

# **Disaster Information Kit for the Media**

*Produced by the Caribbean Disaster Emergency Response Agency - 2005*

*Photo: Tapion land subsidence - 2004*

*Photo Credit: NEMO Secretariat*

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# Introduction

Disaster management is about life and death. A significant responsibility rests on the shoulders of the disaster manager. A similar responsibility rests with the media, which is one of the crucial communication links between the disaster manager and the general public, particularly during a disaster.

It is vitally important therefore that the disaster manager and the reporter or editor work as partners, that they talk the same language, understand the same jargon, and appreciate and respect each other's role.

It is against this background that this manual was conceptualised and written in 1995 and again revised in 2004 both in print and also made available via the World Wide Web at <http://www.cdera.org/doccentre>.

The objectives of the Kit are:

- To provide an easily accessible source of background information on disasters for media practitioners in the Caribbean;
- To ensure consistent interpretation and reporting of basic disaster information by media practitioners across the Caribbean;
- To alleviate the pressure placed on disaster management officials during emergencies by the need to constantly explain basic concepts, terminology, and practices to the media;
- To demonstrate recognition of the important role of the media in disaster management and the commitment to increase cooperation and collaboration between media and disaster management professionals.

Future revisions of this manual will be posted on the World Wide Web at <http://www.cdera.org/doccentre>, which is the source for authoritative and accurate disaster information.

# Disaster Management

## What is it and why it is necessary

### Introduction

Disasters and their impact worldwide are increasing at an alarming rate. The number of natural disasters affecting CDERA member states<sup>1</sup> in the 1960s was 16. In the next decade there were 13, in the 1980s the number increased to 41, with 48 in the 1990s and for the first three years of the 21<sup>st</sup> Century there were already 13.

The cost of the damage was as high as 53 per cent of GDP of one CDERA member state and such costs naturally set back the economic progress and development of a country.

There is an increase both in natural hazards and also in damage to property. The Inter Governmental Panel on Climate Change has warned that the weather variability and long term change in climate patterns are starting to affect the planet and they will result in extreme and detrimental conditions in the coming years as more of an imbalance occurs. The devastating floods in Guyana in January 2005 have brought the issue of erratic weather patterns to the fore. Similarly the 2004 Boxing Day Indian Ocean tsunami has heightened concern about the potential impact of local and tele-tsunamis on the Caribbean. Volcanoes that have been dormant for centuries have rumbled to life with destructive and fatal results in Montserrat while in Dominica 10 others are simmering. The underwater volcano, just north of Grenada, Kick 'em Jenny, is growing and may one day pose a threat to neighbouring islands. A major eruption could shower Grenada and other islands with ash falls, at best, or tsunamis at the worse. A 2003 survey of Kick 'em Jenny found another active submarine volcano which has been named Kick 'em Jack.

Natural hazards occur as a normal part of earth's cycle, the major difference in the last few centuries was man. Man's increased vulnerability comes as a result of:

1. Increasing population. Major disasters can now claim more lives;
2. Affluence is abounding. As people become wealthier they acquire more property which if not constructed properly is vulnerable to any natural disaster;
3. The affluence and increased population means that more people and more property are concentrated along the coastlines making them vulnerable to natural hazards;
4. As populations increase and development abound there can be environmental degradation due to poor land use, deforestation, over cultivation, and over grazing. These make the land more vulnerable to floods and landslides;
5. Increasing industrialization without the appropriate safety measures may result in man-made accidents and disasters;
6. Absence of mitigation or preventative measures in development planning is usually a recipe for a disaster.

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<sup>1</sup> Anguilla, Antigua and Barbuda, The Bahamas, Barbados, Belize, British Virgin Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, St Kitts/Nevis, Saint Lucia, St Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands.

## Definitions

### Acceptable risk

The level of loss a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions.

*In engineering terms, acceptable risk is also used to assess structural and non-structural measures undertaken to reduce possible damage at a level which does not harm people and property, according to codes or "accepted practice" based, among other issues, on a known probability of hazard.*

### Biological hazard

Processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Examples of biological hazards: outbreaks of epidemic diseases, plant or animal contagion, insect plagues and extensive infestations.

### Building codes

Ordinances and regulations controlling the design, construction, materials, alteration and occupancy of any structure to insure human safety and welfare. Building codes include both technical and functional standards.

### Capacity

A combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster. Capacity may include physical, institutional, social or economic means as well as skilled personal or collective attributes such as leadership and management. Capacity may also be described as capability.

### Capacity building

Efforts aimed to develop human skills or societal infrastructures within a community or organization needed to reduce the level of risk. In extended understanding, capacity building also includes development of institutional, financial, political and other resources, such as technology at different levels and sectors of the society.

### Climate change

The climate of a place or region is changed if over an extended period (typically decades or longer) there is a statistically significant change in measurements of either the mean state or variability of the climate for that place or region. Changes in climate may be due to natural processes or to persistent anthropogenic changes in atmosphere or in land use. Note that the definition of climate change used in the United Nations Framework Convention on Climate Change is more restricted, as it includes only those changes which are attributable directly or indirectly to human activity.

### Complex Disasters

Complex disasters exist where adverse political conditions compound a disaster or emergency situation. Such situations are complicated because the breakdown of the political structure makes assistance or intervention difficult. This sort of emergency is usually associated with the problems of displaced people during times of civil conflict or with people in need caught in areas of conflict.

### Comprehensive Disaster Management (CDM)

This is the new thrust for the 21<sup>st</sup> Century being promoted by CDERA. It moves away from the approach of "response and relief" which characterised Caribbean disaster management in the last century to a comprehensive mode to include **all** hazards, **all** phases of the disaster management continuum (prevention, mitigation, preparedness, response, recovery, rebuilding), and **all** sectors of the society (economic, environmental, and social planners, engineers, architects, insurance and banking industry among others).

### Coping capacity

The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human-induced hazards.

### Counter measures

All measures taken to counter and reduce disaster risk. They most commonly refer to engineering (structural) measures but can also include non-structural measures and tools designed and employed to avoid or limit the adverse impact of natural hazards and related environmental and technological disasters.

### Disaster

A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. Though often caused by nature, disasters can have human origins. Wars and civil disturbances that destroy homelands and displace people are included among the causes of disasters. Other causes can be: building collapse, blizzard, drought, epidemic, earthquake, explosion, fire, flood, hazardous material or transportation incident (such as a chemical spill), hurricane, nuclear incident, tornado, or volcano.

A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk.

### Disaster Management

This is a collective term, which includes all aspects of planning for and responding to disasters. It may also refer to the management of both the risks and consequence of disasters.

### Disaster risk management

The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

### Disaster risk reduction (disaster reduction)

The conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development. The disaster risk reduction framework is composed of the following fields of action, as described in ISDR's publication 2002 "Living with Risk: a global review of disaster reduction initiatives", page 23: · Risk awareness and assessment including hazard analysis and vulnerability/capacity analysis; · Knowledge development including education, training, research and information; · Public commitment and institutional frameworks, including organisational, policy, legislation and community action; · Application of measures including environmental management, land-use and urban planning, protection of critical facilities, application of science and technology, partnership and networking, and financial instruments; · Early warning systems including forecasting, dissemination of warnings, preparedness measures and reaction capacities.

### Early warning

The provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response. Early warning systems include a chain of concerns, namely: understanding and mapping the hazard; monitoring and forecasting impending events; processing and disseminating understandable warnings to political authorities and the population, and undertaking appropriate and timely actions in response to the warnings.

### Ecosystem

A complex set of relationships of living organisms functioning as a unit and interacting with their physical environment. The boundaries of what could be called an ecosystem are somewhat arbitrary, depending on the focus of interest or study. Thus the extent of an ecosystem may range from very small spatial scales to, ultimately, the entire Earth (IPCC, 2001).

### El Niño-southern oscillation (ENSO)

A complex interaction of the tropical Pacific Ocean and the global atmosphere that results in irregularly occurring episodes of changed ocean and weather patterns in many parts of the world, often with significant impacts, such as altered marine habitats, rainfall changes, floods, droughts, and changes in storm patterns. The El Niño part of ENSO refers to the well-above-average ocean temperatures along the coasts of Ecuador, Peru and northern Chile and across the eastern equatorial Pacific Ocean, while the Southern Oscillation refers to the associated global patterns of changed atmospheric pressure and rainfall. La Niña is approximately the opposite condition to El Niño. Each El Niño or La Niña episode usually lasts for several seasons.

### Emergency management

The organization and management of resources and responsibilities for dealing with all aspects of emergencies, in particularly preparedness, response and rehabilitation. Emergency management involves plans, structures and arrangements established to engage the normal endeavours of

government, voluntary and private agencies in a comprehensive and coordinated way to respond to the whole spectrum of emergency needs. This is also known as disaster management.

#### Environmental impact assessment (EIA)

Studies undertaken in order to assess the effect on a specified environment of the introduction of any new factor, which may upset the current ecological balance. EIA is a policy making tool that serves to provide evidence and analysis of environmental impacts of activities from conception to decision-making. It is utilised extensively in national programming and for international development assistance projects. An EIA must include a detailed risk assessment and provide alternatives solutions or options.

#### Environmental degradation

The reduction of the capacity of the environment to meet social and ecological objectives, and needs. Potential effects are varied and may contribute to an increase in vulnerability and the frequency and intensity of natural hazards. Some examples: land degradation, deforestation, desertification, wildland fires, loss of biodiversity, land, water and air pollution, climate change, sea level rise and ozone depletion.

#### Forecast

Definite statement or statistical estimate of the occurrence of a future event (UNESCO, WMO). This term is used with different meanings in different disciplines.

#### Geological hazard

Natural earth processes or phenomena that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Geological hazard includes internal earth processes or tectonic origin, such as earthquakes, geological fault activity, tsunamis, volcanic activity and emissions as well as external processes such as mass movements: landslides, rockslides, rock falls or avalanches, surfaces collapses, expansive soils and debris or mud flows. Geological hazards can be single, sequential or combined in their origin and effects.

#### Geographic information systems (GIS)

Analysis that combine relational databases with spatial interpretation and outputs often in form of maps. A more elaborate definition is that of computer programmes for capturing, storing, checking, integrating, analysing and displaying data about the earth that is spatially referenced. Geographical information systems are increasingly being utilised for hazard and vulnerability mapping and analysis, as well as for the application of disaster risk management measures.

#### Greenhouse gas (GHG)

A gas, such as water vapour, carbon dioxide, methane, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), that absorbs and re-emits infrared radiation, warming the earth's surface and contributing to climate change (UNEP, 1998).

### Hazard

A hazard is an extreme, threatening event in the natural or man-made environment that adversely affects human life, property, or activity, or the ecosystem that supports them. A primary hazard disrupts human settlements. A secondary hazard occurs in the aftermath of a primary hazard and contributes to further suffering or loss.

### Hazard analysis

Identification, studies and monitoring of any hazard to determine its potential, origin, characteristics and behaviour.

### Hydrometeorological hazards

Natural processes or phenomena of atmospheric, hydrological or oceanographic nature, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hydrometeorological hazards include: floods, debris and mud floods; tropical cyclones, storm surges, thunder/hailstorms, rain and wind storms, blizzards and other severe storms; drought, desertification, wildland fires, temperature extremes, sand or dust storms; permafrost and snow or ice avalanches. Hydrometeorological hazards can be single, sequential or combined in their origin and effects.

### La Niña

(see El Niño-Southern Oscillation).

### Land-use planning

Branch of physical and socio-economic planning that determines the means and assesses the values or limitations of various options in which land is to be utilized, with the corresponding effects on different segments of the population or interests of a community taken into account in resulting decisions. Land-use planning involves studies and mapping, analysis of environmental and hazard data, formulation of alternative land-use decisions and design of a long-range plan for different geographical and administrative scales. Land-use planning can help to mitigate disasters and reduce risks by discouraging high-density settlements and construction of key installations in hazard-prone areas, control of population density and expansion, and in the siting of service routes for transport, power, water, sewage and other critical facilities.

### Mitigation

Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

### Natural hazards

Natural processes or phenomena occurring in the biosphere that may constitute a damaging event. Natural hazards can be classified by origin namely: geological, hydrometeorological or biological. Hazardous events can vary in magnitude or intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing.

### Preparedness

Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.

### Prevention

Activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological and biological disasters. Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified in areas frequently affected by disasters. In the context of public awareness and education, related to disaster risk reduction changing attitudes and behaviour contribute to promoting a "culture of prevention".

### Public awareness

The processes of informing the general population, increasing levels of consciousness about risks and how people can act to reduce their exposure to hazards. This is particularly important for public officials in fulfilling their responsibilities to save lives and property in the event of a disaster. Public awareness activities foster changes in behaviour leading towards a culture of risk reduction. This involves public information, dissemination, education, radio or television broadcasts, use of printed media, as well as, the establishment of information centres and networks and community and participation actions.

### Public information

Information, facts and knowledge provided or learned as a result of research or study, available to be disseminated to the public.

### Recovery

Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk. Recovery (rehabilitation and reconstruction) affords an opportunity to develop and apply disaster risk reduction measures.

### Rehabilitation

The restoration of basic services and the beginning of the repair of physical, social and economic damage.

### Relief / response

The provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration.

### Resilience / resilient

The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its

capacity for learning from past disasters for better future protection and to improve risk reduction measures.

#### Retrofitting (or upgrading)

Reinforcement of structures to become more resistant and resilient to the forces of natural hazards. Retrofitting involves consideration of changes in the mass, stiffness, damping, load path and ductility of materials, as well as radical changes such as the introduction of energy absorbing dampers and base isolation systems. Examples of retrofitting includes the consideration of wind loading to strengthen and minimize the wind force, or in earthquake prone areas, the strengthening of structures.

#### Risk

Risk is expected loss (deaths, injuries, damage to property or ecosystem on which human life depends, and disruption of economic activity) due to a particular hazard. Risk is the product of hazard and vulnerability.

#### Risk assessment/analysis

A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. The process of conducting a risk assessment is based on a review of both the technical features of hazards such as their location, intensity, frequency and probability; and also the analysis of the physical, social, economic and environmental dimensions of vulnerability and exposure, while taking particular account of the coping capabilities pertinent to the risk scenarios.

#### Structural / non-structural measures

Structural measures refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure. Non-structural measures refer to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts.

#### Sustainable development

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs. (Brundtland Commission, 1987). Sustainable development is based on socio-cultural development, political stability and decorum, economic growth and ecosystem protection, which all relate to disaster risk reduction.

#### Technological hazards

Danger originating from technological or industrial accidents, dangerous procedures, infrastructure failures or certain human activities, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Some examples: industrial pollution,

nuclear activities and radioactivity, toxic wastes, dam failures; transport, industrial or technological accidents (explosions, fires, spills).

### Vulnerability

The vulnerability of a building, a population or an entire country is measured by how susceptible it is to harm or loss in the face of a hazard.

### Wildland fire

Any fire occurring in vegetation areas regardless of ignition sources, damages or benefits.

## How disasters occur

The origins of a disaster can be:

- **Meteorological** - Drought, floods, cyclones, hailstorms, thunderstorms, lightning storms
- **Topographical** (sometimes called geomorphic) - Earthquakes, volcanic eruptions, landslides
- **Technological** - Chemical accidents, industrial accidents, oil spills, pollution
- **Epidemics**

## When disasters occur

Disasters are not easily predicted. However, historical data, geographic location and meteorological and seismographic indicators can pinpoint highly vulnerable areas. Hazard mapping and disaster preparedness can assist in preparing disaster-prone communities.

## Why disasters occur

Factors that contribute to the vulnerability of communities and societies to the impacts of hazards include: Poverty, changes in cultural practices, population growth, environmental degradation, rapid urbanisation, war and civil strife, lack of public awareness and information, inadequate public health systems.

### Levels of Disasters in CDERA System

<b>Level 1</b>	A minor incident for which local resources are adequate and available. A state of emergency may or may not be declared.
<b>Level 2</b>	A moderate incident for which local resources are not adequate and assistance may be required on a limited basis. A state of emergency may or may not be declared.
<b>Level 3</b>	A major incident for which local resources are overwhelmed and regional and international resources are required. A state of emergency is declared.

The United Nations Development Programme's Global Report (launched in 2004) underscored that while disasters and their impacts are still viewed as exceptional natural events that interrupt normal development, the central thesis of the report was that flawed, inappropriate development in itself was responsible for configuring disaster risk.

# Disaster Management Cycle



A disaster can be viewed as a series of phases on a time continuum. The Disaster Management Cycle is made up of the following phases: Alert, Preparedness, Response, Prevention, Mitigation, Rehabilitation, and Reconstruction.

## Alert

The notice issued to indicate that specific precautions should be taken because of the probability or proximity of a dangerous event.

## Preparedness

Measures taken to reduce the impact of disasters through the prior organising of systems to promptly and efficiently respond to them. Preparedness addresses actions in both the pre-disaster phase, for example, warning and evacuation, as well as the post-disaster phase.

Effective preparedness enables communities and institutions to provide a quick and orderly response to disasters. Disaster preparedness is designed to minimise loss of life, injury and damage; to organise the temporary removal of people and property from a threatened location; and to facilitate timely and effective rescue, relief and rehabilitation. Public information and ongoing training activities are necessary to create a culture of disaster preparedness.

## Response

Actions carried out in a disaster situation with the objective to save lives, alleviate suffering and reduce economic losses. Actions include search and rescue, and the provision of shelter, water, food and medical care.

## Mitigation

Measures taken to reduce the loss of life, livelihood and property by disasters, either by reducing vulnerability or by modifying the hazard where possible. Examples are:

- a) The adoption and enforcement of building codes;
- b) The utilisation of design and construction techniques that will make critical facilities adequately resistant to damage by hazards.

## Prevention

Measures taken for the purpose of preventing natural or man-made phenomena from causing or giving rise to disasters or other emergency situations.

Prevention measures include passing legislation that affects urban planning and siting of public works and key facilities and the institutionalisation of policies leading toward disaster reduction.

## Rehabilitation

The short-term repair of physical, social and economic damage – basically enough to get back on one's feet.

## Reconstruction

The medium- and long-term repair of physical, social and economic damage, and the return of affected structures to a condition equal to or better than before the disaster.

Reconstruction actions would include construction of permanent housing, full restoration of all services, and complete resumption of life in the pre-disaster state.

# Tropical Weather Systems

## Definition

Tropical weather systems comprise a number of features ranging from the Inter-tropical Convergence Zone (ITCZ) to hurricanes. Most reporters tend to focus on hurricanes because they are big and ferocious however tropical waves, tropical depressions, or even the ITCZ cause significant damage. In 1998 a slow moving tropical depression dumped almost three feet of rain on Central America triggering massive landslides which killed almost 20,000 people. Heavy rains from a tropical disturbance in May 2004 also triggered mudslides in Haiti and the Dominican Republic killing over 2,000 people and wiping out several villages and later that year, rain associated with Tropical Storm Jeanne caused more destruction and death.

## Types of tropical<sup>2</sup> weather systems affecting the Caribbean

- Inter-Tropical Convergence Zone (ITCZ)
- Trough
- Tropical Cyclone (Tropical Depression, Tropical Storm, and Hurricane)
- Tropical Wave
- Tropical Disturbance

## Where to find information

- National Meteorological Office – see Contact List at the end of the chapter
- Caribbean Institute for Hydrology and Meteorology [www.cimh.edu.bb](http://www.cimh.edu.bb)
- Caribbean Disaster Emergency Response Agency [www.cdera.org](http://www.cdera.org)
- National Hurricane Centre [www.nhc.noaa.gov/](http://www.nhc.noaa.gov/)
- FAQ – Hurricanes, Typhoons, TropCyclones [www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html](http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html)
- UNOCHA – [www.reliefweb.int](http://www.reliefweb.int)

## ITCZ

The Inter-tropical Convergence Zone is a region spanning from five degrees south to five degrees north of the equator where northeasterly and southeasterly tradewinds converge, forming an often continuous band of clouds or thunderstorms near the equator. The ITCZ, is a key component of the global circulation system, and can move up to 40 to 45 degrees north and south of the equator. The thunderstorms and large-scale spin in the ITCZ is an essential element to the birth of tropical cyclones which is dealt with in greater detail below. As the ITCZ move north, it can bring torrential showers and flooding to CDERA member states. The severe flooding experienced by Guyana in January 2005 was a result of the ITCZ interacting with a surface trough.



**Severe flooding in Guyana in January 2005 was the result of the ITCZ interacting with a surface trough which reduced the streets to waterways, accessible only by boat. (Photo: Bryan Mackintosh)**

<sup>2</sup> **TROPICS/TROPICAL:** The region of the earth located between the Tropic of Cancer, at 23.5 degrees North latitude, and the Tropic of Capricorn, at 23.5 degrees South latitude. It encompasses the equatorial region, an area of high temperatures and considerable precipitation during part of the year.

## Trough

An elongated area of low atmospheric pressure that is associated with an area of minimum cyclonic circulation.

## Tropical Cyclone

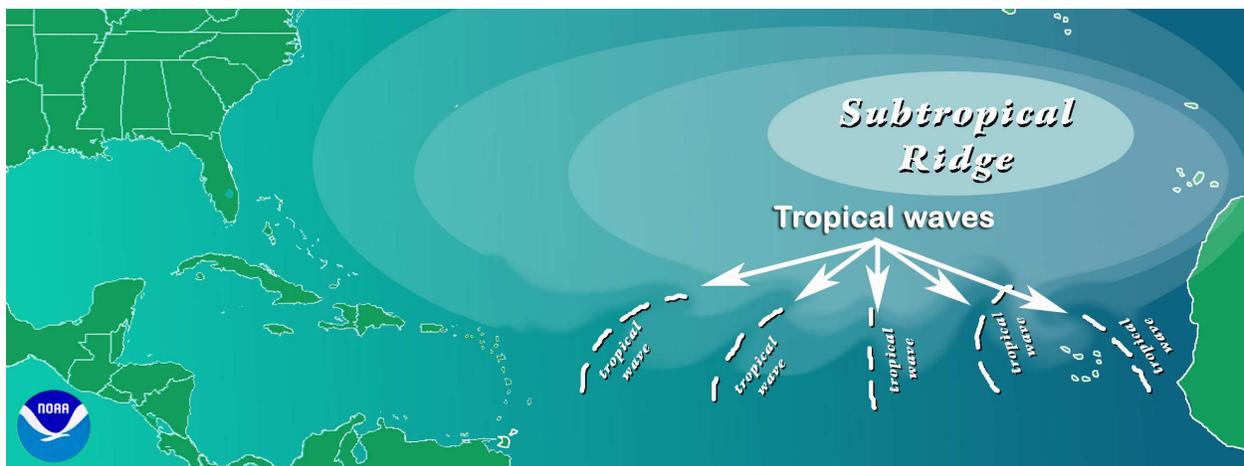
A warm-core low pressure system which develops over tropical, and sometimes subtropical, waters, and has an organized circulation. Depending on sustained surface winds, the system (in the Atlantic and Eastern Pacific Oceans) is classified as a tropical disturbance, a tropical depression, a tropical storm, or a hurricane. In the Caribbean, the layman tend to lump them all together and call them "hurricanes" however the correct term is a "cyclone". In the Indian Ocean they are referred to **Cyclones**, in the Western Pacific as **Typhoons**, and near Australia as **Willy Willy**.

The individual types of cyclones which affect the Caribbean are detailed below.

## Tropical Wave

All things being equal, tropical cyclones will form from a tropical wave. The term which scientists use to describe all the right conditions that form a cyclone is called **Cyclogenesis** (the genesis or beginning of a cyclone).

