended for developers, public works employees, maintenance staff, property managers and other interested parties to review and use when designing and maintaining stormwater BMPs. Recommendations for each BMP are independent of others and are contained in their own sheet, front and back, so that they can be quickly and easily referenced. OCMVCD recognizes that, while vector control for human health is of the utmost importance, improved water quality is a necessary objective. Recommendations made in the handbook are done in consideration of maintaining the effectiveness of water quality treatment, where possible.

The handbook primarily focuses on source control, although it is not always possible in constructed ponds and wetlands. By following the guidelines set forth in this handbook, vector issues resulting from the BMPs and use of chemical or biological pesticides can be minimized. Preventative actions can negate the need for the District to take action and/or execute abatement procedures, which may result in excessively expensive maintenance and/or repairs.

This handbook provides guidance on providing mosquito source control to common points of failure observed by vector control staff. In general, there are a few key critical points that are prescribed for most BMPs:

- Ensure that the BMP draw down in 96 hours or less;
- Minimize aquatic vegetation and harvest excess vegetation annually from the BMP;
- Perform maintenance in the winter in order to avoid bird nesting season. Mosquito disease transmission primarily occurs from late spring to early fall, and it is important to ensure that BMPs are functioning properly during this period;
- Provide alternative mechanisms for BMPs to drain all of the water in the event the media or soil clogs. These often fail to drain due to improper construction and construction techniques, constant dry-weather flows, sediment loading, and a lack of maintenance;
- Ensure that the BMP can be easily accessed by vehicle and on foot for maintenance and inspection; and
- Coordinate with OCMVCD if the BMP will create permanent standing water or have consistent dry-weather flow. These have the highest probability of breeding mosquitoes.

Several other resources are also available which provide additional detailed information on vector reduction. Please refer to the Integrated Vector Management material referenced below. Contact OCMVCD staff for more detailed information and direction.

- Orange County Vector Control District, “Vector Reduction Manual: Procedures and Guidelines” http://www.ocvector.org/documents/VectorReductionFinal.pdf
- California Department of Public Health, “Best Management Practices for Mosquito Control in California” https://www.cdph.ca.gov/HealthInfo/discond/Documents/BMPforMosquitoControl07-12.pdf

BIORETENTION

Description

Vector Risk: ***Medium***

Bioretention areas are typically planters or shallow depressions engineered to filter stormwater runoff prior to infiltration or discharge into downstream receiving waters. Mosquito breeding issues within bioretention areas are typically the result of improper or insufficient maintenance. Although bioretention media is an engineered mix and designed to filter runoff swiftly, sediment deposition and vegetation overgrowth can prevent flow-through and leave stagnant water.

Planning

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent vector breeding must be included and clearly laid out to the owner accepting responsibility for that BMP. Instruct property owners to contact OCMVCD if mosquito breeding occurs in order that to resolve the condition.

Design and Construction Recommendations

The design should minimize the possibility of standing water through redundant control measures. Standard practices are not likely to cause mosquito breeding; however, nuisance flow from dry-weather runoff can compromise design if not accounted for. Design recommendations are:

- Provide pre-treatment to reduce trash and sediment inflow. Inlet filters, fine meshed screens, and sediment forebays are effective at reducing downstream clogging, but require additional maintenance;
- Avoid the use of pumps and sumps that can fail and rely on gravitational flow to drain the soils;
- Avoid planting emergent or riparian vegetation. Sycamores and other trees can shade the water surface area, retarding the growth of unplanned emergent vegetation;
- Incorporate screened overflow risers to prevent excess ponding;
- Design for a drawdown time of 96 hours or less;
- Locate and design around the BMP in a manner to prevent foot traffic, which may compact soil; and
- Soil may become compacted and infiltration rates reduced due to heavy construction equipment. Till the soil prior to planting and do not use heavy equipment afterwards.

Maintenance

Bioretention facilities will not breed mosquitoes with regular and correct maintenance. All BMPs require maintenance, and the requirements for controlling mosquito breeding are often no more stringent than normal operation of the BMP. Recommended maintenance activities are:

- Semi-annually, before and after the wet season
  - Inspect the surface of the BMP for sediment accumulation. Remove accumulated trash and sediment and rototill, if necessary;
  - Inspect inflow points for sediment accumulation;
  - Trim and mow grasses, discard detritus;
  - Remove invasive, unplanned vegetation. If habitat is incorporated into the plan, additional issues regarding protected species may impair maintenance and vector control;
- Renew and replace mulch as needed;
- Regularly inspect filters and screens and clear of any accumulated debris; and
- Minimize the use of heavy equipment and till the soil over any locations that were heavily trafficked. Maintenance activities must not compact the soil and inhibit infiltration capacity.

