DRAINAGE CONSIDERATIONS FOR MOSQUITO CONTROL

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1.0 INTRODUCTION

Drains are generally constructed structures to convey stormwater, waste water, or other sources of water by a flow path or formal channel from a catchment or source to a discharge point. Drains can be part of an organised drainage system or a specific measure to drain depressions or temporary flooded areas. Generally drains in small catchments in undeveloped areas only convey water during or for a few hours after rain, and if they have adequate slope, dry up soon after the rain ceases. However drains with larger catchments or from perennial or artificial sources of water, contain water for relatively long periods and can be significant sources of mosquitoes.

Stormwater drains, particularly those near urban areas or industrial developments that receive organic or nutrient rich wastewater, can be prolific sources of mosquitoes. The mosquito species commonly found in freshwater drains include *Culex quinquefasciatus*, the brown house mosquito, *Culex annulirostris*, the common banded mosquito, and *Anopheles annulipes s.l.*, the common Australian Anopheline. Drains near tidal areas, particularly in the tropics, can be substantial sources of *Ochlerotatus vigilax, Verrallina funerea, Cx. sitiens* and *An. farauti s.l.* or *An. hilli.* As these species include those that are serious pests of people and potential vectors of disease, the presence of large numbers close to people can pose serious public health problems.

Mosquito breeding generally occurs in drains when the flow is continuous, the water has high nutrient levels, and the channel is overgrown with semi aquatic or aquatic vegetation. Breeding also occurs in residual pooling as the drain dries out after ceasing to flow or after tidal inundation. Those drains that are capable of sustaining fish or aquatic bugs and beetles are normally not significant sources of mosquitoes. Drains can be constructed with provisions to reduce or avoid mosquito breeding. Generally well constructed drains are more cost effective in the long term as they are not subject to regular maintenance or the need for expensive rehabilitation, and have little requirement for ongoing insecticide control operations.

2.0 GENERAL CONSIDERATIONS

The amounts of water to be removed when considering drainage for mosquito control may often be small. These may not be significant to the civil engineer or the farmer but maybe of great significance as a mosquito breeding site. Drain features for mosquito control often need to be less sophisticated than civil engineering considerations for storm water control. The water does not need to be contained, and only needs to drain away over a four to five day period before mosquito larvae can mature, rather than a matter of hours for civil engineering drains.

The choice of the drainage method for mosquito control (draining, pumping or tide control) and type of drain depends on the local capabilities, the size and nature of the mosquito problem, the relative cost, the terrain, the soil type, and ongoing maintenance considerations.

The needs for drains can sometimes be reduced. Any land clearance or development operation should include the rectification of small depressions by grading and selective filling so that the finished landscape is free draining without the water being concentrated in defined flowpaths.

Sometimes land development does not fill a number of depressions, or stormwater is concentrated to low lying areas by sealed or impervious areas (buildings, roads). Often it is cheaper to drain these small to moderate depressions rather than fill them. In these cases drainage can often be achieved by simple open drains, such as narrow grassed swales or shallow gently sloped ditches to convey water to a stream or to spread it over sloping ground for infiltration. For larger depressions or greater volumes, drainage may require a broad floodway. The equipment requirements for this drainage are generally simple, ranging from hand tools, bobcats or graders. Usually the input of labour and money for these methods are relatively small, and the works can be carried out without formal measurement and by general contractors.

Where larger water bodies need to be drained or if there is seasonal to continuous flow, a more formal drainage system may be required. The importance of good engineering design for larger scale drainage increases with the size and scope of the problem. Two points to remember are:

a) the minimum structure should be used to achieve the desired result;

b) drains should be rounded or 'U' shaped in cross section to ensure that flow can continue for relatively small volumes, and the drains are self cleansing.

The drainage of large areas or extensive water bodies needs a more thorough engineering appraisal. Drainage of large swamps and large catchment areas that have perennial flow may have permanent effects on the local or down stream environment. These larger engineering projects generally need hydrological, engineering and ecological expertise to ensure that the drainage achieves the desired results without causing deleterious effects. These large scale engineering undertakings are not dealt with in this paper.