A Tropical Wave is an elongated area of low pressure, originating over Africa and blown across the Atlantic by the tradewinds towards the Caribbean Sea, crossing Central America and into the Pacific Ocean. These "waves" can be more correctly thought of as the convectively active troughs along an extended wave train. About 60 of these are generated each year during starting around April or May and continuing to October or November, coinciding with the Atlantic Hurricane Season (June-November). While only about 60% of the Atlantic tropical storms and minor hurricanes (Saffir-Simpson Scale categories 1 and 2) originate from easterly waves, nearly 85% of the intense (or major) hurricanes have their origins as easterly waves. It is suggested, though, that nearly all of the tropical cyclones that occur in the Eastern Pacific Ocean can also be traced back to Africa.



Source: AOML-HRD

## Tropical Disturbance

A discrete tropical weather system of apparently organized mass of thunderstorm, with a slight cyclonic circulation. It is generally 200 to 600 kilometers (100 to 300 nautical miles) in diameter originating in the tropics or subtropics and maintaining this character for 24 hours or more. Disturbances progressing through the tropics from east to west are also known as easterly or tropical waves.

## Tropical Depression

A tropical cyclone in which the maximum sustained wind speed is between 37 and 61 kph (23-38 mph).

## Tropical Storm

Once a tropical depression has intensified to the point where its maximum sustained winds are between 61-118 kph (39-73 mph), it becomes a tropical storm. It is at this time that it is assigned a name. During this time, the storm itself becomes more organized and begins to become more circular in shape -- resembling a hurricane. Rainfall in tropical storms is usually more concentrated near the center with outer rainfall organizing into distinct bands.



**Tropical disturbance, tropical depression, and tropical storm are terms used to describe the progressive levels of organized disturbed weather in the tropics that are of less than hurricane status. (Illustration: AOML-HRD)**

## Hurricane

As surface pressures continue to drop, a tropical storm becomes a hurricane when sustained wind speeds reach 119 kph (74 mph). A pronounced rotation develops around the central core and the system develops an "eye". Located just outside of the eye is the eye wall. This is the location within a hurricane where the most damaging winds and intense rainfall is found. Inside the eye, the weather is calm. There are five categories of hurricanes classified on the Saffir/Simpson Scale (see below). The last three are regarded as "intense" or "major" hurricanes.

## Cyclogenesis

A number of conditions are necessary for a tropical cyclone to develop. There are many factors but some of the most common ones are:

- Warm ocean waters of at least 26.5°C [80°F] throughout a sufficient depth, at least 50 meters [150 ft]. Warm waters are necessary to fuel the heat engine of the tropical cyclone;
- An unstable atmosphere or thundershowers. It is the thunderstorm activity which allows the heat stored in the ocean waters to be liberated for the tropical cyclone development;
- A minimum distance of at least 500 km [300 mi] from the equator;
- A pre-existing near-surface disturbance. Tropical cyclones cannot be generated spontaneously. To develop, they require a weakly organized system with sizable spin and low level inflow.
- Low values (less than about 10 meters per second [20 kts 23 mph]) of vertical wind shear between the surface and the upper troposphere. Strong wind shear prevents storms from forming or rips apart already-formed cyclones while weak wind shear fuels cyclones.

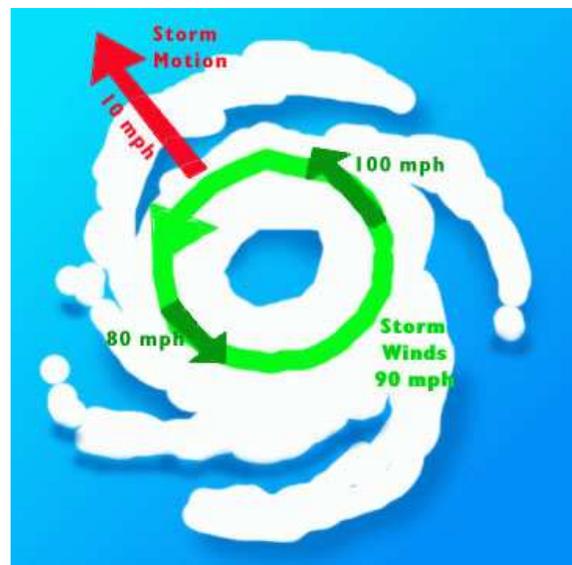


## What to expect as a cyclone approaches

Tropical cyclones are characterised by their destructive winds, storm surges and exceptional levels of rainfall which may cause flooding.

### Destructive Winds

The strong winds generated by tropical cyclones circulate clockwise in the Southern Hemisphere and counter clockwise in the Northern Hemisphere. The reason is that the earth's rotation sets up an apparent force (called the Coriolis force) that pulls the winds to the right in the Northern Hemisphere (and to the left in the Southern Hemisphere). So when a low pressure starts to form north of the equator, the surface winds will flow inward trying to fill in the low and will be deflected to the right and a counter-clockwise rotation will be initiated. The opposite (a deflection to the left and a clockwise rotation) will occur south of the equator. Winds speeds progressively increase towards the core. As the eye arrives, winds fall off to become almost calm but rise again just as quickly as the eye passes and are replaced by hurricane force winds from a direction nearly the reverse of those previously blowing.

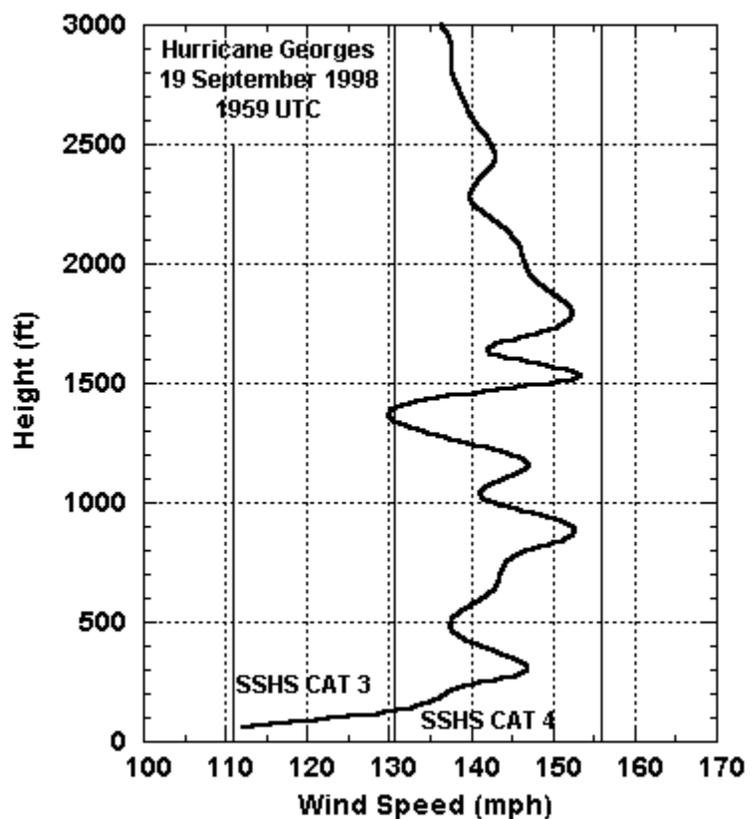


The damage caused by the wind increases exponentially instead of linearly. That is the amount of damage from a cyclone with winds of 128 mph is not double that of a system with 74 mph winds. The 148 mph hurricane (a category four on the Saffir-Simpson Scale) may produce - on average - up to 250 times the damage of the minimal category one hurricane!

Winds are not uniform around the cyclone<sup>3</sup>; they are typically strongest in the northwest quadrant or the right side of the system. The "right side of the storm" is defined according to the storm's motion as shown in the illustrations. If it were moving to the west, the right side would be to the north of the storm; if it is moving to the north, the right side would be to the east of the storm. So that if a cyclone were traveling south of an island going towards the west, the strongest winds would affect the southern section of the island as happened in 1955 with Hurricane Janet moving south of Barbados.

In general, the strongest winds in a hurricane are found on the right side of the storm because the motion of the hurricane also contributes to its swirling winds. A hurricane with a 90 mph [145 km/hr] winds while stationary would have winds up to 100 mph [160 km/hr] on the right side and only 80 mph [130 km/hr] on the left side if it began moving (any direction) at 10 mph [16 km/hr].<sup>1</sup>

Another important element is the wind profile of a tropical cyclone. A practice was for engineers and architects to design stronger high-rise buildings and buildings which are on elevated terrain because of the anticipated stronger winds at those levels. The Hurricane Research Division and the National Hurricane Centre of NOAA conducted tests by ejecting wind dropsondes into the eyewall and outer vortex of major hurricanes. A dropsonde is a small cylindrical device which weighs about 18 pounds and as it falls to the surface from the aircraft it takes atmospheric measurements every 10 seconds. In Hurricane Georges, it showed that while the winds at the surface were 111 mph and so people would be experiencing a category three hurricane, those who were living on a mountain would have been experiencing winds in excess of 145 mph.<sup>4</sup>



**This graph shows the wind profile of Hurricane Georges. At sea level the winds were 110 mph but for people living 300 feet higher on a hill or mountainside the winds were 145 mph**

<sup>3</sup> Dr Chris Landsea, NOAA's Hurricane Research Division FAQ (<http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html>)

<sup>4</sup> HRD/NHC (<http://www.nhc.noaa.gov/aboutwindprofile.shtml>)

## Storm Surge<sup>5</sup>

Storm surge is simply water that is pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level 15 feet or more. In addition, wind driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides. Because much of the United States' densely populated Atlantic and Gulf Coast coastlines lie less than 10 feet above mean sea level, the danger from storm tides is tremendous.

In general, the more intense the storm, and the closer a community is to the right-front quadrant, the larger the area that must be evacuated. The problem is always the uncertainty about how intense the storm will be when it finally makes landfall. Emergency managers and local officials balance that uncertainty with the human and economic risks to their community. This is why a rule of thumb for emergency managers is to plan for a storm one category higher than what is forecast. This is a reasonable precaution to help minimize the loss of life from hurricanes.

Wave and current action associated with the tide also causes extensive damage. Water weighs approximately 1,700 pounds per cubic yard; extended pounding by frequent waves can demolish any structure not specifically designed to withstand such forces.

The currents created by the tide combine with the action of the waves to severely erode beaches and coastal highways. Many buildings withstand hurricane force winds until their foundations, undermined by erosion, are weakened and fail.

## Excessive Rainfall <sup>2</sup>

When it comes to hurricanes, wind speeds do not tell the whole story. Hurricanes produce storm surges, tornadoes, and often the most deadly of all - inland flooding.

While storm surge is always a potential threat, more people have died from inland flooding in the last 30 years (1970-2000). Intense rainfall is not directly related to the wind speed of tropical cyclones. In fact, some of the greatest rainfall amounts occur from weaker storms that drift slowly or stall over an area.

Inland flooding can be a major threat to communities well away from the coast as intense rain falls from these huge tropical air masses.

### RAINFALL RULE OF THUMB

Rainfall is generally heaviest with slower moving storms (less than 10 mph). To **estimate** the total rainfall in inches from a hurricane, divide 100 by the forward speed of the storm in miles per hour (100 / forward speed = estimated inches of rain).

**(SOURCE: National Hurricane Centre)**

Hurricane Mitch in 1998 after making landfall in Honduras rapidly weakened to a weak tropical depression and slowed its forward speed to less than five kmp (5 mph) for a week. It was during that period that he did the worse damage dumping up to 35 inches of rain, primarily over Honduras and Nicaragua, which resulted in flash floods and mudslides that killed thousands of people. It is noted that a large east-west mountain range, with peaks

<sup>5</sup> National Hurricane Center ([http://www.nhc.noaa.gov/HAW2/english/storm\\_surge.shtml](http://www.nhc.noaa.gov/HAW2/english/storm_surge.shtml))

approaching 10,000 feet, covers this part of Central America and this terrain likely contributed to the large rainfall totals. Some heavy rains also occurred in other portions of Central America.<sup>6</sup>

## Likely Impact

### Physical Damage

Structures will be damaged or destroyed by wind force, storm surges, landslides and flooding. Public utilities such as overhead power lines, water and gas distribution lines, bridges, culverts and drainage systems are also subject to severe damage. Fallen trees, wind driven rain and flying debris can also cause considerable damage.



**Massive landslides were triggered by Mitch in Honduras and Guatemala**

### Crops and Food Supplies

The combination of high winds and heavy rain and flooding can ruin crops and trees. Food stocks may be lost or contaminated and it is possible that food shortages will occur.

### Casualties and Public Health

There are relatively few deaths associated with the impact of high winds. However, storm surges may cause many deaths but usually few injuries among survivors. The threat to public health emerges in the aftermath of events when conditions such as water contamination or shortages, flooding and damage to sanitation facilities may favour the spread of diseases.

**Lack of Communication** Communication may be severely disrupted as telephone lines, radio and television antennas and satellite disks are blown down. Roads and railway lines may be blocked by fallen trees or debris and aircraft movements are curtailed for hours after a cyclone.

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<sup>6</sup> National Hurricane Centre Mitch 1998 Preliminary Report (<http://www.nhc.noaa.gov/1998mitch.html>)

## Measuring Hurricanes: The Saffir-Simpson Scale

The table below provides examples of damage and storm surge heights from hurricanes.

Cat	Central Pressure (millibars)	Winds	Surge	Damage
1	Greater than 980	74-95 mph	3-5 ft 1.0-1.7 m	<p><b>MINIMAL</b></p> <p>Damage primarily to shrubbery, trees, foliage, and unanchored homes. No real damage to other structures. Some damage to poorly constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.</p> 
2	979 – 965	96-110 mph	6-8 ft 1.8-2.6 m	<p><b>MODERATE</b></p> <p>Considerable damage to shrubbery and tree foliage; some trees blown down. Major damage to exposed mobile homes. Extensive damage to poorly constructed signs. Some damage to roofing materials of buildings; some window and door damage. No major damage to buildings. Coast roads and low-lying escape routes inland cut by rising water 2 to 4 hours before arrival of hurricane center. Considerable damage to piers. Marinas flooded. Small craft in unprotected anchorages torn from moorings. Evacuation of some shoreline residences and low-lying areas required.</p> 
3	964-945	111-130 mph	9-12 ft 2.7-3.8 m	<p><b>EXTENSIVE</b></p> <p>Foliage torn from trees; large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings; some wind and door damage. Some structural damage to small buildings. Mobile homes destroyed. Serious flooding at coast and many smaller structures near coast destroyed; larger structures near coast damaged by battering waves and floating debris. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Flat terrain 5 feet or less above sea level flooded inland 8 miles or more. Evacuation of low-lying residences within several blocks of shoreline possibly required.</p> 
4	944-920	131-155 mph	13-18 ft 3.9-5.6 m	<p><b>EXTREME</b></p> <p>Shrubs and trees blown down; all signs down. Extensive damage to roofing materials, windows and doors. Complete failures of roofs on many small residences. Complete destruction of mobile homes. Flat terrain 10 feet or less above sea level flooded inland as far as 6 miles. Major damage to lower floors of structures near shore due to flooding and battering by waves and floating debris. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Major erosion of beaches. Massive evacuation of all residences within 500 yards of shore</p> 

Cat	Central Pressure (millibars)	Winds	Surge	Damage
				possibly required, and of single-story residences within 2 miles of shore.
5	Less than 920	156+ mph	19+ ft 5.7+ m	<p><b>CATASTROPHIC</b></p> <p>Shrubs and trees blown down; considerable damage to roofs of buildings; all signs down. Very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings. Extensive shattering of glass in windows and doors. Some complete building failures. Small buildings overturned or blown away. Complete destruction of mobile homes. Major damage to lower floors of all structures less than 15 feet above sea level within 500 yards of shore. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Massive evacuation of residential areas on low ground within 5 to 10 miles of shore possibly required.</p> 

# Messages the media should give to the public

## Emergency Action

### Weather warnings – who warns?

The local meteorological service in association with the national disaster organisation, issue advisories, watches, and warnings. These are broadcast via the local or national television or radio stations.

When a cyclone is approaching your country **the only authoritative and legal source of information is your meteorological office** – not the Internet, not the Weather Channel, nor any foreign news weather service. Only your local meteorologist has the knowledge of your local area and only they can issue a realistic and accurate forecast.

The Tropical Prediction Centre (TPC) in Miami is one of the eight Regional Specialized Meteorological Centres (RSMC) of the World Meteorological Organisation (WMO). Through international agreement, the TPC has responsibility within the WMO to generate and coordinate tropical cyclone analysis and forecast products for twenty-four countries in the Americas, Caribbean, and for the waters of the North Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and the eastern North Pacific Ocean. The TPC comprises three branches, one of which is the National Hurricane Centre in Miami with which most Caribbean journalists are familiar.

The hurricane centre issues a forecast of the broader picture but the local meteorologist must forecast for his/her jurisdiction. Only the local meteorologist has the authority to raise a watch or warning and not the National Hurricane Centre.

### Advisories

Messages issued by the authorities about the formation, location, speed, direction, strength, and potential threat that the system poses to land are normally issued every six hours - at 5 am and 11 am and again at 5 pm and 11 pm. Should the cyclone be close to land, advisories are issued every three hours.

TYPES OF ADVISORIES	ACTIONS PUBLIC SHOULD TAKE
<p style="text-align: center;"><b>Advisory or Bulletin</b></p> <p>The terminology may differ according to each Caribbean territory. An advisory or bulletin is just a simple information note to let the public know of the development of a cyclone or disturbance which they should monitor.</p>	<p style="text-align: center;"><b>On hearing an advisory or bulletin the public should:</b></p> <p>Continue normal activities but stay tuned to radio and television for further messages.</p>
<p style="text-align: center;"><b>Watch</b></p> <p>A “<b>tropical storm watch</b>” is issued by your local meteorological office when it is possible that tropical storm conditions, including winds from 39 to 73 mph could pose a threat to a specific island or coastal area within 36 hours.</p> <p>A “<b>hurricane watch</b>” is issued for a specific island</p>	<p style="text-align: center;"><b>On hearing a storm or hurricane watch, the public should:</b></p> <ul style="list-style-type: none"> <li>• Review emergency preparedness; requirements, especially family emergency plans;</li> <li>• Continue to listen to weather advisories on radio;</li> <li>• Be ready to take quick action in case of a Warning;</li> </ul>

TYPES OF ADVISORIES	ACTIONS PUBLIC SHOULD TAKE
<p>or a coastal area for which a hurricane or a hurricane-related hazard is a possible threat within 36 hours.</p>	<ul style="list-style-type: none"> <li>• Establish contact points.</li> </ul>
<p style="text-align: center;"><b>Warning</b></p> <p>A “<b>tropical storm warning</b>” is issued for a specific island or coastal area when tropical storm conditions, including winds of 39 to 73 mph are expected in 24 hours or less.</p> <p>A “<b>hurricane warning</b>” is issued when a cyclone with sustained winds of 74 mph or stronger is expected in a specific island or coastal area in 24 hours or less. A hurricane warning remains in effect when dangerously high water or a combination of dangerously high water and exceptionally high waves continue even though the winds may have subsided below hurricane intensity.</p>	<p style="text-align: center;"><b>On hearing a storm or hurricane warning, the public should:</b></p> <ul style="list-style-type: none"> <li>• Stay tuned to the radio for information;</li> <li>• Protect property and personal possessions (including important documents);</li> <li>• Place indoors, loose objects found in and around the yard;</li> <li>• Fill up car with gasoline;</li> <li>• Pick fruit and trim trees if near house;</li> <li>• Store water, food and essential medicines;</li> <li>• Feed animals and pets and move indoors or loose;</li> <li>• Know where you are going to shelter if the need arises.</li> </ul>
<p style="text-align: center;"><b>All Clear</b></p> <p>The meteorological service will advise when the system has passed and it is safe to go outdoors.</p>	<p style="text-align: center;"><b>On hearing the all clear, the public should:</b></p> <ul style="list-style-type: none"> <li>• Assist in search and rescue;</li> <li>• Seek medical attention for persons injured;</li> <li>• Clean up debris and effect temporary repairs;</li> <li>• Report damage to utilities;</li> <li>• Assist in road clearance;</li> <li>• Watch out for secondary hazards, fire, flooding, etc.</li> <li>• Assist in community response efforts;</li> <li>• Avoid sightseeing;</li> <li>• Co-operate with Damage Assessors.</li> </ul>

### Other warning systems

The original warning systems may still be in effect by some countries in the Caribbean. They include:

- Ringing of church bells
- Hoisting of hurricane warning flags
- Sounding of sirens

## Prevention and Mitigation Measures

(Long term measures)

### **Risk Assessment**

The evaluation of risks of tropical cyclones should be undertaken and illustrated in a hazard map. The following information may be used to estimate the probability of cyclones which may strike a country.

- Analysis of climatological records to determine how often cyclones have struck, their intensity and locations;
- History of winds speeds, frequencies of flooding, height location or storm surges;
- Information about 50-100 years cyclone activity.

### **Land Use Control**

This is designed to control land use so that the least critical facilities are placed in most vulnerable areas. Policies regarding future development may regulate land use and enforce building codes for areas vulnerable to the effects of tropical cyclones. For example, in coastal areas, regulation can stipulate maximum building heights, types of land and occupant density. Another option includes the purchase of vulnerable areas by government for use of parks, sports facilities and open grazing land.

### **Flood Plain Management**

A master plan for flood plain management should be developed to protect critical assets from flash, riverine and coastal flooding.

### **Reducing Vulnerability of Structures and Infrastructures**

- New buildings should be designed to be wind and water resistant. Design standards are usually contained in building codes;
- Communication and utility lines should be located away from the coastal area or installed underground;
- Improvement of building sites by raising the ground level to protect against flood and storm surges;
- Protective river embankments, levees and coastal dikes should be regularly inspected for breaches due to erosion and opportunities taken to plant mangroves to reduce breaking wave energy;
- Improved vegetation cover. This helps to reduce the impact of soil erosion and landslides and facilitates the absorption of rainfall to reduce flooding.

# Glossary

**ADVISORY:** This has two meanings. It can be given to a group of messages (“watch” and “warning”) from the local meteorological office and the local disaster management office giving warning information with details on tropical cyclone location, intensity, movement and precautions that should be taken, or as an individual item it can be simple “heads-up” information on the development of a disturbance or cyclone to which the population should pay close attention.

**ATMOSPHERIC PRESSURE:** The pressure exerted by the atmosphere at a given point. Its measurement can be expressed in several ways. One is in millibars. Another is in inches or millimeters of mercury (Hg). Also known as barometric pressure.

**BEST TRACK:** A subjectively smoothed path, versus a precise and very erratic fix-to-fix path, used to represent tropical cyclone movement. It is based on an assessment of all available data.

**CAPE VERDE ISLANDS:** A group of volcanic islands in the eastern Atlantic Ocean off the coast of West Africa. A Cape Verde hurricane originates near here.

**CENTER:** The vertical axis or core of a tropical cyclone. It is usually determined by cloud vorticity patterns, wind, and/or pressure distributions.

**CENTER/VORTEX FIX:** The location of the center of a tropical or subtropical cyclone obtained by reconnaissance aircraft penetration, satellite, radar, or synoptic data.

**CLOSEST POINT OF APPROACH:** Point where hurricane eye makes closest contact to shore without actually making landfall.

**COASTAL FLOOD WARNING:** A warning that significant wind-forced flooding is to be expected along low-lying coastal areas if weather patterns develop as forecast.

**COASTAL FLOOD WATCH:** An announcement that significant wind-forced flooding is to be expected along low-lying coastal areas if weather patterns develop as forecast.

**CONVECTION:** Atmospheric motions in the vertical direction resulting from surface heating and the subsequent rising of warm air. This lifting mechanism is capable of generating the rising motions necessary for clouds and precipitation to form.

**CONVERGENCE:** Wind movement that results in a horizontal net inflow of air into a particular region. Convergent winds at lower levels are associated with upward motion. Contrast with divergence.

**CYCLONE:** An atmospheric circulation (low-pressure system) with rotating and converging winds, in which the center has a relative pressure minimum. It usually has a diameter of 2000 to 3000 kilometers. When developing, a cyclone typically consists of a warm front pushing northward and a cold front pushing southward with the center of low pressure (cyclone center) located at the junction of the two fronts. Cyclones in the Northern Hemisphere rotate counter-clockwise while Southern Hemisphere cyclones rotate clockwise.