ORANGE COUNTY MOSQUITO AND VECTOR CONTROL DISTRICT
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RETENTION BASINS, WET PONDS, AND OTHER PERMANENT WATER FEATURES

RETENTION BASINS, WET PONDS, AND OTHER PERMANENT WATER FEATURES

Description

Vector Risk: ***High***

Retention basins, wet ponds, and other aboveground permanent water features are designed to have a pool of water throughout the year and may be supported by flows from urban runoff or water supplies in order to maintain depth. These standing water features frequently serve water quality and aesthetic functions.

Permanent standing water features frequently pose a difficult challenge for mosquito control because nearly all allow mosquitoes to breed to some degree. Over time, emergent and shoreline vegetation create habitats conducive to mosquito breeding that may be difficult or even hazardous for vector control technicians to access. The creation of permanent, standing water features is not advised for effective mosquito control.

Planning

Management of mosquitoes and other vectors in retention basins, wet ponds, and other above-ground permanent water features is critical for protecting public health. With careful planning, such structures can be designed, built, operated, and maintained in a manner that minimizes opportunities for the proliferation of vectors. Adequate funding is required to support long-term site maintenance. Routine monitoring and management of mosquitoes by a qualified agency may also be necessary. Coordination with the Orange County Mosquito and Vector Control District (OCMVCD) on the development of the plan(s) and layout can greatly reduce future maintenance and associated costs. Long-term management of mosquitoes in stormwater ponds, wetlands and watersheds requires integrated biological control, vegetation management, various physical practices, and, if necessary, chemical control.

Planning documents must corroborate on whether or not the creation of habitat is intended. If so, protected species may inhibit vector control activities and require an escalated response to mosquito breeding, entailing a more resource intensive control strategy. Provisions should be included to allow regular inspections of the site by OCMVCD for the detection of developing mosquito populations. Project documents should specifically address this issue to resolve potential conflicts of interest. These types of water quality features require regular maintenance to ensure functionality. In instances where habitat mitigation is a component of the project, specific maintenance and access considerations for vector control must be planned into the design and Operation and Maintenance Plan. Once habitat is established, its removal or modification could require additional mitigation if not already detailed at the onset of the project planning and permitting process.

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair BMP's are necessary to prevent mosquito breeding. Any agreement should be clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs in order that remediation efforts may take place.

Design and Construction Recommendations

The design should maximize open swaths of deep water with minimal emergent vegetation to the water surface. Convenient access to all water surfaces is also important, as technicians must visit open water sites when necessary, to determine if treatment is needed. Design recommendations are:

- Ponds should be surrounded by land with roads or pathways of adequate width to allow safe passage of maintenance staff and/or equipment;
- Maintain a water depth of 4 feet or greater, which is less suitable for mosquito larvae production;
- Banks should be steeply sloped and lined to three feet below the water level with a suitable material such as concrete or clay. If practical, treatment with residual herbicides can ensure permanent weed prevention;
- To minimize invasive emergent vegetation in ponds, use a slope angle of at least 2:1. Bank slopes of 2.5:1 to 4:1 (vertical: horizontal) and minimum depths of four to five feet to significantly reduce bottom-rooted aquatic plants;
- Provide vehicular access for maintenance vehicles to and around large ponds and lakes;
- Ponds or ornamental water features should be stocked with mosquitofish when possible. Contact OCMVCD to see if mosquito fish (*Gambusia spp.*) are appropriate to use; and
- Use grouted riprap or concrete blocks instead of loose riprap to prevent standing water within crevices.