There are a number of specific questions that should be considered before constructing drains. Adequate consideration of these questions can have a large outcome on whether the drains become sources of mosquitoes. The questions include:

a) What type of drain is required (open unlined, open lined, subsoil)?

The type of drain required will be dictated by a host of physical and resource considerations, but the possibility of creating mosquito breeding should be a major consideration.

b) How much water needs to be drained?

The volume of water to be conveyed will determine the size of the drain required. If it is a small volume it may be drained easily in a matter of hours by a simple ditch. If it is larger, it may be drained by a drain of sufficient size over a period of up to 5 days without causing mosquito breeding problems.

c) When is the drainage necessary?

If the drainage is required only during rain episodes there may be no need for any permanent concrete features. There may be little opportunity for mosquito breeding in the drain due to the regular flushing and the rapid draining or drying of the drain when the rain ceases.

d) What is the ecological effect on the drained area?

If a deep water area is drained, the drainage may reduce wave action or disrupt fish ecology. It may become a shallow area that permits emergent vegetation growth which could be conducive to mosquito breeding. If the drained area is only partially drained, or takes a relatively long time to drain, periodic refilling could cause a new hatch of mosquito larvae.

e) Where is the outlet and what will the down stream or upstream effects be?

If the outlet is to the open sea or a large river, it will generally be adequate to prevent mosquito breeding. If the outlet is to a sheltered area near the upper tide limit or to a small creek or a lake, the deposition of silt and subsequent cut off pools or vegetation growth could cause new mosquito breeding sites. If the drain includes drop structures, they may be sufficient to prevent the seasonal redistribution of fish to upstream areas.

f) What is to be done with earth spoil?

If the spoil is placed on the uphill side of a drain it will restrict flow into the drain. Earth spoil should be placed on the downhill side of a drain and have numerous breaks to allow drainage into the drain.

g) What maintenance considerations are necessary?

Open earth drains require regular maintenance, while subsoil drains require only occasional maintenance at a limited number of points. Maintenance procedures will require resources for the longer term and capability of maintaining these resources should be considered before the drain is constructed. Maintenance also requires adequate access for inspection and rectification equipment, which may alienate larger areas of land.

3.0 TYPES OF DRAINS & DESIGN CONSIDERATIONS

3.1 Open Ditching (Surface Drains)

Open drains (OD) can be either simple unlined structures or well constructed and shaped drains with full concrete lining. Open unlined drains (OUD) are often the cheapest and most simple form of drainage but many aspects should be considered before construction. After consideration, it may be clear that partial concrete lining is required, or that it is more practical to construct a subsoil drain.

Open unlined drains are usually subject to regular maintenance for weed control and silt removal. If the drains are in urban or industrial settings, they often contain organic pollution and are overgrown with vegetation and are usually prolific sources of mosquitoes. Upgrading unlined drains to permanent concrete drains is often justified in urban and industrial areas where the flow needs to be contained totally within the drain and where high flows or velocities are experienced. Sometimes upgrading can be justified if regular mosquito control or excessive maintenance is required. If upgrading is required to safely prevent mosquito breeding, the breeding is usually seasonal and occurs with dry season low flows. In these cases the upgrading may only require a central dry season flow concrete insert to facilitate flow and silt movement. These low flow inserts can drastically reduce maintenance requirements by removing the long term water and nutrient sources that encourage vegetation growth and subsequent silt accumulation.

Some of the major aspects that should be considered before the construction of open drains have been outlined below. They are discussed more fully in the listed reference, (Pratt et al., 1972).

a) dimension of drain required

Drains for mosquito control only need to be of dimensions that will drain an actual or potential flooded mosquito breeding site over a period of days, ie. the drain should be as small as possible to achieve the desired aim. For relatively flat topography in undeveloped areas, gently shaped grassed floodways with shallow central inverts can adequately cater for periodic storm flows.

