

# **DRAINAGE**

## **INTRODUCTION**

Drainage is the process by which surface water, waste or any other type of liquid matter is channeled or carried away. A drain is the means by which this process takes place. In this case when we refer to drainage we will be referring to storm water drainage. The collection and disposal of storm water has presented many problems in the Caribbean. An adequately designed drainage system is vital to the successful development of any construction project; but the heavy rainfall which occurs frequently in the Caribbean countries makes it expensive and difficult to provide for the safe disposal of the storm water. No proposed development or road should discharge water directly on to an existing development or road. This paper will provide guidance for collection and disposal of storm water in developments being planned and it suggests policies and strategies in order to provide safe disposal of water waste/storm water in the British Virgin Islands. In order to achieve this there must be established drainage facilities to conform with the rules laid down by the authority concerned. In this connection, the rules of the Ministry of Works and the relevant Public Health Acts take precedence. In the future, the development of this sub-sector should follow proper design of drainage facilities and it should be carried out by engineers experienced in hydrological design.

## **TYPES OF DRAINS**

There are two types of drains i.e. Natural Drains and Artificial Drains.

### ***Natural Drains:***

These are basically ghuts, creeks, and trenches. They are natural formations, a direct result of erosion of the earth's surface via running water.

### ***Artificial Drains:***

These are divided into five (5) types:

#### ***Kerb and Slipper:***

This is a common facility generally used on most streets in the Caribbean. The kerb serves to support the road edge and the slipper conveys the road water to the nearest inlet or catch basin. It is important that the inlet basins be placed at frequent intervals to prevent a build up of flow. The slipper drain does not have the capacity to carry much storm water and is

intended to act only as a partial collector for the water falling on limited stretches of roadway. Maintenance of slipper drains is vital to the stability of the road.

*Side Drains:*

The drains are usually used as main collectors for water from roads in the more rural areas, and are generally earth ditches. The protection of the sub-grade is very crucial where unpaved roads are used, as water can easily penetrate the road surface and weaken the sub-grade. In such cases, it is recommended that the drain should be at least 20 inches below the sub-grade for main roads and 15 inches for access roads. The ditch will keep the flow of water below the pavement layers. The choice of shape and the decision to line or not to line a drain depends on several factors. These include the quantity of run-off to be carried, the protection required of the road sub-grade and the stability of the drain to withstand rainfall and channel erosion.

The cost implications of lining the drain and the ease of maintenance may be determining factors in the design of the drain. For unlined earth drains it is recommended that the trapezoidal section be used as this is reasonably hydraulically efficient and the ditch is easy to maintain. The bottom width should be at least 12 inches to allow a shovel to be used efficiently to clean the drain. To improve the efficiency the drain may be lined with concrete or stone. A concrete lined drain is easier to maintain and presents a better appearance than an unlined earth ditch.

*Main Drains:*

Many developments on hilly ground will require the construction of a main drain to guide storm water around the developments into the existing watercourses. It is recommended that the location and construction of such waterways must be approved by the planning authorities.

*Cross Culverts and Plot Accesses:*

Cross culverts accept flow from the slipper drains or side drains and channel storm water from the roads to the main disposal channel. These culverts will be required at various locations throughout the layout where the drainage lines cross the road reserves. Culverts will have to be constructed to take storm water from open drains across plots to the main channel. Shallow drains will not normally require culverting at plot access ways and at water sections. However deep side drains will require culverts at the access way and at intersections where the drains are carried under the carriageways. Precast concrete pipes are commonly used in the Caribbean for such culverts. Plastic culverts using reinforced high density polyethylene are available in size up to two (2) metres. These culverts offer advantages of light weight and durability. For large crossings “cast in place” rectangular structures have been used. Different cross sections lead to different flow efficiencies, but in general, the choice of a culvert is made on the basis of availability and cost. For ease of maintenance the minimum size (diameter or width) of 18 inches should be used.

*Porous Drain with Filter:*

This type of drain is used primarily in areas where the soil saturates easily. The drain consists mainly of a perforated PVC pipe, submerged beneath the surface and surrounded by aggregates. The pipes are placed longitudinally to the roads edge, such that ground water that seeps into the soil is immediately collected, filtered and channeled away from the road's surface. In the B.V.I. drains such as these can be found mainly on airstrips, particularly the Beef Island Airport.

## **PROBLEMS ASSOCIATED WITH IMPROPER DRAINAGE**

The BVI accommodates a total of some 185.6 km of road, among the 4 major islands. This figure does not take into account those access roads which were cut by individuals for private use. Due to the steep terrain of most of the islands, surface water runs downhill and eventually empties into the ocean. Unfortunately, since most development tends to occur in uphill regions, this interrupts the natural drainage pattern of the surrounding areas. Disturbance of the natural drainage system will result in the following occurrences:

**Erosion:**

This is caused by uncontrolled surface water runoff. It is mainly the wearing away of the earth's surface by running water. Development of land in general tends to involve cutting into hillsides and the removal of existing vegetation, this in turn increases surface runoff and results in erosion of surrounding areas. Uncontrolled runoff erodes the physical infrastructure. Water settles or "ponds" in existing roadways and erodes their asphalt or concrete. This in turn creates potholes which become a nuisance and hazard for the motoring public.