Maintenance

Maintenance for retention basins and ponds is necessary for mosquito control because they are designed to hold water year-round. Physical reduction methods cannot sufficiently eliminate mosquito breeding. Maintenance must be performed regularly to remove dead and dying plant material, trash, debris and invasive vegetation. Dense stands of bulrush and cattails are especially problematic and they must be removed or cut back. Trails and roadways should also be kept clear so that the banks are easily accessible by vehicle and on foot. Invasive plants may also create habitat, which complicates vector control efforts. Recommended maintenance activities are:

- Annually, in the winter
    - Inspect for signs of erosion or clogging of drain outlets, restore as needed;
    - Harvest excess riparian vegetation;
    - Maintain or harvest emergent and perimeter shoreline vegetation;
    - Maintain site and road access;
    - Stock wet ponds/constructed wetlands with mosquito fish
    - Skim and remove floating vegetation and debris, such as duckweed or algae mats, from the water surface;
- Semi-annually, in the fall and spring
    - Remove accumulated trash and debris in the basin. The frequency of this activity may be altered to meet specific site conditions and aesthetic considerations;
    - Inspect for rodent burrows, sediment accumulation, structural integrity of the outlet, and litter accumulation. Repair or remove as needed;
- Maintain vegetation to assist mosquito fish movements to control mosquitoes, as well as to provide access for vector inspectors; and
- For retention basins and other water features which receive storm water runoff
    - Inspect for, and remove, accumulated sediment in the forebay (if any) and main basin; regrade every 5-7 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. If a forebay exists, sediment removal may not be required in the main pool area for as long as 20 years.

VEGETATED SWALES AND BUFFER STRIPS

Description

Vegetated swales, also known as bioswales, are vegetated, depressed open areas of land, which are designed to filter and treat stormwater as it flows through. Buffer strips, also known as biofiltration strips, function in a similar manner, with the exception of being mostly level with the adjacent tributary areas. These vegetated filtration BMPs are not designed to retain water, so any standing water is indicative of a failure in the construction or maintenance of the water quality feature.

Vector Risk: ***Low***

Planning

Vegetated swales and strips are best located in areas where the natural topography contributes to the effectiveness of the BMP. Locations with a moderate slope, so that a 1% or greater slope is achieved in the direction of flow, are preferred. A lesser slope is more susceptible to ponding due to construction error or inadequate maintenance. A geotechnical analysis may also reveal any potential for subsidence or compaction, either of which would cause ponding within a strip or swale. Take extra care to ensure sufficient drainage if the swale or strip is located in an area with low-infiltration rate (group "D" soils); otherwise, soil infiltration may potentially provide sufficient drainage for any volume of water that does not flow through the swale or strip.

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent mosquito breeding must be included and clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs so that they may be consulted on a resolution for the situation.

Design and Construction Recommendations

The design of vegetated filtration BMPs should focus on maintaining a consistent flow through the BMP and reducing the probability of creating low spots where stagnant water will accumulate without infiltrating. Design recommendations are:

- Use a 1% minimum slope;
- Avoid using riprap-lined depressions for infiltration within bioswales. Infiltration rates rapidly degrade without the proper pre-treatment and maintenance, which is difficult to perform beneath riprap;
    - If local depressions are used for infiltration, utilize pre-filters to trap sediment;
- If needed, use grouted riprap splash pads or concrete slabs to dissipate energy; and
- Ensure soils are well compacted to prevent subsidence.

Maintenance

Regular maintenance for bioswales and buffer strips is relatively simple and straightforward. Standard landscape management is usually sufficient to maintain drainage performance. Regular inspections will prevent the creation of mosquito breeding sources. Recommended maintenance activities are:

- Annually in the winter
  - Inspect for erosion and depressions, fill as needed;
  - Inspect for sediment accumulation, remove and replace soil as needed; and
  - At least one week after a rain event, inspect for ponded water, if any is present, determine the cause (depression or poor infiltration) and resolve. Ponded water indicates consistent dry weather flows which will not evaporate or infiltrate, which would breed mosquitoes;
- Semi-annually, before and after the wet season
  - Mow grasses and remove dead and dying vegetation; and
  - Replant areas susceptible to erosion, eroded areas may create local depression that will stagnate and breed mosquitoes.

INFILTRATION BASINS, DETENTION BASINS, AND DRY BASINS

Description

Vector Risk: ***High***

Infiltration basins, detention basins, and dry basins are designed to capture stormwater flows and hold it temporarily until the flows are either discharged or infiltrated. Infiltration basins serve the triple purpose of water quality, groundwater recharge and hydromodification mitigation. Most flow entering an infiltration basin will seep into the ground over time, while any excess is discharged through an overflow orifice. Detention basins are in place to temporarily hold water, usually by restricting the effluent rate.

Planning

Dry basins have a high probability of breeding mosquitoes if infiltration rates decline, and surface unevenness or ruts can breed mosquitoes. Adequate funding is required to support long-term site maintenance, as well as routine monitoring and management of mosquitoes by a qualified agency. Coordination with OCMVCD on the development of the plan(s) and layout can greatly reduce future maintenance and associated costs.