Often the time required for drainage to occur before mosquito breeding can be completed will dictate the dimensions of the required drain. Flooded areas that come under tidal influence at any time of the year should drain within three (3) days, while all freshwater areas should drain within five (5) days. If a drain overflows its banks during periods of high tides or heavy rainfall, the overflow water should drain back into the drain within the above times. Storm floodways or drains may receive continuous seepage or wastewater during dry periods. The seasonal volume of these low flows will determine the dimension of a low flow concrete invert.

b) route and layout of the drain

Generally drains should follow the shortest route from catchment to discharge point. If there are drainage sources of problems adjacent to main drainage routes, smaller lateral drains can be constructed to those areas. For extensive, flat poorly draining areas, a fishbone lateral feeder system may be required. Drains should be as straight as possible, to shorten the length, with no sharp bends that can result in bank erosion or require rectification measures. Any bends, drain junctions or discharge points may need erosion prevention structures, and may require access for silt removal.

c) grade of area to be drained

The grade of the area to be drained will determine the need for erosion control structures and the dimensions of the drain.
The finished grade should be adequate to drain the area over a number of days, but not so steep that erosion occurs. If steep areas are to be drained, adequate erosion control drop structures will need to be installed. A grade of at least 0.05 % is required for concrete drains or drains with concrete inverts. Often grades for mosquito control drains can be considerably lower than for civil engineering purposes. Slightly greater slopes (between 0.1 and 1 % are required for grassed or earth drains where minor silt and vegetation accumulation can cause pooling in the drain.

d) side slope of drain

The side slope of the drain will determine the stability of the drain and largely be determined by soil type. Drains in rock and clay can approach the vertical, while in most soils a 45° slope is required. In sandy soils or sand, reduced slopes are required. The sides of drains with appreciable flow and erodable soils may require erosion prevention measures such as rock baskets.

e) the location of berm spoil;

When drains are constructed in low lying or level areas, any berm or spoil should have regular breaks to allow lateral drainage into the drain such that no pooling occurs outside the drain. In sloping situations the berm should be placed on the downhill side of the drain to prevent ponding uphill of the berm. The spoil should always be placed at a sufficient distance from the drain so that it cannot erode or slump into the drain. Earth spoil on the berm can cause weed growth or ecological change and may require removal or spreading. Soil spreading in very flat areas such as salt marshes may still cause shallow pooling and may require lateral drains through the disturbed areas to the central drain.

f) the final depth of the drain

Drains should only be as deep as required to gain sufficient grade to enable flow to a suitable discharge point. Drains for mosquito control generally should be as shallow as possible. They can be smaller if occasional overflow does not cause problems. The invert of any drain should not be below the seasonal water table. Deep drains promote continued seepage into the drain. This may result in perennial water within the drain, encourage continuous vegetation growth, and result in long term mosquito breeding.

g) the end point

Drains with dry season low flows, or considerable and prolonged flows, should discharge directly into daily flushed tidal areas, large channels or creeks, or large bodies of deep water. Drains with low flows should never discharge to flat, ill defined, low lying, poorly drained areas.

The end point for 100 year flood drains without dry season low flows should be just below the maximum high tide level in tidal areas, or just below the 100 year flood level for larger receiving rivers or water bodies.

The invert of the end point of drains with dry season low flows near tidal areas should be below the average high tide level or to a natural well defined tidal creek that drains freely at low tide. A channel could be dug back from a tidal creek to satisfy this requirement

h) soil type and erosion potential

Open unlined drains of moderate grade through unconsolidated or erosion prone soils will require the installation of erosion prevention structures such as (stone and mesh gabions) wherever there is a likelihood of erosion within the drain.

