CHAPTER 9 LOSS ESTIMATION

9.1 INTRODUCTION

The quantitative vulnerability data available from chapter 8 makes it possible to estimate the likely economic losses that might result from high velocity winds and earthquake induced ground shaking. In this chapter the damage ratio curves from chapter 8 is used to estimate the structural damage to buildings, utility poles and boats from high velocity winds and the structural damage from ground shaking.

In general the methodology involves estimating the replacement cost of the structure and then establishing the economic losses from a given magnitude hazard event by applying the damage ratio for that event. Therefore if the replacement cost of a structure is $100 and a hazard event of magnitude X is found to produce a damage ratio of 30%, then the economic loss is $30. In this way the economic loss for different magnitude of a hazardous phenomena can be estimated.

In this respect the elements at risk inventory as a digital dataset within the GIS database provided a convenient platform for the calculation of loss estimates. Because detailed information on buildings is only available for Road Town, loss estimate calculations were carried out on the building stock of Road Town. Estimates for the rest of the BVI were made by extrapolating the Road Town data to augment data available for buildings outside of Road Town.

9.2 WIND DAMAGE LOSSES TO BUILDINGS

9.2.1 REPLACEMENT VALUE ESTIMATION

The footprints of buildings, in the inventory of the elements at risk provides a measure of the area occupied by buildings. The total area of the building is then calculated by multiplying the footprint

area by the number of floors. The current replacement value of each building was estimated by multiplying the cost per unit area by the total area of the building.

Two general replacement costs per unit area were used. Replacement values of US$100 and US$150 per square foot were used for residential and commercial buildings respectively. Using these figures, the replacement cost for each building in Road Town was calculated. The total value of residential buildings calculated digitized from 1991 data, is US$97 million and commercial buildings US$128 million.

9.2.2 LOSS ESTIMATE CALCULATION

The economic loss for each building was then calculated for (SS) hurricane categories (1-4) by multiplying the replacement value by the damage ratio for each class of building. The estimates are presented in **Table 9.1.**

TABLE 9.1: Estimates of structural damage cost to residential and commercial structures in Road Town.

HURRICANE CATEGORY (SS)	ROAD TOWN (1991) ESTIMATED DAMAGE (million US$)	BVI (1991) (million US$)
1	11	33
2	40	120
3	87	261
4	150	450

From the inventory of buildings dataset it is known that the total building stock in the BVI is about three times the number in Road Town. Table 9.1 therefore gives a rough estimate of the losses to the entire BVI stock, which assumes a similar distribution of building types throughout the rest of the BVI as that of Road Town. A more precise estimation of damage for the entire BVI requires a detailed classification of the buildings similar to that done for Road Town.

9.3 WIND DAMAGE LOSSES TO THE ELECTRICAL DISTRIBUTION SYSTEM

The inventory of the elements at risk dataset and the estimated damage ratios for utility poles given in **Table 8.9** was used to estimate the losses that might result from category 1,2,3 and 4 hurricanes. The inventory of utility poles consists of 1723, 35 foot, wooden poles. Based on a price per pole of US$150, the total value of utility poles is $258,450. Using this figure with the damage ratios from **Table 8.9** yields the estimated losses to utility poles given below in **Table 9.2.**

TABLE 9.2: Estimated losses to utility poles

HURRICANE CATEGORY	VALUE OF POLES DAMAGED (BASE TERRAIN)	VALUE OF POLES DAMAGED (SPEED-UP TERRAIN)	TOTAL POLE DAMAGE (US$)
1	0	1,275	1,275
2	11,625	7,650	19,275
3	69,750	14,025	83,775
4	127,875	19,890	147,765

The number of poles at locations with normal hurricane wind hazard IE in base terrain was determined from the wind hazard susceptibility map as were the poles in areas where there is a speed up effect. The poles in areas of speed up were deemed to be subjected to hurricane force winds of the category higher than that under consideration. Therefore the damage ratio assigned to these areas for each category hurricane corresponded to the ratio of the next higher category.

Since this estimation relies on an incomplete dataset for the electrical transmission line network, this figure is conservative but does provide a ball park figure to work with. Of course the actual cost to repair the transmission lines would require a number of other components in addition to replacing the poles, and therefore the total replacement cost will be much higher.