**DEPRESSION:** In meteorology, it is another name for an area of low pressure, a low, or trough. It also applies to a stage of tropical cyclone development and is known as a tropical depression to distinguish it from other synoptic features.

**DISTURBANCE:** This has several applications. It can apply to a low or cyclone that is small in size and influence. It can also apply to an area that is exhibiting signs of cyclonic development. It may also apply to a stage of tropical cyclone development and is known as a tropical disturbance to distinguish it from other synoptic features

**DOPPLER RADAR:** Weather radar that measures direction and speed of a moving object, such as drops of precipitation, by determining whether atmospheric motion is horizontally toward or away from the radar. Using the Doppler effect, it measures the velocity of particles.

**EASTERLY WAVE:** An inverted, migratory wave-like disturbance or trough in the tropical region that moves from east to west, generally creating only a shift in winds and rain. The low-level convergence and associated convective weather occur on the eastern side of the wave axis. Normally, it moves slower than the atmospheric current in which it is embedded and is considered a weak trough of low pressure. It is often associated with possible tropical cyclone development and is also known as a tropical wave.

**EL NIÑO:** A warming of the Pacific Ocean currents along the coasts of Peru and Ecuador near the Equator that is generally associated with dramatic changes or a shift in the weather patterns of the region. A major El Niño event generally occurs every 3 to 7 years and is associated with changes in the weather patterns worldwide including hurricane.

**EMERGENCY PUBLIC SHELTER:** Generally a public school or other such structure designated by county or city officials as a place of refuge. A volunteer group such as the American Red Cross or Salvation Army usually manages a shelter.

**EMERGENCY OPERATIONS CENTER (EOC):** A government emergency facility that serves as a central location for the coordination and control of all emergency preparedness and response disaster activities.

**EXTRATROPICAL:** A term used in advisories and tropical summaries to indicate that a cyclone has lost its "tropical" characteristics. The term implies both poleward displacement of the cyclone and the conversion of the cyclone's primary energy source from the release of latent heat of condensation to baroclinic (the temperature contrast between warm and cold air masses) processes. It is important to note that cyclones can become extratropical and still retain winds of hurricane or tropical storm force.

**EXTRATROPICAL CYCLONE:** A cyclone in the middle and high latitudes often being 2000 kilometers in diameter and usually containing a cold front that extends toward the equator for hundreds of kilometers. These cyclones form outside the tropics, the center of storm is colder than the surrounding air, have fronts and the strongest winds are in the upper atmosphere.

**EYE:** The center of a tropical storm or hurricane characterized by a roughly circular area of light winds and rain-free skies and the lowest pressure. An eye will usually develop when the maximum sustained wind speeds exceed 78 mph. It can range in size from as small as 5 miles to up to 60 miles (20-50 km) but the average size is 20 miles. In general, when the eye begins to shrink in size, the storm is intensifying.

**EYE WALL:** An organized band of convection surrounding the eye, or center, of a tropical cyclone. It contains cumulonimbus clouds, severest thunderstorms, heaviest precipitation and strongest winds.

**FEEDER BANDS:** In tropical parlance, the lines or bands of thunderstorms that spiral into and around the center of a tropical system. Also known as outer convective bands, a typical hurricane may have three or more of these bands. They occur in advance of the main rain shield and are usually 40 to 80 miles apart. In thunderstorm development, they are the lines or bands of low-level clouds that move or feed into the updraft region of a thunderstorm.

**FLOODING:** A general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of inland or tidal water or rapid accumulation or runoff of surface waters from any source.

**FLOOD PLAIN:** Any land area susceptible to being inundated by water from any source. Normally the regulatory flood plain is characterized by the 100-year meaning there is a 1% chance of flooding per year. The flood plain is often referred to as flood prone areas.

**FLOOD WARNING:** The expected severity of flooding (minor, moderate or major) as well as where and when the flooding will begin.

**FORECAST:** A statement of expected future occurrences. Weather forecasting includes the use of objective models based on certain atmospheric parameters, along with the skill and experience of a meteorologist. Also called a prediction.

**FORWARD SPEED:** The rate of movement (propagation) of the hurricane eye in miles per hour or knots

**FUJIWHARA EFFECT:** A binary interaction where tropical cyclones within a certain distance (300-750 nautical miles depending on the sizes of the cyclones) of each other begin to rotate about a common midpoint.

**GALE WARNING:** A warning of 1-minute sustained surface winds in the range 63-87 kph (39 to 54 mph) inclusive, either predicted or occurring not directly associated with tropical cyclones.

**GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITES (GOES):** Family of NWS weather satellites, which orbit 22,300 miles above the earth and maintain a velocity that allows it to remain over a fixed place above the equator. Images are available to forecasters every 30 minutes.

**GREENWICH MEAN TIME (GMT):** The name of the twenty-four hour time scale that is used throughout the scientific and military communities. Standard Time begins at Greenwich, England, which is the Prime Meridian of Longitude. The globe is divided into twenty-four (24) time zones of 15 degrees of arc, or one hour in time apart. To the east of this meridian, time zones are numbered 1 to 12 and prefixed with a minus (-), while to the west, the time zones are also numbered 1 through 12 but prefixed with a plus (+). Other names for this time measurement are Universal Time Coordinate (UTC) and Zulu (Z).

**HIGH-PRESSURE SYSTEM:** An area of relative pressure maximum that has diverging winds and a rotation opposite to the earth's rotation. This is clockwise in the Northern

Hemisphere and counterclockwise in the Southern Hemisphere. Also known as an anticyclone, it is the opposite of an area of low pressure or a cyclone.

**HUMIDITY:** The amount of water vapor in the air.

**HURRICANE:** A tropical cyclone in the Northern Hemisphere with sustained winds of at least 119 kph (74 mph) or greater in the North Atlantic Ocean, Caribbean Sea or Gulf of Mexico. These winds blow in a large spiral around a relatively calm center of extremely low pressure known as the eye. Around the rim of the eye, winds may gust to more than 200 miles per hour. The entire storm, which can be up to 550 kilometers (340 miles) in diameter, dominates the ocean surface and lower atmosphere over tens of thousands of square miles. Hurricanes draw their energy from the warm surface water of the tropics (usually above 27 Celsius) and latent heat of condensation, which explains why hurricanes dissipate rapidly once they move over cold water or large land masses.

**HURRICANE ADVISORY:** Notice, issued by the local meteorological office or national disaster management office, numbered consecutively for each storm, describing the present and forecasted position and intensity. Advisories are issued at six-hour intervals at midnight, 5 am, 11 am, 5 pm and 11 pm Eastern Caribbean Time. Bulletins provide additional information. Each message gives the name, eye position, intensity and forecast movement of the storm. Advisories will be issued every three hours if the hurricane is close to land.

**HURRICANE EYE:** The relatively calm area near the center of the storm. In this area, winds are light and the sky is often partly covered by clouds.

**HURRICANE EYE LANDFALL:** When the eye, or physical center of the hurricane, reaches the coastline from the hurricane's approach over water.

**HURRICANE HUNTERS:** The 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve, based out of Keesler Air Force Base in Biloxi, Mississippi. As a part of the 403rd Air Wing, the crew flies Lockheed WC-130 aircraft into tropical storms and hurricanes to gather meteorological data for the National Hurricane Center.

**HURRICANE PATH OR TRACK:** Line of movement (propagation) of the eye through an area.

**HURRICANE SEASON:** The portion of the year having a relatively high incidence of hurricanes. The hurricane season in the Atlantic, Caribbean, and Gulf of Mexico runs from June 1 to November 30.

**HURRICANE WARNING:** A warning added to a hurricane advisory that sustained winds of 119 kph (74 mph) or higher associated with a hurricane are expected in a specified coastal area within 24 hours or less. A hurricane warning can remain in effect when dangerously high water or a combination of dangerously high water and exceptionally high waves continue, even though winds may be less than hurricane force. A warning is used to inform the public and marine interests of the storm's location, intensity, and movement.

**HURRICANE WATCH:** An announcement added to a hurricane advisory that hurricane conditions pose a possible threat to a specified coastal area within 36 hours. A watch is used to inform the public and marine interests of the storm's location, intensity, and movement.

**INSTABILITY / UNSTABLE:** Occurs when a rising air parcel becomes less dense than the surrounding air. Since its temperature will not cool as rapidly as the surrounding environment, it will continue to rise on its own. Contrasts with stable air.

**INTERTROPICAL CONVERGENCE ZONE (ITCZ):** The axis dividing the southeast trades from the northeast trades, toward which the surface winds tend to converge. The easterly trade winds of both hemispheres converge at an area near the equator called the "Intertropical Convergence Zone (ICTZ)", producing a narrow band of clouds and thunderstorms that encircle portions of the globe.

**ISOBAR:** The line drawn on a weather map connecting points of equal barometric pressure.

**JET STREAM:** Relatively strong winds concentrated within a narrow current in the atmosphere.

**KNOT:** A unit for the measurement of speed in the nautical system. It is the nautical miles per hour. One knot is equivalent to 1.151 statute miles.

**LANDFALL:** The term used to describe where the hurricane eye actually passes over land, usually used to describe the continental States rather than islands in the Caribbean.

**LATITUDE:** The location north or south in reference to the equator, which is designated at zero (0) degrees. Parallel lines that circle the globe both north and south of the equator. The poles are at 90 degrees North and South latitude.

**LONGITUDE:** The location east or west in reference to the Prime Meridian, which is designated as zero (0) degrees longitude. The distance between lines of longitude are greater at the equator and smaller at the higher latitudes, intersecting at the earth's North and South Poles. Time zones are correlated to longitude.

**LOW-PRESSURE SYSTEM:** An area of a relative pressure minimum that has converging winds and rotates in the same direction as the earth. This is counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Also known as a cyclone, it is the opposite of an area of high pressure, or a anticyclone. See closed low, cold low, and cut-off low for further examples.

**MILLIBAR (MB):** A metric measurement of atmospheric pressure used by weather services. Standard surface pressure is 1,013.2 millibars.

**NATIONAL HURRICANE CENTER (NHC):** A Branch of the Tropical Prediction Center under the US National Weather Service, it is responsible for tracking and forecasting tropical cyclones over the North Atlantic, Caribbean, Gulf of Mexico, and the Eastern Pacific.

**NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA):** An Administration of the U.S. Department of Commerce, it is the parent organization of the National Weather Service. It promotes global environmental stewardship, emphasizing atmospheric and marine resources.

**NAUTICAL MILE:** A unit of length used in marine navigation that is equal to a minute of arc of a great circle on a sphere. One international nautical mile is equivalent to 1,852 meters or 1.151 statute miles. Refer to a sea mile.

**PRESSURE:** The force per unit area exerted by the weight of the atmosphere above a point on or above the earth's surface. Also known as atmospheric pressure or barometric pressure.

**SAFFIR-SIMPSON DAMAGE-POTENTIAL SCALE:** A scale, developed in the early 1970s by Herbert Saffir, a consulting engineer, and Robert Simpson, then Director of the National Hurricane Center, to measure the intensity of a hurricane from 1 to 5. The scale categorizes potential damage based on barometric pressure, wind speeds, and storm surge. Scale numbers are available to public safety officials when a hurricane is within 72 hours of landfall. Scale assessments are revised regularly as new observations are made. Public safety organizations are kept informed of new estimates of the hurricane's disaster potential. In practice, sustained surface wind speed (1-minute average) is the parameter that determines the category since storm surge is strongly dependent on the slope of the continental shelf.

**SMALL CRAFT ADVISORY:** An advisory issued for marine interests, especially for operators of small boats or other vessels. Conditions include wind speeds between 37 kph (23 mph) and 63 kph (39 mph). Issued up to 12 hours ahead of conditions.

**STORM:** An individual low-pressure disturbance, complete with winds, clouds, and precipitation. Examples include thunderstorms, tornadoes, or even tropical cyclones. The name is associated with destructive or unpleasant weather

**STORM SURGE:** An abnormal rise in sea level accompanying a hurricane or other intense storm, and whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the cyclone. Storm surge is usually estimated by subtracting the normal or astronomic high tide from the observed storm tide. Note: waves on top of the storm surge will create an even greater high-water mark.

**STORM TIDE:** The actual level of seawater resulting from the astronomic tide combined with the storm surge. If the storm comes ashore during astronomical low tide, the surge will be decreased by the amount of the low tide. If the storm makes landfall during astronomical high tide, the surge will be that much higher.

**SUBTROPICAL:** The region between the tropical and temperate regions, an area between 35 and 40 degrees North and South latitude. This is generally an area of semi-permanent high pressure that exists and is where the Azores and North Pacific Highs may be found.

**SUBTROPICAL CYCLONE:** A low pressure system that develops over subtropical waters that initially has a non-tropical circulation but in which some elements of tropical cyclone cloud structure are present. Subtropical cyclones can evolve into tropical cyclones.

**SUBTROPICAL DEPRESSION:** A subtropical cyclone in which the maximum sustained surface wind speed (using the U.S. 1-minute average) is 61 kph (38 mph) or less.

**SUBTROPICAL HIGH:** A semi-permanent high-pressure region near 30 degrees latitude.

**SUBTROPICAL STORM:** A subtropical cyclone in which the maximum sustained surface wind speed (using the U.S. 1-minute average) is 63 kph (39 mph) or more.

**THUNDERSTORM:** A local storm produced by a cumulonimbus cloud, always with lightning and thunder, and usually accompanied by strong gusts of wind, heavy rain, and sometimes hail.

**TRADE WINDS:** The wind system, occupying most of the tropics, which are northeasterly in the Northern Hemisphere and southeasterly in the Southern Hemisphere.

**TROPICS/TROPICAL:** The region of the earth located between the Tropic of Cancer, at 23.5 degrees North latitude, and the Tropic of Capricorn, at 23.5 degrees South latitude. It encompasses the equatorial region, an area of high temperatures and considerable precipitation during part of the year.

**TROPICAL CYCLONE:** A general term for all cyclone circulations originating over tropical waters. Its characteristics include a warm-core, non-frontal pressure system of synoptic scale that originates over the tropical or subtropical waters and has a definite organized surface. Used to define wind circulations rotating around an atmosphere which include tropical depressions, tropical storms, and hurricanes. The strongest winds of this cyclone are near the Earth's center.

**TROPICAL DEPRESSION (TD):** A tropical cyclone in which the maximum sustained surface winds (1 minute average) are 61 kph (38 mph) or less. Characteristically having one or more closed isobars, it may form slowly from a tropical disturbance or an easterly wave, which has continued to organize. At this point, it gets a cyclone number, starting with "TD01" at the beginning of each storm season.

**TROPICAL DISTURBANCE:** A discrete system of clouds, showers, and thunderstorms (organized convection) that originate in the tropics. Generally 100 to 300 miles in diameter and originating in the tropics or subtropics, disturbances have a nonfrontal migratory character, and maintain their identity for 24 hours or more. It may or may not be associated with a detectable perturbation of the wind field. An upper level of low pressure causes this to occur. Approximately 100 of these types of events occur annually during hurricane season.

**TROPICAL STORM (TS):** A tropical cyclone in which the maximum sustained surface wind speed (1 minute average) is within the range of 63 to 117 kph (39 to 73 mph). At this point, the system is given a name to identify and track it. In the Atlantic/Caribbean/Gulf of Mexico basin, the names start with "A" each season.

**TROPICAL STORM WATCH:** An announcement issued by the National Hurricane Center for specific areas that a tropical storm or a forecast of tropical storm conditions poses a possible threat to coastal areas generally within 36 hours. A tropical storm watch normally should not be issued if the system is forecast to attain hurricane strength.

**TROPICAL STORM WARNING:** A warning issued by the National Hurricane Center for tropical storm conditions including possible sustained winds within the range 63 to 117 kph (39 to 73 mph) which are expected in a specified coastal area within 24 hours or less. Advisories will be issued every three hours if the storm is close to land.

**TROPICAL WAVE:** Another name for an easterly wave, it is an area of relatively low pressure (trough) moving westward through the trade wind easterlies. Generally, it is associated with extensive cloudiness and showers, and may be associated with possible tropical cyclone development.

**TYPHOON:** A hurricane that occurs in the Pacific Region of the Philippines or the China Sea.

**UNIVERSAL TIME COORDINATE (UTC):** One of several names for the twenty-four hour time that is used throughout the scientific and military communities. Other names for this time measurement are Greenwich Mean Time (GMT) or Zulu Time (Z). See Greenwich Mean Time for more information.

**VORTEX:** Any circular or rotary flow in the atmosphere that possesses vorticity.

**VORTEX FIX:** The location of the surface and/or flight level center of a tropical or subtropical cyclone obtained by reconnaissance aircraft penetration.

**WARNING:** An announcement that is issued when severe weather: 1) has developed; 2) is already occurring and reported; or 3) is detected on radar. Warnings state a particular hazard or imminent danger, such as tornadoes, severe thunderstorms, flash and river floods, hurricanes, etc

# Contact List

## Meteorological Services in CDERA Member States

### Anquilla

Services provided by:  
Antigua and Barbuda Meteorological Services  
V.C. Bird International Airport  
Coolridge  
St John's, Antigua  
Tel: (268) 462-3229/3017  
Email: [metoffice@antigua.gov.ag](mailto:metoffice@antigua.gov.ag)  
URL: <http://www.antiguamet.com/>  
Forecast Information: <http://www.antiguamet.com/>

### Antigua and Barbuda

Antigua and Barbuda Meteorological Services  
V.C. Bird International Airport  
Coolridge  
St John's, Antigua  
Tel: (268) 462-3229/3017  
Email: [metoffice@antigua.gov.ag](mailto:metoffice@antigua.gov.ag)  
URL: <http://www.antiguamet.com/>  
Forecast Information: <http://www.antiguamet.com/>

### Bahamas, The

Department of Meteorology  
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Nassau, N.P., The Bahamas  
Tel: (242) 377-7040/3701  
Email: [awr.met@batelnet.bs](mailto:awr.met@batelnet.bs)  
URL: <http://www.bahamasweather.org.bs/>

### Barbados

Barbados Meteorological Service  
Grantley Adams International Airport  
Christ Church, Barbados  
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Email: [dirmet@sunbeach.net](mailto:dirmet@sunbeach.net)  
URL: [http://www.agriculture.gov.bb/default.asp?V\\_DOC\\_ID=1150](http://www.agriculture.gov.bb/default.asp?V_DOC_ID=1150)  
Forecast Information: <http://www.cdera.org/weather/barbados.php>

### Belize

National Meteorological Service  
Philip Goldson International Airport  
Belize City, Belize  
Tel: (501) 25-2012  
Email: [cfuller@hydromet.gov.bz](mailto:cfuller@hydromet.gov.bz)  
URL: <http://www.hydromet.gov.bz/>  
Forecast Information: <http://www.hydromet.gov.bz/>

### British Virgin Islands

Services provided by:  
Antigua and Barbuda Meteorological Services  
V.C. Bird International Airport  
Coolridge  
St John's, Antigua  
Tel: (268) 462-3229/3017  
Email: [metoffice@antigua.gov.ag](mailto:metoffice@antigua.gov.ag)  
URL: <http://www.antiguamet.com/>  
Forecast Information: <http://www.antiguamet.com/>

### Dominica

Dominica Meteorological Service      Melville Hall Airport  
Canefield Airport                              Dominica  
Roseau, Dominica                              Tel: (767) 445-7101  
Tel: (767) 449-1990                              Email: [metoffmar@cwdom.dm](mailto:metoffmar@cwdom.dm)  
Email: [metoffcan@cwdom.dm](mailto:metoffcan@cwdom.dm)  
URL: <http://www.geocities.com/dominicamet/index.html>  
Forecast Information: <http://www.cdera.org/weather/dominica.php>

### Grenada

Grenada Meteorological Service  
Point Salines International Airport  
Grenada.  
Tel: (473) 444-4142 or (473) 409-1752  
Email: [metqaa@caribsurf.com](mailto:metqaa@caribsurf.com)  
URL:  
Forecast Information: <http://www.cdera.org/weather/grenada.php>

### Guyana

Ministry of Agriculture Hydrometeorological Service  
Georgetown, Guyana  
Tel: (592) 225-4247  
Email: [dkjhym@guyana.net.gy](mailto:dkjhym@guyana.net.gy)  
URL: <http://www.agrinetguyana.org.gy/hydromet/index.htm>  
Forecast Information: <http://www.cdera.org/weather/guyana.php>

### Jamaica

Jamaica Meteorological Service  
Half Way Tree Road  
Kingston 10, Jamaica  
Tel: (876) 929-3694/3700/3706/7268  
Email: <http://www.metservice.gov.jm/contactus.asp>  
URL: <http://www.metservice.gov.jm/>  
Forecast Information: [http://www.cdera.org/weather/jamaica\\_kin.php](http://www.cdera.org/weather/jamaica_kin.php)

### Montserrat

Services provided by:  
Antigua and Barbuda Meteorological Services  
V.C. Bird International Airport  
Coolridge  
St John's, Antigua

Tel: (268) 462-3229/3017  
Email: [metoffice@antigua.gov.ag](mailto:metoffice@antigua.gov.ag)  
URL: <http://www.antiguamet.com/>  
Forecast Information: <http://www.antiguamet.com/>

#### St Kitts and Nevis

Services provided by:  
Antigua and Barbuda Meteorological Services  
V.C. Bird International Airport  
Coolridge  
St John's, Antigua  
Tel: (268) 462-3229/3017  
Email: [metoffice@antigua.gov.ag](mailto:metoffice@antigua.gov.ag)  
URL: <http://www.antiguamet.com/>  
Forecast Information: <http://www.antiguamet.com/>

#### Saint Lucia

Saint Lucia Meteorological Service  
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Tel: (758) 454-6550 (Hewanorra International Airport)  
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Tel: (758) 454-3452 (Weather Information Service)  
Email: [info@slumet.gov.lc](mailto:info@slumet.gov.lc)  
URL: <http://www.slumet.gov.lc>  
Forecast Information: <http://www.slumet.gov.lc>

#### St Vincent and the Grenadines

St Vincent and the Grenadines Meteorological Service  
E.T. Joshua Airport,  
Arnos Vale, St. Vincent  
Tel: (784) 458-4477  
Email: [meteorart@yahoo.com](mailto:meteorart@yahoo.com) or [svgmet@yahoo.com](mailto:svgmet@yahoo.com)  
URL: <http://www.meteo.vc/>  
Forecast Information: <http://www.meteo.vc/>

#### Trinidad and Tobago

Trinidad and Tobago Meteorological Service  
Piarco International Airport  
Trinidad  
Tel: (868) 669-5465/3964/4282/4392  
Email: [dirmet@tstt.net.tt](mailto:dirmet@tstt.net.tt)  
URL:  
Forecast Information: <http://www.cdera.org/weather/grenada.php>

#### Turks and Caicos Islands

Services Provided by:  
The Bahamas Department of Meteorology  
Nassau International Airport  
Nassau, N.P., The Bahamas  
Tel: (242) 377-7040/3701  
Email: [awr.met@batelnet.bs](mailto:awr.met@batelnet.bs)  
URL: <http://www.bahamasweather.org.bs/>

# Earthquakes

## Definition

The Earth's crust is made up of slabs of material called plates which move relative to each other. The process involved in this plate movement is called Plate Tectonics. Friction prevents the plates from moving smoothly past each other, consequently, energy accumulates until there is enough to overcome the restraining frictional force. An earthquake occurs when the plates jerk past each other, releasing stored energy.