Planning documents must corroborate on whether or not the creation of habitat is intended. If so, protected species may inhibit mosquito control activities and require an escalated response to mosquito breeding, resulting in a more resource intensive control strategy. Provisions should be included to allow regular inspections and treatment of the site by OCMVCD for the detection of developing mosquito populations. Project documents should specifically address this issue to resolve potential conflicts of interest. Water quality features require regular maintenance to ensure proper function. T In instances where habitat mitigation is a component of the project, specific maintenance and access considerations for vector control must be planned into the design and Operation and Maintenance Plan. Once habitat is established, its removal or modification could require additional mitigation if not already detailed at the onset of the project planning and permitting process .

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent vector breeding must be included and clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs so that they may be consulted on a resolution for the situation.

Design and Construction Recommendations

Infiltration rates can be reduced down to zero without maintenance and sediment removal. The design of infiltration and detention basins must include redundant measures to ensure that the basin will drain down in entirety after a storm, or with constant dry-weather flows. Most designs do not take into consideration continual dry-weather flows that often occur due to landscape overwatering in upstream, developed urban areas. These persistent dry-weather flows can cause a permanent pools of water to form and breed mosquitoes, making it important to account for in the systems' design. Design recommendations are:

- For infiltration basins
    - Use a sediment forebay to prevent siltation of the basin bottom. Just ¼" of silt on the bottom of a basin can significantly reduce the infiltration rate;
    - Account for dry-weather inflows in the drawdown time calculations;

- For both infiltration and detention basins
    - Design a low-flow channel leading to a screened orifice. Although this may seem redundant for an infiltration basin, as dry-weather flows should infiltrate quickly, it is often not the case, due to inadequate maintenance. The low-flow screen and outlet do not require a high flow rate and priority can be given to allowing time for infiltration. An undulating channel will increase the hydraulic residence time;
    - Design for a drawdown time of 96 hours or less;
    - Provide a 1% slope towards the outlet of the basin. Construction inaccuracies with mild slopes often create pockets of water, which will not drain if clogged from sediment or compaction;
    - Design banks to be steeply sloped, with a ratio of at least 2:1, and lined to protect against erosion;
    - Provide access for maintenance and vector control vehicles around the entire basin;
    - Use grouted riprap, unless the bottom elevation of the riprap is above the soil, allowing it to drain horizontally. Grouted riprap is important for splash pads that are flush with the basin's bottom surface, where clogging of the underlying soil would create standing water between the rocks. Do not rely on infiltration below riprap to provide necessary drainage;
    - Provide an access ramp to the basin floor; and
    - Heavy equipment on the basin bottom often reduces the actual infiltration rate. After grading, the infiltration rate must be restored by loosening the soil.

Maintenance

Dry basins will not breed mosquitoes if maintenance is performed regularly and correctly. Most importantly, unplanned vegetation must be removed on a regular basis and all other vegetation must be maintained. Overgrowth and the establishment of riparian vegetation can cause extensive mosquito breeding. Habitat may also inhibit access making treatment difficult. An access ramp to the basin floor will assist maintenance crews, but any vehicles driven along the floor of the basin can also create ruts or depressions. Shallow ruts may quickly infiltrate and evaporate, but deep, compacted ruts from heavy vehicles can create permanent pools, especially if the basin does not have a low flow channel to contain continuous dry weather flows. Recommended maintenance activities are:

- Semi-annually, in the summer and winter
    - Inspect the surface of the BMP for sediment accumulation. Remove accumulated trash and sediment and rototill, if necessary;
    - Inspect inflow points for sediment accumulation;
    - Trim or harvest vegetation, discard detritus;
    - Inspect filters, screens, and trash racks, and clear of any accumulated trash and debris;
    - Inspect for erosion and repair as needed;
    - Inspect the low flow channel and remove vegetation that inhibits flow;
- Annually, in the winter
    - Remove emergent vegetation such as willows, bulrush, and cattails;
- Bi-monthly, during the wet-season
    - Inspect and remove any sediment and trash from the forebay; and
- Maintenance activities must not compact the soil and inhibit infiltration capacity. Minimize the use of heavy equipment and till the soil over any locations that were heavily trafficked.