In addition to the above erosion removes, fertile topsoil, and this in turn adversely affects the agricultural potential of the region.

**Flooding:**

This occurs mainly as a result of poorly designed and or blocked drains. Drains may become blocked when garbage is stored in them or when sediment is washed down from the hillsides (as a result of erosion) and is deposited within the drain. The blockage impairs the drain's ability to control the flow of water. Flooding tends to occur frequently on flat, low lying areas where there is little or no gradient. Areas with coastal reclamation or natural ponds are highly susceptible.

In addition to this, roads may collect and channel water away from natural water courses to more vulnerable and easily eroded areas. They may also cause increased flow in some areas and overwhelm existing natural and artificial drains causing flooding.

**Hazardous Road Conditions:**

Uncontrolled surface water runoff and eventual ponding of water create slippery conditions for motorists. In addition to this, potholes contribute to the wear and tear on vehicles, and thus increases the owner's operating costs.

**Health Hazard:**

The settlement of water (stagnant water) in the roadway is likely to create ideal breeding grounds for mosquitoes which spread diseases to people. Examples of such diseases are dengue, yellow fever etc. Silt deposited by runoff often dries out on roadways creating a dust problem which in turn can aggravate respiratory ailments in individuals.

**Odors and Unsightly Appearance:**

This relates to stagnant water which causes odors to the surroundings.

**Environmental Degradation:**

This occurs when natural systems, for example, wetlands, salt ponds, ghuts are drained for development purposes, and the natural courses of storm water are changed and re-directed into the ocean. As a result, sediment is deposited into the ocean, onto the reefs etc. and this severely affects the marine life.

**CURRENT DRAINAGE SITUATION**

Unlike other countries where the maintenance of drainage system is done by Town, Municipal or City Councils, the maintenance of the entire public drainage system in the BVI is carried out by the Public Works Department (PWD) - Roads and Bridges Unit. Normally it is carried out on a monthly basis and work is done on a contractual basis. Emergency work is carried out whenever it is necessary. Particular attention is given to the months of May, June and July, the onset of the hurricane season. PWD is supposed to ensure that all drains are checked and or cleared of debris, so as to ensure the uninhibited flow of storm water.

**Funding:**

Public funds under the supervision of PWD are used to pay for construction and maintenance work. No specific sum of money is allocated towards drainage works. The following table outlines funding received by the Roads and Bridges Unit for the 1993-1997 budget years:

| <i>Year</i> | <i>Initial Approved Estimate (Roads and Bridges)</i> | <i>Total Expenditure (Roads and Bridges) (Dec. 31st)</i> | <i>Total Expenditure on Drainage Works</i> |
|-------------|--|--|--|
| 1993        | 700,000  | 1,182,254.00   | 64,760.00                                  |

|      |         |            |              |
|------|---------|------------|--------------|
| 1994 | 500,000 | 787,866.00 | 62,064.25    |
| 1995 | 800,000 | 806,808.00 | 15,025.80*   |
| 1996 | 850,000 | 880,050.00 | 38,995.00    |
| 1997 | 920,000 | N/A        | 121,100.00** |

Source: Recurrent Budget Estimates, BVI Public Works Department

\* August 1995

\*\* Projected Amount

**Problem Areas:**

The following are areas that are affected by the current drainage system:

*TORTOLA:*

*Wickham’s Cay:*

Wickham’s Cay which consists of reclaimed land, has never had a natural drainage system. The drains that are currently in place are too small and cannot adequately accommodate the runoff that occurs in this region. Presently, water settles on the surface creating saturated or swampy conditions.

*Chalwell/ Sea Cows Bay:*

This area is experiencing inadequate drainage. When it rains, storm water runs along access roads, erodes the unpaved sections of the roads and settles in the paved areas of the major road creating potholes and slippery conditions for motorists.

*Paraquita Bay:*

This area has inadequate drainage associated with a design problem. Paraquita Bay is a large watershed, the natural drainage has been interrupted due to development and no adequate alternative has been provided. Presently, the existing road in this area was constructed too close to sea level and water tends to run along access roads, pick up debris and deposits debris on main road. A PVC pipe drain was installed but this was only intended as a temporary solution.

*Baughers Bay:*

The drainage problem in that of flooding. During heavy rainfall, area occurs as a result of the storm water over flow of a non-functional drainage channel which crosses the main road. This in turn impedes vehicular and pedestrian traffic.

*Pockwood Pond:*

There is inadequate redirection of water flow. Presently water from the access road to the incinerator, flows over the newly paved road area. The same water will eventually seep into the roadway and destroy the material. There is a great need to redirect and channel this flow of water into a catchment area.