## Earthquakes in the Lesser Antilles<sup>7</sup>

The Eastern Caribbean is an example of an island arc system formed at a convergent plate boundary (more specifically, at a subduction zone, where two tectonic plates meet and the denser plate is forced beneath the lighter plate). This is the main cause of the volcanic and seismic activity in the Eastern Caribbean. Most of the earthquakes occurring in the Eastern Caribbean are either tectonic or volcanic in origin. Tectonic earthquakes are generated when plates move as accumulated energy is released. Volcanic earthquakes are generated by the movement of magma within the lithosphere. Since magma is less dense than the surrounding rock, it rises to the surface, breaking the rock as it moves, thereby generating earthquakes. In fact, more than 75% of the world's earthquakes occur at convergent plate boundaries. The countries of the Eastern Caribbean are, therefore, highly susceptible to earthquakes. The seismicity map (Fig 1) shows the locations of the major earthquakes which have occurred in the Eastern Caribbean in the 20th century. Volcanic earthquake swarms are excluded.

Symbol sizes indicate magnitude with the largest symbols showing the locations of earthquakes of magnitude greater than 8 and the smallest symbols discernible on this diagram showing earthquakes of magnitude about 3.5.

Symbols are colour coded for depth with red symbols indicating shallow focal depths (less than 15 km) shading through magenta, green and light blue to dark blue, which indicates the deepest earthquakes. The deepest earthquakes in this region occur at depths of a little greater than 200 kilometers.



**Structural damage caused by the Nov 21, 2004 earthquake with an epicenter just north of Dominica**

## Where to find information

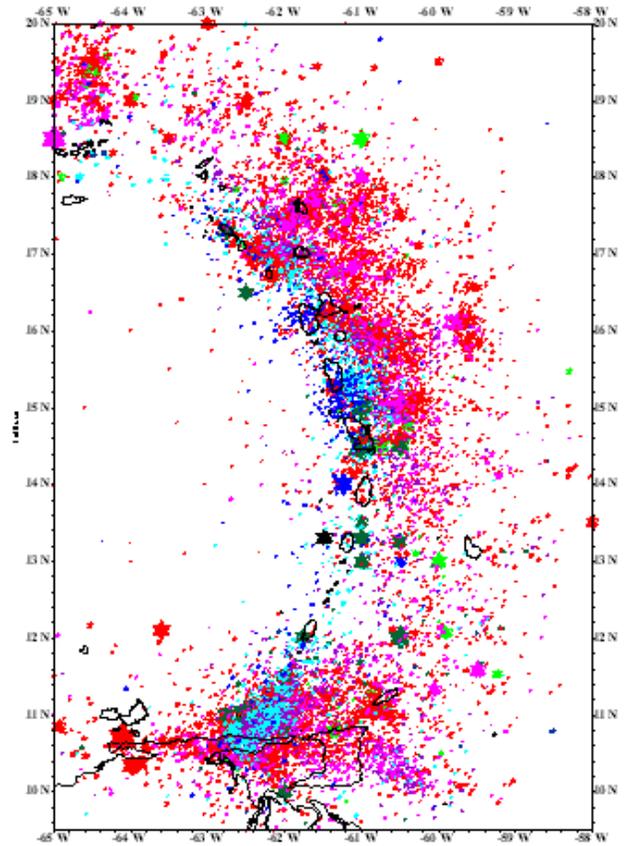
- National Disaster Offices – see Contact Directory
- UWI Seismic Research Unit  
[www.uwiseismic.com](http://www.uwiseismic.com)
- Caribbean Disaster Emergency Response Agency [www.cdera.org](http://www.cdera.org)
- USGS [neic.usgs.gov](http://neic.usgs.gov)
- UNOCHA – [www.reliefweb.int](http://www.reliefweb.int)

<sup>7</sup> UWI Seismic Research Unit (<http://www.uwiseismic.com>)

The overall pattern is fairly typical of an island arc. The shallowest earthquakes occur on the Atlantic Ocean side of the arc. Depths increase across the arc to the Caribbean. Within this pattern there are clusters of higher levels of activity, regions where the level is lower than the average and regions where the depths appear to be anomalous. All of these features have implications for seismic hazard assessment.

It is evident that although there are considerable variations in the level of activity, no island in the region is completely free from the threat of earthquakes. In the southeastern Caribbean, for example, the greatest concentration of activity is to the northwest of Trinidad.

Table 1 below and Figure 1 above clearly indicate that Eastern Caribbean earthquake activity carried on unchanged through the 20th century. It was simply fortuitous that no major earthquake occurred close to a large population centre. During the 20th century, the vulnerability of all islands to major earthquakes increased enormously because of continuous population growth and changes in building and land use practices. At the beginning of the 20th century, most buildings in the region were made of wood or similar materials, which have a high intrinsic earthquake resistance. High rise buildings and the use of reclaimed land were also uncommon. However, the current situation on every island is such that most buildings are made of masonry or concrete and there are numerous high-rise buildings, of which a high proportion are built in areas which were under the sea less than a century ago, i.e. reclaimed land.



**Fig 1 Eastern Caribbean earthquakes in the 20<sup>th</sup> Century (Seismic Research Unit)**

Year	Location and Magnitude	Effects
1690	Close to Antigua. M > 8	Considerable destruction in Antigua, St. Kitts, Nevis, Montserrat. Casualties and economic cost unknown.
1766	Close to Trinidad. M > 8	Total destruction of all masonry buildings in Trinidad. Complete destruction of the economy. Casualties and cost unknown.
1839	Close to Martinique. M ~ 6.5	About 400 dead. Severe damage in St. Pierre and almost total destruction of Fort-de-France.
1843	Between Antigua and Guadeloupe	Considerable destruction in all islands from Saba to Dominica. Nearly 2,000 deaths, mainly in Guadeloupe. Considerable economic disruption in all islands.

**Table 1: Actual earthquake disasters in the Eastern Caribbean over the past 300 years (UWI Seismic Research Unit)**

Year	Location and Magnitude	Effects
1906	M > 7 North-west of St. Lucia.	Severe damage in Saint Lucia and Martinique. No deaths.
1918	M = 6½ North-west of Trinidad.	Most masonry buildings in Port-of-Spain destroyed.
1953	M = 7¾ Depth 175 km North-east of St. Lucia	Felt at damaging intensities in Saint Lucia, Barbados and St. Vincent. Little serious damage because there were few large buildings at the time. Since then there has been very large-scale development of multi-storey hotels in all islands, particularly in Saint Lucia within 50 km of the epicentre.
1954	M = 6½ North of Trinidad	In Port-of-Spain good quality masonry structures collapsed. The number of similar structures has increased since then by a factor of more than ten. There has been considerable unplanned development on reclaimed land close to the epicentre and the population has doubled. A repeat of this event would be disastrous. An increase in magnitude by one unit would be catastrophic. The effect of a repeat of the 1766 earthquake is unimaginable.
1974	North-West of Antigua	Damage in all nearby islands. Increase in vulnerability.

**Table 2: Near Misses during the period 1900 – 2000 (UWI Seismic Research Unit)**

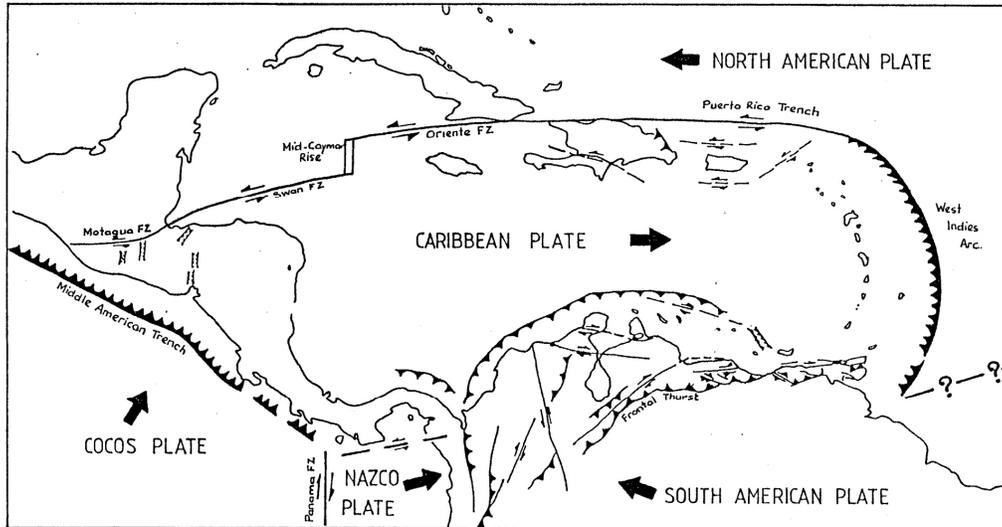
## Types of plate movements and their principal effects

- 1 Oceanic plates pulling away from each other lead to hot volcanic material being expelled from pre-existing fractures in the plates to form mid-ocean ridges;
- 2 When collisions between oceanic and continental plates occur and the oceanic plate is forced under the continental plate, the result is that mountain ranges are pushed up, accompanied by earthquakes and volcanic eruptions;
- 3 Collisions of continental plates release compressed energy resulting in earthquakes and the formation of mountain ranges.

## Faulting

Many earthquakes occur as a result of movement along pre-existing faults or fractures in the earth's crust, e.g. along plate margins.

Tension and compression in the outer shell of the earth are created by the movement of its plates. These forces are sometimes released, producing sudden movements along pre-existing fractures. The energy travels through the crust as seismic waves from the source to the surface of the earth, and is felt as tremors. The tremors or vibratory motions that are felt are what we call earthquakes.



**Tectonic Setting of the Caribbean**  
(after Molnar and Sykes, 1969)

The Caribbean Plate interacts with the North American Plate at its eastern boundary where the Atlantic sea floor is attached to the North American and South American Plates. At this juncture the North American and South American Plate was forced under the Caribbean plate. The subducted material got partially melted and was sometimes forced to the surface by volcanic activity. These processes produced the chain of Caribbean islands. This process of subduction is still occurring and is largely responsible for the seismicity felt today in these islands.

In addition, the sometimes slow, upward, less violent intrusion of molten magma into the crust of these active volcanic areas produces seismic activity which we feel on the surface as earthquakes.

## Likely Impact

Ground shaking, in itself, is not dangerous. However, the resulting damage to buildings and other structures and the risk of casualties from falling debris can make it extremely hazardous. Some of the earthquake effects that can be harmful to people are:

- **Collapsing buildings, walls, bridges, falling furniture or objects, shattering glass windows and mirrors.** Debris from collapsing structures is one of the principal dangers during an earthquake since the impact of large, heavy objects can be fatal to human beings. Earthquakes sometimes cause glass windows and mirrors to shatter and this is also quite dangerous. Earthquake aftershocks can result in the complete collapse of buildings that were damaged during an earthquake.
- **Falling electricity lines.** Earthquakes can cause electricity poles to fall and live wires to become exposed or to start fires.
- **Ruptured gas lines and spillage of flammable substances.** Earthquake-generated fires can cause widespread destruction after a major earthquake. Escaping gas from broken gas lines and the toppling of containers with flammable substances

(e.g. kerosene, household chemicals, etc.) present a significant threat of explosions and fires, which can cause death and destruction of property. Additionally, water pipes are sometimes ruptured during an earthquake and this compounds the problem of controlling such fires.

- **Rock slides and/or landslides on mountains and hillsides.** During an earthquake, large rocks and portions of earth high up in the hills can become dislodged and rapidly roll or slide down into the valleys.
- **Floods caused by the collapse of dam walls.** Earthquakes can cause dam walls to crack and eventually collapse, sending raging waters into surrounding areas and causing severe flooding.
- **Tsunamis.** A tsunami is a large sea wave or series of waves that can be generated by an earthquake. Large tsunamis can completely devastate low-lying coastal areas.
- **Liquefaction.** When sediments with a high water content are subjected to prolonged shaking, the pressure of the water held in pores in the sediment gradually increases eventually, the sediments lose all cohesive strength and begin to behave as if they were liquids. Buildings and other structures sink into the ground or overturn and buried tanks and other cavities rise to the surface. This is known as liquefaction. Liquefaction occurred during the earthquake of 1692 in Jamaica and was responsible for the destruction of the town of Port Royal. Over the past few decades, many parts of the Eastern Caribbean have become increasingly vulnerable to liquefaction because of the increased use of reclaimed land for urban development.

## How earthquakes are measured

Earthquakes generate different types of waves. By measuring the strength of these waves, seismographs record their characteristics. From the measurements, scientists can determine their location and magnitude.

The strength of an earthquake can be measured by *magnitude* and *intensity*.

**Magnitude** is a measure of the physical energy released or the vibration energy of the shock. It is commonly measured on the **Richter Scale** which is an open-ended logarithmic scale. **Intensity** is what people feel on the surface and this is measured by the **Modified Mercalli Scale**. Both scales are first explained below and this is followed by a table showing a comparison between the two.

The Modified Mercalli Scale is an important measurement for informing emergency management. For example, a tsunami can be generated by a strong submarine earthquake. However, if it is close to shore, it might strike before the local disaster office can issue a warning. In this case, the Modified Mercalli Scale can be used by the average citizen to determine how big an earthquake is and take action even, especially in coastal areas, even if the authorities have not yet issued a tsunami warning.

## Modified Mercalli Scale

**Intensity** is the effect of an earthquake on the earth's surface. The intensity scale consists of certain key responses such as people awakening, movement of furniture, structural damage and finally, total destruction.

The version of the modified Mercalli Intensity Scale that is currently used is a 1956 modification by Richter of the 1931 version by the American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity which range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects.

The following is an abbreviated description of the 12 levels of intensity and likely impact:

- I. **Instrumental.** Not felt except by a very few under especially favourable conditions detected mostly by Seismography.
- II. **Feeble.** Felt only by a few persons at rest, especially on upper floors of buildings.
- III. **Slight.** Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck.
- IV. **Moderate.** Felt indoors by many, outdoors by few during the day. At night, some awakening. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing motor cars rock noticeably.
- V. **Rather Strong.** Felt by nearly everyone; many awakened. Some dishes, windows broken. Un-stable objects overturned. Pendulum clocks may stop.
- VI. **Strong.** Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
- VII. **Very Strong.** Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in ordinary structures; considerable damage in poorly built or badly designed structures.
- VIII. **Destructive.** Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of factory stacks, columns, monuments, walls. Heavy furniture overturned.
- IX. **Ruinous.** Damage considerable in specially designed structures; well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
- X. **Disastrous.** Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bend greatly.
- XI. **Very Disastrous.** Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bend greatly.
- XII. **Catastrophic.** Damage total. Lines of sight and level are distorted. Objects thrown into the air.

## Richter Scale

Seismologists use a **Magnitude** scale to express the seismic energy released by each earthquake. Here are the typical effects of earthquakes in various magnitude ranges:

Richter magnitudes	Earthquake effects
Less than 3.5	Generally not felt, but recorded
3.5-5.4	Often felt, but rarely causes damage
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.

6.1-6.9	Can be destructive in areas up to about 100 kilometre across where people live.
7.0-7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

## Comparing the Richter and Modified Mercalli scales

Remember - **Richter measures energy** of the seismic wave or shock while **Mercalli measures intensity** or effect on the surface of the earth.

Richter	Modified Mercalli	Effect
2	I	<b>Instrumental.</b> Not felt except by a very few under especially favourable conditions detected mostly by Seismography.
	II	<b>Feeble.</b> Felt only by a few persons at rest, especially on upper floors of buildings.
3	III	<b>Slight.</b> Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck.
	IV	<b>Moderate.</b> Felt indoors by many, outdoors by few during the day. At night, some awakening. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing motor cars rock noticeably.
4	V	<b>Rather Strong.</b> Felt by nearly everyone; many awakened. Some dishes, windows broken. Un-stable objects overturned. Pendulum clocks may stop.
5	VI	<b>Strong.</b> Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
	VII	<b>Very Strong.</b> Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in ordinary structures; considerable damage in poorly built or badly designed structures.
6	VIII	<b>Destructive.</b> Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of factory stacks, columns, monuments, walls. Heavy furniture overturned.
7	IX	<b>Ruinous.</b> Damage considerable in specially designed structures; well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
	X	<b>Disastrous.</b> Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bend greatly.
8	XI	<b>Very Disastrous.</b> Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bend greatly.
	XII	<b>Catastrophic.</b> Damage total. Lines of sight and level are distorted. Objects thrown into the air.

# Messages the media should give to the public

## Earthquake Preparedness

### Before an Earthquake

- Become actively involved in community preparedness organisations in your district. Call your local disaster management office for contact information;
- Unstable, heavy furniture should be fastened to a wall or bolted to the floor, such as bookcases and cupboards. When loading storage cabinets heavy objects should be placed on lower shelves;
- Water heaters and other appliances should be firmly bolted down;
- All family members should know how to turn off electricity, gas and water using safety valves and main switches;
- Family members should know basic First Aid steps;
- Purchase emergency equipment such as battery-operated radios and fire extinguishers for your home;
- Always have non-perishable food items in stock;
- Set aside emergency supplies and equipment.

### During an Earthquake

- Do not panic, stay calm;
- Protect head and face;
- If inside a building, stand in a strong doorway, or get under a desk, table or bed. Do not try to run out of the building as you can be injured by falling debris;
- Move away from outer walls, windows, glass doors, heavy mirrors, pictures, bookcases, hanging plants and heavy objects;
- Watch for falling plaster, bricks, lighting fixtures and other objects;
- Do not use elevators;
- If you are outside, stay there. Stand away from buildings, trees, and electricity lines;
- If you are driving, you should safely bring the vehicle to a stop away from electricity poles and overhead wires. Don't stop on a bridge or close to buildings from which debris may fall. Remain in the vehicle;
- If you are in a store or shop, move away from display shelves containing bottles, cans, or other objects that may fall.

### After an Earthquake

#### **DO**

- Check for fires;
- Check Utilities - shut off if necessary;
- Check your house for serious damage - evacuate if there's threat of collapse;
- Check for injuries - administer First Aid;
- Be prepared for more earthquake tremors or aftershocks;
- Turn on a transistor radio for emergency bulletins.
- Stay away from landslide-prone areas.
- Collect water;
- Stay away from buildings that may have been damaged or weakened by the earthquake.

- Keep the streets clear for the passage of emergency and rescue vehicles.
- Clear up hazardous materials;
- Assist others;
- Stay away from landslide prone areas;

## **DON'T**

- Do not light a match or turn on a light switch. Use a flashlight!
- Never touch fallen power lines;
- Do not use telephone except in extreme emergency;
- Do not go to the beach to watch for giant sea waves;
- Do not go sightseeing! Keep the streets clear for the passage of emergency and rescue vehicles;
- Do not attempt to move seriously injured persons unless they are in danger of further injury;
- Do not use your telephone, except for a medical or fire emergency. You could tie up the lines needed for emergency response. If the phone doesn't work send someone for help;
- Do not expect firefighters, police, army or other emergency personnel to help you. They may not be available.

## **Emergency Supplies**

The following emergency supplies should be kept in the event of an earthquake

- Fire extinguisher;
- Adequate supplies of medications that you or family members are taking;
- Crescent and pipe wrenches to turn off gas and water supplies;
- First-aid kit and handbook;
- Flashlights with extra bulbs and batteries;
- Portable radio with extra batteries;
- Water for each family member for at least 3 days (allow at least 1 gallon per person per day) and purification tablets or chlorine bleach to purify drinking water from other sources;
- Canned and package foods, enough for several days and MECHANICAL can opener. Extra food for pets if necessary;
- Camp stove or barbecue to cook on outdoors (store fuel out of the reach of children);
- Waterproof, heavy-duty plastic bags for waste disposal.

## Prevention and Mitigation Measures

(Long term measures)

### Risk Assessment

**There are many ways to reduce earthquake damage. Possible actions include:**

- Developing a hazard map with earthquake risk zones;
- Using construction techniques that are seismic resistant;
- Determining which sites are safe for construction through analysis of the soil type and geological structure;
- Instituting incentives to remove unsafe buildings and buildings on unsafe sites or, more probably, to upgrade their level of safety;
- Instituting incentives to encourage future development on safer sites and safer methods of construction through:
  - Land use controls (zoning);
  - Building Codes and standards and means of enforcing them;
  - Favourable taxation, loans, or subsidies to qualify buildings, methods and sites;
  - Land development incentives.
- Reducing possible damage from secondary effects by:
  - Identifying potential landslide sites and restricting construction in those areas;
  - Installing devices that will keep breakages in electrical lines and gas mains from producing fires;
  - Verifying the capability of dams to resist earthquake forces, and upgrading as necessary.

# Glossary

**Active Fault.** A fault that is likely to have another earthquake sometime in the future. Faults are commonly considered to be active if they have moved one or more times in the last 10,000 years.

**Aftershocks.** Earthquakes that follow the largest shock of an earthquake sequence. They are smaller than the mainshock and within 1-2 fault lengths distance from the mainshock fault. Aftershocks can continue over a period of weeks, months, or years. In general, the larger the mainshock, the larger and more numerous the aftershocks, and the longer they will continue.

**Amplification.** Most earthquakes are relatively small, in fact, so small that no one feels them. In order for seismologists to see the recording of the movement of the ground from the smaller earthquakes, the recording has to be made larger. It's like looking at the recording through a magnifying glass, and the amount that it is magnified is the amplification. Shaking levels at a site may also be increased by focusing of seismic energy caused by the geometry of the sediment velocity structure, such as basin subsurface topography, or by surface topography.

**Amplitude.** The size of the wiggles on an earthquake recording.

**Arc.** A chain of volcanoes (volcanic arc) that sometimes forms on the land when an oceanic plate collides with a continental plate and then slides down underneath it (subduction).

**Attenuation.** When you throw a pebble in a pond, it makes waves on the surface that move out from the place where the pebble entered the water. The waves are largest where they are formed and gradually get smaller as they move away. This decrease in size, or amplitude, of the waves is called attenuation.

**Crust.** The outermost major layer of the earth, ranging from about 10 to 65 km in thickness worldwide. The uppermost 15-35 km of crust is brittle enough to produce earthquakes.

**Earthquake.** This term is used to describe both sudden slip on a fault, and the resulting ground shaking and radiated seismic energy caused by the slip, or by volcanic or magmatic activity, or other sudden stress changes in the earth.

**Earthquake Hazard.** Anything associated with an earthquake that may affect the normal activities of people. This includes surface faulting, ground shaking, landslides, liquefaction, tectonic deformation, tsunamis, and seiches.

**Earthquake Risk.** The probable building damage, and number of people that are expected to be hurt or killed if a likely earthquake on a particular fault occurs. Earthquake risk and earthquake hazard are occasionally used interchangeably.

**Epicenter.** The point on the earth's surface vertically above the point in the crust where a seismic rupture begins.

**Fault.** A fracture along which the blocks of crust on either side have moved relative to one another parallel to the fracture. Strike-slip faults are vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally. If the block opposite an observer looking across the fault moves to the right, the slip style is termed right lateral; if the block moves

to the left, the motion is termed left lateral. Dip-slip faults are inclined fractures where the blocks have mostly shifted vertically. If the rock mass above an inclined fault moves down, the fault is termed normal, whereas if the rock above the fault moves up, the fault is termed reverse (or thrust). Oblique-slip faults have significant components of both slip styles.

**First motion.** On a seismogram, the direction of ground motion as the P wave arrives at the seismometer. Upward ground motion indicates an expansion in the source region; downward motion indicates a contraction.

**Focal depth.** A term that refers to the depth of an earthquake hypocenter.

**Foreshocks.** Foreshocks are relatively smaller earthquakes that precede the largest earthquake in a series, which is termed the mainshock. Not all mainshocks have foreshocks.

**Frequency.** The number of times something happens in a certain period of time, such as the ground shaking up and down or back and forth during an earthquake.

**Geomorphology.** The study of the character and origin of landforms, such as mountains, valleys, etc.

**Ground failure.** A general reference to landslides, liquefaction, lateral spreads, and any other consequence of shaking that affects the stability of the ground.

**Ground Motion (shaking).** The movement of the earth's surface from earthquakes or explosions. Ground motion is produced by waves that are generated by sudden slip on a fault or sudden pressure at the explosive source and travel through the earth and along its surface.