UNDERGROUND FACILITIES (DRY WELLS, CHAMBERS, SUMPS AND OTHERS)

Description

Vector Risk: ***High***

Underground storm water facilities vary greatly in purpose, function, and design. Dry wells and infiltration galleries aim to disperse stormwater into the groundwater table. Sumps typically serve to collect trash and sediment, thus creating a permanent underground pool that needs to be carefully monitored and maintained. Underground chambers and pipes convey water and detain them for various drainage reasons. All underground facilities pose significant risk of breeding mosquitoes, which are able to easily seek out unseen water sources and enter gaps as small as a few millimeters. Mosquitoes are able to travel several miles, depending on the species, through the vast majority of storm water systems. Immature mosquitoes can develop safely out of sight within low points, sumps, and infiltration galleries.

Planning

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent vector breeding must be included and clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs so that they may be consulted on a resolution for the situation.

Design and Construction Recommendations

Design of underground systems should focus on ensuring that the amount of standing water is minimized. Reducing breeding opportunities for mosquitoes to enter and lay eggs diminishes the overall number of mosquitoes produced in underground systems. Ample access to view and enter underground systems is important for inspection and treatment by vector control technicians, should mosquito breeding occur. Design recommendations include:

- Removable manhole inserts for all manholes; manhole inserts fit underneath manholes and provide a barrier to entry through the pick hole;
- Incorporate a screening chamber or screens, where possible, upstream of the underground BMP using 2mm perforations. A large enough surface area may be sufficient to drain the design flow, especially for water quality BMPs, which are typically 2- to 10-year flood events. Screening also provides water quality benefits;
- Design for a drawdown time of 96 hours or less;
- For infiltration-type facilities such as dry wells and infiltration galleries
    - Provide adequate trash and sediment pre-filtration;
- For vaults designed to be permanent sumps
    - Install a sump pump which can drain it during the dry season;
- If low flows can bypass the system
    - Construct two parallel pipe systems leading to the underground BMP, one for low flows and one for design storm flows. Screen the entry to the low flow system. Control flows into the design storm systems using a valve that can be open and closed before and after a rain storm. This is only necessary from April through October, as mosquito breeding is significantly lower during the wet season;
- Provide manholes and/or cleanouts to all portions of the system;

Maintenance

Maintenance of underground systems is relatively straightforward. Recommended maintenance activities are:

- Semi-annually, in the spring and fall
  - Inspect inflow points for sediment accumulation;
  - Inspect filters, screens, vault bottoms and trash racks, and clear of any accumulated trash, sediment and debris; and
  - Inspect and repair or replace structural components such as grates, manholes, and filters.

INFILTRATION TRENCHES

Description

Vector Risk: ***Low***

Infiltration trenches are underground, rock filled chambers that store stormwater within interstitial voids. Design and construction is often simple and involves little work other than excavation and fill with the correct materials. Traditionally, trenches are designed to percolate water into the soil in all directions. An alternative method utilizes a perforated pipe subdrain to assist drainage. A typical infiltration trench is wrapped in filter fabric to block soil deposition and is composed of several layers, a sand filtration layer, a primary rock storage layer, and a top layer. A major advantage of infiltration trenches is that, if properly built, very little maintenance is required on the BMP itself.

Planning

Infiltration trenches typically do not pose a significant threat for mosquito breeding, but can if water is not given an alternate route to drain, in the event that the trench fills with water. An adequate design that incorporates overflow will prevent breeding. As infiltration trenches are difficult to perform maintenance on, extra care should be taken during geotechnical testing to ensure that the site will properly infiltrate.

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent vector breeding must be included and clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs so that they may be consulted on a resolution for the situation.

Design and Construction Recommendations

Mosquitoes will not be able to enter and breed in infiltration trenches under normal circumstances when utilizing appropriately sized gravel for the top layer of the infiltration trench. The primary method for a mosquito to breed in an infiltration trench is through any overflow riser or observation port, or if water becomes ponded above the infiltration trench. Both situations are easily preventable through design. Design recommendations are:

- Use a top layer of pea gravel or other medium-fine aggregate 1-inch or smaller in diameter. The depth of the layer should be at least 2 inches;
- Provide a method to drain excess runoff, should the infiltration trench clog. One of the following recommendations can achieve this:
    - Integrate a screened overflow riser that will drain at the level of the trench, and thus capable of capturing any flow that does not percolate into the trench; or
    - If the topography allows, design the trench so that water can runoff to the side instead of pooling above the trench;
- Provide pre-treatment in the form of a buffer strip, swale, or other sediment removal feature;
- Incorporate an underdrain to assist in drainage; and
- Construction activities must not compact the soil and inhibit infiltration capacity. Minimize the use of heavy equipment and till the soil over any locations that were heavily trafficked.