*VIRGIN GORDA:*

For this island, erosion is the major concern. Erosion occurs as a result of cutting into the hill sides for remedial road works etc. The roadway is eroded as potholes result from the action of running water.

*ANEGADA:*

The drainage problem on this island is unique in that the terrain is extremely flat and water tends to settle quite easily on the surface, especially in the Settlement area. Flooding occurs during times of heavy rainfall.

*JOST VAN DYKE:*

This island does not have a serious drainage problem. However, the major development area is located in Great Harbour which contains a natural pond. Ponds provide natural holding areas for excess runoff. Reclamation in this area may increase the probability of flooding in surrounding areas. Ponds also collect and remove suspended silt. If removed and water is taken straight to the sea, increased pollution from silt will result. This area has to be monitored with regards to design of drains for future land developments.

*MOUNTAIN ROADS:*

There is a general problem with the channeling of rain water on existing mountain roads. These roads were constructed initially without consideration of proper drainage system. Roads were constructed in such a way that allows water to flow on the existing roadway, as a result asphalt that is laid in an effort to create traction for motorists is usually washed away with heavy rainfall. There is a need to have a proper design for roads in mountainous areas especially, Joe's Hill, Brewers Bay and Windy Hill roads.

## **EMERGING ISSUES ON DRAINAGE**

### ***Legislation:***

There is no direct legislation or regulation in place which guides or governs the construction and maintenance of drainage facilities for public infrastructure. The only legislation available is on construction of facilities for the disposal of sewage and waste for buildings as outlined by the Organisation of Eastern Caribbean States (OECS) Building Code Ordinance, but as it still awaits local parliamentary approval it cannot be legally enforced.

In addition to this, legislation addressing the following acts should be enacted:

1. Prohibition of the dumping of garbage in natural and artificial drains;
2. Restriction of developers interfering with the natural drainage and making provision for adequate remedial measures.

### ***Cutting Of Access Roads:***

The Public Works Department, Ministry of Works have no design standard in place with regards to cutting of private roads. Cutting is usually carried out without consultation of engineers.

### ***Land Acquisition:***

In some cases it becomes necessary to construct drains with outfalls close to or on private property. In most cases proprietors of such lands are unwilling to allow the construction. As a result major roadways may have to be constructed without adequate drainage.

A comprehensive analysis of the public drainage system needs to be undertaken, so that an assessment of the current status of the territory's drains can be made, corrective measures taken and coordination with future land development works can occur.

## **FUTURE DEVELOPMENT**

So far, we have noted that the government has limited policies in place regarding drainage. These policies are very important guides for future development of drainage system and future development of other infrastructure in the territory. Because of this the government should formulate policies and strategies to alleviate the problems we have seen and to ensure that the development of the sub-sector is environmentally and socially sustainable.

### ***Policies:***

The objective of the policies should aim at providing safe disposal of the drains/storm water. In this case the policies should look at the design of the drainage systems, facilities and qualified and experienced engineers. In general the policies should conform with the standards set by Organization of Eastern Caribbean States (OECS) i.e. PLANNING AND INFRASTRUCTURE STANDARDS with the assistance of UNCHS and UNDP in 1994.

### ***Development Strategies:***

To ensure the above policies are realized the following strategies will be implemented.

1. The legislation on drainage should be enacted immediately. This will guide future developers as far as standards, rules and regulations are concerned. The legislation should conform with OECS drainage standards.
2. Greater emphasis should be on maintenance and rehabilitation of existing drainage system.
3. Make sure that proper design of drainage facilities are carried out by qualified engineers experienced in hydrological design.

4. Follow the standards set by United Nations Centre for Human Settlements and the United Nations Development Programme (UNCHS/UNDP) program for Environmentally Sustainable Land Use Planning and Settlements Development in the OECS in 1997.
5. Training of BVI citizens in the engineering field.

## **SUMMARY OF STANDARDS FOR DRAINAGE**

The following are the standards set by UNCHS and UNDP.

1. Development plans must show all drainage facilities, including sizes and type of channels and culverts and locations of inlet basins and manholes.
2. The location of all points of discharge must be approved by the relevant authority and be in conformity with the existing environmental and public health legislation.
3. No storm water from a development should flow into existing roads without the expressed approval of the Planning Authority.
4. All public and private streets and major access roads should have concrete kerbs and slipper drains.
5. Inlet basins should be installed at each road or drain junction, at all intersections, at changes of grade, and at distances no greater than 200 feet apart.
6. Where ditches are used in urban development they should be lined with concrete. For agricultural feeder roads, the ditches may not be lined, but the velocity of the flow in the ditches reduced by use of drains.
7. The shape of ditch should be based on the determination of appropriate flow velocity required to discharge the storm water into the main channel or sea without flooding.
8. The sizes and location of all facilities should be developed on the basis of the hydrological information available at the Caribbean Meteorological Institute (CMI). It is recommended however that the design of the drainage facility should be carried out by an experienced engineer.