**Hypocenter.** The point within the earth where an earthquake rupture starts. Also commonly termed the focus.

**Intensity.** A number (written as a Roman numeral) describing the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures. Several scales exist, but the ones most commonly used in the United States are the Modified Mercalli scale and the Rossi-Forel scale. There are many intensities for an earthquake, depending on where you are, unlike the magnitude, which is one number for each earthquake.

**Landslide.** The downslope movement of soil and/or rock.

Liquefaction. A process by which water-saturated sediment temporarily loses strength and acts as a fluid, like when you wiggle your toes in the wet sand near the water at the beach. This effect can be caused by earthquake shaking. (See also Earthquake FAQ discussion.)

**Love Wave.** A type of seismic surface wave having a horizontal motion that is transverse (or perpendicular) to the direction the wave is traveling.

**Magnitude.** A number that characterizes the relative size of an earthquake. Magnitude is based on measurement of the maximum motion recorded by a seismograph. Several scales have been defined, but the most commonly used are (1) local magnitude (ML), commonly referred to as "Richter magnitude," (2) surface-wave magnitude (Ms), (3) body-wave

magnitude (Mb), and (4) moment magnitude (Mw). Scales 1-3 have limited range and applicability and do not satisfactorily measure the size of the largest earthquakes. The moment magnitude (Mw) scale, based on the concept of seismic moment, is uniformly applicable to all sizes of earthquakes but is more difficult to compute than the other types. All magnitude scales should yield approximately the same value for any given earthquake. ( See also Earthquake ABC's & FAQ discussion.)

**Mainshock.** The largest earthquake in a sequence, sometimes preceded by one or more foreshocks, and almost always followed by many aftershocks.

**P wave.** A seismic body wave that shakes the ground back and forth in the same direction and the opposite direction as the direction the wave is moving. ( See also Earthquake ABC's.)

**Plate Tectonics.** A theory supported by a wide range of evidence that considers the earth's crust and upper mantle to be composed of several large, thin, relatively rigid plates that move relative to one another. Slip on faults that define the plate boundaries commonly results in earthquakes. Several styles of faults bound the plates, including thrust faults along which plate material is subducted or consumed in the mantle, oceanic spreading ridges along which new crustal material is produced, and transform faults that accommodate horizontal slip (strike slip) between adjoining plates.

**Ring of Fire.** The zone of earthquakes surrounding the Pacific Ocean which is called the Circum-Pacific belt--about 90% of the world's earthquakes occur there. The next most seismic region (5-6% of earthquakes) is the Alpide belt (extends from Mediterranean region, eastward through Turkey, Iran, and northern India.

**Seismicity.** The geographic and historical distribution of earthquakes.

**Seismic wave.** An elastic wave generated by an impulse such as an earthquake or an explosion. Seismic waves may travel either along or near the earth's surface (Rayleigh and Love waves) or through the earth's interior (P and S waves).

**Seismogram.** A record written by a seismograph in response to ground motions produced by an earthquake, explosion, or other ground-motion sources.

**Seismometer or Seismograph.** A seismometer is an instrument used to detect and record earthquakes. Generally, it consists of a mass attached to a fixed base. During an earthquake, the base moves and the mass does not. The motion of the base with respect to the mass is commonly transformed into an electrical voltage. The electrical voltage is recorded on paper, magnetic tape, or another recording medium. This record is proportional to the motion of the seismometer mass relative to the earth, but it can be mathematically converted to a record of the absolute motion of the ground. Seismograph is a term that refers to the seismometer and its recording device as a single unit.

**Subduction.** The process of the oceanic lithosphere colliding with and descending beneath the continental lithosphere.

**Subduction Zone.** The place where two lithosphere plates come together, one riding over the other. Most volcanoes on land occur parallel to and inland from the boundary between the two plates.

**Tectonic.** Refers to rock-deforming processes and resulting structures that occur over large sections of the lithosphere.

**Tectonic Plates.** The large, thin, relatively rigid plates that move relative to one another on the outer surface of the Earth.

**Tsunami.** A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major submarine slides, or exploding volcanic islands.

**Tsunamigenic.** Referring to those earthquakes, commonly along major subduction-zone plate boundaries such as those bordering the Pacific Ocean, that can generate tsunamis.

**Velocity.** How fast a point on the ground is shaking as a result of an earthquake.

# Tsunamis

## Definition

A tsunami (pronounced tsoo-NAH-mee) is a large, potentially destructive sea wave generated by any disturbance that displaces a large water mass from its equilibrium position.

## Causes

Most tsunamis are formed as a result of large submarine earthquakes, which displace large amounts of water. Tsunamis may also result from the eruption or collapse of island or coastal volcanoes, and from the formation of giant landslides on marine margins. Even the impact of a cosmic body like a meteorite may cause a tsunami.

Earthquakes measuring 7.5 or greater may trigger either a local tsunami or a tele-tsunami. A local tsunami is one that occurs close to a coast line so that residents less than one hour to be notified. A tele-tsunami is one that occurs outside of the region and the travel time is several hours before it reaches an island in the Caribbean.

**Note:** A storm surge, or tidal wave, is caused by weather conditions and is not the same thing. Storm surges accompany tropical cyclones.

## Tsunami risk for the Caribbean

When compared to other natural hazards, the tsunami risk is “minor”<sup>8</sup> however the impact could be “major”<sup>9</sup>.

Between 1690 and 2004 there were 360 deaths from tsunamis in the Caribbean compared to 43,120 for hurricanes. There were six destructive tsunamis compared to 28 destructive hurricanes. The most people killed by a single tsunami were 200 compared to 15,600 by a single hurricane. With the increase in population and affluence concentrated in vulnerable coastal areas today, the threat has increased. There are approximately two million people vulnerable to a tsunami and 18 million for a hurricane. However, with improved early warning systems in place for hurricanes and none for tsunamis the forecast for the biggest credible loss of life in a future Caribbean event is 40,000 for a tsunami compared to 20,000 for a hurricane.<sup>10</sup>

### Source of tsunami threat

There are potentially six sources that could trigger a tsunami:

1. A large submarine earthquake which could occur as a result of deformation along the margin of the Caribbean Tectonic Plate located just east of the Caribbean island chain;<sup>3,11,12</sup>
2. Major submarine landslide of unstable sea floor;<sup>3,4</sup>

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<sup>8</sup> “Seismic Research unit comments on proposed tsunami early warning system” – [http://www.cdera.org/cunews/news/article\\_879.php](http://www.cdera.org/cunews/news/article_879.php)

<sup>9</sup> “On the role of IOCARIBE in a Caribbean Tsunami System: Science, Engineering, Management, and Education” by George Maul.

<sup>10</sup> “Tsunami Risks in the Caribbean: How big are they and what should we do?” by John Tomblin

<sup>11</sup> “Estimating the threat of tsunamigenic earthquakes and earthquake induced-landslide tsunami in the Caribbean” by William R. McCann

<sup>12</sup> “Major Caribbean earthquakes and tsunamis a real risk” – Woods Hole Oceanographic Institute

3. A distant earthquake such as along the Azores-Gibraltar fracture zone located in the mid-North Atlantic Ocean about 1500 miles north-east of the island chain; <sup>1,3,4,13</sup>
4. Large explosive eruption at or below sea level by the underwater volcano Kick 'em Jenny; <sup>3</sup>
5. Massive debris avalanche off steep-sided volcano such as Cumbre Vieja on La Palma in the Canary Islands; <sup>3,6</sup>
6. Giant submarine gas release of non-volcanic origin such as in the belt of thick sediments with organic materials in the region from the Orinoco Delta to Barbados; <sup>3</sup>
7. Impact of a large meteorite into the sea. <sup>3</sup>

## Characteristics of a tsunami

- Because of wave physics, tsunamis tend to be small – even imperceptible -- while travelling over open water, and do not “size up” until they approach a shoreline.
- As a tsunami approaches shore, it begins to slow. Often, the sea begins to recede abnormally.
- Tsunamis still reach the coast with tremendous amounts of energy because their height increases as they reach the continental shelf – the part of the earth’s crust that slopes, or rises, from the ocean floor up to the land. Tsunamis may reach a maximum vertical height onshore above sea level of 10, 20, and sometimes even 30 meters – in other words, they can be HUGE.
- A tsunami is a series of waves and the first wave is not necessarily the biggest.
- Because tsunamis can travel very far without losing much energy, they can affect places that are a great distance from their source.
- Generally, tsunamis that are the result of water displacement from above (e.g. landslides, meteor strikes) tend to dissipate quickly and have little impact on far away coastlines.
- There are more large, destructive tsunamis in the Pacific Ocean because of the many major earthquakes along the margins of the Pacific Ocean and also because dip-slip earthquakes (which involve vertical rather than lateral ground motion) are more common in the Pacific than elsewhere.

## Effects

Capable of inundating (flooding) hundreds of meters inland past the typical high-water level, the fast-moving water associated with the incoming tsunami can crush homes and other coastal structures. Tsunamis can sweep boats onto shore. Obviously, they can drown people and animals too. Tsunamis can strip beaches of sand that may have taken years to accumulate and undermine trees and other coastal vegetation.

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<sup>13</sup> “Tsunami threats in the Atlantic Ocean” by Benfield Hazard Research Centre

# Messages the media should give to the public

## Preparedness and Emergency Action

If a Tsunami Warning is issued, **NEVER** go down to the beach to watch the wave come in because you will not live to tell the story! Remember that a tsunami is a series of waves and the first wave is not necessarily the biggest. Stay out of danger until an "all-clear" is issued by the competent authority.

### Preparedness actions

- Familiarise yourself with the Modified Mercalli Scale (See Fact Sheet on Earthquakes). **If you feel an earthquake of magnitude 7.0 or greater and you live near the coast – do not wait for a warning to be issued, as a precautionary measure evacuate immediately and travel inland and uphill. You may have less than 10 minutes before a tsunami arrives;**
- **If you see the sea withdrawing, evacuate the coastline immediately, and travel inland and uphill. Retreating tides are often a precursor to the arrival of a tsunami;**
- Find out if your home is in a danger area;
- If you live in a low-lying coastal area make yourself familiar with the quickest way to retreat to high ground. Make sure all family members know the evacuation plan;
- If you are close to the sea and the water retreats by an abnormal amount, move to high ground at once. Do not stay to see what happens.
- Listen to the radio for official updates and instructions.
- Have the telephone number for your Disaster Response Agency at hand.
- Gather disaster supplies:
  - Flashlight and extra batteries
  - Portable, battery-operated radio and extra batteries
  - First Aid kit and manual
  - Emergency food and water
  - Cash and credit cards
- Develop an emergency plan in the event that family members are separated (for e during the workday when adults are at work and children are at school). Agree c a close friend or relative that should be contacted if children cannot reach their parents and vice-versa.

### After a tsunami

- Stay tuned to a battery-operated radio for the latest emergency information;
- Help injured or trapped persons and persons requiring special assistance (infants, elderly people and persons with disabilities);
- Do not move seriously injured persons unless they are in immediate danger of furtl injury. Call for medical assistance;
- Stay out of damaged buildings. Return home only when authorities say it is safe;
- Shovel mud while it is still moist to give walls and floors an opportunity to dry;
- Check for electrical shorts and live wires. Never attempt to move live wires;
- Check for gas leaks;
- Check for damage to sewage and water lines;
- Check food supplies and have tap water tested by the local health department.
- Fresh food that has come in contact with flood water may be contaminated and should be thrown out.

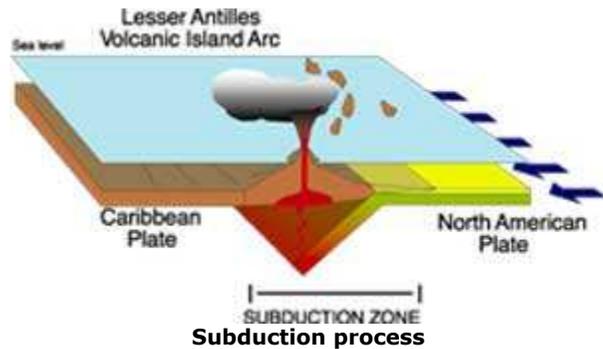
# VOLCANOES<sup>14</sup>

## What is a volcano?

Volcanoes are vents or openings in the Earth's crust through which, hot, molten rock (called magma) and gases from the interior of the Earth are released. Volcanoes in the Eastern Caribbean are mainly steep-sided and roughly conical in shape.

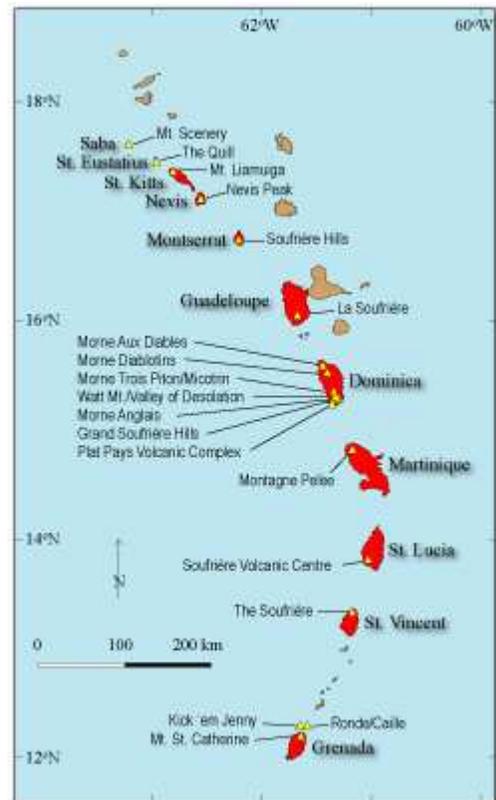
## Why are there volcanoes in the Eastern Caribbean?

The Earth's crust is made up of slabs of material called plates which move relative to each other. The Eastern Caribbean islands lie on a plate boundary. The North American Plate, which is the denser of the two, sinks beneath the Caribbean Plate creating suitable conditions for magma to be produced. The magma then rises to the surface of the Earth where it may erupt to form a volcano. This process is called subduction and this is how the volcanic islands of the Eastern Caribbean were formed. The diagram demonstrates the subduction process.



## Where are volcanoes in the Caribbean?

There are 19 'live' (likely to erupt again) volcanoes in the Eastern Caribbean. Every island from Grenada to Saba is subject to the direct threat of volcanic eruptions (see map). Islands such as Grenada, St. Vincent, St. Lucia, Martinique, Dominica, Guadeloupe, Montserrat, Nevis, St. Kitts, St. Eustatius and Saba have 'live' volcanic centres, while other islands such as Anguilla, Antigua, Barbuda, Barbados, British Virgin Islands, most of the Grenadines and Trinidad & Tobago (which are not volcanic) are close to volcanic islands and are, therefore, subject to volcanic hazards such as severe ash fall and volcanically-generated tsunamis.



## Caribbean volcanic activity

While hurricanes are much more common in the Eastern Caribbean no hurricane has ever completely destroyed the capital of an Eastern Caribbean island (that is to say, made it completely uninhabitable) while volcanic eruptions have done so twice to:

- St. Pierre, Martinique in 1902; and
- Plymouth, Montserrat in 1997.

<sup>14</sup> The majority of the fact sheet is sourced from the UWI Seismic Research Unit (<http://www.uwiseismic.com>)

Additionally, while property destruction levels from severe hurricanes generally range from 10-25%, property destruction levels (and by extension, casualties) in the Eastern Caribbean caused by volcanic eruptions approach 100% in the most severely affected areas. Thus, the only appropriate action that can be taken to prevent this is a total evacuation of the areas likely to be affected. For this reason, public education and awareness in advance is crucial to successful disaster preparedness and mitigation programmes in that it equips the public with the necessary information to be able to make informed decisions and to facilitate (rather than obstruct) disaster response action in the event of a crisis.

In assessing the threat posed by volcanoes to Eastern Caribbean countries, it is useful to review data on actual volcanic disasters over the past 300 years (see tables below). Keep in mind that there have been at least 15 other eruptions that have not resulted in large numbers of deaths or destroyed enough property to be ranked as disasters.

## Submarine volcano - Kick 'em Jenny

Kick 'em Jenny is a submarine volcano located 8km north of Grenada. The volcano is about 1300m high, and its summit is currently thought to be about 180m below the surface of the sea. As far as we know, Kick 'em Jenny is the only 'live' (likely to erupt again) submarine volcano in the Eastern Caribbean. It is also the most frequently active volcano in the region, erupting at least 12 times since it was discovered in 1939. The last eruption of Kick 'em Jenny occurred in December 2001. For details of that eruption go to news archives at the UWI Seismic Research Unit's website (<http://www.uwiseismic.com>). There is 1.5km exclusion zone around the volcano.

Kick 'em Jenny is also a modern day demonstration of how the volcanic islands in this region were formed. With each submarine eruption deposits of volcanic material accumulate around the summit. All of the volcanic islands of the Lesser Antilles began as submarine volcanoes.



**Kick 'em Jenny located approximately 8km north of Grenada at 12.18° N 61.38° W**

Between the 1960's and the late 1970's the depth to the summit of the volcano was approximately 180-190m. In the 1970's and early 1980's the depth to the summit of the volcano decreased to approximately 150m, reflecting the growth of a dome within the crater. This dome was destroyed during eruptions in the late 1980's and a survey conducted by the U.S.-based National Oceanic and Atmospheric Administration (NOAA) in March, 2002 revealed that the summit is currently 180m below the surface of the sea.

Until recently it was thought that Kick 'em Jenny had grown 46m (from 236m to 190m below sea level) between the surveys of 1962 and 1966. However, data collected from the two most recent cruises (March 2002 and March 2003) and a careful re-examination of data collected on even earlier cruises make it clear that the crater rim of Kick 'em Jenny has remained at the same depth below the surface (180-190m, within measurement

uncertainty) since at least 1966. The major sequence of changes over the past forty years has been that a dome grew in the crater between 1976 and 1978. This dome collapsed in either 1988 or 1990 and there is now no trace of it left. There is in fact a new interior crater about 30 metres deep on the site where the dome used to be so it is more accurate to say that the active vent area of Kick 'em Jenny has in fact become deeper. Kick 'em Jenny has, therefore, not grown closer to the surface between 1962-2003. During the 2003 survey, researchers found another active volcano which has been named Kick 'em Jack.

## Where to find information

- National Disaster Offices – see Contact Directory
- UWI Seismic Research Unit  
[www.uwiseismic.com](http://www.uwiseismic.com)
- Caribbean Disaster Emergency Response Agency [www.cdera.org](http://www.cdera.org)
- UNOCHA – [www.reliefweb.int](http://www.reliefweb.int)

## Expected Hazards

There are several processes that occur on the slopes of the volcano that pose hazards to man and his environment. Most of the hazards are directly caused by volcanic eruptions.

- **BLASTED PROJECTILES:** Large projectiles can damage buildings; if these are hot they can start fires;
- **MUD FLOWS** (lahars): Frequently accompany volcanic eruptions and can be lethal. Lakes can mix with volcanic rock and debris to form a near-solid flow which engulfs all in its path;
- **PYROCLASTIC FLOWS:** Mixtures of hot gases, ash, fine pumice and rocks; danger lies in the density and temperature of the ash and rock fragments. Pyroclastic flows can move at very high speeds, possibly over 100 km/h. Hazards include body surface burns, inhalation injuries and asphyxia;
- **GASES:** These may be asphyxiants which are concentrated near the volcanic crater or fissure or respiratory irritants which are more dispersed and can be harmful at lower concentrations;
- **LAVA FLOWS:** These are flows of extremely hot molten rocks extruded by the volcano. The viscosity and high temperature make these flows very dangerous and they are capable of destroying all in their path;
- **LOCAL EARTHQUAKES:** Possible loss of human life and property;
- **TSUNAMIS:** Tsunami is Japanese for "tidal wave", the seismic wave that can hurtle across oceans at up to 600 miles per hour (800 km/hour). Occurrence is unpredictable and can destroy coastlines.

## Likely Impact

The effects that can be expected from these are the damage and injury or death by impact, incineration, burial and bulldozing. Another hazard that is also directly related to volcanic eruption is the fall of volcanic materials ejected from the crater.

# Messages the media should give to the public

## Volcano Preparedness

Volcanic eruptions cannot be predicted but there may be warning signs of a pending eruption such as a prolonged swarm of tectonic earthquakes. Volcanic eruptions can hurl hot rocks for at least 20 miles. Floods, airborne ash, or noxious fumes can spread 100 miles or more. If you live near a known volcano, active or dormant, be ready to evacuate at a moment's notice.

Here are some tips you should broadcast to your community on the subject:

### Before an eruption

- Learn about your community warning systems;
- Be prepared for these disasters that can be spawned by volcanoes:
  - Earthquakes
  - Flash floods
  - Landslides and mudflows
  - Thunderstorms
  - Tsunamis
- Make evacuation plans. You want to get to high ground away from the eruption. Plan a route out and have a backup route in mind;
- Develop an emergency communication plan. In case family members are separated from one another during a volcanic eruption (a real possibility during the day when adults are at work and children are at school), have a plan for getting back together. Ask a relative or friend outside the danger area to serve as the "family contact." After a disaster, it's often easier to call long distance. Make sure everyone knows the name, address, and phone number of the contact person.
- Have disaster supplies on hand:
  - Flashlight and extra batteries
  - Portable, battery-operated radio and extra batteries
  - First aid kit and manual
  - Emergency food and water
  - Nonelectric can opener
  - Essential medicines
  - Cash and credit cards
  - Sturdy shoes
  - Get a pair of goggles and disposal dust and breathing masks for each member of the household.
- Contact your local emergency management office or American Red Cross chapter for more information on volcanoes;
- Evacuate! Although it may seem safe to stay at home and wait out an eruption, doing so could be very dangerous. The rock debris from a volcano can break windows and set buildings on fire. Stay safe. Follow authorities' instructions and leave the area before the disaster begins.

### During an eruption

- Follow the evacuation order issued by authorities;
- Avoid areas downwind of the volcano;
- If caught indoors:
  - Close all windows, doors, and dampers;

- Put all machinery inside a garage or barn;
  - Bring animals and livestock into closed shelters;
- If trapped outdoors:
  - Seek shelter indoors
  - If caught in a rockfall, roll into a ball to protect head
  - Avoid low-lying area where poisonous gases can collect and flash floods can be most dangerous
  - If caught near a stream, beware of mudflows.
- Protect yourself:
  - Wear long sleeved shirts and pants
  - Use goggles to protect eyes
  - Use a dust-mask or hold a damp cloth over face to help breathing
  - Keep car or truck engines off
- Stay out of the area. A lateral blast of a volcano can travel many miles from the mountain. Trying to watch an erupting volcano is a deadly idea.
- Mudflows are powerful "rivers" of mud that can move faster than people can walk or run. Mudflows occur when rain falls through ash-carrying clouds or when rivers are damed during an eruption. They are most dangerous close to stream channels. When you approach a bridge, first look upstream. If a mudflow is approaching or moving beneath the bridge, do not cross the bridge. The power of the mudflow can destroy a bridge very quickly.

## After an eruption

- Listen to a battery-powered radio or television for the latest emergency information;
- Stay away from volcanic ashfall
- When outside:
  - Cover your mouth and nose. A number of victims of the Mount St. Helens volcano died from inhaling ash
  - Wear goggles to protect your eyes
  - Keep skin covered to avoid irritation or burns
- If you have a respiratory ailment, avoid contact with any amount of ash. Stay indoors until local health officials advise it is safe to go outside;
- Avoid driving in heavy ashfall. Driving will stir up more ash that can clog engines and stall vehicles;
- Clear roofs of ashfall. Ashfall is very heavy and can cause buildings to collapse.
- Remember to help your neighbors who may require special assistance - infants, elderly people, and people with disabilities.

## Volcano Bulletins

The Seismic Research Unit regularly issues volcano bulletins for monitored active volcanoes. These bulletins are meant to be inputs in the formulation of disaster response plans for volcanic eruptions and associated hazards. People residing on the slopes of the active volcanoes are also expected to be well informed of the current conditions of the volcano, most particularly whenever eruptions are expected.