Maintenance

Long-term performance of the infiltration trench is primarily dependent on maintenance of the pre-treatment systems. Maintenance of the pre-treatment system must be performed preventatively. Sediment that is allowed to pass through to the trench will degrade performance rapidly and pooling may occur. If maintenance is needed to improve the infiltration rate, the costs are relatively expensive because the trench will need to be rebuilt. However, if water is still allowed to drain off the side of the trench or into an overflow, then no vector issues will be present. Recommended maintenance activities are:

- Semi-annually, before and after the wet season
  - Inspect the overflow riser for clogging and clear as needed;
- At least once during the wet season, one week after a rain event
  - Inspect the BMP for water ponding. If water is ponded, it is most likely due to clogging in the soil or liner. Remove fill, expand the trench to use new soil, install a new liner, and re-fill with rocks and gravel. Expanding the trench removes soil that may have become clogged during BMP operation;

CONSTRUCTED WETLAND

Description

Vector Risk: ***High***

Constructed wetlands are engineered flow-through systems designed to emulate the water quality improvements of natural wetlands. Wetlands are one of the most effective water treatment BMPs because of the multiple natural treatment mechanisms that are implemented. Constructed wetlands can generally be broken down into two categories: surface and subsurface flow. Surface flow constructed wetlands have an open water surface and remove pollutants using settling, biological decomposition and digestion, and filtration. Due to the long hydraulic residence time and permanent water surface, surface flow constructed wetlands will normally breed mosquitoes. Subsurface flow constructed wetlands move water underneath the soil level and remove pollutants through similar methods, but do not settle pollutants.

This section will focus on surface flow wetlands, as mosquito breeding is less problematic in subsurface flow wetlands.

Planning

Constructed wetlands are best when located inside of a buffer from housing and human occupation to reduce biting pressure. A large buffer is optimal for preventing mosquitoes from reaching homes, although some species of mosquitoes may fly up to 10 miles from their breeding site, if winds allow.

Adequate funding is required to support long-term site maintenance, as well as routine monitoring and management of mosquitoes by a qualified agency. Coordinate with OCMVCD on the development of the plan(s) and layout. Proper planning can greatly reduce future maintenance and associated costs.

Planning documents must corroborate on whether or not the creation of habitat is intended. If so, protected species may inhibit vector control activities and require an escalated response to mosquito breeding, entailing a more resource intensive control strategy. Provisions should be included to allow regular inspections and treatment of the site by OCMVCD for the detection of developing mosquito populations. Project documents should specifically address this issue to resolve potential conflicts of interest.

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent vector breeding must be included and clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs so that they may be consulted on a resolution for the situation.

Design and Construction Recommendations

Mosquito breeding in surface flow constructed wetlands is often unavoidable due to the permanent water surface. Therefore, the design should emphasize openness and access to the wetlands, so that maintenance and vector control technicians can easily service the areas. Some design choices can also minimize the risk posed by the wetland and reduce the amount of pesticide needed. Design recommendations for surface flow constructed wetlands are:

- Minimize the density and width of emergent vegetation areas. Heavy vegetation provides safer habitat and steadier water for mosquito larvae;

- Surround the wetlands with paths of adequate width to allow safe passage of maintenance staff and/or equipment
    - For larger wetlands, create a road with a minimum width of 10 feet to allow maintenance vehicle access;
    - Compartmentalize the wetlands into multiple cells with a maximum length of 40' in both dimensions, this makes the water surface easily accessible for maintenance and vector control staff and reduces the maintenance cost;
- Establish deep-water zones with a design water depth as 4 feet or greater, which is less suitable for mosquito larvae production and encourages predation on larvae. Having these deep zones will also create open water that unplanned emergent vegetation cannot grow in;
- Provide shade to the wetlands where possible. Shade will prevent the growth of invasive emergent vegetation;
- Provide pre-treatment that is effective at nutrient removal. The decomposition of organic material reduces dissolved oxygen in the water, which may make the water unsuitable for larvae eating predators such as mosquitofish;
- Provide vehicular access to and from the site; and
- Use grouted riprap or concrete blocks instead of loose riprap, where necessary, to prevent standing water within crevices.