9.4 WIND DAMAGE LOSSES TO BOATS

An estimate of the possible damage to boats was carried out by using the damage ratios presented in **TABLE 8.6** and the inventory of the elements at risk dataset. A replacement cost of $85,000 was used as an average figure for the 35-50 foot yachts which predominate in the BVI charter boat industry. A figure of $40,000 was used as the average replacement cost for small open craft commonly used by fishermen, and as pleasure boats.

Using these figures the estimated losses to unprotected boats from (SS) category 1-4 hurricanes was obtained, **Table 9.3.**

TABLE 9.3: Estimates of damage to unprotected boats.

HURRICANE CATEGORY	DAMAGE RATIO YACHTS (35 -50 FT)	DAMAGE RATIO SMALL OPEN CRAFT	ESTIMATED DAMAGE (US$MILLION)
1	0.065	0.09	5.76
2	0.3	0.41	26.4
3	0.7	0.83	58.6
4	0.95	0.99	76.3

9.5 EARTHQUAKE LOSSES TO BUILDINGS

By utilizing the damage ratios for expected structural damage due earthquake ground shaking in **Table 8.13** it is possible to establish rough estimates for the losses which might result from earthquake events of known MMI (intensity) values.

The total value of buildings in Road Town from the building inventory dataset amounts to about 225 million US dollars. **Table 9.4** shows the losses to structures which might result from different intensity earthquakes. The calculation assumes that all buildings in the dataset were constructed to similar standards. The estimates provide a rough estimate of potential damage to buildings in Road Town.

TABLE 9.4: Estimated losses to Road Town buildings resulting from different intensity earthquakes.

EARTHQUAKE INTENSITY (MMI)	DAMAGE RATIO (%)	EXPECTED LOSSES ROAD TOWN (US$ million)
V	0.5	1.1
VI	1.5	3.4
VII	5.0	11.3
VIII	17	38.0

CHAPTER 10 TECHNOLOGICAL HAZARDS

10.1 INTRODUCTION

Technological hazards refer to the failure of manmade systems, which occur accidentally or deliberately, that have the potential to cause significant loss of life, cause human suffering, and produce significant damage to structures. There is a wide range of hazards of technological origin. Urban centers and ports are more susceptible to technological hazards because of the concentration of industry, mass transportation of cargo, and buildings.

In the BVI which has not been industrialized, the main technological hazards that have the potential to cause disasters are; oil spills, chemical explosions, aircraft accidents, and ferry accidents. Technological hazards which can result in less damage but which non the less pose significant threats are fires, health related hazards, and traffic accidents.

Since natural hazards pose a far greater threat to the BVI, this chapter only briefly outlines the nature of these technological hazards in the BVI.

10.2 OIL SPILLS

The BVI lies close to major shipping lanes through which petroleum products are transported. Because of this the threat of oil spills exist. The existence of sensitive coral reef and near shore ecosystems makes the islands of the BVI vulnerable to extensive damage should a significant oil spill occur. The dataset which shows the near shore ecosystems around the islands of the BVI **Map 7.5** gives a clear indication of the biological systems at risk from a potential oil spill.

The Government of the BVI has in place an oil spill contingency plan that provides detailed guidelines and procedures to deal with an oil spill event.

10.3 EXPLOSIONS

The threat of large explosions in Tortola exists at a few locations where significant quantities of fuel is stored. These include the petroleum fuel storage facilities in Fish Bay, the liquid petroleum gas storage facility in Baughers Bay, and to a lesser extent the service station storage tanks throughout the BVI.

The small petroleum tank farm at Fish Bay is located directly on the coastline and consists of standard welded steel tanks. The position of this facility makes it highly susceptible to high energy waves which might be generated by hurricanes. In addition it has been built on reclaimed land which also makes it susceptible to ground shaking produced by earthquakes.

10.4 AIRCRAFT ACCIDENTS

There is one international airport in the BVI on Beef Island, which accommodates mid sized aircraft carrying up to 60 passengers, and two small air strips, in Anegada and Virgin Gorda which handle small aircraft. Only very minor accidents have occurred in the past with no deaths reported. The Beef Island airport consists of one 1600 foot runway with terminal, security and fire protection facilities which all meet international airport standards. The present orientation of the runway together with the easterly prevailing winds determines that the landing approach is usually from the west. It is only during this landing approach that aircraft fly overland for a very short period. This reduces the chances of aircraft crashes on land.