The Seismic Research Unit's website should be monitored regularly for updates. The website is <http://www.uwiseismic.com>.

# Glossary

**Aa:** Aa , is lava that has a rough, jagged, spiny, and generally clinkery surface. In thick aa flows, the rubbly surface of loose clinkers and blocks hides a massive, relatively dense interior.

**Active volcano:** A volcano that is currently erupting, or has erupted during recorded history. A volcano that is erupting. Also, a volcano that is not presently erupting but that has erupted within historical time and is considered likely to do so in the future .

**Aerosol:** Fine liquid or solid particles suspended in the atmosphere. Aerosols resulting from volcanic eruptions are tiny droplets of sulfuric acid -- sulfur dioxide that has picked up oxygen and water.

**Airfall:** Ash falling from an eruption column or ashcloud.  
Volcanic ash that has fallen through the air from an eruption cloud. A deposit so formed is usually well sorted and layered.  
Also called: ashfall.

**Andesite:** Andesite is a gray to black volcanic rock with between about 52 and 63 weight percent silica . Andesites contain crystals composed primarily of plagioclase feldspar and one or more of the minerals pyroxene and lesser amounts of hornblende. At the lower end of the silica range, andesite lava may also contain olivine. Andesite magma commonly erupts from stratovolcanoes as thick lava flows, some reaching several kilometers in length. Andesite magma can also generate strong explosive eruptions to form pyroclastic flows and surges and enormous eruption columns. Andesites erupt at temperatures between 900 and 1100° C.

**Ash :** Fragments less than 2 millimeters in diameter of lava or rock blasted into the air by volcanic explosions. Fragments of lava or rock smaller than 2 millimeters in size that are blasted into the air by volcanic explosions. Fine pyroclastic material in fragments less than 4.0 millimeters in diameter. "Ash" in this sense is quite distinct from the ash produced by common combustion because the rocks do not catch fire and burn during a volcanic event.

**Ash cloud:** The fine material that is generated by a pyroclastic flow and rises above it. Cloud of ash formed by volcanic explosions or derived from a pyroclastic flow. .

**Ashfall:** See: Airfall.

**Ash flow:** A pyroclastic flow consisting predominantly of ash-sized particles. Also called a glowing avalanche if it is of very high temperature.

**Atmospheric shock wave:** Strong compressive atmospheric wave driven by volcanic ejecta.

**Avalanche:** A large mass of material or mixtures of material falling or sliding rapidly under the force of gravity. Avalanches often are classified by their content, such as snow, ice, soil, or rock avalanches. A mixture of these materials is a debris avalanche. See also: Debris avalanche

**Ballistic fragment:** An explosively ejected rock fragment that follows a ballistic trajectory.

**Basalt:** Basalt is a hard, black volcanic rock with less than about 52 weight percent silica . Because of basalt's low silica content, it has a low viscosity . Therefore, basaltic lava can flow quickly and easily move >20 kilometers from a vent. The low viscosity typically allows volcanic gases to escape without generating enormous eruption columns. Basaltic lava fountains and fissure eruptions, however, still form explosive fountains hundreds of meters tall. Common minerals in basalt include olivine, pyroxene, and plagioclase. Basalt is erupted at temperatures between 1100 to 1250° C. A fine-grained, dark-colored, extrusive igneous rock that forms by the crystallization of lava flows.

**Base surge:** Turbulent, low-density cloud of rock debris and water and steam that moves over the ground surface at high speed. Base surges are generated by explosions.

**Black Sand Beach:** The famous "black sand" beaches of Hawaii were created virtually instantaneously by the violent interaction between hot lava and sea water.

**Blocks:** Tephra is the general term now used by volcanologists for airborne volcanic ejecta of any size. Historically, however, various terms have been used to describe ejecta of different sizes. ... Fragments larger than about 2.5 inches are called blocks if they were ejected in a solid state and volcanic bombs if ejected in semi-solid, or plastic, condition. Fragments of lava or rock larger than 64 millimeters in size that are blasted into the air by volcanic explosions. See: Tephra.

**Blowdown:** Trees felled by a volcanic blast.

**Bombs:** Tephra is the general term now used by volcanologists for airborne volcanic ejecta of any size. Historically, however, various terms have been used to describe ejecta of different sizes. ... Fragments larger than about 2.5 inches are called blocks if they were ejected in a solid state and volcanic bombs if ejected in semi-solid, or plastic, condition. ... Volcanic bombs undergo widely varying degrees of aerodynamic shaping, depending on their fluidity, during the flight through the atmosphere. Based on their shapes after they hit the ground, bombs are variously described, in graphic terms, as "spindle or fusiform", "ribbon", "bread-crust", or "cow-dung". See: Tephra.

**Bread-crust bombs:** See: Bombs.

**Caldera:** A caldera is a large, usually circular depression at the summit of a volcano formed when magma is withdrawn or erupted from a shallow underground magma reservoir. The removal of large volumes of magma may result in loss of structural support for the overlying rock, thereby leading to collapse of the ground and formation of a large depression. Calderas are different from craters, which are smaller, circular depressions created primarily by explosive excavation of rock during eruptions.

**Cenozoic:** An era of geologic time from the beginning of the Tertiary period, spanning the time between 66 million years ago to the present. The Cenozoic contains the Tertiary and the Quaternary periods.

**Cinders:** Cinders are lava fragments about 1 centimeter in diameter.

**Cinder cone:** A steep-sided volcano formed by the explosive eruption of cinders that form around a vent. A small conical-shaped volcano formed by the accumulation of ejected cinders and other volcanic debris that falls back to Earth close to the vent area.

**Composite volcano:** A steep-sided volcano built by lava flows and tephra deposits.

A steep-sided volcano composed of many layers of volcanic rocks, usually of high-viscosity lava and fragmented debris such as lahar and pyroclastic deposits.

Composite volcanoes erupt episodically over tens to hundreds of thousand of years and can display a wide range of eruption styles. See also Monogenetic volcanoes.

Also called: Stratovolcano

Conduit: A subterranean passage through which magma reaches the surface during volcanic activity.

"Continental" Volcanoes: In the typical "continental" environment, volcanoes are located in unstable, mountainous belts that have thick roots of granite or granitelike rock. Magmas, generated near the base of the mountain root, rise slowly or intermittently along fractures in the crust. During passage through the granite layer, magmas are commonly modified or changed in composition and erupt on the surface to form volcanoes constructed of nonbasaltic rocks.

Contour lines: Parallel lines used on topographic maps to show the shape and elevation of the land. They connect points of equal elevations.

Crater: The circular depression containing a volcanic vent.

A steep-sided, usually circular depression formed by either explosion or collapse at a volcanic vent.

Crust: The Earth's outermost layer.

Dacite: Dacite lava is most often light gray, but can be dark gray to black. Dacite lava consists of about 63 to 68 percent silica . Common minerals include plagioclase feldspar, pyroxene, and amphibole. Dacite generally erupts at temperatures between 800 and 1000° C. It is one of the most common rock types associated with enormous Plinian-style eruptions. When relatively gas-poor dacite erupts onto a volcano's surface, it typically forms thick rounded lava flow in the shape of a dome.

Debris avalanche: A rapid and unusually sudden sliding or flowage of unsorted masses of rock and other material. As applied to the major avalanche involved in the eruption of Mount St. Helens , a rapid mass movement that included fragmented cold and hot volcanic rock, water, snow, glacier ice, trees, and some hot pyroclastic material. Most of the May 18 deposits in the upper valley of the North Fork Toutle River and in the vicinity of Spirit Lake are from the debris avalanche.

The very rapid and usually sudden sliding and flowage of an unsorted mixture of soil and weathered rock

Moves away from a volcano at high speed.

Debris flow: A flowing mixture of water and rock debris, sometimes referred to as a lahar or mudflow.

See also: Lahar.

Density Current: A gravity-induced flow of one current through, over, or under another fluid media, owing to density differences. Factors affecting density differences include temperature, salinity, and concentration of suspended particles.

Deposit: Earth material that has accumulated by some natural process. For example, a flowing mixture of water and rock debris is called a debris flow, but when the flow ceases to move, a layer of fine and coarse rock is left which is called a debris-flow deposit.

**Diatreme:** A general term for a volcanic vent or pipe drilled through enclosing rocks by the explosive energy of gas-charged magmas. The diamond-bearing kimberlite pipes of South Africa are diatremes.

**Dike:** A tabular igneous body that cuts across the planar structures of the surrounding rocks.

**Diorite:** A coarse, uniformly grained rock composed of a feldspar and less than 50% amphibole or pyroxene. A quartz diorite has the composition of a diorite plus quartz and biotite, whereas a granodiorite has the composition of a diorite plus quartz and two feldspars. An intrusive igneous rock.

**Directed blast:** A hot, low-density mixture of rock debris, ash, and gases that moves at high speed along the ground surface. Directed blasts are generated by explosions.

**Dome:** A steep-sided mount that forms when very viscous lava is extruded from a volcanic vent. A steep-sided mound that forms when viscous lava piles up near a volcanic vent. Domes are formed by andesite, dacite, and rhyolite lavas. A steep-sided mass of viscous lava extruded from a volcanic vent, often circular in plan view and spiny, rounded, or flat on top. Its surface is often rough and blocky as a result of fragmentation of the cooler, outer crust during growth of the dome. Also called: Lava dome.

**Dormant volcano:** An active volcano that is in repose but is expected to erupt in the future. A volcano that is not presently erupting but that is considered likely to erupt in the future.

**Earthquake:** The abrupt shaking of the ground caused by an abrupt shift of rock along a fracture in the Earth.

**Ejecta:** Material that is thrown out by a volcano, including pyroclastic material and, from some volcanoes, lava bombs.

**Eocene:** An epoch of the Tertiary period, spanning the time between 58 and 37 million years ago.

**Extinct volcano:** A volcano that is not expected to erupt again. A volcano that is not presently erupting and is not likely to do so for a very long time in the future.

**Fumarole:** A vent that releases volcanic gases, including water vapor. An opening at the Earth's surface from which water vapor and other gases are emitted, often at high temperature. An vent or opening in the ground from which hot water vapor and volcanic gases are emitted.

**Fumarolic activity:** Volcanic gas emissions, that may be accompanied by a change in the temperature of the gases or fluids emitted.

**Gabbro:** A coarse-grained rock composed of greenish-white feldspar and pyroxene. Gabbro is usually very dark in color. It is the intrusive equivalent of basalt. An intrusive igneous rock.

**Glacier outburst flood:** A sudden release of melt water from a glacier or glacier-dammed lake sometimes resulting in a catastrophic flood, formed by melting of a channel or by subglacial volcanic activity.

**Graben:** An elongate crustal block that is relatively depressed between two fault systems.

**Granite:** Igneous rocks are formed from melted rock that has cooled and solidified. When rocks are buried deep within the Earth, they melt because of the high pressure and temperature; the molten rock can then flow upward or even be erupted from a volcano onto the Earth's surface. When magma cools slowly, usually at depths of thousands of feet, crystals grow from the molten liquid, and a coarse-grained rock forms. When magma cools rapidly, usually at or near the Earth's surface, the crystals are extremely small, and a fine-grained rock results. A wide variety of rocks are formed by different cooling rates and different chemical compositions of the original magma. Obsidian, granite, basalt, and andesite porphyry are four of the many types of igneous rock. A coarse-grained, light-colored rock composed of quartz and two feldspars, with lesser amounts of mica or amphibole. An intrusive igneous rock.

**Harmonic Tremor:** Continuous rhythmic earthquakes in the Earth's upper lithosphere that can be detected by seismographs. Harmonic tremors often precede or accompany volcanic eruptions. A continuous release of seismic energy typically associated with the underground movement of magma. It contrasts distinctly with the sudden release and rapid decrease of seismic energy associated with the more common type of earthquake caused by slippage along a fault.

**Hawaiian eruption:** "Hawaiian" eruptions may occur along fissures or fractures that serve as linear vents, such as during the eruption of Mauna Loa Volcano in Hawaii in 1950, or they may occur at a central vent such as during the 1959 eruption in Kilauea Iki Crater of Kilauea Volcano, Hawaii. In fissure-type eruptions, molten, incandescent lava spurts from a fissure on the volcano's rift zone and feeds lava streams that flow downslope. In central-vent eruptions, a fountain of fiery lava spurts to a height of several hundred feet or more. Such lava may collect in old pit craters to form lava lakes, or form cones, or feed radiating flows.

**Holocene:** An epoch of the Quaternary period, spanning from 8,000 years ago until the present.

**Hot Spot:** An area in the middle of a lithospheric plate where magma rises from the mantle and erupts at the Earth's surface. Volcanoes sometimes occur above a hot spot.

**Hummocky ground:** A ground surface that has lots of small hills and swales; uneven ground.

**Hydrothermal:** Pertains to hot water or the action of heated water, often considered heated by magma or in association with magma.

**Hydrothermal alteration:** Alteration of rocks or minerals by the reaction of hot water with pre-existing rocks. The hot water is generally heated groundwater and dissolved minerals.

**Igneous:** Solidified from a magma; also applied to processes related to the formation of igneous rocks.

**Igneous rocks:** Igneous rocks are formed from melted rock that has cooled and solidified. When rocks are buried deep within the Earth, they melt because of the high pressure and temperature; the molten rock can then flow upward or even be erupted from a volcano onto the Earth's surface. When magma cools slowly, usually at depths of thousands of feet, crystals grow from the molten liquid, and a coarse-grained rock forms. When magma cools

rapidly, usually at or near the Earth's surface, the crystals are extremely small, and a fine-grained rock results. A wide variety of rocks are formed by different cooling rates and different chemical compositions of the original magma. Obsidian, granite, basalt, and andesite porphyry are four of the many types of igneous rock.

"Island Arc" Volcanoes: In a typical "island-arc" environment, volcanoes lie along the crest of an arcuate, crustal ridge bounded on its convex side by a deep oceanic trench. The granite or granitelike layer of the continental crust extends beneath the ridge to the vicinity of the trench. Basaltic magmas, generated in the mantle beneath the ridge, rise along fractures through the granitic layer. These magmas commonly will be modified or changed in composition during passage through the granitic layer and erupt on the surface to form volcanoes built largely of nonbasaltic rocks.

Jökulhlaup: Icelandic term for Glacial outburst floods

K-Ar dating: Determination of the age of a mineral or rock in years based on the known radioactive decay rate of potassium-40 to argon-40.

Lahar: A flowing mixture of water-saturated rock debris that forms on the slopes of a volcano, and moves downslope under the force of gravity, sometimes referred to as debris flow or mudflow. The term comes from Indonesia.

Lahar-runout flow:

Hyperconcentrated streamflow transitional in sediment concentration between a lahar and normal streamflow.

Lapilli: Fragments of lava or rock between 2 and 64 millimeters in size that are blasted into the air by volcanic explosions.

Rock fragments between 2 and 64 mm in diameter that were ejected from a volcano during an explosive eruption are called lapilli. Lapilli means "little stones" in Italian. Lapilli may consist of many different types of tephra, including scoria, pumice, and reticulite. Rounded tephra particles in this size range are called accretionary lapilli if they consist of tiny ash grains stuck together. Ash sometimes forms such rounded particles in an eruption column or cloud, owing to moisture or electrostatic forces.

Lateral blast: A sideways-directed explosion from the side or summit of a volcano. An explosive event in which energy is directed horizontally instead of vertically as in an eruption column.

Lava: The term used for magma once it has erupted onto the Earth's surface.

Molten rock that erupts from a vent or fissure.

See also: Magma

Lava dome: See: Dome.

Lava flow: Stream of molten rock that erupts relatively nonexplosively from a volcano and moves slowly downslope.

An outpouring of lava onto the land surface from a vent or fissure. Also, a solidified tongue-like or sheet-like body formed by outpouring lava.

Lava lake: Another common lava product is the ponded flow or lava lake. The surface of lava that is ponded is smooth, broken only by polygonal cooling cracks, formed in much the same way as shrinkage cracks in mud that has been dried by the sun. ... The formation of

the lava lake's solid crust by cooling can be compared to the formation of a sheet of ice on top of a body of water during a winter freeze.

**Lava tube:** During long-lived eruptions, lava flows tend to become "channeled" into a few main streams. Overflows of lava from these streams solidify quickly and plaster on to the channel walls, building natural levees or ramparts that allow the level of the lava to be raised. Lava streams that flow steadily in a confined channel for many hours to days may develop a solid crust or roof and thus change gradually into streams within lava tubes. Because the walls and roofs of such tubes are good thermal insulators, lava flowing through them can remain hot and fluid much longer than surface flows. Tube-fed lava can be transported for great distances from the eruption sites.

**Lithic :** Pertains to pyroclastic deposits that contain abundant fragments of previously-formed rocks and/or dense fragments.

**Lithospheric Plates:**

A series of rigid slabs that make up the Earth's outer shell. These plates float on top of a softer, more plastic layer in the Earth's mantle. Also called: Tectonic Plates.

**Loess:** A well-sorted deposit of windblown silt-sized particles that forms a blanket over the landscape.

**Maars:** Also called "tuff cones", maars are shallow, flat-floored craters formed above diatremes as a result of a violent expansion of magmatic gas or steam. Maars range in size from 200 to 6,500 feet across and from 30 to 650 feet deep, and most are commonly filled with water to form natural lakes. A maar is a low-relief, broad volcanic crater formed by shallow explosive eruptions. The explosions are usually caused by the heating and boiling of groundwater when magma invades the groundwater table. Maars often fill with water to form a lake.

**Mafic:** Term used to describe volcanic rock or magma composed chiefly of dark-colored, iron- and magnesium-rich minerals.

**Mafic volcano:** Mafic volcanoes typically erupt for brief time intervals, but some can grow almost as large as composite volcanoes. Subsequent eruptions in the region typically issue from new vents and, over tens to hundreds of thousands of years, build broad fields of many volcanoes.

**Magma:** Molten rock containing liquids, crystals, and dissolved gases that forms within the upper part of the Earth's mantle and crust. When erupted onto the Earth's surface, it is called lava.

Molten rock that contains dissolved gas and minerals. When magma reaches the surface it is called lava.

**Magnetic polarity:** Direction of magnetic poles preserved in igneous rocks after they cool through their Curie temperatures.

**Magnitude:** A numerical expression of the amount of energy released by an earthquake, determined by measuring earthquake waves on standardized recording instruments. The number scale for magnitudes is logarithmic rather than arithmetic; therefore, deflections on a seismograph for a magnitude 5 earthquake, for example, are 10 times greater than those for a magnitude 4 earthquake, 100 times greater than for a magnitude 3 earthquake, and so on.

Mantle: A zone in the Earth's interior between the crust and the core that is 2,900 kilometers thick. (The lithosphere is composed of the topmost 65-70 kilometers .

Mesozoic: The era of geologic time between the Paleozoic and the Cenozoic, spanning the time between 250 and 66 million years ago. The Mesozoic is dividing into the Triassic , Jurassic , and Cretaceous periods.

Metamorphic rocks: Sometimes sedimentary and igneous rocks are subject to pressures so intense or heat so high that they are completely changed. They become metamorphic rocks, which form while buried within the Earth's crust. The process of metamorphism does not melt the rocks, but instead transforms them into denser, more compact rocks.

Miocene: An epoch of the Tertiary period, spanning the time between 24 and 5 million years ago.

Monogenetic volcano: Monogenetic volcanoes typically erupt for only brief time intervals -- weeks to perhaps centuries -- and generally display a narrower range in eruptive behavior. Most monogenetic volcanoes are basaltic in composition.

Mudflow: The flowing mixture of water and debris that forms on the slopes of a volcano. Sometimes called a debris flow or lahar, a term from Indonesia where volcanic mudflows are a major hazard. A flowage of water-saturated earth material possessing a high degree of fluidity during movement. A less-saturated flowing mass is often called a debris flow. A mudflow originating on the flank of a volcano is properly called a lahar. See: Lahar.

Nuees Ardente: See: Pyroclastic Flow.  
See: Pelean eruption.

Obsidian: Obsidian is dense volcanic glass, usually rhyolite in composition and typically black in color. Compared with window glass, obsidian is rich in iron and magnesium; tiny crystals of iron oxide within the glass cause its dark color. Obsidian is often formed in rhyolite lava flows where the lava cools so fast that crystals do not have time to grow. Glass, unlike crystals, has no regular structure and therefore fractures in smooth conchoidal shapes. The intersections of these fractures can form edges sharper than the finest steel blades. For this reason, obsidian was used by many native cultures to make arrowheads and blades.

"Oceanic" Volcanoes: In a typical "oceanic" environment, volcanoes are aligned along the crest of a broad ridge that marks an active fracture system in the oceanic crust. Basaltic magmas, generated in the upper mantle beneath the ridge, rise along fractures through the basaltic layer. Because the granitic crustal layer is absent, the magmas are not appreciably modified or changed in composition and they erupt on the surface to form basaltic volcanoes.

Oligocene: An epoch of the Tertiary period, spanning the time between 37 and 24 million years ago.

Pahoehoe: Pahoehoe (pronounced "pah-hoy-hoy" - a Hawaiian term), is lava that in solidified form is characterized by a smooth, billowy, or ropy surface. Pahoehoe is a Hawaiian term for basaltic lava that has a smooth, hummocky, or ropy surface. A pahoehoe flow typically advances as a series of small lobes and toes that continually break out from a

cooled crust. The surface texture of pahoehoe flows varies widely, displaying all kinds of bizarre shapes often referred to as lava sculpture.

**Paleocene:** An epoch of the Tertiary period, spanning the time between 66 and 58 million years ago.

**Paleozoic:** An era of geologic time, from the end of the Precambrian to the beginning of the Mesozoic, spanning the time between 570 and 250 million years ago. The Paleozoic era contains the Cambrian (570-500), Ordovician (500-425), Silurian (425-400), Devonian (400-365), Mississippian (365-310), Pennsylvanian (310-290), and Permian (290-250) periods.

**Pegmatite:** An igneous rock with very large (usually > one inch), well-formed crystals. A granitic pegmatite has the mineralogy of a granite and abnormally large grains, whereas a gabbroic pegmatite has the mineralogy of a gabbro and very large grains. An intrusive igneous rock. (Plank and Schenck, 1998)

**Pelean eruption:** In a "Pelean" or "Nuee Ardent" (glowing cloud) eruption, such as occurred on the Mayan Volcano in the Philippines in 1968, a large quantity of gas, dust, ash, and incandescent lava fragments are blown out of a central crater, fall back, and form tongue-like, glowing avalanches that move down-slope at velocities as great as 100 miles per hour. Such eruptive activity can cause great destruction and loss of life if it occurs in populated areas, as demonstrated by the devastation of St. Pierre during the 1902 eruption of Mount Pelee on Martinique, West Indies.

**Phreatic eruption:** An explosion of steam, water, mud, and other material. May result from heating of groundwater by magma, and may generate base surges. A type of volcanic explosion that occurs when water comes in contact with hot rocks or ash near a volcanic vent, causing steam explosions. An explosive volcanic eruption caused when water and heated volcanic rocks interact to produce a violent expulsion of steam and pulverized rocks. Magma is not involved. The eruption of Taal Volcano in the Philippine Islands in 1965 typifies "Phreatic" (or steam-blast) behavior. Here, a great column of steam, dust, ash, and cinders is blasted to a height of several thousand feet. This type of violent eruption is believed to occur when a large quantity of ground or surface water comes in contact with hot rock or magma in a volcanic vent and is instantly and explosively flashed to steam.

**Phreatomagmatic eruption:** An explosion composed of magmatic gases and steam derived from groundwater or surface water, combined with lava and other debris.