Maintenance

Maintenance of constructed wetlands can be labor intensive and costly. Ensure that the budget is available and that the future responsible party is aware of the maintenance requirement to maintain water quality and reduce mosquito breeding. Maintenance primarily involves vegetation management and sustaining accessibility to the surface of the water. If the wetland is designed to, or is allowed to, create habitat, then maintenance can only be performed in a narrow window of time between the bird nesting seasons and outside of rainy periods. Recommended maintenance activities for surface flow constructed wetlands are:

- Annually, in late winter
    - Stock wet ponds/constructed wetlands with mosquitofish (*Gambusia spp.*) to enhance natural mosquito and midge control. Contact OCMVCD to determine if mosquito fish are appropriate;
    - Cut down and harvest excess vegetation along roads and trails so that access is maintained;
    - Skim and remove floating vegetation and debris, such as duckweed and algal mats, from the water surface;
    - Cut down and/or remove excess vegetation within the wetlands. If the vegetation is allowed to grow and die off, or is not removed, mats of decomposing plant material will aid in mosquito breeding;
- Semi-annually
    - Inspect for and remove debris in all inlets, outlets, and water conveyance structures; and
    - Inspect for ponding caused by ruts, subsidence, or other factors, and correct as needed.

MISCELLANEOUS PROPRIETARY BMPS

Description

Proprietary BMPs are pre-built water quality treatment systems that are designed and produced by a third party manufacturer before being installed on-site. These BMPs can be broken down into several types, as detailed in the table below:

Type	Examples	Vector Risk
Filter	Tree well, hydrocarbon boom, media filter	***Low***
Permeable surface	Porous pavers, interlocking pavers	***Low***
Underground detention	Arched chamber, cast concrete, cubic chamber	***High***
Underground infiltration	Arched chamber, cast concrete, cubic chamber	***High***

Filters, traps, screens, and permeable surfaces frequently serve as pre-treatment for traditional BMPs such as infiltration basins and wetlands, but can also discharge directly into the storm drain. Some proprietary systems will incorporate multiple types in a "treatment train", which cohesively treats storm water runoff. A typical example may involve a trash trap, screen, media filtration, and an underground infiltration chamber.

Planning

Utilizing proprietary BMPs for pre-treatment is an important step when considering treatment trains and infiltration-type BMPs. Proper pre-treatment will typically serve a two-fold benefit by reducing the overall cost of maintenance on the project and reducing the potential for mosquito production.

Per the above table, several types of BMPs are less likely to breed mosquitoes and are therefore preferred for vector control. Filters, permeable surfaces, and screens generally have a lower capacity for breeding mosquitoes and may cause minimal problems, even if they are neglected. Vortex separation units typically create a sump that will breed mosquitoes unless regularly vacuumed, so caution is necessary. Underground facilities are more difficult to maintain and inspect, which precludes a higher probability of breeding mosquitoes. If vortex separation or underground facilities are part of the project plan, coordinate with OCMVCD during the planning and construction of the site.

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent vector breeding must be included and clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs so that they may be consulted on a resolution for the situation.

Design and Construction Recommendations

Due to the varied and individual nature of each proprietary BMP, only general recommendations will be made. Consult the manufacturer for assistance in minimizing standing water and mosquito production, as they will have had the most experience with their product. General design recommendations are:

- For proprietary underground detention and infiltration facilities, see the information sheet for *Underground Facilities*

- Do not utilize BMPs that will create a permanent sump
    - If a permanent sump is necessary
        - Utilize systems that have an underdrain pipe or porous bottom in the sump. Additional maintenance will be necessary to ensure the performance of the underdrain system;
        - Or, install a sump pump that can periodically drain standing water;
- Where possible, screen all openings to underground BMPs with 2mm or finer mesh to block mosquito access;
- Include removable manhole inserts for all manholes; manhole inserts fit underneath manholes and provide a barrier to entry through the pick hole; and
- Provide vehicular access to and from the site.

Maintenance

For most BMPs, following the manufacturer's maintenance guidelines is sufficient at minimizing mosquito breeding. Mosquitoes may be present and breed at any time of the year, so year round maintenance is important. However, mosquitoes primarily carry disease after winter, so it is important that maintenance occurs in winter. Most BMPs also receive dry-weather flows, so maintenance should continue throughout summer.

RAIN BARRELS

Description

Vector Risk: ***High***

Rain barrels are manufactured containers that capture residential roof runoff for later non-potable uses, such as irrigation. Municipalities and developers often supply rain barrels to residents in order to encourage water conservation and reduce dependence on imported water sources. Most barrels store 55 gallons of water, or about half of the daily irrigation requirements for an average home. Rain barrels are typically implemented in two ways; with a roof downspout directly fitted into the barrel or with an open, wide-mouthed orifice that receives the water.