10.5 FERRY ACCIDENTS

The ferries link the major islands of the BVI and the US Virgin Islands. Ferry ports are located at West End and Road Town in Tortola, and Spanish Town and North Sound in Virgin Gorda and at Great Harbour in Jost Van Dyke. The ferries are relatively small diesel powered boats with capacities of 40-100 passengers. Most of these boats have safety and emergency equipment on board.

10.6 MINOR HAZARDS

Domestic fires occur frequently in the BVI and results in significant damage to structures. These fires are dealt with by the BVI Fire and Rescue Service. Cruise ship fires are also threats which have not been systematically addressed in the BVI, but with the high volume of cruise ship traffic deserves special attention.

Health related hazards pose a threat especially as they relate to diseases caused by the inappropriate disposal of sewage. In the BVI untreated sewage is dumped directly into the sea. As the population increases this practice will have to modified to prevent the buildup of disease producing bacteria near shore and the consequent negative impact on environmental health and tourism and on ecosystems.

There are also hazardous materials which are stored in relatively small quantities such as chlorine for water treatment and pesticides, that have the potential to cause health problems. The BVI Office of Disaster Preparedness is currently finalizing a hazardous materials response plan to deal with the unintentional release of hazardous substances.

CHAPTER 11 HAZARD MITIGATION STRATEGIES

11.1 INTRODUCTION

In the disaster management cycle three discreet phases are recognised; pre-disaster preparedness, disaster response and pos-disaster recovery. A crucial component of pre-disaster preparedness is hazard mitigation which seeks to reduce the potential impacts of hazardous processes. The ODP has implemented a Hazard Mitigation Programme as part of their preparedness efforts to augment the ongoing public education, awareness and disaster management programmes. The Hazard and Risk Assessment Project was implemented to provide crucial information for the formulation of measures, policies, and programmes as part of the BVI's Hazard Mitigation Programme.

The preceding chapters of this report established the types of hazards, their magnitude, geographical distribution, frequency of occurrence and their likely impacts. This chapter presents strategies which might be employed in the BVI to reduce the potential impact of specific hazards. The strategies which are recommended have been largely determined from the findings of the Hazard and Risk Assessment Project described in the preceding chapters of this report.

The strategies presented here emphasizes the need to strengthen the physical development planning function, and to include hazard mitigation measures as a discreet but integral part of that function. The recommendations are presented with the recognition that significant mitigation activity takes place during the course of present development activities. However the most effective approach to hazard mitigation requires a systematic, sustained program for long term results. While specific measures and policies are presented, an effort has been made to outline a general approach and framework within which to develop appropriate mitigation measures.

11.2 GENERAL MITIGATION MEASURES

The results of the previous chapters allows us to establish priorities that facilitates the efficient and effective use of the limited resources available for hazard mitigation. The results indicate that natural hazards are potentially more damaging than technological hazards. Of the natural hazards that pose a threat to the BVI, high velocity winds produced by hurricanes, and ground shaking from earthquakes are the two most serious threats. These are followed by hurricane storm surge, land borne flooding, earthquake tsunamis and landslides. **As a general recommendation therefore it is suggested that reducing the potential impacts of high velocity winds and earthquake ground shaking. mitigation efforts be given priority.**

The mitigation strategies are separated into structural and non-structural measures. Specific mitigation measures are recommended within each group as they relate to different hazards. It should be borne in mind that while some measures seek to reduce potential loss of human life and reduce human suffering specifically, all hazard mitigation efforts ultimately seeks to accomplish this as its primary objective. Priority is also given to measures which reduce the potential impact on critical facilities, and these measure are given special attention.

11.3 STRUCTURAL MEASURES

Structural measures include all measures that allow elements in the built and natural environment to physically withstand the forces produced by specific hazardous phenomenon. This can be achieved by actively not placing the structure in harms way, protecting the structure from the hazard forces or by passively strengthening or modifying the structure or natural element to make it more hazard resistant. Structural measures involve measures that relate to the existing natural and built

environments or which address future developments.

Measures that apply to the existing built and natural environments include:

- Relocation of structures
- Protection
- Retrofitting

Measures that apply to future development include:

- Appropriate location of structures
- Protection
- Hazard resistant design

11.3.1 SPECIFIC STRUCTURAL HAZARD MITIGATION RECOMMENDATIONS

HIGH VELOCITY WIND

1) Future critical facilities should not be located in areas of accelerated winds.

2) The most significant aspect of structural damage to buildings by high velocity wind results from roof damage. The roofs of existing buildings should be inspected and if necessary retrofitted to adequate standards.