**Pillow Lava:** Fluid lava erupted or flowing under water may form a special structure called pillow lava. Such structures form when molten lava breaks through the thin walls of underwater tubes, squeezes out like toothpaste, and quickly solidifies as irregular, tongue-like protrusions. This process is repeated countless times, and the resulting protrusions stack one upon another as the lava flow advances underwater. The term pillow comes from the observation that these stacked protrusions are sack- or pillow-shaped in cross section. Typically ranging from less than a foot to several feet in diameter, each pillow has a glassy outer skin formed by the rapid cooling of the lava by water. Much pillow lava is erupted under relatively high pressure created by the weight of the overlying water; there is little or no explosive interaction between hot lava and cold water. The bulk of the submarine part of a Hawaiian volcano is composed of pillow lavas.

**Pleistocene:** An epoch of the Quaternary period, spanning the time between 2 million years ago and the beginning of the Holocene at 8,000 years ago.

Pliocene: An epoch of the Tertiary period, spanning the time between 5 and 2 million years ago.

Pluton: Pertaining to igneous rock bodies that form at great depth.

Precambrian: All geologic time before the Paleozoic era. This includes about 90% of all geologic time and spans the time from the beginning of the earth to 570 million years ago.

Ponded flow: See: Lava lake

Pumice: A light-colored, frothy volcanic rock, usually of dacite or rhyolite composition, formed by the expansion of gas in erupting lava. Commonly perceived as lumps or fragments of pea size and larger but can also occur abundantly as ash-size particles. (Foxworthy and Hill, 1982) Because of its numerous gas bubbles, pumice commonly floats on water.

Pyroclastic: Pertaining to fragmented (clastic) rock material formed by a volcanic explosion or ejection from a volcanic vent. (Foxworthy and Hill, 1982)

Pyroclastic flow: A hot, fast-moving and high-density mixture of fine and coarse particles and gas formed during explosive eruptions or from the collapse of a lava dome. Lateral flowage of a turbulent mixture of hot gases and unsorted pyroclastic material (volcanic fragments, crystals, ash, pumice, and glass shards) that can move at speed (50 to 100 miles an hour). The term also can refer to the deposit so formed. A hot (300-800 degrees C (570-1470 degrees F)), dry, fast-moving (10 to more than 100 meters per second (20 to more than 200 miles per hour)) and high-density mixture of ash, pumice, rock fragments, and gas formed during explosive eruptions or from the collapse of a lava dome. Moves away from a volcano at high speeds.

Pyroclastic surge: Similar to a pyroclastic flow but of much lower density (higher gas to rock ratio). Turbulent, low-density cloud of hot rock debris and gases that moves over the ground surface at high speed.

Quaternary: Period of geologic time from about 2 million years ago until the present. It contains the Pleistocene (2 million - 8,000) and Holocene (8,000 - present) epochs.

Reticulite: During the exceptionally high fountaining episodes of some eruptions, an extremely vesicular, feathery light pumice, called reticulite or thread-lace scoria, can form and be carried many miles downwind from the high lava fountains. Even though reticulite is the least dense kind of tephra, it does not float on water, because its vesicles are open and interconnected. Consequently, when it falls on water, it becomes easily waterlogged and sinks.

Rhyolite: Volcanic rock (or lava) that characteristically is light in color, contains 69 percent silica or more, and is rich in potassium and sodium. Rhyolite is a light-colored rock with silica (SiO<sub>2</sub>) content greater than about 68 weight percent. Sodium and potassium oxides both can reach about 5 weight percent. Common mineral types include quartz, feldspar and biotite and are often found in a glassy matrix. Rhyolite is erupted at temperatures of 700 to 850° C.

Satellite vent: A secondary vent of flank vent at a volcanic center.

**Scoria:** Scoria is a vesicular (bubbly) glassy lava rock of basaltic to andesitic composition ejected from a vent during explosive eruption. The bubbly nature of scoria is due to the escape of volcanic gases during eruption. Scoria is typically dark gray to black in color, mostly due to its high iron content. The surface of some scoria may have a blue iridescent color; oxidation may lead to a deep reddish-brown color. Scoria forms when blobs of gas-charged lava are thrown into the air during an eruption and cool in flight, falling as dark volcanic rock containing cavities created by trapped gas bubbles.

**Seismicity:** Pertaining to earthquakes or earth vibration.

**Seismograph:** A scientific instrument that detects and records vibrations (seismic waves) produced by earthquakes.

**Shield volcano:** A volcano that resembles an inverted warrior's shield. It has long gentle slopes produced by multiple eruptions of fluid lava flows. A volcano shaped like an inverted warrior's shield with long gentle slopes produced by eruptions of low-viscosity basaltic lava.

**Silica:** The molecule formed of silicon and oxygen that is the basic building block of volcanic rocks and the most important factor controlling the fluidity of magma. The higher a magma's silica content, the greater its viscosity or "stickiness."

**Silicic:** Term used to describe silica-rich volcanic rock or magma.

**Spatter Cone:** Long-lived basaltic lava fountains that erupt spatter, scoria or cinder, and other tephra from a central vent typically build steep-sided cones called spatter-and-cinder cones. The greatest bulk of these cones consists of spatter, but during fountaining a lava flow usually pours down one side of the cone. Eruptions that build spatter and cinder cones are much longer in duration and much more varied in intensity than those that eject only spatter to build spatter cones and ramparts.

**Spreading Ridges:** Places on the ocean floor where lithospheric plates separate and magma erupts. About 80 percent of the Earth's volcanic activity occurs on the ocean floor.

**Stratovolcano:** See Composite volcano.

**Strombolian eruption:** In a "Strombolian"-type eruption observed during the 1965 activity of Irazu Volcano in Costa Rica, huge clots of molten lava burst from the summit crater to form luminous arcs through the sky. Collecting on the flanks of the cone, lava clots combined to stream down the slopes in fiery rivulets.

**Subduction Zone:**

The place where two lithosphere plates come together, one riding over the other. Most volcanoes on land occur parallel to and inland from the boundary between the two plates.

**Tectonic:** Pertaining to the forces involved in the deformation of the Earth's crust, or the structures or features produced by such deformation.

**Tectonic Plates:** See: Lithospheric Plates.

**Tephra:** Solid material of all sizes explosively ejected from a volcano into the atmosphere. Tephra is the general term now used by volcanologists for airborne volcanic ejecta of any size. Historically, however, various terms have been used to describe ejecta of different sizes. Fragmental volcanic products between 0.1 to about 2.5 inches in diameter are called

lapilli; material finer than 0.1 inch is called ash. Fragments larger than about 2.5 inches are called blocks if they were ejected in a solid state and volcanic bombs if ejected in semi-solid, or plastic, condition. See: Ash, Lapilli, Blocks, Bombs.

Tertiary: Period of geologic time from about 66 million years ago until 2 million years ago. It contains the Paleocene (66-58), Eocene (58-37), Oligocene (37-24), Miocene (24-5), and Pliocene (5-2) epochs.

Thread-lace scoria: See: Reticulite.

Topographic map: A map that uses contour lines to represent the three-dimensional features of a landscape on a two-dimensional surface.

Tremor: See: Harmonic Tremor.

Tuff: Used loosely as a collective term for all consolidated pyroclastic rocks.

Tuff Cones: See: Maars.

Tuya: A volcano that erupted under a glacier. A tuya is a volcano that erupts initially beneath a glacier, melts through the ice, and develops an upper, subaerial part, which commonly consists of a flat-topped form capped by a lava flow.

VEI Scale: Some scientists recently proposed the Volcanic Explosivity Index (VEI) to attempt to standardize the assignment of the relative size of an explosive eruption, using ejecta volume as well as the other criteria mentioned earlier. The VEI scale ranges from 0 to 8. A VEI of 0 denotes a nonexplosive eruption, regardless of volume of erupted products. Eruptions designated a VEI of 5 or higher are considered "very large" explosive events, which occur worldwide only on an average of about once every 2 decades. The May 1980 eruption of Mount St. Helens rated a VEI of 5, but just barely; its lateral blast was powerful, but its output of magma was rather small. The VEI has been determined for more than 5,000 eruptions in the last 10,000 years. None of these eruptions rates the maximum VEI of 8. For example, the eruption of Vesuvius Volcano in A.D. 79, which destroyed Pompeii and Herculaneum, only rates a VEI of 5. Since A.D. 1500, only 22 eruptions with VEI 5 or greater have occurred: one VEI 7 (the 1815 Tambora eruption), four of VEI 6 (including Krakatau in 1883), and seventeen of VEI 5 (counting Mount St. Helens in 1980 and El Chichon, Mexico, in 1982). Considered barely "very large," the eruption of Mount St. Helens in May 1980 was smaller than most other "very large" eruptions within the past 10,000 years and much smaller than the enormous caldera-forming eruptions-which would rate VEI's of 8-that took place earlier than 10,000 years ago.

Vent: The opening at the Earth's surface through which volcanic materials (lava, tephra, and gases) erupt. Vents can be at a volcano's summit or on its slopes; they can be circular (craters) or linear (fissures). An opening in the Earth's surface through which volcanic materials (magma and gas) escape.

Vesuvian eruption: In a "Vesuvian" eruption, as typified by the eruption of Mount Vesuvius in Italy in A.D.79, great quantities of ash-laden gas are violently discharged to form a cauliflower-shaped cloud high above the volcano.

Viscosity: Measure of the fluidity of a substance. Taffy and molasses are very viscous; water has low viscosity. Basalt is less viscous than dacite.

Volcano: A vent (opening) in the surface of the Earth through which magma erupts; it is also the landform that is constructed by the erupted material.

Volcanic avalanche: A large, chaotic mass of soil, rock, and volcanic debris moving swiftly down the slopes of a volcano. Volcanic avalanches can also occur without an eruption as a result of an earthquake; heavy rainfall; or unstable soil, rock, and volcanic debris.

Also called: Debris Avalanche.

Volcanic bombs: See: Bombs.

Volcanic cone or edifice: Used to describe the uppermost slopes and summit area of a volcano.

Volcanic landslide: The downslope movement of soil, rock debris, and sometimes glacial ice, with or without water, from the flank of a volcano. See: Debris Avalanche.

Vulcanian eruption: The eruptive activity of Paricutin Volcano in 1947 demonstrated a "Vulcanian"-type eruption, in which a dense cloud of ash-laden gas explodes from the crater and rises high above the peak. Steaming ash forms a whitish cloud near the upper level of the cone.

# Floods

## Definition

**Flood** - Abnormal progressive rise in the water level, which may result in overflowing and inundation of normally dry land. Flooding may occur around river, streams, lakes or other freshwater bodies. It also occurs at the sea coast, especially in low-lying areas, as the result of abnormal tides, storm surges and tsunamis.

**Flash Flood** - A sudden and extreme volume of water, which flows rapidly. Flash floods usually result from large amounts of rain falling in a brief period. They occur with little or no warning and can become quite powerful within a few minutes. Flash flood waters move at very fast speeds and often carry a deadly cargo of debris. They can tear out trees, roll boulders, and destroy bridges and buildings.

## Causes of floods

- Heavy Rainfall
- Dam or levee failures
- Torrential rains from cyclones
- Tsunamis
- Storm Surges
- Burst water mains

## Types of floods

- Flash Floods
- River Floods
- Coastal Floods

## Levels of flooding

Inundations due to flooding vary in cause and severity can be categorized as follows:

### MINOR FLOODING

- Flood waters consigned to the flood plain immediately along a river/channel or in random low lying and topographically depressed areas;
- Flooding is relatively shallow and there is no perceptible flow of water as inundation spreads to adjacent areas slowly;
- Minor flooding is due to the accumulation of excessive surface runoff.

### MAJOR FLOODING

- Coverage of a wide continuous area;
- Rapid spreading to adjacent areas of relatively lower elevation;
- Flooding is relatively deep in most parts of the flood-stricken areas. Currents of flowing floodwater will be swift as the flood spreads to other areas;
- Major flooding is due to torrential rain, overflowing of rivers and lakes, unexpected and serious breaks in dikes, levees and other protective structures or uncontrolled releases of dam water.

## LIKELY IMPACT

Flood waters can destroy infrastructure, particularly those at ground level. Crops and livestock can also be destroyed, and considerable water damage to critical assets will occur in the path of floodwaters. Many persons may be killed especially when flash floods occur but the injuries are few. Food supply may become an issue.

## FLOOD WATCH

Denotes the period during which flood monitoring forecasting and flood warnings are carried out.

The principal activities are:

- Flood monitoring.
- Data collection and processing.
- Assessment of probability of flooding.
- Dissemination of information to public.

### Phases of flood watch

**Alert:** Flooding is present, but its probability is relatively low. This is a period of intense data collection, monitoring and assessment.

**Warning:** Issued when indications show that water levels will exceed the alert level within 24 hours. The Flood Watch converts to flood warning and the appropriate Advisories are issued.

A flood Watch is activated and terminated in accordance with the established conditions and criteria developed by the National Disaster Organisations.

# Messages the media should give to the public

## Emergency Action

Nobody can stop a flood. But if you are faced with one, there are actions you can take to protect your family and keep your property losses to a minimum. Official announcements are issued before, during, and after the occurrence of floods. These are intended to apprise the public in the affected area of the present and projected flood situation.

### Before the Flood

- Know the flood warning system in your community and ensure that your family knows the warnings;
- Learn all you can about the flooding;
- Monitor weather conditions;
- Keep on hand material like lumber, plywood, nails, roped, wires, plastic sheeting, sandbags, etc;
- Keep a portable transistor radio with spare batteries and emergency equipment;
- Store all chemicals away from floodwaters;
- Store livestock feed and supplies above expected water levels.

### During the Flood

- Avoid areas subject to flash flooding;
- Don't attempt to cross rivers or flowing streams where water is above the knees;
- If driving, don't attempt to cross rivers, flowing streams or flash floods where water is – or may be -- deeper than six inches;
- Beware of water-covered roads and bridges;
- **Livestock protection:** Animals can swim well. **DO NOT** leave them tied, or in confined areas or pens. Open gates so that animals can escape.

### After the Flood

- Re-enter buildings with caution. Use flashlights, not lanterns or torches as flammables may be inside;
- Be alert for fire and electrocution hazards such as broken electrical wires;
- If the building has been under water, do not switch on the main, wait for professional assistance. Never touch electrical switches while wet or standing in water;
- Don't use appliances or equipment until they have been cleaned, dried and thoroughly checked for damage;
- Report damaged utility lines (electricity, water, gas and telephone) to the appropriate authorities;
- Boil all water and don't eat left-over food until it is checked for contamination;
- Do not eat food that has been exposed to floodwater. Vegetables and fruits should be disinfected with a bleach solution prior to cooking and/or eating;
- Stay away from disaster areas; your presence may hamper rescue efforts.

## Prevention and Mitigation Measures

(Long term measures)

**Flood Mitigation Measures may be divided into three (3) main areas:**

1. Control over the river;
2. Control over the land;
3. Other measures.

### CONTROL OVER THE RIVER

Reliance is mainly on the physical alteration to the channel, flood plain or watershed to control the river. Measures include:

- Construction of dams, retention basins or reservoirs on mainstreams or tributaries to store excessive water and release it gradually after the threat has passed;
- **Levees or floodwalls** confine flood waters to a floodway, thereby reducing flood damage;
- Channel improvements, which include:
  1. Straightening to remove undesirable bendways;
  2. Deepening and widening to increase size of waterways;
  3. Clearing to remove brush, trees and other obstructions;
  4. Lining with concrete to increase efficiency.
- **Watershed Treatment**, which renders the soil on slopes more absorbent of excessive rainfall until flood heights have receded. Measures include:
  1. Crop rotation;
  2. Construction of terrace;
  3. Contour strip cropping;
  4. Selective planting and reforestation.

### CONTROL OVER THE LAND

Measures are embodied in the following **Land Use Policies**:

- **Designated floodways and encroachment lines** are the lateral boundaries of the floodway where no construction or land filling should be permitted;
- **Zoning** is a legal tool used by governments to control development;
- **Subdivision Regulations** specify the manner in which land may be divided. Typical provisions show the extent of the flood plain on maps. Floodway limits or encroachment lines prohibit filling in channels and floodways that restrict flow and require that each lot contain a building site with an elevation above the flood level;
- **Building Codes** are standards for construction of buildings and other structures and, if enforced, can reduce damages to buildings in flood-prone areas. **Some requirements include:**
  1. Establishment of basement elevations and first floor elevations consistent with potential flood levels.
  2. Structural strength to withstand water pressure or high velocity of flowing water.
  3. Prohibition of equipment that might be hazardous to life when submerged.
  4. Prevention of flotation of buildings by requiring proper anchorage.

### OTHER MEASURES

These include flood proofing, flood forecasting, warning and evacuation systems.

- **Flood Proofing** is a combination of structural changes and adjustment to properties which can be used in new or existing construction. Action includes seepage control, protective coverings, elevation or raising anchorage and under pinning;
- **Flood Forecasting** is reliable, accurate and timely forecasting of floods, coupled with timely evacuation to save lives and reduce property losses;
- **Temporary Evacuation** removes persons and property from the path of flood waters;
- **Permanent Evacuation** removes an affected population from areas subject to inundation. This involves the acquisition of lands and the removal of improvements. The acquired lands can be used for agriculture, parks or other purposes that would not interfere with flood flows or result in material damage;
- **Flood Insurance** assists by compensating for flood damage. Insurance rates should realistically reflect the flood risk in order to avoid encouragement of improper development of flood plains.

# GLOSSARY

**BUILDING CODES** are a set of regulations adopted by Government to set standards for the construction of buildings and other structures.

**FLASH FLOOD** A sudden and extreme volume of water, which flows rapidly. Flash floods usually result from large amounts of rain falling in a brief period. They occur with little or no warning and can become quite powerful within a few minutes.

**FLOOD** Abnormal progressive rise in the water level, which may result in overflowing and inundation of normally dry land.

**FLOOD-PROOFING** is a combination of structural changes and adjustments to properties subject to flooding in order to reduce or eliminate vulnerability to flood damage.

**LEVEES** are earthen embankments used to blockage or confine floodwater

**SUBDIVISION** is a tract of land divided into lots for the purpose of sale or building development.

**WATERSHED TREATMENT** is the treatment of sloping land to render the soil more capable of absorbing and retaining some of the excessive rainfall.

**ZONING** is the legal tool that is used to implement and enforce the detailed plans resulting from the planning programme.

# Landslides

## Definition <sup>15</sup>

Landslides occur when masses of rock, earth, or debris move down a slope. Landslides may be very small or very large, and can move at slow to very high speeds. Many landslides have been occurring over the same terrain since prehistoric times. They are activated by storms and fires and by human modification of the land. New landslides occur as a result of rainstorms, earthquakes, volcanic eruptions, and various human activities.

Slope material that becomes saturated with water may develop a debris flow or mud flow. The resulting slurry of rock and mud may pick up trees, houses, and cars, thus blocking bridges and tributaries causing flooding along its path.

## Likely Impact

1. Acres of property may be damaged and buildings and homes destroyed by landslides. Landslides can provoke associated dangers such as broken electrical, water, gas, and sewage lines, and disrupt roadways and railways.
2. Landslide warning signs include cracks opening on hill slopes, evidence of slow, downhill movement of rock and soil; tilting of trees, poles, or walls; or visible changes such as the formation of sags and bumps in the slope.
3. Landslide, mudflow, and debris-flow problems are often caused by land mismanagement. Improper land-use practices on ground of questionable stability, particularly in mountain, canyon, and coastal regions, can create and accelerate serious landslide problems. Land-use zoning in partnership with professional inspections and proper design can alleviate many problems associated with landslides, mudflows, and debris flows.

## Factors contributing to vulnerability

- Settlements built on steep slopes, softer soils and cliff tops;
- Settlements built at the base of steep slopes, on mouths of streams from mountain valleys;
- Roads, communication lines in mountain areas;
- Buildings with weak foundations;
- Buried Pipelines and brittle pipes;
- Lack of understanding of landslide hazard.

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<sup>15</sup> Source: FEMA (<http://www.fema.gov/hazards/landslides/landslis.htm>)

## Preparedness measures

The media can raise awareness about landslide and mudflows by providing important information to the community. Here are some suggestions:

- In an area prone to landslides, publish a special section with emergency information on landslides and mudflows. Localize the information by including the phone numbers of local emergency services offices;
- Report on what government is doing to reduce the possibility of landslides. Interview local officials about local land-use zoning regulations;
- Work with local disaster management office to prepare special reports for people with mobility impairments on what to do in the event of an emergency.

## Typical post-disaster needs

- Search and rescue (use of earth removal equipment);
- Medical assistance;
- Emergency shelter for homeless.

### Prevention and Mitigation Measures

(Long term measures)

- Capture and drainage of water before it reaches potential slope area
- Underground drainage by using sub-surface pipes
- Land Reform by terracing/re-shaping
- Reforestation, planting of deep rooting trees to prevent surface slips
- Ground cover with grass or agricultural crops
- Use of **gabion** construction to protect water course valleys and control the flow of water down slope

# Technological and Man-Made Disasters

## Introduction

Throughout the world people are becoming victims of industrial accidents when hazardous materials are released into the environment. Such incidents have the potential to cause ecological damage and are therefore likely to impact several countries. It is critical then that Government have the capability to prevent and respond to such events and minimize their harmful effects. In order to assess the potential of a chemical accident, one needs to determine the source and the type of accident.

## Such accidents can occur by:

- Production of materials
- Transport of materials
- Technological system failures
- Contamination of food or the environment by the use of chemicals, or improper waste management.
- Explosion in a plant or storage facility handling toxic substances
- Arson or sabotage
- Other precipitating factors like lightning, flood and earthquake.

## Likely Impact

### Physical damage

- Damage or destruction to structures and infra-structure
- Transportation accidents may damage vehicles and other objects on impact
- Industrial fires may reach high temperatures and affect large areas

### Environmental

- The most dangerous elements are gases, vapors, volatile liquids and suspended particles in the air
- Contamination of water supply, land, and animal life.
- Ecological systems may be disrupted

### Causalities

- Many people may be killed or injured and require medical treatment
- Health Effects
- Direct inhalation of toxic substances is most common in the early phases. Afterwards, skin contaminations become more significant.
- Dose of contamination is critical certain non-carcinogenic substances have threshold levels above which they are harmful to man
- Better protection offered in closed places

## Factors contributing to vulnerability

- Persons or structures, livestock etc. closest to the scene are most vulnerable, however, large scale releases of airborne pollutants may spread for hundreds of kilometers.
- Lack of safety features
- Lack of evacuation plans
- Unawareness of potential danger

# Messages the media should give to the public

## Emergency Action

### Atmospheric contamination

- Close all windows and doors and block off any other openings to the outdoors
- Extinguish any naked flames
- Reduce oxygen consumption by bringing physical activity to a minimum
- Cover mouth and nose with dampened cloth
- Seek First Aid

### Contamination of the skin

- Wash the affected parts to remove toxins
- Use soap and water and wash body carefully
- Remove all clothing while washing
- Do not use chemical antidotes, as the heat generated from the neutralising reaction may make the lesions worse.

### Mitigation methods

- Hazard mapping
- Hazard material identification
- Inspection of chemical plants and storage facilities
- Monitoring toxic waste disposal procedures
- Improve fire-fighting and emergency response capacities
- Prepare and practice evacuation plans
- Test warning systems

### Typical post disaster needs

- Evacuation
- Search and Rescue
- Alternative sources of water
- Clean-up
- Monitoring environmental effects

# Epidemics

## Definition

An epidemic is a widespread long-lasting outbreak of an infectious disease, to the extent that the disease spreads beyond a local population to a wider geographical area. Examples of diseases that can reach epidemic proportions include influenza (flu), cholera, AIDS, typhoid, smallpox, dengue fever and malaria. When an epidemic spreads across the globe, it is called a pandemic.

Several factors determine whether an outbreak of an infectious disease will reach epidemic or pandemic proportions. Broadly stated, the primary factors are:

- the ease with which a microbe moves from person to person, which is in turn affected by several conditions.
- the behaviour of individuals and societies.