If there is a potential for soil erosion or appreciable silt movement in development areas, drains through the area should include silt traps. Silt traps should be constructed upstream of the discharge point to freshwater or tidal creeks. Drains, erosion prevention structures, and silt traps should be installed as a first stage of development, particularly if the drainage discharges into relatively flat areas or to a creek or another water body. Any silt trap should have access for regular maintenance and silt removal.

i) potential for dry season low flows

Urban or industrial areas can often produce dry season low flows in drains. The ultimate standards for urban drains with low flows are impervious underground pipes or open lined channels with central low flow inserts. Central impervious low flow capabilities are essential where there is a likelihood of dry season low flows. Low flows generally occur from institutions with large lawn areas or garden beds which are watered by automatic sprinkler systems (eg. hospitals, schools, shopping centres). Low flows are also highly likely in areas which generate waste water from watering, processing or washing operations (eg. service stations, industrial areas, plant nurseries and shopping centres). In general the larger the catchment, and the more institutions and non residential developments within the catchment, the greater the probability of dry season low flows in drains servicing the catchment.

j) drain maintenance

There should be no vegetation, cut off pools or silt deposits in drains. Drain maintenance such as silt removal, weediciding or vegetation and debris removal for earth lined drains should be programmed on an annual basis. Maintenance easements should be included alongside all open earth lined drains. Drains that discharge into dams or lakes will require periodic silt removal at the discharge point into the water body to prevent the establishment of aquatic and semi aquatic vegetation.

3.2 Subsoil Drainage (Underground Drains)

The types and size of subsoil drains will need to suit local conditions. Subsoil drains can either be impervious or pervious depending on the need to either carry or dissipate the water. Subsoil drainage may be expensive initially but can reduce maintenance and access problems. The decision to construct subsoil drains as opposed to open drains will generally be made on cost and access considerations.

Pervious drains include underground terracotta, perforated pipe, rubble, sand or gravel drains. Sometimes pervious drains can be constructed unintentionally by the breakdown of jointing or leaks in pervious pipe systems.

Pervious drains are used to remove surface water and allow infiltration of wastewater over a larger area. Pervious drains generally can handle only limited amounts of water before saturating the surroundings and causing surface pooling. They are also not adequate for long term drainage, as the pore spaces become compacted or filled with earth and blocked by root growth.

Impervious drains are the most common drainage systems in urban and industrial developments. Generally they are constructed of concrete or PVC pipe sections and convey water to a suitable end point. Impervious drains generally have adequate slope and if they are round in cross section, convey even small amounts of water and are self cleansing. Their main advantage is the reduced access requirements for inspection and machinery, and the reduced maintenance costs. Their main disadvantage is their high initial capital cost.

4.0 PUMPING

Pumping of excess water can be a useful method to drain areas by collecting the water from one point and lifting it so that it can flow to another water body or to a suitable disposal site. Pumping can be used when there are depressions below tide or river levels or the gradient is too small for simple draining or ditching. Pumping has an energy requirement, but with innovation this can be supplied by solar or wind power, as well as electrical pumps. It can be considered for small scale drainage in some situations, as well as for large projects.

5.0 TIDE CONTROL

Draining large low lying areas or drains inundated by tides can be facilitated by tide exclusion. Tide gates or barriers can be installed in drains and across tidal flats to restrict or prevent the inundation of areas below maximum tide level, and then allow the water to drain through a gravity operated gate during low tide levels.

Tide gates can vary from large sophisticated flap valves at the end point of large underground pipes or open channels, to simple hinged barriers in an open earth drain. There can be varying combinations of ditching, dyking, pumping and tide gates in large scale projects. One of the biggest considerations for tide control is the ecological effect on upstream habitats. Tide exclusion in drains can cause a proliferation of freshwater semi aquatic and aquatic reeds upstream of the tide barrier. Sometimes freshwater vegetation in drains or marsh areas can be controlled by allowing occasional tides to inundate the vegetation at critical times in its growth stages.

6.0 CONCLUDING REMARKS

Drainage can be a very efficient method of preventing mosquito breeding, but drain construction without due consideration of certain design features can result in new and prolific mosquito sources. Adequate considerations of these features in the planning of drainage systems can reduce expensive and ongoing maintenance requirements, avoid additional mosquito populations, and reduce potential public health problems.

7.0 REFERENCES

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