3) The roofs of existing critical facilities should be retrofitted to a higher standard to ensure wind resistance.

4) The roof of future critical facilities should ideally be constructed with concrete or to a higher standard to ensure wind resistance.

5) Building openings such as windows and doors also suffer damage from high velocity winds. These openings if not constructed of wood or metal should be protected with shutters or temporary covers of adequate design.

6) Critical facilities should build storm shutters into the design of the building.

7) Government, commercial and institutional buildings constructed of metal sheeting should be inspected to ensure wind resistance.

8) An ongoing programme to inspect utility poles should be implemented to ensure that they meet relevant specifications.

9) In areas of accelerated winds, higher strength utility poles should be used and additional guy wires installed.

10) Adequate boat shelters should be developed to protect highly vulnerable boat stock.

EARTHQUAKE GROUND SHAKING

1) Existing critical facilities built on reclaimed land should be inspected and retrofitted if necessary to ensure earthquake resistance.

2) Future critical facilities should not be located on reclaimed land because of the high potential for liquefaction.

3) Older unreinforced masonry buildings should be inspected and retrofitted if necessary to increase earthquake resistance.

4) Older unreinforced masonry buildings should not be used for critical functions.

STORM SURGE

1) Critical facilities located on the shoreline in areas of high storm surge susceptibility should be protected by sea walls or other appropriate structures. Where possible their critical function should be performed elsewhere.

2) Future critical facilities should not be located on the shoreline in areas of high storm surge susceptibility.

3) Buildings located on the shoreline in areas of high storm surge susceptibility should be designed to withstand storm surge forces.

4) The shoreline in areas of high storm surge susceptibility should be protected by sea defense structures such as sea walls.

INLAND FLOODING

1) Watercourses which pass through significant settlement areas should be properly configured and lined with concrete.

2) Existing bridges should be inspected to determine which ones are too low or which have support pillars within the watercourse channel. Where possible these should be replaced as these features restrict water flow and cause the channels to be easily blocked with debris.

3) Future bridges should not be built with these undesirable features.

4) Buildings constructed adjacent to watercourses should be elevated by at least one meter to prevent potential flood inundation.

5) Critical facilities should not be located adjacent to watercourses.

LANDSLIDES

1) Detailed slope analysis should be carried out where significant natural slope modification is contemplated for development purposes.

2) In this respect the construction of buildings on steep hill slopes should involve a detailed slope analysis to ensure appropriate cut slope design.

3) Locations which are found to be especially prone to recurrent slope failures should be examined with the view to stabilizing the slope with structural support.

11.4 NON-STRUCTURAL MEASURES

These measures consist of all efforts not involving direct implementation of structural activity, that have the effect of reducing the impacts of hazards. They include governmental and non-governmental policies, and programs which promote hazard conscious development.

11.4.1 PHYSICAL PLANNING GUIDELINES AND REGULATIONS

The most effective way to ensure systematic and sustainable hazard mitigation is to integrate hazard mitigation issues into the physical planning process. In this way hazard mitigation issues become part of the whole range of development planning issues considered in the decision making process. It is therefore necessary to implement specific physical planning regulations and development guidelines to ensure consistent appropriate development practices.

The impact of natural hazards on structures is the most significant and therefore the implementation of an appropriate building code can go a far way towards reducing hazard vulnerability. Such a building code should include the following provisions:-

1) Building specifications for roof design to ensure resistance to high velocity winds. Separate specifications should be provided for critical facilities to achieve greater levels of resistance.

2) Guidelines for the proper construction of window shutters.

3) Regulation or guidelines to encourage the inclusion of window shutters into the design of critical facilities.

4) Regulations or guidelines should be developed to ensure the proper design of utility pole installations to ensure wind resistance.

5) Building specifications for building reinforcement to ensure earthquake resistance. Separate specifications should be provided for critical facilities to achieve greater levels of resistance.

6) Efforts should also be made to limit the construction of critical facilities on reclaimed land because of the high risk of earthquake induced liquefaction.

7) Specifications should be provided for the proper design of structures located on reclaimed land because of the high risk of earthquake induced liquefaction.

8) Building guidelines to encourage appropriate design of structures in areas of high storm surge susceptibility.

9) Regulations to limit the placement of critical facilities in areas of high storm surge susceptibility or at locations adjacent to watercourses.