## Where to find information

- Caribbean Epidemiology Centre [www.carec.org](http://www.carec.org)
- PAHO/Caribbean [www.cpc.paho.org](http://www.cpc.paho.org)
- Centres for Disease Control [www.cdc.gov](http://www.cdc.gov)
- Caribbean Disaster Emergency Response Agency [www.cdera.org](http://www.cdera.org)

Outbreaks of disease are caused by transmission of microbes from person to person. A microbe is tiny living organism or germ, such as a virus or bacteria. Microbes can move from person to person in water, through the air, through exchange of or contact with bodily fluids, or be carried by an intermediary species, such as mosquitoes or fleas. These intermediary carriers are called vectors. Microbes can also be transmitted to humans from infected animals such as rats, pigs, or birds.

In investigating and defining an epidemic, data should indicate who, where, and how many are infected.

### General Characteristics:

- Risk of introduction or spread of the disease
- Possible large number of cases of the disease
- Severe cases leading to disability or death
- Risk of social or economic disruption
- Lack of adequate professional personnel and needed supplies
- Danger of international transmission

### Likely causes and contributing factors

- Unsanitary conditions, overcrowding and poverty
- Contamination of water and food supply
- Non-immune persons emigrate to areas where the disease is endemic
- Immune carriers emigrate to areas where the population has little or no immunity.
- Environmental changes (weather, vegetation, etc) that favour breeding of the vector
- Poor nutrition
- Poor public health system
- Evolution of drug-resistant strains of a disease
- Disasters may cause or exacerbate the above conditions.

## Likely impact

- Illness and death
- Economic losses resulting in social and political disruption
- Physical and mental incapacities due to trauma

## Methods of control

### Elimination of Source

- Treatment of cases, and at times, carriers
- Isolation of cases, depending on the nature of the epidemic
- Surveillance of suspects
- Notification of cases to authorities
- Control of animal reservoirs of disease

### Strategies for interrupting transmission

- Environmental health measures including water supplies, excreta disposal and elimination of vector breeding centres
- Food hygiene
- Personal hygiene
- Vector control
- Disinfection and sterilisation of surroundings
- Restriction of population movements and migration

### Protecting Susceptible Individuals

- Immunisation, where applicable
- Chemoprophylaxis – the prevention of disease by drugs
- Personal protection from contact with disease agents or conditions
- Better nutrition
- Better sanitation
- Evacuation

In an emergency situation where time is critical, the emphasis is usually on interrupting transmission, since it takes time to obtain information relating to the history of the epidemic, identify the cases and carriers, and implement control measures.

# Information the media should give to the public

## Know your diseases

**AIDS** – Acquired Immune Deficiency Syndrome. A disease caused by the Human Immunodeficiency Virus (HIV), which weakens the immune system and progressively destroys the body's ability to fight infections and certain cancers. Thus it is not the virus itself that kills, but diseases such as pneumonia and tuberculosis that eventually kill AIDS victims. HIV is most commonly spread through sexual contact with an infected partner, but can also be transmitted through other means of exchange of body fluids, primarily semen, blood, and blood products. Progress has been made in prolonging the life of AIDS patients, but treatment is expensive and there is no cure for the disease.

**Cholera** – an intestinal disease characterised by extreme diarrhoea, sharp muscular cramps, vomiting and fever. It is sometimes fatal, usually due to dehydration. The cholera bacteria is transmitted by ingestion of fecally-contaminated food or water, contact with the vomit or fecal matter of infected person, and by ingestion of contaminated seafood, particularly if undercooked. Water is an excellent medium for transmitting fecal contamination, hence the danger of cholera typically increases after flooding.

**Dengue fever** – a virus transmitted from the bite of the *Aedes aegypti* mosquito, which feeds primarily after daybreak and in the late afternoon. Symptoms include headaches, fever, joint pain, and a rash. The disease can be fatal if the patient goes into shock or contracts the hemorrhagic type of dengue known as DHF. There are four distinct, but closely related, viruses that cause dengue. Recovery from infection by one provides lifelong immunity against that serotype, but confers only partial and transient protection against subsequent infection by the other three. There is good evidence that sequential infection increases the risk of more serious disease resulting in DHF. Dengue fever occurs in most tropical areas.

**Diphtheria** – an acute bacterial disease that usually attacks the respiratory tract. A sore throat with a grayish membrane is the most obvious symptom. There is also a type of diphtheria (cutaneous) that affects the skin. The disease is spread by contact with respiratory secretions and by airborne droplets (from sneezing or coughing) from an infected person. An effective vaccine exists to prevent contracting diphtheria.

**Influenza (flu)** – a viral respiratory tract infection, usually accompanied by fever and aching. Flu can be caught from contact with respiratory secretions and airborne droplets (from sneezing or coughing) from an infected person. It can also be carried by other species, such as pigs and birds. The flu can kill; the very old and very young are most vulnerable.

**Malaria** – a tropical parasitic disease spread by the *anopheles* mosquito. Symptoms include high fever, severe chills, vomiting, anemia, jaundice and enlarged spleen. If treated promptly, it is curable. Malaria kills more people than any other communicable disease except tuberculosis. The emergence of multi-drug resistant strains of the malaria parasite has caused a resurgence of this disease.

**Plague** – a devastating bacterial infection, transmitted by bites from fleas that have fed on an infected rat. Symptoms include high fever, chills, weakness, and enlarged lymph nodes that turn black. In the 15<sup>th</sup> Century, the plague was carried by traders from China to Europe, where it killed 1/3 of Europe's population over a five year period and became

known as “the black death.” The plague is now rare – the World Health Organization reports 1,000 to 3,000 cases of plague every year – but the basic elements of transmission continue to make future epidemics a possibility. Preventative measures are the proper disposal of garbage and protecting household animals from flea infestation.

**Smallpox** - a highly contagious and often deadly disease caused by the *variola* virus. Spread through infected saliva droplets in coughs and sneezes, and also by direct contact with the skin lesions caused by the disease, smallpox was common prior to and during the 19<sup>th</sup> century.

A collaborative global vaccination programme led by the World Health Organization led to the official – and apparently total – eradication of smallpox in 1979. However, the virus is still maintained at laboratories at the Centers for Disease Control and Prevention (CDC) in the US and at the Institute of Virus Preparations in Moscow, Russia.

The use of *Bacillus anthracis* in the United States in the autumn of 2001 with the intent to harm a civilian population has raised public health concerns about potential exposure to intentionally released *Variola virus* and other biological agents. Efforts by WHO to support Member States in the event of intentional use of *Variola virus* as a biological weapon include surveillance, working to create a global vaccine reserve to support emergency response, and preparing protocols for response in the post-eradication era.

**SARS** – Sudden Acute Respiratory Syndrome was first observed in February 2003. It is a contagious, atypical pneumonia of unknown cause, spread by airborne droplets in coughs and sneezes. So far the response has been to isolate cases and potential carriers in order to prevent potential epidemics of this emerging disease. The WHO is monitoring outbreaks of the disease.

**Tuberculosis (TB)** – an infectious disease that is spread in airborne droplets emitted by sneezing or coughing. The bacteria can infect any part of the body but usually attacks the lungs, causing a persistent cough that produces bloody mucous. TB was once rampant, but nutrition, housing, sanitation, medical care, and the introduction of antibiotics reduced its incidence over the past 50 years or so. TB is now on the rise again. HIV/AIDS sufferers are particularly vulnerable.

**Typhoid** – a communicable disease marked by sustained fever, diarrhea, prostration, headache and intestinal inflammation. It is caused by the bacterium *salmonella typhosa*, which lives only in humans. Typhoid fever affects about 12.5 million persons in the developing world each year. Persons with typhoid fever carry the bacteria in their bloodstream and intestinal tract and shed *S. Typhi* in their feces (stool). Contact with feces of infected persons must therefore be avoided.

**Yellow fever** – a viral disease carried by the *Aedes* mosquito. The effects can vary widely from mild symptoms to sudden death. Symptoms include headache, fever, muscle pain, chills, loss of appetite, and nausea. During the early phase of infection, yellow fever can easily be confused with other diseases. In the later phase, jaundice may appear, along with internal bleeding and kidney failure. An effective vaccine exists, but in some parts of the world, yellow fever is now a serious public health issue again. Vaccination is the single most important measure for preventing yellow fever. In populations where vaccination coverage is low, vigilant surveillance is critical for prompt recognition and rapid control of outbreaks. Mosquito control measures should also be taken.

# Glossary

Acquired Immune Deficiency Syndrome (AIDS)-- A medical condition where the immune system cannot function properly and protect the body from disease. As a result, the body cannot defend itself against infections (like pneumonia). AIDS is caused by the Human Immunodeficiency Virus (HIV). This virus is spread through direct contact with the blood and body fluids of an infected individual. High risk activities include unprotected sexual intercourse and intravenous drug use (sharing needles). There is no cure for AIDS, however, research efforts are on-going to develop a vaccine.

Active immunity-- The production of antibodies against a specific disease by the immune system. Active immunity can be acquired in two ways, either by contracting the disease or through vaccination. Active immunity is usually permanent, meaning an individual is protected from the disease for the duration of their lives.

Acute-- A short-term, intense health effect.

Allergy-- A condition in which the body has an exaggerated response to a substance (e.g. food or drug). Also known as hypersensitivity.

Anthrax-- An acute infectious disease caused by the spore-forming bacterium *Bacillus anthracis*. Anthrax most commonly occurs in hooved mammals and can also infect humans.

Antibiotic-- A substance that fights bacteria.

Antibody-- A protein found in the blood that is produced in response to foreign substances (e.g. bacteria or viruses) invading the body. Antibodies protect the body from disease by binding to these organisms and destroying them.

Antigens-- Foreign substances (e.g. bacteria or viruses) in the body that are capable of causing disease. The presence of antigens in the body triggers an immune response, usually the production of antibodies.

Antitoxin-- Antibodies capable of destroying microorganisms including viruses and bacteria.

Antiviral-- Literally "against-virus" -- any medicine capable of destroying or weakening a virus.

Arthritis-- A medical condition characterized by inflammation of the joints which results in pain and difficulty moving.

Asthma-- A chronic medical condition where the bronchial tubes (in the lungs) become easily irritated. This leads to constriction of the airways resulting in wheezing, coughing, difficulty breathing and production of thick mucus. The cause of asthma is not yet known but environmental triggers, drugs, food allergies, exercise, infection and stress have all been implicated.

Asymptomatic infection-- The presence of an infection without symptoms. Also known as inapparent or subclinical infection.

Attenuated vaccine-- A vaccine in which live virus is weakened through chemical or physical processes in order to produce an immune response without causing the severe effects of the

disease. Attenuated vaccines currently licensed in the United States include measles, mumps, rubella, polio, yellow fever and varicella. Also known as a live vaccine.

Autism-- A chronic developmental disorder usually diagnosed between 18 and 30 months of age. Symptoms include problems with social interaction and communication as well as repetitive interests and activities. At this time, the cause of autism is not known although many experts believe it to be a genetically based disorder that occurs before birth.

Bacteria-- Tiny one-celled organisms present throughout the environment that require a microscope to be seen. While not all bacteria are harmful, some cause disease. Examples of bacterial disease include diphtheria, pertussis, tetanus, Haemophilus influenza and pneumococcus (pneumonia).

Bias-- Flaws in the collection, analysis or interpretation of research data that lead to incorrect conclusions.

Bone marrow-- Soft tissue located within bones that produce all blood cells, including the ones that fight infection.

Booster shots-- Additional doses of a vaccine needed periodically to "boost" the immune system. For example, the tetanus and diphtheria (Td) vaccine which is recommended for adults every ten years.

Chronic health condition-- A health related state that lasts for a long period of time (e.g. cancer, asthma).

Communicable-- That which can be transmitted from one person or animal to another.

Crohn's disease-- A chronic medical condition characterized by inflammation of the bowel. Symptoms include abdominal pain, diarrhea, fever, loss of appetite and weight loss. The cause of Chron's disease is not yet known, but genetic, dietary and infectious factors may play a part.

Communicable-- Capable of spreading disease. Also known as infectious.

Conjunctivitis-- Inflammation of the mucous membranes surrounding the eye causing the area to become red and irritated. The membranes may be irritated because of exposure to heat, cold or chemicals. This condition is also caused by viruses, bacteria or allergies.

Convulsion-- See Seizure.

Crib or Cot Death-- See Sudden Infant Death Syndrome (SIDS).

Diabetes-- A chronic health condition where the body is unable to produce insulin and properly breakdown sugar (glucose) in the blood. Symptoms include hunger, thirst, excessive urination, dehydration and weight loss. The treatment of diabetes requires daily insulin injections, proper nutrition and regular exercise. Complications can include heart disease, stroke, neuropathy, poor circulation leading to loss of limbs, hearing impairment, vision problems and death.

Diphtheria-- A bacterial disease marked by the formation of a false membrane, especially in the throat, which can cause death.

Disease-- Sickness, illness or loss of health.

Encephalitis-- Inflammation of the brain caused by a virus. Encephalitis can result in permanent brain damage or death.

Encephalopathy-- A general term describing brain dysfunction. Examples include encephalitis, meningitis, seizures and head trauma.

Epidemic-- The occurrence of disease within a specific geographical area or population that is in excess of what is normally expected.

Endemic-- The continual, low-level presence of disease in a community.

Etiology-- The cause of.

Exposure-- Contact with infectious agents (bacteria or viruses) in a manner that promotes transmission and increases the likelihood of disease.

Hepatitis A-- A minor viral disease, that usually does not persist in the blood; transmitted through ingestion of contaminated food or water.

Hepatitis B-- A viral disease transmitted by infected blood or blood products, or through unprotected sex with someone who is infected.

Hepatitis C-- is a liver disease caused by the Hepatitis C virus (HCV), which is found in the blood of persons who have the disease. HCV is spread by contact with the blood of an infected person.

Hepatitis D-- is a defective virus that needs the hepatitis B virus to exist. Hepatitis D virus (HDV) is found in the blood of persons infected with the virus.

Hepatitis E-- is a virus (HEV) transmitted in much the same way as hepatitis A virus. Hepatitis E, however, does not often occur in the United States.

Herpes Zoster-- A disease characterized by painful skin lesions that occur mainly on the trunk (back and stomach) of the body but which can also develop on the face and in the mouth. Complications include headache, vomiting, fever and meningitis. Recovery may take up to 5 weeks. Herpes Zoster is caused by the same virus that is responsible for chickenpox. Most people are exposed to this virus during childhood. After the primary infection (chickenpox), the virus becomes dormant, or inactivated. In some people the virus reactivates years, or even decades, later and causes herpes zoster. Also known as the shingles.

Hives-- The eruption of red marks on the skin that are usually accompanied by itching. This condition can be caused by an allergy (e.g. to food or drugs), stress, infection or physical agents (e.g. heat or cold). Also known as urticaria.

Hypersensitivity-- A condition in which the body has an exaggerated response to a substance (e.g. food or drug). Also known as an allergy.

Hyposensitivity-- A condition in which the body has a weakened or delayed reaction to a substance.

Immune globulin-- A protein found in the blood that fights infection. Also known as gamma globulin.

Immune system-- The complex system in the body responsible for fighting disease. Its primary function is to identify foreign substances in the body (bacteria, viruses, fungi or parasites) and develop a defense against them. This defense is known as the immune response. It involves production of protein molecules called antibodies to eliminate foreign organisms that invade the body.

Immunity-- Protection against a disease. There are two types of immunity, passive and active. Immunity is indicated by the presence of antibodies in the blood and can usually be determined with a laboratory test. See active and passive immunity.

Immunization-- The process by which a person or animal becomes protected against a disease. This term is often used interchangeably with vaccination or inoculation.

Immunosuppression-- When the immune system is unable to protect the body from disease. This condition can be caused by disease (like HIV infection or cancer) or by certain drugs (like those used in chemotherapy). Individuals whose immune systems are compromised should not receive live, attenuated vaccines.

Incidence-- The number of new disease cases reported in a population over a certain period of time.

Incubation period-- The time from contact with infectious agents (bacteria or viruses) to onset of disease.

Infectious-- Capable of spreading disease. Also known as communicable.

Infectious agents-- Organisms capable of spreading disease (e.g. bacteria or viruses).

Inflammation-- Redness, swelling, heat and pain resulting from injury to tissue (parts of the body underneath the skin). Also known as swelling.

Influenza-- A highly contagious viral infection characterized by sudden onset of fever, severe aches and pains, and inflammation of the mucous membrane.

Jaundice-- Yellowing of the eyes. This condition is often a symptom of hepatitis infection.

Lesion-- An abnormal change in the structure of an organ, due to injury or disease.

Live vaccine-- A vaccine in which live virus is weakened through chemical or physical processes in order to produce an immune response without causing the severe effects of the disease. Attenuated vaccines currently licensed in the United States include measles, mumps, rubella, polio, yellow fever and varicella. Also known as an attenuated vaccine.

Lupus-- A disease characterized by inflammation of the connective tissue (which supports and connects all parts of the body). Chronic swelling of the connective tissue causes damage to the skin, joints, kidneys, nervous system and mucous membranes. The disease begins with fever, joint pain and fatigue. Additional symptoms continue to develop over the years including nausea, fatigue, weight loss, arthritis, headaches and epilepsy. Problems with heart, lung and kidney function may also result. This condition is diagnosed most frequently in young women but also occurs in children.

Lyme disease-- A bacterial disease transmitted by infected ticks. Human beings may come into contact with infected ticks during outdoor activities (camping, hiking). Symptoms include fatigue, chills, fever, headache, joint and muscle pain, swollen lymph nodes and a skin rash (in a circular pattern). Long-term problems include arthritis, nervous system abnormalities, irregular heart rhythm and meningitis. Lyme disease can be treated with antibiotics or prevented with the use of a vaccine recently licensed by the Food and Drug Administration.

Measles-- A contagious viral disease marked by the eruption of red circular spots on the skin.

Meningitis-- Inflammation of the brain and spinal cord that can result in permanent brain damage and death.

Meningoencephalitis-- ["men in joe en sef uh LIGHT iss"] -- inflammation of the brain and meninges (membranes) that involves the encephalon (area inside the skull) and spinal column.

Multiple Sclerosis-- Multiple sclerosis is a disease of the central nervous system characterized by the destruction of the myelin sheath surrounding neurons, resulting in the formation of "plaques." MS is a progressive and usually fluctuating disease with exacerbations (patients feeling worse) and remissions (patients feeling better) over many decades. Eventually, in most patients, remissions do not reach baseline levels and permanent disability and sometimes death occurs. The cause of MS is unknown. The most widely held hypothesis is that MS occurs in patients with a genetic susceptibility and that some environmental factors "trigger" exacerbations. MS is 3 times more common in women than men, with diagnosis usually made as young adults. Also see demyelinating disorders.

Mumps-- Acute contagious viral illness marked by swelling, especially of the parotid glands.

Neuropathy-- A general term for any dysfunction in the peripheral nervous system. Symptoms include pain, muscle weakness, numbness, loss of coordination and paralysis. This condition may result in permanent disability.

Outbreak-- Sudden appearance of a disease in a specific geographic area (e.g. neighborhood or community) or population (e.g. adolescents).

Pandemic-- An epidemic occurring over a very large area.

Pathogens-- Organisms (e.g. bacteria, viruses, parasites and fungi) that cause disease in human beings.

Pertussis-- (whooping cough) Bacterial infectious disease marked by a convulsive spasmodic cough, sometimes followed by a crowing intake of breath.

Pneumonia-- Inflammation of the lungs characterized by fever, chills, muscle stiffness, chest pain, cough, shortness of breath, rapid heart rate and difficulty breathing.

Poliomyelitis-- (polio) An acute infectious viral disease characterized by fever, paralysis, and atrophy of skeletal muscles.

Potency-- A measure of strength.

Precaution-- A condition in a recipient which may result in a life-threatening problem if the vaccine is given, or a condition which could compromise the ability of the vaccine to produce immunity.

Prevalence-- The number of disease cases (new and existing) within a population over a given time period.

Quarantine-- The isolation of a person or animal who has a disease (or is suspected of having a disease) in order to prevent further spread of the disease.

Recombinant-- Of or resulting from new combinations of genetic material or cells; the genetic material produced when segments of DNA from different sources are joined to produce recombinant DNA.

Risk-- The likelihood that an individual will experience a certain event.

Rotavirus-- A group of viruses that cause diarrhea in children.

Rubella-- (German measles) Viral infection that is milder than normal measles but as damaging to the fetus when it occurs early in pregnancy.

Serology-- Measurement of antibodies, and other immunological properties, in the blood serum.

Seizure-- The sudden onset of a jerking and staring spell usually caused by fever. Also known as convulsions.

Side Effect-- Undesirable reaction resulting from immunization.

Smallpox-- An acute, highly infectious, often fatal disease caused by a poxvirus and characterized by high fever and aches with subsequent widespread eruption of pimples that blister, produce pus, and form pockmarks. Also called variola.

Strain-- A specific version of an organism. Many diseases, including HIV/AIDS and hepatitis, have multiple strains.

Sudden Infant Death Syndrome (SIDS)-- The sudden and unexpected death of a healthy infant under 1 year of age. A diagnosis of SIDS is made when an autopsy cannot determine another cause of death. The cause of SIDS is unknown. Also known as "crib" or "cot" death.

Teratogenic-- Of, relating to, or causing developmental malformations.

Tetanus-- Toxin-producing bacterial disease marked by painful muscle spasms.

Vaccine-- A product that produces immunity therefore protecting the body from the disease. Vaccines are administered through needle injections, by mouth and by aerosol.

Virus-- A tiny organism that multiplies within cells and causes disease such as chickenpox, measles, mumps, rubella, pertussis and hepatitis. Viruses are not affected by antibiotics, the drugs used to kill bacteria.

Whooping Cough-- See Pertussis

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# Bibliography

International Strategy for Disaster Reduction - <http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm> Feb 25, 2005

Golden Gate Weather Service - <http://ggweather.com/glossary.htm>, Feb 25, 2005

Department of Geological Science at the California State University, <http://seis.natsci.csulb.edu/rbehl/ITCZ.gif>, Feb 27, 2005

About.com(™) - <http://geography.about.com/library/weekly/aa050301a.htm>, Feb 27, 2005

The Guyana Flood Website, Reports and Stories by Bryan Mackintosh - [http://www.cdera.org/doccentre/20050123\\_guyana\\_flood.php](http://www.cdera.org/doccentre/20050123_guyana_flood.php), Feb 27, 2005

Atlantic Oceanographic and Meteorological Laboratory, Hurricane Research Division, FAQ Hurricanes, Typhoons and Tropical Cyclones - <http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html>, Feb 27, 2005

Atlantic Oceanographic and Meteorological Laboratory, Hurricane Research Division, What is an easterly wave - <http://www.aoml.noaa.gov/hrd/tcfaq/A4.html>, Feb 27, 2005

Atlantic Oceanographic and Meteorological Laboratory, Hurricane Research Division, What is a tropical disturbance, a tropical depression, or a tropical storm? - <http://www.aoml.noaa.gov/hrd/tcfaq/A5.html>, Feb 27, 2005

Seismic Research Unit of the University of the West Indies, Earthquakes - [http://www.uwiseismic.com/Earthquakes/eq\\_hpage.html](http://www.uwiseismic.com/Earthquakes/eq_hpage.html), Feb 27, 2005

USGS Earthquake Hazard Programme FAQ - <http://earthquake.usgs.gov/faq/prepare.html>, Feb 27, 2005

FEMA Fact sheet on Volcanoes - <http://www.fema.gov/hazards/volcanoes/volcanof.shtm>, Feb 27, 2005

USGS/Cascades Volcano Observatory, Glossary of Volcano and Related Terminology - [http://vulcan.wr.usgs.gov/Glossary/volcano\\_terminology.html](http://vulcan.wr.usgs.gov/Glossary/volcano_terminology.html), Feb 27, 2005

Centers for Disease Control, Terms/glossary - <http://www.cdc.gov/nip/webutil/terms/glossary.htm>, Feb 27, 2005