The vector risk of *high* is primarily due to the uncontrollable circumstances around residential use and maintenance. Rain barrels can easily be neglected and fall into disuse for years, while still holding water.

Planning

Both types of rain barrels can easily breed mosquitoes, even if screens and/or flap valves are incorporated. The primary reason for this is that upkeep of the barrels is often neglected or ignored by residents, even with the best of intentions. Rain barrels require constant use, monitoring, and maintenance to ensure that mosquitoes do not lay eggs within. Screens can become torn or loose, and flaps can be obstructed and kept open. Most barrels have spigots that are several inches from the bottom and as such, cannot be fully emptied unless water is pumped out or the barrel is inverted.

Implementation Recommendations

Rain barrels must have a 2mm or finer screen, attached to the barrel, over all openings.

Due to the large number of potential rain barrels, and required permission from the property owner to enter a back yard, monitoring by vector control can be challenging. To ease inspection, rain barrels should be placed in easily accessible location.

Rain barrels that are fitted to a downspout are open throughout the downspout, which allows mosquitoes to seek and breeding within. To prevent this, a screen or self-activated flap valve can be used to exclude entry.

Maintenance

Residents must be instructed to inspect perform maintenance for the rain barrel on a regular basis. When the barrel contains water, it should be inspected weekly for mosquito breeding. Screens should be inspected closely for tears and gaps on a monthly basis. The flap gates and downspout should also be inspected for obstructions that may hold the gate open. After the wet-season and any dry-season rain events, the barrels should be inverted, emptied of all standing water, and cleaned.

If needed, residents can also purchase bacterial mosquito larvicides from home improvement stores and place them in the rain barrels. These are safe when used according to the manufacturers specification and will not affect irrigation.

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TRASH CAPTURE DEVICES

Description

Vector Risk: ***Medium***

Trash capture devices and screens are typically installed as retrofits in a catch basin, or may be independent systems in-line with storm water drainage, such as with vortex separation units and baffle boxes. Typical designs use a screen that is either inserted below a catch basin opening or surrounds the connector pipe. The primary purpose of trash capture devices is to capture objects that are larger than 5mm, or approximately 0.2" in diameter. These capture trash and environmental debris. If constructed and maintained correctly, trash capture screens can reduce mosquito breeding downstream by reducing clogging points and removing nutrients.

Planning

The primary risk factor for mosquito breeding in trash capture devices is a lack of maintenance. It is best to reduce the number of screen installations to as few as possible by installing devices further downstream. Devices which capture runoff from multiple inlets reduce the time and expense required to clean, maintain, and treat for trash and mosquito breeding issues. In addition to this, a comprehensive budget should be set aside to ensure that there will be the time and funding available to keep the screens functional.

In-line screens such as vortex separation units and baffle boxes often integrate a permanent sump into their design. The permanent sump allows for storage and settling of trash and debris, but also creates a permanent mosquito breeding habitat. The use of these and other permanent sump devices should be kept at a minimum, and if they are necessary, ingress/egress to the device should be screened off to prevent mosquito entry as much as practicable.

BMPs often breed mosquitoes and fail to perform as planned due to a lack of awareness and maintenance by the property owner. A binding agreement to maintain and repair a BMP as necessary to prevent vector breeding must be included and clearly laid out to the owner accepting responsibility. Instruct property owners to contact OCMVCD if mosquito breeding occurs so that they may be consulted on a resolution for the situation.

Design Recommendations

Each catch basin or drain line is unique, and discretion during design is required to reduce mosquito breeding. Screens should be carefully selected to minimize the chance for standing water, and be easily accessible from the manhole . In general, catch basin inserts that are elevated above the inlet are preferable because they are more easily drained by gravity and can be accessed and inspected efficiently.

Sediment and debris may build up and hold water in between maintenance cycles, so it is necessary that the devices are easily accessible from the manhole, without the need for a person to enter. A mechanism to release, remove, or open the device should be built in. This allows for inspection and treatment of the device and outlet pipe.

Maintenance

Trash capture screens should be inspected after major rainfall events, and as frequently as every 2 weeks during the peak mosquito breeding season of May to October. In addition to removing all accumulated trash and debris, the screen should be cleaned to remove any clogging that may have occurred.

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