10) Guidelines should be developed for bridge design so as not to increase the risk of localised flooding due to channel blockage.

11) Guidelines should be developed for building on steep slopes and designing road cuts to ensure slope stability of modified slopes and therefore prevent landslides.

11.4.2 DISASTER MANAGEMENT

The most important nonstructural measures that can be implemented by the ODP is the development of evacuation plans to protect human lives. This applies to areas susceptible to high storm surge and also to the boating community. The ODP also provides a significant mitigation function by developing hazard warning systems. In the BVI this primarily requires the ability to monitor and track weather systems and seismic activity.

While the ODP currently has the ability to monitor, track and receive predictions about extreme weather systems, there is no capacity to monitor seismic activity. **It is recommended that at least one seismic monitoring/recording station be installed in the BVI.**

11.4.3 GOVERNMENT PROGRAMMES

Government programs that encourage hazard mitigation can take the form of assistance programmes or development programmes. Financial assistance programmes to encourage the inspection of roofs and retrofitting to meet building code specifications of high velocity wind resistance is one example. This could be carried out at first on critical facilities. Such a programme could also be applied to development of boat shelters.

Specific development programmes can have a significant impact on hazard mitigation. In some cases these projects can only be undertaken by the government. In addition these projects add infrastructure and if properly designed can also have economic spinoffs for the community. These projects can also generate opportunities for employment. Examples of projects that could be undertaken are the redesign of water courses in Road Town and the building of a promenade around Road Harbour which would act as a sea defense structure.

11.4.4 PRIVATE SECTOR PROGRAMMES

The private sector can also play a significant role in hazard mitigation. Financial institutions and materials suppliers could for example make financing available for roof retrofitting. Insurance companies can have a powerful impact on building design by offering premium incentives for building design and location that meets building code specifications.

11.4.5 INSTITUTIONAL CAPACITY

In order to achieve hazard mitigation objectives requires sustained effort by informed personnel within functional institutions. The development planning agencies and the disaster management agency therefore have to be strengthened to carry out theses tasks.

REFERENCES

1995 Annual Report - Cosalc I - Beach & Coastal Stability in the Lesser Antilles - Gillian Chambers - March 1996

Caribbean Conference on Natural Hazards: Volcanoes, Earthquakes, Windstorms, Floods. Improving natural hazard awareness and reduction in circum-Caribbean region - abstracts - October 1993

Disasters, Planning and Development: Managing Natural Hazards to reduce Loss - OAS/OFDA - December 1990

Draft Building Guidelines for the OECS - Consulting Engineer Partnership Ltd./Alwyn T. Watson - May 1991

Earthquake damage evaluation data for California: ATC-13 1985

Engineering report on the rainfall hydraulics of the watershed at Kingstown Island of Tortola - IVO M: Kurg - June 1981

Generalised estimates of probable maximum precipitation and rainfall frequency data for Puerto Rico and Virgin Islands - technical paper No. 2 - US Department of Commerce - 1961

Hurricane vulnerability and risk analysis of the VINLEC transmission and distribution system - USAID/OAS CDMP - Applied research associated inc. - July 1996

National Mitigation Strategy - FEMA 1995

Notes and readings for short course on geographic information system - September 23-27, 1993 - Department of Land Surveying, Faculty of Engineering - UWI St. Augustine

Post Hurricane Hugo Assessment - focusing on sustainable development issues in the BVI - Lynette Atwell - December 1993

Report on the geotechnical exploration conducted among East End Bay, Tortola, BVI - Carlos R. Sierra, P.E. - October 1990

Storm Hazard Assessment for Montego Bay, Jamaica - CDMP - OAS/USAID - September 1995

STUDIES ON EARTHQUAKE INSURANCE. PROCEEDINGS OF THE CENTRAL AMERICAN CONFERENCE ON EARTHQUAKE ENGINEERING, VOL. II, SAN SALVADOR, EL SALVADOR: SAUTER F., AND SHAH H.C., 1978

US-ASIA CONFERENCE ON ENGINEERING FOR MITIGATING NATURAL HAZARDS DAMAGE - CHIU/KARASUDHI/NUTALAYA - BANGKOK, DECEMBER 1997

VIRGIN ISLANDS RESOURCE MANAGEMENT COOPERATIVE - BIOSPHERE RESERVE RESEARCH REPORT NO. 4 - ANDERSON/LUND/GLADFELTER/DAVIS - OCTOBER 1986